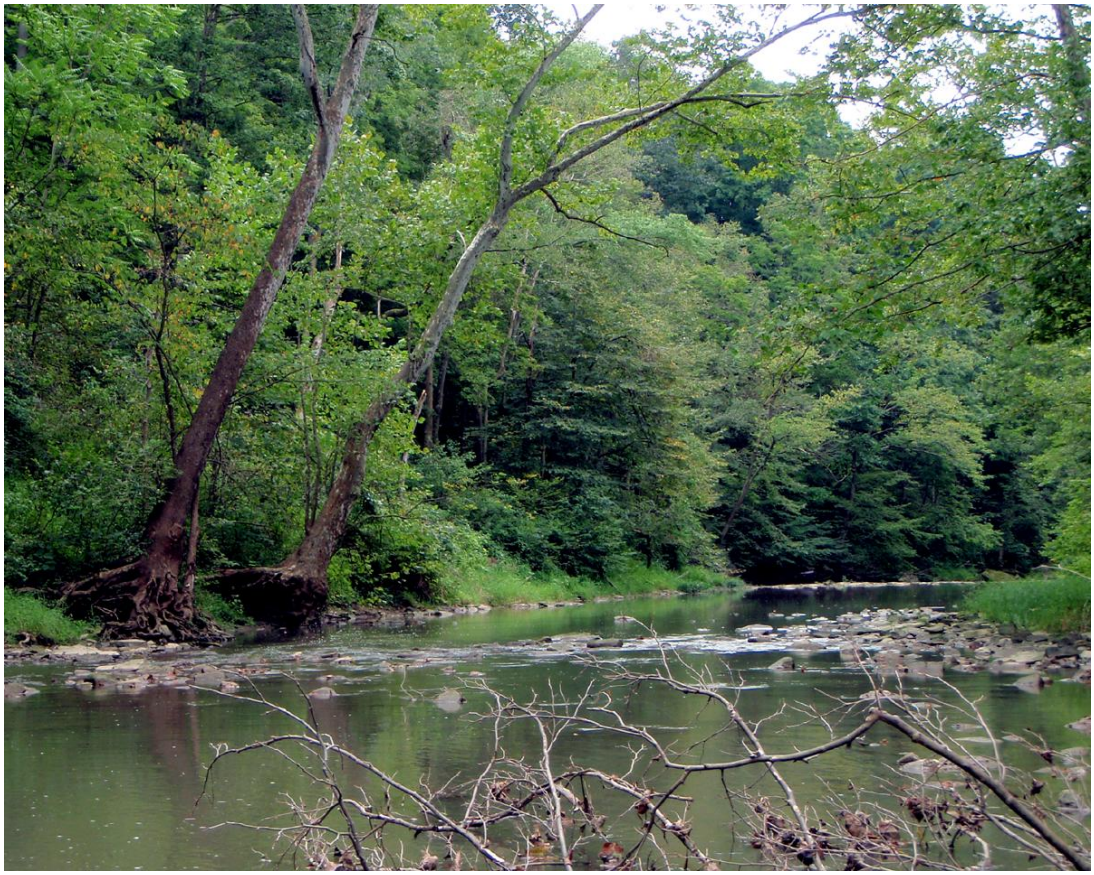
Biological and Water Quality Study of the Cross Creek Basin and Selected Ohio River Watersheds (Island Creek, Croxton Run and Wills Creek)

2010

Jefferson and Harrison Counties



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Division of Surface Water
Ecological Assessment Section &
Southeast District Office
April 1, 2013

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OEPA Report EAS 2013-02-02

prepared by

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Executive Summary

Rivers and streams in Ohio support a variety of uses related to recreation, water supply, and aquatic life. As part of the biological and water quality survey process, Ohio EPA annually evaluates streams from selected watersheds to determine their appropriate beneficial use designations and to verify the uses are meeting the goals of the federal Clean Water Act.

In 2010, 31 sites from 17 streams in the Cross Creek, Island Creek, Wills Creek, and Croxton Run watersheds were assessed for aquatic life and recreation use potential (see Table 1 and Figure 2 for sampling locations). These watersheds are direct Ohio River tributaries and are located in Jefferson and Harrison counties near Stuebenville, Wintersville and Mingo Junction.

