IV. WATER QUALITY

A. WATERSHED FEATURES

STREAMS

The headwaters of the Darby Watershed begin in some of the highest areas of Ohio in Logan and Champaign County where there are many hills and steep slopes. The gradient begins to level out into highly productive agricultural land through the central counties of the watershed and then falls more rapidly in Pickaway County to the Scioto River. Along the mainstems of Big and Little Darby Creek a substantial forested buffer exists which has helped to buffer negative impacts. There are no substantial urban areas along either the Big or Little Darby Creek however several tributaries are experiencing increased urbanization in Union and Franklin Counties.

This section of the inventory examines all streams recognized in the National Hydrography Dataset (NHD) by the USGS which includes all perennial and most intermittent streams in the watershed. This stream database is the same set of streams the EPA used when analyzing the Darby Watershed. Figure 69 illustrates the total number of stream miles analyzed by county and also includes county maintained ditches. The last entry in the figure labeled "Madison/Franklin" is the mainstem of Big Darby between Madison and Franklin County.

Figure 69: Stream Miles Analyzed by County

County	*Total Stream Miles*	*Percent of Total Miles*
Madison	197.48	27.63%
Union	153.37	21.46%
Champaign	130.42	18.25%
Franklin	90.72	12.69%
Pickaway	84.15	11.77%
Logan	45.88	6.42%
Franklin/Madison	12.69	1.78%
Totals	**714.71**	**100.00%**

Following sections will examine the stream gradient, buffers, channel condition, and point and non point pollution sources.

GRADIENT

The gradient of the watershed varies greatly from moderately high in the headwaters of the watershed to low in the midsection of the watershed. The mainstem of the Big Darby has an elevation of 1170 feet above sea level at its start in Logan County and an elevation of 643 feet at its mouth in Pickaway County. The average gradient of the Big Darby Creek is 6.8 feet per mile. The gradient of other major Ohio streams is displayed in Figure 70.

Figure 70: Gradient of Selected Ohio Streams		
Stream	*Total Stream Miles*	*Gradient (Ft/Mile)*
Maumee River	105.4	1.3
Stillwater	67.2	4.2
Little Miami River	105.5	6.5
Big Darby Creek	**78.7**	**6.8**
Cuyahoga River	100.1	7.1

Source: ODNR, Streams Gazetteer, 2nd Edition, 2001.

Many stream channels through agricultural areas of the watershed have been straightened and deepened to improve drainage in flat regions of the watershed. An example of a stream that has been altered to improve drainage is Flat Branch in Logan County which only falls 21 feet in 4.7 miles. Figure 71 below summarizes the average fall of major streams in the Darby Watershed.

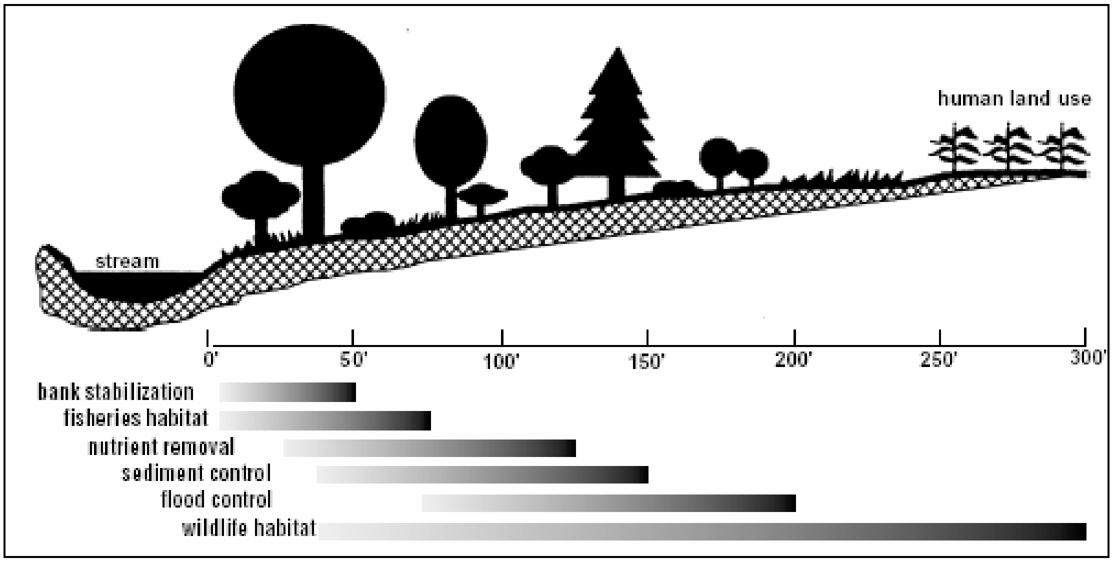
Figure 71: Gradient of Streams in Darby Watershed				
Stream Name	*Length (miles)*	*Elev. at Source*	*Elev. at Mouth*	***Av. Fall Ft per Mile***
Flat Branch	4.7	1,069	1,048	**4.5**
Buck Run	6.8	999	960	**5.7**
Little Darby Creek	69.1	1,045	820	**5.9**
Big Darby Creek	78.7	1,170	643	**6.8**
Spring Fork	12	1,028	941	**7.2**
Sugar Run	5	942	903	**7.8**
Barron Creek	4.8	1,003	963	**8.3**
Sugar Run	4.4	983	944	**8.9**
Hay Run	3.6	1,011	977	**9.4**
Robinson Run	3.2	952	918	**10.6**
Prairie Run	2.5	988	961	**10.8**
Hellbranch Run	12.8	921	777	**11.2**
Springwater Run	0.6	775	767	**13.3**
Threemile Run	5.3	972	880	**17.4**
Lake Run	4.1	1,081	1,008	**17.8**
Treacle Creek	14.2	1,240	986	**17.9**
Proctor Run	6	1,125	997	**21.4**
Howard Run	3.2	1,079	1,005	**23.1**
Greenbrier Creek	2.6	820	730	**34.6**
Georges Creek	0.5	745	725	**40.0**
Little Darby Creek (Logan Co.)	4.5	1,232	1,047	**41.1**
Pleasant Run	8	1,340	1,004	**42.0**
Jumping Run	2.7	1,180	1,064	**43.9**
Clover Run	3.8	1,250	1,037	**56.1**

