State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of the Big Darby Creek Watershed, 2001/2002

Logan, Champaign, Union, Madison, Franklin and Pickaway Counties

Central Mottled Sculpin
(Cottus bairdi bairdi)

Greenside Darter
(Etheostoma blennioides blennioides)

Clubshell Mussel
(Pleurobema clava)

Spotted Darter
(Etheostoma maculatum)

Eastern Banded Darter
(Etheostoma zonale zonale)

Helgrammite (Corydalus cornutus)

Smallmouth Bass *(Micropterus doloieui dolomieui)*

stonefly nymph

mayfly nymph
(*Isonychia sp.*)

June 28, 2004

Bob Taft, Governor
Christopher Jones, Director

Biological and Water Quality Study of Big Darby Creek and Selected Tributaries 2001/2002

Logan, Champaign, Union, Madison, Franklin and Pickaway Counties, Ohio

June 2004

Ohio EPA Technical Report EAS/2004-6-3

prepared by

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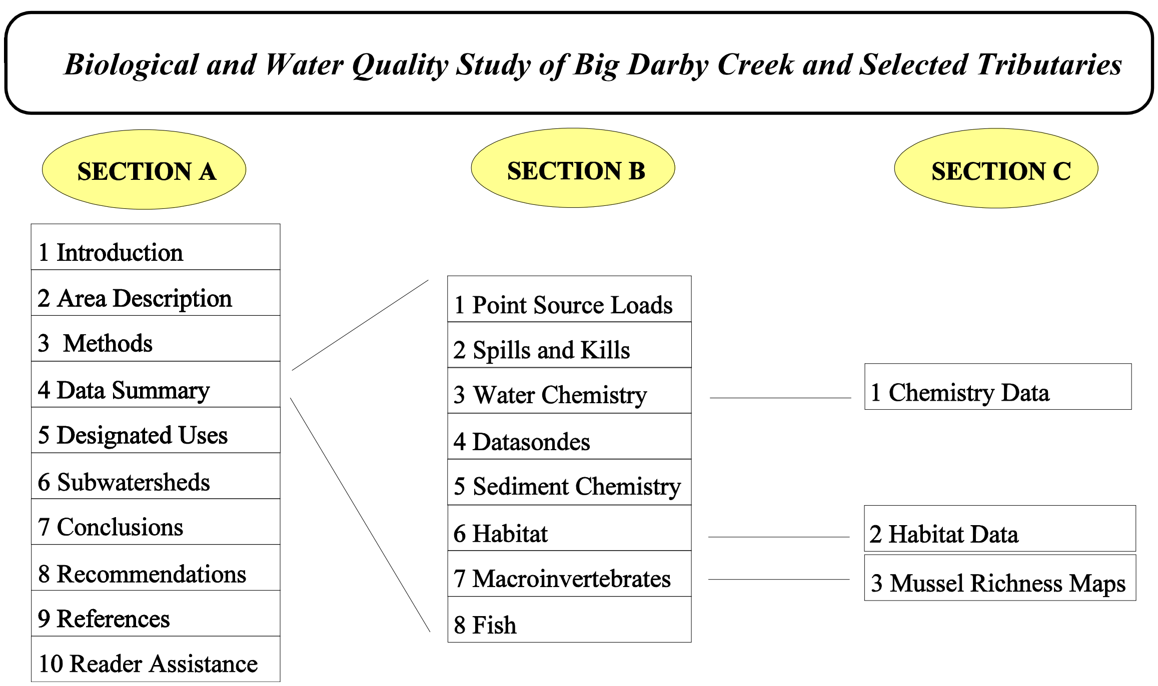
How to Use this Document

Ohio EPA and others have collected data in the Big Darby Creek watershed for decades, yet this is the first published report of findings that the Agency has produced. Thus, there is much to say. Organizing the information into a digestible format has proven to be a challenge, especially given that many audiences of varying skill in deciphering scientific and regulatory language have an interest in the watershed. The goal here is to present all the pertinent information, explain how decisions have been made, and give the reader some tools to decide which parts, and how much detail, will satisfy his or her needs.

The report consists of three sections. Section A contains descriptions of the study area and study methods, summaries of findings in various formats, conclusions, and recommendations. The last chapter in Section A contains some tools that may be helpful to readers: a list of acronyms, a glossary, and a primer on common causes of water quality impairment. Section B amplifies some of the findings in Chapter 4 of Section A, presenting much more detail and numerous figures and tables. Section C contains tables of raw data and maps of mussel species richness.



Copies of this report can be downloaded from the Ohio EPA internet Web page (www.epa.state.oh.us/dsw/document_index/psdindx.html) and are available on CD from:

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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, 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. 1989a. 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., Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. 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 Ohio EPA have become available. These publications should also be consulted as they represent the latest information and analyses used by 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. 1995a. 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. 1995b. 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. 1995c. 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 may be obtained by writing to:

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FOREWORD

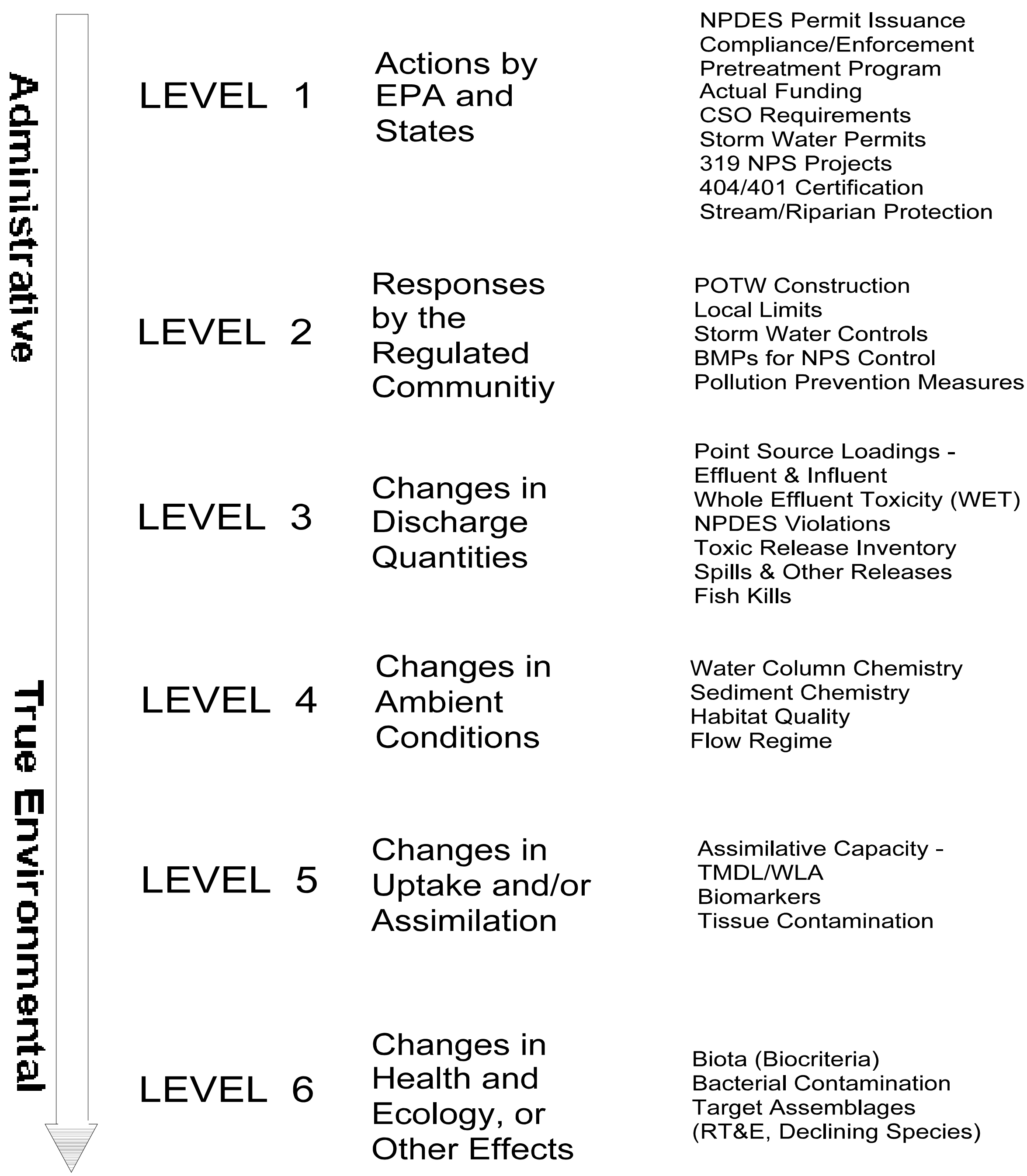
What is a Biological and Water Quality Survey?
A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two 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 several study areas with an aggregate total of 250-300 sampling sites.

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), and are eventually incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and reporting submitted to U.S. EPA as required in Sections 305(b) and 303(d) of the Clean Water Act.

Hierarchy of Indicators
A carefully conceived ambient monitoring approach, using cost-effective indicators comprised 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 (see illustration). 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 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 recreational 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 Ohio Nonpoint Source Assessment, reporting submitted to U.S. EPA as required in Sections 305(b) and 303(d) of the Clean Water Act, 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) *Cold-water 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 is simply having a water depth of at least one meter over an area of at least 100 square feet or where canoeing is a feasible activity. If a water body is too small and shallow to 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.

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 Agricultural Water Supply (AWS) and Industrial Water Supply (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, and sportfish consumption advisories are issued by Ohio EPA.

A.1 INTRODUCTION

As part of the Total Maximum Daily Load (TMDL) effort and the five year basin approach to monitoring, assessment, and the issuance of National Pollution Discharge Elimination System (NPDES) permits, ambient biological, water column chemical, sediment, and fish tissue sampling was conducted in the Big Darby Creek watershed from June through October, 2001, and during a similar period in 2002. This study area included the entire 83.2 length of the mainstem and every major tributary, including many previously unsampled tributaries. Table A.1 details locations of the 2001 sampling sites. Table A.2 details locations of additional samples collected during the 2002 field season to fill gaps and further document identified impact areas.

Specific objectives of this evaluation were to:

1) Monitor and assess the chemical, physical and biological integrity of the streams within the 2001 and 2002 Big Darby Creek study area;

1) Characterize the consequences of various land use practices on water quality within the Big Darby Creek watershed;

3) Evaluate the influence of various wastewater treatment plants (WWTPs) within the watersheds;

4) Evaluate the potential impacts from spills, nonpoint source pollution (NPS), and habitat alterations on the receiving streams; and

5) Determine the accuracy and appropriateness of currently designated Warmwater Habitat (WWH), Exceptional Warmwater Habitat and Modified Warmwater Habitat aquatic life uses; determine the appropriate aquatic life use in currently undesignated streams and segments and other non-aquatic use designations; and recommend changes where appropriate.

The findings of this evaluation 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) and are incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and reporting submitted to U.S. EPA as required in Sections 305(b) and 303(d) of the Clean Water Act. The findings also form the foundation for the analysis of Total Maximum Daily Loads (TMDLs) to address areas not attaining water quality standards.

The report consists of three sections. Section A contains descriptions of the study area and study methods, summaries of findings in various formats, conclusions, and recommendations. The last chapter in Section A contains some tools that may be helpful to readers: a list of acronyms, a glossary, and a primer on common causes of water quality impairment. Section B amplifies some of the findings in Chapter 4 of Section A, presenting much more detail and numerous figures and tables. Section C contains tables of raw data and maps of mussel species richness.

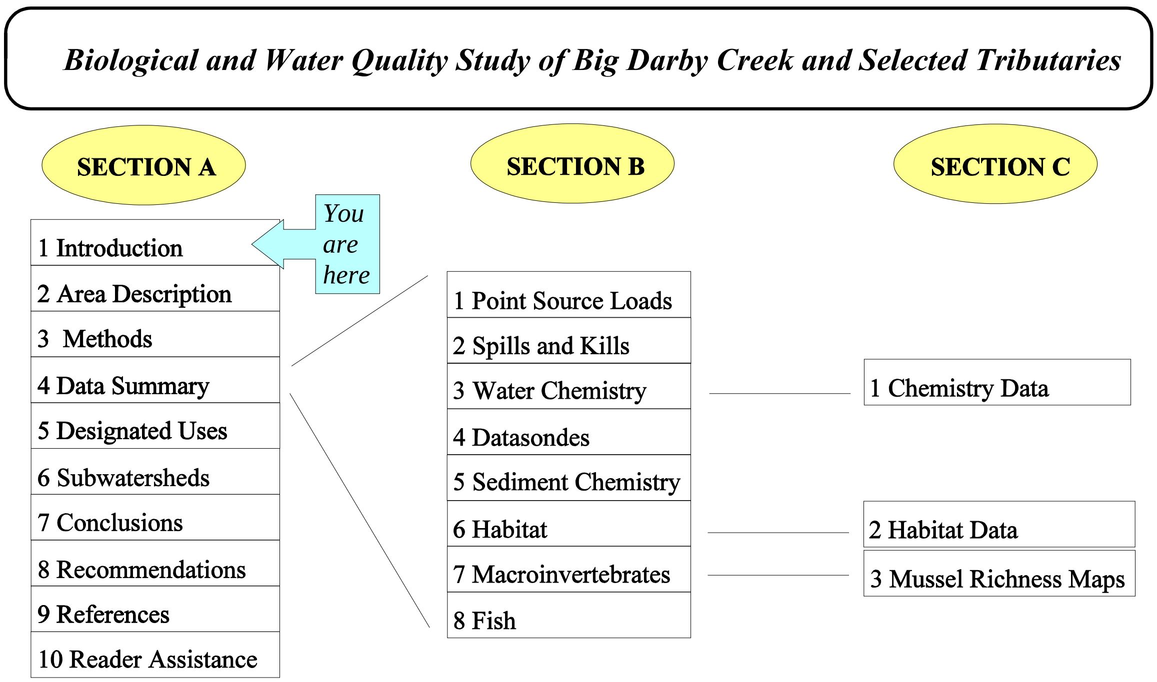


Table A.1. Sampling locations in the Big Darby Creek watershed, June - October, 2001

F - fish, B - bug, C - water chemistry, Cs - water chemistry screening site, CO - water chemistry organics, SD - sediment chemistry, D - Datasonde, M - Modeler's Screening Site, SS - Storm site, R - Reference site, and FT - Fish Tissue Site

River Mile	Sampling Type	Lat./Long. (DDMMSS)	USGS Quad	Landmark
Big Darby Creek (02-200)[a]				
83.2	B	40.3176/83.5887	E. Liberty - 387	Upstream, pvt. Property
82.5	F,B,C	40.3200/83.5825	E. Liberty - 387	CR 152
80.8	F,M	40.2992/83.5703	E. Liberty - 387	SR 287
79.2	F,B,C,SS,M,S,D	40.2778/83.5583	E. Liberty - 387	Twp. Rd. 157
78.4	F,B,C,D	40.2689/83.5517	E. Liberty - 387	dst. Flat Branch
76.6	F,B,C,SD,FT	40.2492/83.5344	N. Lewisburg -422	N. Lewisburg Rd.
69.5	F,B,C	40.1958/83.4744	Milford Ctr - 423	ust. Collins Rd., ust. Trib.
67.0	F	40.1817/83.4414	Milford Ctr - 423	ust. Milford Ctr.
63.8	F,B,C,SD,D,FT	40.1589/83.4975	Milford Ctr - 423	ust. Streng Rd., ust. Buck Run
62.5	F,B,C,D	40.1503/83.3819	Milford Ctr - 423	SR 38
54.2	F,B,C,SD,FT,CO	40.1228/83.2731	Plain City -458	US 42,ust Robinson Run and Ranco
53.9	F,B,C,SD,CO	40.1231/83.2692	Plain City -458	dst. US 42, dst. Riffle
52.5	F,B,C,D	40.1072/83.2572	Plain City -458	ust. P. C. WWTP, dst. Sweeny Run
52.0	F,B,C,SD,D	40.1072/83.2572	Plain City -458	dst. Plain City WWTP
49.5	F,B,C,D,FT	40.0825/83.2497	Hilliard -459	ust. Amity Pike
42.0	F,B,C,FT	39.9836/83.2492	Galloway - 493	I-70, high Free Pike
38.9	FT	39.9472/83.2356	Galloway - 493	US Rt. 40, dst. Lake Darby Estates
34.1	F,B,C,SD,D,FT,CO	39.8936/83.2178	Galloway -493	Alkire Rd., ust. L. Darby Cr.
29.1	F	39.8494/83.1875	Harrisburg - 527	adj. Darbydale
23.8	F,B,C,SD,D,CO	39.7942/83.1669	Harrisburg - 527	SR 762
22.8	F,B,C,D,CO	39.7903/83.1617	Harrisburg - 527	dst. PCI WWTP
18.7	F,B,C,FT	39.7519/831414	Harrisburg - 527	Mt. Sterling-Comm. Pt. Rd.
13.4	F,B,C,SD,D,FT	39.7025/83.1114	Darbyville -561	SR 316
3.1	F,B,C,SD,D,FT	39.6289/83.0081	Darbyville - 561	SR 104
0.3	F	39.6142/82.9664	Darbyville -561	mouth
Flat Branch (02-223) (RM 78.48)[b]				
3.2	F,B,C	40.3025/83.5194	E. Liberty -387	O'Dell Rd.
2.2	B	40.2869/83.5253	E. Liberty -387	Adj. SR 739, dst. Tribs
0.8	F,B,C,SD,D,R	40.2767/83.5433	E. Liberty -387	near mouth
U. T. to Flat Branch (02-365) (RM 1.5)				
0.1	B	40.2822/83.5344	E. Liberty -387	North Trib TRC
Little Darby Creek(02-251)(RM78.34)				
3.5	F,B,C,SD,R	40.2822/83.5944	E. Liberty -387	SR 287
0.4	F,B,C,SD,D	40.2678/83.5575	E. Liberty -387	CR 153
Tributary to Big Darby Creek (RM 74.91)				
0.2	F,B,Cs	40.2353/83.5253	N.Lewisburg - 422	CR153
U.T. to Big Darby Creek (02-361) (RM 74.91)				
0.2/0.3	F,B	40.2350/83.5256	N.Lewisburg - 422	CR 153
Spain Creek				
5.7	F,B,Cs	40.2139/83.6053	N.Lewisburg - 422	Lewisburg Rd.
3.7	F,B,C	40.2161/83.5772	N.Lewisburg - 422	Gilbert Rd.
0.2	F,B,C,SD	40.2286/83.5228	N.Lewisburg - 422	Cratty Rd.

Continued.

Table A.1. Continued.

River Mile	**Sampling Type**	**Lat./Long. (DDMMSS)**	**USGS Quad**	**Landmark**
Pleasant Run (02-221) (RM 72.01)				
4.6	F	40.1903/83.5669	N.Lewisburg - 422	Burton Rd.
4.1	B	40.1919/83.5572	N.Lewisburg - 422	Burton Rd.
0.5	F,B	40.2106/83.5000	N.Lewisburg - 422	M'burg-P'City Rd.
U.T. to Big Darby Creek (02-360) (RM 69.4)				
0.2/0.4	F,B	40.1981/83.4789	N.Lewisburg - 422	M'burg-P'City Rd.
Hay Run (02-220) (RM 67.6)				
0.3/0.2	F,B	40.1839/83.4519	N.Lewisburg - 422	M'burg-P'City Rd.
Prairie Run (02-219) (RM 63.84)				
0.3	F	40.1575/83.3994	N.Lewisburg - 422	M'burg-P'City Rd.
Buck Run (02-209) (RM 63.74) (WWH)				
10.4/10.4	F,B	40.2400/83.4750	Milford Center -423	Allen Ctr. -P'burg Rd.
7.8/7.8	F,B	40.2239/83.4622	Milford Center -423	SR 245
5.0/5.0	F,B	40.2011/83.4283	Milford Center -423	Milford-Amrine Rd.
0.1/0.6	F,B	40.2011/83.4283	Milford Center -423	Orchard Rd.
Robinson Run (02-207) (RM 53.69) (WWH)				
/5.5	B	40.1569/83.3289	Marysville - 424	Dst. Hawn Rd.
2.1/2.1	F,B	40.1350/83.2869	Marysville - 424	SR 736
0.7/0.8	F,B	40.1286/83.2700	Marysville - 424	US 42
Sweeny Run (02-357) (RM 52.11) (Undesignated/WWH Recommended)				
0.1/0.2	F,B	40.1042/83.2592	Plain City - 458	Mouth
Sugar Run (02-206) (RM 50.92)				
7.5/7.7	F,B	40.1667/83.2547	Marysville - 424	Ind.Pkwy.@farm
7.0/6.9	F,B	40.1597/83.2542	Marysville - 424	Taylor rd.,Dst.landfill
Sugar Run (02-206) (RM 50.92) (WWH)				
5.4/5.5	F,B	40.1428/83.2483	Shawnee Hills -425	US 42
0.5/0.5	F,B	40.0939/83.2503	Hilliard -459	Cemetery Pike
U.T. to Sugar Run (02-358) (RM 7.39)				
0.1/0.1	F,B	40.1667/83.2525	Shawnee Hills -425	Ind.Pkwy.
Worthington Ditch (02-356) (RM 50.62)				
0.2/0.2	F,B	40.0839/83.2539	Plain City - 458	P'city-G'ville Rd.
Ballenger-Jones Ditch (02-355) (RM 49.68)				
0.4/0.2	F,B	40.0717/83.2522	Plain City - 458	P'city-G'ville Rd.
Yutzy Ditch (02-364) (RM 47.1)				
0.4/0.4	F,B	40.0419/83.2642	Plain City - 458	P'city-G'ville Rd.
Fitzgerald Ditch (02-272) (RM 44.96)				
0.5/0.5	F,B	40.0178/83.2619	Plain City - 458	P'city-G'ville Rd.
Little Darby Creek (02-210) (RM 34.1)				
41.2/41.2	F,B	40.0711/83.5786	Mechanicsburg - 456	Alison Rd.
39.6/39.3	F,B	40.0678/83.5522	Mechanicsburg - 456	Ust SR 29dst fert.dist.
38.8/38.8	F,B	40.0747/83.5417	Mechanicsburg - 456	Wing Rd. Dst M'burg WWTP
34.7/34.6	F,B	40.1092/83.4928	Mechanicsburg - 456	Irwin Rd.

Continued

Table A.1. Continued.

River Mile Type	Sampling	Lat./Long. (DDMMSS)	USGS Quad	Landmark
Little Darby Creek (02-210) (RM 34.1)				
29.5/29.4	F,B	40.1156/83.4250	Mechanicsburg - 456	Axe Handle Rd.
24.5/24.5	F,B	40.0736/83.4028	Mechanicsburg - 456	Rosedale-Plain City Rd.
/17.0	B	39.9869/83.3756	Mechanicsburg - 456	Adj. L. Darby Rd.
15.3/15.4	F,B	39.9731/83.9731	Mechanicsburg - 456	US 42
6.5/6.4	F,B	39.9450/83.2600	Mechanicsburg - 456	US 40, Ust W. Jeff WWTP
4.1/3.8	F,B	39.9183/83.2611	Mechanicsburg - 456	Roberts Rd. Dst WWTP
0.2/0.5	F,B	39.8942/83.2206	Mechanicsburg - 456	Mouth @ Metropark
Clover Run (02–218) (RM 39.8)				
0.6/0.6	F,B	40.0631/83.5642	Mechanicsburg - 456	Rd to Maple Grove Cem.
Lake Run (02-216) (RM 36.9)				
0.9/0.9	F,B	40.0928/83.5233	Mechanicsburg - 456	SR 4
0.3/0.2	F.B	SR 559	Mechanicsburg - 456	
Treacle Creek (02-213) (RM 31.3) (EWH)				
11.8/11.7	F,B	40.1203/83.5828	Mechanicsburg - 456	M'burg-Belle. Rd.
8.3/8.3	F,B	40.1186/83.5272	Mechanicsburg - 456	Eagle Rd.
6.0/6.0	F,B	40.1236/83.4942	Plumwood - 457	SR 161 at Irwin
/0.7	B	40.1381/83.4525	Milford Center - 423	Covered bridge nr. mouth
Howard Run (02-215) (RM 5.4) (EWH)				
0.5/0.6	B	40.1331/83.5006	N. Lewisburg - 422	McMahill Rd.
Proctor Run (02-214) (RM 3.69) (EWH)				
4.9/4.9	F,B	40.1658/83.5542	N.Lewisburg - 422	Park Rd.
3.1/3.2	F,B	40.1642/83.5269	N. Lewisburg - 422	SR 559
1.6/1.7	F,B	40.1583/83.5064	N. Lewisburg - 422	McMahill Rd.
Barron Creek (02-212) (RM 24.4)				
2.1/2.1	F,B	40.0792/83.4347	Plumwood - 457	Rosedale-Plain City Rd.
0.2/0.1	F,B	40.0725/83.4036	Plumwood - 457	SR 38
Wamp Ditch (02-363) (RM 23.0)				
0.1/0.1	F,B	40.0572/83.3936	Plumwood - 457	Vogelburg Rd.
Spring Fork (02-211) (RM 17.46) (EWH)				
15.8/15.8	F,B	40.0442/83.5419	Mechanicsburg -456	Wren Rd.
13.7/13.3	F,B	40.0375/83.5036	Mechanicsburg -456	Ust. SR 29, ust. Trib.
10.1/10.1	F,B	40.0667/83.4747	Plumwood - 457	Ust. Cemetary Rd.
7.8/7.7	F,B	40.0475/83.4428	Plumwood - 457	R'dale-M'Ctr. Rd
Bales Ditch (02–362) (RM 3.64)				
0.4/0.4	F,B	40.0083/83.4253	Plumwood - 457	R'dale-M' Ctr. Rd.
Smith Ditch (02-353) (RM 31.69)				
2.1/2.1	F,B	39.8633/83.2458	Harrisburg -527	G'ville-W'ville Ditch
0.3/0.2	F	39.8633/83.2458	Harrisburg -527	Biggert Rd.
Trib to Smith Ditch (02-354) (RM 0.06)				
0.2/-	F	39.8611/83.2192	Harrisburg -527	Biggert Rd.
Gay Run (02-298) (RM 26.48)				
2.2/2.2	F,B	39.8292/83.2022	Harrisburg -527	Boyd Rd.
Hellbranch Run (02-204) (RM 26.1) (WWH)				
10.3/9.4	F,B	39.9217/83.1775	Galloway - 493	Dst. Conflu./dst. Al

Continued.

Table A.1. Continued.

River Mile Type	Sampling	Lat./Long. (DDMMSS)	USGS Quad	Landmark
Hellbranch Run (02-204) (RM 26.1) (WWH)				
7.4/7.4	F,B	39.9019/83.1639	Galloway - 493	Kunz Rd.
5.8/5.7	F,B	39.8822/83.1544	Galloway - 493	Dst Ohurst Knolls WWTP
3.7/3.7	F,B	39.8600/83.1564	Harrisburg - 527	Beatty Rd.
1.0/0.9	F,B	39.8292/83.1603	Harrisburg - 527	Lambert Rd.
0.5/0.5	F,B	39.8247/83.1608	Harrisburg - 527	Dst. Timberlake WWTP
Hamilton Ditch (02-259) (RM 11.19)				
3.4/3.4	F,B	39.9900/83.1881	Galloway - 493	Walker Rd.
0.5/0.5	F,B	39.9508/83.1817	Galloway - 493	US 40
Clovergroff Ditch (02-245) (RM 11.19)				
4.7/4.7	F,B	40.0036/83.1706	Hilliard - 459	Roberts Rd.
0.8/0.8	F,B	39.9506/83.1689	Galloway - 493	Dst. US 40
Springwater Run (02-203) (RM 24.0)				
0.8/0.2	F,B	39.8081/83.1717	Harrisburg - 527	US 62 at mouth
U.T. to Big Darby Creek (02-352) (RM 23.77)				
0.1/-	F	39.7997/83.1703	Harrisburg - 527	South of SR 762
U.T. to Big Darby Creek (02-270) (RM 20.2)				
0.8/0/8	F,B	39.7681/83.1603	Harrisburg - 527	H’burg-D’ville Rd.
U.T. to Big Darby Creek (02-366) (RM 18.41)				
0.1/0.1	F,B	39.7514/83.1375	Harrisburg - 527	Mouth
Greenbrier Creek (02-202) (RM 16.75)				
2.7/2.7	F,B	39.7525/83.1708	Harrisburg - 527	Mt.Ster.-Com. Pt. Rd.
1.3/1.1	F,B	39.7417/83.1433	Five Points -560	H’burg-D’ville Rd.
Georges Creek (02-201) (RM 14.4)				
0.5/0.5	F,B	39.7417/83.1433	Five Points -560	C.Ville-London North Rd.
Lizard Run (02-273) (RM 12.93)				
0.2/0.2	B	39.6947/83.1122	Darbyville - 561	London Northern Rd.

a River code for the Ohio EPA OhioECOS database
b River Mile location of the confluence of a particular tributary with its receiving stream.

Table A.2. Sampling locations in the Big Darby Creek watershed, June - October, 2002.

F - fish, B - bug, C - water chemistry, Datasonde - D, and FT - Fish Tissue Site

Site Name River Mile	Sampling	Lat. / Long. (DDMMSS)	USGS Quad	Landmark
Big Darby Creek				
78.6	D	40.2710/83.5538	E. Liberty - 387	Ust. Flat Branch
78.4	D	40.2685/83.5579	E. Liberty - 387	Dst. Flat Branch
76.6R	FT	40.2489/83.5329	N. Lewisburg-422	N. Lewisburg Rd.
67.2	B	40.1810/83.4419	Milford Ctr - 423	Ust. Milford Center
66.0/66.0	F, B	40.1781/83.4279	Milford Ctr -423	dst. Milford Center (old dam located downstream from SR 36)
63.8	FT	40.1594/83.3959	Milford Ctr -423.	Ust. Streng Rd, ust Buck Run
54	FT	40.1327/83.2728	Plain City - 458	US 42, ust Robinson Run and RANCO
51.6	D	40.0972/83.2615	Plain City - 458	Adj. Plain City-Geosville Rd.
49.5	FT	40.1015/83.2598	Hilliard - 459	Ust. Amity Pike
40.7	FT	39.9693/83.2461	Galloway - 493	Adj. Camp Ken-Jockety
38.9	FT, B	39.9782/83.2504	Galloway - 493	US Rt. 40, dst. Lake Darby Estates
34.1	FT	39.8947/83.2176	Galloway - 493	Alkire Rd. ust L. Darby Ck
29	FT	39.8496/83.1855	Harrisburg - 527	Adj. Darbydale
28.6	B	39.8500/83.1814	Harrisburg - 527	Dst. Darbydale
26.1	F,B	39.8200/83.1682	Harrisburg - 527	Dst. Hellbranch Run
22.1	D	39.7852/83.1503	Harrisburg - 527	Adj. Sanke Island
19.5	D	39.7525/83.1543	Harrisburg - 527	Ust. Mt. Sterling-Commercial Point Rd.
19.1	FT	39.7529/83.1473	Harrisburg - 527	Mt. Sterling-Commercial Point Rd.
18.9	D	39.7521/83.1445	Harrisburg - 527	Dst. Mt. Sterling-Commercial Point Rd.
18.45	D	39.7500/83.1377	Harrisburg - 527	Dst. Mt. Sterling-Commercial Point Rd.
18.1	D	39.7487/83.1313	Five Points - 560	Keplar Rd.
15.8	B	39.7229/83.1230	Darbyville - 561	Gulick Cemetery
15.7	D, F	39.7223/83.1221	Darbyville - 561	Dst. Unnamed trib.
15.1	B	39.7313/83.1336	Darbyville - 561	Dst. Greenbrier Creek
14.2	D	39.7087/83.1220	Darbyville - 561	Dst. Georges creek
13.4	FT,C	39.7021/83.1109	Darbyville - 561	SR 316
12.9	D	39.6948/83.1079	Darbyville - 561	dst. Lizard Run

Site Name River Mile	Sampling	Lat. / Long. (DDMMSS)	USGS Quad	Landmark
11.2	D,B	39.6761/83.0956	Darbyville - 561	access rd. adj. east bank from N end of Circleville - Florence Chapel Rd.
10.4	F	39.6660/83.0909	Darbyville - 561	Dst. Florence Cemetery
8.7	F, D	39.6622/83.0743	Darbyville - 561	Dst. U.T. BDC RM 8.8
7.9	D	39.6617/83.0635	Darbyville - 561	Dst. U.T. BDC RM 8.5
5.4	D	39.6475/830308	Darbyville - 561	Ust. McLean Mill Rd. bridge
5.3	B	39.6463/83.0298	Darbyville - 561	Ust. McLean Mill Rd. bridge
3.2	FT	39.6285/83.0099	Darbyville - 561	SR 104
Little Darby Creek				
41.2	F	40.0709/83.5784	Mechanicsb.-456	Allison Rd, historical
33.2	B	40.1147/83.4715	Plumwood - 457	Rosedale - Milford Center Rd.
29.5	FT	40.1166/83.4257	Plumwood - 457	Axe Handle Rd., hog farm, dst. Treacle Ck.
26.6	F	40.0999/83.3925	Plumwood - 457	at or dst. Chuckery (161)
26.5	B	40.0989/83.3927	Plumwood - 457	dst. Chuckery
24.7	FT	40.0739/83.4028	Plumwood - 457	Rosedale-Plain City Rd.
23.2	B	40.0596/83.3968	Plumwood - 457	ust. Finley Guy Rd.
23.1	F	40.0594/83.3962	Plumwood - 457	Finley Guy Rd.(dst Barron and Wamp Ditch)
20.5	F,B	40.0252/83.3897	Plain City - 457/491	Bradley Rd.
15.3	B	39.9720/83.3558	W. Jefferson - 492	ust. US 42 (USGS Gage)
15.2	FT,C	39.9892/83.3765	W. Jefferson - 492	US 42 (USGS Gage)
3.9	FT	39.9180/83.2575	W. Jefferson - 492	Roberts Rd., dst W.Jeff
0.7	FT	39.8961/83.2284	Galloway - 493	Mouth (@ metro park)
Hellbranch Run				
6	FT	39.8854/83.1573	Galloway - 493	Norton Rd.
1	FT	39.8292/83.1601	Harrisburg - 527	Lambert Rd (Weekly Grabs)
0.5	B	39.8249/83.1599	Harrisburg - 527	dst Timberlake WWTP
U.T. to BDC (RM 20.2)	D	39.7629/83.1505	Harrisburg - 527	Dst. Mt. Sterling-Commercial Point Rd.
U.T. to BDC (RM 18.41)	B	39.7512/83.1377	Harrisburg - 527	Dst. Mt. Sterling-Commercial Point Rd.
Greenbrier Creek				
1.3	B	39.7419/83.1435	Five Points - 560	Harrisburg - Darbyville Rd.

Site Name River Mile	Sampling	Lat. / Long. (DDMMSS)	USGS Quad	Landmark
Prairie Run, 0.3	F	40.1553/83.3994	Milford Ctr. -423	Middleburg-Plain City Rd.
Flat Branch				
0.8	D	40.2789/83.5423	E.Liberty - 387	Old SR 33
Spring Fork				
10.1	F,B	40.0665/83.4745	Plumwood - 457	Ust. Cemetery Rd.
3.4	B	40.0055/83.4174	Plumwood - 457	Dst. Bales Ditch
3.3	F,B	40.0044/83.4174	Plumwood - 457	ust. SR 38
0.75	D	39.9919/83.3892	Plumwood - 457	Lafayette-Plain City Rd, historical

A.2 STUDY AREA DESCRIPTION

A.2.1 Location / Size

Big Darby Creek and its tributaries drain 355,200 acres (555 square miles) of predominantly high quality agricultural landscapes across six counties: Champaign, Franklin, Logan, Madison, Pickaway and Union. The headwaters rise in Logan County, coursing through low hills; with the Little Darby and mainstem draining areas of more gentle relief downstream and to the confluence with the Scioto River at Circleville (Figure A.1). Selected reaches of the mainstem on the Franklin - Madison county border (as well as Hellbranch Run) drain landscapes under current or imminent development pressure from the expanding Columbus metropolitan region.

A.2.2 Climate

Climatological conditions of the Big Darby watershed have influenced the geology, soil development and the presence and distribution of flora and fauna. Ephemeral weather conditions (i.e., convectional storms, frontal precipitation, freeze-thaw cycles) in turn play a role in surface runoff and stream flows.

Central Ohio lies within a climatic region (i.e., Humid Continental - Koppen classification Cfa) which is influenced by the interaction of cold-dry Canadian air masses and warmer, more humid air masses from the Gulf of Mexico (Strahler 1963). The meeting of these conflicting air masses produces weather which may cause short and intense periods of precipitation or longer but less intense periods of precipitation.

Winter sees increased movement of cold dry Canadian air masses over the watershed while Spring brings an increase of warm wet air masses from the Gulf of Mexico. When these maritime air masses “collide” with lingering Canadian air, atmospheric conditions are more conducive to tornado production. These conditions are observed annually in the Big Darby Creek watershed

The Caribbean and Gulf “hurricane season” (normally late summer and early fall) may influence the Darby system’s surface flow if tropical storms track inland while moving from south to north along the East Coast or north from the Gulf of Mexico. These incidences, though infrequent, are capable of dramatically raising stream levels.

The frequent incursion of maritime air masses (Gulf) during spring and early summer is reflected in the weather data recorded at Irwin, Ohio between 1991 and 1997. Heaviest precipitation occured in June and July, with an annual mean of 38.14 inches. Mean temperatures for this same period and site ranged between a monthly mean of 27 degrees (F) in February to 74.1 (F) in July.

While weather data for the Irwin station was not available for the year 2001 (personal communication, State Climatologist), precipitation during the months of January, February and

March at Bellefontaine and Marysville deviated markedly from expected numbers and those of years 2000, 2002 and 2003. Precipitation data from 2000 through 2003 are summarized in Table A.3.

Table A.3. Total monthly precipitation for the years 2000 -2003, Bellefontaine and Marysville stations

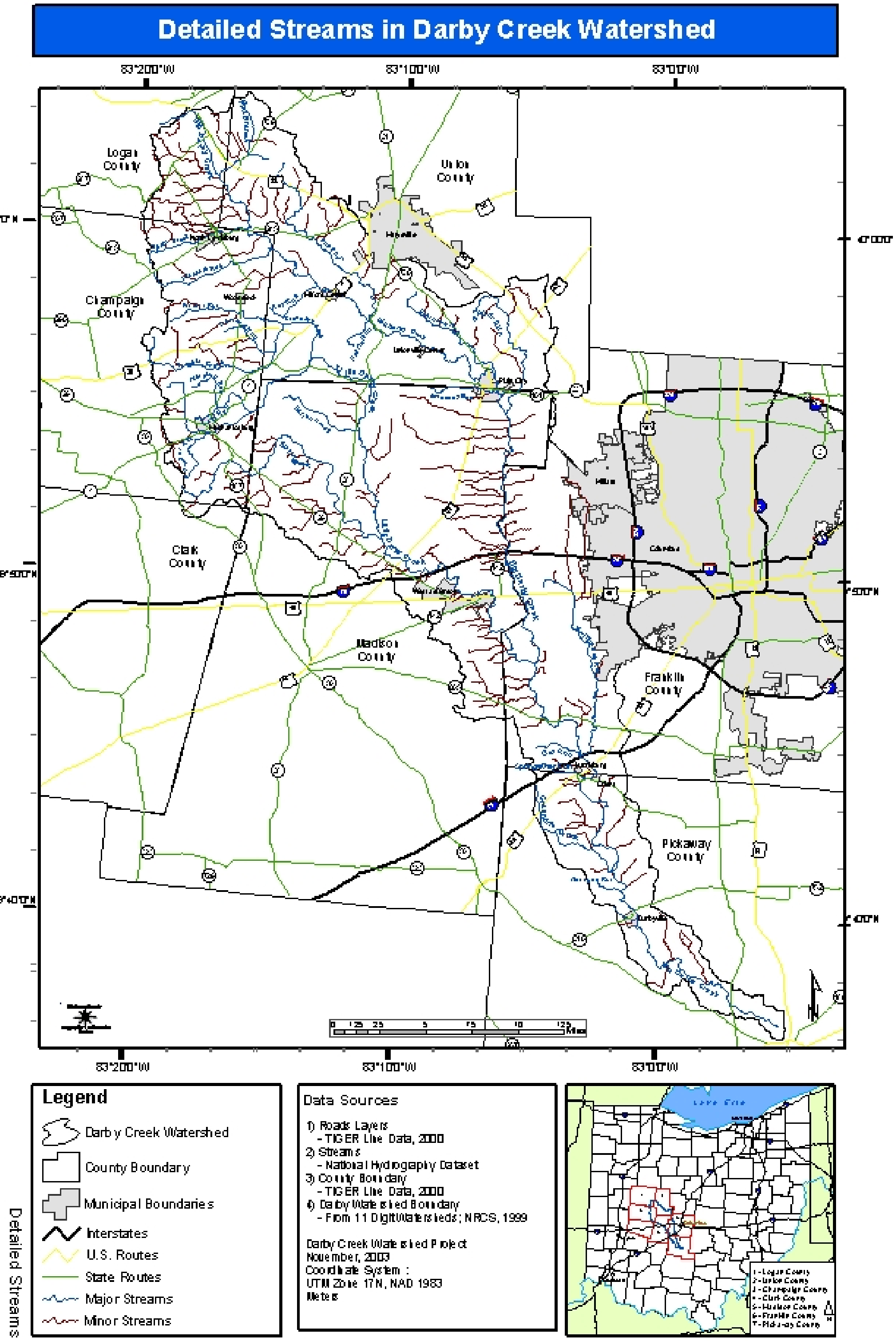
Bellefontaine

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	2.38	2.63	1.79	3.84	5.62	6.29	2.17	6.04	5.06	1.60	2.00	2.65
2001	0.94	1.64	1.25	3.84	6.97	4.26	3.37	4.29	4.18	5.22	2.64	2.88
2002	1.73	1.91	3.46	8.34	3.92	3.28	1.79	2.05	4.47	2.13	3.58	3.41
2003	1.75	3.33	2.99	2.56	5.71	3.71	N.A.	5.61	6.23	2.76	3.90	N.A.

Marysville

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	3.25	2.75	2.30	4.28	4.75	3.65	3.31	4.06	3.97	2.11	1.97	2.45
2001	1.02	1.41	0.86	4.26	6.11	2.84	3.14	5.64	3.53	4.87	3.75	3.19
2002	1.22	1.78	3.43	4.87	3.70	2.86	4.79	2.53	7.98	2.17	3.04	2.71

Figure A.1. Map of the Big Darby Creek watershed



A.2.3 Geology

All watersheds' drainage patterns, topography, soils and water chemistry are influenced by their underlying geology. The geology of the Big Darby Creek watershed is, in large part, the result of interactions between four successive glacial periods and the Teays River, a fluvial system which drained most of the region for millions of years prior to the Pleistocene Epoch (see Figure A.2). Glacial ice dammed the Teays system, depositing poorly draining sediments which filled its valley and created new drainage patterns as the dammed water eventually flowed over older drainage divides.

The glacial ice itself deposited materials ranging from fine silts to boulders. Glacial meltwater carried fines to lakes where they accumulated yielding highly impermeable beds. The retreating glacial front dropped materials, once icebound, which resulted in unconsolidated layers of till across the Central Ohio landscape. The meltwater, carved valleys into the till, leaving behind the present mainstem course of Big Darby Creek (The Nature Conservancy, 2003).

Substrates of the Big Darby Creek watershed reflect this geological history. Throughout the watershed, the substrates are derived of the calcareous-sedimentary parent materials seen in the region's bedrock. Igneous substrate constituents and glacial erratics also appear in the Darby system. They were carried to Ohio by the continental ice sheets.

A series of end moraines in the Big Darby Creek watershed resulted from the advances and retreats of the glaciers which influence the stream system itself and the watershed landscape in multiple ways. Among these are watershed topography and spring water contribution to tributaries and the mainstem. Indirect indications of ground water influence include the presence of obligate coldwater and coolwater taxa . Direct indications of ground water flow were low measured temperatures observed in Darby system stream segments by this study's field staff (personal communication: Marc Smith, Ecological Assessment Section, Ohio Environmental Protection Agency).

Portions of the Cable Moraine extend from north eastern Champaign County south to London then south east to Commercial Point (Figure A.2). Streams proximate to this glacial landform with anecdotal field evidence of ground water inflow include: Upper Big Darby Creek, Little Darby Creek, Clover Run, Gay Run, Hay Run, Pleasant Run, Smith Ditch, Spain Creek and Springwater Run.

A.2.4 Ecoregion

The Big Darby system drains portions of the Eastern Cornbelt Plains Ecoregion (Figure A.3). Common landscape features seen in this ecoregion are rolling till plains and local end moraines characteristic of glaciation. Wisconsin Age deposition is extensive and soils are better drained and loamier than most seen in Northwest Ohio. Beech forests were common on these Wisconsin soils with elm joining beech in wetter areas (Omernik, 1988).

Figure A.2. Glacial geology in west central Ohio

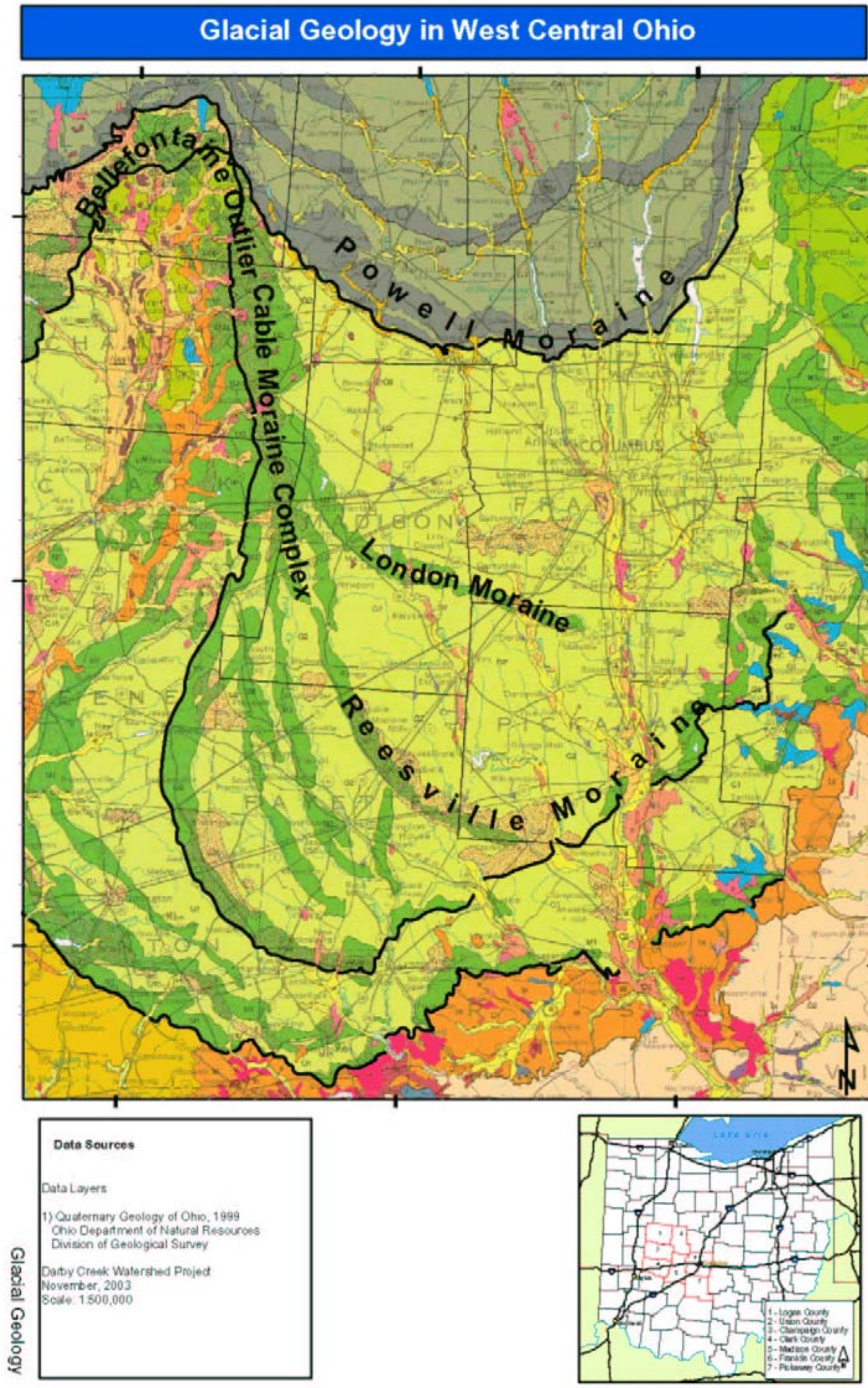
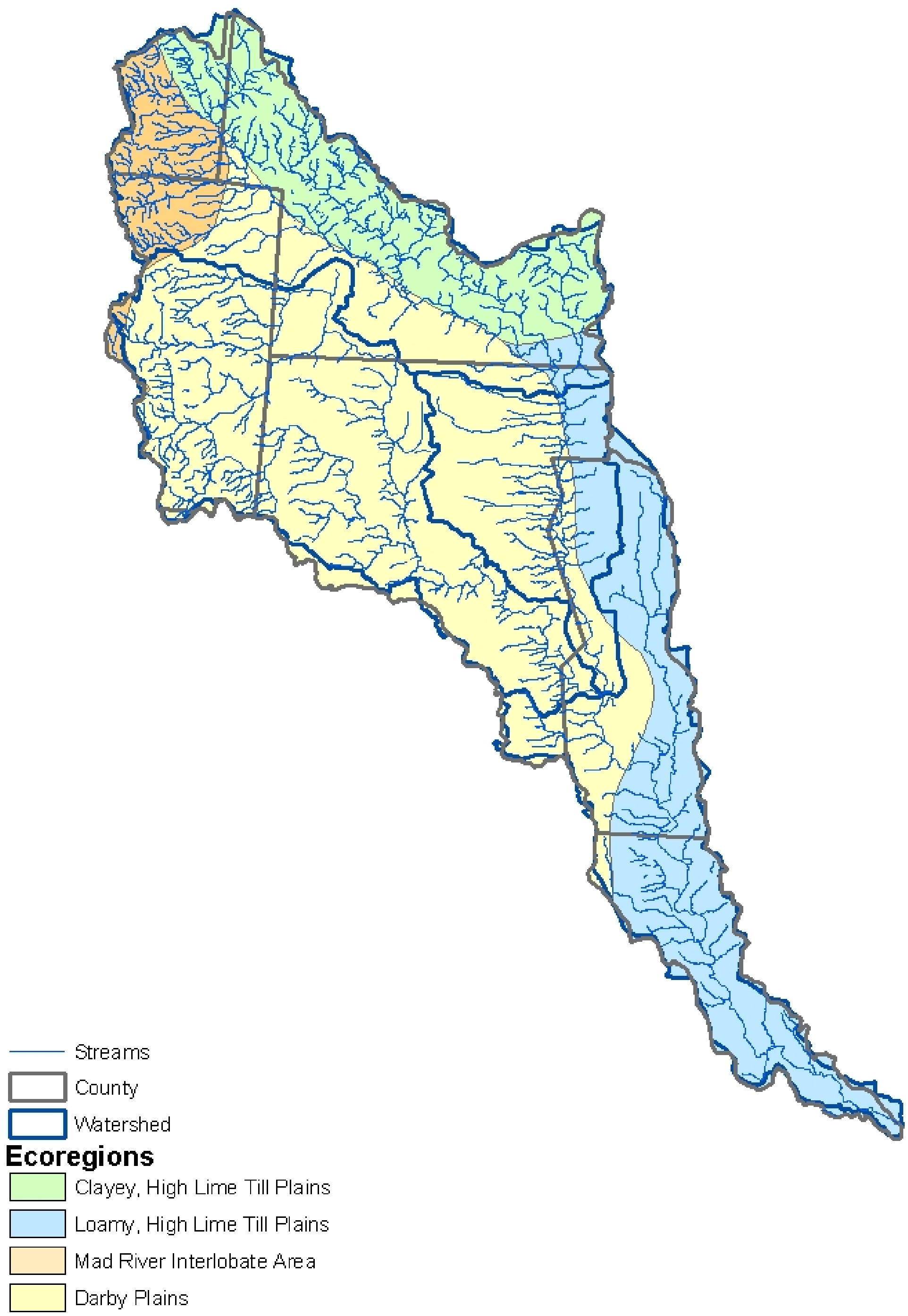


Figure A.3. Ecoregions of Ohio with subecoregions



Darby system tributaries in Union County drain two distinct subregions of the Eastern Corn Belt Plains. Near Milford Center, the tributaries flowing from the northwest to the mainstem drain clayey, high lime till plains with a higher requirement for artificial drainage than watershed portions further south. The tributaries that flow from the south to the mainstem in Union County drain the Darby Plains, an area of level to undulating landscapes characterized by productive crop and livestock farms (Omernik, Gallant 1988).

Virtually all of the Big Darby system in Madison and Champaign counties (including Little Darby Creek) also drains the Darby Plains. Prior to the settlement of non-indigenous peoples, the Darby Plains were characterized by a distinct assemblage of oak forests, end moraine prairies, gravel filled preglacial valleys and seasonally wet areas.

Most of the Darby system flowing across Pickaway County drains the more loamy, high lime till plains of the Eastern Cornbelt. This nearly level terrain is generally better drained than portions of the watershed upstream in northwestern Union County.

A.2.5 Ground Water

Groundwater resources in the Big Darby watershed vary considerably (Figure A.4). The highest yields are seen in the Big Darby flood plain, extending from I - 70 south to the confluence with the Scioto River and the flood plain of Little Darby Creek, east of Mechanicsburg in Champaign County. These areas, most particularly the Big Darby flood plains, are underlain by the most extensive buried glacial valleys in the watershed (Figure A.2).

A.2.6 Soils

Soils result from the interaction of geological parent materials, flora, fauna, topography and climate over time. Climatic change and the resultant glaciation of what is now the Big Darby watershed have had a profound influence on the development of its soils. Within the Little Darby Creek subwatershed of the study area, soil associations particularly reflective of glacial influence are seen. The five dominant soil associations in order of prevalence are: 1) Kokomo-Crosby-Miamian, 2) Miamian - Celina - Crosby, 3) Brookston - Crosby - Celina, 4) Crosby - Miamian - Brookston, and 5) Blount - Glynwood - Morley (Figure A.5).

Reflective of the factors which led to their development, each soil and soil association type appears with varied frequency across different portions of the watershed Figure A.5). Each in turn exhibits varying physical characteristics (i.e., erosion potential, permeability) which may affect chemistry of the water column, as summarized in Table A.4 (personal communication, Natural Resource Conservation Service, Delaware County).

Figure A.4. Glacial groundwater yield in the Big Darby watershed

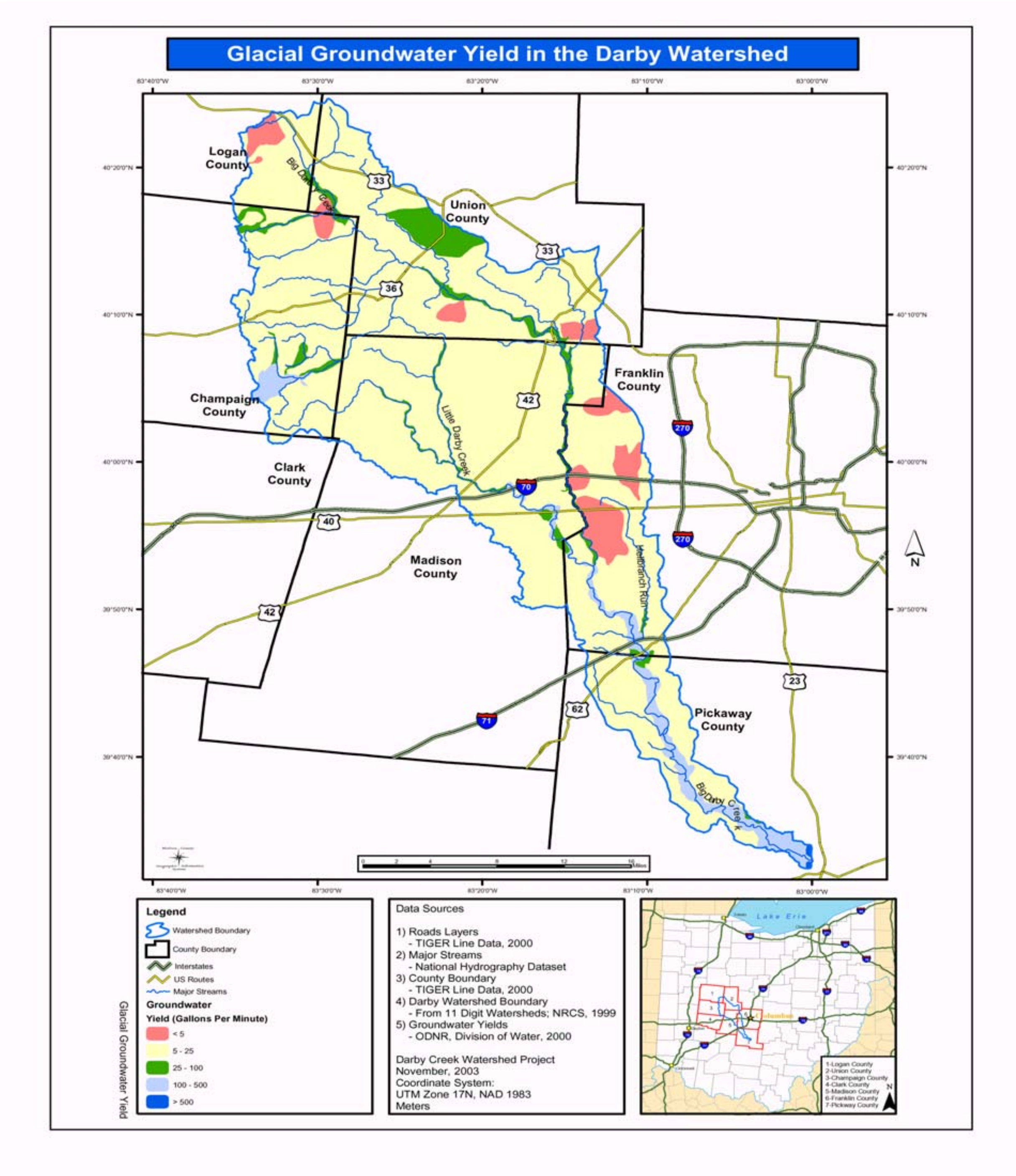


Figure A.5.   Generalized soils map

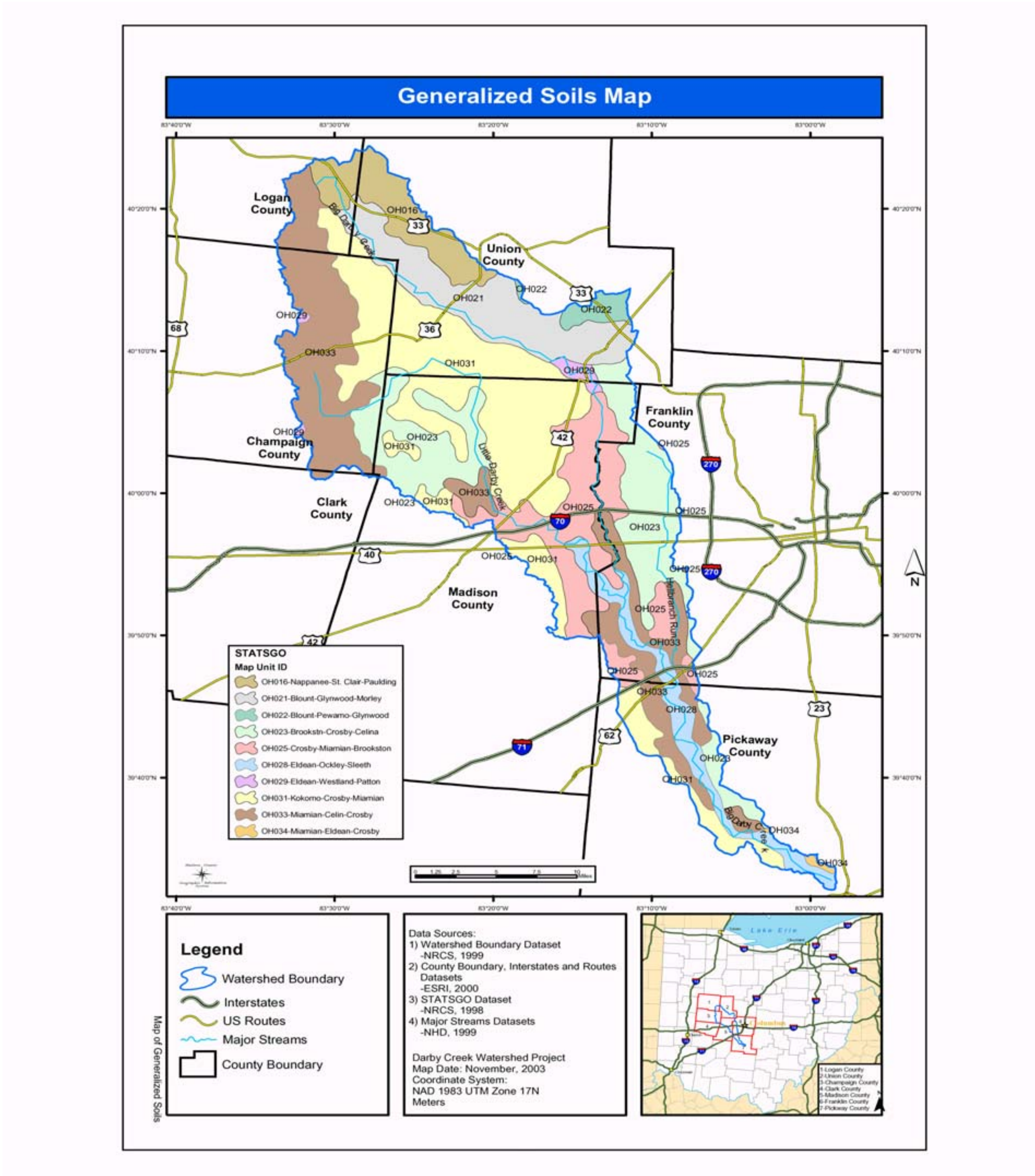


Table A.4. Dominant soil associations of the Big Darby Creek watershed by percentage of the watershed, general location and characteristics

Soil Associations	Percent of Watershed	Primary Location	Major Characteristics
Kokomo-Crosby-Miamian	27.9	Between Big and Little Darby Creeks, from Logan and Champaign Counties to Marysville and south to I-70.	Very poorly drained on flats, high water tables, seasonal wetness, Crosby requires artificial drainage. Seen on ground moraines.
Miamian-Celina-Crosby	20.3	Big and L. Darby source water areas in Logan and Champaign counties. Bordering the flood plain of Big Darby Creek . and Little Darby Creek. in Franklin and Pickaway Counties.	Well drained to moderately well drained. (Crosby requires artificial drainage.) Seen on level to gentle slopes.
Brookston-Crosby-Celina	16.3	Northern half of Hellbranch drainage in Franklin County. S.Western drainage area of Little Darby Creek in Madison County.	Brookston, a naturally wet soil found on uplands - very poor drainage.
Crosby-Miamian-Brookston	11.9	Big Darby Creek flood plain south of Plain City extending to I-70. Southern half of Little Darby Creek drainage in Madison County.	Somewhat poorly drained, prone to seasonal wetness. Miamian - well drained. Seen in the Darby Plains.
Blount-Glynwood-Morley	10.2	North side of Big Darby Creek. drainage between Logan County and Plain City.	Found on hills and slopes. Somewhat poorly drained to moderately well drained.