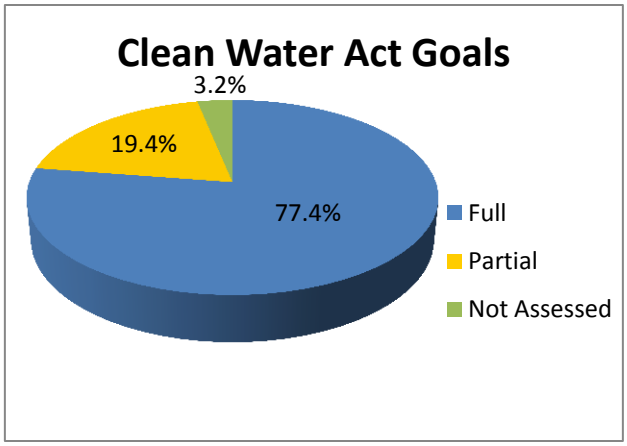

Figure 1. Aquatic life use attainment in the Cross Creek study area, 2010.

Of the 31 biological samples collected, 24 sites (77.4%) were fully meeting the designated or recommended aquatic life use, six (19.4%) were in partial attainment, and one (3.2%) was unassessed (Figure 1). The six impaired streams were smaller, headwater sampling sites (<20 sq. mi.) located in areas influenced by mine drainage or municipal waste water discharges.

Croxton Run, Island Creek and Wills Creek supported very good to exceptional aquatic communities and were recommended for Coldwater Habitat (CWH) due to the presence of cool water fish and/or aquatic macroinvertebrate taxa. These watersheds are located north of Steubenville and Wintersville in Jefferson County.

The biological community in the mainstem of Cross Creek was marginally good to exceptional, which is consistent with the current Warmwater Habitat (WWH) aquatic life use designation. Populations of the state endangered eastern hellbender salamander also occur in the mainstem of Cross Creek. Eastern hellbender populations have been declining across the state of Ohio but Cross Creek is one of two locations in the state of Ohio where juvenile eastern hellbender salamanders have been found. The habitat scores of Cross Creek indicated the potential to support Exceptional Warmwater Habitat (EWH) communities; however, the headwaters were impacted by mine drainage and were only marginally meeting WWH. Two landfills (Cross Ridge Landfill and C&D Disposal Technologies) and one industrial facility (Satralloy now owned by Cyprus Amax Minerals) are located on Cross Creek downstream from Barbers Hollow and Fernwood. The facilities have storm water discharges that negatively impact the macroinvertebrate community. While the macroinvertebrate scores were meeting WWH, they showed a decline downstream from these facilities. Other potential impacts in lower Cross Creek include mine drainage from Dry Fork (tributary to Cross Creek at Kolmont), Rocky's Junkyard (salvage yard in Mingo Junction located on slag in the flood plain of Cross Creek), and slag pile runoff from a former Wheeling Pittsburg Steel disposal area in Cool Springs which is currently being mined and reprocessed by Phoenix Services.

Six sites in the Cross Creek watershed were in partial attainment due to mine drainage or municipal wastewater discharges. Barbers Hollow receives discharges from both the Wintersville A and the Jefferson County M wastewater treatment plant (WWTPs). Both plants are currently receiving periodic flows above their design capacity so bypasses and sludge blowouts have caused organic enrichment in Barbers Hollow impacting the macroinvertebrate community. The remaining five

locations in partial attainment (N. Branch Cross Creek, Leas Branch, Grassy Run, Longs Run and Dry Run) were associated with active and abandoned mine lands and pollutants common to mine drainage, such as total dissolved solids (TDS), metals, and siltation. Historic and active coal mining are widespread throughout Jefferson County and south into Belmont County. Compared to the watersheds just south of Cross Creek, the prevalence of both surface and underground mining, and the magnitude of in-stream impacts, tends to be more significant in the Short Creek and Wheeling Creek basins. Most of the historic mining in Cross Creek occurred on the fringes of the watershed and the coal seams are positioned below grade so mine drainage typically doesn't freely flow into Cross Creek. Jefferson and Harrison counties are underlain by a mixed limestone geo-type which buffers the streams against water quality impacts commonly associated with mine drainage thereby preventing severe acidic or low pH impacts and highly toxic heavy metals concentrations. The combination of optimal buffering capacity, low elevation coal seams, widespread reclamation activities and natural recovery of the damaged landscape resulted in less severe biological impacts in-stream, than what would otherwise be expected.