Source: ODNR, Stream Gazetteer, 2nd Edition, 2001

STREAM BUFFERS

Streamside buffers, often referred to as riparian buffers, vary in width from extensive 1,000 foot buffers to a 10 foot grassed buffer along county maintained ditches. The riparian buffer refers to vegetative strips of grass, shrubs, and/or trees along the banks of streams. These strips filter polluted runoff and provide a transition zone between streams and human land uses. Landowners can determine appropriate buffer widths based on their goals for water quality or control. The following Figure 72 from the Connecticut River Watershed, illustrates appropriate buffer widths based on what the landowner's goals.

Figure 72: Riparian Buffer Width Goals



Source: Connecticut River Watershed, 2000. *Introduction to Riparian Buffers*. Charlestown, NH. Pg. 3

The figure above is a general guideline typically applied to larger streams with steeper slopes. In flatter topography, bank stabilization and sediment filtration are effective at 35 feet. Each additional foot of buffer width provides increased benefits.

The following figure was included in research by Ward et. al. (2002) on natural stream processes. Figure 73 defines recommended stream buffer widths based on a specific goal such as wildlife or bank stabilization.

Figure 73: Recommended Widths for Vegetated Stream Buffers

Function	Study	Relevant Details	Width (feet)
Riparian Habitat Areas	Washington State (2001)	Fish and Wildlife based on review of nearly 1500 articles	150-250 or 100-year floodplain
Wildlife Protection	Rabeni (1991)[1]	Fish, amphibians,birds	25 - 200
	Cross (1985)[1]	Small mammals	30 – 60
	Brown el al. (1990)[1]	Provision of food, water, cover	300-600
Water-Quality	Ahola (1990)[1]	General Improvements	160
	Pinay & Decamp (1988)[1]	As above	3-6
	Correll & Weller (1989)[1]	Nitrate control	About 60
Sediment Control	Peterjohn & Correll (1984)[1]	Nutrient Control	About 60
Bank Stabilization	Ontario Ministry Agriculture (1998)	Agricultural ditch bank stabilization	10
Urban Stream Buffer	Schueler (1995)	Survey of 36 buffer programs	20-200

1.As cited by Large and Petts (1994).

Source: Ward et. al., 2002. *Sizing Stream Setbacks to Help Maintain Stream Stability*. Prepared for 2002 ASAE Annual International Meeting. Chicago Illinois, July 28 – July 31, 2002.

Agricultural Stream Buffers

Why Needed?

Two major pollution concerns from agricultural land, sediment and nutrients, can be effectively controlled by vegetative buffers adjacent to agricultural land. Iowa State University found that along a 6.8 mile stretch of a local stream, stream bank erosion was reduced by 72 percent by installing a forest buffer. This same area illustrated that buffers of 66 foot widths reduced overland sediment flow by more than 90 percent (Zaimes et. al, 2004).

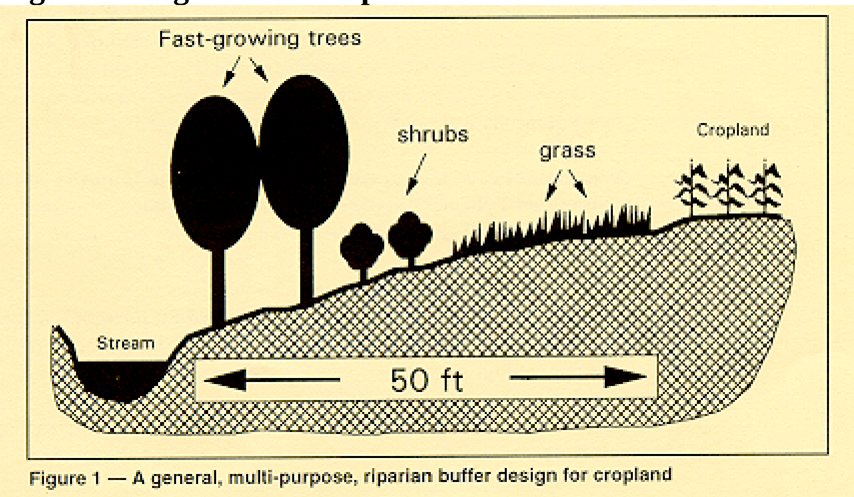
Sediment has been recognized as the number one pollutant to Ohio streams. Sedimentation is the accumulation of excess soil particles in streams which can suffocate organisms and block sunlight needed by aquatic life. Nutrients such as phosphorus and nitrogen can attach to soil particles and be transported to streams. Phosphorus and Nitrogen cause excessive algae growth, deteriorate water quality, and can kill fish.

In 2002, the Wisconsin Natural Resource board adopted a resolution that will require a mandatory buffer provision to be in place by January, 2008 (Wisconsin Rivers, 2002). This provision will require stream buffers along all high quality and impaired streams where cost share dollars are available.

How Large?

The recommended buffer width and type vary depending on the research and site conditions. For example, the Natural Resource board in Wisconsin determined that a minimum of 30 feet to be an adequate buffer width to protect water quality. Researchers from the USDA AgroForestry Center and Iowa State University created guidelines for a multi-purpose riparian buffer that included two rows of trees, two rows of shrubs and then 20 feet of grass adjacent to the agricultural land for a total buffer width of 50 feet on each side of the stream (See Figure 74).