A.2.7 Tributaries

The Gazetteer of Ohio Streams listed the length of Big Darby Creek as 78.7 miles from its source in Logan County. The elevation at its source is recorded as 1170 feet. Twenty three named watercourses are listed by the Gazetteer between its confluence with the Scioto and the system headwaters. They include: Flat Branch, Little Darby Creek (Logan County) Pleasant Run, Hay Run, Prairie Run, Buck Run, Sugar Run (Union County), Robinson Run, Sugar Run, Threemile Run, Clover Run, Jumping Run, Lake Run, Howard Run, Proctor Run, Treacle Creek, Barron Creek, Spring Fork, Little Darby Creek, Hellbranch Run, Springwater Run, Greenbrier Run, Georges Creek, and the Big Darby Creek mainstem (Ohio Department of Natural Resources 2001). The current study evaluated all of those watercourses with the exception of Three Mile Run as well numerous other smaller unnamed tributaries (Figure A.1, Table A.5).

Table A.5. Stream characteristics and identified pollution sources within the 2002 Big Darby Creek study area.[1]

Stream	Length (miles)	Average Fall (feet/mile)	Drainage Area (square miles)	Non-point Source Pollution Categories	Point Sources
Big Darby Creek	78.7	6.8	556.6	Crop production, Livestock Pasture Urban Storm sewers Sanitary sewers Construction sites Surface runoff On site wastewater treatment systems Gravel mining	Flat Branch WWTP Darby Creek Golf Course Fairbanks School WWTP Plain City WWTP Suburbans MHP WWTP Wisslohican Sanitary Sewer District WWTP Battelle Memorial Inst. WWTP Lake Darby Estates WWTP Greentree MHP WWTP Darby Dan Farm WWTP Oak Hill MHP WWTP Darbydale Elementary WWTP Pickaway Correctional Institute WWTP Foxlair Farms MHP WWTP
Georges Creek	0.5	40.0	1.2	Urban Storm sewers Sanitary sewers Construction sites Surface runoff	
Greenbrier Creek	2.6	34.6	9.8	Urban Storm sewers Sanitary sewers Construction sites Surface runoff	
Springwater Run	0.6	13.3	3.46	Urban Storm sewers Sanitary sewers Construction sites Surface runoff	

Continued.

Table A.5. Continued

Stream	Length (miles)	Average Fall (feet/mile)	Drainage Area (square miles)	Non-point Source Pollution Categories	Point Sources
Hellbranch Run	12.8	11.2	35.56	Urban Storm sewers Sanitary sewers Construction sites Surface runoff Channelization On site wastewater treatment systems	Oakhurst Knolls WWTP Pleasantview School Timberlake Subdivision WWTP
Little Darby Creek	38.0	5.9	176.0	Crop production Urban Storm sewers Sanitary sewers Construction sites Surface runoff On site wastewater treatment systems Channelization	Mechanicsburg WWTP Fisher Cast Steel Jefferson Lodge MHP, WWTP Oakwood Acres WWTP B&B Motel WWTP West Jefferson WWTP
Spring Fork	12.0	7.2	38.3	Urban Crop production Livestock Construction sites	Green Meadows MHP WWTP
Barron Creek	4.8	8.3	6.30	Urban Crop production Construction sites On site wastewater treatment systems	
Treacle Creek	14.2	17.9	37.88	Urban Crop production Livestock Construction sites	
Proctor Run	6.0	21.4	10.52	Urban Crop production Livestock Construction sites	

Continued.

Table A.5. Continued.

Stream	Length (miles)	Average Fall (feet/mile)	Drainage Area (square miles)	Non-point Source Pollution Categories	Point Sources
Howard Run					
	3.2	23.1	2.72	Crop production Livestock	
Lake Run					
	4.1	17.8	7.02	Urban Crop production Livestock Pasture Construction sites	
Jumping Run					
	2.7	43.9	2.48	Urban Crop production Pasture Urban	
Clover Run					
	3.8	56.1	2.10	Crop production Pasture Urban Construction sites	
Threemile Run					
	5.3	17.4	5.34	Not evaluated in study	
Sugar Run (Madison Co.)					
	5.0	7.8	16.20	Crop production Livestock Pasture Urban Construction sites	
Robinson Run					
	3.2	10.6	11.84	Crop production Livestock Pasture Urban Construction sites	St. Johns Church WWTP Darby Meadows WWTP
Sugar Run (Union Co.)					
	4.4	8.9	4.30	Crop production Livestock Pasture Urban Construction sites	

Continued.

Table A.5. Continued.

Stream	Length (miles)	Average Fall (feet/mile)	Drainage Area (square miles)	Non-point Source Pollution Categories	Point Sources
Buck Run	6.8	5.7	29.98	Crop production Livestock Pasture Urban Construction Streambank mod	
Prairie Run	2.5	10.8	3.04	Crop production Livestock Pasture Urban Construction sites	
Hay Run	3.6	9.4	5.82	Crop production Livestock Pasture Urban Construction sites	
Pleasant Run	8.0	42.0	9.48	Crop production Livestock Pasture Urban Construction sites	
Little Darby Creek (Logan Co.)	4.5	41.1	7.22		
Flat Branch	4.7	4.5	14.46	Crop production Livestock Pasture Urban Construction sites Surface runoff Channelization	Honda E. Liberty WTP Honda Benton Rd. WTP

1. Ohio Environmental Protection Agency. 1994

A.2.8 Prairies / Wetlands

The prairies in what has been called Ohio's "Prairie Peninsula" have been known to Ohio botanists since the earliest days of the state. In the 1970s, the Prairie Survey Project sponsored by the Ohio Biological Survey attempted to identify and describe remnants of the once extensive prairies in west-central and north-central Ohio (Cusick and Troutman 1978).

The prairie complexes in the Darby Plains of Union, Madison, and Franklin Counties and further north in the Sandusky Plains represent the tip of the wedge of the Prairie Peninsula as mapped and described by Transeau (1935). These once extensive prairie and savannah complexes have largely disappeared from Ohio's landscape in the face of intensive ditching, tiling and agriculture except for a few relicts.

Curtis (1959, p. 262) defined prairie as "...an open area covered by low-growing plants, dominated by grasslike species of which at least one-half are true grasses, and with less than one mature tree per acre. Similar communities with more than one-half of their dominants in the sedge group are called sedge meadows, while areas with more than one tree per acre but with less than one-half of the total area covered by the tree canopy are called savannas." Curtis (1959) also defined a continuum of types of prairies from xeric to mesic to wet (hydric) prairies. His prairie community continuum included dry prairies, dry-mesic prairies, mesic prairies, wet-mesic prairies, wet prairies and sedge meadow.

As with the Sandusky Plains further north (Mack 2002), the Darby Plains was a wet prairie - mesic prairie - bur oak savannah complex that developed between the Powell, Cable and London Moraines (Figure A.6). The dominant soils of the Darby Plains is Kokomo (poorly drained mollisol) and Crosby (silt loam on slightly better drained knolls and shallow rises). This interwoven complex corresponds exactly to the Luray/Milford-Centerburg/Tiro complex in the well studied Sandusky Plains to the north. Mack (2002) and Whitney and Steiger (1988) showed that the this complex resulted in highly interwoven complex wet prairie, prairie sedge meadow, and prairie pothole marsh on the poorly drained soils, grading into mesic (tallgrass) prairie and bur oak savannah on the better drained knolls of till embedded in the poorly drained soils. The Darby Plains present identical conditions and had a similar complex of prairie and savannah (King 1981).

Sears (1926, p. 137) includes an early anecdotal description of the Darby Plains:

> ...a great portion of Madison County was originally covered with water most of the year. The first settlers called these lands barrens and looked upon them as utterly unfit for farming purposes...The prairies consisted of level stretches of country covered with sedge-grass, and dotted here and there with patches of scrubby burr-oak [sic] growing upon the highest points of land. The sedge-grass [sic] grew to enormous height, sometimes sufficient to hide man and horse when traveling [sic] through it...Nearly every autumn prairie fires swept over the country, destroying everything in their path...But...these fires grew less frequent...Timber on the east banks of the streams was always the largest, as these fires ran from west to east...The growth of burr-oak [sic] on the prairies was

> impeded by these periodical fires, and the greater amount of the present timber..has grown up since.

Little Darby Creek and its tributaries was completely embedded in the heart of the Darby Plains prairie-savannah complex. Flows out of this system would have been diffuse with many of the streams being low-gradient “prairie” streams. Anecdotal accounts like the one cited above, soil maps, and vegetation reconstructions make it clear that shallow ponded water and saturated soil conditions persisted throughout much of the year until late summer in the Darby Plains. Conversion of the region to agricultural uses would have significantly increased hydrologic loadings (as well as sediment and nutrient loadings) to all of the streams in the region. Selective restoration of wet prairie, prairie sedge meadow, and savannah would help restore hydrologic loadings and reduce sediment and nutrient inputs by retaining water on landscape.

Also of note on the Little Darby Creek are the many ground water expressions (i.e., seeps, springs, and saturated soils, etc.) and ground water driven (“slope”) wetlands (Figures A.7 and A.8). Numerous fens and forest seeps are have been noted along stretches of the Little Darby. These typically occur on shallow slopes and terraces above the creek or at “breaks-in-the-slope” of the creek valley walls and the floodplain. This input of clean, cool ground water would have a positive impact and stream water quality throughout the year and would provide a buffering capacity to pollutant loadings. These slope wetlands exert a positive influence on the stream considerably greater than would be expected from their size.

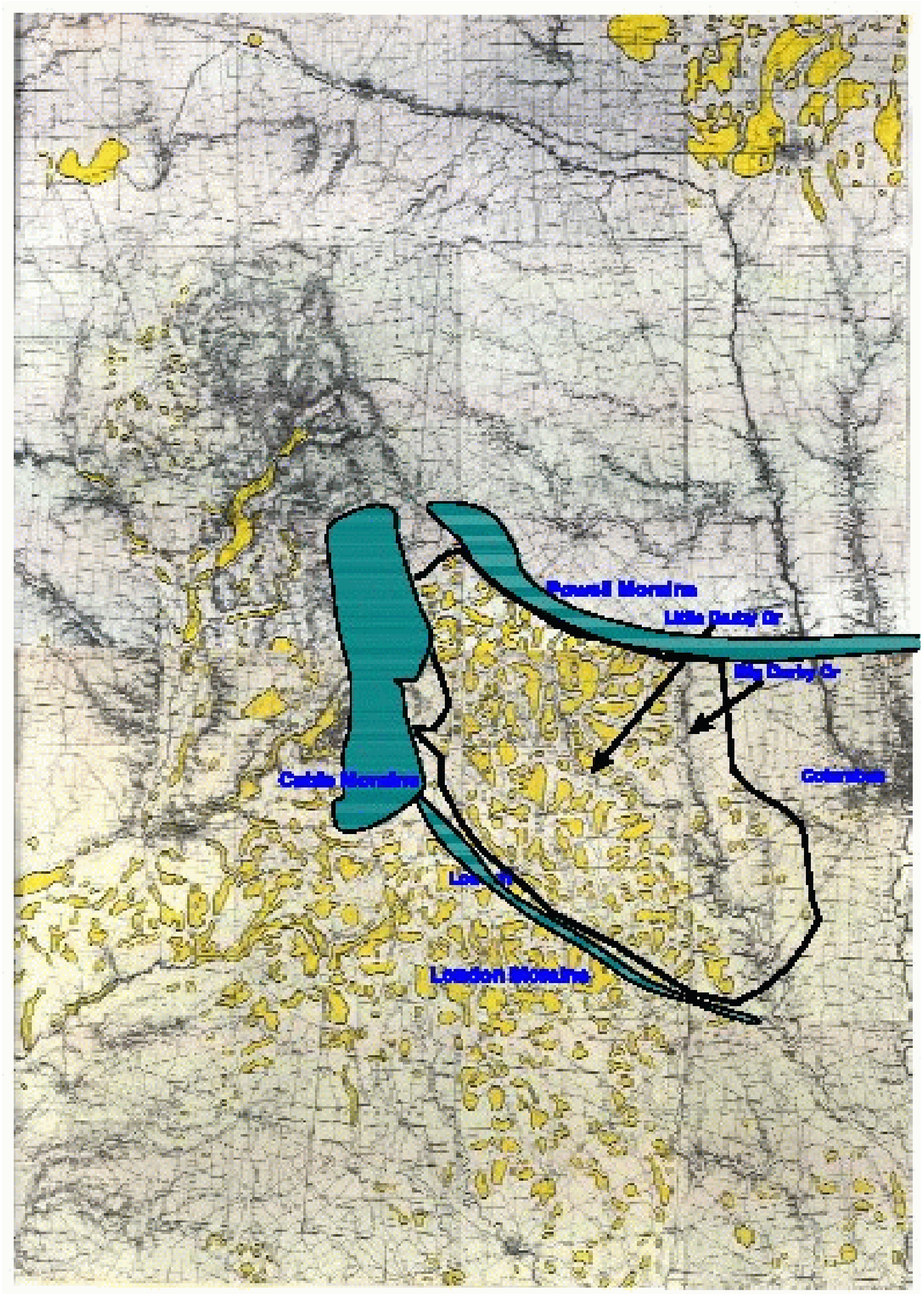


Figure A.6. Prairies of the "Virginia Military Lands" as mapped by Dobbins (1937) from scanned bitmap image of original pen and ink map, 1937 PhD. Dissertation, located at The Ohio State University libraries, Columbus, Ohio. Note how Little Darby Creek and its tributaries were completely embedded in the heart of the Darby Plains prairie-savannah complex.

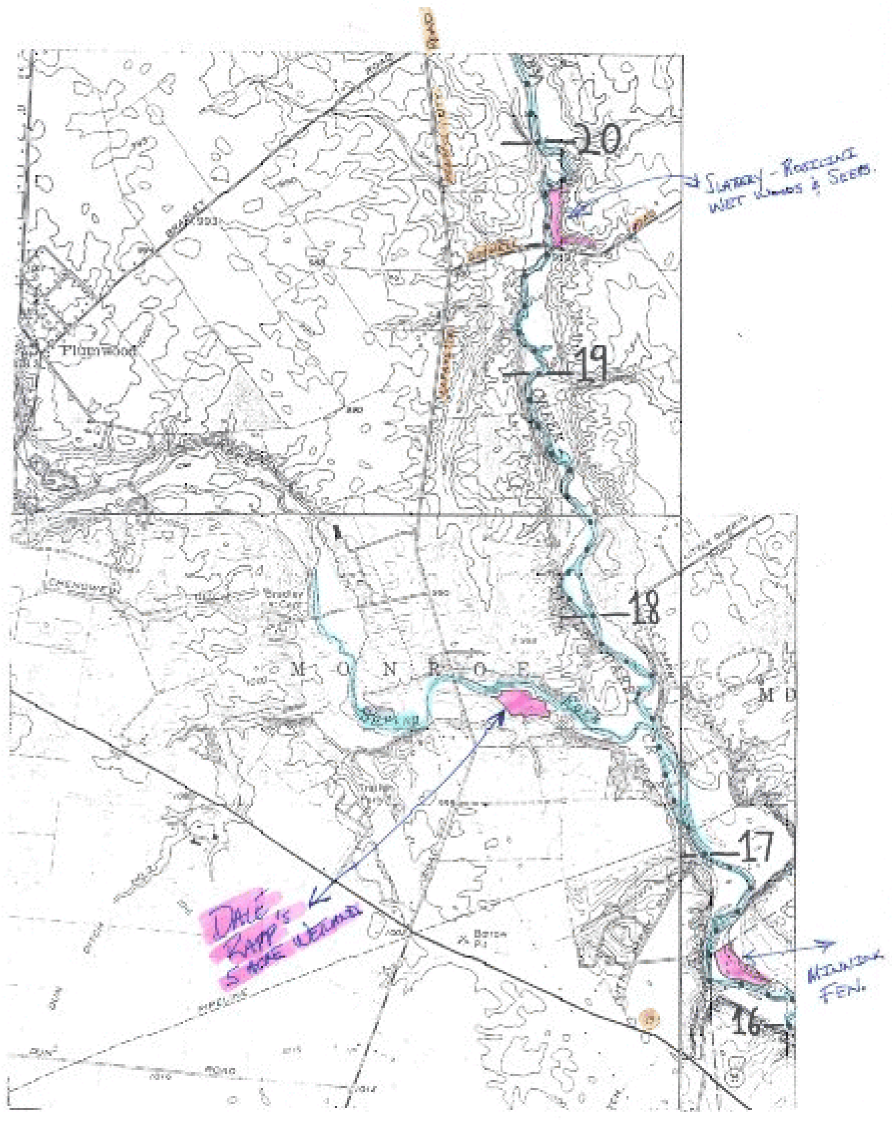


Figure A.7. Map of some fens and forest seeps on a portion of the Little Darby Creek. Map prepared by Steve Flint, formerly of Ohio Chapter of the Nature Conservancy.

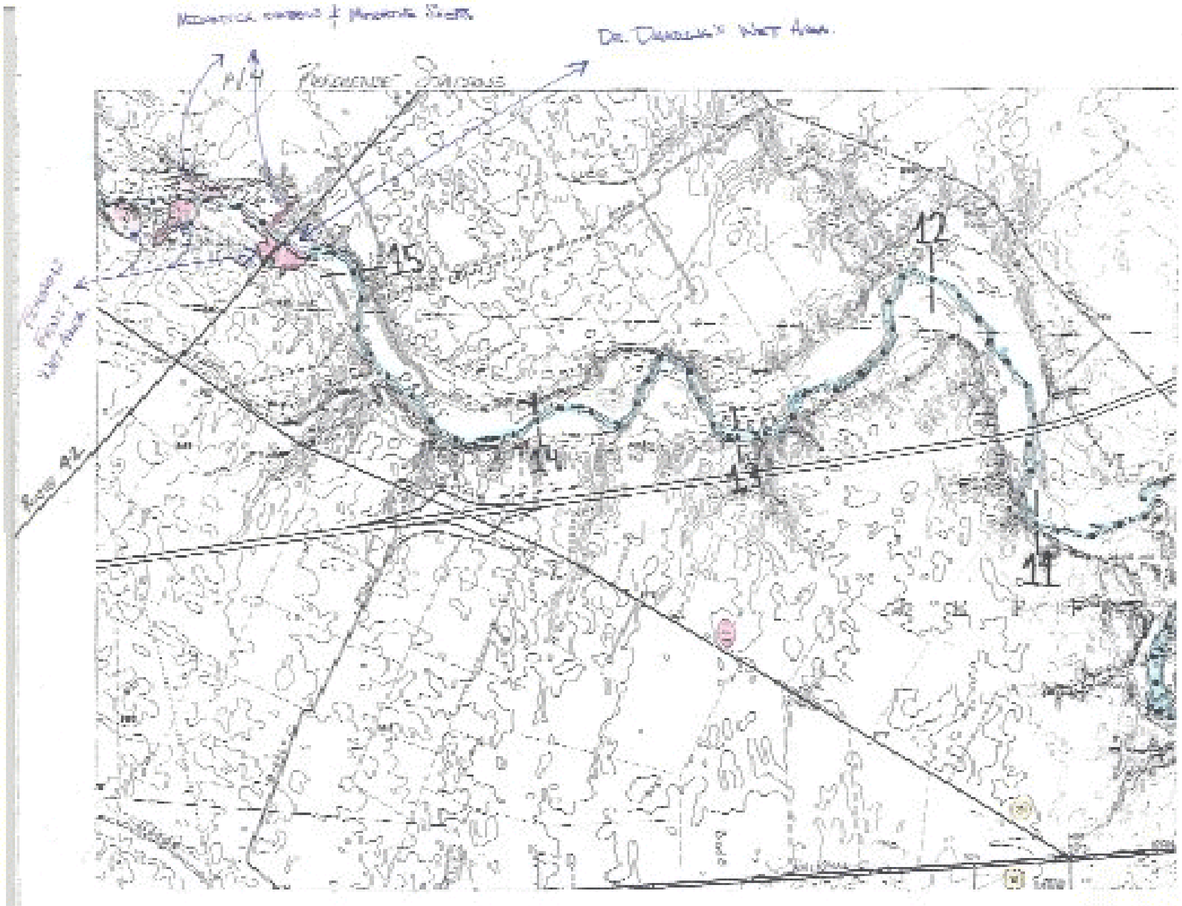


Figure A.8. Map of some fens and forest seeps on a portion of the Little Darby Creek. Map prepared by Steve Flint, formerly of Ohio Chapter of the Nature Conservancy.

A.2.9 Land Use

Though residential, industrial and commercial land uses are expanding, agriculture is still the dominant land use in the study watershed. Maps compiled from Landsat data in years 1994 and 1997 by ODNR and The Ohio State University, respectively, show watershed agriculture land use ranging between 86.90% and 63.33%. This discrepancy is attributable to the inclusion of "open urban" land uses, which include parks, lawns, golf courses and similar grassy areas within the 1994 Agriculture category. The more detailed and accurate land use classifications of 1997 identify additional land use types such as mixed urban and sparse woodland. (Approximately 1,600 acres near Circleville, Ohio was not assessed for the 1997 compilation.) Under this categorization scheme, agricultural use comprises approximately 63% of the total. When combined with wooded lands (14%) and herbaceous-shrub land cover (14%) the total is 91% (Gordon, S.I. 1994).

The maps reveal distinct land use distributions within the watershed (Figure A.9). Comparatively denser patterns of heavily wooded acres are present in Union County north of the mainstem and in the hilly headwater areas of Logan and Champaign counties. These woodlands are more commonly encountered outside of the riparian corridor and flood plain.

Within Madison County and south of the mainstem in Union County, the watershed acres are more intensively farmed. Here, wooded acreage is concentrated in the flood plains and riparian corridors. This pattern of wooded acreage concentrated in the flood plains and riparian corridor continues along the mainstem in Franklin and Pickaway counties to the confluence with the Scioto River.

Concentrations of urban, residential and commercial land uses are found along the U.S. Route 33 corridor in Logan County and western Union County, proximate to the Honda manufacturing complex; at North Lewisburg which is drained by Spain Creek; and Mechanicsburg which is drained by Little Darby Creek in Champaign County. Plain City and West Jefferson, both in Madison County show concentrated urban land uses and drain to the mainstem and Little Darby Creek, respectively (Figure A.9).

Transportation land uses contrast with urban and mixed urban uses which co-mingle surface types (lawns and small landscaped areas), capable of capturing surface runoff to the Big Darby system. Transportation land uses offer less contrast among surface types, showing a greater prevalence of impervious surface among most examples: limited access highways (U.S. Route 33), state routes, county roads, parking lots. Concentrated impervious surfaces are notable for their role in rapid introduction of pollutants to the water column.

Transportation comprises more than 8% of all land use in several Big Darby sub-watersheds: Big Darby Creek (High Free Pike to above Little Darby Creek), 9.99%; Flat Branch, 9.43%; Big Darby Creek below Hellbranch Run to Darbyville, 8.31%; Hellbranch Run, 8.01%.

The Franklin County portion of the Big Darby Creek watershed exhibits, arguably, the most intensive development pressure in the study area, due to its proximity to Columbus' expanding western fringe. Concentrations of actively expanding residential and related land uses are seen along Hellbranch Run including the Hilliard - Rome Road - Interstate 70 intersection, as well as the Hubbard Road developments north of U.S. Route 40.

In southwestern Franklin County and northwestern Pickaway County similar, though older, concentrations are seen along the mainstem at Darbydale, Harrisburg and Orient.

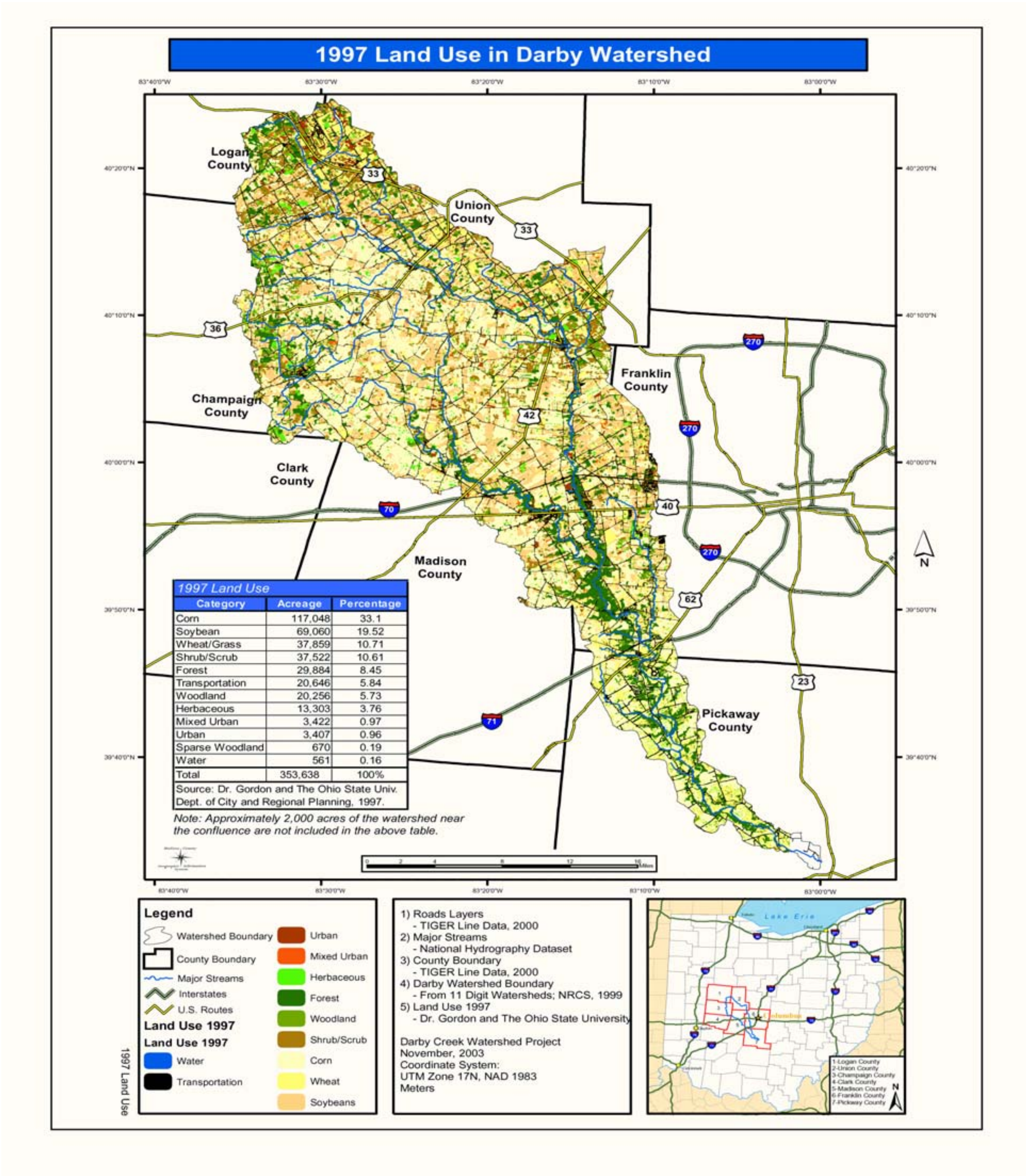


Figure A.9. 1997 land use in Darby Creek watershed

Table A.6. Surface area coverages of land use practices in the Big Darby Creek watershed, 1997.

Type	Acreage	Percentage
Corn	117048	33.1
Soybeans	69060	19.52
Wheat-Grass	37859	10.71
Shrub - Scrub	37522	10.61
Forest	29884	8.45
Transportation	20646	5.84
Woodland	20256	5.73
Herbaceous	13303	3.76
Mixed Urban	3422	0.97
Urban	3407	0.96
Sparse Woodland	670	0.19
Water	561	0.16
Total	**353638**	**100%**

A.2.10 Protected Lands

Figure A.10 and its table indicate the location and acreage of known protected tracts within the Big Darby watershed. The largest assemblage of protected watershed riparian corridor land is held by Columbus and Franklin County Metroparks in south western Franklin County. The Nature Conservancy ranks second in acreage holdings, followed by a variety of other entities which include electric power companies, townships and individuals. (Current efforts by these holders to obtain-protect additional riparian acreage are not detailed in this report.) These protected riparian holdings are significant due to the well documented relationship between water quality, biological integrity and vegetated riparian corridor. Protective easements obtained by the Franklin Soil and Water Conservation District are discussed below.

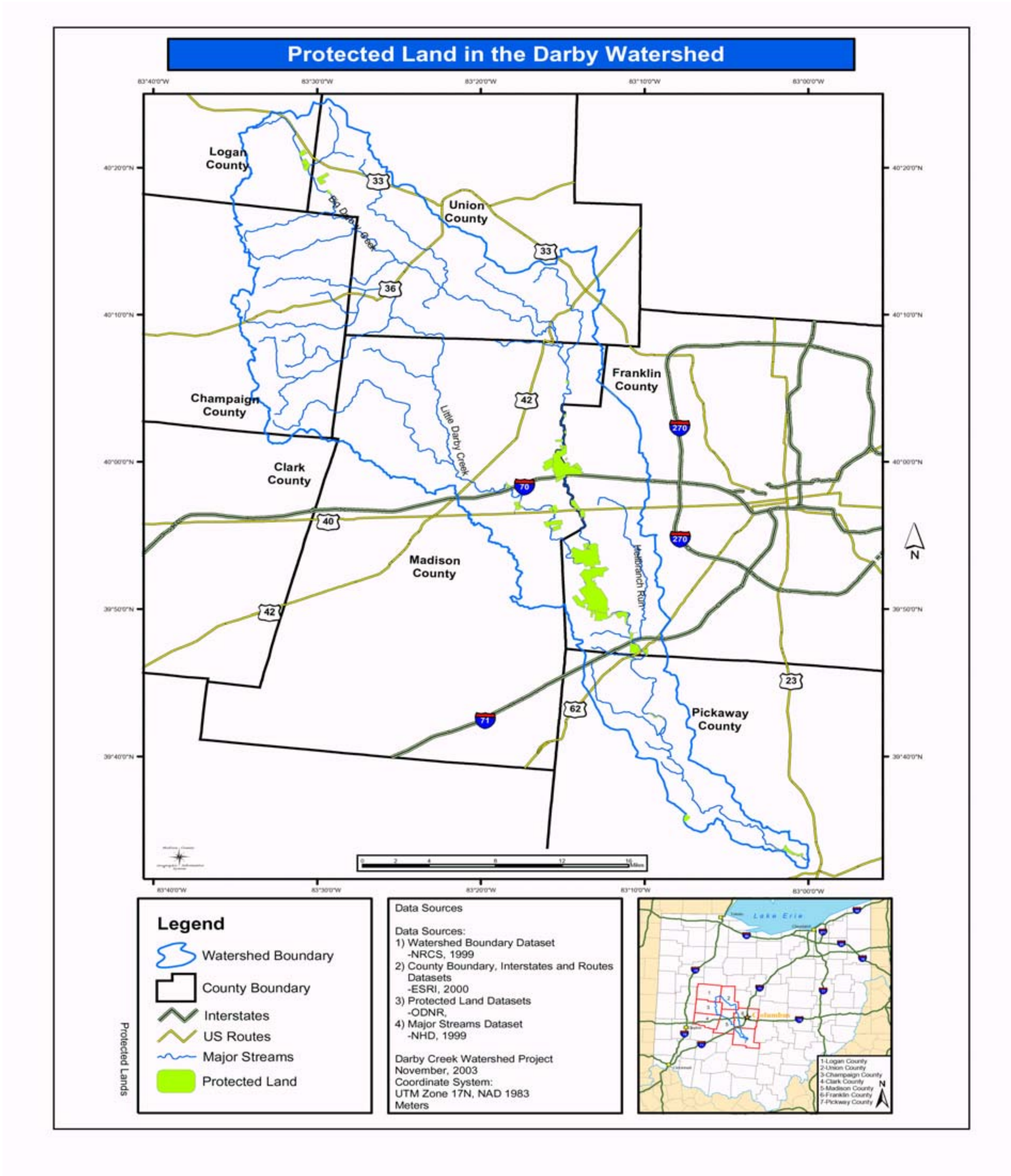


Figure A.10. Protected land

A.2.11 Watershed Protection Funding Mechanisms - Non Point Source Pollution

In 1995, the Ohio Environmental Protection Agency developed a means of funding watershed protective agricultural practices. This program, the Watershed Pollution Control Loan Fund (WPCLF) Linked Deposit, has supported a variety of agricultural best management practices (BMPs). Most of the funding has been used to purchase conservation tillage equipment, but other items and practices have also been funded. These include: manure management equipment, livestock exclusion fencing, filter strips, grassed waterways, computerized soil mapping, GPS equipment and software, yield monitors, windbreaks and fertilizer storage areas with spill containment. Between 1995 and December of 2002, Linked Deposit loans in the Big Darby Creek watershed totaled $2,701,468 (Table A.7).

Table A.7. WPCLF Linked deposit loan awards by county: 1995 - 2002

County	Number of Loans
Champaign	10
Franklin	4
Logan	11
Madison	21
Pickaway	13
Union	19

The current (2002) development of countywide home sewage management plans by Madison and Pickaway counties will provide eligibility for WPCLF loans that could finance replacements and upgrades of home systems in the Big Darby Creek watershed.

In 2001 the Franklin County Soil and Water Conservation District was awarded a 319 grant of $190,604 for riparian conservation efforts in the Hellbranch Run subwatershed. The key elements of this project include acquisition of riparian easements and the establishment of riparian vegetative buffers. Local matching funds will increase the project total to $347,286. As of December 2003, this project had established more than 230 acres of conservation easements and 20 acres of stream buffer. Nine thousand tree seedlings had been planted. Fifteen Hellbranch watershed landowners had participated. This project continued in 2004. Active easement acquisitions and buffer establishment were proceeding during the writing of this report.

A.2.12 Local Government Structure - Land Use Planning

There is no single unifying governmental entity for the watershed; rather a patchwork of many local governmental units which include six counties, eight small cities, twenty seven townships, unincorporated townships within counties, and special organizational units. The land development process is influenced by a multitude of entities. Such an arrangement requires a coordination of action for effective watershed protection. This coordination could be characterized as a challenging goal that has not yet been reached (Table A.8).

Watershed protection at the county level may include: land use and related planning, zoning (when not exercised by townships), subdivision approval, control of on-site sewage systems and building permit and well approval.

Very different land uses may be found (in relatively similar settings) across watershed counties and townships due, in part, to the contrasts between zoning codes, general plans (where they exist) and the vigorousness of their application and inspection to ensure compliance.

The Mid Ohio Regional Planning Commission, a quasi-governmental body established under state law, maintains an influential advisory position on zoning, subdivision and planning decisions for member counties. Franklin County has long been a member of MORPC utilizing a variety of its services. The communities of London, Marysville and West Jefferson are participating members; although Madison, Pickaway and Union counties are not (personal communication: Mid Ohio Regional Planning Commission). The City of Columbus has increased its land use planning activity in its portion of the watershed along with the increase in development and public interest in the watershed's protection.

Table A.8. Watershed townships with comprehensive land use plans

County	Townships - Plan or County Plan	Townships - Plan in Progress	Townships - Zoning Code
Franklin	Pleasant (2002) Brown (1999) Washington(1993) [1]	Prairie	
Logan[3]	Perry Zane		Perry Zane
Madison[3]	Canaan Darby Jefferson Monroe Pike		
Pickaway	Darby		Darby Jackson, Muhlenberg Scioto
Union	Darby [2] Jerome [2] Union [2]	Jerome	All with exception of Jackson.
Champaign	Goshen Rush		Goshen Rush

[1] Township zoning updated in 2000.
[2] Adopted Union County comprehensive plan.
[3] County comprehensive plan.
[4] County plans - zoning under discussion. Possible revision in Champaign, Logan and Union (11/02.)

A.2.13 Conservation Programs - Practices

Numerous federal and state agricultural programs address soil conservation, erosion and water quality protection through the installation of best management practices (BMPs) on the agricultural landscape. The Big Darby Creek watershed presents a mosaic of these practices. Across the watershed the utilization of specific BMPs varies dependent on physical attributes such as soil type, slope and specific "on farm" considerations. Frequency of BMP application also varies in part with local traditions and the interaction between local agricultural service providers, (i.e., NRCS, county SWCD offices, FSA and Ohio State Extension) and watershed land owners and farmers.

In 1991 the United States Department of Agriculture (USDA) chose Darby Creek as one of 70

Hydrologic Unit Areas. During the period of its existence, USDA agencies and Ohio State University Extension worked with other entities to forward a Hydrologic Plan for the watershed. The project's efforts were focused on reduction of sediments moving to the stream system and the protection and restoration of the riparian corridor. During its life, this effort resulted in an variety of watershed protective actions that included: a 208% increase in conservation tillage, sediment reduction estimated at 35,000 tons/year, 389 acres of trees planted along the stream system, nutrient and pest management plans for 14,654 watershed acres, 21,688 feet of livestock exclusion fencing, 3,000 feet of stream bank protections and 174 acres of filter strips (WRP), urban sediment control plans for 1000 watershed acres and the installation of fourteen water and sediment control basins (WASCOBS). Table A.9 summarizes watershed conservation practices.

Table A.9. USDA Darby hydrologic unit area conservation practices:1991-1998[a]

Practice	Required Maintenance Period to Receive Payment	Units Reported Accomplished
Tree Planting	10 years	389 acres
Filter Strips	3 - 5 years	17 acres (94,743') 80' average width
Fencing	10 years	21,688 lineal feet
Wildlife-Upland	none	242 acres
Wildlife-Wetland	none	17 acres
Wetland Restoration	none	20 acres
Wetland Reserve Program	30 year, perpetual easements	58,080 lineal feet
Conservation Reserve Program (pasture and hayland)	10 years	5,186 acres
Streambank Protection	none	2,595 lineal feet
Conservation Tillage	1 year	39,282 acres
Grass Waterways	10 years	194 acres

[a] as reported by Ohio State University Cooperative Extension Service

Funds from the Conservation Reserve Program (CRP) were first allocated to the Big Darby Creek watershed in 1985. The Conservation Reserve Program provides direct payments to landowners to remove environmentally sensitive acres from active cropping for a extended period of time and to subsidize the establishment of erosion preventive vegetative cover. Table A.10 provides details of recent enrollment by county in the CRP programs.

Table A.10. Acres of land enrolled in CRP in the Big Darby Creek watershed by county, 1990 - 1992

County	Water-shed Acres	CRP Eligible Acres	Enrolled through 1990	Enrolled through 1991	Enrolled through 1992	Total	Percent - Eligible Acres
Champaign	56,898	19,000	1,767	1,815	855	4,437	23%
Franklin	57,175	1,250	550	1,547	95	2,192	175%
Logan	18,267	9,150	1,500	510	328	1,338	15%
Madison	116,010	30,400	1,500	1,173	605	3,278	11%
Pickaway	40,529	2,050	363	483	454	1,300	63%
Union	82,757	27,650	400	2,538	1,223	4,161	15%
TOTAL	**371,668**	**89,500**	**5,080**	**8,066**	**3,560**	**16,706**	**19%**

More recent figures for estimated CRP watershed enrollment were generated by the U.S. Fish and Wildlife Service in 2003 (Table A.11).

Table A.11. Acres of land enrolled in CRP in the Big Darby Creek watershed by county, 2002

County	Acreage
Champaign	1,570
Franklin	571
Logan	172
Madison	1,060
Pickaway	864
Union	1,500 - 2,286
TOTAL	**5,737 - 6,523**

The USDA, Environmental Quality Incentives Program (EQIP) applies cost share dollars with the intent of improving livestock operation and implementing conservation practices which may benefit water quality. Between 1998 and 2001, EQIP contracts were present in all but two Big Darby Creek watershed counties (Table A.12).

Table A.12. USDA EQIP contracts in the Big Darby Creek watershed by county, 1998-2002

	2001		**2000**		**1999**		**1998**	
County	**Acres**	**No.**	**Acres**	**No.**	**Acres**	**No.**	**Acres**	**No.**
Champaign	518	7	487.5	2	0		0	
Franklin	67	2	0		200	1	0	
Madison	1	1	0		0		0	
Logan	0		0		0		0	
Pickaway	0		0		500	2	0	
Union	0		0		0		0	

Available conservation tillage (i.e., No Till) data for Big Darby Creek watershed counties in 2002 show a difference between corn and soybean acres, with soybean acres showing considerably higher No Till application than corn. Data from the NRCS indicates a range between 24% and 52% for watershed county corn acreage. The range for soybeans is notably higher, between 65% and 83% (Table A.13).

Table A.13. Percentage of corn and soybean acreage utilizing the No Till Cropping Practice in Big Darby Creek watershed counties, 2002.

County	**Percentage of Corn Acres**	**Percentage of Soybean Acres**
Champaign	34%	83%
Franklin	47%	72%
Logan	45%	65%
Madison	52%	67%
Pickaway	32%	75%
Union	24%	75%

A.3 METHODS

All chemical, physical, and biological field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes I through III (Ohio Environmental Protection Agency 1987a, 1987b, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989, 1995) for aquatic habitat assessment. Chemical, physical and biological sampling locations are listed in Tables A.1 and A.2.

A.3.1 Determining Use Attainment Status

Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). Assessing aquatic use attainment status involves a primary reliance on the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-14). These are confined to ambient assessments and apply to rivers and streams outside of mixing zones. Numerical biological criteria are based on multimetric biological indices including the Index of Biotic Integrity (IBI) and modified Index of Well-Being (MIwb), indices measuring the response of the fish community, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Numerical endpoints are stratified by ecoregion, use designation, and stream or river size.

Three attainment status results are possible at each sampling location: full, partial, or non-attainment. Full attainment means that all of the applicable indices meet the biocriteria. Partial attainment means that one or more of the applicable indices fails to meet the biocriteria. Non-attainment means that none of the applicable indices meet the biocriteria or one of the organism groups reflects poor or very poor performance. An aquatic life use attainment table (Table A.15) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (i.e., full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and a sampling location description.

The attainment status of aquatic life uses (i.e., full, partial, and non-attainment) is determined by using the biological criteria codified in the Ohio Water Quality Standards (WQS; Ohio Administrative Code [OAC] 3745-1-07, Table 7-14). The biological community performance measures used include the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. The IBI and ICI are multimetric indices patterned after an original IBI described by Karr (1981) and Fausch et al. (1984). The ICI was developed by Ohio EPA (1987b) and further described by DeShon (1995). The MIwb is a measure of fish community abundance and diversity using numbers and weight information and is a modification of the original Index of Well-Being originally applied to fish community information from the Wabash River (Gammon 1976; Gammon et al. 1981).

Performance expectations for the principal aquatic life uses in the Ohio WQS (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes et al. 1986; Omernik 1987). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of the aquatic life use is FULL if all three indices (or those available) meet the applicable biocriteria, partial if at least one of the indices does not attain and performance is fair, and non-attainment if all indices fail to attain or any index indicates poor or very poor performance. Partial and non-attainment indicate that the receiving water is impaired and does not meet the designated use criteria specified by the Ohio WQS. Additional information about determination of the aquatic life use designation process and final recommendation for use changes can be found in Section A.5.1.

A.3.2 Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the habitat characteristics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. Scores greater than 75 frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

A.3.3 Macroinvertebrate Community Assessment

Macroinvertebrates were sampled quantitatively using multiple-plate, artificial substrate samplers (modified Hester/Dendy) at locations with drainage areas greater than 20 square miles. A qualitative assessment of the available natural substrates was conducted at all locations. During the present study, macroinvertebrates collected from the natural substrates were also evaluated using an assessment tool currently in the field validation phase. This method relies on tolerance values derived for each taxon, based upon the abundance data for that taxon from artificial substrate (quantitative) samples collected throughout Ohio. To determine the tolerance value of a given taxon, ICI scores at all locations where the taxon has been collected are weighted by its abundance on the artificial substrates. The mean of the weighted ICI scores for the taxon results in a value which represents its relative level of tolerance on the 0 to 60 scale of the ICI. For the qualitative collections in the Sugar Creek study area, the median tolerance value of all organisms from a site resulted in a score termed the Qualitative Community Tolerance Value (QCTV). The QCTV shows potential as a method to supplement existing assessment methods using the natural substrate collections. Use of the QCTV in evaluating sites in the Big Darby Creek watershed study area was restricted to relative comparisons between sites and was not unilaterally used to interpret quality of the sites or aquatic life use attainment status.

A.3.4 Fish Community Assessment

Fish were sampled once or twice at each site using pulsed DC electrofishing methods. Discussion of the fish community assessment methodology used in this report is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989b).

A.3.5 Fish Tissue Assessment

All field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989), and Ohio EPA Fish Tissue Guidance Manual (Ohio EPA 1994a). Fish tissue sampling locations are listed in Table B.8.3.1. Fish tissue sample specifications (species, lengths/weights, type of sample, etc.) are provided in Table B.8.3.2. Summarized results are presented in Table B.8.3.3 and B.8.3.4.

Fish were collected using a variety of pulsed DC electrofishing equipment, with collections occurring between June - October, 2002. Fish tissue samples were placed on either dry or wet ice in the field and transported back to the Ecological Assessment Section Laboratory at 4675 Homer Ohio Lane, Groveport, Ohio 43125 and placed in a chest freezer prior to being delivered to the Ohio EPA Division of Environmental Services Laboratory for analysis. Fish tissue sampling procedures are detailed in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 1989) and the Fish Tissue Guidance Manual (Ohio EPA 1994a).

Frozen fish tissue samples were transported to the Division of Environmental Services Laboratory (DES) and placed in freezers there.

A.3.6 Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are used to judge aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria, within a weight of evidence framework, has been extensively discussed elsewhere (Karr et al. 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, land use data, and biological results (Yoder and Rankin 1995). Thus the assignment of principal causes and sources of impairment in this report represents the association of impairments (based on response indicators) with stressor and exposure indicators. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified, or have been experimentally or statistically linked together.

The ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem “health” compared to human patient “health” (Suter 1993), this document refers to the process for evaluating biological integrity and causes or sources associated with observed impairments, not whether human health and ecosystem health are analogous concepts.

A.4 SUMMARY OF FINDINGS BY DATA TYPE

This chapter summarizes the detailed data discussion contained in Section B of this report. Section B contains voluminous tables and figures that illustrate data, and these sources are frequently referenced in this chapter.

A.4.1 Point Source Pollutant Loadings

(See Section B.1 for detailed discussion.)

There are 51 active point source discharges in the Big Darby Creek watershed (Table B.1.1, Figures B.1.1 and B.1.2.). Most of these facilities (48) are small waste water treatment plants (WWTPs) discharging from 2,000 to 100,000 gallons per day of sewage, known generically as "package plants."

These "package plants" combine to account for approximately 4.5% of the wastewater flow, 9.4% of the $cBOD_5$ loading, 35.3% of the ammonia loading, and 6.8% of the suspended solids loading discharged to the Big Darby watershed (Figures B.1.3 - B.1.6) from all point services. Thus, compared to their contributions of flow, these facilities discharge disproportionately high loads of ammonia, $cBOD_5$ and suspended solids. Many of these package plants have a history of maintenance and operational problems (discussed more fully in Section B) and have been ordered to divert their influent waste to regional facilities. The number of package WWTPs should decrease dramatically over the next several years. The regional plants accepting this influent have staff sufficient to handle the operation and maintenance of WWTPs and thus yield a higher quality and more consistent effluent. The expectation is that where these package plants or unsewered areas are eliminated, there will be a local improvement in water quality. There is concern that diversion of flow to these regional facilities will shift the load to other portions of the watershed and potentially impact these areas. This is a legitimate concern and every effort must be made to ensure that ongoing and adequate operation and maintenance takes place. Follow-up monitoring should also take place shortly after these package WWTPs are tied into their respective regional plants to ensure that permit limits are properly calibrated to meet designated uses.

Only a handful of permitted entities are responsible for the majority of the flow and pollutant loadings to the watershed (i.e., due to point sources). These include the Plain City WWTP, West Jefferson WWTP, Clark's Lake Subdivision WWTP, Pickaway Correctional Institute WWTP, Lake Darby Estates WWTP, North Lewisburg WWTP, Mechanicsburg WWTP and Olen Corporation.

Olen Corporation, a mining operation situated a short distance upstream from U.S. Route 70, historically accounted for more than 50% of the median flow to the watershed. Olen ceased operation in 2003 and turned over the property to the Franklin County Metropark system. Similarly, loadings from the Clark’s Lake Subdivision WWTP will be diverted from its unnamed tributary to the Pickaway Correction Institute WWTP.

For the balance of entities listed above (with the exception of the Lake Darby Estates WWTP), Ohio EPA is currently working with the facilities to decrease net loadings to the watershed; provide more consistent treatment overall; and improve water quality through a combination of repairs, plant upgrades, expansions, and increased training and certification.

A.4.2 Spills and Wild Animal Kills in the Big Darby Creek Watershed: 1979-2002

(See Section B.2 for detailed discussion)

Lists of spills and wild animal kills can be useful to explain measured instream biological impacts that are not correlated with documented water chemistry problems or degraded instream habitat.

For the time period of 1979 to 2002, there were 22 incidents where a total of 147,587 fish were killed within the basin (Table B.2.1). The two largest kills of 52,134 and 36,767 animals resulted from spills of ammonia and liquid fertilizer, respectively. Both of these kills resulted from spills at an agribusiness in Mechanicsburg that drained into the Little Darby Creek in the middle 1980s. Half of the spills were directly attributable to agricultural sources which resulted in 96% (i.e., 142,748 fish) of the total body count. Virtually all of the counties in the watershed were represented (Figures B.2.1, B.2.5 and B.2.6). An additional twenty spills were reported where on-site investigations revealed no observable dead animals. Fertilizer was the most frequent reason for these investigations followed by unknown causes.

Most of the incidents reported were for spills with amounts of 300 gallons or less of material. Petrochemicals, particularly diesel fuel, were the most commonly reported spilled materials accounting for 1187 gallons. One spill of ammonia released ~ 1000 gals of material. However, the largest spill was 194,000 gallons of sewage which came from the village of Milford Center in 1997. This small previously unsewered village has now been sewered and tied into the Marysville WWTP.

The second largest release of material in the watershed also emanated from Milford Center. A mixture of fermenting grain and molasses (~24,000 gal) was pumped from the basement of a custom-blend feed mill into Big Darby Creek via a storm drain. This decaying material stripped the dissolved oxygen from the water for several miles downstream for approximately one week, killing an estimated 24,000 fish and other aquatic organisms.

This "spill" highlights one finding of this study: in many cases these spills were preventable, particularly the larger events. Given the great harm that can and has resulted to this high quality resource in a short period of time, every effort should be made to determine how to best avoid spills, to prepare emergency response plans for quickly reacting to spills when they do take place, and to promote education and outreach tools to convey these plans to stakeholders in the watershed.

Another discovery of the current study was the effect of spills and kills on the distribution of bivalve molluscs suggesting the reason for the absence of bivalves in portions of the watershed. Consult the discussion of trends in unionid mussel communities for details (Section B.7.4).

A.4.3 Chemical Water Quality

(See Section B.3 for detailed discussion. Data are available in Appendix C.1.)

Big Darby Creek Upper Mainstem

There were no violations of Ohio Water Quality Standards (WQS) criteria for chemical or physical parameters found in upper Big Darby Creek. However, fecal coliform bacteria and E. coli bacteria were evident in all samples and in excess of the maximum Primary Contact Recreation (PCR) criteria. Bacteria appeared to be arising from a variety of sources including tributary streams, point sources, and diffuse sources. Flat Branch consistently contributed considerable amounts of bacteria to Big Darby Creek irrespective of weather. Mean concentrations decreased with downstream distance, but increased just downstream of Buck Run. This trend of decrease continued until reaching the Village of Plain City where Robinson Run adversely impacted chemical water quality in upper Big Darby Creek.

Flat Branch was a major source of total suspended solids loading to Big Darby Creek as documented by sample results and photographs. Drainage from the Honda of America property is a possible source. The pollution influence from Flat Branch extended well downstream and was augmented by total suspended solids loadings from the Flat Branch WWTP and Buck Run.

Comparison of suspended solids concentrations among stream segments of like drainage areas revealed that most upper Big Darby EWH sites exhibited total suspended solids concentrations significantly above those found in similar-sized streams in the watershed.

The appearance of algal blooms in the upper mainstem, witnessed at various times during the 2001 field effort, are indicative of nutrient enrichment. Partial biological attainment in the mainstem beginning downstream of Flat Branch may be caused by degraded chemical water quality as evidenced by elevated suspended solids and nutrients.

Nitrate+nitrite displayed a fairly steady increase over the entire range of the upper Big Darby Creek. Several tributary streams are contributing significant concentrations of nutrients to Big Darby Creek. Spain Creek (with North Lewisburg WWTP contributing), Buck Run, Robinson Run, and Sweeney Run are all included in this group. The Plain City WWTP contributed a significant spike to mean nitrate-nitrite concentrations. Downstream assimilation appeared to keep pace with inputs with mean nitrate-nitrite concentrations plateauing at approximately 15 mg/l.

Flat Branch (02-223) (RM 78.48)

Numerous chemical water quality problems plagued Flat Branch during the survey period. Chemical water quality criteria were violated for temperature and copper. The copper violation was due to the use of an algicide (Cutrine) by Honda of America in ponds directly drained by

Flat Branch or its tributaries. Bacterial contamination was also common. Total suspended solids were consistently well above background, and this problem extended into Big Darby Creek. Honda of America is sponsoring studies to determine the source of these problems. Turbid water emanating from Flat Branch was visible as far downstream as the Big Darby Creek confluence with Buck Run.

Unnamed tributary to Flat Branch (02-365) (RM 1.5)
Similar water quality problems to Flat Branch existed but were not as severe.

Little Darby Creek (02-251) (RM 78.34)
Fairly good water quality matched well with other sites of comparable drainage area.

Unnamed tributary to Big Darby Creek (02-361) (RM 74.91)
Comparison of this stream with others of the same drainage area indicated excessive concentrations of nitrate plus nitrite as well as E. coli bacteria counts whereas the presence of other nutrients, suspended solids, and fecal coliform bacteria were at or below the values found in similar streams.

Spain Creek (02-222) (RM 74.30)
There were no chemical WQS criteria violations in Spain Creek during the survey period, however, there were violations of recreational water quality criteria at each site, both for the geometric mean and maximum bacteria values. The upper watershed showed a more negative impact from suspended solids than the lower reaches.

The North Lewisburg WWTP contributed to the enrichment of the lower section of the creek, especially for organic nitrogen (TKN), nitrite, total phosphorus, and to some extent, ammonia.

Pleasant Run (02-221) (RM 72.01)
Pleasant Run had some of the lowest ranges of suspended solids and nutrient concentrations and some of the most stable dissolved oxygen readings for a stream of its size indicating little negative impact from chemical pollutants. Maximum recreational criteria were exceeded for both E. coli and fecal coliform bacteria.

Unnamed tributary to Big Darby Creek (02-360) (RM 69.40)
E. coli and fecal coliform concentrations in this tributary exceeded WQS criteria in up to 80% of samples. This tributary also showed indications of nutrient enrichment with a median D.O. concentration of approximately 120% saturation as well as higher median nitrate concentrations than similar-sized streams.

