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 75th 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.

Flat Branch (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).

Little Darby Creek (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.

Spain Creek (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.

<u>Drainage Area Range: 7.0 - 13.2 mi^2</u>
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.

<u>Drainage Area Range: 14.0 - 19.4 mi^2</u>
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.

Drainage Area Range: 32-64 mi^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.

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

Drainage Area Range: 128-256 mi^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.

Drainage Area Range: 256-512 mi^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.

Drainage Area Range: >512 mi^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.