Figure 74: Agricultural Riparian Buffer Model



Source: Dosskey, Schultz, and Isenhart, 1997. *Riparian Buffer Design for Cropland*. Agroforestry Notes. USDA Forest Service, Rocky Mountain Station.

The placement of trees along stream banks are important in improving water quality. Trees shade streams and help protect aquatic life from high summer temperatures. Leaf material from trees also serves as food for aquatic life. Certain aquatic species are not capable of surviving in streams without a wooded buffer.

Urban and Residential Stream Buffers

Why Needed?

There are a large number of pollutants that can enter urbanized stream such as petroleum byproducts, salt, metals, and construction sediment. Increases in impervious surfaces in urbanizing areas can often result in increased stream flooding and bank erosion as more water enters the stream in a short period of time. This may force government officials to deal with flooding and property damage by structurally confining stream channels which only shifts flooding problems downstream and places landowners in greater risk when the river does break through constructed defenses.

Instead of attempting to control streams, urbanizing areas should consider what impacts development could have on their stream, backyard, and downstream neighbors. A stream buffer of adequate width can protect the communities water supply, protect property from flooding, support stream life, and can provide communities with value.

How Large?

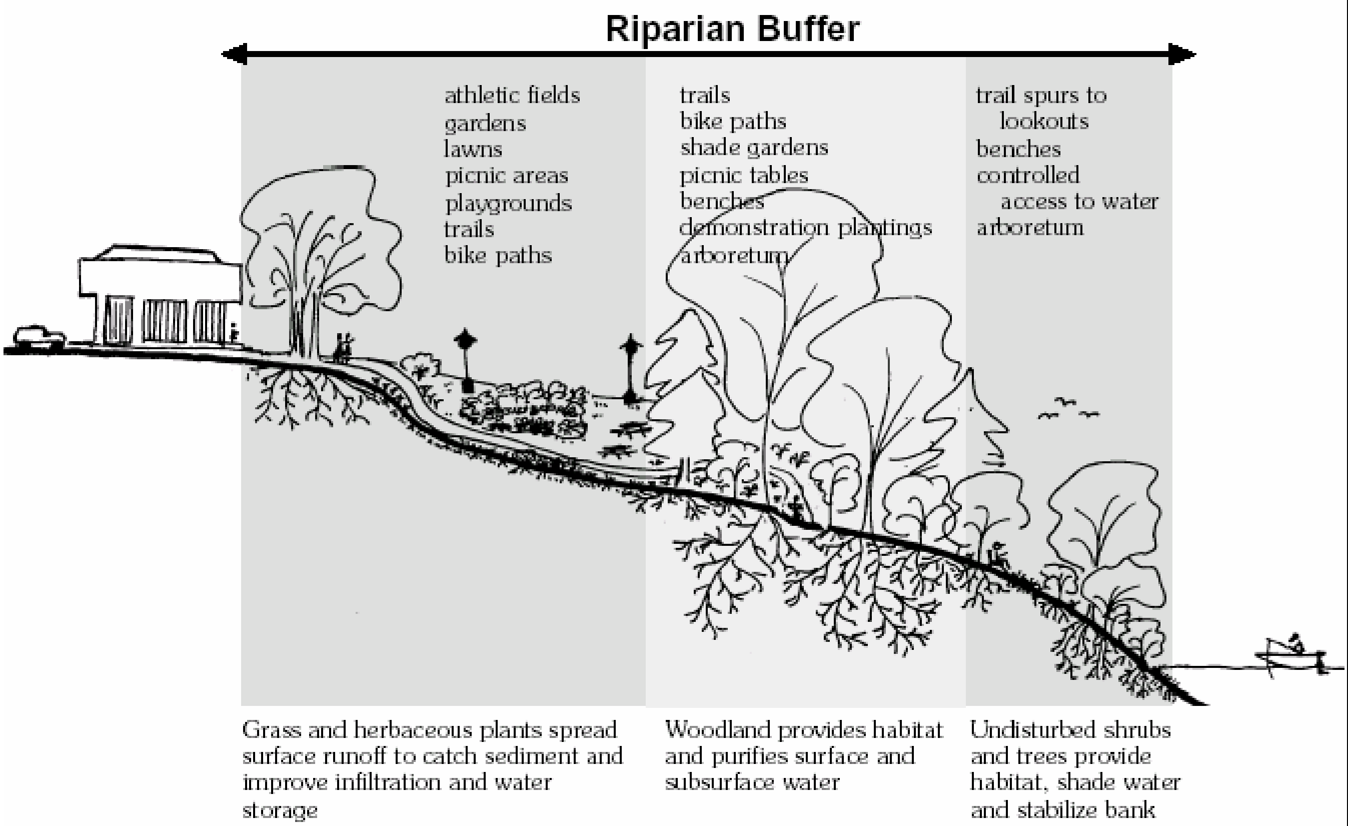
Research suggests a riparian buffer for urban areas in three zones to maximize the local benefit. The Connecticut River Watershed (2000) illustrates the three zone approach to stream buffers in Figure 75.

Figure 75: Three Zone Urban Buffer

Three Zone Buffer System

The most effective urban buffers have three zones.