Hay Run (02-220) (RM 67.6)
Nitrate showed the second highest median concentration and the highest actual concentration of all WWH streams of comparable size. These chemical data and visual observations of large algal blooms instream suggest that Hay Run suffers from significant nutrient enrichment.

Prairie Run (02-219) (RM 63.84)
No chemical water quality samples were taken.

Buck Run (02-209) (RM63.74)
Buck Run was impaired by insufficient dissolved oxygen and elevated concentrations of suspended solids, bacteria, and nutrients.

WQS criteria violations of the WWH minimum dissolved oxygen (D.O.) criterion occurred twice during the survey. The mean D.O. values in Buck Run were slightly greater than the WWH average D.O. criterion of 5 mg/l at RM 7.80, 5.00, and 0.10. Bacterial concentrations were also elevated with fecal coliform and E. coli concentrations in excess of the PCR maximum criterion. Most of these exceedences occurred at RM 10.40 and RM 0.10.

Robinson Run (02-207) (RM 53.69)
Robinson Run had comparable concentrations of nutrients to similar sized WWH streams. All of the WWH streams in this drainage range seemed impaired by nutrients. The WWTPs in the upper portion of the watershed did not appear to be causing this nutrient enrichment. However, bacterial counts were found in excess of the PCR maximum criterion for both E. coli and fecal coliform bacteria.

Sweeney Run (02-357) (RM 52.11)
Bacterial counts in this stream were elevated. Nutrient enrichment was apparent with large algal blooms instream coupled with excessive concentrations of ammonia, nitrate, organic nitrogen, and total phosphorus.

Some nitrates were elevated above the 90th percentile of background; many of the fecal coliform bacteria counts were high. Organic nitrogen, ammonia and total phosphorus were also present in significantly higher concentrations than similar sized streams in the Eastern Corn Belt Plains (ECBP) ecoregion.

Big Darby Creek Middle Mainstem
There were no violations of chemical criteria in the middle Big Darby Creek mainstem. A single violation of the fecal coliform bacteria NPDES permit limit was detected at the Plain City WWTP outfall. Biosolids deposits were observed immediately downstream of the outfall, in violation of the "free froms" in the WQS. Significant increases in bacterial and nutrient concentrations in Big Darby Creek were found immediately downstream. These problems are due to the lax limits imposed on the WWTP via the old NPDES permit.

The Plain City WWTP was the main cause of degradation and partial biological attainment in this segment of stream. Nutrient concentrations immediately downstream of the outfall were always greater than the background median and often very high. Concentrations of suspended solids, nitrate+nitrite, TKN, and total phosphorus remained elevated over two miles downstream and were likely due to the residual effects of the Plain City WWTP discharge. Chemical water quality and biological attainment were not compromised ten miles downstream and beyond. The numerous small WWTPs scattered along this stretch of river did not appear to impair water quality or the biota.

Sugar Run (02-206) (RM 50.92)
Low dissolved oxygen and contamination from E. coli bacteria were evident in Sugar Run although recreational water quality criteria were met. Sugar Run was suffering from gross nutrient enrichment in the modified section and moderate nutrient enrichment in the WWH portion. Ammonia concentrations were routinely above background conditions and contributed to nutrient pollution along with nitrate+nitrite.

Since the majority of the subwatershed has degraded habitat, even the reach near the mouth (which had better habitat and exhibited biological attainment) was nutrient enriched and negatively impacted by suspended solids.

Worthington Ditch (02-02-356) (RM 50.62)
Bacterial contamination from E. coli was noted. Nutrient concentrations in Worthington Ditch were significantly greater than median ECBP reference conditions. Water chemistry in this stream compares favorably with others of the same drainage area exhibiting lower ammonia, suspended solids and bacterial concentrations as well as moderate to good oxygen saturation. However, TKN values were all above ECBP reference median concentrations and well above those of some other small streams with in the watershed.

Ballenger-Jones Ditch (02-355) (RM 49.68)
Bacterial contamination and nutrient enrichment in this stream were due in part to the discharge from the Jonathan Alder High School WWTP which is overloaded and currently not providing adequate treatment. Comparison with other streams of the same drainage area shows similar concentrations of ammonia, total suspended solids, phosphorus, and bacteria with moderately elevated concentrations of TKN.

Yutzy Ditch (02-364) (RM 47.10)
Bacterial contamination from E. coli was noted. Elevated concentrations of nutrients were also noted and similar to those found in Ballenger-Jones Ditch. The Canaan Elementary School WWTP discharges to this stream during the school year.

Fitzgerald Ditch (02-272) (RM 44.96)
Nutrient concentrations were excessive in Fitzgerald Ditch with values for ammonia, nitrates, and total phosphorus all greater than the 75th percentile of the ECBP reference concentrations with some exceeding the 95th percentile. Instances of bacterial contamination and nutrient enrichment were due in part to the discharge from the poorly operated and maintained Canaan Community MHP WWTP, approximately one mile upstream.

Fitzgerald Ditch had some of the highest chemical concentrations of similar sized drainage area streams in the watershed. Elevated concentrations of bacteria as well as suspended solids, TKN, phosphorus, and ammonia were the norm as was dissolved oxygen supersaturation.

Little Darby Creek (02-210) (RM 34.1)
No violations of chemical criteria were found and only a few instances of bacterial contamination were found primarily in the Mechanicsburg area. Mean bacterial concentrations were high up and downstream of the Mechanicsburg WWTP apparently resulting from on-site waste treatment systems and the WWTP.

Bacterial concentrations dropped precipitously at the next downstream site and then increased downstream from Treacle Creek. Bacterial numbers then decreased to insignificant levels towards the mouth. Dry weather flow from the West Jefferson WWTP did not appear to contribute to any bacterial degradation.

Dissolved oxygen supersaturation was indicative of nutrient enrichment and poor riparian coverage as well a modified stream channel with poor pool development at the mouth. TSS showed a marked increase downstream of Mechanicsburg to RM 24.50. Some of this increase was attributable to Treacle Creek and Barron Creek, both of which contributed large amounts of suspended solids to Little Darby Creek yielding average values well in excess of ECBP reference site median concentrations.

Mean concentrations of nitrate+nitrite were decreased by half just downstream of Lake Run and remained relatively consistent down to the mouth. Neither Mechanicsburg WWTP nor the West Jefferson WWTP significantly increased instream nitrate+nitrite concentrations. However, median nitrate+nitrite concentrations at most sites were among the highest detected for comparably-sized stream segments in the watershed. Three-fourths of the nitrate+nitrite results in Little Darby Creek were greater than the ECBP reference site median concentration with a third greater than the 75^{th} percentile.

In contrast, TKN concentrations were lower than at other sites with ammonia undetected except in a few instances downstream of the Mechanicsburg WWTP and downstream of Treacle Creek. Mean total phosphorus showed notable peaks downstream of Mechanicsburg WWTP and West Jefferson WWTP as well as a gradual increase moving downstream.

Storm water monitoring was performed at various times throughout the year in Little Darby Creek at Middle Pike. Loadings of suspended solids, ammonia, nitrate+nitrite, and total phosphorus all increased with increasing flow volume, though not directly proportional. Comparisons of the flows and loadings between events showed increased flow (1.8 fold) resulted in a 3.8 fold increase in suspended solids, a slightly increased loading of nitrate+nitrite, a 1.6 fold increase in ammonia loadings, and a 3.8 fold increase in phosphorus loadings.

Clover Run (02-218) (RM 39.80)
E. coli bacteria levels were elevated in every sample taken in 2001 but otherwise water quality was good compared to other comparable sized WWH sampling sites.

Lake Run (02-216) (RM 36.90)
Lake Run exhibited no violations of chemical water quality criteria although bacterial contamination from E. coli was evident in 80% of the samples. Some nutrient parameters were slightly elevated and some were slightly below median.

Jumping Run (02-217) (RM 3.90)
Nutrient concentrations in Jumping Run were comparable with other stream segments of similar drainage area with some of the lowest TSS in this range. Water quality sampling in Jumping Run in 2001 showed no violations of chemical water quality criteria. Bacterial contamination from E. coli was evident in the majority of the samples however

Treacle Creek (02-213) (RM 31.30)
E. coli bacteria were found in the majority of the samples at concentrations greater than PCR water quality criteria with the uppermost and lowermost sites exhibiting the most contamination, however recreational criteria were not violated in Treacle Creek. Dissolved oxygen ranges exhibited some disturbingly low values that were very near the EWH minimum criteria of 5 mg/l at RM 11.80 and RM 0.80.

Total suspended solids concentrations in Treacle Creek increased with distance downstream. Mean values increased more than 3-fold from RM 8.30 to RM 6.00 with half of the concentrations in excess of the 75th percentile of background at the lower 2 sites. Comparison of suspended solids concentrations at the lower site showed a large disparity between similarly-sized sites on Hellbranch Run (even though Hellbranch Run is only a WWH stream) and Spring Fork with Treacle Creek showing much greater values and a median concentration much higher than background.

Upper Treacle Creek exhibited some of the highest ammonia concentrations compared to similarly sized stream segments in the watershed. Two ammonia values topped the 95th percentile for background. Organic nitrogen (TKN) and total phosphorus concentrations were also elevated in comparison with similar streams and nitrate values that were analogous. Median nitrate+nitrite concentrations in the middle reaches of Treacle Creek were among the highest of comparably-sized streams.

Lower Treacle Creek exhibited slight increases in the mean concentrations of ammonia, nitrate+nitrite, and TKN.

Treacle Creek appears threatened by excessive numbers of E. coli bacteria over the entire stream channel along with high concentrations of suspended solids and immoderate nutrient concentrations in the upper and lower watersheds. This is likely due to runoff from multiple agricultural sources (e.g., animal operations and rowcrop agriculture).

Howard Run (02-215) (RM 5.40)
E. coli bacteria from Howard Run may contribute to contamination in Treacle Creek. Otherwise, water quality fell within the range of other comparable sized stream sample sites.

Proctor Run (02-214) (RM 3.69)
Upper Proctor Run bacterial concentrations were noticeably higher than comparable stream segments. TSS concentrations were nearly all above the background median and generally greater than comparable EWH waterways. Other nutrient concentrations were commensurate or minutely higher than comparable streams (total phosphorus, ammonia, TKN) or significantly lower (nitrate+nitrite).

All nutrient concentrations in lower Proctor Run were commensurate with stream reaches of similar drainage area as a consequence of assimilation/attenuation from upstream concentrations Nitrate-nitrite was the sole outlier with a hot spot at RM 3.1. Numerous water quality problems were identified throughout this subwatershed.

Barron Creek (02-212) (RM 24.40)
There were no violations of chemical water quality criteria noted although serious chemical water quality problems were verified.

Fecal coliform bacteria and *E. coli* concentrations were excessive with bacterial concentrations well above similar EWH streams and indicative of a chronic contaminant source.

Total suspended solids concentrations were all greater than the background median and higher than similarly sized streams. Ammonia, organic nitrogen (TKN), and phosphorus were all present in concentrations that were in excess of other EWH streams of the same drainage area.

Water Chemistry Trends

Big Darby Creek Mainstem
Fecal coliform bacteria have become more prevalent in recent years with the higher mean concentrations in the headwaters dropping to the "normal" range of values downstream of Spain Creek. A definite spike was also noted downstream of the Plain City WWTP, similar to problems at the plant that were first noticed during the 1997 survey.

Dissolved oxygen values in 2001 were noticeably lower in certain areas of the mainstem although none of the values dropped below the WWH or EWH average criteria. In particular, the areas downstream from Flat Branch and Buck Run exhibited lower mean concentrations than in previous years as did the areas downstream of Sugar Run, Little Darby Creek and Hellbranch Run. Even though these decreases seemed minor, this may constitute a threat to the stream segments affected and to the watershed as a whole.

Mean total suspended solids concentrations generally exhibited decreases from those observed in previous surveys except in the upper watershed and downstream of Flat Branch and Spain Creek. In this segment, suspended solids concentrations showed increases over 1992 values and most 1979 values. This could be part of the cause for fish community impairment.

Mean nitrate+nitrite concentrations showed decreases from previous surveys. Organic nitrogen (measured via TKN) was at levels comparable those documented in 1992 and 1997 in the upper and lower watershed. However, concentrations peaked downstream from the Plain City WWTP in both 1997 and 2001 indicating worsening nutrient enrichment downstream of the plant. Survey results obtained in 1979 exhibited much higher concentrations of TKN than other survey years indicating improved chemical water quality conditions for this parameter again except for downstream of the Plain City WWTP.

Patterns in mean total phosphorus concentrations were more variable. The upper watershed showed some slight increases compared with previous surveys, especially downstream of Flat Branch. These concentrations remained consistent until downstream of Pleasant Run where they dipped below previous results. Phosphorus concentrations peaked in three other places on the mainstem, just upstream of Robinson Run, downstream of the Plain City WWTP, and downstream of the complex of wastewater treatment facilities including PCI-ODRC WWTP, Clark's Lake Tributary and Foxlair Farms WWTP.

Hellbranch Run (02-204) (RM 26.1)
In Hellbranch Run, mean ammonia and mean dissolved oxygen trends were consistent until the site downstream of the Timberlake WWTP outfall. There, ammonia spiked higher and dissolved oxygen drifted lower than measured in previous years. Wastewater treatment plant influences seemed to provide the majority of nutrient spikes as in the past. Mean bacterial values were found to be generally the same or lower than in the past except downstream of the Oakhurst Knolls WWTP. Mean total suspended solids concentrations were generally lower than historical values except in the headwaters. The negative influence from both Clover Groff and Hamilton Ditches, which drain the upper watershed, are contributing to these problems

Little Darby Creek (02-210) (RM 34.1)
Trends for both mean TSS and mean fecal coliform bacteria were down from past evaluations as were concentrations of total phosphorus. Mean dissolved oxygen trends showed little change except for a slight drop at the headwaters and an increase around RM 15.30. Mean organic nitrogen concentrations trended higher downstream of Barron Creek to the mouth. Mean nitrate+nitrite concentrations were highest of any year at the headwaters falling to levels between those found in 1992 and 1997.

Treacle Creek (02-213) (RM 31.3)
Total phosphorus and total suspended solids in the 2001 data showed the lowest mean concentrations of any year. Mean dissolved oxygen concentrations were among the highest of any year. Fecal coliform bacteria mean concentrations were midway between other years as were concentrations of nitrate+nitrite.

A.4.4 Datasonde™ Results (Short term continuous water quality monitoring)

(See Section B.4 for detailed discussion.)

The concentration of chemicals dissolved in water are seldom uniform over time. Repeated grab water sampling attempts to characterize the range of variability present at a given sampling site. For many chemical parameters this is an adequate approach and provides a fairly good representation of concentrations present at that site during that time frame. However, for other parameters, and dissolved oxygen in particular, large diel swings in concentration can take place. Frequently, the lowest concentrations occur in the predawn hours when algal respiration has depleted substantial portions of the dissolved oxygen from the water column, potentially stressing aquatic communities. Short term continuous water quality monitoring can provide a more accurate reading on the extremes in concentration of the parameters monitored.

Most stations on the Big Darby Creek mainstem yielded dissolved oxygen (D.O.) concentrations meeting or exceeding the minimum EWH standard of 5.0 mg/l. There were localized indications of problems with the stations located downstream from Flat Branch and downstream from Plain City falling below the EWH minimum. These two sites, as well as the site downstream from Darbydale, exhibited mean dissolved oxygen that violate the 6.0 mg/l EWH D.O. average criterion. Problems elsewhere in the watershed are evident; over half of the stations violated the 6.0 mg/l EWH D.O. average criterion. Most of the below standard oxygen values were recorded at night when plants switch from photosynthesis to respiration.

The stations where the average criterion violations occurred were downstream from Flat Branch and Buck Run, upstream and downstream from the Plain City WWTP, upstream from Little Darby Creek, downstream from Darbydale, downstream from Scioto Darby Road, adjacent Gulick Road, downstream from Georges Run, upstream from State Route 316, adjacent to Florence Chapel Road, and several sites in the lower mainstem.

Little Darby Creek and Tributaries

All of the Little Darby Creek mainstem stations had D.O. concentrations meeting or exceeding the minimum EWH standard of 5.0 mg/l. One station at Axe Handle Road (RM 29.5) yielded a violation of the 6.0 mg/l EWH D.O. average criterion.

Dissolved oxygen concentrations from Treacle Creek (RM 0.75) yielded a violation of the 5.0 mg/l minimum EWH criteria. A violation of the 6.0 mg/l EWH D.O. average criterion occurred in Spring Fork at Lafayette Plain City Road. Dissolved oxygen concentrations from Proctor Run (designated EWH) met the EWH water quality criteria (average and minimum criteria).

Big Darby Creek Upper Tributaries

Flat Branch (02-223) (RM 78.48)

Data collected from Flat Branch indicate that there is a problem, but one round of sampling is not sufficient to document the full severity of the problem. In 2001 D.O. concentrations at all three Flat Branch mainstem stations (designated MWH) fully met the minimum and average MWH criteria. However, in 2002 violations of the average MWH D.O. criteria of 4.0 mg/l were found at the mouth. Dissolved oxygen concentrations upstream from Flat Branch in Big Darby Creek fully met the WWH criteria (minimum and average) but fell below the minimum EWH criterion of 5.0 mg/l downstream from Flat Branch. Big Darby Creek is currently designated WWH upstream from Flat Branch and EWH downstream from Flat Branch. Flat Branch is causing a decrease in dissolved oxygen in the mainstem of Big Darby Creek.

Buck Run (02-209) (RM 63.74)
Two concentrations went below the average WWH D.O. criteria (5.0 mg/l) at the Buck Run location (RM 0.1 at Orchard Road). The Big Darby Creek location upstream from Buck Run fully met the EWH criterion for D.O. (average and minimum) but six concentrations went below the average EWH D.O. criterion (6.0 mg/l) at the Big Darby Creek location downstream from Buck Run. The results indicate that Buck Run may be causing decreased D.O. level, in the mainstem of Big Darby Creek.

Robinson Run (02-207) (RM 53.69) and Sugar Run (02-206) (RM 50.92)
Dissolved oxygen concentrations from Robinson Run and Sugar Run, both designated WWH, met the WWH water quality criteria (average and minimum criteria).

Unnamed Tributary to Big Darby Creek (02-206) (RM 20.2)
Dissolved oxygen concentrations below the 4.0 mg/l WWH minimum standard measured for all readings, with the highest concentration at 1.62 mg/l and the lowest at 0.52 mg/l (Figure B.4.11). The significant water quality violations are most likely caused by the discharge from the Fox Lair MHP but could also be a result of the dam release just upstream from the Fox Lair MHP.

A.4.5 Sediment Chemistry

(See Section B.5 for detailed discussion.)

Sediment samples were analyzed from selected sites throughout the watershed. Parameters analyzed included persistent organic contaminants, selected metals, nutrients, total organic carbon and particle size distribution.

Very few organic compounds were detected in the sediments sampled in the Big Darby Creek watershed. Only dieldrin (1 detection) and acetone (3 detections) were found. The detection of dieldrin, a pesticide, at RM 52.00 on Big Darby Creek, just downstream from the Plain City WWTP, was sufficiently high to be greater than a threshold effect concentration which may have contributed to the decline in the ICI, total EPT taxa and sensitive macroinvertebrate taxa documented downstream from Sweeney Run and the Plain City WWTP. The acetone source(s) are unknown and did not seem to pose a threat to the stream or aquatic life.

Tributary Nutrient Results
Ammonia concentrations were highest in Hellbranch Run near the mouth and in Robinson Run. Decreased fish community performance coincidently was observed at both of these sites. Both of these streams receive effluent from package WWTPs which may be contributing to the sediment ammonia levels. The site with the next highest concentration was on Little Darby Creek at RM 15.3 (U.S. Route 42) which may be due to NPS runoff (57 mg/kg). There has been a slight decrease in macroinvertebrate community quality here over time.

Total organic carbon was found in all tributary streams at concentrations above the lowest effect level (LEL). Total organic carbon values in tributary streams were comparable to values documented in other ECBP tributary streams in central Ohio, such as Bokes Creek and Olentangy River tributary streams.

Sediment total phosphorus exceeded LEL concentrations at all sites analyzed. Total phosphorus concentrations in sediments were highest in Little Darby Creek (RM 15.3), Hellbranch Run at the mouth, Treacle Creek (RM 0.8), Robinson Run (RM 0.7) and Sugar Run (RM 0.7). The Green Meadows MHP WWTP, which has numerous documented violations of its NPDES permit limits, is a logical source of some of the total phosphorus found at RM 15.30 in Little Darby Creek. There has been a slight decline in macroinvertebrate community quality over time at this site. The Timberlake WWTP, which has a history of problems with operation, is significantly impacting the Hellbranch Run value. Robinson Run has nonpoint source (NPS) and WWTP inputs. Again, reduced fish performance was observed at the Hellbranch Run and Robinson Run sites. Sugar Run and Treacle Creek sites had sedimentation, nutrient enrichment, and low dissolved oxygen problems which yielded decreased biological community performance.

Big Darby Creek Nutrient Results

Nutrients found in Big Darby Creek followed the same pattern as the tributaries in most instances. Ammonia concentrations were not as elevated as some of those found in the tributaries, however the three sites with higher concentrations have shown trends of decreasing biological quality. The highest concentrations were found at RM 3.10 (83 mg/kg), at RM 63.8 (68 mg/kg), and at RM 53.9 (52 mg/kg). All three areas have accumulated sediment from upstream NPS inputs (i.e., agriculture, livestock operations, tributaries and other sources). Spills may have also contributed to the elevated ammonia levels at RMs 63.8 and RM 53.9. Sediment ammonia, along with other factors, likely contributed to decreased mussel diversity in these reaches.

In general, sediment nutrient values greater than the LEL indicate that the sediment is marginally to significantly polluted and that it will produce some toxicity concerns for benthic organisms living in them. The proportion of fine grained sediment in the segment will determine the magnitude of the toxicity associated with elevated concentrations of nutrients. If fines are a small proportion of the stream bed materials, elevated concentrations of nutrients will not exacerbate enriched conditions in the water column. In contrast, nutrient enrichment may be a problem where you have substrates dominated or embedded by fine-grained sediments.

Tributary Metals Results

Tributary stream sediments were also evaluated for heavy metals. The most impacted stream locale was Sugar Run at RM 7.00. Here, arsenic concentrations were elevated as were chromium and iron. Copper, nickel, and zinc concentrations were slightly elevated. This was the only tributary that exhibited detectable concentrations of chromium and nickel as well as the highest values for copper, iron, and zinc. The Hershberger Landfill may be the source of these metals.

Big Darby Creek Metals Results

Metals were found in sediments throughout the Big Darby Creek mainstem. There were two locations of particular concern: RM 52.00, downstream of the Plain City WWTP, and at RM

3.10 near the mouth. Sediment lead concentrations of 108 mg/kg greatly exceeded the TEC at RM 52.00. The sediment chromium concentration exceeded the LEL. Other relatively higher concentrations of zinc (114 mg/kg) and copper (27.2 mg/kg) indicated metals present in the sediments possibly from a defunct metal plating shop, the Plain City WWTP and Sweeney Run nonpoint source inputs. Toxicity from these sediment metals could have contributed to the decrease in macroinvertebrate community ICI and diversity at this site compared to upstream.

At RM 3.1 on Big Darby Creek sediment aluminum and barium was elevated in comparison to the Ohio EPA sediment reference values. Nickel was elevated (48 mg/kg) and exceeded the TEC concentration. The zinc sediment concentration at RM 3.1 of 128 mg/kg also exceeded the TEC concentration. The sediment chromium exceeded the LEL. The elevated sediment metals and silt bedload with attached phosphorus and ammonia noted earlier likely contributed to decreased mussel diversity in this reach.

Sediment metals including nickel, lead, zinc and chromium at RM 54.2 and RM 53.9, which are in the vicinity of Ranco and U.S. Route 42, may be causing toxicity. These sediment metal concentrations along with other factors (i.e., sediment total phosphorus and ammonia) could have contributed to the documented decline of mussel diversity in this reach.

A.4.6 Instream and Riparian Habitat in Support of Aquatic Life

(See Section B.6 for detailed discussion. Data are available in Appendix C.2.)

Upper Big Darby Creek - Headwaters to Plain City

The headwaters of Big Darby Creek have been impacted by road construction activities and have been recovering from those activities with the assistance of a re-engineered channel and natural stream recovery processes. The sediments released by the original construction activities appear to be working their way downstream. The expectation is that these sediments will result in some further decline downstream (absent any activities to ameliorate this downstream migration) as it passes through. However, based on the experience of recovery seen at site in the vicinity of TR 152, habitat quality is expected to improve as the sediments are flushed out or stabilized and planned restoration and protection measures are enacted. The overall segment average QHEI should further increase. This segment has shown a remarkable ability to rebound from sedimentation to the point that the upper reaches of Big Darby Creek, which only a few years ago were considered impaired by this stressor, are currently being recommended for re-designation to EWH based on the improved instream biological community performance. The high mean segment QHEI scores coupled with the majority of sites meeting applicable EWH criteria support the appropriateness of this use designation.

Industrial development of the Flat Branch subwatershed has resulted in significant declines in habitat quality in that subwatershed as well as substantial changes in the hydrology as well. Habitat quality just downstream from the confluence with Flat Branch appears modestly compromised by this stressor. Efforts by Honda Corporation to deal with storm water issues on its property should alleviate some of the concern about this problem on the mainstem.

In general there is gradual improvement in habitat quality with downstream distance in this segment despite the few small interruptions.

Middle Big Darby Creek - (Plain City to the confluence with L. Darby Creek: RM 52.1 - 34.1) This stream segment also revealed a trend of gradual improvement with downstream distance. The average QHEI for the segment (82.9) well exceeded the values judged suitable for supporting EWH aquatic communities. Although major strides have been made towards protecting or maintaining existing habitat quality within this segment, impacts have taken place in the upper reaches, particularly in the vicinity of Plain City. This segment also includes the majority of protected land adjacent to the stream bank within the watershed. Expectations are for habitat quality in this segment to improve slightly over time as land recently acquired is converted from its previous uses to a more natural state.

Lower Big Darby Creek (confluence of Little Darby Creek to its confluence with the Scioto River RM 34.1 - 0.0)
The segment average QHEI was 83.6. Similar to the upstream segments evaluated, this stretch possesses an abundance of positive habitat features more than capable of supporting EWH aquatic biological communities and which ranks it as one of the high quality stream segments in the state of Ohio.

Significant changes in riparian and instream habitat in the lower reaches of Big Darby Creek since the last major sampling in the early 1990s were associated with the June 1997 flood. This major flood caused significant damage to some of the dikes in this lower reach that had separated the stream from its floodplain. Some of the dikes were repaired (without prior 401 authorization) by dredging and bulldozing streambed sediments to re-establish the berm, causing impact to local aquatic communities. Further downstream at the mouth, a collaborative project between the local landowner, ODNR Division of Wildlife (DOW) and Division of Soil and Water Conversation (DSWC), Pickaway Soil and Water Conservation District (SWCD) and the U.S. Fish and Wildlife Service (USFWS) resulted in moving the dike away from the stream channel which permitted the re-establishment of a floodway and a wooded riparian buffer. Discussions are ongoing to further extend this project upstream. As a result of this project, natural stream recovery processes should result in improved habitat scores in this very lower reach. Another project that will likely go forward is the re-opening of the original eastern channel around Snake Island planned by ODNR DOW and the Ohio Department of Rehabilitation and Corrections (DRC), which will increase channel length by approximately one mile. This will effectively reduce local gradient and should reduce some of the erosion problems currently being experienced in the vicinity.

Big Darby Creek Upper Tributaries - Flat Branch to Robinson Run

Flat Branch (02-223) (RM 78.48)
The stream channel of Flat Branch has been extensively modified in the past yielding poor to very poor instream and riparian habitat quality. The preponderance of high and moderate influence negative habitat attributes currently limits the potential for this tributary to support aquatic communities.

In recognition of the impact of the reduced habitat quality of Flat Branch on resident aquatic communities and the changes in hydrology on the Big Darby Creek mainstem, a variety of activities are being studied or implemented to improve or restore stream habitat. Restoration projects discussed have included a wetland or series of wetlands created or restored in the upper watershed to improve water quality, ameliorate flood peaks, and provide habitat. Efforts have also been made on the part of Honda of America to widen the vegetated buffer and put in storm water retention ponds.

Little Darby Creek (Logan County) (02-251) (RM 78.34)

This very high quality headwaters stream has consistently yielded some of the highest QHEI scores in the state. However, some streamside landowners have recently channelized portions of Little Darby Creek, damaging it to the point that is causing concern of flooding to those downstream. There is also concern that as these impacts accumulate they will result in the eventual partial or non-attainment of the current EWH and CWH aquatic life uses.

Spain Creek (02-222) (RM 74.3)

There have been significant declines in habitat quality in the headwaters of Spain Creek resulting from a shift in land use to higher density residential. The main difference between the years was the increase in the embeddedness and the disappearance of silt-free substrates. Habitat quality in the lower reaches of Spain Creek downstream from North Lewisburg has been evaluated on several occasions since 1981 and has always yielded QHEI scores in the mid to high 70s, clearly capable of supporting EWH biological communities.

Ground Water Contribution

Several tributaries to Big Darby Creek originating in the Cable moraine and particularly ones draining the boulder belt of the Cable Moraine appear to have a significant portion of their base flow resulting from ground water inflow. This conclusion is supported by temperature and biology data. Several streams in this portion of the watershed have consistently been measured with lower water temperatures (i.e, in the 60° F range when air temperatures were in the +80° F range) than would normally be expected in other ECBP streams during the same time frame. Additionally, many of these same streams support aquatic organisms that are either obligate cold water taxa (i.e., organisms that must be in coldwater) or cool water taxa (i.e., ones that prefer cool water and are only found in abundance in stream segment possessing cooler water).

The inflow of cool ground water has another consequence – the ability to somewhat ameliorate the adverse impacts associated with habitat degradation and modest nutrient enrichment, resulting in higher quality instream biological communities than would otherwise be expected. Hay Run is the perfect example of this phenomenon. Despite extensive portions of its headwaters being maintained under the County Ditch Law by the Union County Soil and Water Conservation District and the site evaluated yielding only a QHEI of 52.5, Hay Run possessed instream biological communities fully meeting EWH biocriteria. However, the positive effects of this phenomenon can be overwhelmed. Situations with habitat disruption (i.e., channelization), severe nutrient enrichment coupled with removal of riparian vegetation leading to anoxic organic deposits on the streambed were sufficient to overwhelm the benefits of the cool ground water (e.g., lower reaches of Barron Creek).

Buck Run (02-209) (RM 63.74)
Land use in the subwatershed is a mixture of rowcrop agriculture, livestock and pasturage. Local habitat in 2001 varied widely in quality from very good to excellent at the site at the mouth to poor at several sites scattered throughout this small stream. Inspection of the site description sheets reveals that in almost every situation the lowered habitat quality has been associated with pasturage with open access to the stream. This results in trampled and false banks, increased siltation and embeddedness, and reduced instream cover amounts and diversity.

Habitat in Buck Run has been repeatedly evaluated since 1988 and Buck Run has demonstrated the ability to improve over time. However, periodic disruptions are slowly lowering overall habitat quality. Channelization and free access of livestock to the stream appear to be sources most significantly contributing to the accumulation of high and moderate influence modified habitat attributes in the Buck Run watershed.

Robinson Run (02-207) (RM 53.69)
Habitat in the upper reaches of Robinson Run were not evaluated. However, casual visual inspection shows that it had been channelized with little recovery from that impact. In contrast, the segment evaluated from Hickory Ridge Road to the mouth appeared to have partially recovered from similar channelization. The mean QHEI for the two sites evaluated was 67. Values in this range generally have been found suitable to support WWH communities. Habitat improved slightly towards the mouth and was associated with an increase in local streambed gradient. A comparison with previous sampling conducted in 1992 revealed almost identical scores to the 2001 results. Robinson Run appears to be maintaining its good habitat quality in the reach evaluated.

Big Darby Creek Middle Tributaries

Sweeney Run (02-357) (RM 52.11)
Much of Sweeney Run's length has been channelized in the past. In its upper reaches the channel work has been done in conjunction with agricultural drainage and in the lower reaches in association with the development of Plain City. Numerous storm water drains and debris are also present in the channel within Plain City. Despite these habitat disruptions the segment at the mouth of Sweeney Run had fair-good habitat and was judged suitable for supporting WWH communities in that reach.

Sugar Run (02-206) (RM 50.62)
Sugar Run definitely presents a gradient of habitat quality ranging from very poor in its upper reaches to a segment at the mouth judged to be suitable for supporting WWH. There has been a definite trend of decline in the upper watershed resulting from a variety of activities. Previously, channelization and habitat destruction associated with livestock having free access to the stream were documented. The construction of a golf course and more recent residential development have furthered this decline. Substantial portions of Sugar Run and its source tributaries are now

under maintenance by the Union County Soil and Water Conservation District and will be maintained indefinitely. More troubling are the declines documented in the middle reaches where habitat quality has slipped from the range which could support very good aquatic communities (i.e., QHEI = 72). Steady declines in the intervening years has yielded ever worsening habitat with the most recent sampling yielding a QHEI of 38.5.

Tributaries Immediately South of Plain City

Scattered along the western shore of Big Darby Creek south of Plain City are several small streams that drain primarily agricultural subwatersheds. Most of them have been channelized in the past in their upper reaches and are now at least partially under maintenance by the Madison County Engineer. In many cases these streams have a more residential land use in their lower reaches. This has had the consequence that more riparian and instream habitat have remained and are suitable to support WWH communities. All would benefit by habitat improvements upstream and also within the evaluated reaches. These streams include Worthington Ditch, Ballenger -Jones Ditch, Yutzy Ditch, Fitzgerald Ditch and probably by extension some of the other small streams scattered in between that were not evaluated.

Little Darby Creek and Tributaries

Along its length Little Darby Creek flows through a variety of different landscape features that yield a wide range of stream bed gradients and consequent instream habitat characteristics. Habitat quality varies from among the best in the state (e.g., QHEI= 99 at RM 4.1) to good (e.g., QHEI = 63.5 at RM 0.7) towards the mouth and within the area that is still recovering from the removal of a run-of-the-river dam. The average QHEI for the eleven sites evaluated in 2001 was 80.5. This demonstrates that habitat quality overall is suitable for sustaining EWH biological communities and that the existing EWH is appropriate and should be retained. Despite the overall high quality, documented problems have also been noted. High quality habitat is frequently interspersed with areas where most if not all of the riparian vegetation has been stripped, and bank erosion is contributing fines to the stream channel.

Glacial maps of Ohio reveal that the stream course of Little Darby Creek within the ground moraine portion of its course is lined with significant deposits of alluvium and glacial outwash. These deposits are responsible for the relatively coarse substrates and the ground water input to the stream. Middle reaches of the stream (from ~ RM 30 to RM 15) possess fairly low gradients on the order of ~ 2-3 ft/mi. Gradients in this range are classified as low (Ohio EPA, 1989) and possess less potential energy, thus having less ability to expel and transport sediments and re-establish natural channel features after disruption. These areas need more help if disrupted, and more protection if currently undisturbed.

As in the upper Big Darby Creek watershed, groundwater contribution also appears to be an important factor in explaining the high biodiversity and high instream biological quality in streams in the headwaters of Little Darby Creek. Many of these streams also originate in the Cable moraine with its attendant habitat enhancing features. As seen in the Big Darby Creek phenomenon, streams that have been subject to modest habitat disruptions or moderate amounts of nutrient enrichment are able to support higher than expected instream biological quality by virtue of the ameliorating effects of the inflow of cool groundwater. Streams that appear to be benefitting from ground water inflow include the headwaters of Little Darby Creek, Clover Run, Lake Run, Jumping Run, portions of Treacle Creek, Howard Run, Proctor Run, Barron Creek, Wamp Ditch, Spring Fork and Bales Ditch.

Clover Run (02-218) (RM 39.8) (EWH)
Overall riparian and instream habitat was good, suitable for supporting WWH aquatic biological communities. Moderate siltation and embeddedness and little to moderate erosion were the main negative habitat influences noted.

Lake Run (02-216) (RM 36.9) (EWH/EWH Deferred)
This small tributary originates just north of Mechanicsburg. It flows through the Cable end moraine and has a couple of glacial kettle lakes situated on it or draining to it. These lakes presumably gave rise to its name. Very few negative habitat attributes were present at the site evaluated. Those that are present resulted from historical channelization and recent construction activities which had delivered sediment to the stream channel. The stream is close to being recovered from channelization. This stream should quickly recover from the temporary sedimentation impact and therefore the existing EWH use is being retained pending future monitoring.

Jumping Run (02-217) (RM 3.9)
Jumping Run is a 2.8 square mile tributary to Lake Run. Although silt and muck substrates contributed to the moderate embeddedness detected this stream, it was still judged to be suitable for the WWH aquatic life use.

Treacle Creek (02-213) (RM 31.3)
Several Treacle Creek sites have been evaluated since 1992. With the exception of the site at Winget Road, all segments evaluated have received QHEI scores in the 60s, yielding a segment average of 65.3. The site at Winget Road had been channelized in the past and maintenance has resumed more recently. In all years evaluated, an extensive pasture lined both sides of the stream. Livestock with free access to the stream had severely trampled both banks yielding thick deposits of silt that blanketed essentially the whole site, resulting in some places in unconsolidated layers as thick as 24 inches. This has translated into problems in Little Darby Creek downstream from the confluence where heavy/moderate silt cover and high to moderate overall embeddedness has occurred.

Ground water contribution to the stream channel and proximity to higher quality stream segments has ameliorated the impact of the negative attributes in Treacle Creek and permitted either full or partial support of EWH communities at all sites except the most downstream site.

Howard Run (02-215) (RM 5.4) (EWH)
The site evaluated had a mix of positive and negative habitat attributes yielding a QHEI of 55.5. Only one high influence, modified habitat attribute was noted - low sinuosity. This was understandable since the site was recovering from historical channelization. Given the steep overall gradient of the stream, there is judged to be sufficient energy for this site to revert to the

high quality present in the rest of the stream. Therefore, the existing EWH aquatic life use designation was recommended to be retained.

Proctor Run (02-214) (RM 3.69) (EWH)
Three sites were evaluated in Proctor Run yielding QHEI scores ranging from 65 to 73. Positive warmwater habitat attributes predominated at all three sites. No high influence modified habitat attributes were found although moderate amounts of silt and embeddedness somewhat lowered habitat quality.

Although slight differences were noted between the years at the one site that had been previously sampled, overall habitat quality was judged very similar and of very good quality. No negative trends in habitat quality were apparent in this small subwatershed.

Barron Creek (02-212) (RM 24.4) (EWH)
Habitat at the site sampled has been impacted by channelization yielding low to no sinuosity, fair to poor development, silt substrates in spots, slower currents and moderate overall and riffle embeddedness. The QHEI was 44.5, in the poor range. The presence of a spring in the sampling zone prevented worse instream biological performance.

Wamp Ditch (02-363) (RM 23.0)
Habitat quality was poor (QHEI=44.5) with four high influence modified habitat attributes including recent or no recovery from channelization, no sinuosity, sparse cover and little residual pool volume. A number of moderate influence modified habitat attributes further limit habitat quality including fair to poor development and moderate overall embeddedness.

Spring Fork (02-211) (RM 17.46) (EWH)
Habitat quality in Spring Fork has been undergoing changes that document the ability of the stream to recover from impacts if the riparian area is allowed to revegetate. Unfortunately, the impacts of negative shifts in landuse have also been documented. On balance, habitat quality in Spring Fork was in the good range and the support of EWH communities strongly suggested the influence of ground water inflow.

Bales Ditch (02-362) (RM 3.64)
Habitat quality was judged very good (QHEI=70). A moderately wide to wide riparian buffer coupled with an undisturbed stream channel, moderately high gradient and glacial till yielded a diverse and moderately stable stream channel. The habitat was judged to be easily capable of supporting a WWH aquatic biological community.

Hellbranch Run and Tributaries

Hamilton Ditch (02-259) (RM 11.9)
When this small subwatershed was first evaluated in 1992/1993 it was primarily agricultural in nature. Large portions of the stream course had been channelized, and upstream and adjacent land uses yielded a preponderance of high and moderate influence modified habitat attributes. Thick and unconsolidated layers of sand in backwater areas revealed a recent and ongoing

problem with erosion contributing significant amounts of sediment to the stream. Habitat quality did improve downstream due to increased gradient and a more intact riparian buffer. Unfortunately, in the intervening decade, habitat quality has dramatically worsened in the headwaters. Inadequate measures to control erosion from construction sites appear to be the cause of the habitat declines and a significant proportion of the biological community impacts were documented here.

Clover Groff Ditch (02-245) (RM 11.19)
Similar to Hamilton Ditch, in 1992/1993 the upper portion of this subwatershed had been significantly modified with the three sites upstream from Feder Road averaging a QHEI of only 32.7. Low gradient coupled with extensive channelization and the contribution of agricultural and construction derived sediment had resulted in the poor conditions. Habitat quality in the lower reaches of Clover Groff Ditch were improved from upstream but observations made during sampling suggest that habitat quality in this tributary was declining. Although the extensiveness of siltation was estimated to be less than in Hamilton Ditch, sand entering the stream from upstream and adjacent land uses were starting to cause embeddedness and loss of channel volume. Additionally, developers and new residents of the watershed were removing the riparian buffer which resulted in increased stream bank erosion.

Further declines have been noted during the recent sampling. Differences between the years include the loss of pool depth, the shift in assessment that the channel was recovering from channelization to no recovery, maximum depth less than 40 centimeters, no fast currents and extensive embeddedness. Clearly, inadequate erosion control and storm water BMPs in the upper reaches of Clover Groff Ditch have resulted in the deposition of large amounts of silts in the stream channel filling in the pools and smothering the coarse streambed materials.

Hellbranch Run (02-204) (RM 26.1)
Hellbranch Run in general followed the same pattern seen in its source tributaries with increased quality with downstream distance. Unfortunately Hellbranch Run also followed another pattern seen in its source tributaries, one of decline over time, which currently is primarily limited to its upper reaches. Habitat quality in the lower reaches of Hellbranch Run are of excellent quality particularly downstream from RM 5.0 where there is a change in surficial geology and a relatively intact riparian buffer. This segment, in reflection of the high quality habitat, supports EWH aquatic communities and is being recommended to be re-designated EWH.

Lower Big Darby Creek Tributaries

Smith Ditch (02-353) (RM 31.69)
Habitat quality was very good to excellent in this small direct tributary to Big Darby Creek as a result of its coarse substrates, highly sinuous course, wooded canopy and well developed channel features.

Gay Run (02-298) (RM 26.48)
Gay Run has habitat adequate to support WWH biological communities. The presence of perennial pools, ground water flow contribution in its upper reaches and the proximity to the

high quality repopulation resource of the mainstem Big Darby Creek are more than adequate to supersede the occasional intermittency found at the mouth. The WWH aquatic life use designation is recommended.

Springwater Run (02-203) (RM 24.0)
This small tributary flows through the center of Harrisburg. Recovery from past channelization was observed. The QHEI for the stream segment downstream from Main Street was 50, in the fair range. Although coarse substrates in the form of boulders, cobble and gravel were present, the moderate amount of sand also present contributed to the moderate overall and riffle embeddedness noted for this site. While not possessing optimal habitat for supporting aquatic life, this site did possess an adequate number of WWH attributes which, when associated with the ameliorative effects of the ground water augmenting the stream base flow, permitted the maintenance of a WWH aquatic community in this stream.

Unnamed tributary to Big Darby Creek (02-366) (RM 18.41)
Although this small stream is being recommended to be designated WWH based on the current instream biological performance, this stream has the potential to support an EWH community when water quality conditions at the Clark's Lakes Subdivision are rectified. The only WWH attribute missing from this stream was silt free substrates, which also contributed to some of the negative attributes noted. Ground water was also a strong influence on the biological composition of this stream. One fish species, the central mottled sculpin, an obligate cool water species, comprised a large percentage of the resident fauna.

Greenbrier Creek (02-2020) (RM 16.75)
QHEI scores ranged from 57.0 at Scioto-Darby Road to 74.5 at Harrisburg - Darbyville Road. The segment average QHEI was 65.75 well within the range judged suitable for supporting WWH communities.

Georges Creek (02-201) (RM 14.4)
Despite the high gradient found in Georges Creek, which was higher than optimal, other habitat attributes were positive. These included no channelization, coarse substrates including boulder, cobble and gravel, moderate sinuosity, moderate cover amounts, slightly greater than normal embeddedness, and deep pools. This yielded a QHEI of 61.0 with the stream judged capable of supporting WWH aquatic communities which was verified by the concurrent biological sampling conducted.

Lizard Run (02-273) (RM 12.93)
Multiple trips to sample Lizard Run revealed it to be a truly ephemeral stream primarily as a function of the glacial geology that underlies the stream channel and yields a losing stream with little or no flow except after rain events or snow melt periods. As a consequence of the natural ephemeral nature of this stream and the limitations imposed by this stressor, this stream is recommended to be designated as a Limited Resource Water.

A.4.7 Biological Assessment: Macroinvertebrate Community

(See Section B.7 for detailed discussion. Mussel richness maps are available in Appendix C.3.)

In this section, the condition of macroinvertebrates in the Big Darby Creek watershed is summarized, followed by a discussion of trends and drainage area relationships. A discussion of trends in mussel communities is also included.

A.4.7.1 Watershed Assessment

Big Darby Creek Mainstem

The aquatic macroinvertebrate community was of very good to exceptional quality in the headwaters of Big Darby Creek (from RM 83.2 downstream to the confluence of Flat Branch with Big Darby Creek at RM 78.48). This reach, at and downstream from RM 83.2, was also recommended to be classified as Coldwater Habitat (CWH) based on the cool water fauna collected.

A significant decline in community quality occurred downstream from the confluence of Flat Branch. The community abundance doubled with a large increase of less sensitive organisms due to elevated nutrients, excess suspended algae present, and total suspended solids. Excess TSS, nutrient, and metals inputs from the Flat Branch WWTP and an elevated copper concentration from Flat Branch also contributed to decreased quality. Low instream D.O. from Flat Branch and some added negative inputs from Flat Branch WWTP caused WQS criteria violations of the EWH minimum and mean D.O. criteria. Recovery occurred and persisted to Milford Center despite continued high TSS and nutrient inputs.

Non-attainment of the EWH biocriterion occurred downstream from Milford Center. Recent agricultural (2000 fish and mussel kill) and periodic fertilizer spills and kills, and past sewage and storm water inputs from Milford Center impaired the macroinvertebrate community. Silted and embedded substrates also limited natural habitat colonization for some sensitive organisms. Macroinvertebrate community abundance increased 4- or 5-fold compared to upstream Milford Center and was composed of more tolerant or nutrient-loving organisms in response to increased diffuse nutrient inputs and the spills.

The community recovered for only a short reach to exceptional levels upstream from Streng Road. Decreased mussel diversity and marginally exceptional community quality persisted downstream from Buck Run to near U.S. Route 42. Decreased community performance in this reach was the result of past and continuing spills and kills, silty conditions, elevated TSS and other effects associated with nonpoint sources (NPS) (i.e., nutrient enrichment, lower dissolved oxygen concentrations, and elevated sediment metals, P, and NH_3). Buck Run NPS inputs in this reach contributed excess nitrogen, sedimentation, ammonia, and some lower D.O. concentrations. Land application of manure appears to be increasing, although information on land application rates have not been made available. Spills are also increasing in frequency particularly into tributaries near Milford Center and in the surrounding upper Darby watershed.

A significant decline in macroinvertebrate quality occurred downstream from the Plain City WWTP amid inputs of excess organic solids, high fecal coliform bacteria exceedences, excessive nutrients and low diel D.O. concentration violations.

Recovery to exceptional conditions occurred upstream of Amity Rd., but spills and/or possible kills and occasional episodes of low dissolved oxygen have been documented from Plain City and the lower reaches of Sugar Run. These negative inputs could continue to potentially impact Big Darby Creek through this reach until NPS inputs are reduced and spills eliminated.

Exceptional macroinvertebrate community performance continued downstream from Interstate 70 to upstream U.S. Route 40.   Mussel diversity was still low here compared to Amity Road, and compared to past historical collections, due to chronic raw sewage from a former campground, past poor WWTP performance, spills and kills, and sedimentation. Other possible sources are quarry discharges upstream and rare seasonal hypolimnetic waters released from an impoundment. Near U.S. Route 40 the mussel diversity is showing some recent improvements due to mitigation of some of these past sources.

Exceptional habitat quality within the Franklin County Metropark property supported Exceptional Warmwater Habitat biological performance from the upstream park boundary to the Little Darby Creek confluence and on to Darbydale. Nutrient enrichment occurred about one mile downstream from Darbydale, an unsewered community, as evidenced by a mean phosphorus concentration of just under 6 mg/l. This resulted in limited mussel diversity in this location compared to upstream. The regional wastewater plant to be constructed will improve the water quality in this reach and downstream.

Exceptional habitat downstream from Hellbranch Run ameliorated some of the effects of Hellbranch Run inputs. An exceptional macroinvertebrate community was present, but the number of sensitive and EPT taxa decreased compared to nearby sampling sites. Accumulated sediment from Hellbranch Run was observed embedding some riffle/run segments and in depositional zones downstream from the confluence. Poor quality WWTP inputs from lower Hellbranch Run will be diverted soon to a regional waste treatment facility which will improve water quality inputs to Big Darby Creek. Increased silt, though, was present near State Route 762, but the broken bedrock slab helped protect against smothering by silt of some smaller substrates and microhabitats for the 100+ different taxa collected here. However, sediment from Hellbranch Run or from erosional effects of Hellbranch Run storm water need controlled to maintain stable habitat in downstream Big Darby Creek reaches.

Downstream from the PCI WWTP, macroinvertebrate communities still met the EWH biocriterion. Several unsewered areas and small package WWTPs are scheduled to tie into the PCI WWTP between 2003 and 2005. These will include the Derby area, the Clark’s Lake WWTP, and several local mobile home parks. These actions will eliminate many localized problem areas in the lower watershed and should result in higher water quality downstream. Maintaining a high quality effluent from the PCI WWTP will be critical to protecting endangered and sensitive biological communities.

Exceptional biological performance was evident at Scioto Darby Road. Extensive instream habitat sheltered the 113 taxa collected - including 20 mussel taxa (highest totals of any site in the Darby watershed survey). The federally endangered species once found infrequently in this reach, the northern riffleshell mussel *(Epioblasma torolusa rangiana*), was not observed here during this survey. Downstream from the Scioto Darby bridge the night D.O. concentrations dropped to about 5.5 to 5.6 mg/l for extended periods on 10-11 July 2002. The mean daily D.O. concentrations stayed just above the minimum WQS of 6.0 mg/l at 6.03 and 6.01 mg/l during this continuous monitoring in July 2002. Decreased inputs of nutrients from eliminated unsewered areas, reduced agricultural NPS contributions and reduced organic enrichment from WWTPs diverted to the PCI WWTP should result in locally improved instream conditions in this reach upstream and downstream from Scioto Darby Road. Storm water effects from development in the watershed further upstream is still an issue of concern and is being addressed in local development plans. Current NPDES actions parallel some recovery plans and will improve water resource quality in this ecologically sensitive reach (USFWS 1994, 2002)

Macroinvertebrate communities continued to meet exceptional quality in the lower reach of Big Darby Creek. However, agricultural NPS inputs in this segment yielded nutrient enriched conditions. Through these lower reaches the riparian width varied with property owner. Nutrient inputs occurred directly from agricultural fields or through delivery via small tributaries to Big Darby Creek. Increasing riparian widths along small agricultural tributaries draining floodplain agricultural fields would partially decrease nutrient inputs in the lower Darby watershed.

In some reaches levees impinged on the stream channel creating open canopy conditions. Similarly, areas that contained insufficient and limited wooded riparian width, canopy, or natural floodplain width have had storm water events that have eroded through the narrow riparian banks or levees. Now unnatural riprapped banks with open canopy conditions exist and allow more algal production to occur with commensurate wider D.O. fluctuations including chronically low night D.O. concentrations. The highest community densities were at sample locations near some of these reaches of unstable bank habitat and largely open canopy (i.e., Gulick Road and near Georges Creek). Dissolved oxygen in deeper pools may be at risk in these lower reaches of Big Darby Creek.

Unstable and migrating bottom substrates from erosion and storm water activity also have destabilized instream habitat, which parallels decreased mussel diversity and numbers in these same reaches. Within segments where wider adjacent and upstream riparian widths and wooded banks are still present, stable instream habitat (i.e., stable riffles, bars, woody debris and side pools) allowed increased macroinvertebrate and mussel diversity. Increasing riparian widths, including woody riparian replacement/additions on the immediate stream banks and allowing more movement of the river in the floodplain where needed, will stabilize banks and reduce erosional effects of storm water runoff. Sedimentation and/or erosion during high flows is a concern in the lower reaches of Big Darby Creek where riparian areas were too narrow or of inadequate density. Unstable habitat will continue to limit mussel populations in the lower portion of the Big Darby Creek mainstem. Controlling upstream storm water runoff will assist in stabilizing the lower reaches of Big Darby Creek. According to the U.S. Fish and Wildlife

Service (USFWS 1994), current and future state agency projects to improve, stabilize and enhance streamside habitat and riparian corridors will be beneficial and more protective to this biologically diverse and sensitive portion of Big Darby Creek.

Big Darby Creek Upper Tributaries - Flat Branch to Sweeney Run

Flat Branch (02-223) (RM 78.48)
Flat Branch was a channelized stream that met its aquatic life use despite excess nutrients, bacteria, and sediment/suspended solids present. Non-point source pollution from upstream agricultural fields contributed sedimentation, nutrient runoff and excess algal production. White-green color suspended solids from drainages in the vicinity of Honda were evident in the water column in the middle reaches. One sampled small tributary (at Flat Branch RM 1.5) full of fine clays, silt, bacteria and nutrients was a large contributor of inputs to Flat Branch and to Big Darby Creek. An acutely toxic copper concentration was documented in Flat Branch at RM 2.2.

Habitat near Big Darby Creek at the downstream site improved with the riparian corridor widening to 40-50 feet of mature trees. The ICI indicated exceptional quality despite the modified instream channel characteristics. Nutrient concentrations and bacteria counts were still elevated at the mouth of Flat Branch and consequently increased loadings to Big Darby Creek. Low dissolved oxygen measurements in Big Darby Creek downstream from the confluence with Flat Branch were mostly the result of Flat Branch inputs of low D.O. resulting from excess nutrients, algae and TSS inputs.

Little Darby Creek (02-251) (RM 78.34)
Little Darby Creek in Logan County was a high quality exceptional and coldwater stream. Both sites sampled have been used as ecoregional reference sites as a result of their relatively undisturbed condition and high water resource quality. Even in this small subbasin, some agricultural NPS nutrients and E. coli concentrations were elevated. While these elevated nutrient concentrations may have increased loadings to the mainstem of Big Darby Creek the relatively higher instream dissolved oxygen concentrations and lower water temperatures in Little Darby Creek probably improved water quality in Big Darby Creek when compared to inputs from Flat Branch. Some channelization occurred after sampling in 2002 which will adversely impact water resource quality in the future.

Unnamed Tributary to Big Darby Creek (02-361) (RM 74.91)
This tributary supported a very good macroinvertebrate community and was designated EWH despite some unstable habitat including eroding and collapsed banks where the riparian corridor was too narrow and destabilized during high flow. Siltation and partial embeddedness in the riffles and runs had occurred with deposition in pools present. Excessive silt, bacteria, and nutrient inputs could be reduced to this tributary and to Big Darby Creek if the riparian corridor was widened and tile delivery slowed or decreased.

Spain Creek (02-222) (RM 72.01)
Spain Creek marginally met the WWH biocriterion in upper Spain Creek despite unrestricted cattle access, past channelization, and the associated nutrient and sediment inputs. Increased

riparian corridor widths and decreased cattle access would alleviate these inputs. Cool ground water recharge ameliorated habitat deficiencies, and cool water taxa were present, confirming the CWH designation. With improving habitat downstream, the proposed EWH biocriterion was marginally met with a relatively large number of cool water taxa collected. High TSS, local construction inputs, ammonia, and elevated E. coli counts indicated sporadic stress to the macroinvertebrate community.

Macroinvertebrate quality near the mouth of Spain Creek, downstream from the North Lewisburg WWTP, greatly exceeded the EWH biocriterion. There was a more balanced macroinvertebrate community with many sensitive organisms present. Some nutrient concentrations increased downstream from the WWTP. Shading from the tree canopy deferred negative effects from excess nutrient enrichment. The overall water quality inputs from Spain Creek positively influenced Big Darby Creek water quality downstream from the Spain Creek confluence near Collins Road.

Pleasant Run (02-221) (RM 72.01)
Pleasant Run met the EWH biocriterion upstream at Dunn Road despite previous channelization, narrowed riparian corridor, elevated bacterial concentrations, and nutrient enrichment from agricultural sources. Pleasant Run benefits from the cool ground water, as discussed elsewhere.

Near the mouth and upstream from Middleburg-Plain City Rd., the macroinvertebrate sample at this ecoregion reference site indicated exceptional water resource quality Wide riparian areas (from 30 feet to greater than 100 feet) of larger trees were shading most of the stream channel; consequently, most NPS nutrient concentrations were low, and bacteria counts had decreased slightly from upstream values. Pleasant Run significantly contributed to the exceptional conditions found downstream from its confluence to Big Darby Creek.

Unnamed Tributary to Big Darby Creek (02-360) (RM 69.4)
This tributary met the recommended WWH biocriterion. Its macroinvertebrate community, however, lacked diversity and had a much higher percentage of tolerant organisms due to silt, TSS, and nutrient enriched conditions.

Hay Run (02-220) (RM 67.6)
Hay Run near its mouth exhibited a very good macroinvertebrate community and marginally met the EWH biocriterion. This groundwater-fed stream contained rocky substrates with decent base flows. Hay Run inputs into Big Darby Creek contributed to the enrichment found upstream from Milford Center. Wider riparian corridor would result in decreased NPS nutrient inputs (more filtered runoff) that would improve community quality here and downstream in Big Darby Creek.

Buck Run (02-220) (RM 63.74)
Buck Run was sampled at four locations and only marginally met the WWH biocriterion. Elevated silt and nutrient inputs led to excessive nutrient enrichment and low night D.O. concentrations. Riparian restoration and bank stabilization would increase habitat quality by

reducing erosion, siltation, nutrient inputs, and algal production, and would allow for improved stream riffle/run/pool development. Decreased loadings to Big Darby Creek are needed, as the ICI in Big Darby Creek decreased significantly and only marginally met the EWH biocriterion downstream from the confluence. Overall, riparian habitat improvements, livestock setbacks and exclusion, and widening of the corridor surrounding Buck Run would improve the biological community and decrease silt, nutrient, bacterial and TSS inputs downstream into Big Darby Creek.

Robinson Run (02-207) (RM 53.69)
Robinson Run did not meet the WWH biocriterion in the upper and middle watershed. At its headwaters, the stream was channelized with a mostly open canopy containing decayed, blackish anaerobic scum on the substrates from excess algal production due to nutrient enriched conditions. Low dissolved oxygen conditions had undoubtedly limited macroinvertebrate community quality. Establishing a riparian buffer would be a good first step to improving water resource quality of Robinson Run in this segment.

Fair communities existed in the mid reaches. Agricultural NPS runoff as well as the small WWTP discharge upstream were the primary stressors. Increased shading though a wider wooded riparian would yield a higher quality macroinvertebrate community.

The downstream site on Robinson Run at U.S. Route 42, while still nutrient enriched, marginally met the WWH biocriterion. Habitat quality had also improved within a largely intact wooded riparian corridor. Decreasing the NPS inputs upstream would stabilize and improve macroinvertebrate community quality. Decreased nutrient and sediment loadings into the pooled reach of Big Darby Creek upstream from Plain City would benefit from improved quality in Robinson Run. Biological scores had decreased slightly in this segment of Big Darby Creek. A closed landfill adjacent to Ranco Inc is still being monitored.

Sweeney Run (02-357) (RM 52.11)
Sweeney Run was affected by agricultural runoff, storm water runoff and storm water inputs from Plain City (i.e., nitrates, nitrites, E. coli and TSS) and supported a fair macroinvertebrate community. Sanitary sewer work in 1997 and 1998 decreased some sewage and storm water inputs into Sweeney Run. Additional chemical and biological samples in Sweeney Run are warranted to determine water quality upstream from Plain City and help locate municipal NPS storm water runoff sources that affect stream quality.

Big Darby Creek Middle Tributaries - Sugar Run to upstream Little Darby Creek

Sugar Run (02-206) (RM50.92)
The channelized upper reaches of Sugar Run were recommended for redesignation as MWH. The fair macroinvertebrate community documented upstream met the MWH biocriterion despite enriched conditions, low D.O. levels due to agricultural and golf course runoff. Marginally good conditions were found in the unnamed tributary to Sugar Run (RM 7.39) despite low flows in a modified channel and algal mats from excess nutrient enrichment.

Water quality conditions, habitat, and macroinvertebrate community quality in Sugar Run improved longitudinally downstream and attained the WWH biocriterion from Taylor Road to the mouth. Siltation, TSS, elevated nutrients with occasional low D.O. levels still occasionally affect stream quality. Spills also were recorded with some regularity in Sugar Run. Stabilizing stream banks, increasing wooded riparian widths and fencing out cattle would readily improve stream water quality and reduce loading inputs to Big Darby Creek. Any decrease in nutrients and sediment discharged from Sugar Run associated with habitat improvements in the upper watershed would improve Big Darby Creek water quality and protect vital biological communities downstream from Plain City where WWTP loads are already being assimilated.

Worthington Ditch, Ballenger-Jones Ditch, Yutzy Ditch, and Fitzgerald Ditch are all tributaries originating in ground moraine from the west bank of Big Darby Creek that have had some modifications upstream. All were sampled near their mouth, and all met the WWH biocriterion. Groundwater ameliorated the impacts associated with inferior habitat upstream. A longer reach of much better natural habitat was available in Ballenger-Jones Ditch, and an exceptional quality macroinvertebrate community was documented. Allowing more trees upstream in the grassy area and increasing the extent of the stream canopy would further benefit Ballenger-Jones Ditch. The lower reach of Yutzy Ditch was natural and free flowing upstream from State Route 142 and supported marginally good macroinvertebrate communities. Fitzgerald Ditch receives effluent from the Canaan Community MHP WWTP upstream from the sampling site near State Route 142. Nutrient enrichment was evident, but the community overall was determined to be good. Nutrient reduction in all these streams would benefit stream quality and reduce NPS inputs to Big Darby Creek, particularly nitrates, ammonia, and total P (and sometimes fecal bacteria). Additional sampling should be conducted further upstream prior to recommending an aquatic life use for the upper portions of these streams. Improving habitat upstream in these tributaries will improve community quality, and more importantly, reduce NPS inputs into Big Darby Creek through this mainstem reach where biological diversity could be improved and protected.

<u>Little Darby Creek</u> (02-210) (RM34.2)
Sixteen sites were sampled for macroinvertebrates in the Little Darby Creek mainstem. All sites met the established and recommended EWH biocriterion scores and CWH at upper sites. There were differences in exceptional quality through different reaches of Little Darby Creek. There was a range of fifteen to 27 EPT taxa, 28 to 46 sensitive taxa, and zero to twelve mussels collected per sampled site. Different highlights, variables, and challenges to stream community quality are discussed below.

The macroinvertebrate community density immediately downstream from Mechanicsburg indicated excess nutrient enrichment (approximately 4000 individuals/square foot) with the likely sources including livestock manure and fertilizers. Some slumped, spongy and caved-in banks in the open pasture area along with consistently elevated E. coli counts, decreased diversity and community quality. Increased bank stabilization, cattle exclusion and more dense stream bank riparian and canopy cover upstream on the Little Darby Creek mainstem and tributaries (i.e., Clover Run, Treacle Creek, Howard Run, and Proctor Run) would decrease the erosional sedimentation/siltation and nutrient inputs from various sources. Improvement to the Mechanicsburg WWTP and the elimination of raw wastewater bypasses and other inputs (e.g., eliminate chronic dairy waste spill in area, sediment/nutrients from Lake Run RM 36.90) with increased riparian corridor width and density will further improve water quality conditions downstream from Mechanicsburg.

Sensitive taxa, and mussels in general, had higher diversity where wider, mature, and more stable riparian areas were adjacent to Little Darby Creek, and where there weren't point source inputs or tributary NPS inputs that elevated silt and nutrient concentrations. Wider riparian corridors adjacent to Little Darby Creek and its tributaries would limit sediment and nutrient inputs into the system and be more protective of sensitive organisms.

Downstream from Rosedale - Milford Center Road (Bates Road in Union County), no riparian buffer was present due to open pastures. Banks were broken down and devoid of vegetation. Sedimentation, resulting from the free access of livestock to the stream channel, had degraded instream quality. Similar livestock agricultural practices were observed adjacent to Treacle Creek near Irwin and near the mouth that yielded denuded, slumped, or false banks and excessive silt or sediment inputs. Violations of the minimum EWH D.O. concentration in Treacle Creek were recorded, and critically low D.O. concentrations were noted at Axe Handle Road. During sampling, black-green solids, perhaps rotting fresh hay or grass, were suspended in the water and floated downstream. These solids contributed to the oxygen demand further lowering instream dissolved oxygen concentrations and contributed to decreased community quality. Related NPS nutrient inputs from livestock and rowcrop cultivation were evident downstream in Little Darby Creek, as nutrients (i.e., TSS, ammonia, nitrate, and nitrite) instream were elevated. Reducing sedimentation, TSS, fecal bacteria, and nutrient inputs in the mainstem upstream and in Treacle Creek will improve water quality in Little Darby Creek through this reach and protect downstream resources.

It is critical that the sediment/silt load contributed to this reach (i.e., downstream from Rosedale - Milford Center Road (Bates Road in Union County) to downstream Chuckery - including Treacle Creek and its tributaries) be reduced significantly in order to protect one of the last strongholds in the Big Darby Creek watershed of the federally endangered clubshell mussel, *Pleurobema clava*, which occurs downstream sporadically from Chuckery to downstream Interstate 70. Since it burrows well below the surface, its habitat requirements include loose well-aerated sand and gravel substrates in riffles and runs free from silt, which allow interstitial flow and oxygen regeneration to deeper substrates (Watters, 1993). Limiting siltation and sedimentation from erosion or runoff from upstream sources is a vital habitat enhancement goal critical to the protection of this unique mussel's habitat (USFWS, 1994). Likely triggered by high pHs from excess enrichment, some rocky bottom substrates in open reaches were covered with precipitated calcium which hardened or embedded the bottom substrates. Increasing canopy cover adjacent to Little Darby Creek would decrease instream temperatures, pHs, and algal production. This would raise baseline D.O. concentrations and preserve loose aerated substrates to protect the more intolerant organisms in the macroinvertebrate community. Allowing woody vegetation to fill in riparian corridor gaps, increasing riparian width, and stabilizing unprotected banks would improve water quality through the middle reaches of Little Darby Creek.

The macroinvertebrate community was exceptional in Little Darby Creek from the confluence with Spring Fork to downstream from U.S. Route 40. Habitat protection, a limit to municipal inputs and storm water controls upstream and adjacent to West Jefferson are needed to protect this reach of Little Darby Creek upstream from the West Jefferson WWTP.

Downstream from the West Jefferson WWTP near Roberts Road an exceptional macroinvertebrate community was still present in Little Darby Creek, but the community was showing evidence of nutrient enrichment. Community quality had decreased significantly from upstream due to periodic solids and overflow problems from the wastewater treatment plant. Plant and infrastructure improvements are needed to improve WWTP quality, decrease nutrient inputs, and protect biological integrity and diversity below West Jefferson WWTP and further downstream into the park property and Big Darby Creek.

Barron Creek (02-212) (RM 24.20)
Barron Creek community quality was challenged by a lack of canopy cover upstream where banks were mowed. Cold ground water countered the effects of decaying mats of algae that had accumulated on the bottom substrates and which resulted from nutrient enrichment. In open canopy areas, communities were found in rocky margin substrates and avoided the bottom substrates.

The area under the bridge was the main source of shading in this segment. This small reach was the area of greatest macroinvertebrate diversity. All bottom substrates were clean with ample dissolved oxygen concentrations present.

Barron Creek needs streamside habitat improvements to decrease inputs associated with nonpoint sources (fecal bacteria at >60000-80000 counts/100 ml, TSS = 48 mg/l, and elevated NH_3, nitrites, TKN, and P).

Spring Fork (02-211) (RM 17.4)
Inputs from Spring Fork were likely affecting Little Darby Creek quality. Spring Fork did not meet the EWH macroinvertebrate biocriterion in the upper and middle reaches. Excess nutrients from upstream included livestock inputs and other agricultural NPS inputs. Limited habitat, nutrient inputs and open pastures were the main issues documented which led to partial attainment of EWH macroinvertebrate biocriterion. Discharges from the Greentree MHP WWTP which had water quality violations for TSS, fecal coliform, CBOD and dissolved oxygen. Private landowners did not grant access to lower Spring Fork, so conditions there and immediately downstream from the confluence in Little Darby Creek could not be fully assessed. The ability to sample and monitor lower Spring Fork is necessary to accurately assess the impact of the Green Meadows MHP WWTP on biological communities in Spring Fork and Little Darby Creek. Better knowledge of water resource quality will better protect endangered or very sensitive organisms that have low populations in Little Darby Creek. Conditions that favor protection of these organisms include a good riparian stream corridor with high quality water and aerated, non-silty, unembedded sandy substrates. Therefore, point source and NPS inputs from Spring Fork need to be minimized by the re-establishment of a consistent wooded riparian corridor in this lower section of stream.

Bales Ditch (02362) (RM 3.64)
Bales Ditch met the WWH macroinvertebrate biocriterion as sufficient groundwater flow ameliorated excess nutrient inputs, moderate sedimentation and habitat modifications. Some cool water taxa were present indicating higher quality potential in Bales Ditch. Agricultural inputs to Bales Ditch could be decreased by establishing or increasing its woody riparian widths to capture sediment and nutrients from large adjacent livestock farms upstream.

Hellbranch Run and Tributaries

Hellbranch Run (02-204) (RM 26.1)
Hellbranch Run, formed by the confluence of Hamilton Ditch and Clover Groff Ditch, was sampled at six sites, and macroinvertebrate community scores ranged from good to exceptional (high score of 50). The upper reach downstream to RM 4.0 attained the WWH biocriterion, but siltation and storm water runoff from upstream sources were affecting substrates with areas of less stable riparian habitat more greatly affected. A decrease in NPS silt inputs via storm water and/or eroding unprotected banks and wider riparian corridors with more riparian shading would promote greater diversity and quality in this upper half of Hellbranch Run.

Hellbranch Run macroinvertebrate community quality decreased to good downstream from the Oakhurst Knolls WWTP and adjacent to the golf course. The number of sensitive organisms significantly decreased compared to the previous upstream sample site. This was the only macroinvertebrate site that did not at least marginally achieve the EWH biocriterion. Only TKN, TP, and E. coli bacteria concentrations were consistently elevated. Periodic inflow and infiltration issues need addressed and resolved at the Oakhurst WWTP to prevent possible bypasses/spills of partially treated or untreated waste. Nutrient runoff from the golf facility could also be affecting the macroinvertebrate community downstream. Careful application of nutrients or herbicides/pesticides on golf courses can minimize runoff impacts on receiving streams.

Better habitat and exceptional or very good biological performance allowed the lower reach of Hellbranch Run to be designated EWH use. Continued efforts to decrease sediment and nutrient inputs should permit even greater water quality and biological diversification. The Timberlake WWTP (RM 0.5) has historically experienced operational problems. Highly elevated NH_3, TP, and TKN concentrations were recorded downstream along with violations of the minimum low D.O. criterion. A very good macroinvertebrate community was observed but it was lower in EPT taxa and overall diversity compared to upstream. The substrates were highly embedded from accumulated silt. With the Timberbrook Subdivision WWTP tying into a regional WWTP by 2005, improvement to a solidly exceptional macroinvertebrate community downstream would likely occur soon after tie-in had occurred. Sediment accumulation along with nutrient inputs would still be the biggest detriment to biological quality in the lower Hellbranch Run.

Clover Groff Ditch (02-2245) (RM 11.19)
Clover Groff, the eastern tributary forming Hellbranch Run that is contiguous with Hilliard and metropolitan Columbus, was sampled at two locations. The MWH biocriterion was not met at the most upstream site where with very poor macroinvertebrate community performance was

documented. Accumulated sediment neutralized most habitat, and gray septic storm water inputs with high elevated fecal bacteria, NH_3, nitrite, and TP from the adjacent suburban area collectively caused enriched conditions that were likely periodically toxic. Leeches, tolerant of periodic low dissolved oxygen, were common in all habitats and was one of the predominant pool organisms. Practices to hold, slow down and/or treat municipal storm water runoff would improve the quality of Clover Groff Ditch. Decreased upstream sedimentation would allow flushing, improve D.O. concentrations, and allow the macroinvertebrate community to access the rocky or firm substrates present in the bottom substrates but currently buried or covered.

Clover Groff Ditch, at the downstream sampling location, supported a fair macroinvertebrate community that did not meet WWH expectations. Embedded natural substrates and nutrient enrichment limited the population diversity and size. Other possible adverse inputs affecting this downstream macroinvertebrate community were a school discharging at RM 1.30, failing on-site septic systems discharges, and NPS nutrient inputs. Some elevated E. coli concentrations indicated the presence of some organic waste inputs. With orders for the private school discharge to be connected to the city of Columbus sanitary sewer and upstream construction slowing, any riparian corridor widening and reductions in sedimentation would allow improvements in water quality and in the macroinvertebrate community.

Hamilton Ditch (02-259) (RM 11.19)
Hamilton Ditch, the more western tributary forming Hellbranch Run, was sampled upstream from Walker Road at RM 3.4. Upstream influences were agriculture and storm water and sediment runoff from subdivisions. Total suspended solids concentrations of 140 mg/l and 96 mg/l were among the highest values recorded during the survey, along with highly elevated ammonia, TKN, and TP. The fair macroinvertebrate performance met the MWH biocriterion, but by decreasing the NPS sediment, organic, and chemical inputs and allowing some natural stream development, Hamilton Ditch water resource quality could greatly improve.

The lower site met the WWH macroinvertebrate biocriterion despite a low gradient, pool and slow run habitat (lack of riffles) with silt and clay substrates prevalent. This silt sink will continue to transport sediment downstream during high flows unless floodplain deposition can occur. A wetland flood depositional complex just upstream from U.S. Route 40 on Hamilton Ditch is being considered. Quality will continue to improve with decreased negative NPS inputs from upstream.

Lower Big Darby Creek Tributaries (downstream from Little Darby Creek to the mouth)
Most of these lower tributaries need increased riparian corridor widths to decrease NPS nutrient and sediment inputs. Even Smith Ditch (RM 31.69), which lies partially in parkland and achieved its recommended EWH biocriterion, still had issues with embedded substrates and elevated instream bacteria and phosphorus concentrations. Several streams will have decreased WWTP and urban storm water NPS inputs due to WWTPs or sewer systems being diverted to regional wastewater facilities (i.e., unnamed tributary to Big Darby Creek at RM 20.2), Greenbrier Creek (RM 16.75), and Springwater Run (RM 24.0). These should improve in quality over time. Several (e.g., unnamed tributary to Big Darby Creek at RM 18.41, Georges Creek (RM 16.75), and Lizard Run) have had modifications which have limited habitat or habitat

is recovering. Most lower Big Darby Creek tributary macroinvertebrate communities achieved the WWH expectations despite some negative factors. Springwater Run, due to influences from Harrisburg (nutrient enrichment /low D.O.), and the modified and silted unnamed tributary to Big Darby Creek at RM 18.41 did not meet the WWH biocriterion. Occasional spills in the Derby area could be a threat to Greenbrier Creek community quality.

A.4.7.2 Changes in Biological Community Performance: Macroinvertebrate Communities

Big Darby Creek Mainstem: 1977 to 2001-02

The 1979 survey data revealed poorer instream macroinvertebrate community performance in some segments particularly in the upper portion which were associated with point sources or unsewered communities. One segment with lowered community performance extended from downstream of the then unsewered Village of Milford Center (~RM 66) to Ranco, Inc. near Plain City (~RM 53). The other area of fair macroinvertebrate community performance was also associated with dischargers. This segment extended from approximately U.S. Route 40 (RM 40.6) downstream to RM 36. Dischargers immediately upstream from this impaired segment included Olen Corporation, Camp Wissalohican (an unsewered community at the time), Battelle Memorial Institute, Camp Ken-Jockety, and Lake Darby Estates WWTP and the Greentree MHP WWTP.

All sites downstream from the Little Darby Creek confluence to the lowest sampling site in the Big Darby Creek mainstem either met or marginally met the EWH biocriterion in 1979.

Growth and development in the upper watershed, particularly in the area around the Honda complex, Flat Branch and North Lewisburg, resulted in decreased community quality in 1986 and 1988. Some issues that affected the macroinvertebrate community in the late 1980s were also evident downstream from Buck Run, near Ranco, U.S. Route 42, and Robinson Run. The Plain City WWTP and nonpoint source issues from Buck Run still impacted macroinvertebrate community quality during the 2001-2002 water quality survey.

Macroinvertebrate sampling results from 1990-1993 revealed that WWTP upgrades and subsequent improved wastewater treatment had fueled improvements in macroinvertebrate community performance in the upper Big Darby Creek watershed. This included segments upstream from Plain City and from upstream from I-70 to downstream from U.S. Route 40. Results near Harrisburg, Orient, and downstream from the PCI WWTP showed some improvements but also some inconsistencies with storm water inputs and wastewater overflows after rain events that affected the community quality.

The 1997 sampling recorded the effects of the ODOT project that relocated the upper Big Darby Creek mainstem, as scores at RM 82.5 and RM 81.5 were decreased. At RM 82.5 in 2002 the ICI of 46 indicated recovery to exceptional conditions, though the canopy was still immature and more open conditions were still present

Impacts were apparent downstream from the Pickaway Correctional Institute WWTP in 1997 (i.e., ICI was 40). Plant improvements and an expansion to accommodate the connection of poorly performing package WWTPs and unsewered areas have resulted in improvements in stream quality downstream from the discharge with an ICI of 56 recorded in 2001. The eliminations of these WWTPs and local unsewered areas should benefit stream quality downstream from Harrisburg to Scioto Darby Road.

A spill of organic material in 2000 from an agricultural business in Milford Center (~RM 66) killed a large percentage of fish and macroinvertebrates (including mussels) residing in a segment extending five miles downstream. Fair quality conditions were observed at RM 63.8 soon after the spill passed downstream. Follow-up samples collected in late summer indicated significant recovery had occurred. However, the vast majority of the bivalve community had been eliminated. Sensitive benthic organisms were also still severely impacted. Some mussels did survive and were observed through the sampled reach in September 2000. The site downstream from Milford Center still did not attain the EWH biocriterion in 2002.

Major upgrades and improvements have occurred or are ongoing at many WWTPs. Also new or existing regional plants will soon begin accepting wastewater from currently poorly functioning small WWTPs and provide service to the unsewered communities. The elimination of poorly treated or untreated domestic waste, particularly between RM 34 and RM 19, should improve water quality significantly in a very sensitive reach of Big Darby Creek if the regional WWTPs are maintained and operated consistently. Widely adopted storm water controls should also be encouraged to assist in stabilizing downstream habitat which is strongly suspected as a contributing factor towards the decline of bivalve molluscs and other habitat sensitive species.

<u>Flat Branch</u> (02-223) (RM 78.48): 1988 - 2001
Flat Branch water quality had improved toward the mouth in 2001 compared to 1988 and 1997 surveys. More stabilization in the subwatershed (i.e., less construction and NPS inputs) allowed increased diversity in the macroinvertebrate community. There still were increased nutrients and TSS, though, that affected Big Darby Creek water quality in 2001 downstream from the confluence (i.e., low dissolved oxygen concentrations).

<u>Little Darby Creek</u> (02-251) ((RM 78.48): 1988-2001
All of the samples over the years in Little Darby Creek (Logan County) met the EWH biocriterion except for the 1988 sample which was evaluated as good. However, a portion of the stream was channelized after the 2001 sample which likely affected community quality for some distance. Inputs from Little Darby Creek (Logan Co.) helped ameliorate the effects from Flat Branch on Big Darby Creek.

<u>Spain Creek</u> (02-222) ((RM 74.3): 1988 - 2001
Improvements in treatment at the North Lewisburg WWTP has resulted in improvements in the macroinvertebrate communities over time. Sampling sites in the lower reaches reflected the improved conditions and supported the recommended EWH biocriterion for the middle and lower reaches. However, full capacity of the ~0.2 MGD WWTP is projected to be reached by 2010, so the exceptional biological community downstream in Spain Creek and in Big Darby Creek could be threatened by higher pollutant loads.

Pleasant Run (02-221) (RM 72.01): 1998 - 2001
All sites met or marginally met the EWH biocriterion in 1988, 1997 and 2001. The ICI score in 2001 of 56 at RM 0.5 improved from the1988 survey and was similar to the 1997 survey.

Buck Run (02-209) (RM63.74): 1990 and 2001
Buck Run samples in 2001 indicated marginal attainment of the WWH biological standard despite the same issues as previous surveys, including absence of streamside habitat, erosion, nutrient runoff, TSS and sedimentation.

Robinson Run (02-207) (RM53.69): 1992 and 2001
Robinson Run near the mouth had similar diversity between the 1992 and the 2001 sample. A slight improvement at RM 0.8 could be related to sealing a landfill leak near Ranco. Upstream agricultural non-point inputs and a small WWTP input still affected the upstream macroinvertebrate community.

Sugar Run (02-206) (RM50.92): 1990 - 2001
Stream quality has improved, particularly between RM 8.0 and RM 3.0, since 1992 and 1995. Contributing factors include the closing of the Hershberger Landfill upstream and the stabilization of the land surface in the upper watershed. Construction adjacent to Sugar Run and its tributaries and the channel manipulation/straightening through the industrial area has been completed or diminished. Some stream manipulation has continued to occur sporadically in the Sugar Run subbasin, hence similar quality (very good) macroinvertebrate communities were observed at the RM 0.5 site in 1995 and 2001. No improvement has occurred. Open pastures bracketing State Route 161 and associated erosion and sedimentation from broken and destabilized stream banks were still affecting downstream quality. The exceptional score at RM 6.9 in 1990 indicated higher water quality potential from RM 7.0 downstream if the streamside habitat is allowed to stabilize the banks and the channel is not manipulated.

Little Darby Creek (02-210) (RM 34.1): 1979 to 2001-02
There have been some improvements in the macroinvertebrate communities in the vicinity of the Mechanicsburg WWTP resulting from improvements at the WWTP. More improvements in the collection system and waste treatment in Mechanicsburg are mandated for the near future and, with their completion, stream quality should improve further in upper Little Darby Creek.

A widened woody riparian buffer upstream from U.S. Route 42 yielded higher scores than those from the early 1990s. The sag in community quality downstream from West Jefferson WWTP (~RM 4) has decreased over time but has not been eliminated. Ongoing improvements at the West Jefferson WWTP and its municipal collection system, when finished, will improve final effluent quality and should eliminate losses of solids from the WWTP.

The two reaches that showed the largest relative declines in the current sampling were downstream from Rosedale-Milford Center Road to near Axe Handle Road and from downstream of Rosedale-Plain City Road to Bradley Road. These declines were related to habitat and NPS inputs. Inadequate woody riparian width, excess nutrients, periodic lower diel D.O. values and sedimentation contributed to the declines observed.

The collapse and removal of the dam near the mouth of Little Darby Creek has allowed the re-invasion of lower Little Darby Creek by some fish species long cutoff from that portion of the watershed. More mussel species were present in the now free flowing lower reach due to better flow and substrate conditions. The bigeye chub has migrated back into Little Darby Creek. Its presence might benefit the rabbitsfoot mussel population and distribution. It is a possible host. It is utilized by a sympatric species in the Cumberland River system.

Treacle Creek (02-213) (RM 31.3): 1992 - 2001
Upstream portions of Treacle Creek have remained stable over time and met the EWH criterion with similar scores likely related to the stable habitat and cool groundwater inputs. Sedimentation and bacterial inputs are still occurring. Downstream reaches, where sedimentation and nutrients from open pastures in the vicinity were still concerns, did not meet the EWH biological standard in 1992 or in 2001. The 1997 ICI of 42 at RM 0.7 marginally met the EWH biocriterion which confirmed the potential and the appropriateness of the designated use.

Spring Fork (02-211) (RM 17.46): 1992 - 2002
Spring Fork sites were sampled in 1992 and 2001/02. Macroinvertebrate communities did not meet the EWH biocriterion upstream from Wren Road and near Rosedale - Milford Center Road (RM 7.7) in either 1992 or 2001. Both reaches were affected by nutrient runoff and sedimentation from row crop agriculture and/or open pastures. The lower portions of Spring Fork met the EWH biocriterion. The recent status of the lower mile of Spring Fork was not assessed. The lack of access to sample Spring Fork has resulted in the Green Meadows MHP WWTP not being adequately evaluated for its impact on resident aquatic communities and into sensitive areas downstream in the Little Darby Creek below the confluence.

A.4.7.3 Drainage Area Comparisons: Macroinvertebrate Communities

Drainage Area Range: 1.2 - 2.6 mi^2
Sites in this drainage area range were in a blend of EWH and WWH designated segments. The EWH sites met applicable criteria because cool groundwater from the bouldered and hummocky moraine fields into these headwater streams supported exceptional communities and ameliorated slight deficiencies in habitat quality. The one WWH non-attaining site had problems with storm water inputs of nutrients and silt. Impacts from these stressors were exacerbated by the site's open canopy which caused excessive algal production. The other WWH sites had increased sedimentation from reduced riparian width which resulted in NPS runoff and eroding and unstable banks. Disturbed habitat in or around the streambed can naturally recover if left alone.

Drainage Area Range: 3.3-6.7 mi^2
Approximately half of the sites in this drainage area range were categorized as EWH streams. All twelve sites originate in end moraines with hummocky till substrates that contribute cool groundwater which minimizes the effects of bacterial inputs, some sedimentation and NPS agricultural inputs. Habitat quality was generally higher in these EWH streams. The one non-attaining macroinvertebrate site was at Spring Fork (RM 15.8). Excess sedimentation, elevated TSS, and high nitrogen and phosphorus inputs were enough to reduce the community

performance to the good range.   An important observation was that the four EWH streams that had lower nutrient inputs (i.e., near median ECBP concentrations or with a few samples greater) had more, wider, and/or intact contiguous woody riparian corridors than the other sites.

Five sites were in Modified Warmwater Habitat segments. The non-attaining site was affected by residential storm water runoff and excess siltation that contributed to the very poor community performance. The two sites with higher performance had at least some shading and therefore comparatively cooler stream temperatures. Two sites that just met the MWH minimum contended with excess silt and nutrient enriched conditions coupled with algal accumulation.

Eighteen of the thirty-five 4.5 $mi.^2$ sites were designated WWH with four (22%) not meeting the WWH biocriterion. Three of those four did not meet the biocriterion due to residential storm water runoff, spills, and/or accumulated wastewater inputs. The remaining site was affected by excess agricultural inputs, high algal accumulation resulting from an open canopy and nutrients, and periodic low dissolved oxygen conditions. Fifty percent of the sampled WWH sites only marginally met the WWH biocriterion. These sites generally were hampered by lack of riparian corridor upstream and excess sediment and nutrient accumulation from agricultural NPS inputs.

Drainage Area Range: 7.0 - 13.2 mi^2

Half of the sites in this range were EWH sites, most of the remaining were WWH sites with a few MWH sites. All EWH sites originate in end moraines with hummocky till substrates (western portion of Big Darby Creek basin) that contribute cool groundwater which minimized the effects of bacterial inputs, some sedimentation and NPS agricultural inputs. All also met or marginally met the EWH biocriterion. The sites with higher community performance (i.e., in the range of ICIs = 54-56) had wider and more continuous riparian corridors ranging in width from 30 feet to greater than 150 feet at and upstream from the sample sites. This factor kept NPS nutrient inputs to near the median ECBP concentrations or less. The shaded canopy also decreased algal production and allowed for more instream assimilation.   The two sites with lower performance resulted from WWTP inputs and bridge construction just prior to sampling.

Seven of the eight WWH or MWH sites met their respective biocriterion. The site not attaining criteria had elevated nutrient inputs from agricultural NPS inputs and a small WWTP discharge which caused nutrient enriched conditions and periodic low dissolved oxygen concentrations. The impacts were lessened due to the riparian corridor (i.e., 5-7 feet of grass/weeds adjacent with 15-20 feet of small trees). The sites within this drainage area range tended to be more biologically stable and better able to withstand the occasional perturbation.

Drainage Area Range: 14.0 - 19.4 mi^2

Only one of six sites in this drainage area range did not attain its designated use.   Community performance was only in the good range at this EWH site. This was due to a myriad of negative inputs that stemmed from having a one-sided riparian corridor with destabilized banks opposite from a hay field / open pasture. Stressors impacting instream biological community performance included buried natural substrates, excess sedimentation, manure, and excess nutrient inputs, and higher water temperatures (i.e., 76.5 °F) resulting from the open pasture and lack of canopy along one bank. These factors have led to lower D.O. concentrations and lowered overall instream water quality.

Buck Run at RM 5.0 marginally met the WWH biocriterion (marginally good) due to unstable banks and gross erosion and sedimentation resulting from a lack of a stabilizing woody riparian buffer adjacent to the stream in this former open pasture. Available large rocky substrates permitted some benthic colonization. At this drainage area range a reasonable wooded riparian corridor around a naturally meandering stream appears to limit nutrient inputs and siltation and permits aquatic communities to meet their potential.

Drainage Area Range: 28.0 - 37.3 mi^2

Streams in this drainage area range are able to withstand some exposure to stressors and still maintain biological performance within the range of expectations. However some of the more sensitive taxa may be eliminated from the catch at sites with perturbations. Sites in this drainage area range appeared to have a wide range of stressors including inadequate riparian corridors, elevated sediment bedload, nutrient enrichment, sheet, rill and bank erosion, slumped banks, low dissolved oxygen concentrations, urban storm water issues and WWTP inputs. The agriculturally impacted sites that showed some declines in community quality were Buck Run (RM 0.6), and lower Treacle Creek (RM 0.7). Hellbranch Run (RMS 5.7, 0.9 and 0.5) sites were affected by storm water runoff, sedimentation and/or WWTP inputs. Even at the four highest performing macroinvertebrate community sites total suspended solids or sediment bedload decreased diversity or simplified community structure (i.e., decreased stenonemid mayfly diversity, caddisfly diversity/abundance and/or increases in facultative or tolerant organism numbers).

Drainage Area Range: 70.0 - 88.0 mi^2

These larger wadeable streams demonstrated exceptional biological performance barring any catastrophic impacts, such as the 2000 spill in Milford Center, or large constant inputs such as large dischargers which could acutely or chronically affect macroinvertebrate community performance.

Macroinvertebrate community quality appeared to be directly related to the width and quality of the riparian buffer. In general the wider riparian corridor along Big Darby Creek and Little Darby Creek at this drainage area range buffered the biological communities and helped protect against large or continuing impact events.

A.4.7.4 Trends in Unionid Mussel Communities

The Big Darby Creek watershed is well known for its diverse unionid mussel fauna. There has been a decline in species diversity and population abundance throughout the watershed in recent years. Five species have disappeared from the catch all together.

Typically lower mussel diversity coincided with areas having lowered fish community scores. Lower mussel diversity also was found in stream segments with low habitat quality. Factors contributing to these correlations included toxic impacts, sedimentation/siltation, substrate embeddedness, lack of riparian corridor width, lack of stream shading from decreased canopy cover, bank destabilization, and nutrient inputs causing excess algal production and low nighttime dissolved oxygen concentrations.

The strongest spatial correlation was decreased mussel diversity downstream from dischargers - typically in segments with elevated BOD5, ammonia, TKN, or nitrates present and the metals lead, zinc, copper and cadmium, parameters normally associated with point source dischargers. Additionally elevated chlorides, sulfates, higher conductivity, hardness and pH were also found downstream from point source dischargers in areas with decreased mussel diversity.

An analysis of mussel distribution by decade revealed impacts in the middle reaches in the 1980s (i.e., in the vicinity of Plain City and West Jefferson, and in the segment from upstream of I-70 to downstream from U.S. Route 40 downstream from package WWTPs and campgrounds). Impacts were also seen in the 1980s in the lower reaches of Big Darby Creek downstream from dischargers and associated with elevated BOD, low dissolved oxygen ammonia, and metals.

In the 1990s there were losses in mussel diversity in upper Big Darby Creek around Flat Branch and in the middle reaches within and downstream from Plain City. Decreased mussel diversity in Little Darby Creek was found immediately downstream from the Mechanicsburg and West Jefferson WWTPs. Hellbranch Run had reduced mussel diversity which was associated with residential growth.

There were indications that nutrient enrichment (i.e., high concentrations of N and P) and associated nighttime dissolved oxygen sags were partially responsible for the declines documented in the 1990s.

There were a few positive findings. Bivalve diversity had increased in a couple of locations in the lower watershed. Close inspection of both sites revealed that habitat stability had contributed to the increased diversity. This is an increasingly rare feature in lower Big Darby Creek and is thought to be related to changes in hydrology that is yielding less stable streambed features.

Another interesting discovery was the dynamic equilibrium between the forest canopy and the relatively high concentrations of calcium bicarbonate found in portions of the Little Darby Creek subwatershed. Areas with intact riparian buffers shading the stream and high calcium carbonate and the appropriate type of substrates had good bivalve populations. Adjacent areas with reduced canopy had increased algal growth which shifted the pH and resulted in precipitation of the bicarbonate out of solution cementing the substrate together. These areas had reduced bivalve diversity. The key protective measure for bivalves in these areas seems obvious: allow trees to grow along the stream.

Stable mussel habitat would benefit from increases in the riparian corridor width and subsequent streambank protection and decreases in storm water flows which would decrease erosion and slow down substrate bedload. Over time, desirable features would develop including side channels, side bars, aquatic vegetation (like water willow) and side pools in conjunction with woody substrates.

A.4.8 Biological Assessment: Fish Community

(See Section B.8 for detailed discussion.)

This section contains a summary of the fish sampling results, including drainage area comparisons and a discussion of fish tissue sampling results.

A.4.8.1 Watershed Assessment

Big Darby Creek Mainstem

In general fish communities were judged to be very good or excellent and exceeded or marginally met their respective EWH criteria. There were a few noteworthy exceptions to this pattern, which were limited to the upstream portions of the watershed.

Upper Big Darby Creek - (02-200) Headwaters to Plain City

The fish communities in the very headwaters of Big Darby Creek have been impacted by activities associated with the construction of the upgraded U.S. Route 33 and roadways accessing this major thoroughfare. Fish communities have been impacted and recovered from the sedimentation associated with this construction. However, sediment from this activity is still gradually working its way downstream resulting in declines in its path with subsequent recovery expected due to the stream bed gradient and other factors. Downstream from the confluence with Flat Branch, changes in hydrology, nutrient enrichment, depressed dissolved oxygen concentrations and metals are layered on top of the sedimentation yielding the lowest fish community scores on the mainstem of Big Darby Creek. Several initiatives should yield improvements in this segment.

Declines were also noted bracketing Milford Center. The cause upstream from town is currently unknown. The downstream decline, however, was due to the massive fish kill that occurred during the summer of 2000. There might be additional factors keeping this segment suppressed since fish communities that have good re-population sources in close proximity typically rebound fairly quickly which is the case here. Enrichment resulting from nutrients discharged from Buck Run has yielded low dissolved oxygen concentrations and a slight decline in the fish community downstream from State Route 38 (RM 62.5).

Middle Big Darby Creek - Plain City to Little Darby Creek

A significant impact was detected downstream from the Plain City WWTP with both fish indices declining into the WWH range. The shifts in fish community composition detected were characteristic of a pattern of modest nutrient enrichment from a WWTP. There were several water chemistry measurements and physical observations supporting this conclusion. The rest of this segment fully met EWH by virtue of the very high quality instream habitat, relatively intact riparian buffer and recent improvements in wastewater treatment.

Lower Big Darby Creek - Little Darby Creek to the mouth

Exceptionally high quality fish communities were found from US Route 70 to the mouth of Big Darby Creek, a distance of at least 42 miles. The most significant indication of stress in this segment was found at RM 8.4 where the IBI dropped to levels approaching WWH. Nutrient enrichment appears to be a problem associated with the tributary discharging at RM 8.4. This segment bears watching in the future.

Big Darby Creek Upper Tributaries: Flat Branch to Robinson Run

Flat Branch (02-223) (RM78.48) (MWH)
Reduced habitat quality obviously contributed greatly to the diminished biological performance in Flat Branch. However, other factors further suppressed community performance. Patterns in the fish community suggested periodic dissolved oxygen depletion. Scouring flows disrupt habitat through stream channel destabilization and disrupt both benthic flora and macroinvertebrate fauna. Flat Branch has also been documented to be the source of water quantity and quality problems. Although Flat Branch accounts for less than 3% of the total watershed area of Big Darby Creek, it has been measured to contribute more than 11% percent of the total watershed flood flows (OSU, 2003). During normal flows, Flat Branch accounts for 88% of the flow at its confluence with Big Darby Creek even though it covers only 70% of the drainage area at that point.

Little Darby Creek (Logan Co.) (02-251) (RM 78.34)
The significant presence of the obligate coldwater mottled sculpin both historically and at both sites sampled in the current survey, coupled with the significant presence of coldwater macroinvertebrate taxa, has resulted in the recommendation that Little Darby Creek be also designated as Cold Water Habitat (CWH). This small EWH stream has also scored highly during most sampling, however, it is currently threatened by active channelization taking place in its headwaters and towards its mouth.

Unnamed tributary to Big Darby Creek (02-361) (RM 74.91)
The high number of darter and sculpin species, simple lithophilic spawning species, minnow species and other positive metric results yielded an IBI of 50, in the excellent range. This high of an IBI score coupled with a rather modest QHEI score suggests that the hydrology of this stream may be augmented with good ground water inflow. The very high number of mottled sculpins and fairly high numbers of southern redbelly dace and blacknose dace further support this conclusion.

Spain Creek (02-222) (RM 74.3)
The large number of intolerant species and species with specialized feeding or spawning requirements documented the high environmental quality present in lower Spain Creek. This segment has consistently met EWH criteria over the years and justifies the recommendation of the EWH use. Spain Creek upstream from North Lewisburg has not been sampled as extensively. Habitat quality in this segment was only in the fair- good range and probably explains the marginally lower scores. The existing WWH aquatic life use designation was recommended to be retained for this portion of Spain Creek.

The high number of cool water southern redbelly dace in concert with the high percentages of mottled sculpin and supporting coldwater macroinvertebrate assemblage resulted in the recommendation of Cold Water Habitat for the length of Spain Creek.

There is a slight pattern of decline at the very mouth of Spain Creek associated with the gradual deterioration of the sewers leading to the WWTP.   North Lewisburg, though delaying the resolution of this issue and others, should be achieving higher effluent quality in the future. This should yield improved fish communities.

Pleasant Run (02-221) (RM72.01)
This extremely high quality, groundwater augmented stream has consistently yielded some of the highest fish community scores in the state. Recent channelization has reduced habitat quality in the lower reaches and poses a threat to the perpetuation of this high quality resource.

Unnamed tributary to Big Darby Creek (02-369) (RM 69.40)
The fish communities scored solidly in the good range for the IBI (i.e., 44) fully meeting the criterion for the WWH aquatic life use and were reflective of the relatively good habitat documented at this site.

Hay Run (02-220) (RM 67.6)
Habitat quality has been modestly compromised by historical channelization and adjacent agricultural landuse practices implemented with limited erosion best management practices in lower Hay Run. The fish community in Hay Run was doing very well despite less than optimal habitat quality. Ground water contribution from the Cable moraine is the suspected factor augmenting habitat quality to permit instream biological performance solidly in the EWH range. The abundance of mottled sculpin and variety and abundance of darters reflect the perennial nature of this stream.

Prairie Run (02-219) (RM 63.84)
Prairie Run, a truly ephemeral stream, was designated LRW.

Buck Run (02-209) (RM 63.74)
There has been a gradual decline in habitat quality through the middle reaches of Buck Run over the last twenty years. This has been matched with a gradual decline in fish community performance. Habitat quality was not the sole reason for the suppressed fish community performance. Stream dessication and poor water chemistry were contributing factors in the headwaters. In the middle reaches, low dissolved oxygen and very high nutrient concentrations were issues. In contrast, at the mouth, habitat quality actually appears to have improved over time and this has been reflected in improved fish community scores. This segment appears to fall in the backwaters of Big Darby Creek.

Robinson Run (02-207) (RM 53.69)
Habitat quality in Robinson Run was capable of supporting a much higher quality community than what was measured there. There were strong indications of nutrient enrichment, lowered dissolved oxygen, etc, in the upstream portions of the subwatershed. A spill may have also contributed to the fair fish community scores measured. Historically, the mouth of Robinson Run has the documented ability to support WWH communities. However, in 1992, results were highly variable suggesting variable water quality and quick recovery due to the proximity to high quality portions of Big Darby Creek. In contrast, fair communities were found during both

sampling passes in 2001. Additional sampling will be conducted with a broader parameter list to determine if the closed Ranco Inc. landfill immediately upstream has any bearing on the lowered performance.

Big Darby Creek Middle Tributaries: Sweeney Run to Little Darby Creek

Sweeney Run (02-357) (RM 52.11)
Despite the slightly less than optimal habitat found in lower Sweeney Run, an IBI score of 46, which is in the very good range, was recorded. Darters, which in most cases represent high quality habitat, accounted for almost seventy percent of the catch in this segment. The proximity of the mouth of this tributary to a portion of Big Darby Creek that supports a high quality and diverse fish fauna undoubtedly plays a strong role in repopulation of lower Sweeney Run after periods of stress.

Sugar Run (02-206) (RM 50.92)
In Sugar Run, fish communities ranged in quality from poor adjacent to the Rolling Meadows Golf Course (RM 7.5) to good at the site adjacent to the Forest Grove Cemetery at Cemetery Pike (RM 0.5). Fish community quality in 2001 displayed a distinct trend of improving quality with downstream distance. Habitat quality followed a very similar pattern. Unfortunately, habitat quality, particularly in the upper reaches, is also displaying a pattern of decline over time as more and more of the channel is altered. This was taking place at the same time as considerable efforts were focused on Sugar Run to improve water quality. Two poorly operating package WWTPs were eliminated and a landfill that received hazardous waste has been capped and a leachate collection system installed as well as other water quality improvement projects. These water quality improvements have been reflected in the fish community scores at the mouth of Sugar Run which have been improving along with habitat quality over time. However, the upstream reaches of Sugar Run are highly nutrient enriched and, as more of the channel is physically altered, it will be less able to process these nutrients and will export more of the load downstream into Big Darby Creek. Spills have also been a very important factors altering biological communities. The source of these impacts have been dealt with and should no longer be a problem.

Western Tributaries to Big Darby Creek south of Plain City
Several small, primarily agricultural tributaries enter Big Darby Creek from the west just south of Plain City. Portions of the headwaters of many of these stream are petitioned and maintained by the Madison County Engineer's Office under the County Ditch Ordinance. However, close to their respective mouths and where they are bridged by Plain City - Georgesville Road (State Route 142), these streams become more residential in nature and more of the riparian area has had vegetation retained. Fish community scores in these streams seem to strongly reflected the amount of habitat that has been allowed to remain and many of them have been recommended to be designated WWH from that vicinity down to the mouth. These streams include Worthington Ditch, Ballenger-Jones Ditch, Yutzy Ditch, Fitzgerald Ditch and probably some of the smaller tributaries not sampled.

Little Darby Creek (02-210) (RM 34.1)
Fish community performance in Little Darby Creek ranged from fair at Wing Road downstream from the Mechanicsburg WWTP to exceptional downstream from Chuckery at RM 26.6. In general, fish community performance was suppressed in the headwaters particularly in the vicinity of Mechanicsburg with a trend of gradual improvement towards the mouth. Fish communities fully met or marginally met EWH criteria downstream of Chuckery to the mouth.

Siltation associated with open access pasturage suppressed fish community scores at the very headwaters. Further downstream adjacent to Mechanicsburg, pasturage, spills from an agricultural chemical facility and nutrient enrichment prevented full attainment of EWH. The Mechanicsburg WWTP and in particular a bypass pipe from the WWTP forced fish community scores to their lowest levels on the mainstem of Little Darby Creek. The only site from here on down to the mouth that did not at least marginally meet EWH criteria for fish was downstream from the confluence with Treacle Creek at Axe Handle Road. This location has previously supported EWH fish. Problems associated with nutrient enrichment and its consequent effects on dissolved oxygen appear to be strong candidates for causing the depressed fish community results. Continuous dissolved oxygen monitoring has revealed dissolved oxygen dropping below EWH minimums upstream from the bridge and in the downstream reaches of Treacle Creek, whose confluence is immediately upstream.

Fish scores were then exceptional all the way to the mouth although communities near the Big Darby Creek confluence had not yet fully recovered to the expected condition after the removal of the dam across the mouth.

Little Darby Creek Tributaries

Clover Run (02-218) (RM 39.8)
Although currently designated as Exceptional Warmwater Habitat, the sampling site yielded a good headwater Warmwater Habitat fish community. The habitat evaluated at the site also suggest WWH potential for Clover Run absent other mitigating factors.

Lake Run (02–216) (RM 36.9)
Habitat in Lake Run is significantly better than in Clover Run. It had been channelized historically and has almost recovered from that impact. Siltation from the construction of a golf course a short distance upstream has resulted in increased sedimentation and stream bed embeddedness with a concomitant shift in community structure. This is felt to be a temporary impact that should dissipate over time. The current EWH use is being retained pending future monitoring.

Jumping Run (02-217 (RM 3.9)
The segment of Jumping Run sampled was much different than that found in Lake Run. Significant portions of the sampling zone consisted of relatively deep pools with deposits of mucky silts and slow current velocities. These characteristics yielded habitat that were judged to be capable of supporting WWH biological communities. Although these habitat problems

contributed to the impairment of the fish communities, nutrient enrichment of an episodic nature were thought to be also contributing to the problem.

Treacle Creek (02-213) (RM 31.3)
Fish community performance ranged from good at the upstream site, a significant departure from the EWH IBI criterion, to meeting or marginally meeting the criteria at both of the other sites sampled. Sampling should have also been conducted at RM 0.8, Winget Road to replicate historical sampling efforts.

Habitat within the segment evaluated, although in the very good range, averaged somewhat less than would normally be expected for this level of biological community performance. Cooler water temperatures strongly suggested ground water inflow that would ameliorate the impacts of water quality perturbations and permit higher than expected performance.

Nutrient enrichment at the headwaters yielded the slight depressed fish community scores. Sampling results in the middle reaches of Treacle Creek appeared to be relatively stable over time. The trend at Winget Road was one of decline over time in the 1990s . It was not possible to determine if that pattern continued into the 2000s as access was denied during the most recent sampling.

Howard Run (02-215) (RM 5.4)
The site sampled was recovering from historical channelization and, given the steep overall gradient of the stream, has sufficient energy for this site to revert to the high quality habitat present in the rest of the stream. Siltation lowered quality modestly. Cooler water and the closed canopy appeared to have ameliorated the impacts from NPS inputs and permitted the high level of performance documented at this site.

Proctor Run (02-214) (RM 3.69)
Raw sewage and elevated nutrients in the upstream reaches of Proctor Run prevented EWH performance. However, the stream had recovered downstream sufficiently enough to support the appropriateness of the EWH use. Fish community performance and habitat quality in 2001 were identical to historical results.

Barron Creek (02-212) (RM 24.4)
A large percentage of Barron Creek is under maintenance. Despite habitat reflective of the maintained nature of the stream channel, the fish community did very well in 2001 demonstrating marginal EWH performance. Inspection of the composition of the actual catch revealed an assemblage of fish species that favor rooted aquatic vegetation and that would be expected to inhabit clear water, vegetated, prairie streams (e.g., central mudminnow, grass pickerel, tadpole madtom and to a lesser extent hornyhead chub). Groundwater input which maintained fairly cool water temperatures was the suspected ameliorating factor enhancing fish community performance.

Wamp Ditch (02-363) (RM 23.0)
Wamp Ditch is under maintenance by the Madison County Engineer's Office. However, in this case, the ameliorating effects of ground water augmentation did not appear as effective in reducing the impacts associated with the adjacent landuse, instream habitat degradation and water chemistry problems. The IBI in Wamp Ditch did appear to reflect the diminished habitat quality and the attendant water quality problems associated with channelization and adjacent pasturage.

Spring Fork (02-211) (RM 17.46)
With the exception of the site upstream from Guy-Cemetery Road, all sites in Spring Fork both historically and during the more recent sampling effort had mean IBIs that marginally or fully met EWH criteria. These results reinforce the appropriateness of the existing EWH aquatic life use designation. The high percentage of pioneering species coupled with the very high quality macroinvertebrate community documented at this site in 2001 strongly suggested a temporal impact, though not severe, had occurred.

Sampling results in Spring Fork have shown that it can recover in time from habitat impacts because of high stream gradient and the type of sediments present, but success will require protection of the riparian buffer.

Bales Ditch (02-362) (RM 3.64)
The richness of species found in Bales Ditch was exceptional for a stream having just over 5.0 miles of drainage area. Most of the other IBI metrics also suggested an exceptional fish community and the IBI score of 50 provided confirmation.

Habitat quality was judged very good at the time of evaluation (QHEI=70). A moderately wide to wide riparian buffer coupled with an undisturbed stream channel, moderately high gradient and glacial till yielded a diverse and moderately stable stream channel. The habitat was judged to be easily capable of supporting very good to exceptional aquatic biological communities.

Hellbranch Run (02-204) (RM 26.1)
In general, there was a trend of gradual improvement in fish community condition from the very headwaters of the source tributaries towards the mouth of Hellbranch Run. The upstream sites in the tributaries Hamilton Ditch and Clover Groff Ditch had fish communities in the very poor and poor range, respectively. A combination of severely altered instream habitat and poor water chemistry were the causes of impairment in both streams. Habitat in Hamilton Ditch improved marginally as did fish community performance towards its mouth. However, it still remained in the poor range, which is understandable since habitat remained a significant stressor. In contrast the habitat in lower Clover Groff Ditch greatly improved into the range felt capable of supporting WWH communities. Despite this significant improvement in the potential of the habitat fish communities only improved into the low fair range. Obviously, water quality is still an important factor suppressing fish community performance at the mouth of Clover Groff Ditch. The source of this impact was the Cypress Wesleyan School WWTP at RM 1.30 only 0.5 mile upstream. This WWTP is scheduled to be connected to Columbus city sewers eliminating this discharge.

There were also several other sources of stress contributing to the reduced fish community in lower Clover Groff Ditch including failing septic systems and other NPS inputs.

The upper reaches of Hellbranch Run habitat quality was less than optimal with smothered bottom substrates and a silt and sand bedload. Despite the poor habitat, fish communities were partially meeting WWH criteria. The presence of cool water and obligate coldwater taxa suggested groundwater was positively affecting results. Nutrient enrichment was still an issue.

Habitat quality and fish community performance in general improved towards the mouth eventually meeting the EWH biocriteria. The impact of the Timberlake WWTP at the mouth interrupted this pattern. But with its removal in the near future, lower Hellbranch Run should fully meet EWH for approximately five miles.

Trends in the Fish Community

Hellbranch Run (02-204) (RM 26.1)
Sampling during the current study has documented extremely poor conditions in the very headwater reaches of Hellbranch Run's source tributaries that is the result of both water chemistry problems and further declines in habitat quality. This has translated to declines at the mouth sites in both Clover Groff Ditch and Hamilton Ditch.

In the mainstem of Hellbranch Run, most of the sites that matched up over the years sampled had fairly similar scores. Major discrepancies were noticed in the middle reaches and at the very mouth. The problems associated with the Timberlake WWTP, although long running, have gotten worse in recent years.

Smith Ditch (02-353) (RM 31.69)
Smith Ditch had many characteristics of a high quality headwater stream in its headwaters and yielded a fish community in the exceptional range. Field notes state that the site towards its mouth should have been a classic good intermittent stream with very deep pools, strong ground water influence and a wooded riparian corridor. The low number of fish was noteworthy with low D.O. conditions attributed to groundwater a suspected cause and source.

Tributary to Smith Ditch (02-354) (RM 0.2)
Because of several positive community attributes, this truly headwater stream yielded a fish community in the exceptional range despite the high percentage of tolerant individuals present.

Gay Run (02-298) (RM 26.48)
Although there is direct evidence that the headwaters periodically are not connected to its receiving stream, there is also evidence that the pools are perennial and do not warm up and become stagnant. Central mottled sculpins are obligate cool water species and several were found in this sampling location. Similarly, southern redbelly dace are headwater species and require perennial pools. For that reason, this stream has been recommended to be designated as WWH.

Springwater Run (02-203) (RM 24.0)
Despite the obvious nutrient enrichment problems at the location sampled the fish community scored an IBI of 50, in the excellent range. Groundwater influence had obviously ameliorated stress associated with localized nutrient enrichment issues with numerous mottled sculpins and a handful of southern redbelly dace affirming that observation.

Tributary to Big Darby Creek (02-352) (RM 23.77)
Flow in this stream was only slightly greater than interstitial at the time sampled. Although there were small seeps present along the stream, there is a strong suspicion that the stream dries up on occasion. That all species present are pioneering in nature supports this premise.

Tributary to Big Darby Creek (02-270) (RM 20.2)
The quality of the instream and riparian habitat suggest that this stream is capable of supporting very good to exceptional fish communities. Sampling results revealed an aquatic community on the verge of the exceptional range. Expectations are that, when the Clark's Lake Subdivision is tied into the PCI Regional WWTP, water quality will improve and commensurate improvements in the biological communities will occur.

Greenbrier Creek (02-202) (RM 16.75)
Instream and riparian habitat were slightly poorer upstream than downstream, but QHEI scores averaged well within the range capable of supporting WWH fish communities. Such communities were documented at these two sites with the downstream site having the higher quality habitat and marginally scoring in the exceptional range.

Georges Creek (02-201) (RM 14.4)
Southern redbelly dace, a signature headwater species, was the most numerous fish collected in the stream (51.26% of total individuals), a very unusual occurrence. The low number of sensitive species and low percentage of insectivorous species were the two metrics which prevented the IBI from exceeding the EWH biocriterion.

Lizard Run (02-273) (RM 12.93)
Lizard Run appears to be a true ephemeral stream that only flows during rain events and snow melt. The underlying glacial geology results in Lizard Run becoming a losing stream and, thus, naturally limited biologically resulting in the recommended LRW use designation.

Fish Community Trends: Big Darby Creek Mainstem, 1979-2002
Several intensive surveys have been conducted along the mainstem of Big Darby Creek by the Ohio EPA since 1979. In virtually all years sampled a similar pattern was revealed. Lowest index scores (IBI and MIwb) were found in the headwaters and the most populated portions of the watershed. Scores then increased gradually towards the mouth. This pattern also corresponded well with the trend of gradually increasing habitat quality towards the mouth.

In general, scores in 1992 were higher and less variable than those measured in 1979. Higher flow during 1979 may explain part of the difference. However, there have been significant improvements in wastewater treatment in the watershed in the intervening years.

Significant fish community declines were noted in the more targeted 1997 survey. These included the headwaters, downstream from the Plain City WWTP, downstream from the PCI WWTP and downstream from the Shady Acres Mobile Home Park. Problems with sedimentation and its adverse effects on habitat quality were the reason for the decline in the headwaters. Problems with water quality were the documented reason of the other declines.

Longitudinal trends in fish community performance from 2001 and 2002 have already been discussed in the previous sections Overall, fish community results in 2001 and 2002 are improved from those documented in 1997. In several cases, the improvements can be directly tied to improvements or changes at WWTPs.

Monitoring of Big Darby Creek over time has documented numerous changes in the watershed. One significant observation is that improvements at WWTPs and subsequent improvements in the biota cannot be considered permanent. As systems age and service populations expand, WWTP loads increase and new problems can emerge. As a result of this study, numerous small package WWTPs are being tied into larger regional plants, significantly reducing the potential number of failing WWTPs in the future. Maintaining compliance should be much easier and yield a net improvement. Impacts in the headwaters of Big Darby Creek remain a problem.

A.4.8.2 Drainage Area Relationships

In general it was found that, as expected, mean cumulative number of species and mean number of sensitive fish species increased with drainage area, supporting the basic premise of the river continuum concept. Mean IBI, however, showed a somewhat different pattern.

Sites with a drainage area of less than two square miles in the Big Darby Creek watershed yielded fairly high IBIs. Excluding the one site that had a severe problem with nutrient enrichment, IBI scores averaged 48.8 which is in the exceptional range. Mean habitat quality, although judged to be good, was less than what typically would be expected to support the very good quality of fish communities present.

Mean IBIs were noticeably lower at sites falling in the drainage area ranges of 2-4 mi^2, 4-8 mi^2 and 8-16 mi^2. In many cases, the low IBI scores coincided with segments having poor instream habitat as reflected by low QHEI scores. Many of these sites had additional stressors adversely affecting fish community performance. Mean IBI increased significantly up to the drainage area range of 64 -128 mi^2 and leveled off thereafter. Mean MIwb, where applicable, was in the marginal EWH range from 32-64 mi^2 to 128 - 256 mi^2 and fully met the EWH criterion at larger drainage areas.

Drainage Area Range: <2 mi^2

Land use at this scale varied considerably. One site was immediately downstream from a very small town, another had highway run-off as the major stressor, another was situated in a wooded rural large lot area, etc. This makes it difficult to generate commonalities other than the observation that, at this size of a subwatershed, it is not unusual for one land use or stressor to predominate. Despite this, none of these sites were in non-attainment of the applicable criteria aquatic life use criteria.

Drainage Area Range: 2-4 mi^2

Sites in this drainage area range spanned the spectrum of quality from exceptional to poor. Many sites were in segments that had not been previously sampled.

Poor habitat resulting from channelization was a strong contributing element to the poor performance of the fish community at one- third of these sites. A few of the sites, although strongly influenced by channelization, appeared to be suffering from toxicity. These were located in a suburbanizing subwatershed. Additional sites appeared to have been subjected to spills, probably of substances causing nutrient enrichment.