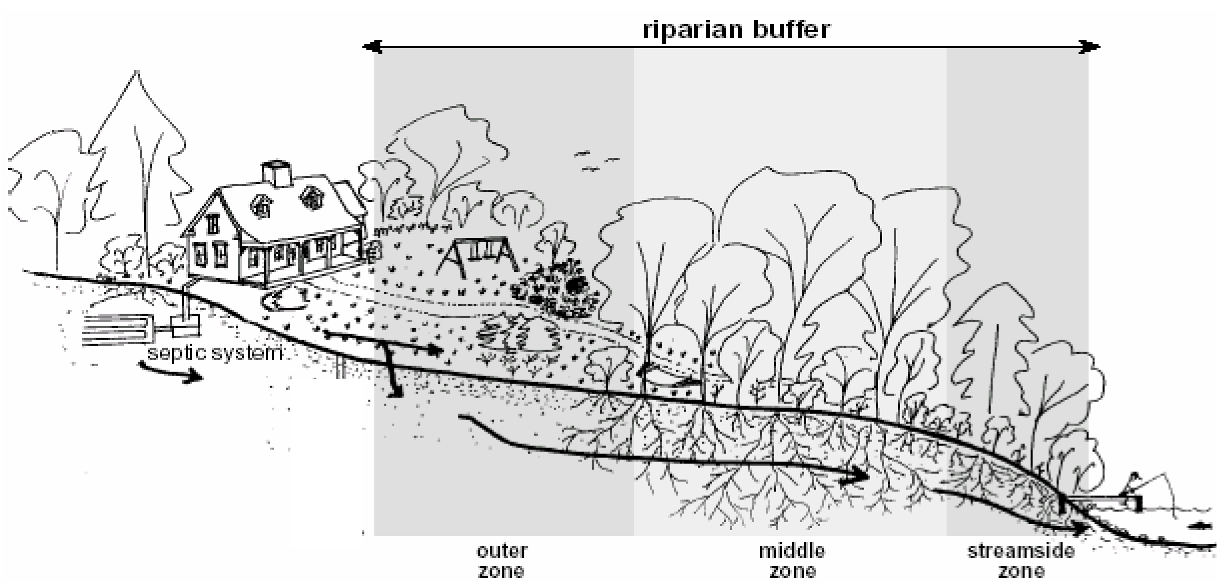
- **streamside**: to top of bank for erosion control, shade, visual screen, noise control
- **middle zone**: inland from top of bank; to capture pollutants and recharge ground-water; width should ideally reflect size of stream, extent of 100 year flood plain, and adjacent steep slopes; the goal is a mature woodland, with some clearing for recreational uses
- **outer zone**: between the rest of the buffer and the nearest permanent structure; to capture sediment and absorb runoff; open, unpaved space (turf or lawn); playing fields, gardens, playgrounds, and other common community activities are suitable



Source: Connecticut River Watershed, 2000. *No. 6 Urban Buffers*. Charlestown, NH. Pg. 5

The three zone approach above is more typically applied in urban setting but can also be altered to fit rural properties with stream access in their backyard. The Connecticut River Watershed also prepared a diagram for "backyard" buffers as seen in Figure 76.

Figure 76: Three Zone Backyard Buffer



A THREE ZONE BUFFER SYSTEM — the most effective backyard buffer has three zones:

- **streamside**: from the water to the top of the bank. Protects the bank and offers habitat. The best buffer has mature forest but large shrubs may be a better choice where trees have collapsed a bank. Let it grow and let it go for the best protection.
- **middle zone**: from the top of the bank inland. Protects stream water quality and offers habitat. Varies in width depending on size of stream and the slope and use of nearby land. The best buffer has trees, shrubs, and perennial ground plants. It can allow some clearing for recreational use.
- **outer zone**: the yard, garden, or woods between your home and the rest of the buffer. Traps sediment; play areas, gardens, compost piles, and other common residential activities are suitable here.

Source: Connecticut River Watershed, 2000. *No.2 Backyard Buffers*. Charlestown, NH. Pg. 2

In the past five to ten years municipalities across the country have placed an increased emphasis on the protection of stream buffers. For example in 2003, New Jersey passed a statewide zoning rule that prohibits new development within 75 feet of a stream (Riparian Buffer Ordinance, 2004). Additionally, Cobb County, Georgia created a no disturb zone between 50 and 200 feet depending on the size of the stream (England and Roy, 2001).

Within the Darby Watershed, the External Advisory Group (EAG) is advising Ohio EPA on how development should proceed in the Hellbranch subwatershed in Western Franklin County. As part of the recommendations a riparian forest and floodplain protection will be created which will not permit development within the 100 year floodplain or the beltwidth of the river (calculated based on drainage area of stream), whichever is greater. Also a recommended minimum setback of 100 feet on either side of the stream should be established regardless of stream size or floodplain (ESDA EAG Recommendations Draft, 2004).

Effectiveness of Grass Filter Strips

Grass filter strips are effective in removing both agricultural and urban nonpoint source pollutants. The following tables below are taken from research conducted by Leeds et. al (1994) which examined filter strips and their application, installation and maintenance. The first table, Figure 77, summarizes the amount of sediment removed from grass filter strips versus that of land with no vegetative filter strip. The overall sediment removed was between 65 and 97 percent with increasing sediment removal percents as the filter strip width increased.

Figure 77: Average percent removal of pollutants in runoff[1]

Location	*Rainfall Source*	*Soil Texture*	*Slope (%)*	*Flow Conditions[2]*	*Filter Strip Width (feet)*	*Captured Sediment*	*Percent Removal Nitrogen[3]*	*Phosphorus*
Indiana (1979)	Rainfall Simulator	Silt loam	2	OLF	56	-[4]	-	-
			4		70	-	-	-
			8		94	-	-	-
			12		95	-	-	-
Virginia (1989)	Rainfall Simulator	Silt loam	11-16	OLF	15	70%	54%	61%
					30	84%	73%	79%
				CF	15	83%	83%	85%
					30	93%	82%	87%
Maryland (1989)	Rainfall Simulator	Sandy loam	3-4	OLF	15	66%	0%	27%
					30	83%	48%	46%
Iowa[5] (1991)	Natural Rainfall	Silt loam	7	OLF	10	72%	-	-
					20	83%	-	-
					30	97%	-	-
			12	OLF	10	88%	-	-
					20	90%	-	-
					30	96%	-	-
Virginia (1992)	Natural Rainfall	Silt loam	4-12	OLF	13	65%	-	-
					26	65%	-	-
Iowa (1993)	Rainfall Simulator	Silt loam	3-6	OLF	15	72%	-	-
					30	76%	-	-

[1] Percent removal compared to similar conditions with no vegetative filter strip.
[2] Characteristics of runoff as it entered filter strip; OLF – shallow uniform overland flow; CF – concentrated flow.
[3] Values given are for total nitrogen and total phosphorus.
[4] Data not collected in this study.
[5] Demonstration sites were not replicated; sediment removal for 40- and 60-foot wide filters were generally same as for 30-foot width.