The Big Darby Creek watershed possesses some features which facilitate the propagation of EWH communities particularly in the Little Darby Creek subwatershed where many of these sites fall. These very same features also seem to be able to ameliorate stresses that would result in greater biological declines in similar streams in the ECBP ecoregion or support a higher level of biological community performance than would be found at sites with comparable habitat quality in other ECBP streams. The inflow of ground water to the stream channel is probably the main beneficial factor. Ground water typically is cooler than surface water runoff and has fewer contaminants than tile drainage and surface water. Additionally, in the Little Darby Creek subwatershed, end moraines and particularly the boulder belt of the Cable moraine provide adequate gradient for flushing contributed sediments, provide coarse substrates which engender high quality habitat, and contribute a large aquifer to provide good ground water inflow.

Drainage Area Range: 4-8 mi^2

Half of the sites in this drainage area range had biological communities performing at levels that were deemed appropriate to their current or recommended aquatic life use. Hydromodification was a pervasive element in sites not performing at this level at this drainage area range.

Drainage Area Range: 8-16 mi^2

Sites in this drainage area range ran the gamut from EWH to Limited Resource Waters. Poor habitat caused by channelization resulted in poor performance of the fish community at one third of these sites.

The majority of the remaining sites fell within the Little Darby Creek subwatershed with most of them meeting or marginally meeting criteria. These sites possessed good to very good habitat, but it appeared that the ground water influence was still buoying community performance. Sites that didn't attain had a very wide range of stressors that were responsible for the less than expected performance.

Drainage Area Range: 16-32 mi^2

Many of the sites in this drainage area range appear to be threatened. They are currently marginally meeting the criteria of their respective designated uses with NPS associated stressors the reason for less than expected performance. There are indications that NPS conditions may worsen (e.g., recent removal of riparian vegetation) causing further declines. Point source related stressors that are currently causing problems, in contrast, are being dealt with and expected to result in localized improvements.

<u>Drainage Area Range: 32-64 mi</u>^{2}
Sites falling within this drainage area range either are meeting their respective criteria or are impacted by WWTPs and plans are underway to remediate those problems.

<u>Drainage Area Range: 64-128 mi</u>^{2}
Spills and nutrient enrichment appear to be the key factors adversely affecting fish community structure and function at this drainage area range.

<u>Drainage Area Range: 128-256 mi</u>^{2}
Although the majority of the sites in this drainage area range fully met their EWH criteria they also appear to be stressed or at risk by WWTPs and growth.

<u>Drainage Area Range: 256-512 mi</u>^{2}
All sites in this range fully met their respective EWH criteria with some of the highest scores recorded from any where in the state. The most significant contributing factor to this performance was the extremely high quality instream and riparian habitat with both shorelines protected and possessing an almost contiguous wooded riparian buffer for a majority of the segment.

<u>Drainage Area Range: >512 mi</u>^{2}
All sites fully met their respective EWH criteria again displaying some very high values reflective of the exceptionally high diversity and production emanating from lower Big Darby Creek. Habitat quality is the factor driving this incredible diversity with mean segment QHEI of 81. In this grouping of sites there was one site that suggested that there are problems developing. The site at RM 8.4 although marginally meeting the EWH criteria was significantly lower than sites that bracketed it. Just upstream from this site was a small tributary that was highly nutrient enriched. Large mats of algae coated the bottom of its channel where the canopy was open enough to permit sunlight to reach the waters surface.

A.5 FINDINGS: STATUS OF DESIGNATED USES

Current and recommended aquatic life, water supply and recreation uses are presented in Table A.14. This chapter discusses how uses are determined and the condition of the streams of the Big Darby watershed relative to the designated uses.

A.5.1 Status of Aquatic Life Uses

A number of the tributary streams evaluated in this study were originally assigned aquatic life use designations in the 1978 and 1985 Ohio water quality standards (WQS) based largely on best professional judgement, while others were left undesignated. The current biological assessment methods and numerical criteria did not exist then. In this study, several sub-basin streams have been evaluated for the first time using a standardized biological approach as part of this study. Table A.15 provides the attainment status for sites sampled in 2001 and 2002 and is based on the current or recommended aquatic life use.

The existing Exceptional Warmwater Habitat aquatic life use designation should be retained for the Big Darby Creek mainstem. The only recommended change is to extend the EWH use designation further upstream in recognition of the improved performance of the biological communities in that segment and that all applicable EWH criteria were fully met at the majority of sites within that segment. The EWH aquatic life use designation should be extended to the very headwaters.

The ongoing and significant presence of obligate coldwater macroinvertebrate and fish taxa in the upstream three sampling locations on the Big Darby Creek mainstem support designation of Big Darby Creek as Cold water Habitat in addition to the current EWH use designation from its headwaters to RM 78.5, which is just upstream from the confluence with Flat Branch (RM 78.48). Several other tributaries have also been recommended to be designated as Cold Water Habitat. Rationale for these recommendations are provided in this chapter.

Use attainability analyses of small water courses resulted in the recommended designation of Modified Warmwater Habitat (MWH) and Limited Resource Water (LRW) segments where poor habitat quality was unlikely to improve in the foreseeable future. These streams were channelized and maintained to facilitate agricultural activities and offered very limited habitat. It is not realistic to expect typical WWH aquatic communities under these conditions. In most cases this survey is the first time these habitat limited segments have been evaluated using biological and habitat data and does not represent a downgrading of the previous WWH use which was based on unverified designations in the 1978 and 1985 Water Quality Standards. Other small streams were impacted by habitat modification but retained the WWH use where recovery of natural habitat features such as a wooded riparian and multiple cover types was evident. Additional habitat improvement is possible through the application of management practices to limit soil loss and restore wooded riparian areas. The rationale for assigning or retaining aquatic life use designations can be found in this chapter.

Table A.14. Waterbody use designations for the Big Darby Creek basin based on sampling conducted during 2001 and 2002.

Designations based on Ohio EPA biological field assessments appear as a plus sign (+). Designations based on the 1978 and 1985 standards for which results of a biological field assessment are now available are displayed to the right of existing markers. Designated uses based on results other than Ohio EPA biological data are marked with an circle (o). A delta (Δ) indicates a new recommendation based on the findings of this report.

Water Body Segment	Use Designations												
		Aquatic Life Habitat						Water Supply			Recreation		
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Big Darby Creek (02-200)[a] - Headwaters to RM 79.2			Δ+			Δ+			Δ+	Δ+		Δ+	
RM 79.2 to mouth			+						+	+		+	
Flat Branch (02-223) (RM 78.48)[b]				+					+	+		+	
Tributary to Flat Branch (02–365) (RM 1.5)				Δ+					Δ+	Δ+		Δ+	
Little Darby Creek (02-251) (RM 78.34) RM 3.5 to mouth			Δ+			Δ+			Δ+	Δ+		Δ+	
U.T. to B. Darby Cr. (02-361) (RM 74.91) RM 0.75 to mouth			Δ+						Δ+	Δ+			Δ+
Spain Creek (02-222) (RM 74.3) - Headwaters to RM 5.0		+				Δ+			+	+		Δ+	
RM 5.0 to mouth			Δ+			Δ+			+	+		Δ+	
Pleasant Run (02-221) (RM 72.01)			+						+	+		*+	
U.T. to Big Darby Creek (02-360) (RM 69.4) RM 1.8 to mouth		Δ+							Δ+	Δ+			Δ+
Hay Run (02-220) (RM 67.6) RM 1.1 to mouth			Δ+						+	+		*+	
Prairie Run (02-219) (RM 63.84)							Δ+		Δ+				Δ+
Buck Run (02-209) (RM 63.74)		+							+	+		Δ+	
Robinson Run (02-207) (RM 53.69)		+							+	+		*+	
Sweeney Run (02-357) (RM 52.11) RM 1.7 to mouth		Δ+							Δ+	Δ+		Δ+	
Sugar Run (02-206) (RM 50.92) - Headwaters to RM 7.0				Δ+					+	+		*+	
RM 7.0 to mouth		+							+	+		*+	
U.T. to Sugar Run (02-358) (RM 7.39)				Δ+					Δ+	Δ+		Δ+	
Worthington Ditch (02-2356) (RM 50.62) RM 0.4 to mouth		Δ+							Δ+	Δ+		Δ+	
Ballenger-Jones Ditch (02-355) (RM 49.68) RM 3.72 to mouth		Δ+							Δ+	Δ+		Δ+	
Yutzy Ditch (02-364) (RM 47.1) RM 1.38 to the mouth		Δ+							Δ+	Δ+		Δ+	

Table A.14. (Continued.)

Water Body Segment	Use Designations												
		Aquatic Life Habitat						Water Supply			Recreation		
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Fitzgerald Ditch (02-272) (RM		△+							△+	△+		△+	
Little Darby Cr.(02-210) (RM 34.1) Headwaters to RM 36.9			+			△+			+	+		+	
Little Darby Cr.(02-210) (RM 34.1) RM 36.9 to mouth			+						+	+		+	
Clover Run (02-218) (RM 39.8)		△+							*+	*+			△+
Lake Run (02-216) (RM 36.9)		△+							*+	*+		*+	
Jumping Run (02-217) (RM 3.9)		△+							*+	*+		*+	
Treacle Creek (02-213) (RM 31.3)			+						*+	*+		*+	
Howard Run (02-215) (RM 5.4)			*+						*+	*+		*+	
Proctor Run (02-214) (RM 3.69)			+						*+	*+		*+	
Barron Creek (02-212) (RM 24.4)		△+							*+	*+			△+
Wamp Ditch (02-363) (RM 23.0)		△+							△+	△+			△+
Spring Fork (02-211) (RM 17.46)			+						*+	*+		*+	
Bales Ditch (02-362)(RM 3.64) RM 1.72 to mouth		△+							△+	△+			△+
Smith Ditch (02-353) (RM 31.69)			△+						△+	△+		△+	
Tributary to Smith Ditch (02-354)(RM0.06)			△+						△+	△+		△+	
Gay Run (02-298) (RM 26.48)		△+							△+	△+		△+	
Hellbranch Run (02-204) (RM 26.1) Headwaters to RM 5.0		+							+	+		+	
Hellbranch Run (02-204) (RM 26.1) RM 5.0 to mouth			△+						+	+		+	
Hamilton Ditch (02-259) (RM 11.19) -Hdwtrs to Feder Rd.				+					*+	*+		△+	
Feder Rd. to mouth		+							*+	*+		△+	
Clover Groff Ditch (02-245) (RM 11.19 - Hdwtrs to Feder Rd.				+					*+	*+		△+	
Feder Rd. to mouth		+							*+	*+		△+	
Springwater Run (02-203) (RM 24.0)		+							+	+		△+	
U.T. to Big Darby Creek (02-352) (RM 23.77)		△+							△+	△+			△+
U.T. to Big Darby Creek (02-270) (RM 20.2)		△+							△+	△+		△+	
U.T. to Big Darby Creek (02-366) (RM 18.41)		△+							△+	△+			△+
Greenbrier Creek (02-202) (RM 16.75)		+							+	+		*+	
Georges Creek (02-201) (RM 14.4)		+							+	+			△+
Lizard Run (02-273) (RM 12.93)							△+		+	+			△+

a - River code of the river or stream segment
b - River Mile of the confluence point with applicable receiving stream

Table A.15. Aquatic life use attainment status for the streams sampled in the Big Darby Creek watershed during July - October, 2001 and based on the recommended uses.

Additional sampling was conducted during July - October, 2002 to fill in gaps and further characterize and evaluate impacted areas (sites and results noted in **bold**). The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities.

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Big Darby Creek (02-200) (WWH/EWH + CWH Recommended)								
-- /83.2	1.3	71.43	-	-	42^{ns}	-	(Full)	Ust. At pvt prop.
82.5/82.5	1.5	43.48	52	NA	46	68.0	Full	CR 152
80.8/ --	4.4	19.61	42*	NA	-	61.0	(Non)	SR 287
79.2/79.3	5.6	12.2	48^{ns}	NA	56	64.5	Full	TR 157
Big Darby Creek (02-200) (EWH)								
78.4/78.5	19.4	12.5	37.3*	NA	52	63.5	Partial	Dst. Flat Branch
76.6/76.5	32	6.94	43*	8.91^{ns}	56	73.5	Partial	N. Lewisburg Rd.
69.5/69.4	69	5.92	52	9.24^{ns}	52	70.5	Full	Ust. Collins Rd.,ust.trib
67.0/**67.2**	81	4.35	44*	8.34*	**E**	-	**Partial**	Ust. Milford Center
66.0/66.0	**83**	**4.35**	**52**	**9.2^{ns}**	**40***	**74.5**	**Partial**	Dst. Milford Center
63.8/64.4	89	8.93	49^{ns}	8.18*	50	80.5	Partial	Ust. Streng Rd.,Buck Run
62.5/62.9	121	3.80	47^{ns}	7.52*	42^{ns}	83.5	Partial	SR 38, Dst. Buck Run
54.2/54.1	136	4.76	53	9.23^{ns}	42^{ns}	83.5	Full	US 42, ust. Ranco Inc
53.9/53.9	136	4.76	52	9.35^{ns}	E	93.0	Full	Dst US 42, dst Ranco Inc
52.5/ --	150	7.04	51	9.08^{ns}	-		(Full)	Ust SR 161&Sweeney Run
/52.1	150	5.21	-	-	52	-	(Full)	Ust.. Plain City WWTP
52.0/52.0	150	5.21	43*	8.78*	44^{ns}	81.0	Partial	Dst. Plain City WWTP
49.5/49.7	171	4.69	48^{ns}	8.3*	56	76.0	Partial	Ust. Amity Pike
42.0/42.1	240	7.40	55	9.87	50	81.5	Full	Ust. US Rt 70
38.9/**38.9**	247	3.97	51	9.01^{ns}	**52**	82.5	**Full**	Dst. L.D. Estates WWTP
34.1/34.2	253	4.48	55	10.14	52	93.5	Full	Ust. Little Darby Creek
29.1/-	449	4.52	54.7	10.82	**-**	86.0	(Full)	Ust. Darbydale
/**28.6**	450	4.52	-	-	**E**	-	**(Full)**	Dst. Darbydale
-- /26.9	453	5.85	-	-	54	-	(Full)	Adj Gville-Hburg Rd.
26.1 /26.1	496	7.87	**56**	**9.4**	**E**	**94.5**	**Full**	Dst. Hellbranch Run
23.8/23.8	498	6.71	55	10.20	46	87.5	Full	SR 762
22.8/22.5	505	4.1	53	11.36	56	84.5	Full	DST. PCI WWTP
18.7/19.1	513	4.74	52	10.53	E^{X15}	85.0	Full	Adj Darby Creek Rd.
15.7 /15.8	529	3.94	**56**	**10.5**	**52**	**88.5**	**Full**	Adj. Gulick Rd.
/**15.1**	532	3.94	-	-	**54**	-	**(Full)**	Dst. Georges Run
13.4/13.5	534	4.37	52	10.82	56	85.5	Full	SR 316, Darbyville
10.4/11.2	**537**	**4.15**	**56**	**9.6**	**52**	**85.0**	**Full**	Off Darby Rd.
8.4 /8.4	544	4.74	**48^{ns}**	**9.4**	**52**	**69.5**	**Full**	Dst. Ag Trib. (Conflu RM 8.5)
/**5.3**	550	7.35	-	-	**52**	-	**(Full)**	Dst. Ag Trib. (Conflu RM 5.86)
3./1/3.2	552	2.86	54	11.02	56	82.0	Full	SR 104
0.30/0.30	555	12.2	50	11.01	-	71.5	(Full)	Adj. NSCD project

Continued

Table A.15. (Continued)

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Flat Branch (02-223) (RM 78.48) (MWH)								
3.2/3.2	3.3	9.09	26	NA	G	25.5	Full	O'Dell Rd.
/2.2	9.3	6.67	-	-	MG	-	(Full)	Adj. SR 739, dst. Tribs
0.8/1.0	13.9	4.93	28	NA	50	36.5	Full	Near mouth
U. T. to Flat Branch (02-365) (RM 1.5) (Undesignated/MWH Recommended)								
/0.1	3.5	4.42	**-**	**-**	F	36.5	(Full)	North Trib TRC
Little Darby Creek (02-251) (RM 78.34) (Logan Co.) (Undesignated/EWH + CWH Recommended)								
3.5/3.5	2.4	31.25	55	NA	54	71.5	Full	SR 287
0.4/0.4	3.9	26.32	50	NA	50	68.0	Full	CR 153
U.T. to Big Darby Creek (02-361) (RM 74.91) (Undesignated/ EWH Recommended)								
0.2/0.3	3.9	13.51	50	NA	VG[ns]	62.5	Full	CR 153
Spain Creek (02-222) (RM 74.3) (WWH/WWH + CWH Recommended)								
5.7/5.7	3.5	22.22	44	NA	MG[ns]	66.0	Full	Lewisburg Rd.
Spain Creek (02-222) (RM 74.3) (WWH/EWH + CWH Recommended)								
3.7/3.4	6.0	21.74	56	NA	44[ns]	72.0	Full	Gilbert Rd.
0.1/0.1	9.1	11.36	53	NA	56	76.0	Full	Cratty Rd.
Pleasant Run (02-221) (RM 72.01) (EWH)								
4.6/4.1	4.5	22.22	54	NA	VG[ns]	72.0	Full	Dunn Rd.
0.5/0.5	9.4	14.3	58	NA	56	59.5	Full	M'burg-P'City Rd.
U.T. to Big Darby Creek (02-360) (RM 69.4) (Undesignated/WWH Recommended)								
0.2/0.4	4.6	17.68	50	NA	G	64.5	Full	M'burg-P'City Rd.
Hay Run (02-220) (RM 67.6) (WWH/EWH Recommended)								
0.3/0.2	5.8	7.35	54	NA	VG[ns]	52.5	Full	M'burg-P'City Rd.
Prairie Run (02-219) (RM 63.84) (Undesignated/LRW Recommended)								
0.3/ -	3.0	13.89	28	NA	**-**	**23.0**	**Full**	M'burg-P'City Rd.
Buck Run (02-209) (RM 63.74) (WWH)								
10.4/10.4	5.1	5.99	26*	NA	MG[ns]	40.0	Non	Allen Ctr. -P'burg Rd.
7.8/7.8	9.2	6.58	28*	NA	G	55.5	Partial	SR 245
5.0/5.0	18.1	4.83	-	-	MG[ns]	-	(Full)	Milford-Amrine Rd.
0.1/0.6	29.7	6.71	44	7.14*	MG[ns]	70.5	Partial	Orchard Rd.
Robinson Run (02-207) (RM 53.69) (WWH)								
/5.5	4.6	6.71	-	-	VP*	-	(Non)	Dst. Hawn Rd.
2.1/2.1	8.4	9.35	30*	NA	F*	64.0	Non	SR 736
0.7/0.8	11.5	15.87	30*	NA	MG[ns]	70.0	Partial	US 42
Sweeny Run (02-357) (RM 52.11) (Undesignated/WWH Recommended)								
0.1/0.2	4.0	31.25	46	NA	F*	58.0	Partial	Mouth
Sugar Run (02-206) (RM 50.92) (WWH/MWH Recommended)								
7.5/7.7	4.1	7.52	26	NA	F	31.0	Full	Ind.Pkwy.@farm
7.0/6.9	9.5	7.52	26	NA	MG	29.5	Full	Taylor rd.,Dst.landfill

Continued

Table A.15. (Continued)

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Sugar Run (02-206) (RM 50.92) (WWH)								
5.4/5.5	11.0	5.21	34*	NA	G	38.5	Partial	US 42
0.5/0.5	19.4	7.69	40	NA	VG	65.5	Full	Cemetery Pike
U.T. to Sugar Run (02-358) (RM 7.39) (Undesignated/MWH Recommended)								
0.1/0.1	5.0	3.73	30	NA	MG	27.0	Full	Ind.Pkwy.
Worthington Ditch (02-356) (RM 50.62) (Undesignated/WWH Recommended)								
0.2/0.2	4.4	20.83	24	NA	MG^{ns}	--	Non	P'city-G'ville Rd.
Ballenger-Jones Ditch (02-355) (RM 49.68) (Undesignated/WWH Recommended)								
0.4/0.2	6.0	15.15	40	NA	E	69.0	Full	P'city-G'ville Rd.
Yutzy Ditch (02-364) (RM 47.1) (Undesignated/WWH Recommended)								
0.4/0.4	4.3	27.03	-	-	MG^{ns}	NA	(Full)	P'city-G'ville Rd.
Fitzgerald Ditch (02-272) (RM 44.96) (Undesignated/WWH Recommended)								
0.5/0.5	5.1	33.33	32*	NA	G	56.5	Partial	P'city-G'ville Rd.
Little Darby Creek (02-210) (RM 34.1) (EWH/ EWH + CWH Recommended)								
41.2/41.2	3.3	43.47	42*/**48**	NA	VG^{ns}	80.5/**70**	Part/**Full**	Alison Rd.
39.6/39.3	9.4	13.33	42*	NA	48	69.5	Partial	Ust SR 29dst fert.dist.
38.8/38.8	13.2	12.99	35*	NA	48	82.0	Partial	Wing Rd. Dst M'burg WWTP
Little Darby Creek (02-210) (RM 34.1) (EWH)								
34.7/34.6	25.9	4.72	49^{ns}	NA	56	82.5	Full	Irwin Rd.
- /**33.2**	28.0	4.50	-	-	**54**	-	**(Full)**	Ust. R.dale-Mford Center Rd.
29.5/29.4	70.0	2.67	45*	8.8*	50	66.5	Partial	Axe Handle Rd.
26.6 /**26.5**	72.0	21.7	**54**	**10.0**	**52**	**58.0**	**Full**	Dst. Chuckery
24.5/24.5	83.0	2.02	52	9.3^{ns}	58	62.5	Full	Rosedale-Plain City Rd.
23.1/23.2	89.0	2.02	**48^{ns}**	**9.5**	**E**	**55.5**	**Full**	Dst. Finley -Guy Rd.
20.5/20.5	98.0	3.18	**56**	**9.3^{ns}**	**48**	**64.5**	**Full**	Ust. Arthur Bradley Rd.
/17.0	142	4.42	-	-	48	-	(Full)	Adj. L. Darby Rd.
15.3/15.4	151	2.69	57	9.6	50	95.5	Full	US 42
/**15.3**	151	2.69	-	-	**46**		**(Full)**	Dst. US 42
6.5/6.4	163	8.47	58	9.3^{ns}	54	95.5	Full	US 40, Ust W. Jeff WWTP
4.1/3.8	170	5.59	55	9.7	52	99.0	Full	Roberts Rd. Dst WWTP
0.2/0.5	176	9.9	49^{ns}	9.0^{ns}	56	77.5	Full	Mouth @ Metropark
Clover Run (02–218) (RM 39.8) (EWH/WWH Recommended)								
0.6/0.6	2.0	47.62	36^{ns}	NA	VG	60.0	Full	Rd to Maple Grove Cem.
Lake Run (02-216) (RM 36.9) (EWH/EWH Deferred)								
0.9/0.9	6.0	16.39	42*	NA	VG^{ns}	71.0	Full	SR 4
Jumping Run (02-217) (RM 3.9) (EWH/WWH Recommended)								
0.3/0.2	2.4	16.67	30*	NA	G	63.0	Partial	SR 559
Treacle Creek (02-213) (RM 31.3) (EWH)								
11.8/11.7	5.7	15.63	40*	NA	VG^{ns}	67.5	Partial	M'burg-Belle. Rd.
8.3/8.3	10.3	34.48	52	NA	E	67.5	Full	Eagle Rd.

Continued

Table A.15. (Continued)

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Treacle Creek (02-213) (RM 31.3) (EWH)								
6.0/6.0	17.0	16.13	48^{ns}	NA	VG^{ns}	66.5	Full	SR 161 at Irwin
0.8/0.7	37.3	3.45	-	-	MG*	29.5	(Non)	Covered bridge nr. mouth
Howard Run (02-215) (RM 5.4) (EWH)								
0.5/0.6	2.6	13.27	52	NA	VG^{ns}	55.5	Full	McMahill Rd.
Proctor Run (02-214) (RM 3.69) (EWH)								
4.9/4.9	3.9	41.67	42*	NA	VG^{ns}	71.5	Partial	Park Rd.
3.1/3.2	9.1	22.22	48^{ns}	NA	VG^{ns}	65.0	Full	SR 559
1.6/1.7	10.0	12.35	52	NA	E	73.0	Full	McMahill Rd.
Barron Creek (02-212) (RM 24.4) (EWH/WWH Recommended)								
2.1/2.1	4.9	5.26	48^{ns}	NA	MG^{ns}	44.5	Full	Rosedale-Plain City Rd.
0.2/0.1	6.3	14.58	-	-	MG^{ns}	-	Full	SR 38
Wamp Ditch (02-363) (RM 23.0) (Undesignated/WWH)								
0.1/0.14.8	12.50		30*	NA	MG^{ns}	45.5	Partial	Vogelburg Rd.
Spring Fork (02-211) (RM 17.46) (EWH)								
15.8/15.8	4.3	17.24	48^{ns}	NA	G*	60.5	Partial	Wren Rd.
13.7/13.3	8.3	12.99	54	NA	VG^{ns}	62.5	Full	Ust. SR 29, ust. Trib.
10.1/10.1	14.6	3.73	**40***	NA	56	**69.0**	**Partial**	Ust. Cemetery Rd.
7.8/7.7	19.3	3.33	48^{ns}	NA	G*	54.5	Partial	R'dale-M'Ctr. Rd
/**3.4**	32	8.3	-	-	**E**	-	**(Full)**	Dst. SR 38
/**3.3**	32	8.3	**52**	**9.8**	**56**	**67.5**	**Full**	Dst. SR 38
Bales Fork (02–362) (RM 3.64) (Undesignated/WWH Recommended)								
0.4/0.4	5.2	12.86	50	NA	G	70.0	Full	R'dale-M' Ctr. Rd.
Smith Ditch (02-353) (RM 31.69) (Undesignated/EWH Recommended)								
2.1/2.1	5.9	40.0	52	NA	E	77.5	Full	G'ville-W'ville Ditch
0.3/0.2	6.7	35.71	28*	NA	E	73.0	Partial	Biggert Rd.
Trib to Smith Ditch (02-354) (RM 0.06) (Undesignated/EWH Recommended)								
0.2/-	0.9	7692	50	NA	-	67.0	(Full)	Biggert Rd.
Gay Run (02-298) (RM 26.48) (Undesignated/WWH Recommended)								
2.2/2.2	1.2	55.56	46	NA	G	66.5	Full	Boyd Rd.
Hellbranch Run (02-204) (RM 26.1) (WWH)								
10.3/9.4	24.8	3.37	36^{ns}	6.76*	46	39.5	Partial	Dst. Conflu./dst. Al
7.4/7.4	27.9	7.52	32*	8.17^{ns}	48	51.0	Partial	Kunz Rd.
5.8/5.7	30.5	7.3	35*	8.16^{ns}	G	65.5	Partial	Dst Ohurst Knolls WWTP
Hellbranch Run (02-204) (RM 26.1) (WWH/EWH Recommended)								
3.7/3.7	32.6	16.67	47^{ns}	9.02^{ns}	50	83.5	Full	Beatty Rd.
1.0/0.9	35.3	11.36	49^{ns}	9.18^{ns}	VG^{X15ns}	84.5	Full	Lambert Rd.
0.5/0.5	35.4	11.36	41*	9.07^{ns}	VG^{ns}	83.5	Partial	Dst. Timberlake WWTP
/**0.5**	35.4	11.36	-	-	**VG^{ns}**	-	(**Full)**	Dst. Timberlake WWTP
Hamilton Ditch (02-259) (RM 11.19) (MWH)								
3.4/3.4	3.4	4.44	16*	NA	F	21.0	Non	Walker Rd.

Continued

Table A.15. (Continued)

River Mile Fish/Invert.	Drainage Area (mi²)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Hamilton Ditch (02-259) (RM 11.19) (WWH)								
0.5/0.5	9.4	7.41	24*	NA	40	36.5	Non	US 40
Clover Groff Ditch (02-245) (RM 11.19) (MWH)								
4.7/4.7	3.8	3.39	18*	NA	VP*	22.0	Non	Roberts Rd.
Clover Groff Ditch (02-245) (RM 11.19) (WWH)								
0.8/0.8	6.7	9.90	28*	NA	20*	61.5	Non	Dst. US 40
Springwater Run (02-203) (RM 24.0) (WWH)								
0.8/0.2	1.8	50.0	50	NA	F*	48.5	Partial	US 62 at mouth
U.T. to Big Darby Creek (02-352) (RM 23.77) (Undesignated/WWH Recommended)								
0.1/-	0.8	111.11	30*	NA	-	61.5	(Non)	South of SR 762
U.T. to Big Darby Creek (02-270) (RM 20.2) (Undesignated/WWH Recommended)								
0.8/0/8	4.3	25.64	44	NA	G	77.5	Full	H'burg-D'ville Rd.
U.T. to Big Darby Creek (02-366) (RM 18.41) (Undesignated/WWH Recommended)								
0.1/**0.1**	**2.0**	27.78	42	NA	**F***	52.5	**(Partial)**	Mouth
Greenbrier Creek (02-202) (RM 16.75) (WWH)								
2.7/2.7	4.4	34.48	40	NA	MG[ns]	57.0	Full	Mt.Ster.-Com. Pt. Rd.
1.3/**1.3**	8.2	17.86	46	NA	**VG**	74.5	**Full**	H'burg-D'ville Rd.
Georges Run (02-201) (RM 14.4) (WWH)								
0.5/0.5	1.2	58.82	46	NA	MG[ns]	61.0	Full	C.Ville-London North Rd.
Lizard Run (02-273) (RM 12.93) (Undesignated/LRW)								
0.2/0.2	1.2	41.67	-	-	VP*	-	(Non)	London Northern Rd.

* Significant departure from ecoregion biocriteria; poor and very poor results are underlined.
** Attainment status not applied to mixing zones.
ns Nonsignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).
a Narrative evaluation is used in lieu of ICI for qualitative samples (E=Excellent, VG=Very Good, G=Good, MG=Marginally good, F=Fair, P=Poor, VP=Very Poor).
b Qualitative Habitat Evaluation Index (QHEI) values based on the most recent version (Rankin 1989).
c Use attainment status based on one organism group is parenthetically expressed.
X15 Less than optimal flow over artificial substrate samplers

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWHd
IBI - Headwaters/Wading	40	50	24
Mod. Iwb - Wading	8.3	9.4	5.8
ICI	36	46	22

d - Modified Warmwater Habitat for channel modifications.

A.5.1.1 Understanding Use Attainability

Until recently the process of determining use attainment status was largely an exercise of checking to see if there should be any changes to existing, previously verified aquatic life uses. Determining and assigning new uses for previously undesignated segments or streams were infrequent occurrences. However, more intense interest in watershed-wide analysis, hastened by the Total Maximum Daily Load (TMDL) program, has resulted in more and smaller drainage area streams being sampled, the majority of them previously undesignated. The use attainability process and the rationale for assigning uses to particular streams and segments is provided below. Much of the text in this section is abstracted from Rankin and Yoder (1998).

A.5.1.1.1 Background

A principle goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the surface waters of the United States. A critical step towards meeting this goal is the requirement that each state must establish water quality standards. Water quality standards have three major components; 1) use designations, 2) water quality criteria to support each use which includes chemical, physical, and biological criteria, and 3) an anti-degradation policy.

Aquatic life uses constitute the goals set for individual rivers and streams. Aquatic life uses are defined as designations (classifications) assigned to a waterbody based on the ***potential*** aquatic community that can realistically be sustained given the regional reference conditions and the level of protection afforded by the applicable criteria. These chemical, physical, and biological criteria have been documented to achieve and maintain the aquatic life goals. Ohio EPA has developed a set of tiered aquatic life uses that reflect the range of aquatic life potential that exists in Ohio streams.

Most natural streams and rivers in Ohio have a variety of habitat features dominated by a meandering channel with numerous riffles, runs, pools, islands, gravel bars, backwater areas and other channel features which in the aggregate comprise its aquatic habitat. The combination of these features are essential for supporting diverse and healthy assemblages of aquatic organisms. The majority of streams in Ohio have been assigned the Warmwater Habitat (WWH) aquatic life use designation. Streams and rivers which support a much higher diversity of aquatic organisms (fishes, mussels, and other aquatic invertebrates) are classified as Exceptional Warmwater Habitats (EWH). EWH streams generally exhibit an unusually diverse array of natural habitat characteristics, have high biological integrity, and frequently harbor the largest populations of rare and endangered species.

Some Ohio streams and watersheds have been modified extensively for agricultural drainage and/or flood control and, through ongoing maintenance activities, have stream channels kept continuously in an altered state. The Modified Warmwater Habitat (MWH) aquatic life use designation was developed in recognition of the essentially permanent nature of these modifications. The biological criteria for these streams has been adjusted to account for the tolerant assemblages of aquatic life yielded by these constant and officially sanctioned habitat modifications.

Very small streams (usually draining <3 sq. mi.) that have a very limited biological potential are classified as Limited Resource Waters (LRW). This is the lowest level of protection afforded to our streams by the Ohio Water Quality Standards.

A.5.1.1.2 Requirements

Properly assigning an aquatic life use to a stream or stream segment requires conducting a Use Attainability Analysis using a procedure with minimum data requirements and a logical and step-wise procedure to ultimately derive the appropriate aquatic life use. UAA requirements and the steps involved in the process follow.

<u>Minimum Data Requirements</u>

Ambient biological data collected in accordance with Ohio EPA protocols (Ohio EPA 1987, 1989a,b; Rankin 1989) are usually needed when conducting an UAA, especially to support assigning a use to a stream segment that does not meet Clean Water Act goals. In Ohio these uses are Modified Warmwater Habitat (MWH) and Limited Resource Water (LRW). If these data are not available, recommendations to assign or change a use may be deferred until adequate data are available to ensure that an accurate and adequately protective aquatic life use is assigned. Biological sampling results are the most definitive determinant of aquatic life use attainment and, therefore, for the appropriateness of the designation. In a few cases (e.g., small streams in the HELP ecoregion), QHEI results alone may be sufficient to justify the MWH or LRW use. Generally, fish and macroinvertebrates are both used in an UAA. However, in some instances one organism group, typically fish, may be sufficient. The number of sampling sites needed for an UAA will vary in response to the complexity of the stream segment and changes in habitat. The importance of having credible data for performing an UAA cannot be overemphasized. Poor quality or insufficient data results in underestimates of either the current state or the potential of a stream which could lead to an inappropriate use designation.

<u>Water Quality Standards (WQS)</u>

Prior to initiating an UAA, it is necessary to determine if the stream or stream segment being evaluated has been previously assigned an aquatic life use. Ohio WQS are rules in the Ohio Administrative Code (OAC) at Section 3745, Chapter 1. Sections 3745-1-08 (Hocking River) through 3745-1-26 (Cuyahoga River) of the Ohio WQS are organized by major river basins. Individual rivers and streams are listed by drainage order within each basin. Many smaller Ohio streams either lack an existing designation or were assigned a “default” use designation that may not yet have been verified by the results of a biosurvey (typically denoted with a ‘*’ in the WQS). Streams that have been evaluated and confirmed are usually (but not always) designated with a ‘+’ which indicated that an UAA has been performed. Ohio EPA routinely updates these designations in the WQS based on UAAs conducted, according to administrative procedures for rule-making set forth by the State of Ohio.

Are Clean Water Act Goal Uses Attainable?

The first step in the process, if a stream or stream segment has an assigned use, is to determine if the goals are attainable. U.S. EPA regulations (40 CFR Part 131.10 (g)(1-6)) allow lower than Clean Water Act goal uses where they are precluded by:

- naturally occurring pollutant levels;
- natural flow conditions (i.e., ephemeral - does not apply when flow is augmented by an effluent discharge)
- human - induced conditions which can not be remediated;
- hydrological modifications (dams, diversions, channel modifications) which cannot be operated in a manner consistent with the CWA goal use;
- natural physical features (substrate, flow, depth); controls to attain use would cause widespread, socioeconomic impacts.

If the stream or stream segment does not fall into any of these categories then the following steps need to be taken.

Process and Information Requirements

The Use Attainability Analysis requires the following information and knowledge:

- existing status of waterbody based on biocriteria;
- habitat assessment to evaluate potential;
- reasonable relationship between impaired state and precluding activity based on assessment of multiple indicators used in appropriate roles;
- recommendation subject to WQS rulemaking process reviewable every three years - a “temporary” designation.

Existing Use and Attainability Criteria in Federal WQS Regulations (40 CFR Part 131)

Existing use:

- existing condition of a waterbody on November 28, 1975;
- existing uses must be maintained - uses reflecting a lower condition may not be assigned;
- applies to all waters regardless of designation status.

Uses are considered to be attainable if

- point source loadings can be reduced via technology or WQS based limitations;
- nonpoint sources can be abated with the application of “reasonable” best management practices.

A.5.1.2 Results

Aquatic life uses were assessed at 128 sites ranging in drainage area from 0.8 mi^2 to 555 mi^2 (Table A.15) for the evaluation period of 2001 and 2002. Eighty-five (66.41%) of these sites fully met either the currently designated or the recommended use. Thirty (23.62%) sites partially met and 12 (9.38%) sites were not attaining their designated or recommended use.

In this section, the results from the recent sampling are discussed. The streams are discussed individually, from upstream to downstream. Some streams are also assigned a second use, as discussed in the next section of this chapter.

A.5.1.2.1 General Assigned Use Recommendations

During the 2001/2002 sampling effort, over 83 miles of the Big Darby Creek mainstem were assessed (Table A.15). The evaluation was based upon biological, chemical and physical sampling and evaluated the creek from its very headwaters to its mouth. Of the 83.2 miles of stream evaluated, 59.4 miles (71.4%) were in full attainment, 21.75 miles (26.1%) in partial attainment and only 2.05 miles (2.5%) in non attainment of the designated or recommended aquatic life use biocriterion. The non-attaining segment was limited to the headwaters in an area recovering from the sedimentation associated with the relocation of U.S. Route 33 and Logan Country Road 152. Partial attainment of biological criteria was limited to three segments: downstream from the confluence with Flat Branch, from Milford Center to downstream from Buck Run and downstream from the Plain City WWTP.

<u>Big Darby Creek Headwaters</u> (Headwaters - 79.2) (WWH/EWH Recommended)
The headwaters of Big Darby Creek have been subjected to channel modifications associated with the initial construction of U.S. Route 33 and subsequent relocations of portions to accommodate the expansion of the Honda Corporation manufacturing complex. The contribution of a significant sediment bed load to the stream channel from the lack of sediment erosion control BMPs during and post construction and the simplification of channel morphology associated with straightening of the channel resulted in declines in instream biological performance and habitat quality. Re-design and re-construction of the stream channel using natural stream channel design have subsequently resulted in improved local habitat quality. Flushing of contributed sediments downstream have resulted in gradually improving habitat scores in the immediate impact area. However, this movement of sediments downstream also has had the consequence of shifting impacts downstream causing declines in biological community performance. Based on the response pattern documented upstream, this should be a temporary situation with eventual improvement to close to pre-impact conditions.

Data from 1983, collected as part of the Environmental Impact Assessment for the re-location of U.S. Route 33, documented EWH quality fish communities within the project area. However, sampling coverage was sparse and the original designation of this area was based on subsequent Ohio EPA sampling conducted further downstream. Communities in this segment at that time were performing largely in the WWH range. Habitat quality similarly indicated this segment was suitable for supporting at least WWH communities and that designation was applied from the confluence with Flat Branch upstream to the headwaters. Follow-up monitoring conducted by the Ohio EPA and consultants hired by ODOT since the initial channel relocation and reconstruction has documented gradual recovery and improvement of both habitat quality and biological performance. Full attainment of EWH criteria was documented at RM 83.2 (in 1997 and 1999), Logan County Road 152 (RM 82.5) and Township Road 157 (RM 79.2) in 2001; therefore, it is recommended that the existing EWH designation be extended to include the very headwaters of Big Darby Creek.

Big Darby Creek Mainstem (RM 79.2 -0.0) (EWH)
Habitat quality immediately downstream from the confluence with Flat Branch has declined for a short distance in recent years as a result of problems emanating from the Flat Branch watershed. Honda Corporation was notified and they are currently evaluating the situation and developing a plan to address this problem and other identified water quality problems. The balance of the sites along the mainstem retain the high quality habitat documented in previous evaluations. Exceptional Warmwater Habitat biological communities have been documented repeatedly since 1979 throughout this reach and, therefore, the existing EWH use is recommended to be retained.

Big Darby Creek Tributary Attainment Status

Flat Branch (02-223) (RM 78.48) (MWH)
Flat Branch is currently designated as MWH. This use had been verified based on a previous biological survey. Three sites were sampled along the mainstem of Flat Branch in 2001. All three sites fully met and in fact exceeded MWH criteria. Therefore the existing MWH is judged appropriate and is recommended to be retained.

Habitat improvement projects have been proposed by the U.S. Army Corps of Engineers, The Nature Conservancy and Honda Corporation for Flat Branch that should result in significantly improved habitat and water quality if implemented. These efforts should go a long ways towards resolving the water quality problems emanating from Flat Branch. Sampling will be conducted post - construction to determine if adequate improvement has taken place.

Unnamed Tributary to Flat Branch (02-365) (RM 1.5) (Undesignated/ MWH Recommended)
This small tributary flows from the north across the Honda Property. The stream channel has been modified throughout its entire length. Habitat quality at the site sampled yielded a QHEI of 36.5, in the poor range. The pervasiveness of the channel modification in this small subwatershed and the preponderance of modified habitat attributes coupled with the instream biological performance support the MWH aquatic life use designation.

Little Darby Creek (02-251) (RM 78.34) (Undesignated/EWH Recommended)
This Little Darby Creek in Logan County is currently undesignated. With the exception of the earliest sampling in 1988, which was conducted during one of the most severe droughts on record, historical sampling as well as the sampling conducted during 2001 has documented full attainment of EWH biological criteria from RM 3.5 to the mouth. Therefore this segment of Little Darby Creek is recommended to be designated as EWH.

Unnamed Tributary to Big Darby Creek (02-361) (RM 74.91) (Undesignated/EWH Recommended)
This small unnamed tributary to Big Darby Creek was sampled at Cratty Road (RM 0.2/0.3). Both organism groups met EWH criteria at that site. The EWH aquatic life use designation is recommended to extend from the confluence of the first significant tributary upstream from the Erie-Lackawanna Rail Line (RM 0.75) to the mouth (RM 0.0). The balance of the tributary will remain undesignated pending further sampling.

Spain Creek (02-222) (RM 74.3) (WWH - Headwaters to RM 5.0) (WWH/EWH Recommended RM 5.0 to mouth)

Spain Creek is currently designated WWH. Spain Creek has been repeatedly sampled since 1981, primarily at the mouth and downstream from North Lewisburg and the North Lewisburg WWTP. Except for the drought in 1988 and the sampling site in the very headwaters, all samples have met or exceeded EWH criteria for both organism groups. Sampling results from 2001 documented EWH performance in both fish and macroinvertebrates from Gilbert Road (RM 3.7) to the mouth. Spain Creek is recommended to be redesignated EWH from Erie - Lackawanna Railroad Crossing (RM 5.0) to the mouth and retain the existing WWH for the balance of the subwatershed.

Pleasant Run (02-221) (RM 72.01)

Pleasant Run is currently designated as EWH based on sampling conducted in 1988, one of the worst droughts in Ohio history. It performed at the EWH level at that time and during subsequent sampling in 1989, 1997 and 2001. In 2001 sampling in addition to the site at Middleburg - Plain City Road was also conducted further upstream in the watershed. Sampling at River Mile 4.6 yielded exceptional fish and very good macroinvertebrate communities confirming the accuracy of the EWH use designation. Therefore, it is recommended that the existing EWH aquatic life use be retained for Pleasant Run.

Tributary to Big Darby Creek (02–360) (RM 69.40)

This small direct tributary to Big Darby Creek confluences just upstream from the Collins Road bridge from the west. It has not been sampled previously. Evaluation of instream habitat quality revealed a preponderance of high quality warmwater habitat attributes and the potential to support better than average WWH biological communities. Fish communities affirmed the accuracy of that assessment, actually meeting the EWH criterion. Macroinvertebrate communities did well but only at the WWH level. Based on the mixed performance of the biota and good habitat, it is recommended that this tributary be designated WWH from the confluence of the north and south source tributaries at RM 1.8 to the mouth.

Hay Run (02-220) (RM 67.6)

Significant portions of Hay Run, from approximately RM 1.1 upstream to RM 3.75, have been formally petitioned under the County Ditch Law and are under the jurisdiction of the Union County Soil and Water Conservation District and, therefore, kept in a maintained state. Despite this routine maintenance upstream and the less than optimal habitat (i.e. QHEI = 52.5) within the sampling zone, biological communities performed in the EWH range at Middleburg - Plain City Road. Hay Run is recommended to be designated EWH from RM 1.1 to the mouth. Although maintained throughout much of the rest of its length, due to the unusual character of the stream (i.e., performing much better than habitat would normally suggest and probably as a result of good ground water inflow to the stream), assigning an aquatic life use designation upstream from this segment will be reserved until additional sampling can be conducted.

Prairie Run (02-219) (RM 63.84) (Undesignated/ LRW)

Prairie Run is incorrectly designated in the Ohio WQS as having a verified WWH use based on previous sampling. It has never been sampled biologically by the Ohio EPA. On several occasions during the 2001 and 2002 field seasons Prairie Run at Middleburg-Plain City Road was found to be dry and was determined to be a genuine ephemeral stream. Based on the small size of the subwatershed it is being recommended to be redesignated as Limited Resource Water.

Buck Run (02-209) (RM 63.74) (WWH)
Buck Run has a verified WWH aquatic life use based on prior sampling. It was first sampled in 1981 and subsequently in 1992, 1993 and 2001. Although there have been some changes in habitat quality, including noteworthy declines at RM 7.8, Wilber Road, and comparable improvements at RM 0.4, adjacent State Route 38, overall habitat quality remains in the range consistent with the WWH aquatic life use and, therefore, the existing WWH aquatic life use is recommended to be retained.

Robinson Run (02-207) (RM 53.69) (WWH)
Robinson Run is currently listed in the Ohio WQS as WWH based on sampling conducted at RM 0.7, U.S. Route 42, in 1992. Sampling in 2001 extended further upstream into the watershed. Habitat quality in the segment that included RM 2.1, at Hickory Ridge Road and State Route 736 was judged suitable for supporting WWH communities. Although macroinvertebrate sampling was conducted further upstream, no habitat evaluation was conducted due the lack of fish sampling. However, given the average habitat quality, the recommendation is to preserve the existing WWH use designation.

Sweeney Run (02- 357) (RM 52.11) (Undesignated/ WWH Recommended)
Sweeney Run is currently undesignated. Sampling just upstream from the mouth in 2001 revealed mixed biological results. Fish communities did very well, marginally meeting the EWH IBI biocriterion. Macroinvertebrate communities, however, did not fare as well with only fair performance reported. However, during the summer, lower Sweeney Run routinely receives overspray from mosquito fogging which may explain the macroinvertebrate decline. The QHEI at RM 0.1 was 58 and, while slightly less than desired, was suitable for WWH support. The segment being designated extends from Lafayette - Plain City Road (RM 1.7) to the mouth.

Sugar Run (02-206) (RM 50.92) (WWH/ MWH Recommended - headwaters to RM 7.0) (WWH RM 7.0 to mouth)
The headwaters of Sugar Run have been subjected to a wide variety of stressors which have kept instream biological performance low (i.e., habitat disruption, spills, toxic leachate from landfills, poorly operated package WWTPs, etc.). Additionally, the two source tributaries have been petitioned and are under routine maintenance by the Union County Soil and Water Conservation District and kept in a habitat impacted condition. Although the headwaters of Sugar Run itself has not been petitioned, it has been extensively altered in the past to the point that it will not support WWH biological communities. Historical sampling has documented Sugar Run with habitat suitable for supporting WWH communities from upstream U.S. Route 42 to the mouth. Therefore, Sugar Run is recommended to be redesignated MWH from its headwaters to Taylor Road (RM 7.0) and WWH from Taylor Road to the mouth (RM 7.0 to 0.0).

Tributary to Sugar Run (02- 358) (RM 7.39) (Undesignated/MWH)
The entire length of this small stream has been petitioned under the County Ditch Law. It is under routine maintenance by the Union County Soil and Water Conservation District and kept in a habitat impacted condition. The evaluation of instream habitat revealed a channelized,

shallow and mostly pooled stream with very low flow and slow current due to its gradient and modified channel. The banks were mostly grass or lined with rip rap. Additionally, some areas had slumped banks. The resultant QHEI of 27 fell in the very poor range. Modified Warmwater Habitat is the recommended aquatic life use for this currently undesignated stream.

Worthington Ditch (02-356) (RM 50.62) (Undesignated/WWH Recommended)
Worthington Ditch is a previously unsampled stream that enters Big Darby Creek from the west just south of Plain City. Although channelized upstream from Plain City - Georgesville Road, groundwater influx and shading from a modest amount of wooded riparian vegetation in the lower reach downstream from State Route 142 has yielded cooler instream water temperatures and ameliorated some of the effects from nutrient enrichment introduced to the channelized open stream segment upstream. The macroinvertebrate communities marginally meet the WWH criterion for WWH between State Route 142 and the confluence with Big Darby Creek. As such, this is the recommended aquatic life use for this segment (i.e., RM 0.4 to the mouth). Increasing the grass and/or wooded riparian buffer upstream from State Route 142 would improve water quality of Worthington Ditch and the water quality being delivered to Big Darby Creek at RM 50.62.

Ballenger-Jones Ditch (02-355) (RM 49.68) (Undesignated/ WWH Recommended)
Although Ballenger -Jones has had much of the riparian vegetation removed from the stream bank upstream from State Route 142, the meander pattern of the stream channel and its instream habitat structure have been retained. Additionally, downstream from State Route 142, the wooded riparian vegetation has been retained as well. As a consequence instream habitat quality was judged as good (i.e., QHEI - 69.0) which was reflected in the instream biological community performance. Ballenger - Jones Ditch is recommended to be designated WWH from RM 3.72 to the mouth. County Ditch maintenance extends from RM 7.35 - 3.72.

Yutzy Ditch (02-364) (RM 47.1) (Undesignated/ WWH Recommended)
Yutzy Ditch was of marginally good quality at the site near State Route 142, RM 0.4, and met the recommended WWH aquatic life use biocriterion for macroinvertebrates. There was still some slight flow and groundwater recharge or supplemental interstitial flow and modest canopy in the lower reach that moderated water temperatures (~70º F.). A more natural stream channel was present about 400-500 yards upstream from State Route 142 with riffles and functional pools comprised of predominately rocky substrates. This pattern continued downstream to the mouth (confluence with Big Darby Creek at RM 47.1). Yutzy Ditch is recommended WWH from where county ditch maintenance ends to its mouth (RM 1.38 -0.0)

Fitzgerald Ditch (02-272) (RM 44.96) (Undesignated/WWH Recommended)
Another tributary originating from the western side of Big Darby Creek confluences with Big Darby Creek 0.5 mile upstream from the Lucas Road/Beach Road Suspension Bridge. Much of the upper reaches of Fitzgerald Ditch have been channel modified. Lower reaches (i.e., ~RM 1.5 downstream) have been modified to a much lesser degree. The instream habitat evaluation conducted downstream from State Route142 yielded a QHEI of 56.4. Moderate influence negative habitat attributes were the main factors resulting in the slightly less than optimal habitat but were not judged to preclude eventual full attainment of the WWH use with improvements at

the MHP WWTP. Fitzgerald Ditch is recommended to be designated WWH from RM 1.75 to the mouth.

Little Darby Creek (02-210) (RM 34.1)
Only one site along the length along the mainstem of Little Darby Creek did not fully meet the current EWH aquatic life use designation. The rest of the sites either marginally or fully meet the applicable EWH biocriteria. Repeated sampling over the last 15 years has yielded the same result; the Exceptional Warmwater Habitat aquatic life use designation is appropriate for Little Darby Creek and should be retained.

Clover Run (02-218) (RM 39.8) (EWH/WWH Recommended)
This small tributary originates in the very headwaters of Little Darby Creek and confluences with it immediately south of Mechanicsburg. Previously unsampled by the Ohio EPA, Clover Run was assigned the EWH aquatic life use designation based on best professional judgement in the 1978 Water Quality Standards. Sampling in 2001 yielded a good headwater Warmwater Habitat fish community and a very good macroinvertebrate community. The relative high number of blacknose dace and mottled sculpin suggest perennial pools and cool water potential from ground water sources. The habitat evaluated affirmed the WWH potential (QHEI $\geq$ 60) for Clover Run absent other mitigating factors and Clover run is therefore recommended to have the aquatic life use revised from EWH to WWH.

Lake Run (02-216) (RM 36.9) (EWH/ EWH Retained)
Lake Run was designated in the 1978 WQS as EWH based on best professional judgement. Current sampling has revealed biological communities that are only partially meeting the current EWH biocriteria as a consequence of a recent and temporal impact (i.e., inadequate implementation of erosion and storm water BMPs that have delivered excess sediment to the stream channel). It is felt that, given time for the disturbed land to stabilize with vegetation and the contributed sediment to be flushed downstream, this high gradient stream should easily be able to fully meet the EWH criteria. The current EWH designation has therefore been recommended to be retained. The asterisk denoting that the designation needs to be verified by survey will also be retained in the WQS table to permit resampling in a few years after the stream has been allowed time to recover at which time the decision will be made and whether to retain or revise the EWH designation.

Jumping Run (02-217) (RM 3.9) (EWH/WWH Recommended)
Jumping Run is a small headwater stream (i.e., 2.4 mi.^{2} drainage) that empties into Lake Run at RM 3.00 north of Mechanicsburg. Like many other Little Darby Creek subwatershed, Jumping Run was assigned the EWH aquatic life use designation based on best professional judgement in the 1978 Water Quality Standards. Habitat evaluations conducted in 2001 revealed a channel mainly consisting of pools with bottoms of unconsolidated sediments and some detritus from agricultural sources. Included in this segment was a rocky riffle comprised of cobble, and smaller substrates along with some woody debris. A decent forest corridor was also present downstream and water temperatures were cooler. The resultant QHEI of 63.0 fell into the good range and was judged suitable for supporting WWH communities.

Treacle Creek (02-213) (RM 31.3) (EWH)
Treacle Creek has been sampled several times over the years since first evaluated in 1992. Although there have been localized problems associated with severe nutrient enrichment and sedimentation at the mouth, almost all of the other sites sampled either fully or partially met the applicable EWH biocriteria over the years. That pattern was replicated in 2001. The EWH aquatic life use designation is appropriate and should be retained.

Howard Run (02-2215) (RM 5.4) (EWH)
Previously unsampled by the Ohio EPA, Howard Run was assigned the EWH aquatic life use designation based on best professional judgement in the 1978 Water Quality Standards. Sampling in 2001 fully met applicable EWH biocriteria and therefore documented the appropriateness of the current EWH aquatic life use. Evaluation of the instream habitat revealed a site having a mix of positive and negative habitat attributes yielding a QHEI of 55.5. Only one high influence, modified habitat attribute was noted - low sinuosity. However, the site was recovering from historical channelization and given the steep overall gradient of the stream, there is sufficient energy for this site to revert to the high quality present in the rest of the stream.

Proctor Run (02-214) (RM 3.69) (EWH)
Proctor Run originates in Champaign County in the boulder belt of the Cable Moraine. It then flows almost directly east downslope through the rest of the Cable moraine and into ground moraine and Union County. Proctor Run is six miles long with a local gradient of 21.4 ft/mi , in the high range. Three sites were evaluated in Proctor Run in 2001 yielding QHEI scores ranging from 65 to 73. Positive warmwater habitat attributes predominated at all three sites. No high influence modified habitat attributes were found although moderate amounts of silt and embeddedness somewhat lowered habitat quality. A single site, RM 1.7 - upstream from Mc-Magill Road, had been evaluated previously in 1992 as well as in 2001. Although slight differences were noted between the years, overall habitat quality was judged very similar and of very good quality. Biological sampling in 1992 yielded exceptional biological communities which resulted in the EWH aquatic use designation assignment. Sampling was extended further upstream in 2001 to determine the appropriateness of the EWH use for the rest of the subwatershed. All three sites either fully or partially met EWH biocriteria verifying the accuracy of the EWH designation.

Barron Creek (02-212) (RM 24.4) (EWH/WWH)
Barron Creek, a direct tributary to Little Darby Creek, confluences just downstream from the Rosedale- Plain City Road bridge over Little Darby Creek in Madison County. Previously unsampled by the Ohio EPA, Barron Creek was assigned the EWH aquatic life use designation based on best professional judgement in the 1978 Water Quality Standards.

Barron Creek is listed in the Gazetteer of Ohio Streams as intermittent. Despite this notation, discernable flow was present during the summer of 2001, one of the driest periods on record in central Ohio. Barron Creek is a strongly groundwater influenced stream with a spring noted within the sampled reach and low water temperatures recorded (~60^{o} F). Habitat at the sites sampled has been impacted by channelization yielding low to no sinuosity, fair to poor development, silt substrates in spots, slower currents and moderate overall and riffle embeddedness. The QHEI was 44.5, in the poor range at the sampling site (RM 2.1). Currently, a large percentage of Barron Creek is under maintenance conducted by the Madison County Engineer Office. This includes the segment that was sampled downstream from the Rosedale - Plain City Road bridge over Barron Creek. Despite habitat reflective of the maintained nature of the stream channel (i.e., QHEI = 44.5), the fish community did very well and the macroinvertebrate communities did moderately good in 2001. This has led to the recommendation of a change from EWH to WWH. There is a strong suspicion that establishment of a riparian buffer would result in much better biological performance.

Wamp Ditch (02-363) (RM 23.0) (Undesignated/WWH)
Wamp Ditch originates on the east side of Little Darby Creek entering about one mile upstream from the Morris Road bridge. Local gradient is 12.5 ft/mi, in the moderate range. Habitat quality is poor (QHEI=44.5) with four high influence modified habitat attributes including recent or no recovery from channelization, no sinuosity, sparse cover and little residual pool volume. A number of moderate influence modified habitat attributes drive habitat quality further down including fair to poor development and moderate overall embeddedness. Wamp Ditch is similar to Barron Creek in many respects. A large portion of Wamp Ditch, including the segment evaluated, is under maintenance conducted by the Madison County Engineer's Office which has led to the reduced habitat quality detailed above. It is also strongly influenced by ground water with low water temperatures recorded instream (61° F). Instream biological results yielded mixed results. The macroinvertebrate communities were marginally good and in the WWH range while the fish communities were in the fair range with an IBI of 30. Given identical habitat quality ratings and similar thermal regimes, it is suspected that water chemistry problems are more pronounced than that found in Barron Creek. Since the biological communities partially meet WWH criteria, Wamp Ditch is recommended to be designated as WWH.

Spring Fork (02-211) (RM 17.46) (EWH)
Spring Fork's designation as an EWH stream was verified based on sampling conducted in 1992 just upstream from the mouth (~ RM 0.9). Sampling results recorded there rank amongst the highest in the state. The IBI of 58 places it in the 99.5th percentile. A total of 18,230 samples have been taken over the state in the past 26 years and in that time only 92 samples have achieved an IBI of 58. Sampling in 2001 extended further up along the mainstem and all sites along the length of Spring Fork either fully or partially met the EWH criteria supporting the accuracy of that aquatic life use designation for the entirety of Spring Fork.