Adapted from: Leeds et. al., 1994. *Vegetative Filter Strips: Application, Installation and Maintenance*. Ohio State University Extension. Columbus, Ohio table 1

Additional information was included in the same research on expected percentage of pollutants removed from grass filter strips in Illinois, Iowa, and Ohio (Figure 78). Overall it is difficult to determine whether the buffer width played a large factor in the percentage of pollutant removal because other factors such as the filter strip vegetation quality, slope, and soil texture could all play a determining role as well. However, as with the research above it is clear that a vegetative buffer (grass, shrubs, or trees) can remove large percentages of sediment and pollutants from runoff. Even a narrow grassed buffer along agricultural ditches can greatly improve water quality in areas with narrow or no filter strips.

Figure 78: Predicted Pollutant Removal in Runoff [1]

State/Site	*Filter Width (feet)*	*Drainage Area[2] (acre)*	*Slope (%)*	*Soil Texture*	*Vegetation Quality[3]*	*Percent Removal*		
Illinois						**Sediment**	**Phosphorus[4]**	**Nitrogen**
1	99	2.5	7.3%	Silt Loam	Fair	42%	36%	36%
2	99	28	4%	Silt Loam	Good	67%	68%	68%
Iowa						**Sediment**	**Phosphorus[4]**	**Nitrogen**
1	66	39	2.2%	Loam	Excellent	75%	71%	71%
2	99	30	3.8%	Silt Loam	Fair	61%	54%	54%
Ohio						**Sediment**	**Phosphorus[4]**	**Nitrogen**
1	66	9.9	2.6%	Silt Loam	Good	71%	72%	72%
2	99	32	0.6%	Silty Clay Loam	Good	71%	73%	73%

[1] CREAMS model predictions on CRP sites in Illinois, Iowa, and Ohio; percent removal compared to similar conditions with no filter strip.

[2] Land area draining into filter-strip area.

[3] Poor, Fair, Good and Excellent relate to uniformity of cover and resistance to flow.

[4] Values are total phosphorus and nitrogen.

Source: Leeds et. al., 1994. *Vegetative Filter Strips: Application, Installation and Maintenance*. Ohio State University Extension. Columbus, Ohio pgs Table 2

Darby Creek Watershed Stream Buffer Widths

In the spring and summer of 2004 the buffers along all streams were examined to inventory current buffer conditions. A combination of a driving survey and aerial photography were used to calculate actual buffer types (trees or grass) and widths. The information was recorded in GIS to create maps and statistics on riparian buffers. The following figure summarizes the vegetated buffer widths in the entire watershed.

Figure 79: Darby Watershed Stream Buffer Information

Buffer	*Total Length (mi)*	*Percent of Total Miles*
No buffer	48.36	6.77%
grassed	143.53	20.08%
1 - 25ft wooded	113.29	15.85%
26 - 50ft wooded	76.09	10.65%
51 - 100ft wooded	59.48	8.32%
100ft and greater	195.82	27.40%
County Maintained	78.18	10.94%
Totals	**714.75**	**100.00%**

Figure 80 defines the width of grassed buffers in the Darby Watershed. County maintained ditches are not included in the totals below. Nearly 61 miles of county maintained ditches have a grassed easement of 10 feet. Union County maintains a grassed buffer of 15 feet for just over 17 miles within the Darby Watershed.

Figure 80: Grassed Buffer Widths

Buffer Width	*Total Length (mi)*	*Percent of Total Miles*
10 Feet or less	34.7470	24.21%
10 to 25 Feet	45.9310	32.00%
25 - 50 Feet	28.0700	19.56%
Greater than 50 Feet	34.7860	24.24%
Totals	143.5300	100.00%

Over 27 percent of the watershed has a 100 foot wooded buffer or greater on either side of the stream. There are several areas in the watershed that have over 1,000 feet of wooded buffer along Little and Big Darby Creeks. In **Map 18** the different buffer widths are color coded and presented for the entire watershed. The following figure examines the amount of 100 feet and greater wooded areas in the watershed by county.

Figure 81: 100ft or Greater Buffer By County		
County	*Buffer Miles*	*Percent of total stream miles in County*
Franklin	37.76	41.63
Pickaway	33.35	39.62
Union	38.88	25.35
Champaign	29.48	24.13
Madison	40.63	20.60
Logan	7.93	17.28
Watershed	**195.82**	**27.44**

This stream buffer analysis explored both the width and type of buffer (forest or grass) in the Darby watershed. The following section describes stream modifications that were also recorded during this same research inventory of stream buffers in 2004.

STREAM MODIFICATIONS

Alterations to the shape, size, and vegetation along streams has occurred on many streams within the Darby Watershed in the past 200 years. The most prevalent modification that has occurred on streams is channelization and woody vegetation removal. Much of the stream channelization occurred between 70 and 80 years ago. In general, tributary streams in the central portion of the watershed have the most modification. Figure 82 displays the most prevalent stream modifications by type for the entire watershed. It is important to note that over 40% of all streams had no evident modification.

Figure 82: Darby Watershed Stream Modifications			
Source #1	*Source #2*	*Length (Miles)*	*Percent of Total Miles*
No Evident Impacts		294.976	41.27%
Channelized Agriculture	Woody Vegetation Removal	173.790	24.31%
Channelized Agriculture		110.269	15.43%
Woody Vegetation Removal		32.027	4.48%
Hydromodification Agriculture		31.404	4.39%
Channelized Development		19.968	2.79%
Channelized Development	Woody Vegetation Removal	13.475	1.89%
Hydromodification Development		10.423	1.46%
Hydromodification Agriculture	Woody Vegetation Removal	9.277	1.30%
Remaining 29 Sources		*19.14*	2.68%
Totals		**714.75**	**100.00%**

The straightening and/or deepening of streams through channelization is the most common stream modification in the watershed. The combination of both channelizing and removing woody vegetation along streambanks occurs on over 24 percent of streams in the watershed.

Approximately 50 stream miles have been hydromodified, or tiled in the past 20-30 years. The streams database upon which this research was conducted displayed all open channels, but was completed in the 1970s and 1980s. Therefore any open channel that was no longer evident from aerial photography or on the ground was determined to be tiled. An example of hydromodification from development would be in Logan County near Honda in which several miles of stream channel were placed in tile under roads or parking lots. An example of hydromodification from agriculture, is typically in the headwaters of ditches and streams where open streams were replaced by tile.

Nearly 11 percent of the 24 percent of streams both channelized and lacking woody vegetation are under county maintenance. The following series of Figures 83-86 further define stream modifications by ranking the counties by the percent of modified stream miles within the Darby Watershed. Figures 81-84 do not include county maintained ditches.

Figure 83: No Evident Impact

County	*Percent Total Miles*
Pickaway	68.02%
Franklin	51.26%
Champaign	41.65%
Madison	41.33%
Union	39.46%
Logan	34.25%

Figure 84: Channelized and No Trees along Stream Bank

County	*Percent Total Miles*
Champaign	25.74%
Union	23.69%
Logan	19.56%
Madison	14.81%
Pickaway	10.01%
Franklin	9.73%

Figure 85: Channelized (Agriculture and Development)

County	*Percent Total Miles*
Union	49.76%
Logan	48.34%
Franklin	44.09%
Champaign	43.66%
Madison	31.49%
Pickaway	21.24%

Figure 86: No Trees along Stream

County	*Percent Total Miles*
Champaign	35.88%
Union	30.38%
Madison	27.67%
Logan	24.86%
Pickaway	16.48%
Franklin	11.69%

A considerable amount of stream modification has occurred in most of the watershed particularly in the western counties. More detailed data will be utilized for stream segments not meeting water quality standards in each **subwatershed plan**.

B. Water Quality Data

SAMPLING SITES

The Darby Watershed is one of the most studied watersheds in the state of Ohio. Beginning in 1979 Ohio EPA began periodic water quality testing as a result of the Clean Water Act. In the past 34 years there have been nearly 1000 fish and 300 bug samples in addition to other water quality sampling. (Appendix I lists all historical fish and bug samples since 1979 when Ohio EPA first started water quality sampling). For example, the most sampled stream segment is a half mile section of Little Darby Creek near US 42 that has been sampled for fish 33 times between 1979 and 2001. Appendix J list all of the sampling sites and their results from Ohio EPA's water quality survey in 2001 and 2002. A total of 127 sites were sampled by Ohio EPA during 2001 and 2002. The number of sampling sites is divided by county in Figure 87.

Figure 87: Darby Watershed Sampling Sites by County

County	*Sites*	*Full Attainment*	*Partial Attainment*	*Non Attainment*
Champaign	16	10	6	0
Franklin	21	12	5	4
Logan	7	5	1	1
Madison	32	24	7	1
Pickaway	18	14	2	2
Union	33	19	10	4
Total	127	84	31	12

Source: Ohio EPA, *Darby Creek Watershed Technical Support Document for 2001-02,* June, 2004. pgs A3 – A9.

WATER QUALITY ATTAINMENT

The goal of the Clean Water Act is to restore and maintain water quality and habitat of all surface waters. An important step towards meeting this goal is requiring each state to establish water quality standards that address the needs of both aquatic life and humans.

Recreational Use Standards

The water quality standards as applied to human use or recreational use is based on accepted levels of either fecal coliform or E. coli. Most streams in the Darby Watershed were not attaining E. coli bacterial criteria, but some subwatersheds and their tributaries had fecal coliform bacteria levels that met the criteria. The mainstem of lower Big Darby Creek from downstream of Hellbranch Run to SR 104 in Pickaway County is the only stream segment that is in attainment of both bacteria levels. Flat Branch and Barron Run both had very high fecal coliform and E. Coli results. Overall, most streams in the Darby Watershed are considered unsafe for human contact based on elevated bacteria levels. The bacteria standards and sampling results in the watershed are listed in Appendix K.

AQUATIC LIFE STANDARDS

Aquatic life standards are based on the variety and abundance of fish, bugs, and vegetation. A very strong connection exists between water quality and the abundance and variety of fish, bugs, and vegetation. Ohio, Arkansas, Maine, and North Carolina are among a handful of states that use both chemical and biological data in determining water quality standards. The water quality standards as applied to aquatic life are assigned based on the potential fish, bugs, and vegetation that can be expected to live in a specific region. Many streams in the Darby Watershed (Big and Little Darby, Buck Run, Hellbranch Run, Flat Branch…) have an aquatic life designated use based on the condition of the fish, bugs, and vegetation during previous samplings. When portions of a watershed do not meet water quality standards they are analyzed to determine whether their current use meets the designated aquatic life use. Additionally, many new points in the watershed were sampled that did not have an aquatic life designated use (Barron Run, Smith Ditch…). Through a formal rule making process by Ohio EPA, an aquatic life use designation will be applied to new streams based on the potential of the stream to perform at pre-determined water quality standards. By default, all streams in Ohio that have not been sampled and have no aquatic life use designation are warmwater habitats (WWH). It is important to know that the aquatic life designated use of a stream must always be protected as to not degrade, streams but only maintain and improve. The specifics of aquatic life designated uses and how this is determined will be discussed in the following sections.