Bales Ditch (02-362) (RM 3.64) (Undesignated/WWH Recommended)
Bales Ditch, a small tributary to Spring Fork, originates in ground moraine and flows in a general easterly direction confluencing with Spring Fork close to Plumwood, Ohio. The local gradient at the site sampled was 17.86 ft/mi placing it in the moderate high range. The stream appears to possess the potential energy adequate for recovery from habitat disruptions and the ability to transport and expel fine sediments and thus improve. A moderately wide to wide riparian buffer coupled with an undisturbed stream channel, moderately high gradient and glacial till yielded a diverse and moderately stable stream channel. Habitat quality was judged very good (QHEI=70) and easily capable of supporting WWH aquatic biological communities. Fish community results were excellent with macroinvertebrate community scores in the good range. Therefore, the recommendation is being made for Bales Ditch to be designated WWH.

Smith Ditch (02-353) (RM 31.69) (Undesignated/ EWH Recommended)
Smith Ditch originates in Madison County just north of the village of Lily Chapel. It flows in a southeasterly direction to the Madison - Franklin County line near Wrightsville where is takes on a more direct easterly course flowing through the Battelle- Darby Metropark before joining with Big Darby Creek less than 2.5 miles downstream from the confluence with Little Darby Creek. Gradient in this small direct tributary is very steep ranging between 35-40 ft/mi, in the very high range. Habitat quality was judged to be very good to excellent as a result of its coarse substrates, highly sinuous course, wooded canopy and well developed channel features. Confirmation of its ability to support EWH aquatic biological communities was secured during sampling in 2001. EWH criteria were fully met at the upstream site and partially met at the downstream site where fish did not perform to expectations.

Tributary to Smith Ditch (02-354) (RM 0.06) (Undesignated/EWH Recommended)
This very small tributary enters Smith Ditch almost at its mouth. Gradient is even steeper than found in sites sampled in Smith Ditch (i.e. 76.92 ft/mi). Gradients this steep are not optimum for supporting normal aquatic life. However, other habitat attributes were very good with coarse substrates and a good representation of cover types with deep pools and aquatic macrophytes the only significant missing elements. The stream channel was moderately to highly sinuous and possessed a wide forested buffer for a good percentage of the sampling zone. In all, the stream was judged capable of supporting very good aquatic biological communities. The fish community, in fact, was performing at the Exceptional Warmwater Habitat level. Given that level of performance and the similarities of this tributary to Smith Ditch, the decision was made to designate this small stream EWH.

Gay Run (02-298) (RM 26.48) (Undesignated/WWH Recommended)
Gay Run enters Big Darby Creek from the west approximately halfway between Darbydale and Harrisburg. Gay Run at its mouth is a losing stream, losing surface water flow to the thick layer of glacial till found along the lower valley of Big Darby Creek. As a consequence, the lower site was found to be dry when sampling was attempted during the drought conditions of 2001. In contrast the upstream site had deep pools and perennial flow with springs observed within the sampling zone. It was evaluated and sampled in 1997 and 2001 and yielded QHEIs in the mid sixties on both occasions. Gay Run clearly has habitat adequate to support WWH biological communities. The presence of perennial pools, ground water flow contribution in its upper reaches and the proximity to the high quality repopulation resource of the mainstem of Big Darby Creek are more than adequate to supercede the occasional intermittency found at the mouth and support the assignment of the WWH designation.

Hellbranch Run (02-204) (RM 26.1) (WWH - Headwaters to RM 5.0, EWH - RM 5.0 to mouth)
Concern about the effects of suburban encroachment on this significant and major tributary to Big Darby Creek has resulted in repeated sampling of this subwatershed since 1981. Although the upper reaches of the mainstem are still impacted by stressors emanating from its source tributaries, Hellbranch Run is still judged suitable for supporting WWH communities. Additionally, in the lower reaches of Hellbranch Run, instream habitat quality improves dramatically. This occurs where Hellbranch Run transitions through an area where geological settings has been characterized by the ODNR Division of Geological Survey as ground moraine/silty loam till/boulder field. In addition to a significant increase in local gradient, the

stream channel have been left relatively natural with intact riparian buffers. There was also an almost total absence of modified habitat attributes and a preponderance of WWH attributes including coarse substrates, good sinuosity, extensive cover, variety of current types, low riffle/run and overall embeddedness, and adequate residual pool volume. Based on this excellent habitat, it has long been felt that following improvements in water quality this segment of Hellbranch Run held the potential to support EWH biological communities. As improvements have been made to some of the small package WWTPs, there have been gradual improvements in biological performance to the point where marginal attainment of the EWH aquatic life use has been met in lower Hellbranch Run. Elimination of the Timberlake WWTP by 2005 will remove the main reason the most downstream site only partially meets EWH. Hellbranch Run is being recommended to be re-designated as EWH from RM 5.0 to the mouth.

<u>Hamilton Ditch</u> (02-259) (RM 11.19) (MWH - Headwaters to Feder Road (RM 2.1), WWH - Feder Road (RM 2.1) to mouth)
Although habitat quality has declined in the very headwaters of Hamilton Ditch due to construction and agricultural run-off, there are no recommendations to change use designations. Several studies are underway to determine how to improve the quality of Hellbranch Run's source tributaries. Future sampling subsequent to the implementation of any habitat improvement/water management plans will be conducted to determine the need to change the designated aquatic life uses.

<u>Clover Groff Ditch</u> (02-245) (RM 11.19) (MWH - Headwaters to Feder (RM 2.5), WWH - Feder Road (RM 2.5) to mouth)
Although habitat quality has declined in the very headwaters of Clover Groff Ditch due to construction run-off, there are no recommendations to change use designations. Several studies are underway to determine how to improve the quality of Hellbranch Run's source tributaries. Future sampling subsequent to the implementation of any habitat improvement/water management plans will be conducted to determine the need to change the designated aquatic life uses.

<u>Springwater Run</u> (02-203) (RM 24.0) (Harrisburg) (Undesignated/WWH Recommended)
This small tributary happens to drain a very narrow end moraine from the late Wisconsinan glaciation which occurs as hummocky ridges that are higher than the adjacent terrain. Local gradient was 50 ft./mi. which exceeds the very high range and, although capable of flushing fines downstream, would not be optimal for supporting aquatic life. This small tributary flows through the center of Harrisburg and was obviously channelized in the past and was observed to be recovering from that impact. The QHEI for the stream segment downstream from Main St. was 50, in the fair range. Although coarse substrates in the form of boulders, cobble and gravel were present, the moderate amount of sand also present contributed to the moderate overall and riffle embeddedness noted for this site. While not possessing optimum habitat for supporting aquatic life, this site did possess an adequate number of WWH attributes which, when associated with the ameliorative effects of the ground water augmenting the stream base flow, permitted the maintenance of a WWH aquatic community in this stream.

Tributary to Big Darby Creek (02-352) (RM 23.77) (Undesignated/WWH)
This small tributary flows from the west and confluences with Big Darby Creek just south of the State Route 762 bridge opposite of the small village of Orient. Stream gradient of this very small stream was the highest in the study area at 111.1 ft/mi. Streams with this high of gradient characteristically have a flashy hydrograph. Although water fills the stream channel after rainfall or snowmelt in many cases during normal to low flow conditions the channel will dry up to isolated pools or if receiving groundwater to interstitial flow. This was indeed the case during the sampling accomplished in 2001. The stream had interstitial flow. Despite the very low flow there were a preponderance of WWH attributes that would have scored higher under higher flow. This site received a QHEI of 61.5 and is recommended to be designated WWH.

Tributary to Big Darby Creek (02-270) (RM 20.20) (Undesignated/WWH Recommended)
This small tributary enters Big Darby Creek from the west away from any major road crossing at RM 20.2 feeds to a segment that supports some of the rarest species encountered in the Big Darby mainstem. Habitat at RM 0.8 upstream from Harrisburg - Darbyville Road had been evaluated in 1994 and during the 2001 survey. Though largely similar between the years and yielding an evaluation of excellent a slight decline was noted in 2001 (i.e., from a QHEI of 80.5 to 77.5). This was mainly due to an increase in the amount of embeddedness noted. There has been an increase in large lot residential development in the subwatershed that is probably responsible for this shift. Although this small stream is being recommended to be designated WWH based on the current instream biological performance, this stream probably has the potential to support an EWH community when water quality conditions resulting from the poorly operated package WWTPs upstream are eliminated. The only WWH attribute missing from this stream was silt free substrates, which also contributed to some of the negative attributes noted. Ground water was a strong influence on the biological composition of this stream. One fish species, the central mottled sculpin, an obligate cold water species, comprised a large percentage of the resident fauna. Sampling should be conducted after the elimination of the Dot-Mar MHP WWTP, Foxlair Farms WWTP and Clark's Lake WWTP from the subwatershed to determine at that point whether or not to retain the WWH designation or upgrade to EWH.

Greenbrier Creek (02-202) (RM 16.75) (Undesignated/WWH Recommended)
This creek debouches into Big Darby Creek from the east and some distance downstream from the Scioto-Darby Creek Road bridge. A small reservoir is situated on its very headwaters with the balance of the watershed agriculture in land use. Local gradient was >27ft./mi. which would place it in the high range. Positive WWH attributes included normal overall and riffle embeddedness. High influence modified habitat attributes included no sinuosity, sparse cover and shallow maximum depths. The QHEI score for this site was 52.5. Although less than optimal, partial attainment of the WWH use was recorded here and, therefore, that aquatic life use is being recommended.

Georges Run (02-201) (RM 14.4) (WWH)
Georges Creek enters Big Darby Creek from the west ~1.4 miles upstream from the small village of Darbyville. The stream channel for most of its course flows through a steep valley coming off the edge of Late Wisconsinan ground moraine. Local stream gradient was >58 ft/mi. which is steeper than the very high range. Due to the velocity of flows encountered at this steepness of gradient, particularly at flood stage, it is felt to be more than is optimal for the support of aquatic

life. Other habitat attributes, however, were positive. These included no channelization, coarse substrates including boulder, cobble and gravel, moderate sinuosity, moderate cover amounts, slightly greater than normal embeddedness, and deep pools. This yielded a QHEI of 61.0 with the stream judged capable of supporting WWH aquatic communities. This was verified by the concurrent biological sampling conducted.

Lizard Run (02-273) (RM 12.93) (Undesignated/LRW Recommended)
This small tributary which also flows from the west and discharges to Big Darby Creek at the village of Darbyville was found to be dry when attempted to be sampled mid-field season 2001. Subsequent trips to sample or evaluate Lizard Run have yielded similar results; Lizard Run is a true ephemeral stream. This is largely a function of the glacial geology that underlies the stream channel and results in Lizard Run becoming a losing stream with little or no flow except after rain events or snow melt periods. As a consequence of the natural ephemeral nature of this stream and the limitations imposed by this stressor, this stream is recommended to be designated as a Limited Resource Water.

A.5.1.2.2 Dual Assigned Use Recommendations

Sampling in the past in the upper Big Darby Creek watershed has provided positive indications that some of the tributaries and portions of the Big Darby Creek mainstem might be suitable for the Cold Water Habitat aquatic life use designation. The sampling conducted in 2001 and 2002 provided the opportunity to analyze the more extensive database and provide recommendations for assigning the Cold Water Habitat use (see Table A.16). The rationale and justification for assigning the Cold Water Habitat Aquatic Life use follows. It should also be pointed out that in all cases the Cold Water Habitat use designation is being recommended in concert with another aquatic life use designation, typically either Warmwater Habitat or Exceptional Warmwater Habitat. Dual aquatic life use designations have precedence in the Water Quality Standards and are appropriate. They are assigned to protect this very sensitive component of Ohio’s aquatic fauna.

Big Darby Creek Mainstem (02-200)

The upper Big Darby Creek site at RM 83.2 could be classified with a Cold Water Habitat (CWH) use. Seven cold water taxa, including the caddisfly *Diplectrona modesta*, comprised 9.1 percent of the total taxa collected. The cold water taxa totaled > 11 percent of the macroinvertebrate population collected. There was 100 feet of large, mature trees adjacent to both banks (25% open to closed canopy).

Table A.16. Cold water (CW) fish and macroinvertebrate taxa collected in the Big Darby Creek watershed during sampling conducted in 2001 and 2002

Stream	RM	#CW macroinvertebrates	#CW caddis-flies	#CW may-flies	#CW stone-flies	#CW midges	Total % CW taxa	Total % CW population	#CW fish taxa	% CW fish (by no.)
Big Darby Creek	83.2	7	1			6	9.1 %	>11%	1[a]	1.3-4%
	82.5 to 82.6*	2				2	3 %	1.1%	1	2.9-3.4 %
	80.8								1	14-19.2 %
	79.2 to 79.3	3	1			2	3.5 %	< 2 %	1	8.4 - 14 %
Little Darby Creek	41.2	6	2	1		3	11 %		1	64-85%
	39.3 to 39.6	4	1			3	4.9 %	7 %	1	38.8 %
	38.8	5	2			3	6 %	6 %	1	11.2 -12.8 %
Spain Creek	5.7	1				1	1.85%		1	17.1%
	3.4	5	1			4	6.9 %	2 %	1	18.7 %
	0.1	3	1			2	4.5 %	2.2 %	1	0.9-2%
other Little Darby Creek (to BDC @ RM 78.34)	3.4	6	1	1		4	8.3 %	4-5 %	1	16.7 %
	0.4	4			1	3	4.8 %	4-5 %	1	7.25 %

[a] No available sample at that location in 2001/2002 but was sampled in 1997 and 1999.

* Past ODOT project - moved Big Darby Creek and still in recovery.

The mottled sculpin, a cold water fish, was present at the upper three sites and slightly further downstream, but the cold water component of the macroinvertebrate population sampled at RM 82.5 had decreased to two taxa (site was downstream from the ODOT project where stream was relocated and still with limited canopy). The cold water macroinvertebrates were further affected by the lack of thick mature riparian corridor in this area where only 30-40 feet of short shrubs and grass lined the streambanks with very limited shading (50% to 25% open canopy). Eventually the riparian canopy should expand and vertical shading should increase.

The next downstream site at RM 79.3, with 40 to 100 feet of large trees and increased shading adjacent Big Darby Creek (50% open to closed canopy), had three Cold water taxa present including the caddisfly *Ceratopsyche slossonae*, but they comprised < 2 percent of the macroinvertebrate community population. The mottled sculpin still comprised 8.4 - 14.1 percent of the population collected in 2001. With the cold water macroinvertebrate taxa showing increased representation further downstream from the ODOT stream segment and mottled sculpin represented well past the confluence with Flat Branch, it is recommended to also designate Big Darby Creek with a CWH use designation from the headwaters to RM 78.5 which is just upstream from the confluence with Flat Branch (RM 78.48).

Little Darby Creek (02-251) (RM78.34)
The Little Darby Creek (Logan County) (at RM 78.34) supported six cold water macroinvertebrate taxa that comprised 8.3 percent of the taxa collected. The cold water caddisfly *C. slossonae* and the mayfly *Baetis tricaudatus* were among those collected, and the cold water macroinvertebrates were 4 - 5 percent of the collected sample population. There was 30 to 75 feet of large trees adjacent to the stream with primarily a closed canopy keeping water temperatures cooler. The cold water mottled sculpin totaled nearly 17 percent of the sampled population at RM 3.4

At RM 0.4 there was still four cold water taxa despite a thinner riparian corridor on one side. There were > 100 feet of trees on the other side, so the stream was still largely shaded with a range of only 25 percent open canopy to a completely closed canopy. Temperatures were still 66 to 68 ^{o} F, and two cold water taxa collected included a stonefly and the cold water midge *Paratanytarsus n. sp. 1*. Cold water fish were still over 7 percent of the sampled population near the mouth at RM 0.4. Based on these biological findings, the Little Darby Creek (unnamed tributary to Big Darby Creek at RM 78.34) should be also classified as CWH use designation.

Spain Creek (02-222) (RM74.3)
Spain Creek in its upstream reach was negatively affected by storm water and sediment runoff, from slumpage in open pastures, development, and a lack of consistent woody canopy. Habitat in the reach was mostly grass/weeds with small trees at 10-30 feet width with less cover further downstream. This diminished representation by macroinvertebrate cold water taxa that were present further downstream. Only one cold water midge taxon, *Parametriocnemus sp.*, was present, even though the mean temperature was 16.5^{o} C or 61-62^{o} F. The cold water fish, the mottled sculpin, was abundant. Decreasing the negative inputs by widening the riparian buffers and fencing pastures would allow more sensitive cold water taxa to reinhabit this reach, as was demonstrated downstream.

At RM 3.4, with better habitat (QHEI = 72.0) and less negative NPS inputs, five cold water macroinvertebrate taxa were present which comprised approximately seven percent of the total taxa collected and two percent of the total sampled population. Total canopy cover and shading increased significantly (>100 ft. wide riparian corridors with 25 percent open to closed canopy present), yielding a mean temperature of 65^{o} F.

Similar closed canopy and > 100 foot corridors of large trees adjacent to Spain Creek at RM 0.1 (mean water temperature of 68^{o} F.) ameliorated some of the effects of the North Lewisburg

WWTP discharge. Three cold water taxa, including the caddisfly, *C. slossonae*, were still present (4.5 percent of taxa collected) despite consistent and numerous permit violations through the 1990s. With improved treatment the sensitive cold water component of the macroinvertebrate community will increase. The cold water fish, the mottled sculpin, was represented throughout Spain Creek from 2 percent (below the WWTP) to 18 percent of the sampled population. Based on these biological findings, the recommendation is for Spain Creek to be classified also as CWH.

<u>Little Darby Creek</u> (02-210) (RM 34.1)
Little Darby Creek at Allison Road (RM 41.2), with its water temperature at 57° F., had six cold water macroinvertebrate taxa which represented 11 percent of the total taxa collected. Cold water taxa collected included the mayfly *Baetis tricaudatus* and caddisflies *Glossosoma sp.* and *Ceratopsyche slossonae*. The cold water sculpin dominated the fish community at RM 41.2 with 64 to 85 percent of the population collected.

Despite excess nutrient inputs near RM 39.3 from NPS agricultural sources (open canopy and open pasture with cows in stream and Clover Run) and municipal run-off (Mechanicsburg and possibly from the fertilizer plant) , there were still four cold water taxa present, including C. *slossonae*, representing approximately seven percent of the collected total population. Temperature at sampling was 64 ° F., and the mottled sculpin population still comprised ~39 percent of the total population.

At RM 38.8 five cold water taxa were present downstream from the Mechanicsburg WWTP discharge. The cold water taxa, which included the caddisflies *C. slossonae* and *Glossosoma sp.* and the midge *Micropsectra sp.*, totaled six percent of both the collected taxa and the sampled population. The instream temperature can be decreased if the canopy is increased by allowing more trees to grow along right bank and fencing out cows with only a couple of smaller crossing areas.

The obligate cold water fish, mottled sculpin, was found in significant numbers within the same reach ranging in abundance from almost over 85 percent at RM 41.2, Allison Road to 12 percent at RM 38.8, Wing Road.

The CWH designation is recommended for Little Darby Creek from the headwaters to ~RM 37.0 which is upstream from the confluence with Lake Run (RM 36.9).

These recommendations have been incorporated into the 2001/2002 attainment table (Table A.15) and other tables in the fish and macroinvertebrate community discussions.

Table A.17. Watercourses petitioned to be maintained under the provisions of the County Ditch Law (Chapters 6131, 6133, and 6135) by County Engineer offices within the Big Darby Creek watershed based on interviews and file searches conducted during January, 2003.

County Name	Stream Name	Maintained Segment	Distance Maintained
Logan	None in watershed	NA	NA
Champaign	Jumping Run	1.5-2.4	0.9 miles
	McMullen Ditch (Howard Run)	1.15-3.8	2.65 miles
	Fullington Ditch	0.1-2.8	2.7 miles
	Crowder Ditch	2.4-2.9	0.8 miles
Union	Bailey Ditch	0.2-0.5	0.3 miles
	Bown Ditch	13.3-14.2	0.9 miles
	Hay Run	1.1-3.85	3.75 miles
	L.R. Sugar Run	Entire length	
	Post Road Ditch		
	Prairie Run	Entire length	2.2 miles
	S.C.S. Sugar Run	Entire length	
	Wildcat Pond Ditch	Entire length	1.2 miles
Madison	Big Darby Creek	None	
	Sweeny Run	RM 4.55-3.37	1.18 miles
	Bidwell Elsey Ditch	None	
	Sugar Run	None	
	Worthington Ditch	None	
	Cary Ditch	None	
	Heafy Ditch	RM 2.90-1.60	1.30
	Ballenger Jones Ditch	RM 7.35- 3.72	3.63
	Ballenger Ditch	None	
	Powell Ditch	RM 2.73-0.81	1.92
	H.B. Beachy Ditch	RM 0.26-0.19	0.07
	Converse Ditch	None	
	Yutzy Ditch	RM 4.85-1.38	3.47
	A.W. Wilson Ditch	RM 2.85-0.75	2.10
	Ella Beach Ditch	RM 2.27-1.03	1.24
	Chandler Ditch	None	
	D.A. Fitzgerald Ditch	RM 4.65-1.75	2.90
	Bidwell Ditch		
	Bridenstine Ditch	None	

Continued

Table A.17. Continued.

County Name	Stream Name	Maintained Segment	Distance Maintained
Madison	Dry Ditch	None	
	Silver Ditch	None	
	McGuire Ditch	RM 1.42-0.60	0.82
	Thomas Ditch	None	
	Smith Ditch	RM 6.59-5.51	1.08
	McGuire Guilliland Ditch	RM 1.78-1.47	0.31
	Barron Creek	RM 5.43-0.81	4.62
	Little Darby Creek		None
	Boerger Ditch	None	
	Wamp Ditch/ Cleo Lawr. Ditch	RM 1.65-0.0	1.65
	Straley Ditch	RM 0.63-0.26	0.37
	Sanford Ditch	RM 1.08-0.40	0.68
	Bridgman Ditch	RM 1.73-0.29	1.44
	Hamilton Ditch	RM 0.83-0.58	0.25
	Kent Ditch		
	Spring Fork	None	
	Patrick Ditch	None	
	Booth Ditch	RM 2.13 - 0.43	1.70
	Bales Ditch	RM 4.26-1.72	2.53
	Chenoweth Ditch	RM 2.0-0.5	1.50
	Dun Ditch No. 2	RM 3.8-1.35	2.45
Franklin	None in watershed	NA	NA
Pickaway	Greenbrier Run	Entire length as needed	
	Georges Run	Entire length as needed	
	Springwater Run	Entire length as needed	

A.5.2 Recreation Uses

Individual water bodies are considered to attain their assigned recreation use designation when both the mean and maximum criteria values of either fecal coliform or E. coli associated with the assigned use are met.

In the vast majority of cases, the stream reaches in the Big Darby Creek watershed were in non-attainment of the E. coli bacterial criteria. However, some of the subwatershed and their individual tributaries were attaining recreational uses for fecal coliform bacteria; thus, these assessment units were deemed in attainment of the recreational standard in spite of the *E. coli* results, according to the current criteria.

Because the primary contact recreation E. coli criteria listed in the Ohio Water Quality Criteria (WQS) is the same as the bathing waters criteria (126 per 100 ml mean, 298 per 100 ml maximum), some view the criteria as being somewhat over protective, since the recreation use of these streams is Primary Contact Recreation (PCR). An E. coli target estimated to convey a similar level of public health protection as the existing PCR fecal coliform standard was developed and used for comparison in this study (336 per 100 ml mean, 626 per 100 ml maximum).

Each of the bacterial water quality criteria has a mean, expressed as a geometric mean, and a maximum value. All mean values indicated in this evaluation are geometric means. The WQS specify that the maximum bacterial criteria not be exceeded in more than 10% of the samples. Therefore, a 90th percentile was calculated from the sampling results and compared to the maximum bacterial water quality criterion. Where the geometric mean or the 90th percentile exceeded the respective targets for both of the bacterial groups (fecal coliform or E. coli), the stream was judged to be in non-attainment of its recreation use.

The WQS specify that the geometric mean bacterial standard not be exceeded, based on not less than 5 samples collected in a 30 day period. The sampling regime for the 2001 and 2002 water quality survey did not provide for all samples to be collected in a 30 day period. However, it is important that the recreation use be evaluated. U.S. EPA's draft Implementation Guidance for Ambient Water Quality Criteria (November, 2003) recommends the following guidance on this situation:

> With regard to the geometric mean component of the criteria, there has been a common misconception of how water quality data should be used to determine whether or not a waterbody has attained the applicable geometric mean value. Some states and authorized tribes have mistakenly interpreted the water quality criteria as requiring a minimum number of samples in order to determine the attainment of the geometric mean component of the water quality criteria. The confusion may have arisen because the water quality criteria recommend a monitoring frequency of five samples taken over a 30-day period. The recommendation does not intend to imply that five samples are needed before a geometric mean can be calculated. The minimum number of samples used in the 1986 water quality criteria for bacteria is for accuracy purposes only; clearly, more frequent sampling yields more accurate results when determining the geometric mean. Further in some instances averaging periods greater than 30 days may be appropriate (e.g., data collected over a recreation season). Unless specified otherwise in a state or authorized tribe's water quality standards or assessment methodology, the geometric mean should be calculated based on the *total number of samples collected* over the specified monitoring period, and used in conjunction with an upper percentile value to determine attainment of

the numeric water quality criteria (e.g. CWA §303(d) listing for fresh and marine waters.) This interpretation encourages the collection and use of data and is what has always been intended. EPA notes that this interpretation was used by the Agency when promulgating water quality standards for the Colville Confederated Tribes (40 CFR 131.35).

Ohio EPA considered the above guidance when evaluating recreation use attainment. Since the samples did not meet the 30 day window of time for strict evaluation versus the water quality criteria, it was determined that larger sample sizes would overcome this deficiency. Therefore, data was pooled by WAU (watershed assessment unit; for more information on Big Darby Creek watershed's four WAUs, see Chapter A.6), and by reach with the objective of maintaining sample sizes sufficiently large to give a good representation of the bacterial quality of the streams, as opposed to making a sampling site by sampling site analysis.

<u>Upper Big Darby Creek</u> *(headwaters to downstream Sugar Run) Subwatershed*
Recreational uses in the upper watershed were in non-attainment of the maximum PCR criteria for fecal coliform bacteria and *E. coli* when evaluating data from the entire subwatershed (Table A.18). Only two tributary streams, Flat Branch and the mainstem of Spain Creek, exceeded both the geometric mean and maximum values for both types of bacteria. Most streams exceeded the maximum for both E. coli and fecal coliform bacteria. Only one tributary within this subwatershed completely met both the mean and maximum fecal coliform recreational criteria, the Little Darby Creek in Logan County (Table A.18). The mainstem of Big Darby Creek and its tributaries are impaired in this subwatershed by bacterial contamination. Point sources of this contamination include the Flat Branch WWTP and North Lewisburg WWTP and small package WWTPs. Nonpoint sources of bacteria include runoff from urbanized areas, Honda of America, and agricultural runoff, land application of manure, runoff from feedlot, breeding facilities and pastures as well as unrestricted access of livestock to various streams in this subwatershed.

<u>Middle Big Darby Creek</u> *(downstream Sugar Run to upstream Little Darby Creek) Subwatershed*
Recreational uses in this subwatershed fell within attainment ranges for primary contact fecal coliform recreational criteria for both mean and maximum concentrations of bacteria (Table A.18). The main channel of Big Darby Creek in this segment showed complete attainment of PCR use as did most of its tributaries (Table A.18). In this subwatershed, many of the tributary streams appear to exhibit a threatened recreational attainment status as their 90th percentile values are within a few percent of the 90th percentile maximum of 2000/100 ml and in excess of the E. coli target of 626/100 ml. Both Fitzgerald Ditch and Yutzy Ditch exceeded the maximum recreational criteria for both E. coli and fecal coliform bacteria. Canaan Community MHP may be a source of bacteria as well as nonpoint sources related to agribusiness.

<u>Little Darby Creek</u> *(headwaters to Big Darby Creek) Subwatershed*
This entire subwatershed should be listed in non-attainment of the maximum recreational bacterial criteria. While the mainstem of Little Darby Creek was shown to be in attainment of fecal coliform criteria, all of the tributary streams exhibited non-attainment of the bacterial maximums except for Treacle Creek and Howard Run. Barron Creek was an example of a small stream within the Little Darby subwatershed that had extremely serious bacterial contamination which exceed both the mean and maximum criteria, likely resulting from unlimited access of livestock to the stream (Table A.18).

There are various sources of bacterial pollution in this watershed ranging from point sources such, as the Mechanicsburg WWTP and the Green Meadows MHP WWTP, to non point sources, including failing or poorly managed on-lot sewage treatment, runoff from urbanized areas, and livestock feedlots or pastures, including the reaches with unlimited access of livestock to the stream (e.g., the mouth of Spring Fork). Stream reaches that are attaining recreational criteria should be closely monitored to ensure continued attainment in this threatened subwatershed. Those streams in non-attainment should be considered as candidates for the application of best management practices to limit the input of bacteria to streams.

Lower Big Darby Creek *(Little Darby Creek to mouth) Subwatershed*
The lower Big Darby Creek subwatershed exhibited attainment of the mean and maximum PCR criteria when evaluated as a whole. Individual streams such as Georges Run, and Greenbrier Creek also showed attainment based on meeting the fecal coliform criteria. The Hellbranch Run subwatershed including Springwater Run were in non-attainment of the maximum PCR fecal coliform criteria. Development pressures along with poorly operated or aging WWTPs and failing on-site sewage disposal systems found in the Hellbranch Run subwatershed are contributing to non-attainment. Springwater Run was the only stream in this subwatershed to exceed both the mean and maximum criteria, likely due to failing on-site sewage disposal systems.

Attainment of recreational criteria in the Big Darby Creek watershed may be related to many factors including the presence of WWTPs, urbanized areas, agricultural activities, and on-site sewage disposal facilities with an important variable being available stream flow or dilution. Generally, waterbodies in the Darby watershed exhibit non-attainment where there is little or no available dilution. Watersheds with sufficient dilution, either from a large drainage area or high groundwater input (such as Big Darby Creek and Little Darby Creek), exhibit attainment of the PCR use (Table A.18). Obviously, this is not the case in areas where ongoing development[b] and its associated runoff is a factor (e.g., Hellbranch Run). Streams like Spring Fork are also in need of restoration where a combination of point source (e.g., Green Meadows WWTP) and non-point source loadings of bacteria (e.g., unlimited access of livestock to the stream) inhibit recreational use attainment.

Table A.18. Analysis of Primary Contact Recreation (PCR) use attainment in the Big Darby Creek watershed based on ambient survey data collected during 2002.

(FC - fecal coliform; EC - *E. coli*) Values in bold exceed the respective target.

Unit	Geometric Mean			90th Percentile		
	FC	EC		FC	EC	
Recreation Standard	*1000*	*126*$_a$	*336*$_b$	*2000*	*298*$_a$	*626*$_b$
Upper Big Darby (Headwaters to downstream Sugar Run) [05060001 190] (FC n=167, EC n=139)	850.2	**1131.9**	**1131.9**	**6901**	**8802**	**8802**
Upper Big Darby Creek RM 82.5-52.0 (mainstem only) (FC n=52, EC n=43)	855.4	**1282.1**	**1282.1**	**7844**	**12250**	**12250**
Flat Branch and tribs incl.Little Darby (Logan Co.) (FC n=30, EC n=24)	906.9	**1475.8**	**1475.8**	**22000**	**30027**	**30027**
Flat Branch and tribs. (FC n=20, EC n=16)	**1418.9**	**2810.1**	**2810.1**	**22616**	**35986**	**35986**
Little Darby (Logan Co.) (FC n=10, EC n=8)	370.4	**407.1**	**407.1**	1231	**1265**	**1265**
Spain Creek incl. Pleasant Run and U.T. to BDC at RM 74.91 (FC n=30, EC n=24)	**1058.8**	**994.1**	**994.1**	**3936**	**4612**	**4612**
Spain Creek (FC n=15, EC n=12)	**1208.4**	**1249.8**	**1249.8**	**4692**	**4736**	**4736**
Pleasant Run (FC n=10, EC n=8)	902.4	**754.9**	**754.9**	**3010**	**2586**	**2586**
Hay Run incl. U.T. to BDC at RM 69.40 (FC n=10, EC n=8)	780.4	**618.1**	**618.1**	**2209**	**1726**	**1726**
Buck Run (FC n=20, EC n=16)	684.1	**1133.3**	**1133.3**	**8009**	**6970**	**6970**
Robinson Run incl. Sweeney Run (FC n=14, EC n=12)	655.8	**825.1**	**825.1**	**3843**	**5963**	**5963**
Sugar Run (n=16)	405	**361**	**361**	1470	**740**	**740**

Unit	Geometric Mean			90th Percentile		
	FC	EC		FC	EC	
Recreation Standard	*1000*	*126$_a$*	*336$_b$*	*2000*	*298$_a$*	*626$_b$*
Middle Big Darby (Sugar Run to Upstream Little Darby Creek) [050600001 200] (n=28)	324.6	**300.5**	300.5	1704	**790**	**790**
Middle Big Darby Creek RM 49.5-34.1 (mainstem only) (n=12)	138.4	**146.5**	146.5	494	**562**	562
Ballenger-Jones Ditch and Worthington Ditch (n=8)	368.3	**301.9**	301.9	1858	**704**	**704**
Fitzgerald Ditch and Yutzy Ditch (n=8)	659.9	**609.0**	**609.0**	**2274**	**3749**	**3749**
Ballenger-Jones, Worthington, Fitzgerald, and Yutzy Ditches (n=16)	493.0	**428.8**	**428.8**	1897	**1810**	**1810**
Little Darby Creek (headwaters to Big Darby Creek) [050600001 210] (n=132)	476.5	**430.0**	**430.0**	**3790**	**3723**	**3723**
Little Darby Creek (mainstem) (n=49)	207.5	**158.6**	158.6	967	**928**	**928**
Clover Run, Lake Run, Jumping Run (n=15)	782.1	**842.6**	**842.6**	**4282**	**3363**	**3363**
Treacle Creek incl. Howard Run and Proctor Run (n=40)	641.0	**522.3**	**522.3**	**3329**	**2708**	**2708**
Howard Run and Proctor Run (n=20)	600.0	**530.5**	**530.5**	**4029**	**4273**	**4273**
Howard Run (n=5)	833.9	**806.7**	**806.7**	1097	**1720**	**1720**
Proctor Run (n=15)	537.6	**461.3**	**461.3**	**7075**	**6750**	**6750**
Treacle Creek (n=20)	684.8	**514.3**	**514.3**	1864	**2300**	**2300**
Spring Fork incl. Bales Ditch and Barron Creek (n=28)	**1025.0**	**988.0**	**988.0**	**17108**	**12741**	**12741**
Spring Fork incl. Bales Ditch (n=23)	526.3	**553.5**	**553.5**	**4733**	**5258**	**5258**
Barron Creek (n=5)	**21999.7**	**14203.1**	**14203.1**	**40166**	**39952**	**39952**

Unit	Geometric Mean			90th Percentile		
	FC	EC		FC	EC	
Recreation Standard	*1000*	*126a*	*336b*	*2000*	*298a*	*626b*
Lower Big Darby Creek (Little Darby Creek to the Mouth) [05060001 220] (n=122)	340.6	**315.3**	315.3	1690	**1202**	**1202**
Lower Big Darby Creek RM 27.0-3.1 (mainstem) (n=30)	104.3	116.6	116.6	292	221	221
Smith Ditch and tribs. (n=10)	377.1	**352.1**	**352.1**	955	**851**	**851**
Hellbranch Run and tribs. incl. Springwater Run (n=54)	602.2	**514.0**	**514.0**	**2200**	**2606**	**2606**
Hellbranch Run and tribs. (n=49)	541.8	**506.3**	**506.3**	**2038**	**2457**	**2457**
Springwater Run (n=5)	**1694.6**	**382.3**	**382.3**	**6534**	**1565**	**1565**
Unnamed Trib. at RM 20.20 (n=5)	606.1	**548.1**	**548.1**	1739	**1477**	**1477**
Georges Run and Greenbrier Creek (n=13)	335.3	**280.6**	280.6	730	**679**	**679**

FC = Fecal Coliform bacterial standard found in the Ohio Water Quality Standards (WQS), (OAC 3745 -1)
EC = *E. coli* bacteria
a = The current *E. coli* primary contact recreation (PCR) standard found in the Ohio WQS
b = A target *E. coli* value under evaluation as a more appropriate concentration for streams designated PCR
n = # of observations
boldface type indicates non-attainment of the recreational use, or a value exceeding the target

A.6 FINDINGS: DISCUSSION BY SUBWATERSHED

There is a growing appreciation that the quality of our water resources are integrally linked with what takes place on the adjacent landscape. And since many problems are cumulative in nature, protection of water quality requires that the analysis of problems take place at least at the subwatershed scale. To that end, the results of the 2001/2002 study are discussed here in terms of the four watershed assessment units (WAUs, interchangeable with the 11-digit USGS Hydrologic Unit Code) of the Big Darby Creek watershed.

The watershed assessment units are described in Table A.19 and depicted in Figure A.11. To assist in the development of subwatershed action plans, summaries of the study results for each of the four subwatersheds and the aquatic life use performance are provided in individual tables (Tables A.21 through A.28). Principal causes and sources of impact on aquatic life are summarized in the tables, as well as recreation uses and significant contaminants in sediment and fish tissue.

Finally, the summary tables include some information that is pertinent to Ohio's Clean Water Act Section 303(d) reporting. Each subwatershed is placed in one of five categories that are defined in federal guidance and described in the 2002 and 2004 Integrated Water Quality Monitoring and Assessment Reports (Ohio EPA, 2004a) (see Table A.20). All four subwatersheds of Big Darby Creek watershed are identified as impaired and requiring that TMDLs be developed. This TMDL work is underway and expected to be completed in 2004.

The assessment unit score is an average grade of aquatic life use status based on recommended uses. The method of calculation is presented in the 2004 Integrated Water Quality Monitoring and Assessment Reports (Ohio EPA, 2004a). An assessment unit score of 80 is used as the benchmark above which a watershed in considered to be in good condition relative to aquatic life uses. A maximum assessment unit score of 100 is possible if all monitored sites meet designated aquatic life uses.

Table A.19. Watershed assessment unit subdivisions of the Big Darby Creek watershed

Watershed Assessment Unit			Summary Tables
Number	Name	Containing Streams[a]	
05060001 190	Big Darby Creek (headwaters to downstream Sugar Run)	Big Darby Creek mainstem (RM 83.2 to RM 50.92) Flat Branch unnamed tributary to Flat Branch Little Darby Creek (Logan Co.) Spain Creek Pleasant Run Buck Run Robinson Run Sweeny Run Sugar Run unnamed tributary to Sugar Run	A.21, A.22
05060001 200	Big Darby Creek (downstream Sugar Run to upstream Little Darby Creek)	Big Darby Creek mainstem (RM 50.92 to RM 34.2) Worthington Ditch Ballenger-Jones Ditch Powell Ditch Yutzy Ditch Fitzgerald Ditch	A.23, A.24
05060001 210	Little Darby Creek	Little Darby Creek Clover Run Lake Run Jumping Run Treacle Creek Howard Run Proctor Run Barron Creek Wamp Ditch Spring Fork Bale Ditch	A.25, A.26
05060001 220	Big Darby Creek (downstream Little Darby Creek to mouth)	Big Darby Creek mainstem (RM 34.2 to RM 0.0) Smith Ditch unnamed tributary to Smith Ditch Gay Run Hellbranch Run Hamilton Ditch Clover Groff Ditch unnamed tributary to BDC (RM 23.77) unnamed tributary to BDC (RM 20.2) unnamed tributary to BDC (RM 18.41) Greenbrier Creek Georges Run Lizard Run	A.27, A.28

[a] Streams that are indented are tributary to the stream listed just above them in the column.

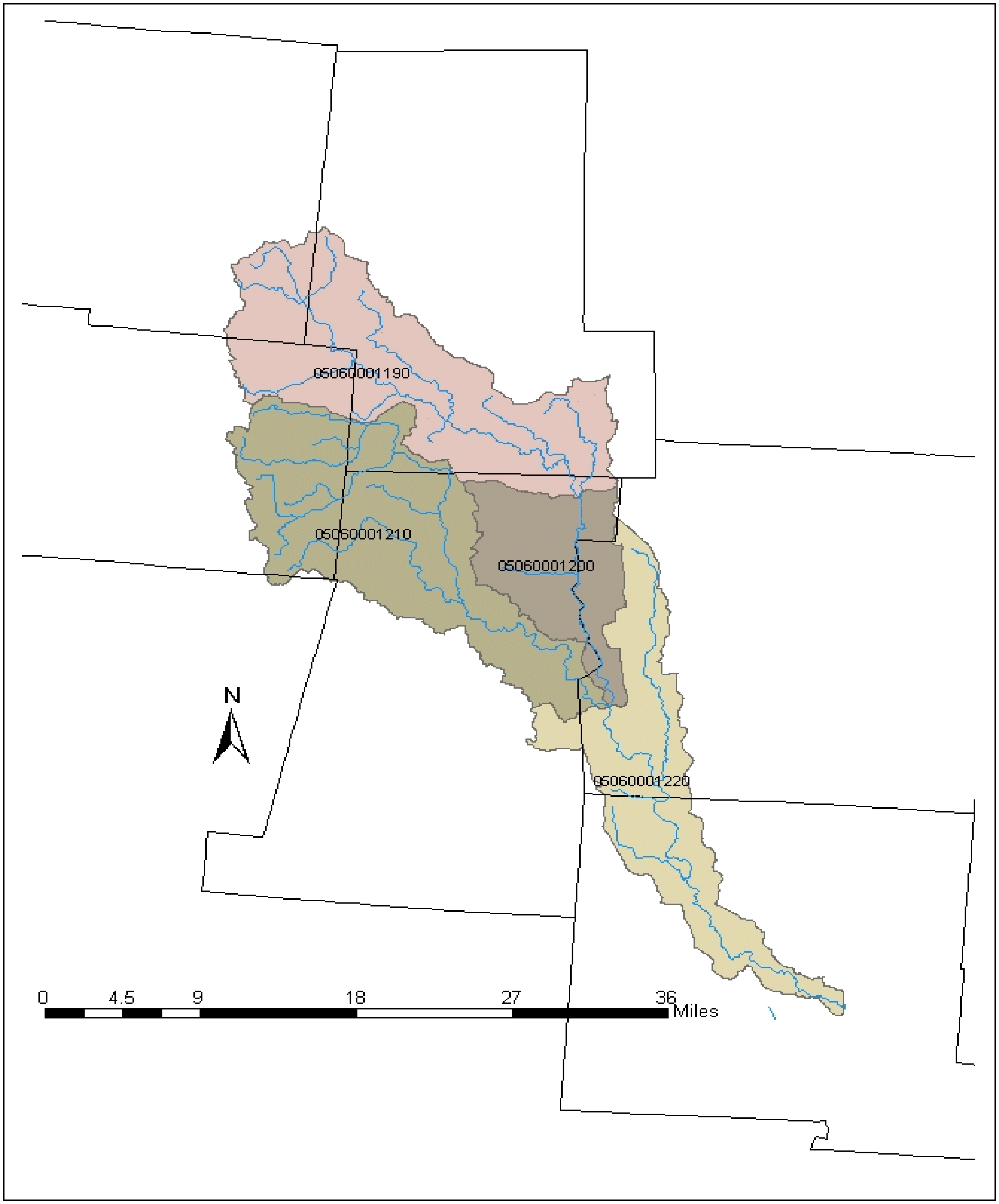


Figure A.11. The four watershed assessment units of the Big Darby Creek watershed.

Table A.20. Section 303(d) reporting categories

Category	Results of Data Assessment and Determination of WQS Use Attainment
1	All designated uses are met, and no use is threatened
2	Some of the designated uses are met but there is insufficient data to determine if all designated uses are met
3	Insufficient data to determine whether any designated uses are met
4	Water is impaired or threatened but a TMDL is not needed
4A	TMDL has been completed
4B	Other required control measures will result in attainment of WQS
4C	Impairment or threat not caused by a pollutant
5	Water is impaired or threatened and a TMDL is needed

Table A.21. Summary of findings for 05060001 190: Big Darby Creek (headwaters to downstream Sugar Run), based on sampling conducted in 2001 and 2002

Watershed Name: Scioto
93 Basin Name: Big Darby Creek
Assessment Unit Number: 05060001 190
Assessment Unit Name: Big Darby Creek (Headwaters to downstream of Sugar Run)

Stream Name(s): Big Darby Creek (headwaters to Sugar Run), Flat Branch, U.T. to Flat Branch, L. Darby Creek (Logan Co.), U.T. to BDC - RM 74.91, Spain Creek, Pleasant Run, U.T. to BDC - RM 69.4, Hay Run, Prairie Run, Buck Run, Robinson Run, Sweeney Run, Sugar Run and U.T. to Sugar Run.

Year(s) of data collection: 2001 and 2002 303(d) category: 5

Attainment status based on percentage of sampled sites < 50 mi^2

Stratification	Number of sites	Number of sites in FULL attainment	Percentage of sites in FULL attainment	Number of sites in Partial attainment	Percentage of sites in Partial attainment	Number of sites in **NON** attainment	Percentage of sites in **NON** attainment
< 5 mi^2	16	13/16	81.3%	1/16	6.3%	2/16	12.5%
5 to 20 mi^2	16	10/16	62.5%	4/16	25.0%	2 /16	12.5%
(if including < 5 mi^2 then) average			71.9%		15.7%		12.5%
>20 to 50 mi^2	2	½	50.0%	½	50.0%	0/2	0.0%
average			61.0%		32.9%		6.3%

Attainment status based on mileage in sampled segments > 50 mi^2

50 mi^2 to 500 mi^2 RM 71.5 to RM 50.92 Number of miles in segment(s) excluding "unassessed" miles	Number of miles in FULL attainment	Percentage of miles in FULL attainment	Number of miles in Partial attainment	Percentage of miles in Partial attainment	Number of miles in **NON** attainment	Percentage of miles in **NON** attainment
20.58 miles	9.35/20.58	45.4%	11.23/20.58	54.5%	0/20.58	0.0%
WAU scores		53.2		42.5		3.2

Site size vs. type	All	WWH	EWH	MWH	LRW	CWHSSH	Mixing Zone(s) (exclude from assessment status)
Number of sites < 50 mi^2	34	13	14	6	1	9	0
Number of sites > 50 mi^2	10	0	10	0	0	0	0
Total number of sites	44	13	24	6	1	9	0

Size of smallest sampled drainage area in WAU	1.3 mi^2	Size of largest sampled drainage area in WAU	150 mi^2

Table A.21. Continued.

Causes	Sources
Direct habitat alteration	Channelization, riparian removal
Siltation	Road construction
Changes in hydrology	Channelization, hardening of watershed
Nutrients	Domestic sewage, agriculture, spills, livestock breeding facility, land application of manure
Metals	Municipal point source, industrial point source
Low Dissolved Oxygen, Organic enrichment/D.O.	Municipal point source, industrial point source Spills -sewage and agricultural products

Recreation Use Assessment

Subcategory of Use: Primary Contact
Impairment: Yes

Fish Consumption Advisory (FCA) Assessment

Waters in the WAU Sampled and Assessed: Yes
FCA Issued: Yes
(See the 2004 Ohio FCA for more detailed information at "www.epa.state.oh.us/dsw/fishadvisory/index.html")
Impairment Due to FCA: Mercury and PCBs - U.S. Route 42(RM 54.1) to Alkire Road (RM 34.1)

Comments:

Big Darby Creek (020-200)
In the very headwaters of Big Darby Creek siltation and hydromodification associated with road construction has adversely affected aquatic community performance.

The lowest fish community index scores on the mainstem of Big Darby Creek were found within this WAU immediately downstream from the confluence with Flat Branch. This impact which extended a few miles downstream was judged to be due to complex mix of causes and sources of pollution. They included elevated nutrients from both the Flat Branch WWTP and Flat Branch itself which resulted in a dissolved oxygen sag in Big Darby Creek. Elevated metals from both Flat Branch and Big Darby Creek upstream from the confluence with Flat Branch were also stressors. Hydromodification and turbidity emanating from Flat Branch exacerbated the impact.

Upstream from Milford Center and downstream from Collins Road the fish community was impacted by an unknown source of stress. A quarry on the east side of Big Darby Creek may be a possible source of this stress.

Downstream from Milford Center as far downstream as the confluence with Buck Run biological communities have yet to fully recover from a spill that took place in July of 2000. Spills of agricultural products and domestic waste, dissolved oxygen depletion and organic enrichment were the causes of impairment in this reach of the mainstem. Additional spills have been recorded in this reach and may be suppressing these communities rate of recovery.

Sedimentation, elevated nutrients (e.g., sediment total - phosphorus > LEL) as well as spills from the Fairbanks HS WWTP and from a tank storage area at an adjacent agricultural business yielded partial attainment downstream from the confluence with Buck Run.

Upstream from Ranco Inc. and US Rt. 42 although marginally meeting criteria was being adversely affected by sediments and elevated nutrients which led to a dissolved oxygen sag.

At the downstream limit of the mainstem within this WAU elevated TSS, depressed dissolved oxygen values, high nutrients (i.e., NH3, TKN nitrates, nitrites, and T-P >95 ECBP background concentration), high bacterial counts and biosolids were found downstream from the Plain City WWTP contributing to the partial attainment of the EWH criteria downstream from the WWTP. Additionally, numerous spills have been documented within the Village limits of Plain City which would have subsequently drained to Sweeney Run and contributed to the impact. The site downstream from the Plain City WWTP was the only location with Dieldrin > TEC within the watershed and the presence of this banned insecticide may have also contributed to the lowered ICI scores.

Flat Branch (02-223) (RM 78.48)
Although fully meeting the biocriteria benchmarks for its designated MWH aquatic life use Flat Branch is contributing to the impacts documented in Big Darby Creek downstream from the confluence with low dissolved oxygen and high TSS values persistent downstream.

Little Darby Creek (Logan Co.) (02-251) (RM 78.34)
Although this stream is fully meeting biocriteria at the sites sampled ongoing habitat alteration has led to declines and if continued should result in future non-attainment.

Table A.21. Continued.

Buck Run (02-209) (RM 63.47)
Partial and non-attainment in the upstream reaches of Buck Run resulted from a combination of nutrient enrichment, sedimentation and livestock impacts. Mid reaches were stressed by high nitrogen and phosphorus, low dissolved oxygen (i.e., violations of the WWH minimum criteria) and TSS concentrations amongst the highest in the watershed. These impacts extended into Big Darby Creek and contributed to declines a short distance downstream in that watercourse.

Robinson Run (02-207) (RM 53.69)
The very poor results in the headwaters are due to very high nutrient concentrations which has led to low dissolved oxygen levels and black anoxic streambed sediments. Channelization has also contributed to the problems documented here. The depressed fish community scores seen at the site downstream from U.S. Route 42 are likely due to a combination of sediment contamination and water quality problems arising from Ranco Inc. One of the highest sediment ammonia concentrations (94 mg/kg) was found at this site. Arsenic and cyanide have been parameters of concern at this location. Further investigation needs to be conducted on Robinson Run bracketing Ranco Inc., the landfill and Chemfix piles with an expanded parameter list to pin down the causes and sources of this impairment.

Sweeney Run (02-357) (RM 52.11)
Sweeney Run has been subject to numerous spills over the years including diesel fuel, milk, oil, manure and material from the water treatment plant. It also receives leachate from septic systems which contributes to the high bacterial counts documented there. Additionally during mosquito season Sweeney Run within the village limits routinely receives overspray of insecticide, which may be contributing to the depressed macroinvertebrate communities in its lower reaches.

Sugar Run (02-206) ((RM 50.62)
The upstream reaches of Sugar Run are currently designated as WWH, but are recommended to be re-designated as MWH. Although biological samples met applicable biocriteria values for the recommended aquatic life use even this lower use is threatened. in upper Sugar Run. Very high nutrients, degrading habitat, and spills have led to dissolved oxygen concentrations (i.e, 2.88 mg/l) which exceed the MWH criterion, lowered biological community scores and exported stressors downstream.

The sampling site at the mouth of Sugar Run (RM 0.7) had one of the highest total phosphorus sediment concentrations in the watershed. Other Sugar Run sites had sedimentation, nutrient enrichment and low dissolved oxygen problems which yielded decreased biological community performance.

The most impacted stream locale for sediment contaminants was Sugar Run at RM 7.00. Here, arsenic concentrations were elevated as were chromium and iron. Copper, nickel, and zinc concentrations were slightly elevated (Table B.5.4). This was the only tributary that exhibited detectable concentrations of chromium and nickel as well as the highest values for copper, iron, and zinc. The Hershberger Landfill is probably source of these metals.

Recreation Uses

Recreation uses were in non-attainment of the Primary Contact Recreation maximum criteria for the entire WAU with Little Darby Creek (Logan County) the sole exception. (See Section A.5.2 for a discussion of recreational use attainment).

Sediment Quality

All sediment samples had total organic carbon and total phosphorus values that exceeded LEL concentrations. The sampling site at the mouth of Sugar Run (RM 0.7) had one of the highest total phosphorus sediment concentrations in the watershed.

Sugar Run at RM 7.00 had the highest sediment metal concentrations in the watershed. Here, arsenic concentrations were elevated as were chromium and iron. Copper, nickel, and zinc concentrations were slightly elevated (Table B.5.4). This was the only tributary that exhibited detectable concentrations of chromium and nickel as well as the highest values for copper, iron, and zinc. The Hershberger Landfill may be the source of these metals.

Fish Tissue Samples

Only one fish tissue sample exceeded the meal per week criterion for PCBs The only fish tissue sample with DDT residues of a magnitude to exceed the do not eat threshold was found at RM 63.8, upstream from Streng Road. Most fish tissues samples had mercury concentrations that fell in the one meal per week consumption category. The advisory that was issued for portions of the mainstem of Big Darby Creek within this WAU resulted from the risk assessment procedure which takes into account fish tissue samples collected from the entire mainstem. There are plans to secure additional carp samples in 2004 to match the size and number collected in lower Big Darby Creek to determine if there is a need to extend the advisory further upstream.

Table A.22. Aquatic life use attainment status for the streams sampled in Big Darby Creek watershed assessment unit **05060001 190** during July - October, 2001

Additional sampling was conducted during July - October, 2002 to fill in gaps and further characterize and evaluate impacted areas (noted in **bold**). The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI,MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities. (Last updated 03/04/03)

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Big Darby Creek (02-200) (WWH/EWH + CWH Recommended)								
-- /83.2	1.3	71.43	-	-	42^{ns}	-	(Full)	ust. At pvt prop.
82.5/82.5	1.5	43.48	52	NA	46	68.0	Full	CR 152
80.8/ --	4.4	19.61	42*	NA	-	61.0	(Non)	SR 287
79.2/79.3	5.6	12.2	48^{ns}	NA	56	64.5	Full	TR 157
Big Darby Creek (02-200) (EWH)								
78.4/78.5	19.4	12.5	37.3*	NA	52	63.5	Partial	Dst. Flat Branch
76.6/76.5	32	6.94	43*	8.91^{ns}	56	73.5	Partial	N. Lewisburg Rd.
69.5/69.4	69	5.92	52	9.24^{ns}	52	70.5	Full	Ust. Collins Rd.,ust.trib
67.0/**67.2**	81	4.35	44*	8.34*	**E**	-	**Partial**	Ust. Milford Center
66.0/66.0	**83**	**4.35**	**52**	**9.2^{ns}**	**40***	**74.5**	**Partial**	Dst. Milford Center
63.8/64.4	89	8.93	49^{ns}	8.18*	50	80.5	Partial	Ust. Streng Rd.,Buck Run
62.5/62.9	121	3.80	47^{ns}	7.52*	42^{ns}	83.5	Partial	SR 38, Dst. Buck Run
54.2/54.1	136	4.76	53	9.23^{ns}	42^{ns}	83.5	Full	US 42, ust. Ranco Inc
53.9/53.9	136	4.76	52	9.35^{ns}	E	93.0	Full	Dst US 42, dst Ranco Inc
52.5/ --	150	7.04	51	9.08^{ns}	-		(Full)	Ust SR 161&Sweeny Run
/52.1	150	5.21	-	-	52	-	(Full)	Ust.. Plain City WWTP
52.0/52.0	150	5.21	43*	8.78*	44^{ns}	81.0	Partial	Dst. Plain City WWTP
Flat Branch (02-223) (RM 78.48) (MWH)								
3.2/3.2	3.3	9.09	26	NA	G	25.5	Full	O'Dell Rd.
/2.2	9.3	6.67	-	-	MG	-	(Full)	Adj. SR 739, dst. Tribs
0.8/1.0	13.9	4.93	28	NA	50	36.5	Full	Near mouth
Unnamed Tributary to Flat Branch (02-365) (RM 1.5) (Undesignated/MWH)								
/0.1	3.5	4.42	**-**	**-**	F	36.5	(Full)	North Trib TRC
Little Darby Creek (02-251) (RM 78.34) (Logan Co.) (Undesignated/EWH + CWH Recommended)								
3.5/3.5	2.4	31.25	55	NA	54	71.5	Full	SR 287
0.4/0.4	3.9	26.32	50	NA	50	68.0	Full	CR 153
U.T. to Big Darby Creek (02-361) (RM 74.91) (Undesignated/ EWH Recommended)								
0.2/0.3	3.9	13.51	50	NA	VG^{ns}	62.5	Full	CR 153
Spain Creek (02-222) (RM 74.3) (WWH/WWH + CWH Recommended)								
5.7/5.7	3.5	22.22	44	NA	MG^{ns}	66.0	Full	Lewisburg Rd.
Spain Creek (02-222) (RM 74.3) (WWH/EWH + CWH Recommended)								
3.7/3.4	6.0	21.74	56	NA	44^{ns}	72.0	Full	Gilbert Rd.
0.1/0.1	9.1	11.36	53	NA	56	76.0	Full	Cratty Rd.
Pleasant Run (02-221) (RM 72.01) (EWH)								
4.6/4.1	4.5	22.22	54	NA	VG^{ns}	72.0	Full	Dunn Rd.
0.5/0.5	9.4	14.3	58	NA	56	59.5	Full	M'burg-P'City Rd.
U.T. to Big Darby Creek (02-360) (RM 69.4) (Undesignated/WWH Recommended)								
0.2/0.4	4.6	17.68	50	NA	G	64.5	Full	M'burg-P'City Rd.

Continued.

Table A.22. Continued.