Aquatic Life Use Designations

Ohio EPA has four different aquatic life use designations (See below) that are assigned based on the fish, bugs, and vegetation of a sampling area as compared to other typical streams found in the same region. For example, Big Darby Creek has the fish, bugs, and habitat to perform at the highest level of water quality, an excellent warmwater habitat (EWH), whereas portions of Flat Branch have undergone significant modification and therefore only perform at the modified warmwater habitat (MWH) level. **Map 19** displays the various proposed aquatic life use designations on the Darby Streams.

LRW (Limited Resource Water) – Very small streams that typically totally dry up during the year (i.e., no pools remain) that have a very limited biological potential (Think Lizard Run in Pickaway County)

MWH (Modified Warmwater Habitat) - Streams in an essentially permanent altered or maintained state (Think County Maintained Ditches and Flat Branch)

WWH (Warmwater Habitat) - Stream capable of supporting diverse and healthy organisms (Think Robinson Run or Buck Run)

EWH (Excellent Warmwater Habitat) – Streams that display an unusually diverse array of natural habitat and unique or rare organisms (Think Big and Little Darby Creek)

The designations listed above are based on natural stream conditions in Ohio which include meandering channel with numerous rifles, runs, pools, islands, gravel bars, and backwater areas. The combination of theses features creates a habitat that supports diverse and healthy fish, bugs, and vegetation. The above designations are determined based on a combination of the aquatic life (biological) data and stream habitat.

Stream Habitat (**QHEI**) + Biological (**ICI** + **IBI** + **MIwb**) = Aquatic Life Use Designations.

The other variables in the equation will be defined in the following sections.

In addition to the four aquatic life use designations above. Ohio EPA has proposed a Coldwater Habitat (CWH) on four streams in the watershed. During sampling a significant number of coldwater bugs and fish were found at sites along these streams. There is large groundwater input into these streams from the Cable Moraine complex in Logan and Champaign Counties that is responsible for the coldwater. Figure 88 below explains the stream segments designated as both warmwater and coldwater habitats.

Figure 88: Streams with Proposed Coldwater Habitat (CWH) Aquatic Use Designations

Stream	*County*	*Total Designated Miles*	*Location*
Big Darby Creek	Logan	5.49	Upstream CR 152 to Flat Branch
Little Darby Creek	**Logan**	4.28	TR 29 to Big Darby Creek
Spain Creek	Champaign/ Union	8.17	Upstream Reid Rd to Big Darby Creek
Little Darby Creek	Champaign/ Madison	9.35	Stringtown Rd just into Madison County ¾ mile from Van Ness Rd.

Ohio EPA in June of 2004, published their proposed aquatic life use designations for the Darby Watershed. **Map 19** illustrates the proposed aquatic life use designations for sampled streams in the Darby Watershed.

Aquatic Life Indices

To better define the terminology used in water quality standards, the following example on Big Darby Creek will be used from Ohio EPA sampling data.

Big Darby Creek **(EWH)**						
River Mile	**IBI**	**MIwb**	**ICI**	**QHEI**	**Attainment Status**	**Comments**
66.0	52	9.2	40	74.5	Partial	Dst. Milford Center

Ohio EPA utilizes both aquatic life (fish and bugs) and habitat (See Stream Habitat Assessment section below) to determine the appropriate use attainment of a stream segment. Ohio EPA developed different levels of aquatic life uses that illustrate the range of fish, bugs, and habitat potential that exists in Ohio Streams. There are three aquatic life indices. The indices listed below evaluate the fish and bug communities at a site. The numerical values given are the typical **minimum** value within a defined category (for ICI a score of 46 is the typical low score before it drops to a WWH).

ICI (Invertebrate Community Index) – Evaluates and ranks the **bugs** at a site

MWH - 24
WWH - 36
EWH - 46

IBI (Index of Biotic Integrity) – Evaluates and ranks the **fish** found at the site

MWH - 24
WWH - 36
EWH - 46

MIwb (Modified Index of Well-Being) – Evaluates and ranks **fish** at a site.
***Streams must be larger to receive this score. For example the headwaters of the Big Darby in Logan County do not have a MIwb score whereas portions in Madison County have a MIwb score.*

MWH – 5.8
WWH – 7.8
EWH – 8.9

ATTAINMENT STATUS

The attainment status (below) is determined from the three indices mentioned above at each site.

Attainment Status = ICI + IBI + MIwb (if available)

Full Attainment – All available indices meet or exceed these scores for their assigned category
Partial Attainment – One or more indices does not meet scores and performance is fair
Non Attainment – All indices fail to attain or any index indicates poor or very poor performance

In the example on Big Darby, the Fish (IBI and MIwb) were meeting the Excellent Waterwater Habitat (EWH) criteria but the bugs (ICI) were only meeting the Warmwater Habitat (WWH). Since only two of the three indices meet the EWH designated use, Big Darby Creek at river mile 66.0 is in Partial Attainment. The designated use of this stream segment is not lowered to a WWH because it has the potential to recover back to full attainment of the EWH based on surrounding stream segments.

The attainment status of the 127 sampling sites in 2001 and 2002 by Ohio EPA is displayed in **Map 20**.

Figure 89: Attainment Status of Designated or Recommended Use

Full Attainment	85 Sites	67%
Partial Attainment	30 Sites	24%
Non Attainment	12 Sites	9%

STREAM HABITAT ASSESSMENT

The fourth index listed in the example on Big Darby is labeled QHEI (Qualitative Habitat Evaluation Index). This index evaluates the quality of a **stream segment's** bed material (sand, silt, cobbles), the buffer area, stream gradient, the presence of pools, rifles and runs among other things. The QHEI is used to help determine the aquatic life use designation as included in the equation for aquatic life use designations.