River Mile Fish/Invert.	Drainage Area (mi²)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Hay Run (02-220) (RM 67.6) (WWH/EWH Recommended)								
0.3/0.2	5.8	7.35	54	NA	VG	52.5	Full	M'burg-P'City Rd.
Prairie Run (02-219) (RM 63.84) (Undesignated/LRW Recommended)								
0.3/ -	3.0	13.89	28	NA	**-**	**23.0**	**Full**	M'burg-P'City Rd.
Buck Run (02-209) (RM 63.74) (WWH)								
10.4/10.4	5.1	5.99	26*	NA	MG[ns]	40.0	Non	Allen Ctr. -P'burg Rd.
7.8/7.8	9.2	6.58	28*	NA	G	55.5	Partial	SR 245
5.0/5.0	18.1	4.83	-	-	MG[ns]	-	(Full)	Milford-Amrine Rd.
0.1/0.6	29.7	6.71	44	7.14*	MG[ns]	70.5	Full	Orchard Rd.
Robinson Run (02-207) (RM 53.69) (WWH)								
/5.5	4.6	6.71	-	-	VP*	-	Non	Dst. Hawn Rd.
2.1/2.1	8.4	9.35	30*	NA	F*	64.0	Non	SR 736
0.7/0.8	11.5	15.87	30*	NA	MG[ns]	70.0	Partial	US 42
Sweeny Run (02-357) (RM 52.11) (Undesignated/WWH Recommended)								
0.1/0.2	4.0	31.25	46	NA	F*	58.0	Partial	Mouth
Sugar Run (02-206) (RM 50.92) (WWH/MWH Recommended)								
7.5/7.7	4.1	7.52	26	NA	F	31.0	Full	Ind.Pkwy.@farm
Sugar Run (02-206) (RM 50.92) (WWH)								
7.0/6.9	9.5	7.52	26	NA	MG[ns]	29.5	Full	Taylor rd.,Dst.landfill
5.4/5.5	11.0	5.21	34*	NA	G	38.5	Partial	US 42
0.5/0.5	19.4	7.69	40	NA	VG	65.5	Full	Cemetery Pike
U.T. to Sugar Run (02-358) (RM 7.39) (Undesignated/MWH Recommended)								
0.1/0.1	5.0	3.73	30	NA	MG	27.0	Full	Ind.Pkwy.

* Significant departure from ecoregion biocriteria; poor and very poor results are underlined.

** Attainment status not applied to mixing zones.

ns Nonsignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).

a Narrative evaluation is used in lieu of ICI for qualitative samples (E=Excellent, VG=Very Good, G=Good, MG=Marginally good, F=Fair, P=Poor, VP=Very Poor).

b Qualitative Habitat Evaluation Index (QHEI) values based on the most recent version (Rankin 1989).

c Use attainment status based on one organism group is parenthetically expressed.

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWHd
IBI - Headwaters/Wading	40	50	24
Mod. Iwb - Wading	8.3	9.4	5.8
ICI	36	46	22

d - Modified Warmwater Habitat for channel modifications.

Table A.23. Summary of findings for 05060001 200: Big Darby Creek (downstream Sugar Run to upstream Little Darby Creek), based on sampling conducted in 2001 and 2002

Watershed Name: Scioto
93 Basin Name: Big Darby Creek
Assessment Unit Number: 05060001 200
Assessment Unit Name: Big Darby Creek (Downstream Sugar Run to upstream Little Darby Creek)

Stream Name(s): Big Darby Creek mainstem (Downstream Sugar Run to upstream Little Darby Creek), Worthington Ditch, Ballenger-Jones Ditch, Yutzy Ditch, and Fitzgerald Ditch.

Year(s) of data collection: 2001, 2002 303d category: 5

Attainment status based on percentage of sampled sites < 50 mi^2

Stratification	Number of sites	Number of sites in FULL attainment	Percentage of sites in FULL attainment	Number of sites in Partial attainment	Percentage of sites in Partial attainment	Number of sites in **NON** attainment	Percentage of sites in **NON** attainment
< 5 mi^2	2	½	50.0%	0/2	0.0%	½	50.0%
5 to 20 mi^2	2	½	50.0%	½	50%	0/2	0.0%
(if including < 5 mi^2 then) average			50.0%		25.0%		25.0%
>20 to 50 mi^2	0	NA	NA	NA	NA	NA	NA
average			50.0 %		25.0%		25.0%

Attainment status based on mileage in sampled segments > 50 mi^2

50 mi^2 to 500 mi^2 RM 50.92 to RM 34.1 Number of miles in segment(s) excluding "unassessed" miles	Number of miles in FULL attainment	Percentage of miles in FULL attainment	Number of miles in Partial attainment	Percentage of miles in Partial attainment	Number of miles in **NON** attainment	Percentage of miles in **NON** attainment
16.82 miles	11.65/16.82	69.3%	6.42/16.82	30.73%	0/16.82	0.0%
WAU scores		59.6		27.9		12.5

Site size vs. type	All	WWH	EWH	MWH	LRW	CWHS SH	Mixing Zone(s) (exclude from assessment status)
Number of sites < 50 mi^2	4	4	0	0	0	0	0
Number of sites > 50 mi^2	4	0	4	0	0	0	0
Total number of sites	8	4	4	0	0	0	0

Size of smallest sampled drainage area in WAU	4.3 mi^2	Size of largest sampled drainage area in WAU	253 mi^2

Table A.23. Continued.

Causes	Sources
Nutrients	Spills, agricultural run-off, domestic sewage
Low dissolved oxygen	Spills, agricultural run-off, domestic sewage
Organic enrichment	Non-irrigated crop production
Habitat alteration	Channelization, riparian removal
Sedimentation	Channelization, riparian removal

Recreation Use Assessment

Subcategory of Use: Primary Contact
Impairment: Yes

Fish Consumption Advisory (FCA) Assessment

Waters in the WAU Sampled and Assessed: Yes
FCA Issued: No
(See the 2004 Ohio FCA for more detailed information at "www.epa.state.oh.us/dsw/fishadvisory/index.html")
Impairment Due to FCA: Yes (Channel Catfish: Mercury, PCBs entire length of Big Darby Creek within WAU)

Comments:

Big Darby Creek (02-200)
The upstream reach of Big Darby Creek within this WAU (i.e., RM 49.5) has carryover impacts from the Plain City WWTP, Sweeney Run and Sugar Run. These include high TSS, biosolids, spills (primarily to Sweeney Run) and low dissolved oxygen. The pooled nature of this segment of the stream has a tendency to exacerbate the problems associated with nutrient enrichment due to extended retention times and lower re-aeration rates. However, this does have the benefit of reducing downstream transport of nutrients.

Full recovery to EWH levels of community performance were evident from Interstate Route 70 (RM 42.1) to the downstream terminus of this WAU. This was due to a combination of factors. Despite the presence of several point sources most were of small volume, many of which discharged primarily to small tributaries. Several of the direct dischargers have been upgraded and documented to be operating within permit limits. One of the largest dischargers, Olen

Corporation ceased operation in 2003. Another major potential source of stress, nonpoint source (NPS) inputs, was ameliorated by the relatively intact wide and wooded riparian buffers present throughout most of this reach. Instream gradient was adequate to flush contributed fines and the intact nature of the stream channel had the net result of a gradual improvement in habitat quality from upstream of exceptional to extraordinary downstream.

Fitzgerald Ditch (02-272) (RM 44.96) - Fitzgerald Ditch is partially meeting the WWH aquatic life use designation in its lower reaches. The reasons for the partial departure from expectations are stream dessication, nutrient enrichment, inadequate dechlorination and modest habitat degradation.

Sediment Quality

Very few organic compounds were detected in the sediments sampled in the Big Darby Creek watershed and no organic compounds were detected in samples from this WAU. However sampling sites from the mainstem just upstream this WAU did have detections of acetone and dieldrin. The dieldrin might be of concern since it was found at levels, just downstream from the Plain City WWTP, at a concentration greater than a threshold effect concentration (TEC, MacDonald, 2000). This concentration of dieldrin, an insecticide, may have contributed to the decline in the ICI, total EPT taxa and sensitive macroinvertebrate taxa documented downstream from Sweeney Run and the Plain City WWTP. Since there are significant depositional areas within this WAU immediately downstream it is not unreasonable to suspect that there might be sinks of this compound there.

All sediment samples taken within the WAU revealed total organic carbon concentrations and total phosphorus concentrations exceeding the LEL. The sampling site at the mouth of Sugar Run (RM 0.7), which discharges directly to this WAU, had one of the highest total phosphorus sediment concentrations in the watershed.

Fish Tissue Samples

PCB contamination in general was not a significant issue within this WAU based on samples collected. Only one channel catfish collected at RM 49.5, upstream from Amity Pike, had a value that would place it in the one meal per week category. All other samples had values less than the method detection limit. Mercury, a pervasive problem throughout the Midwest, was found in all samples taken within this WAU. More higher mercury tissue values were found in the mainstem of Big Darby Creek within this WAU than anywhere else within the watershed. One third of the samples fell into the one meal per month range for mercury with the site at RM 49.5, upstream from Amity Pike, accounting for four of the samples.

Table A.24. Aquatic life use attainment status for the streams sampled in the Big Darby Creek watershed assessment unit **05060001 200** during July - October, 2001

Additional sampling was conducted during July - October, 2002 to fill in gaps and further characterize and evaluate impacted areas (noted in **bold**). The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities.

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Big Darby Creek (02-200) (EWH)								
49.5/49.7	171	4.69	48[ns]	8.3*	56	76.0	Partial	Ust. Amity Pike
42.0/42.1	240	7.40	55	9.87	50	81.5	Full	Ust. US Rt 70
38.9/**38.9**	247	3.97	51	9.01[ns]	**52**	82.5	**Full**	Dst. L.D. Estates WWTP
34.1/34.2	253	4.48	55	10.14	52	93.5	Full	Ust. Little Darby Creek
Worthington Ditch (02-356) (RM 50.62) (Undesignated/WWH Recommended)								
0.2/0.2	4.4	20.83	<u>24</u>	NA	MG[ns]	--	Non	P'city-G'ville Rd.
Ballenger-Jones Ditch (02-355) (RM 49.68) (Undesignated/WWH Recommended)								
0.4/0.2	6.0	15.15	40	NA	E	69.0	Full	P'city-G'ville Rd.
Yutzy Ditch (02-364) (RM 47.1) (Undesignated/WWH Recommended)								
0.4/0.4	4.3	27.03	-	-	MG[ns]	NA	(Full)	P'city-G'ville Rd.
Fitzgerald Ditch (02-272) (RM 44.96) (Undesignated/WWH Recommended)								
0.5/0.5	5.1	33.33	32*	NA	MG[ns]	56.5	Partial	P'city-G'ville Rd.

* Significant departure from ecoregion biocriteria; poor and very poor results are underlined.
** Attainment status not applied to mixing zones.
ns Nonsignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).
a Narrative evaluation is used in lieu of ICI for qualitative samples (E=Excellent, VG=Very Good, G=Good, MG=Marginally good, F=Fair, P=Poor, VP=Very Poor).
b Qualitative Habitat Evaluation Index (QHEI) values based on the most recent version (Rankin 1989).
c Use attainment status based on one organism group is parenthetically expressed.

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWHd
IBI - Headwaters/Wading	40	50	24
Mod. Iwb - Wading	8.3	9.4	5.8
ICI	36	46	22

d - Modified Warmwater Habitat for channel modifications.

Table A.25. Summary of findings for 05060001 210: Little Darby Creek, based on sampling conducted in 2001 and 2002 and based on recommended uses

Watershed Name: Scioto
93 Basin Name: Big Darby Creek
Assessment Unit Number: 05060001 210
Assessment Unit Name: Little Darby Creek

Stream Name(s): Little Darby Creek mainstem, Clover Run, Lake Run, Jumping Run, Treacle Creek, Howard Run, Proctor Run, Barron Creek, Wamp Ditch, Spring Fork, Bales Fork.

Year(s) of data collection: 2001, 2002 303d category: 5

Attainment status based on percentage of sampled sites < 50 mi^2

Stratification	Number of sites	Number of sites in FULL attainment	Percentage of sites in FULL attainment	Number of sites in Partial attainment	Percentage of sites in Partial attainment	Number of sites in **NON** attainment	Percentage of sites in **NON** attainment
< 5 mi^2	6	3/6	50.0%	3/6	50.0%	0/6	0.0%
5 to 20 mi^2	14	8/14	57.1%	6/14	42.9%	0/14	0.0%
(if including < 5 mi^2 then) average			53.6%		46.5 %		0.0%
>20 to 50 mi^2	5	4/5	80.0%	0/5	0.0 %	1/5	20.0%
average			66.8%		23.3%		10.0%

Attainment status based on mileage in sampled segments > 50 mi^2

50 mi^2 to 500 mi^2 RM 31.35 to RM 0.0 Number of miles in segment(s) excluding "un-assessed" miles	Number of miles in FULL attainment	Percentage of miles in FULL attainment	Number of miles in Partial attainment	Percentage of miles in Partial attainment	Number of miles in **NON** attainment	Percentage of miles in **NON** attainment
31.35 miles	28.05	89.5%	3.3	10.5%	0	0.0%
WAU scores		78.2		16.9		5.0

Site size vs. type	All	WWH	EWH	MWH	LRW	CWHS SH	Mixing Zone(s) (exclude from assessment status)
Number of sites < 50 mi^2	26	6	20	0	0	3	0
Number of sites > 50 mi^2	11	0	11	0	0	0	0
Total number of sites	37	6	31	0	0	3	0

Size of smallest sampled drainage area in WAU	2.6 mi^2	Size of largest sampled drainage area in WAU	176 mi^2

Table A.25. Continued.

Causes	Sources
Unknown toxicity	Spills
Sedimentation	Pasture land, habitat disruption, channelization
Nutrients	Pasture land, agricultural run off
Low dissolved oxygen	Domestic sewage, pasture land, agricultural run off

Recreation Use Assessment

Subcategory of Use: Primary Contact
Impairment: Yes (maximum criteria)

Fish Consumption Advisory (FCA) Assessment

Waters in the WAU Sampled and Assessed: Yes
FCA Issued: No
(See the 2004 Ohio FCA for more detailed information at "www.epa.state.oh.us/dsw/fishadvisory/index.html")
Impairment Due to FCA: Yes (PCBs - Little Darby Creek threatened See Ohio 2004 Integrated Water Quality Monitoring and Assessment Report Section 7.2 and Table 7-1)

Comments:

Little Darby Creek (02-210) (RM 34.1)
The very headwaters of Little Darby Creek also appears to be suitable for co-designating as CWH. Several lines of evidence point to that conclusion including measured low mean water temperatures, the presence of the requisite number of coldwater macroinvertebrate taxa and the obligate coldwater mottled sculpin. The recommendation is being made to designate Little Darby Creek from its headwaters to RM 37.0 just upstream from the confluence with Lake Run. Although all macroinvertebrate sites on the Little Darby Creek mainstem met either the recommended or current EWH ICI biocriterion there were indications of challenges to this continued level of performance. Impairments to the fish communities were the main reason for partial attainment of the EWH use which was limited to the upper third of the mainstem.

Little Darby Creek upstream from Mechanicsburg as mentioned above is strongly influenced by cool ground water. It is also strongly influenced by the upstream land use which is pasturage. This has led to false bank formation and the transport of silt and fines downstream smothering substrates and increasing embeddedness. This has led to variable sampling results over time and in the most recent a fish community that did not meet the EWH criteria. The high gradient and strong influx of clean, cool ground water though provide the potential for swift recovery.

The next sampling site was downstream of State Route 29, RM 39.6, where Little Darby Creek winds southeast and east just south of most of Mechanicsburg. This site was also downstream from the confluence with Clover Run and just downstream from a fertilizer / feed distributor storage facility and an open pasture with unrestricted access of livestock to the stream. Fish community scores here appeared to be impaired as a result of historic spills, nutrient enrichment and some sedimentation associated with pasturage.

Downstream from the Wing Road bridge, RM 38.8, untreated sewage discharged from an unpermitted bypass pipe was responsible for the impact to the fish community. The macroinvertebrates sampled just upstream from the pipe were not impacted clearly documenting the culpability of this discharge to the impact. Little Darby Creek should be re-evaluated after the bypass pipe has been sealed and the Mechanicsburg WWTP upgraded.

The next stream segment suffering declines was immediately downstream from the confluence with Treacle Creek and upstream from Axe Handle Road. This segment had previously supported EWH communities and habitat quality had not significantly declined. In 2001 this site dropped below the EWH range. The loss of intolerant species and the fairly low number on non-tolerant individuals were the metrics showing the greatest deviation from expectations. Problems associated with nutrient enrichment and its consequent effects on dissolved oxygen appear to be strong candidates for the depressed fish community results. Continuous dissolved oxygen monitoring has revealed dissolved oxygen dropping below EWH minimums upstream from the bridge and in the downstream reaches of Treacle Creek, whose confluence is immediately upstream.

Fish community scores in general gradually increased with increasing downstream distance towards the mouth. The major exception to this pattern was the site just upstream from the confluence with Big Darby Creek which is marginally meeting EWH criteria. This site is located in an area that prior to the mid 1990s was impounded by a dam across the mouth of Little Darby Creek. As sediments are flushed and more natural features develop this portion of Little Darby Creek is expected to perform at levels comparable to those found just upstream.

Clover Run (02-218) (RM 39.8)
Clover Run is fully meeting the recommended WWH aquatic life use designation biocriteria for both fish and benthic macroinvertebrates. The significant presence of the obligate coldwater mottled sculpin and the facultative cool water blacknose dace as well as a handful of cold water macroinvertebrate taxa suggest that Clover Run might have been suitable for the Coldwater Habitat ALU in the past. However the removal or thinning of the riparian buffer and

sedimentation had lowered biological performance to the point that use designation is not currently being proposed.

Lake Run (02-216) (RM 36.9)
Lake Run was designated in the 1978 WQS as EWH based on best professional judgement. Current sampling has revealed biological communities that are only partially meeting the current EWH biocriteria as a consequence of a recent and temporal impact (i.e., inadequate implementation of erosion and storm water BMPs that have delivered excess sediment to the stream channel). It is felt that given time for the disturbed land to stabilize with vegetation and the contributed sediment to be flushed downstream this high gradient stream should easily be able to fully meet the EWH criteria. The current EWH designation has therefore been recommended to be retained. The asterisk denoting that the designation needs to be verified by survey will also be retained in the WQS table to permit resampling in a few years after the stream has been allowed time to recover and determine the true quality and the appropriate aquatic life use designation.

Jumping Run (02-217) ((RM 3.9)
Siltation and episodic nutrient enrichment were judged to be the causes for the partial attainment of the recommended WWH biocriteria in Jumping Run.

Treacle Creek (02-213) (RM 31.3)
Treacle Creek, currently designated EWH its entire length, partially met criteria in it headwaters and is in non-attainment towards its mouth. Habitat although solidly in the very good range is less than generally expected to yield EWH communities. This is a common trait in many of the streams that drain the Cable moraine, particularly those streams draining the boulder belt. One attribute that repeatedly appears is the cooler water temperatures found in these streams, including Treacle Creek. Siltation and elevated nutrients were thought to be the cause of the slightly lowered values in the headwaters. A wide variety of stressors were adversely affecting biological communities towards the mouth of Treacle Creek. Poor habitat resulting from channelization and free access livestock pasturage has resulted in all native substrates being covered in a thick layer of soft, unconsolidated clays and silts. High fecal coliform bacteria and elevated nutrients also contributed to the decline which extended its reach into Little Darby Creek.

Howard Run (02-215) (RM 5.4)
A small tributary to Treacle Creek is fully meeting EWH biocriteria. Cooler water and a largely closed canopy helped to lessen the impacts from NPS inputs. Reducing siltation, widening the woody riparian corridor and permitting natural recovery from past channelization would improve the quality of Howard Run. These actions would also reduce sedimentation and nutrient inputs to Treacle Creek and in turn improve that receiving stream.

and sandy substrates with an increased sediment bedload. There were also indications of modest nutrient enrichment and very high fecal coliform bacteria counts (i.e., >40,000/100 ml.) measured here could have been agricultural runoff and/or from failing septic systems.

Barron Creek (02-212) (RM 24.4)
Barron Creek performed much better than would be predicted based on a cursory evaluation of channel morphology and instream habitat quality. Barron Creek is currently under ongoing maintenance by the Madison County Engineer's Office. A large percent of the watercourse has been channelized yielding an open canopy and groomed grass buffer strips. Excess nutrient inputs caused enrichment with gross algal production and large stands of emergent aquatic macrophytes. Substrates in the bottom of shallow pools were black and anoxic from the accumulated decaying detritus. Cool ground water inputs appear to have ameliorated the impacts that would normally be associated with the elevated levels of nutrients documented in Barron Creek. Establishing a wooded riparian buffer Barron Creek would benefit the aquatic communities locally and Little Darby Creek downstream from the confluence.

Wamp Ditch (02-363) ((RM 23.0)
Wamp Ditch, a small direct tributary to Little Darby Creek, is one of the few that drain into Little Darby Creek from the east. A significant portion of Wamp Ditch is under maintenance by the Madison County Engineer's Office. However, in this case the ameliorating effects of ground water augmentation did not appear to be as effective in reducing the impacts associated with the adjacent land use, instream habitat degradation and nutrient enrichment as it had been in Barron Creek. Wamp Creek possessed similar habitat, and also had significant ground water contribution leading to the conclusion that the water chemistry was probably more severely impacted. Unfortunately no water chemistry samples were taken. In view of the partially meeting of the WWH criteria the stream is being recommended to be designated as WWH. Future monitoring should include water chemistry sampling in addition to the biological and habitat quality monitoring. Restoration of a woody riparian buffer would also benefit Wamp Ditch and the sensitive portion of Little Darby Creek which receives Wamp Ditch water.

Spring Fork (02-211) (RM 17.46)
Spring Fork had a mix of full and partial attainment of the EWH use along its length. As was the case in many of the Little Darby Creek tributaries nutrient enrichment was a significant contributor to the lessened performance and partial attainment seen. Although habitat quality was in the good range throughout most of the reach sampled siltation and sedimentation were felt to have reduced overall performance. Lack of access downstream from the Green Meadows Mobile Home Park WWTP limited the ability to accurately assess the full impact of that point source. However, it was possible to determine that the WWTP was responsible for some of the highest nutrient concentrations in the subwatershed (including ammonia) and that there was a dissolved oxygen sag downstream from the WWTP which approached or exceeded the EWH minimums. Efforts to improve the quality of effluent leaving this WWTP will benefit the

downstream reaches of Spring Fork and the sensitive reach of Little Darby Creek that receives water from Spring Fork.

Bales Ditch (02-362) (RM 3.64)
Bales Ditch possessed very good instream habitat (QHEI - 70). Gradient in the moderate - high range indicates the potential energy to recover from habitat disruptions and to transport and expel fine sediments and thus improve. A moderately wide to wide riparian buffer coupled with an undisturbed stream channel, moderately high gradient and glacial till yielded a diverse and moderately stable stream channel. The habitat was judged to be easily capable of supporting a WWH aquatic biological community and yielded an excellent fish community and a good macroinvertebrate community. Again, cool ground water inflow appeared to have ameliorated the effects of elevated nutrient concentrations.

The Little Darby Creek subwatershed has benefitted greatly by the contribution of ground water to a large percentage of its tributaries. Comparable instream habitat and equivalent concentrations of nutrients in this system without the ground water would have led to a much higher percentage of Warmwater Habitat streams with more widespread and more severe impairment. Thus, recovery can be much quicker if protective measures are taken. Additionally, every effort should be made to protect the aquifer that is supplying cool water to this unique oasis of biodiversity.

Sediment Quality
Very few organic compounds were detected in the sediments sampled in the Big Darby Creek watershed and none were found within the Little Darby Creek subwatershed.

Nutrient analysis for sediments included both ammonia, total phosphorus, and total organic carbon. The third highest concentration in the watershed for ammonia was on Little Darby Creek at RM 15.3 (U.S. Route 42) which may be due to NPS runoff (57 mg/kg). There has been a slight decrease in macroinvertebrate community quality here over time. The highest total phosphorus concentration in the entire watershed was also found at RM 15.3 in Little Darby Creek.

Total organic carbon was found in the Little Darby Creek WAU at concentrations above the lowest effect level (LEL, Persaud and Jaagumagi, 1993). Total organic carbon values in Little Darby Creek (2.2 mg/kg - 5.0 mg/kg) were comparable to values documented in other ECBP tributary streams in central Ohio, such as Bokes Creek (2.5 mg/kg -3.5 mg/kg) and Olentangy River tributary streams (1.5 mg/kg - 9.4 mg/kg) (Ohio EPA 2000 and Ohio EPA 2001).

Sediment total phosphorus was evaluated at all but two sites on Little Darby Creek and all exceeded LEL concentrations. The high total phosphorus concentration in sediments in the watershed was found at Little Darby Creek (RM 15.3). Non-point sources of total phosphorus are likely responsible for the value found at RM 15.30 in Little Darby Creek since there are no point sources nearby. There has been a slight decline in macroinvertebrate community quality over time at this site.

Fish Tissue Contamination

A total of 22 samples were collected from this WAU. All samples were taken from the mainstem of Little Darby Creek extending from RM 29.5, Axe Handle Road downstream to the mouth. Only two of the samples had PCB concentrations that were greater than method detection limits. Both of these samples were taken at RM 0.7 and had concentrations that would place them in the high one meal per week range. Mercury values for most sites and samples fell in the one meal per week range with two samples just over into the one meal per month range. Three samples fell into the unlimited consumption concentration range, which is a fairly unusual occurrence for samples from the Midwest. Two of those samples were taken from RM 24.4, Rosedale-Plain City Road.

Recreation Use

The entire Little Darby Creek WAU is not meeting the primary contact maximum bacterial standard. While the mainstem of Little Darby Creek was shown to meet the criteria, most of the tributary streams did not, in many cases doubling the water quality criterion of 2,000 fecal coliform bacteria per 100 ml. Howard Run was an exception amongst the tributaries as was the mainstem of Treacle Creek. Both streams met recreational criteria, although when taken in its entirety, the Treacle Creek subwatershed was in non-attainment. Barron Creek was an example of a small stream within this subwatershed that had extremely serious bacterial contamination, likely resulting from unlimited access of livestock to the stream.

Various sources of bacterial pollution exist in this watershed, ranging from poorly operated WWTPs to on-lot sewage treatment systems, livestock feedlots or pastures as well as the reaches with unlimited access of livestock to the stream. Stream reaches that are attaining recreational standards should be closely monitored to ensure continued attainment as the situation seems threatened by the bacterial pollution noted in many of the tributary streams.

Table A.26. Aquatic life use attainment status for the streams sampled in the Big Darby Creek watershed assessment unit **05060001 210** during July - October, 2001 and based on recommended uses

Additional sampling was conducted during July - October, 2002 to fill in gaps and further characterize and evaluate impacted areas (noted in **bold**). The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) and macroinvertebrate communities (ICI).

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Little Darby Creek (02-210) (RM 34.1) (EWH + CWH Recommended)								
41.2/41.2	3.3	43.47	42*/**48**	NA	VG[ns]	80.5/**70**	Part/**Full**	Alison Rd.
39.6/39.3	9.4	13.33	42*	NA	48	69.5	Partial	Ust SR 29dst fert.dist.
38.8/38.8	13.2	12.99	35*	NA	48	82.0	Partial	Wing Rd. Dst M'burg WWTP
Little Darby Creek (02-210) (RM 34.1) (EWH								
34.7/34.6	25.9	4.72	49[ns]	NA	56	82.5	Full	Irwin Rd.
- /**33.2**	28.0	4.50	-	-	**54**	-	**(Full)**	Ust. R.dale-Mford Center Rd.
29.5/29.4	70.0	2.67	45*	8.8*	50	66.5	Partial	Axe Handle Rd.
26.6 /**26.5**	72.0	21.7	**54**	**10.0**	**52**	**58.0**	**Full**	Dst. Chuckery
24.5/24.5	83.0	2.02	52	9.3[ns]	58	62.5	Full	Rosedale-Plain City Rd.
23.1/**23.2**	89.0	2.02	**48[ns]**	**9.5**	**E**	**55.5**	**Full**	Dst. Finley -Guy Rd.
20.5/**20.5**	98.0	3.18	**56**	**9.3[ns]**	**48**	**64.5**	**Full**	Ust. Arthur Bradley Rd.
/17.0	142	4.42	-	-	48	-	(Full)	Adj. L. Darby Rd.
15.3/15.4	151	2.69	57	9.6	50	95.5	Full	US 42
/**15.3**	151	2.69	-	-	**46**		**(Full)**	Dst. US 42
6.5/6.4	163	8.47	58	9.3[ns]	54	95.5	Full	US 40, Ust W. Jeff WWTP
4.1/3.8	170	5.59	55	9.7	52	99.0	Full	Roberts Rd. Dst WWTP
0.2/0.5	176	9.9	49[ns]	9.0[ns]	56	77.5	Full	Mouth @ Metropark
Clover Run (02–218) (RM 39.8) (EWH/WWH Recommended)								
0.6/0.6	2.0	47.62	36[ns]	NA	VG	60.0	Full	Rd to Maple Grove Cem.
Lake Run (02-216) (RM 36.9) (EWH/EWH Deferred)								
0.9/0.9	6.0	16.39	42*	NA	VG[ns]	71.0	Full	SR 4
Jumping Run (02-217) (RM 3.9) (EWH/WWH Recommended)								
0.3/0.2	2.4	16.67	30*	NA	G	63.0	Partial	SR 559
Treacle Creek (02-213) (RM 31.3) (EWH)								
11.8/11.7	5.7	15.63	40*	NA	VG[ns]	67.5	Partial	M'burg-Belle. Rd.
8.3/8.3	10.3	34.48	52	NA	E	67.5	Full	Eagle Rd.
6.0/6.0	17.0	16.13	48[ns]	NA	VG[ns]	66.5	Full	SR 161 at Irwin
0.8/0.7	37.3	3.45	-	-	MG*	29.5	(Non)	Covered bridge nr. mouth
Howard Run (02-215) (RM 5.4) (EWH)								
0.5/0.6	2.6	13.27	52	NA	VG[ns]	55.5	Full	McMahill Rd.
Proctor Run (02-214) (RM 3.69) (EWH)								
4.9/4.9	3.9	41.67	42*	NA	VG[ns]	71.5	Partial	Park Rd.
3.1/3.2	9.1	22.22	48[ns]	NA	VG[ns]	65.0	Full	SR 559
1.6/1.7	10.0	12.35	52	NA	E	73.0	Full	McMahill Rd.

Continued.

Table A.26. Continued.

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Barron Creek (02-212) (RM 24.4) (EWH/WWH Recommended)								
2.1/2.1	4.9	5.26	48[ns]	NA	MG[ns]	44.5	Full	Rosedale-Plain City Rd.
0.2/0.1	6.3	14.58	-	-	MG[ns]	-	Full	SR 38
Wamp Ditch (02-363) (RM 23.0) (Undesignated/WWH)								
0.1/0.14.8	12.50		30*	NA	MG[ns]	45.5	Partial	Vogelburg Rd.
Spring Fork (02-211) (RM 17.46) (EWH)								
15.8/15.8	4.3	17.24	48[ns]	NA	G*	60.5	Partial	Wren Rd.
13.7/13.3	8.3	12.99	54	NA	VG[ns]	62.5	Full	Ust. SR 29, ust. Trib.
10.1/10.1	14.6	3.73	**40***	NA	56	**69.0**	**Partial**	Ust. Cemetary Rd.
7.8/7.7	19.3	3.33	48[ns]	NA	G*	54.5	Partial	R'dale-M'Ctr. Rd
/**3.4**	32	8.3	-	-	**E**	-	**(Full)**	Dst. SR 38
/**3.3**	32	8.3	**52**	**9.8**	**56**	**67.5**	**Full**	Dst. SR 38
Bales Fork (02–362) (RM 3.64) (Undesignated/WWH Recommended)								
0.4/0.4	5.2	12.86	50	NA	G	70.0	Full	R'dale-M' Ctr. Rd.

* Significant departure from ecoregion biocriteria; poor and very poor results are underlined.
** Attainment status not applied to mixing zones.
ns Nonsignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).
a Narrative evaluation is used in lieu of ICI for qualitative samples (E=Excellent, VG=Very Good, G=Good, MG=Marginally good, F=Fair, P=Poor, VP=Very Poor).
b Qualitative Habitat Evaluation Index (QHEI) values based on the most recent version (Rankin 1989).
c Use attainment status based on one organism group is parenthetically expressed.
X15 Less than optimal flow over artificial substrate samplers

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWHd
IBI - Headwaters/Wading	40	50	24
Mod. Iwb - Wading	8.3	9.4	5.8
ICI	36	46	22

d - Modified Warmwater Habitat for channel modifications.

Table A.27. Summary of findings for 05060001 220: Big Darby Creek (downstream Little Darby Creek to mouth), based on sampling conducted in 2001 and 2002

Watershed Name: Scioto
93 Basin Name: Big Darby Creek
Assessment Unit Number: 05060001 220
Assessment Unit Name: Big Darby Creek (Downstream from Little Darby Creek to mouth)

Stream Name(s): Big Darby Creek mainstem (Downstream from Little Darby Creek to mouth), Smith Ditch, Trib to Smith Ditch, Gay Run, Hellbranch Run, Hamilton Ditch, Clover Groff Ditch, Springwater Run, U.T. to Big Darby Creek - RM 23.77, Clark's Lake Outlet, U.T. to Big Darby Creek, Greenbrier Creek, Georges Creek, Lizard Run.

Year(s) of data collection: 2001, 2002 303d category: 5

Attainment status based on percentage of sampled sites < 50 mi^2

Stratification	Number of sites	Number of sites in FULL attainment	Percentage of sites in FULL attainment	Number of sites in Partial attainment	Percentage of sites in Partial attainment	Number of sites in **NON** attainment	Percentage of sites in **NON** attainment
< 5 mi^2	11	5/11	45.4%	2/11	18.2%	4/11	36.4%
5 to 20 mi^2	5	2/5	40.0%	1/5	20.0%	2/5	40.0%
(if including < 5 mi^2 then) average			42.7 %		19.1%		38.2%
>20 to 50 mi^2	7	4/7	57.1%	3/7	42.9%	0/7	0.0 %
average			49.9 %		31.0 %		19.1%

Attainment status based on mileage in sampled segments > 50 mi^2

50 mi^2 to 500 mi^2 and greater: RM 34.1 to RM 0.0 Number of miles in segment(s) excluding "unassessed" miles	Number of miles in FULL attainment	Percentage of miles in FULL attainment	Number of miles in Partial attainment	Percentage of miles in Partial attainment	Number of miles in **NON** attainment	Percentage of miles in **NON** attainment
34.1 miles	34.1/34.1	100.0%	0.0/34.1	0.0%	0.0/34.1	0.0%
WAU scores		75.0		15.5		10.0

Site size vs. type	All	WWH	EWH	MWH	LRW	CWHS SH	Mixing Zone(s) (exclude from assessment status)
Number of sites < 50 mi^2	23	18	2	2	1	0	0
Number of sites > 50 mi^2	15	0	15	0	0	0	0
Total number of sites	38	18	17	2	1	0	0
Size of smallest sampled drainage area in WAU	0.8 mi^2	Size of largest sampled drainage area in WAU	555 mi^2				

Table A.27. Continued.

Causes	Sources
Low dissolved oxygen	Ground water, septic systems, package plants
Nutrients	Septic systems, rowcrop, suburban run-off, package plants
Unionized ammonia	Package plants, septic systems
Siltation	Construction, hydromodification
Sediment metals (nickel, zinc, chromium)	Unknown source

Recreation Use Assessment

Subcategory of Use: Primary Contact
Impairment: Yes (maximum criteria)

Fish Consumption Advisory (FCA) Assessment

Waters in the WAU Sampled and Assessed: Yes
FCA Issued: Yes
(See the 2004 Ohio FCA for more detailed information at "www.epa.state.oh.us/dsw/fishadvisory/index.html")
Impairment Due to FCA: Yes (PCBs, mercury - Big Darby Creek from Little Darby Creek to mouth. See Section B.8.3 for details).

Comments:

Big Darby Creek (02-200)
All sites sampled on the mainstem of Big Darby Creek fully met all applicable biocriteria within this WAU. There were, however, indications that certain segments are currently under stress and starting to decline.

A short distance downstream from the community of Darbydale nutrient enrichment and low dissolved oxygen have led to several negative macroinvertebrate community attributes including a 300% increase in relative abundance, a 20% drop in sensitive EPT taxa, and the disappearance of viable bivalves. Construction of the planned Darbydale WWTP should eliminate this problem by incorporating all of the existing septic systems and unsewered portions of Darbydale as well as several small package WWTPs. Due to the potential for construction of WWTPs to foster increased development and higher population density the Darbydale WWTP service area has been delineated to keep these problems in check. Ensuring optimum performance of this WWTP will be important to maintaining the very high quality nature of this portion of Big Darby Creek.

The extremely high quality habitat downstream from the confluence with Hellbranch Run appeared to have ameliorated most of the impacts that would be expected downstream from this tributary. There was a slight decline in the ICI and, while the IBI recorded was 54, there was a noteworthy decline in the number of sucker species and overall numerical abundance. Elimination of the Timberlake WWTP, which is currently the main source of impairment in lower Hellbranch Run, should improve this situation.

Conditions appear to have improved downstream from the PCI WWTP in recent years. However, when last sampled in 1997 fish communities posted significant declines downstream from the PCI WWTP. The WWTP was routinely operating above design flow between 1988 and 1998, which had led to increased pollutant loadings to this segment of Big Darby Creek and the subsequent biological impairment. Recent upgrades and process improvements at the WWTP have led to much improved treatment, lowered loadings and much improved biological performance. With the planned expansion of this facility and the elimination of several package plants and diversion of their sewage to PCI, the loadings from this plant are expected to increase, while the overall loadings to the stream will decrease. Ensuring optimum performance of this WWTP as the expected changes occur will be important to the very high quality of the receiving stream and protection of sensitive and endangered organisms downstream.

Conspicuous algal mats observed in recent years at locations where the stream canopy has permitted sunlight to reach the water's surface suggest that lower Big Darby Creek is being subjected to increasing nutrient loads. Additionally, changes in hydrology have resulted in destabilization of the streambed making it hostile to bivalve molluscs, as documented in 2001/2002. See the macroinvertebrate and fish discussions in Sections B.7 and B.8, respectively, for specific details.

Smith Ditch (02-353) (RM 31.69)
Smith Ditch is a high quality direct tributary to Big Darby Creek. Field notes indicate that this site should have been a classic good intermittent stream with very deep pools, strong ground water influence and a wooded riparian corridor. The low number of fish at the downstream site was noteworthy with low D.O. from groundwater a suspected source.

Hamilton Ditch and Clover Groff Ditch are both severely impaired in their headwaters with very slight improvement with downstream distance.

Hamilton Ditch (02-259) (RM 11.19)
Hamilton Ditch is the more rural western tributary forming Hellbranch Run. Upstream adverse influences include historical channelization that has resulted in very poor instream habitat. The

straightening of the channel has greatly reduced habitat diversity and entrenchment, particularly harmful because the streambed's low gradient has trapped sediment within the stream channel. Recently, residential construction run-off is delivering silt from sites with inadequate storm water BMPs. Significant suppression of the instream biological community would be expected with the poor habitat but not to the levels evident here. Clearly poor water quality was contributing to the toxic response observed. Hamilton Ditch was documented to be extremely nutrient enriched with ammonia, TKN and total phosphorus in the 90 to 95th percentile versus ecoregional (ECBP) background concentrations. This enrichment resulted from a mix of agricultural and residential sources.

Clover Groff Ditch (02-245) (RM 11.19)
Clover Groff Ditch is the easternmost tributary that is being encroached upon by Hilliard and metropolitan Columbus. Clover Groff Ditch has also been channelized historically with accumulated sediment trapped in the modified, entrenched channel. These sediment deposits cover the most rocky substrates and neutralized most of the habitat. Sedimentation has become a more pronounced problem in recent years due to inadequate implementation of erosion control BMPs. Gray septic storm water inputs from the adjacent suburban area as well as inadequately treated sewage have collectively caused enriched conditions that were likely periodically toxic. Supporting this conclusion were measured concentrations of ammonia, nitrite and total phosphorus in the 90 to 95th percentile range of ecoregional (ECBP) background conditions. Fecal coliform counts were also elevated

Hellbranch Run (02-204) (RM 26.1)
Biological condition at the three upstream sites of Hellbranch Run, although improved from values recorded at the downstream sites in its source tributaries (Hamilton and Clover Groff Ditches), still only marginally and partially met WWH criteria. Habitat quality was obviously a factor in the suppressed performance at the upstream site with a QHEI of only 39.5 recorded there. Habitat quality in general improved with downstream distance and quickly became less of a factor. The improved biological performance did indicate an improved water quality condition and perhaps ground water augmentation given that the biological performance was higher than the evaluated habitat would normally deliver. The presence of mottled sculpins, an obligate coldwater taxa, not only here but in increased numbers at all sites downstream support this observation. However, there were water column indications of modest nutrient enrichment which extend at least downstream to RM 5.8, downstream from the Oakhurst Knolls WWTP.

Habitat quality in the lower five miles of Hellbranch Run exceeds that necessary to support Exceptional Warmwater Habitat biological communities and marginally meets those criteria at RM 3.7 and 1.0. Hellbranch Run partially attains the EWH use at RM 0.5, downstream from the Timberlake WWTP. This WWTP has a history of operational problems and consistently violates permit limits with sludge frequently detected in stream and very high ammonia concentrations and other nutrient parameters in evidence. The influent to this WWTP is being redirected to a regional WWTP by 2005, which should lead to significant improvement in the lower reach of Hellbranch Run.

Springwater Run (02-203) (RM 24.0)
Springwater Run is the small tributary draining Harrisburg. Downstream from town, channelization and nutrient enrichment have led to low dissolved oxygen levels and algal productivity which is impacting the benthic macroinvertebrates. Harrisburg is currently investigating options for dealing with domestic sewage and should eliminate most of the nutrient inputs to Springwater Run.

Unnamed tributary to Big Darby Creek (02-352) (RM 23.77)
This small creek is believed to be a naturally intermittent stream that dries out after freshets as a result of the underlying alluvial geologic deposits which have resulted in it being a losing stream.

Unnamed tributary to Big Darby Creek (02-270) (RM 20.2)
Although fully meeting its recommended use the elimination of effluent from the Clark's Lake Subdivision, Dot Mar MHP WWTP, and Foxlair Farms WWTP should improve water quality to the point that biological communities would meet the criteria for EWH based on the instream habitat potential.

Unnamed tributary to Big Darby Creek (02-366) (RM 18.41)
Although the habitat was judged suitable for supporting WWH communities, nutrient enrichment and sedimentation were preventing the macroinvertebrate communities from meeting criteria. Agricultural run-off was the source of these stressors.

Greenbrier Creek (02-202) (RM 16.75)
Natural stream dessication associated with the underlying alluvial deposits yielded poor macroinvertebrate results in 2001 at RM 1.1. However, both sites upstream in 2001 and 2002 met biocriteria.

Lizard Run (02-273) (RM 12.93)
This small stream was found dry even after a recent rain and must flow only during significant precipitation events. The underlying alluvial deposits make it a losing stream.

Sediment Quality

Nutrients found in the Big Darby Creek mainstem followed the same pattern as the tributaries in most instances. Ammonia concentrations were not as elevated as some of those found in the tributaries, however the three sites with higher concentrations have shown trends of decreasing quality. The highest concentrations were found at RM 3.10 (83 mg/kg) (Table B.5.3). This area has accumulated sediment from upstream nonpoint source inputs (i.e., agriculture, tributaries and other sources). Sediment ammonia, along with other factors, likely contributed to decreased mussel diversity in this reach (see mussel trends discussion in Section B.7.4).

All sites exhibited total organic carbon concentrations greater than the lowest effect level (LEL, Persaud and Jaagumagi, 1993). Total organic carbon values in the Big Darby Creek mainstem (range 2.8 mg/kg - 7.2 mg/kg) compare favorably with those in other central Ohio waterbodies such as the Olentangy River (2.1 mg/kg - 9.0 mg/kg), Stillwater River (2.1 mg/kg - 9.1 mg/kg), and the middle Scioto River (1.5 mg/kg - 15.0 mg/kg) (Ohio EPA 2000 and Ohio EPA 2001).

All sites analyzed for total phosphorus were also greater than the LEL (Ibid). Results for other ECBP streams show that the lower value of the Big Darby Creek sediment phosphorus concentration range (i.e., 971 mg/kg - 1700 mg/kg) was almost double to more than double the lower values from the Olentangy and Stillwater Rivers, respectively (Olentangy River - 527 mg/kg -1060 mg/kg, Stillwater River - 480 mg/kg - 1610 mg/kg).

Acetone was the only detectible organic contaminant found in the sediment samples in this WAU and was found on the mainstem of Big Darby Creek at RM 3.10. There were no known sources for this contaminant. The concentration found was not at a level that would pose a threat to aquatic life.

In contrast, metals were found in sediments throughout the Big Darby Creek mainstem. Two locations within this WAU are of particular concern: RM 52.0, downstream of the Plain City WWTP, and RM 3.1 near the mouth.

At RM 3.1 on Big Darby Creek sediment aluminum and barium were elevated in comparison to the Ohio EPA sediment reference values. Nickel was elevated (48 mg/kg) and exceeded the TEC concentration. The zinc sediment concentration at RM 3.1 of 128 mg/kg also exceeded the TEC concentration. The sediment chromium exceeded the LEL (Table B.5.3). The elevated sediment metals and silt bedload with attached phosphorus and ammonia noted earlier likely contributed to decreased mussel diversity in this reach. Further investigation should be conducted to identify this source and an effort made to remediate it.

Fish Tissue

A total of 34 fish tissue samples were collected from sites in this WAU accounting for approximately 41% of total samples collected in the watershed. Twenty five samples were collected from the mainstem and nine from Hellbranch Run. PCBs were either below detection limits or very close to the do not eat threshold at the upstream site on the mainstem of Big Darby Creek within this WAU. From RM 13.4, downstream from Darbyville to the mouth the picture was different. Samples within this segment yielded the highest PCB values in the watershed including a very large flathead catfish which had PCB levels high enough to place it in the one meal per two month category. Much of the higher levels can be attributed to the greater size of the fish included in the samples. Almost all of the fish tissue samples on the mainstem had mercury levels that fell into the one meal per week range. The previously mentioned flathead catfish yielded the highest mercury concentration again largely due to its advanced age.

Table A.27. Continued.

None of the nine fish tissue samples taken in Hellbranch Run yielded concentrations greater than method detection limit for PCBs. Mercury concentrations were also fairly low with all values falling into the meal per week range.

Recreation Use

The lower Big Darby Creek WAU evaluated as a whole showed attainment of the primary contact recreational standard. Individual streams such as Smith Ditch, Georges Run, and Greenbrier Creek also showed attainment. However, the Hellbranch Run subwatershed and Springwater Run were in non-attainment of the maximum primary contact recreational standard with Springwater Run violating both the geometric mean and maximum criteria. Residential development pressures, coupled with the poorly functioning or aging WWTPs and failing on-site sewage disposal systems found in the Hellbranch Run subwatershed, are contributing to non-attainment. The situation in Springwater Run is similar, with many failing on-site sewage disposal systems. Plans for several of the WWTPs in Hellbranch Run should improve conditions downstream from them. The failing septic systems still need to be addressed; bacterial problems will persist until solutions are developed and implemented. Harrisburg is currently investigating options for sewage treatment; bacterial problems will persist until a solution is developed and implemented.

Table A.28. Aquatic life use attainment status for the streams sampled in the Big Darby Creek watershed assessment unit **05060001 220** during July - October, 2001

Additional sampling was conducted during July - October, 2002 to fill in gaps and further characterize and evaluate impacted areas (noted in **bold**). The Index of Biotic Integrity (IBI), Modified Index of Well Being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI,MIwb) and macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities. (Last updated -10/01/03)

River Mile Fish/Invert.	Drainage Area (mi^2)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
29.1/-	449	4.52	54.7	10.82	**-**	86.0	(Full)	Ust. Darbydale
/**28.6**	450	4.52	-	-	**E**	-	**(Full)**	Dst. Darbydale
-- /26.9	453	5.85	-	-	54	-	(Full)	Adj Gville-Hburg Rd.
26.1 /26.1	496	7.87	**56**	**9.4**	**E**	**94.5**	**Full**	Dst. Hellbranch Run
23.8/23.8	498	6.71	55	10.20	46	87.5	Full	SR762
22.8/22.5	505	4.1	53	11.36	56	84.5	Full	DST. PCI WWTP
18.7/19.1	513	4.74	52	10.53	E^{X15}	85.0	Full	Adj Darby Creek Rd.
15.7 /15.8	529	3.94	**56**	**10.5**	**52**	**88.5**	**Full**	Adj. Gulick Rd.
/**15.1**	532	3.94	-	-	**54**	-	**(Full)**	Dst. Georges Run
13.4/13.5	534	4.37	52	10.82	56	85.5	Full	SR 316, Darbyville
10.4/11.2	**537**	**4.15**	**56**	**9.6**	**52**	**85.0**	**Full**	Off Darby Rd.
8.4 /8.4	544	4.74	**48**^{ns}	**9.4**	**52**	**69.5**	**Full**	Dst. Ag Trib. (Conflu RM8.5)
/**5.3**	550	7.35	-	-	**52**	-	**(Full)**	Dst. Ag Trib. (Conflu RM5.86)
3./1/3.2	552	2.86	54	11.02	56	82.0	Full	SR 104
0.30/0.30	555	12.2	50	11.01	-	71.5	(Full)	Adj. NSCD project
Smith Ditch (02-353) (RM 31.69) (Undesignated/EWH Recommended)								
2.1/2.1	5.9	40.0	52	NA	E	77.5	Full	G'ville-W'ville Ditch
0.3/0.2	6.7	35.71	28*	NA	E	73.0	Partial	Biggert Rd.
Trib to Smith Ditch (02-354) (RM 0.06) (Undesignated/EWH Recommended)								
0.2/-	0.9	7692	50	NA	-	67.0	(Full)	Biggert Rd.
Gay Run (02-298) (RM 26.48) (Undesignated/WWH Recommended)								
2.2/2.2	1.2	55.56	46	NA	G	66.5	Full	Boyd Rd.
Hellbranch Run (02-204) (RM 26.1) (WWH)								
10.3/9.4	24.8	3.37	36^{ns}	6.76*	46	39.5	Partial	Dst. Conflu./dst. Al
7.4/7.4	27.9	7.52	32*	8.17^{ns}	48	51.0	Partial	Kunz Rd.
5.8/5.7	30.5	7.3	35*	8.16^{ns}	G	65.5	Partial	Dst Ohurst Knolls WWTP
Hellbranch Run (02-204) (RM 26.1) (WWH/EWH Recommended)								
3.7/3.7	32.6	16.67	47	9.02	50	83.5	Full	Beatty Rd.
1.0/0.9	35.3	11.36	49	9.18	VG^{X15}	84.5	Full	Lambert Rd.
0.5/0.5	35.4	11.36	41	9.07	VG	83.5	Full	Dst. Timberlake WWTP
/**0.5**	35.4	11.36	-	-	**VG**	-	(**Full)**	Dst. Timberlake WWTP
Hamilton Ditch (02-259) (RM 11.19) (MWH)								
3.4/3.4	3.4	4.44	16*	NA	F	21.0	Non	Walker Rd.
Hamilton Ditch (02-259) (RM 11.19) (WWH)								
0.5/0.5	9.4	7.41	24*	NA	40	36.5	Non	US 40

Continued

Table A.28. Continued.

River Mile Fish/Invert.	Drainage Area (mi²)	Gradient (ft/mi)	IBI	Mod. Iwb	ICIa	QHEIb	Attainment Status[c]	Comments
Clover Groff Ditch (02-245) (RM 11.19) (MWH)								
4.7/4.7	3.8	3.39	18*	NA	VP*	22.0	Non	Roberts Rd.
Clover Groff Ditch (02-245) (RM 11.19) (WWH)								
0.8/0.8	6.7	9.90	28*	NA	20*	61.5	Non	Dst. US 40
Springwater Run (02-203) (RM 24.0) (WWH)								
0.8/0.2	1.8	50.0	50	NA	F*	48.5	Partial	US 62 at mouth
U.T. to Big Darby Creek (02-352) (RM 23.77) (Undesignated/WWH Recommended)								
0.1/-	0.8	111.11	30*****	NA	**-**	61.5	(Non)	South of SR 762
U.T. to Big Darby Creek (02-270) (RM 20.2) (Undesignated/WWH Recommended)								
0.8/0/8	4.3	25.64	44	NA	G	77.5	Full	H'burg-D'ville Rd.
U.T. to Big Darby Creek (02-366) (RM 18.41) (Undesignated/WWH Recommended)								
0.1/**0.1**	**2.0**	27.78	42	NA	**F***	52.5	**(Partial)**	Mouth
Greenbriar Creek (02-202) (RM 16.75) (WWH)								
2.7/2.7	4.4	34.48	40	NA	MG[ns]	57.0	Full	Mt.Ster.-Com. Pt. Rd.
1.3/**1.3**	8.2	17.86	46	NA	**VG**	74.5	**Full**	H'burg-D'ville Rd.
Georges Creek (02-201) (RM 14.4) (WWH)								
0.5/0.5	1.2	58.82	46	NA	MG[ns]	61.0	Full	C.Ville-London North Rd.
Lizard Run (02-273) (RM 12.93) (Undesignated/LRW)								
0.2/0.2	1.2	41.67	**-**	-	VP*	**-**	(Non)	London Northern Rd.

* Significant departure from ecoregion biocriteria; poor and very poor results are underlined.

** Attainment status not applied to mixing zones.

ns Nonsignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).

a Narrative evaluation is used in lieu of ICI for qualitative samples (E=Excellent, VG=Very Good, G=Good, MG=Marginally good, F=Fair, P=Poor, VP=Very Poor).

b Qualitative Habitat Evaluation Index (QHEI) values based on the most recent version (Rankin 1989).

c Use attainment status based on one organism group is parenthetically expressed.

X15 Less than optimal flow over artificial substrate samplers

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWHd
IBI - Headwaters/Wading	40	50	24
Mod. Iwb - Wading	8.3	9.4	5.8
ICI	36	46	22

d - Modified Warmwater Habitat for channel modifications.

A.7 CONCLUSIONS

The Big Darby Creek watershed is arguably one of Ohio's most valued natural resources. It is host to one of the most diverse warmwater biological faunas in the midwest. In Ohio many rare and endangered fish and bivalve mollusc species have their strongest populations in this watershed. The watershed's proximity to major universities and schools make it a logical choice for a natural laboratory and science class field trips. This very same proximity to a major metropolitan center has also put this high quality resource at risk. Currently, fully two-thirds of all locations sampled within the watershed fully meet expectations for aquatic biological community performance, with another 23% of the sites partially meeting expectations and the balance, slightly over ten percent, not meeting expected aquatic life use goals.

Because of its high quality and a general desire to maintain that quality, the Big Darby Creek watershed has been one of the most sampled watersheds by the Ohio EPA over the years. As a result of this frequent examination, it has been possible to document and deal with some of the causes and sources of impairment during this same time frame. The original focus of the Ohio EPA monitoring efforts was the evaluation and regulation of point source dischargers. Sampling conducted in 1992 and 1993 documented statistically significant improvements in water resource quality from conditions present in 1979. Improvement in wastewater treatment at major dischargers, required by the Clean Water Act to be completed by 1988, was the major driver of these changes.

More targeted sampling in 1997 revealed that some of the same dischargers that had improved prior to the 1992 and 1993 sampling were again causing impairments. Over the intervening years a variety of changes had taken place. Service populations to the wastewater treatment plants had increased, taxing their ability to treat waste effectively; equipment and infrastructure had aged; and budgets to support operation, maintenance, and training had been reduced. The combination of these factors resulted in the same consequence – poorer quality effluent and subsequent degradation to the water resource.

Based on the findings of this most recent intensive survey, Ohio EPA has focused considerable effort on solving problems with point source dischargers in the watershed. Many chronically poorly operating package WWTPs will be eliminated with their influent diverted to new or upgraded regional wastewater treatment plants. Plans have been developed for all of the improved regional facilities to solve problems identified during this survey cycle. Expectations are that water resource quality downstream from the decommissioned package WWTPs and the upgraded or repaired regional WWTPs should improve and overall ecological performance of the watershed should subsequently show improvement. Additionally, Ohio EPA is encouraging governmental entities to facilitate planning for service areas to prevent overlap and duplication of services and prevent overwhelming the ability of the receiving stream to assimilate the effluent without causing decline.

Ohio EPA's monitoring emphasis has gradually shifted over time in response to improvements at point sources of pollution. To define the higher relative contribution from non-point sources of pollution, more sites within a watershed and sites of smaller drainage area are sampled. In the Big Darby Creek watershed, alteration of instream habitat and non-point source pollution were responsible for the majority of the partial and non-attainment of applicable biocriteria in 2001 and 2002. In particular, sedimentation and concomitant substrate embeddedness, coupled with nutrient enrichment and its accompanying effect on algal communities and dissolved oxygen concentrations, were the most significant factors adversely affecting instream biological community performance in the Big Darby Creek watershed.

A noteworthy and somewhat surprising finding of the current survey was the magnitude and significance of groundwater influence on water resource quality, particularly in the headwaters of Big Darby Creek and the Little Darby Creek subwatershed. Many of these smaller tributaries have been channel modified. Yet these same streams with reduced habitat quality currently support aquatic biological communities of much higher caliber than would be expected at other streams with similar physical and chemical characteristics and within the same ecoregion. The only significant difference appears to be the presence of cool, abundant ground water. If not for the ameliorating effects of this ground water, the Big Darby Creek watershed as a whole would perform more poorly, particularly the two upper watershed assessment units (the drainage upstream of Little Darby Creek). The ground water also has the potential of increasing the rate of improvement and the success of restoration and protection measures. Many of these streams drain the Cable moraine and, besides possessing the diluting effects of the ground water (which ensures adequate base flow), the high gradient will flush out contributed sediments and speed natural stream channel recovery processes. Protection of this aquifer, therefore, is critically important to ensure the continuing high quality of the Big Darby Creek watershed. Particular threats include wells that would lower the water table and development activities (urban, suburban or agricultural) that would adversely affect ground water recharge.

Nutrients, an important set of stressors historically, are a growing problem in the watershed. Concentrations of many nutrient parameters were found at very high levels at sites scattered throughout the watershed. Dissolved oxygen concentrations, critical to sustaining aquatic life, have been shown to be marginally less than in previous years. This trend perhaps signals the onset of a decline. Algal blooms that persist for long periods of time and that cover large stretches of the river have become common in recent years.

Exceedences of bacteria water quality criteria are now commonplace throughout the watershed. Sources of these bacterial exceedences resulted from a combination of poorly performing WWTPs, inadequately treated wastes from on-lot septic systems, lawn fertilization, wildlife, livestock and land application of manure. Frequently, some of the highest bacterial counts were found in stream segments that were adjacent to or immediately downstream from areas with open access pasturage. Other areas without livestock or normal anthropogenic sources also yielded very high values. For example, in the headwaters of Big Darby Creek land application of manure is likely to be the source of high bacterial counts. However, it has been difficult to obtain information about the locations and application rates of manure. More spills of manure are being reported and, as more people move into the watershed, less acreage will be available to receive this waste. Additionally, there are indications that the number of animal units are increasing in the watershed, further complicating the disposal of this nutrient-rich waste.

Although the immediate consequences of a spill are well understood, an in-depth analysis of reported spills (many go unreported) in the Big Darby Creek watershed has revealed their long term impact. In particular, spills have been shown to be an important factor controlling the distribution of some of the rarer species in the watershed, particularly the bivalve molluscs. In addition, biological communities downstream from Milford Center have yet to recover from a significant spill that occurred two years prior to the most recent sampling. Recovery patterns of aquatic biological communities scattered throughout the watershed indicate that they are recovering from episodes of extreme nutrient enrichment which might result from a spill of manure, ammonia or fertilizer.