Figure 90: Ohio Aquatic Life Use Designations

Designation	*Typical Characteristics of each Designation*
Excellent Warmwater Habitat (EWH)	Streams capable of displaying an unusually diverse amount of natural habitat and unique or rare organisms.
Warmwater Habitat (WWH)	Typical Stream in Ohio that exhibits natural stream features and supports diverse and healthy fish, bugs, and vegetation
Modified Warmwater Habitat (MWH)	A stream that is essentially in a permanent state of modification such as a county maintained ditch or channel impacted by urbanization
Limited Resource Water (LRW)	Very small streams that typically dry up during the year that have a very limited biological potential

General or Typical Scores
- MWH – less than 45
- Potential WWH greater than 45 but less than 60 (requires closer analysis of attributes)
- WWH – 60
- EWH – 75 or greater

In the example of Big Darby Creek the QHEI score is a 74.5 which places it the EWH range.

WATER QUALITY SAMPLING TRENDS

With the vast amount of water quality data available, an analysis was completed that illustrated trends in water quality results in regions that were sampled in multiple years. In total there were 93 locations that were sampled in multiple years and 56 locations that were only sampled once for a total of 149 locations. The IBI (fish) and ICI (bug) scores collected by Ohio EPA between 1979 and 2002 were used to determine the trends in water quality data which is displayed in Map 18 (See Appendix I for complete list of historical sampling results). Of all sampling locations, 43 were improving, 30 were declining, and 20 have stayed about the same. **Map 21** displays the water quality trends in the Darby Watershed. The majority of sites with declining water quality results were in Franklin and Union County.

SPILLS

Between 1979 and 2002 Ohio EPA documented 22 fish kill incidents that resulted in a total of 147,587 fish killed in the watershed. The largest number of fish were killed in two separate spills from Champaign Landmark in Mechanicsburg. The first spill was ammonia in 1983 which killed 52,134 fish and the second was liquid fertilizer in 1987 which killed 36,767 fish both in Little Darby Creek. The remainder of fish kills are documented in Appendix L.

In addition to the fish kills in the watershed, the Ohio EPA Division of Emergency and Remedial Response documented 129 spills between 1989 and 2002. Ohio EPA noted that spills often go unreported which can cause considerable harm to the Darby streams. An example is of the spill in Milford Center in 2000 which was not reported for over 4 days but resulted in over 24,000 fish killed.

LOG JAMS

According the Landowner Survey sent out in 2002, log jams are a major concern of landowners. Landowners want help in removing trees and limbs which have fallen into the stream. The exact location of these log jams will need to be collected from streamside landowners through a survey which should take place in the summer and fall of 2005 (See Appendix M).

LIVESTOCK ACCESS

The history of the Darby Watershed indicates that livestock were often allowed free access to streams for watering and cooling in summer months. However, in an effort to improve water quality conditions, this practice is not recommended. Livestock can have a water quality impact on a smaller stream such as sedimentation and bacteria. Through survey work by Ohio EPA and the watershed coordinator, sections of Logan, Champaign, Union, and Madison County have areas of unrestricted livestock access along Spain Creek, Sugar Run, Little Darby Creek, Treacle Creek, Proctor Run, and Spring Fork. Financial assistance exists to fence cattle away from the stream, to provide an additional watering source, and stream crossings if needed. Further work will be conducted on this issue in the future.

NPDES PERMITS

NPDES is an acronym for National Pollutant Discharge Elimination System. According the Clean Water Act, any point source discharge into a navigable waterway must have an NPDES permit from the U.S. Environmental Protection Agency (USEPA). The program has three types of permits including surface water discharge permit (for pollutants discharged from a point source such as a pipe), pretreatment industrial user's permit, and storm water permit. There are 51 active permitted point source discharges (NPDES permits) into Darby Creek Watershed (see **Map 22**). The Ohio EPA monitors Ohio's streams and determines if there are violations of NPDES permits. (Appendix N) provides a narrative of each NPDES location in the Darby Watershed.

A total of 48 facilities are small wastewater treatment plants (WWTP) serving small cities, villages, schools, business, and mobile home parks. These small plants which discharge between 2,000 and 100,000 gallons per day (GPD) are referred to as "package plants." These package plants combine to account for approximately 4.5% of the wastewater flow, 9.4% of $cBOD_5$ (dissolved oxygen needed to break down organic materials in water), 35.3% of the ammonia loading, and 6.8% of suspended solids loading discharged into Darby Creek Watershed. The disproportionate amounts of the above parameters is result of improper operation and maintenance of many package plants in the watershed.

LANDFILLS OR CHEMICAL SITES

In the Darby Watershed there are several properties that have been abandoned or idled in which redevelopment or expansion is complicated by a possible release of a hazardous substance. The Ohio EPA offers information about the cleanup and reuse of such properties. A total of five such properties exist in the watershed. Only the Hershberger / Unico Landfill in Union County is monitored for contaminates. Figure 91 summarizes the sites and recent actions.

Figure 91: Darby Creek Watershed Landfill and Contamination Sites

County	*Township*	*Year*	*Name*	*Contaminate*	*Recent Actions*
Franklin	Prairie	1998	Doherty Road Site	Lead – Former Shooting Range	Dominion Homes cleaned site for homes
Madison	Canaan	1990	Scheiderer Farm	Asphalt Plant – Petroleum Products	1,300ft^3 soil were removed
Union	Jerome	1970-1975	Hershberger Landfill/Unico Landfill	Landfill Leachate – volatile organic compounds	As of May 2003 6 million gallons of leachate removed – capped and monitored
Pickaway	Darby	1989	Countrymark	Pesticide mixing facility	Filtration installed In1990 no chemicals
Pickaway	Darby	1993	Rankin Oil Transport Spill	Tanker spilled 8,500 gasoline	7,200 gallons removed, site closed in 1998