Unfortunately, many of the spills and particularly some of the largest spills were preventable or would have had much smaller impact if reported immediately and clean-ups initiated more swiftly. This has led to the recommendation that a plan be developed to deal with spills in the watershed. Suggestions for dealing with this problem are included in Appendix B.2, Spills and Wild Animal Kills.

Storm water issues are currently affecting discrete portions of the watershed, but are expected to become a more important factor driving water resource quality as population density increases. There is direct evidence of the impact of storm water problems emanating from Flat Branch, Clover Groff Ditch and Hamilton Ditch and indirect evidence of impacts to lower Big Darby Creek from Hellbranch Run. Little Darby Creek in the vicinity of West Jefferson warrants increased attention in the future. Recent and pending development of large distribution centers north of West Jefferson have the potential to adversely impact the very high quality communities downstream. Developments that have the potential to increase the rate and amount of run-off should incorporate measures to deal with the amount and quality of runoff flows to protect high quality resource.

Steps along this line are already being taken for development in the Hellbranch Run subwatershed. The External Advisory Group (EAG) of the Environmentally Sensitive Development Area (ESDA), which is a component of Ohio's State Water Quality Management Plan for the Scioto River Basin (208 plan), was convened to ensure that development of western Franklin County within the Big Darby Creek watershed was properly planned and executed to protect environmental quality. Plans developed by that group might serve as a starting point for other areas in the watershed that are currently subject to increased development.

Historically, many of the impairments to instream biological communities in the Big Darby Creek watershed have resulted from a small combination of stressors which could reasonably be resolved. However, as industrial, business and population density has increased, the set of stressors has become more complex. A good example of this phenomenon is found in the very headwaters of Big Darby Creek. Downstream from the confluence with Flat Branch, Big Darby Creek is currently impaired by a complex blend of environmental stressors including channelization, changes in hydrology, turbidity, elevated nutrients, depressed dissolved oxygen concentrations and elevated metals. Sorting out and solving this problem will require the collaboration and the ongoing commitment of private industry and businesses, farming interests, the conservation community as well as local and state governmental entities.

Just as previous studies identified water quality problems that were subsequently addressed, this study documents the problems that exist today and anticipates new threats. An area of particular interest is the future development of the improved and widened U.S. Route 33 corridor. Comprehensive planning could minimize potentially severe impacts to the upper watershed of Big Darby Creek. A variety of potential stressors exist including regulation of municipal and industrial discharges, storm water control dealing with both volume and quality of storm water run-off, nutrient management plans for fertilizer, and construction related issues.

A.8 RECOMMENDATIONS

Once a watershed's condition has been studied and any impairments identified, it is useful to examine ways to correct the problems. In this chapter, some general recommendations for the Big Darby Creek watershed are discussed. More specific, quantified recommendations may result from the Total Maximum Daily Load project, scheduled to be completed in late 2004.

Recommendations are not limited to this chapter. Recommendations for changes at specific locations that would benefit stream resource quality (for example, riparian and streamside buffer practices or landuse changes) are dispersed throughout this document. Another type of recommendation, pertaining specifically to altering stream use designations, are contained in Section A.5.2.

A.8.1 Protect Ground Water Sources

Water resource quality of the upper Big Darby Creek and the upper half of the Little Darby Creek benefits considerably from the positive effects of ground water inflow, a relic of the glacial geology of the upper watershed. More stable stream base flows and lower water temperatures are direct advantages that the ground water provides. The ground water inflows have reduced the stresses associated with modest nutrient enrichment and habitat simplification. Ultimately, the ground water flows increase the potential for recovery of the impaired streams when other stressors are eliminated.

Every effort should be taken to protect the integrity of the ground water source. Excessive withdrawals would be harmful; protective efforts should include restrictions on wells that would lower the water table to the point that they would reduce the expression of ground water in these streams. Recharge of the resource should be promoted. Hardening of the watershed and other activities that limit infiltration and reduce recharge should be discouraged. Providing riparian canopy (e.g., trees on stream banks) extends benefits such as lower stream temperatures further downstream. Other practices to protect this groundwater source should be investigated and implemented.

A.8.2 Manage Storm Water

Some of the impairments of water resource quality in portions of the Big Darby Creek watershed are directly related to the quantity and quality of water draining from the land, especially during and after rain storms. Storm water effects including sedimentation, habitat changes and changes in hydrology. The headwaters of Big Darby Creek, Flat Branch and Big Darby Creek immediately downstream, the Hellbranch Run subwatershed, and the lower reaches of Big Darby Creek are already being affected. Other areas are under threat, such as Little Darby Creek near West Jefferson where commercial development is occurring.

Excessive storm water decreases stream stability. Increased flow destabilizes stream banks resulting in collapse, increased erosion and reduced habitat diversity. Increased delivery of eroded sediments results in embeddedness (i.e., smothering of the stream bed), loss of instream habitat, filling of the pools and less in-channel storage of water, which results in more frequent out-of-channel flooding. Excessive storm water runoff reduces groundwater infiltration, which reduces groundwater contribution to stream base flows, which in turn results in stream desiccation and more frequent intermittency. All of these factors result in reduced biological diversity and productivity, generally yielding less diverse, more tolerant aquatic biological communities.

The potentially dramatic changes that occur as a watershed is hardened must be planned for and adequately dealt with through proper storm water best management practices (BMPs) for both water quantity and water quality. Timely compliance inspections and rigorous enforcement when plans are not followed are useful deterrents.

Many of these issues for suburbanizing subwatersheds are currently being dealt with in the portion of the Big Darby Creek watershed labeled the Environmentally Sensitive Development Area of the State's Water Quality Management Plan for the Scioto River Basin (208 plan). An advisory group is developing plans to prevent further degradation of this subwatershed, which drains to one of the highest quality, most diverse segments on the mainstem of Big Darby Creek. Key elements of their plan include riparian buffer restrictions, comprehensive storm water management, conservation development (cluster development which promotes the preservation of tracts of open land including farmland), and adequate public facilities to support any proposed development.

A.8.3 Reduce Nutrient Enrichment

Nutrients contribute to water resource degradation throughout the watershed. Concentrations of phosphorus and nitrogen well above background reference conditions are common. Areas with depressed dissolved oxygen concentrations have been identified, and some areas have shown declines in mean concentrations over time. Algal blooms, once a rare occurrence, are now common and cover long stream distances.

Generally, reducing the contributions from common sources will improve the condition of the watershed with respect to nutrient enrichment. Nutrient enrichment is widespread and not confined to one particular subwatershed, although there are indications that some areas are adding more than "their share." A variety of sources contribute to the problem: leachate from septic systems, land application of manure, inadequately treated domestic sewage, over application of fertilizer, spills of manure, and inadequate riparian buffers. The sources in each subwatershed are different, and the solutions to the problem in each subwatershed will need to reflect those differences. Accurate identification of and reliable information about activities that contribute nutrients will be critical to taking effective action.

A.8.4 Improve Habitat Quality

Many of the small headwater streams and the very headwaters of many of the larger streams in the Big Darby Creek watershed have been physically altered. Some small water courses have been legally petitioned under the provisions of the County Ditch Law to facilitate drainage. They will be maintained in this condition in perpetuity or until their petitions are revoked. Other streams were altered by individual landowners or under provisions of older ditch laws. Regardless, channelization has lowered habitat quality in large portions of the Big Darby Creek watershed.

This study has discovered that conditions would be much poorer if not for the positive influence of cool, abundant ground water. In many altered streams, both groundwater influenced and the more typical channelized streams, the absence of riparian vegetation and the presence of nutrient intensive activities on adjacent lands leads to the export of excess nutrients. Little filtering takes place, yielding swift and direct delivery of nutrient-rich storm water to these hydraulically simplified channels. This in turn results in swift delivery of this nutrient enriched water downstream with little instream processing. The enrichment problems that are increasing on the mainstem of Big Darby Creek and other significant tributaries are a direct result of these habitat problems.

To remedy these problems throughout the watershed an effort should be made to take advantage of the natural assimilative capacity of stream channels. Streams allowed to develop naturally provide a variety of beneficial services: flushing of fine sediments into adjacent floodplains, processing of nutrients into productive biomass instead of nuisance algae, improvement of water quality, creation of diverse instream habitats, and ultimately – and most important for adjacent landowners – evolution into a stable channel. To accomplish this goal the streamway approach should be adopted wherever possible (Ward et al., 2002; ODNR, 2004). Allowing riparian land, water and vegetation to naturally evolve will reduce or eliminate many of the current causes and sources of stress within the watershed. In addition, where feasible, previous physical modifications should be "undone" (e.g., remove the few remaining dams, restore cutoff channels, exclude livestock, and move dikes and levees away from the stream bank to accommodate the streamway approach).

Nutrient management on upland areas, coupled with the reestablishment of wooded riparian buffers, would reduce the severity of this particular impact. An intact riparian canopy would provide shading and transpiration which would maintain lower water temperatures and reduce nuisance algal growth. Vegetation would also stabilize the stream banks, reducing erosion and sedimentation, which are also identified as problems in many areas. Shading has also been shown to be critical in the overall plan to protect some of the endangered bivalve mussel species. These areas should be targeted for funding to protect these important species.

In some areas, free access livestock pasturage is causing both habitat and nutrient enrichment problems. Livestock exclusion and single point of access watering would allow reestablishment of riparian vegetation which would result in more stable stream banks, less erosion, some filtering of nutrients and lower water temperatures. Again, funding should be targeted to provide support for this effort.

A.8.5 Develop a Spill Response Plan

Spills were documented to be an important controlling factor in the distribution and abundance of some of the rarer organisms inhabiting this watershed. Additionally, many of the spills investigated, particularly the larger ones, were preventable. A plan should be developed to prevent, reduce, and minimize the impact of spills on this valuable, high quality resource. Equally important would be to develop and implement a mechanism to educate the public about spill prevention and how to deal with spills when they occur.

A.8.6 Reduce Bacteria Levels

High levels of indicator bacteria (fecal coliform and E. coli) in streams are a concern because of human health. People can be exposed to contaminated water while wading, swimming and fishing. Fecal coliform and E. coli bacteria are relatively harmless in most cases, but their presence indicates that the water has been contaminated with feces from a warm-blooded animal. Although intestinal organisms eventually die off outside the body, some will remain virulent for a period of time and may be dangerous sources of infection, especially a problem if the feces contained pathogens or disease-producing bacteria and viruses. Reactions to exposure can range from a skin rash, sore throat or ear infection to a more serious flu-like symptoms.

Recreation is an important function of Big Darby Creek, with fishing, wading, and canoeing being popular during warmer months. A significant amount of the land is devoted to parks with easy access to the water. Unfortunately, exceedences of bacteria water quality criteria are common throughout the watershed. As a result of this most recent sampling, Ohio EPA has been working with WWTPs to reduce their impacts, but many sources remain: livestock (open access pasturage), land application of manure, inadequately treated wastes from on-lot septic systems.

The same BMPs for land application of manure that are used to reduce nutrients can also reduce pathogens (proper manure application rates, timing, buffer strips, etc.) and the facilities could also do additional processing of the manure prior to land application (e.g., composting, digestion). Such actions are required for regulated agricultural facilities; for non-regulated facilities it is voluntary. State and federal agricultural agencies should be able to help develop the appropriate plans.

Likewise, BMPs that address the habitat and nutrient enrichment problems caused by free access livestock pasturage would help with the bacteria issues. Possible actions include livestock exclusion (fencing) and single point of access watering.

Given the high recreation potential of the Big Darby watershed, if initial efforts to reduce bacteria by eliminating obvious sources are not sufficient, it may be necessary to engage in more indepth study to identify more elusive sources of bacteria contamination.

A.8.7 Monitor Watershed Condition

Due to the proximity of this watershed to the growing Columbus metropolitan area, the potential for adverse impacts from suburbanization is great. At the same time, corrective actions for some point sources of pollution are already underway. As with all watersheds, changes will occur and revisiting the watershed to measure progress or decline is important to decision-making. Given the exceptionally high quality of the Big Darby Creek watershed and the significant threats, such measurement is critically important in this case.

Although future monitoring may not be possible at the same comprehensive level of coverage as the 2001/2002 survey, specific areas should be targeted based on the findings of this report. The Big Darby Creek watershed should receive follow-up intensive sampling within one to two years after the majority of the recommendations contained within this report and the TMDL report are implemented.

Monitoring should be conducted in the Big Darby Creek watershed for three purposes:

- To further investigate unknown situations, specifically in Flat Branch and Robinson Run
- To document improvements or declines
- To ensure compliance with permits.

Details on the specific goals of this monitoring are provided below.

A.8.7.1 Investigative Monitoring

The 2001/2002 monitoring identified impairments in two areas, but additional monitoring is needed to better identify stressors and sources.

Flat Branch and upper Big Darby Creek - Big Darby Creek downstream from the confluence with Flat Branch is currently impaired by a complex blend of environmental stressors including hydromodification, changes in hydrology, turbidity, elevated nutrients, depressed dissolved oxygen concentrations and elevated metals. Sorting out and solving this problem will require the collaboration and the ongoing commitment of private industry and businesses, farming interests, and the conservation community as well as local and state governmental entities.

The impact of development proceeding without adequately addressing measures to protect aquatic resources has been well documented in this portion of the watershed. Future development of the improved and widened US Rt. 33 corridor must be done under the umbrella of a comprehensive plan if further and more severe impacts to the upper watershed of Big Darby Creek are to be avoided. This would include, but not be limited to, dealing with industrial dischargers, controls for both the volume and quality of storm water runoff, and nutrient management plans for fertilizer.

Robinson Run - The fish communities in lower Robinson Run show impacts from episodic stresses. The proximity to Ranco Inc. and their closed landfills necessitates an in-depth investigation of Robinson Run that includes sampling for parameters that might be leaching from the landfill.

A.8.7.2 Periodic Follow-up Monitoring

Big Darby Creek Mainstem

Headwaters of Big Darby Creek - The large sediment bedload delivered to Big Darby Creek from the relocation of TR 152 and the channel relocation of upper Big Darby Creek has resulted in the only site on the mainstem of Big Darby Creek not attaining its recommended designated use. Expectations are that the stream should recover through natural recovery processes and this should be documented through follow-up sampling. Additionally there are several potential recovery plans being proposed. The impact of these projects on water resource quality should be documented if implemented.

Flat Branch and upper Big Darby Creek - This area is discussed in the previous section. As stressors are identified and eliminated, follow-up sampling will be needed to document changing conditions.

Vicinity of Milford Center and Unionville Center - Big Darby Creek immediately downstream from Milford Center was subject to a significant spill that had an adverse and long term impact to the biological communities immediately downstream. Fish and macroinvertebrate communities had yet to recover fully from the spill two years after its occurrence. Spills have also been reported from an agricultural chemical application firm at SR 38 and a large livestock breeding operation in Unionville Center. One of the lowest MIwb fish community score was recorded downstream from SR 38. Periodic follow-up sampling should be undertaken to plot the rate of recovery of the biological communities resulting from the original spill and sampling to determine the impact associated with these two facilities. Site inspections at these facilities should include the development of plans to eliminate future spills or releases.

Darbydale to Darbyville - Significant improvements to water resource quality are expected in this reach of Big Darby Creek as a result of significant improvements in wastewater treatment. Several poorly operated package WWTPs will be eliminated, sending their waste to either the upgraded and expanded PCI WWTP or to the newly constructed Darbydale WWTP. While these improvements will eliminate several problem areas, they will also concentrate these sources into single points of discharge. Since the net loadings to the stream segments receiving these point sources may actually increase, monitoring should be conducted to determine that effluent limits are meeting resource quality goals.

Snake Island project - This collaborative project between ODNR, adjacent landowners and the Ohio Department of Rehabilitations and Corrections to open up the historical high flow channel around Snake Island would locally increase the channel length and reduce gradient. The hope is that this action will reduce stream bank erosion and re-establish historically important bivalve mussel habitat. Monitoring would document the effectiveness of this habitat enhancement project, if implementation funds are eventually secured..

Big Darby Creek Mouth - Another collaborative project along the very lower reaches of Big Darby Creek resulted in moving severely eroding dikes away from the stream channel and allowing the stream to re-establish natural meanders. This site should be sampled periodically over time to track its progress and determine the merit of extending this streamway project to similar locations further upstream.

Big Darby Creek Tributaries - Due to limited monitoring resources, sampling was confined to the lower reaches of many tributary streams. This has had the consequence that recommendations for changes to aquatic life uses were limited to areas where definitive use decisions could be made. Efforts to extend the designation process further up into the headwaters would require additional sampling.

Robinson Run - Robinson Run is discussed in the previous section. As stressors are identified and eliminated, follow-up sampling will be needed to document changing conditions.

Sweeney Run - Additional chemical and biological samples in Sweeney Run are warranted to determine water quality upstream from Plain City and help locate municipal storm water runoff sources that affect stream quality.

Lake Run - A temporal impact is believed to have prevented Lake Run from achieving EWH instream biological community performance. Thus, changing the use designation is being deferred until follow-up monitoring can be conducted. Monitoring is recommended after the stream has a chance to flush out contributed sediments and recover.

Treacle Creek - Fish sampling was not conducted at the historical site near the mouth. This prevented determining if the trend of decline seen previously was continuing. Impacts seen downstream from the confluence in Little Darby Creek strongly suggest that this pattern is continuing and needs to be documented. Sampling should be conducted in Treacle Creek and into Little Darby Creek to better determine the impact associated with this tributary to Little Darby Creek.

Spring Fork - Access again was denied for monitoring a specific stream segment. The number of violations from the Green Meadows MHP WWTP strongly suggest that this entity may be adversely impacting what was one of the highest quality stream segments that Ohio EPA has documented in Ohio. Sampling this segment would better permit determination of the magnitude of this impact and assist in the regulation of this NPDES discharger.

Wamp Ditch - Due to resource constraints, water chemistry samples were not collected in this small stream. It appears that nutrient enrichment probably was the cause for the observed impairment. Water chemistry sampling would document the nature of this impairment.

Hellbranch Run - Considerable interest in this subwatershed has led to many proposals for protection and remediation. Periodic monitoring would document the effectiveness of these projects and show the effects of suburbanization of this subwatershed.

A.8.7.3 Compliance Monitoring

Increased compliance sampling is warranted at several permitted discharges within the Big Darby Creek watershed. These include the following.

Flat Branch WWTP - This WWTP has had numerous recent reported NPDES violations and discharges to the segment of the Big Darby Creek mainstem that has the lowest documented fish community scores. The entity also receives a considerable amount of commercial and industrial influent that is difficult to treat with the existing WWTP design. Therefore, closer oversight is warranted to ensure proper operation and compliance.

Mechanicsburg WWTP - This entity has a long history of causing water quality problems in Little Darby Creek. The most recent sampling documented a bypass pipe downstream from the WWTP that resulted in the lowest fish community index scores in Little Darby Creek and partial attainment of the EWH use.

Plain City WWTP - This WWTP is currently causing impairment of the fish communities. Plans are underway to upgrade and expand the WWTP. Plain City is in close proximity to the Columbus metropolitan area and in an area of major growth, which will further tax its ability to treat domestic waste as its service populations grows. Plain City is also located at the head of the segment that has the greatest level of riparian protection. For all these reasons, a high quality effluent from this facility must be maintained.

PCI WWTP - This facility is targeted to receive influent from many package WWTPs that are currently producing poor quality effluent and from unsewered areas in the lower watershed. Despite overall improved treatment of the total waste volume, higher net pollutant loadings will be delivered to this very high quality segment of Big Darby Creek. Close attention is warranted as the many changes and tie-ins occur.

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A.10 READER ASSISTANCE

Three tools are provided here to facilitate the use of this report: a list of acronyms, a glossary with definitions of scientific and technical terms that might not be familiar or in every day usage, and some background information on water quality impairments found in the Big Darby Creek watershed.

A.10.1 List of Acronyms and Abbreviations

ALU	aquatic life use
AWS	Agricultural Water Supply
BDC	Big Darby Creek
BMP	best management practices
BNA	base neutral and acid extractable compounds
BW	Bathing Water
CFR	Code of Federal Regulations
CRP	Conservation Reserve Program
CWA	Clean Water Act
CWH	Cold Water Habitat
D.O.	dissolved oxygen
DNAP	Division of Natural Areas and Preserves (part of ODNR)
DOW	Division of Wildlife (part of ODNR)
DSWC	Division of Soil and Water Conservation (part of ODNR)
ECBP	Eastern Corn Belt Plains (ecoregion)
EQIP	Environmental Quality Incentive Plan (USDA program)
EWH	Exceptional Warmwater Habitat
FSA	Farm Service Agency
gpd	gallons per day
HELP	Huron Erie Lake Plain (ecoregion)
I/I	infiltration and inflow
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
IWS	Industrial Water Supply
l	liter
LEL	lowest effect level
LRW	Limited Resource Water
mg	milligram
MHP	mobile home park
MIwb	Modified Index of well being
ml	milliliter
MOR	monthly operating report
MORPC	Mid-Ohio Regional Planning Commission
MWH	Modified Warmwater Habitat

n	number (of data points in a grouping)
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRCS	Natural Resource Conservation Service
NRCS	Natural Resource Conservation Service
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OSC	onsite coordinator
OSUE	Ohio State University Extension
PCB	polychlorinated biphenyls
PCR	Primary Contact Recreation
PEC	probable effect concentration
PWS	Public Water Supply
QCTV	Qualitative Community Tolerance Value
QHEI	Qualitative Habitat Evaluation Index
RM	river mile
SCR	Secondary Contact Recreation
SEL	severe effect level
SMP	sludge management plan
SRW	State Resource Water
SSH	Seasonal Salmonid Habitat
SWCD	Soil and Water Conservation District
TEC	threshold effect concentration
TKN	total kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TSS	total suspended solids
U.S. EPA	United States Environmental Protection Agency
UAA	Use Attainability Analysis
USACOE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOC	volatile organic compound
WASCOBS	water and sediment control basins
WAU	watershed assessment unit
WPCLF	Water Pollution Control Loan Fund
WQS	water quality standards
WRP	Wetland Reserve Program
WTP	water treatment plant
WWH	Warm Water Habitat
WWTP	wastewater treatment plant

A.10.2 Glossary

Many of the definitions of the terms came directly from Armantrout, 1998.

A

Aerobic	A process conducted in the presence of oxygen which facilitates the reduction of wastewater pollutants.
Alluvial	Related to material deposited by running water.
Alluvial deposit	Clay, sand, silt, gravel or other sediment carried by flowing waters and deposited when the water velocity drops below that required to keep the material in suspension or move the bed load. Synonymous with alluvial fill.
Ambient	Refers to general conditions in the environment.
Anaerobic	(1) Environmental conditions where free oxygen is absent. (2) Life processes that occur in the absence of molecular oxygen.
Anoxic	Lack of oxygen.
Aquatic	Term applied to growing, living in, frequenting or pertaining to water.
Aquatic ecosystem	Any body of water, such as a wetland, stream, lake, reservoir or estuary that includes all organisms and nonliving components, functioning as a natural system.
Aquatic habitat	A specific type of area with environmental (i.e., biological, chemical or physical) characteristics needed and used by an aquatic organism, population or community.
Assimilation	Ability of a water body to absorb materials and substances to purify itself.
Assimilation capacity	(1) Capacity of a natural water body to receive wastewaters, without deleterious effects or toxic materials, without damage to the environment or humans who consume the water. (2) To incorporate and convert waste waters without deleterious effects. (3) Biological Oxygen Demand (BOD), within prescribed dissolved oxygen limits.
Association	(1) Plant and animal communities of a particular kind that are consistently found together. (2) A group of plants and animal species.

B

Backwater	(1) A pool formed by water backing upstream from an obstruction, such as narrowing of the channel by a bedrock or boulder constriction. (2) Abandoned channel that remains connected to the active main stem river. (3) Secondary channel in which the inlet becomes blocked with substrate deposition when water velocities decrease as the river subsides but the outlet remains connected with the active channel.
Bank	Ground bordering a channel above the stream bed and below the level of rooted vegetation that often has a gradient steeper than 45 and exhibits a district break in slope from the stream bottom. The portion of the channel cross section that restricts lateral movement of water during normal stream flow. Right and left banks are determined while looking downstream.

Bank erosion	Erosion of bank material caused by water current, wave action or surface erosion.
Bank-full depth	Depth of water measured from the surface to the channel bottom when the water surface is even with the top of the stream bank.
Bank-full discharge	Maximum stream flow that can be accommodated within the channel without overtopping the banks and spreading onto the flood plain. Generally the level associated with two- or three-year stream flow events.
Bank-full stage	Stream stage where stream reaches bank-full depth.
Bank-full width	Channel width between the tops of the most pronounced banks on either side of a stream reach.
Bank height	Distance between the channel bed and the top of the bank.
Bar	A submerged or exposed ridge-like accumulation of sand, gravel, or other alluvial material formed in the lake, or in the channel, along the banks, or at the mouth of a stream, where a decrease in velocity induces depositon.
Bedrock	Rock outcrop or rock covered by a thin mantle (less than 10 cm) of consolidated material.
Bioaccumulation	The net accumulation of a substance by an organism as a result of uptake from all environmental sources.
Bioconcentration	The net accumulation of a substance by an aquatic organism as a result of uptake directly from the ambient water through gill membranes or other external body surfaces.

C

Carbonaceous	The portion of the total biochemical oxygen demand that is from materials composed primarily of carbon (as opposed to being composed primarily of nitrogen).
$cBOD_5$	The analytical result for carbonaceous biochemical oxygen demand of the wastewater after 5 days.
Coldwater fish	Those species of fish that thrive in relatively cold water. These species include, but are not limited to, salmon and trout (Salmonidae), and may include sculpins (Cottidae) and certain minnow (Cyprinidae) species.
Comminutor	A pump or grinder that shreds inorganic material, generally located at the influent end of a wastewater treatment plant.
Confluence	The point where two or more bodies of water flow together.
Channel	A natural or artificial waterway that periodically or continuously contains moving water, has a definite bed, and has banks that serve to confine water at low to moderate stream flows.
Channelization	Deepening an existing stream channel or creating new stream channel by human activity to increase the rate of runoff or to lower the water table.
Clarifier	A tank that allows settling of solids, providing a “clear” overflow of wastewater.
Criteria	Elements of water quality standards, expressed as constituent concentrations, levels or narrative statements, representing a quality of water that supports a particular designated use.

D

Decant	The removal of the clearest portion of wastewater or sludge.
Degradation	Lowering of the existing water quality in the surface waters of the state.
Deposit	An accumulation of organic or inorganic material resulting from naturally occurring biological, chemical or physical processes.
Demand (as in oxygen)	The amount of oxygen needed to reduce wastewater pollutants over a period of time.
Designated use	A use of the surface waters of the state, established by the water quality standards, Chapter 3745-1 of the Administrative Code.
Dessication	Process of dehydration or drying up.
Detention	The amount of time that wastewater remains in the treatment system.
Detritus	A non-dissolved product of disintegration or wearing away. Pertains to small organic particles like leaves and twigs. Detritus may pertain to material produced by erosion, such as soil, sand, clay, gravel and rock, carried down a watercourse, and deposits on an outwash fan or floodplain.
Diatom	Microscopic algae with a siliceous skeleton that occurs as plankton or attaches to the substrate.
Diel	Pertaining to a 24-hour period or a regular occurrence in every 24-hour period.
Director	The director of the Ohio Environmental Protection Agency.
Dissolved oxygen	Concentration of oxygen dissolved in water, where saturation is the maximum amount of oxygen that can theoretically can be dissolved in water at a given altitude and temperature. Expressed as milligrams liter or percent saturation.
Discharge	The addition of any pollutant to the waters of the state from a point source.
Distribution	Occurrence, frequency of occurrence, position or arrangement of animals or plants within an area. May also be applied to a rate such as the number per unit of area or time.
Disturbance	A force that causes changes in habitat or community structure and composition through (a) natural events such as fire, flood, wind or earthquake; (b) mortality due to insect or disease outbreaks; or (c) human activities such as agriculture, grazing, logging, mining, road construction, etc.
Ditch	A long narrow excavation in the ground (usually an open and unpaved channel, trench or waterway smaller than a canal) for conveying water to or from a specific location for purposes such as drainage or irrigation.
Diversity	Variation that occurs in plant and animal taxa (i.e., species composition), habitats or ecosystems within a given geographic location.

E

E. coli	A specific bacterial species included in the fecal coliform bacteria group, the presence of which in surface waters has been correlated with gastrointestinal illness in swimmers.

Ecosystem	Any complex of living organisms interacting with nonliving chemical and physical components that form and function as a natural environmental unit.
Eddy	Circular movement of water, sometimes quite strong, diverging from and initially flowing against the main current in streams. Eddies are usually formed where water flows past some obstruction or on the inside of river bends. Eddies often form backwater pools, alcove pools or pocket water in rapids or cascades.
Effluent	(1) Discharge of liquid into a water body or emission of a gas into the environment. Usually composed of waste material. For example, emission of combustion gases into the atmosphere from industry or manufacturing. (2) May also be used to describe a stream flowing out of a lake or reservoir.
Embeddedness	Degree that gravel and larger sizes of particles (boulders, cobble or rubble) are surrounded or covered by fine sediment (e.g., less than 2mm.).
Emergent vegetation	Rooted aquatic plants with some herbaceous vegetative parts that project above the water surface. Also referred to as emersed vegetation.
End moraine	A ridge of glacial till that remains in equilibrium at the terminus of a valley glacier or at the margin of an ice sheet.
Endemic	Species that is unique or confined to a specific locality.
Enrichment	Process where discharges or runoff carries nutrients into a waterbody, enhancing the growth potential for bacteria, algae and aquatic plants.
Entrenchment	Stream channel incision from fluvial processes.
Environment	Combination of physical, chemical, climatic and biotic conditions that influence the development, growth, structure and vigor of an organism, population or community.
Ephemeral	Short lived or transitory.
Ephemeral flows	Stream flows in channels that are short-lived or transitory and occur from precipitation, snow melt or short-term water releases.
Erosion	(1) Process of weathering or wearing away of streambanks and adjacent land slopes by water, ice, wind or other factors. (2) Removal of rock and soil from the land surfaces by a variety of processes including gravitational stress, mass wasting or movement in a medium.

F

Facultative	Capable of living under varying conditions.
Fecal	A bacteria “fecal coliform” that indicates feces has contaminated the water.
Fecal coliform	The portion of the coliform group of bacteria which is present in the intestinal tract of warmblooded animals and is evidence of the presence of human or animal wastes.
Fines	Particulate material, less than 2 mm in diameter, including sand silt, clay and fine organic material.

Fish habitat	Aquatic and riparian habitats that provide the necessary biological, chemical and physical (i.e., environmental) requirements of fish species at various life stages.
Flood plain	(1) Area adjoining a water body that becomes inundated during periods of overbank flooding and that is given rigorous legal definition in regulatory programs. (2) Land beyond a stream channel that forms the perimeter for the maximum probability flood. (3) Strip of land bordering a stream that is formed by substrate deposition. (4) Deposit of alluvium that covers a valley flat from lateral erosion of meandering streams and rivers.
Fluvial	Pertaining to or living in streams or rivers or produced by the action of flowing water.
Fork	The point at which a stream branches into two channels that may be of similar size and flow.
Free-flowing	Stream or stream reach that flows unconfined and naturally without impoundment, diversion, straightening, rip-rapping or other modification of the waterway.

G

Geomorphology	Study of the origin of landforms, the processes that form them, and their material composition.
Glide	A shallow stream reach with a maximum depth that is 5% or less of the average stream width, a water velocity less than 20 cm (8 in) per second and without surface turbulence.
Gradient	(1) General slope or the change in vertical elevation per unit of horizontal distance, of the water surface in a flowing stream. (2) Rate of change of any characteristic per unit of length.
Gravel	Substrate particle size between 2 and 64 mm (0.1 and 2.5 in.) In diameter.
Ground moraine	Thin deposits left underneath a retreating glacier that may have a gently rolling or hummock-like appearance.
Ground water	(1) Water located interstitially in the substrate of the earth that is recharged by infiltration and enters streams through seepage and springs. (2) Subsurface water in a zone of saturation, standing in or passing through (ground water flow) the soil and the underlying strata.

H

Habitat	Specific type of place within an ecosystem occupied by an organism, population or organism that contains both living and nonliving components with specific biological, chemical and physical characteristics including the basic life requirements of food, water and cover or shelter.
Habitat component	Single element (such as velocity, depth or cover) of the habitat or area where an organism lives or occurs. Component is synonymous with attribute.
Habitat diversity	Number of different types of habitat within a given area.

Hardness	Total concentration of calcium and magnesium ions expressed as milligrams per liter (mg/L) of calcium carbonate. Synonymous with total hardness.
Hardpan	A layer of earth that has become relatively hard and impermeable, usually through mineral deposits. A chemically hardened layer where the soil particles are cemented together with organic matter of SiO_2, sesquioxides or $CACO_3$.
Homogeneous	Refers to a waterbody that has a uniform chemical composition throughout.
Hummock	Rounded, undefined or chaotic pattern of steep-sided low hills and hollows.

I

Impermeable	Refers to a layer of material of sufficient composition, density, thickness that is does not permit passage of a liquid or a gas.
Impervious	Refers to material through which water cannot pass or passes with great difficulty.
Impoundment	Natural or artificial body of water that is confined by a structure such as a dam to retain water, sediment or wastes.
Indicator organisms	(1) Organisms that respond predictably to various environmental changes and whose presence, absence and abundance are used as indicators of environmental conditions. (2) Any plant or animal that, by its presence, its frequency or its vigor, indicates any particular property of a site.
Indigenous	A fish or other aquatic organism native to a particular water body, basin or region.
Indirect toxicity	Toxicity that affects organisms by interfering with their food supply or modifying their habitat instead of acting directly on the organisms.
Infiltration	(1) Process by which water moves from the earth or surface water into the ground water system. (2) Clean water that enters the wastewater treatment system through cracks in the pipes and/or equipment.
Inflow	(1) Location where water from one source enters another water body. Also, the movement of water from one source into another water body. (2) Clean water entering the wastewater treatment system through a direct connection.
Instream	Within the wetted perimeter of the stream channel.
Instream cover	Area with structure (e.g., boulders, rocks, logs, etc.) in a stream channel that provide aquatic organisms with shelter or protection from predators or competitors. Also a place with low water velocity where organisms can rest and conserve energy.
Intermittent	(1) Alternately starting and stopping. (2) Water that flows or exists sporadically or periodically.
Intermittent flow	Flows that occur at certain times of the year only when ground water levels are adequate but may cease entirely in low flow years or be reduced to a series of separated pools.

J

Jam	Wholly or partially submerged accumulation of woody debris from winds, water currents or logging activities that partially or completely blocks the stream channel and obstructs streamflow.

K

Kame	A ridge-like or hilly local glacial deposit of coarse alluvium formed as a delta at the front of glaciers by meltwater streams.

L

Leachate	Soluble substance that has been removed from other material by water percolation.
Lentic	An aquatic system with standing or slow flowing water (e.g., lake, pond, reservoir, swamp, marsh and wetland). Such systems have a non-directional net flow of water.
Loadings	The mass, typically in kilograms per day, of a pollutant delivered to stream.
Longitudinal profile	A plot of elevations with distances to depict stream channel characteristics.
Losing stream	Stream or stream reach that contributes water to the zone of saturation.
Lotic	Aquatic system with rapidly flowing water such as a brook, stream or river where the net flow of water is unidirectional from the headwaters to the mouth.
Low-head dam	A low barrier that is placed in a waterway to retain or redirect flows.

M

Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 0.595 mm (U.S. # 30) screen.
Macrophyte	A plant that can be seen without the aid of optics.
Main stem	Principal, largest or dominating stream or channel in any given area or drainage system.
Meander	Sinuous course of a river having specific geometric dimensions that describe the degree of curvature. More particularly, one curved portion of a sinuous or winding stream channel, consisting of two consecutive loops, one turning clockwise and the other counterclockwise.
Mean high water	Average height of the high water over 19 years.
Mean low water	Average height of the low water over 19 years.
Mesic	(Ecology) Moderately moist: said of a habitat.
Mitigation	(1) Action taken to alleviate or compensate for potentially adverse effects on aquatic habitat that have been modified through anthropogenic actions. (2) In-kind mitigation may be substituted for compensation to replace a resource that has been negatively impacted with a similar resource (e.g., a stream for a stream). (3) Out-of-kind mitigation refers to replacement of one resource with another (e.g., a lake for stream).

Moraine	Irregular, surficial deposit of sand, rock and debris left by a retreating glacier.
Morphology	Physical attributes of a waterbody and the methods for measuring those attributes.
Muck	Soft fine-grained soil composed of silt, clay or organic substrate material, typically dark in color, that consists of 20-50% highly decomposed organic matter with intermingled silt and clay.

N

Native species	Plant and animal species that occur naturally in aquatic and terrestrial habitats.
Nitrogenous	The nitrogen portion of the total biochemical oxygen demand in the wastewater.
Non-contact cooling water	Water that cools without coming into contact with the item to be cooled.
Nonpoint source	Usually applied to pollutants entering a waterbody in a diffuse pattern rather than from a specific, single location that includes land runoff, precipitation, atmospheric deposition or percolation.
Nutrient	Element or compound essential for growth, development and life for living organisms such as oxygen, nitrogen, phosphorus and potassium.
Nutrient cycling	Circulation of nutrient elements and compounds in and among the atmosphere, soil, parent rock, flora and fauna in a given area such as a water body.
Nutrient loading	Addition of nutrients into the water column via runoff, discharge, internal re-circulation, ground water or atmosphere.
Nutrient spiraling	Cycling and downstream transport of nutrients from physical and biological activities in a stream.

O

Organic debris	Material of organic origin that ranges in size from fine particulate matter large trees.
Organism	Any individual animal or plant having diverse organs and parts that function together as a whole to maintain life and its activities.
Outfall	Outlet of a water body, drain, culvert or other structure.
Overflow channel	Abandoned channel in a floodplain that carries water during periods of high runoff.
Overhang	Organic or inorganic materials that project over a waterbody.
Overhead cover	Plant foliage or overhanging material that provides protection to fish or other aquatic animals.

P

Parameter	Any quantitative characteristic that describes an individual, population or community or that describes the biological, chemical and physical components of an ecosystem.

Parent material	Unconsolidated (more or less) weathered material or organic matter from which soil is developed.
Particle	Individual fragment of organic or mineral material.
Particle size	Linear dimension, usually designated as "diameter," that characterizes the size of a particle.
Particle size distribution	Frequency distribution (expressed as d_n) of the relative amounts of particles in a sample that are within a specified size range or a cumulative frequency distribution of the relative amounts of particles that are coarser or finer than a specified size.
Peat	Unconsolidated, partially decomposed organic - mainly plant - material deposited under waterlogged, oxygen-poor conditions. A layer of organic material containing plant residues that have accumulated in a very wet environment.
Pebble	Small (2-64 mm.), gravel-sized stone with rounded edges, especially one smoothed by the action of water.
Perennial	Stream, lake or other water body with water present continuously during a normal water year.
Perennial flow	Flows that are continuous throughout the year.
Periphyton	Attached microflora growing on the bottom or on other submerged substrates, including higher aquatic plants.
Pesticide	Any chemical used to control populations of organisms that are undesirable to humans. The term "pesticide" is a generic term that is applied to chemicals used to control animals. More specific terms include "herbicide" (to control plants), "insecticide" (to control insect) and "lampricide" (to control sea lampreys).
pH	Measure of the acidity and alkalinity of a solution, expressed as the negative $\log_{10}$ of the hydrogen-ion concentration on a scale of 0 (highly acidic) to 14 (highly basic). A pH of 7 is neutral.
Plain	Any flat or gently sloping (elevation differences of less than 150 m [500 ft]) area formed from deposition of eroded substrates at low elevations and that may be forested or bare of trees.
Photosynthesis	The production of organic substances, chiefly sugars, from carbon dioxide and water occurring in green plant cells supplied with enough light to allow chlorophyll to aid in the transformation of the radiant energy into a chemical form.
Plankton	Small animals and plants, generally smaller than 2 mm and without strong locomotive ability, that are suspended in the water column and carried by currents or waves that may make daily or seasonal movements in the water column.
Polishing	Continued reduction of pollutants from the effluent.
Pool	Aquatic habitat in a stream with a gradient less than 1% that is normally deeper and wider than aquatic habitats immediately above and below it.
Point source	Any discernible, confined or discrete conveyance from which a pollutant is or may be discharged to the surface waters of the state.

Pollutant	Sewage, industrial waste or other waste as defined by divisions (B) to (D) of Section 6111.01 of the Revised Code.
Pollute	To contaminate land, water, air, plants, animals or microorganisms with substances considered objectionable or harmful to the health of living organisms.
Pollution	Presence of matter or energy, usually of human origin, whose nature, location or quantity produces undesired environmental effects on natural systems.
Pool	Small depression with standing water such as found in a marsh or on a floodplain. Aquatic habitat in a stream with a gradient less than 1% that is normally deeper and wider than aquatic habitats immediately above and below it.
Pretreatment	Wastewater that has been treated to reduce the pollutants, generally prior to reaching a wastewater treatment plant.
Protozoan	One type of microorganism(s) found within the biomass (sludge) that metabolizes the wastewater pollutants.

R

Receiving waters	The surface waters of the state into which point and nonpoint sources flow.
Relicts	(Geology) A physical feature, structure, etc. that remains after other components have wasted away or been altered.
Respiration	Process by which a living organism or cell takes in oxygen from the air or water, distributes and utilizes it in oxidation, and gives off products of oxidation, especially carbon dioxide.
Riffle	Shallow reaches with low sub-critical flow (1-4% gradient) in alluvial channels of finer particles that are unstable, characterized by small hydraulic jumps over rough bed material, causing small ripples, waves and eddies, without breaking the surface tension. Stable riffles are important in maintaining water level in the pool immediately upstream of the riffle.
Riparian area	(1) Of, pertaining to, situated or dwelling on the margin of a river or other water body. (2) Also applies to banks on water bodies where sufficient soil moisture supports the growth of mesic vegetation that requires moderate amount of moisture. Also referred to as riparian zone, riparian management area or riparian habitat.
Riparian vegetation	Vegetation growing on or near the banks of a stream or other waterbody that is more dependent on water than vegetation that is found further upslope.
Riprap	Hard materials, such as logs, rock or boulders (often fastened together) used to protect a bank or another important feature of a stream, lake, reservoir or other waterbody.
River	Large natural or human modified stream that flows in a defined course or channel or a series of diverging and converging channels.

River continuum	Ecological succession that occurs from the headwaters to the mouth in a river and that is associated with an increase in nutrients and organic matter.
Riverine (riverain)	(1) Habitats that are formed by or associated with a river or stream. (2) Wetlands and deeper water habitats within a channel that are influenced strongly by the energy of flowing water. (3) Also applied to vegetation growing in a floodplain, in close proximity to water courses with flowing water or on islands in a river.
Rootwad	Root mass from a tree. Synonymous with butt ends.
Run	Swiftly flowing stream reach with a gradient greater than 4%, little or no surface agitation, waves or turbulence, no major flow obstructions, approximately uniform flow, substrates of variable particle size, and water surface slope roughly parallel to the overall stream gradient.

S

(sic)	Used within brackets "[sic]," to show that a quoted passage, especially one containing some error or something questionable, is precisely reproduced.
Sludge	A concentration of biological organisms that metabolize the wastewater pollutants.
Solids	A small portion of the biomass or sludge.
Stream	Natural watercourse containing flowing water, at least part of the year, together with dissolved and suspended materials, that normally supports communities of plants and animals within the channel and the riparian vegetation zone.
Storm event	Major episode of atmospheric disturbance that often is associated with heavy precipitation.

T

Terminal moraine	Geologic deposits at the front lobe or foot of a glacier that marks the furthest point reached by a glacier.
Threatened or endangered species	Those species of the state's biota which are threatened with statewide extirpation or national extinction, as listed in rule 1501:31-23-01 of the Administrative Code or 50 C.F.R. 17 or that are listed as endangered or threatened under section 4 of the Endangered Species Act, 16 U.S.C. 1531 *et seq.* (as amended).
Toxicity	Acute toxicity: Adverse effects that result from an acute exposure and occur within any short observation period which begins when the exposure begins and usually does not constitute a substantial portion of the life span of the organism. Chronic toxicity: Concurrent and delayed adverse effects that occur only as a result of a chronic exposure. Chronic exposure is exposure of an organism for any long period or for a substantial portion of its life span.

U

Uptake	The acquisition of a substance from the environment by an organism as a result of any active or passive process.
Use attainability analysis	A structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological and economic factors.

W

Wasting (sludge)	Removal of sludge from the treatment system to a holding tank, another treatment unit or another WWTP.
Water quality standards	The rules set forth in Chapter 3745-1 of the Administrative Code establishing stream use designations and water quality criteria protective of such uses for the surface waters of the state.
Warmwater fish	Those species of fish that inhabit relatively warmwater. These species include, but are not limited to, bass, crappies and sunfish (Centrachidae) and catfish (Ictaluridae), and may include certain suckers (Catostomidae), minnows (Cyprinidae) and perch and darter (Percidae) species.
Wastewater	Water that has been contaminated with pollutants.
Wetland	Areas of land where the water table is at, near or above the land surface long enough each year to result in the formation of characteristically wet (hydric) soil types and support the growth of water-dependent (hydrophytic) vegetation. Wetlands include, but are not limited to marshes, swamps, bogs and other such low lying areas.
Woody debris	Collection of materials in the water or substrate on the bank or shoreline that is primarily composed of wood.

Z

Zone of saturation	The soil zone that is located below the permanent water table.

A.10.3 Mechanisms for Water Quality Impairment

The following paragraphs present causes of impairment that were encountered during the 2001/2002 survey. While the various perturbations are presented separately, it is important to remember that they are often interrelated and cumulative in impact.

A.10.3.1 Habitat and Flow Alterations

Habitat alterations impact biological communities directly by limiting the complexity of living spaces available to aquatic organisms. Consequently, fish and macroinvertebrate communities are not as diverse. Habitat and flow alterations include channelization (the straightening and deepening of a stream) and the installation of field tiles to facilitate drainage. The removal of trees on the stream bank usually accompanies this action.

In tiled fields, after a rain event most of the water quickly drains rather than filtering through the soil and recharging the ground water and reaching the stream at a lower volume and more sustained rate. As a consequence, small streams in watersheds predominated by tiled fields more frequently go dry or become intermittent.

Shading of the stream channel by trees is important because it limits the amount of sunlight reaching the water's surface reducing instream photosynthesis (i.e., algal production) and reduces temperature swings of the water column. Removal of the riparian tree canopy eliminates an important source of coarse organic matter essential for a balanced ecosystem. Erosion impacts channelized streams more severely due to the lack of a riparian buffer zone to slow runoff, trap sediment and stabilize banks. Additionally, deep trapezoidal channels lack a functioning flood plain and therefore cannot trap sediments as would occur during flood events along natural watercourses.

The lack of water movement under low flow conditions can exacerbate impacts from organic loading and nutrient enrichment by limiting re-aeration of the stream and promotion of algal productivity. The amount of oxygen soluble in water decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion, but channelization eliminates turbulence produced by riffles, meanders and debris snags. Plant photosynthesis produces oxygen, but at night, respiration reverses the process and consumes oxygen. Oxygen is also used by bacteria that decay dead organic matter. Nutrient enrichment can promote the growth of nuisance algae that subsequently dies and serves as food for bacteria. Under these conditions, oxygen can be depleted unless it is replenished from the air.

A.10.3.2 Sedimentation

Whenever the natural flow regime is altered to facilitate drainage, increased amounts of sediment are likely to enter streams either by overland transport or increased bank erosion. The removal of wooded riparian areas furthers the erosional process. Channelization keeps all but the highest flow events confined within the artificially high banks. As a result, areas that were formerly flood plains and permitted for the deposition of sediment outside of the stream channel no longer serve this function. As water levels fall following a rain event, interstitial spaces between larger rocks fill with sand and silt and the diversity of available habitat to support fish and macroinvertebrates is reduced. Silt can also clog the gills of both fish and macroinvertebrates, reduce visibility thereby excluding sight feeding fish species and smother the nests of lithophilic fishes. Lithophilic-spawning fish require clean substrates with interstitial voids in which to deposit eggs; conversely, pioneering species benefit. They are generalists and best suited for exploiting disturbed and less varied habitats. The net result is a lower diversity of aquatic species compared with a typical warmwater stream with natural habitats.

Sediment also impacts water quality, recreation and drinking water. Nutrients adsorbed to soil particles remain trapped in the watercourse. Likewise, bacteria, pathogens and pesticides which also attach to suspended or bedload sediments become concentrated in waterways where the channel is functionally isolated from the landscape. Community drinking water systems address these issues with more costly advanced treatment technologies.

A.10.3.3 Nutrients

The element of greatest concern is phosphorus because it is critical for plant growth and it is often the limiting nutrient. The form that can be readily used by plants, and therefore can stimulate nuisance algae blooms, is orthophosphate (PO_4^{-3}). The amount of phosphorus tied up in the nucleic acids of food and waste is actually quite low. This organic material is eventually converted to orthophosphate by bacteria. The amount of orthophosphate contained in synthetic detergents is a great concern however. It was for this reason that the General Assembly of the State of Ohio enacted a law in 1990 to limit phosphorus content in household laundry detergents sold in the Lake Erie drainage basin to 0.5% by weight.

Phosphorus originates from both point and nonpoint sources of pollution. Most of the phosphorus discharged by point sources is soluble. Point sources, for example, municipal sewage treatment plants, tend to have a continuous impact on the streams that receive them. The contribution from failed on-lot septic systems can also be significant, especially if many are located in a small area. The phosphorus concentration in raw waste water is generally 8-10 mg/l; after secondary treatment, generally 4-6 mg/l. Further removal requires the added cost of chemicals such as lime or alum to form a precipitate; most phosphorus (80%) ends up in the sludge. Phosphorus discharged by nonpoint sources is usually delivered intermittently; e.g., associated with storm water runoff. Most of this phosphorus is bound tightly to soil particles and enters streams from erosion, although some comes from tile drainage. Urban storm water is more of a concern if combined sewer overflows are involved.

The impact from rural storm water varies depending on land use and management practices and includes contributions from livestock feedlots and pastures and row crop agriculture. Crop fertilizer includes granular inorganic types and organic types such as manure or sewage sludge. Pasture land is especially a concern if the livestock have access to the stream. Large feedlots with manure storage lagoons create the potential for overflows and accidental spills. Land management is an issue because erosion is worse on streams without any riparian buffer zone to trap runoff. The impact can be more pronounced in streams that are channelized because they no longer have a functioning flood plain and cannot expel sediment during flooding. Oxygen levels may also be affected because phosphorus is released from sediment at higher rates under anoxic (oxygen-starved) conditions.

There is no numerical phosphorus criterion established in the Ohio Water Quality Standards, but there is a narrative criterion stating that phosphorus should be limited to the extent necessary to prevent nuisance growths of algae and weeds (Administrative Code, 3745-1-04, Part E). An Ohio EPA study found significant correlation between phosphorus and the health of aquatic communities (Association Between Nutrients, Habitat and Aquatic Biota in Ohio Rivers and Streams, MAS/1999-1-1). Biological community performance in headwater and wadeable streams was highest where phosphorus concentrations were lowest. The lowest phosphorus concentrations were associated with the highest quality habitats, indicating that habitat is a critical component of stream function. The report recommends WWH criteria of 0.08 mg/l in headwater streams (<20 mi^2 watershed size), 0.10 mg/l in wadeable streams (>20-200 mi^2) and 0.17 mg/l in small rivers (>200-1000 mi^2).

A.10.3.4 Organic Enrichment and Low Dissolved Oxygen

The amount of oxygen soluble in water is low and decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion. Drainage practices such as channelization eliminate turbulence produced by riffles, meanders and debris snags. Although plant photosynthesis produces oxygen by day, it is consumed by the reverse process of respiration at night. Oxygen is also consumed by bacteria that decay organic matter, so it can be quickly depleted unless it is replenished from the air. Sources of organic matter include inadequately treated waste water, sewage bypasses and dead plants and algae.

Dissolved oxygen criteria are established in the Ohio Water Quality Standards to protect aquatic life. The minimum and average limits are tiered values and linked to aquatic life use designations (Administrative Code 3745-1-07, Table 7-1).

A.10.3.5 Ammonia

Ammonia gas (NH_3) readily dissolves in water to form the compound ammonium hydroxide (NH_4OH). In aquatic ecosystems an equilibrium is established as ammonia shifts from a gas to undissociated ammonium hydroxide to the dissociated ammonium ion (NH_4^{+1}). Under normal conditions (neutral pH 7 and 25°C) almost none of the total ammonia is present as gas, only 0.55% is present as ammonium hydroxide and the rest is ammonium ion. Alkaline pH shifts the equation toward gaseous ammonia production, so the amount of ammonium hydroxide increases. This is important because while the ammonium ion is almost harmless to aquatic life, ammonium hydroxide is very toxic and can reduce growth and reproduction or cause mortality.

The concentration of ammonia in raw sewage is high, sometimes as much as 20-30 mg/l. Treatment to remove ammonia involves gaseous stripping to the atmosphere, biological nitrification and de-nitrification and assimilation into plant and animal biomass. The nitrification process requires a long detention time and aerobic conditions like that provided in extended aeration treatment plants. Under these conditions, bacteria first convert ammonia to nitrite (*Nitrosomonas*) and then to nitrate (*Nitrobacter*). Nitrate can then be reduced by the de-nitrification process (*Pseudomonas*) and nitrogen gas and carbon dioxide are produced as by-products.

Ammonia criteria are established in the Ohio Water Quality Standards to protect aquatic life. The maximum and average limits are tiered values based on sample pH and temperature and linked to use designations (Administrative Code 3745-1-07, Tables 7-2 through 7-8).

A.10.3.6 Metals

Metals can be toxic to aquatic life and hazardous to human health. Although they are naturally occurring elements many are extensively used in manufacturing and are by-products of human activity. Certain metals like copper and zinc are essential in the human diet, but excessive levels are usually detrimental. Lead and mercury are of particular concern because they often trigger fish consumption advisories. Mercury is used in the production of chlorine gas and caustic soda and in the manufacture of batteries and fluorescent light bulbs. In the environment it forms inorganic salts, but bacteria convert these to methyl-mercury and this organic form builds up in the tissues of fish. Extended exposure can damage the brain, kidneys and developing fetuses. The Ohio Department of Health (ODH) issued a statewide fish consumption advisory in 1997 advising women of child bearing age and children six and under not to eat more than one meal per week of any species of fish from waters of the state because of mercury. Lead is used in batteries, pipes and paints and is emitted from burning fossil fuels. It affects the central nervous system and damages the kidneys and reproductive system. Copper is mined extensively and used to manufacture wire, sheet metal and pipes. Ingesting large amounts can cause liver and kidney damage. Zinc is a by-product of mining, steel production and coal burning and used in alloys such as brass and bronze. Ingesting large amounts can cause stomach cramps, nausea and vomiting.

Metals criteria are established in the Ohio Water Quality Standards to protect human health, wildlife and aquatic life. Three levels of aquatic life standards are established (Administrative Code 3745-1-07, Table 7-1) and limits for some elements are based on water hardness (Administrative Code 3745-1-07, Table 7-9). Human health and wildlife standards are linked to either the Lake Erie (Administrative Code 3745-1-33, Table 33-2) or Ohio River (Administrative Code 3745-1-34, Table 34-1) drainage basins. The drainage basins also have limits for additional elements not established elsewhere that are identified as Tier I and Tier II values.

A.10.3.7 Bacteria

High levels of indicator bacteria (fecal coliform and E. coli) in streams are a concern because of human health. People can be exposed to contaminated water while wading, swimming and fishing. Fecal coliform and E. coli bacteria are relatively harmless in most cases, but their presence indicates that the water has been contaminated with feces from a warm-blooded animal. Although intestinal organisms eventually die off outside the body, some will remain virulent for a period of time and may be dangerous sources of infection. This is especially a problem if the feces contained pathogens or disease-producing bacteria and viruses. Reactions to exposure can range from a skin rash, sore throat or ear infection to a more serious flu-like symptoms. Some types of bacteria that are a concern include *Escherichia*, which cause diarrhea and urinary tract infections, *Salmonella*, which can cause typhoid fever and gastroenteritis (food poisoning) and *Shigella*, which causes severe gastroenteritis or bacterial dysentery. Some types of viruses that are a concern include polio, hepatitis A and encephalitis. Disease causing microorganisms such as cryptosporidium and giardia are also a concern.

Since fecal coliform bacteria are associated with warm-blooded animals, there are both human and animal sources. Human sources, including effluent from sewage treatment plants or discharges by on-lot septic systems, are a more continuous problem. Bacterial contamination from combined sewer overflows are associated with wet weather events (i.e., rain or snow storms). Animal sources are usually a more intermittent problem and are also associated with rainfall, except when livestock have access to the water. Large livestock farms store manure in holding lagoons and this creates the potential for an accidental spill. Liquid manure applied as fertilizer is a runoff problem if not managed properly (i.e., applied on frozen ground or ground without vegetation to incorporate the nutrients) and it sometimes seeps into field tiles.

Bacterial criteria are established in the Ohio Water Quality Standards to protect human health. The maximum and average limits are tiered values and linked to use designation, but only apply during the May 1-October 15 recreational season (Administrative Code 3745-1-07, Table 7-13). The standards also state that streams must be free of any public health nuisance associated with raw or poorly treated sewage during dry weather conditions (Administrative Code 3745-1-04, Part F).

A.10.3.8 Sediment Contamination

The chemical quality of sediment is a concern because many pollutants bind strongly to soil particles and are persistent in the environment. Some of these compounds accumulate in the aquatic food chain and trigger fish consumption advisories, but others are simply a contact hazard because they can cause skin cancer and tumors with sufficient exposure. The physical and chemical nature of sediment is determined by local geology, land use and contribution from manmade sources. As some materials enter the water column they are attracted to the surface electrical charges associated with suspended silt and clay particles. Others simply sink to the bottom due to their high specific gravity. Sediment layers form as suspended particles settle, accumulate and combine with other organic and inorganic materials. Sediment is most physically, chemically and biologically reactive at the sediment-water interface because this is where it is affected by sunlight, current, wave action and benthic organisms. Assessment of the chemical nature of this layer can be used to predict ecological impact.

The Ohio EPA evaluation of sediment chemistry results are evaluated using a dual approach, first by ranking relative concentrations based on a system developed by Ohio EPA (1996) and then by determining the potential for toxicity based on guidelines developed by MacDonald *et al.* (2000). The Ohio EPA system was derived from samples collected at ecoregional reference sites. Classes are grouped in ranges that are based on the median analytical value (non-elevated) plus 1 (slightly elevated), 2 (elevated), 4 (highly elevated), and 8 (extremely elevated) inter-quartile values. The MacDonald guidelines are consensus-based using previously developed values. The system predicts that sediments below the threshold effect concentration (TEC) are absent of toxicity and those greater than the probable effect concentration (PEC) are toxic.

Sediment samples collected by Ohio EPA are measured for a number of physical and chemical properties. Physical attributes included % particle size distribution (sand ≥60 µ, silt 5-59 µ, clay ≤4 µ), % solids and % organic carbon. Due to the dynamics of flowing water, most streams do not contain a lot of sediment and samples often consist mostly of inert sand. This scenario changes if the stream is impounded by a dam or channelized. Chemical attributes measured include concentration of metals, volatile and semi-volatile organic compounds, pesticides and polychlorinated biphenyls (PCBs).