Dry Fork was designated Limited Resource Water (LRW) after the 1983 biological survey due to mine drainage. While still affected by mine drainage, the impacts to Dry Fork are seasonal and occur in the late winter or early spring when a highwall in the headwaters discharges to a tributary to Dry Fork. The discharge from the highwall is discolored due to iron precipitant which smothers aquatic life on the streambed and disrupts spring spawning. Even though mine drainage impacts continue to impair the macroinvertebrate community, the presence of good quality habitat, exceptional fish community, and cold water fish and macroinvertebrate taxa warranted a use designation change from LRW to CWH. ODNR has the ability to complete reclamation activities in the Dry Fork watershed if they receive approval from local landowners who have been unwilling to agree to a partnership.

Slab Run was designated CWH in the 1978 WQS. The fish community of Slab Run was nearly absent with an IBI score of 24 however, the macroinvertebrate community was marginally good and consisted of four cold water taxa which warranted the confirmation of CWH. Even though the IBI score was poor in Slab Run, the stream was not considered impaired because the fish biological assessment method is not appropriate for primary headwater streams due to the small drainage area (OEPA 2012b). Therefore, the macroinvertebrate narrative score and the presence of cold water taxa were used to determine attainment status.

The 2010 biological survey findings resulted in additional recommendations for aquatic life use changes which include a change from WWH to CWH for Croxton Run, Wills Creek, and upper Dry Fork (Cross Creek basin) due to the presence of cold water taxa. Cedar Lick Creek was recommended to be changed from WWH to the dual, CWH and EWH designation while Claylick Creek switched from CWH to EWH, due to exceptional biological performance, but no cold water indicative taxa. Leas Branch, Cedar Lick Run and Slab Run were confirmed as CWH during the 2010 biological sampling results. In contrast, Grassy Run, Little McIntyre Creek, and Longs Run (all McIntyre Creek tributaries) were listed as unconfirmed CWH (*) but lacked requisite cold water populations; re-designation to WWH was recommended for each stream. All remaining confirmed and unconfirmed WWH designated streams retained their uses.

Nine locations in the Cross Creek watershed and selected tributaries were tested for bacteria indicators (*Escherichia coli*) to determine recreation use attainment status. Evaluation of *E. coli* results revealed that only 4 of 9 locations attained the applicable geometric mean criterion, and were in full attainment of the designated recreation use. Five sites in the Cross Creek watershed were impacted by sanitary waste from failing home sewage treatment systems or poor agricultural activities such as cattle with free access to the creek.

Table 1. Cross Creek watershed and selected Ohio River tributary sampling locations from the Ohio EPA 2010 survey.

Site Number*	Stream Name /Location	River Mile	Drainage Area	Latitude	Longitude
Cross Creek Basin					
1	Cross Ck @ TR 309 ust N. Br. Cross Ck	24.87	11.80	40.360708	-80.870778
2	Cross Ck @ CR 39 (Unionport Rd)	22.90	28.30	40.357610	-80.848053
3	Cross Ck @ Broadacre (SR 152)	16.20	53.50	40.365583	-80.784457
4	Cross Ck @ CR 26 (Bloomingdale - Fernwood Rd)	9.72	78.00	40.334206	-80.716479
5	Cross Ck @ TR 166 ford Dst Landfills	6.95	88.60	40.321672	-80.676203
6	Cross Ck @ CR 74 (Mingo Junction - Goulds Rd)	4.15	117.00	40.313100	-80.660300
7**	Cross Ck @ South Commercial Ave.	0.78	128.00	40.316040	-80.613210
8	North Branch Cross Ck Adj TR 309	0.10	11.30	40.360840	-80.870083
9	Salem Ck @ TR 136	4.57	8.01	40.396047	-80.847856
10	Salem Ck @ Private Drive nr. mouth	0.28	15.30	40.370747	-80.796165
11	Leas Branch @ T-136	0.15	2.72	40.395375	-80.839705
12	Grassy Run @ T-205, ust. Seminary pond	0.68	4.16	40.391530	-80.815333
13	Clay Lick Creek @ TR 166	0.03	6.61	40.364213	-80.774670
14	Cedar Lick Ck @ TR 166	0.05	6.60	40.368286	-80.756475
15	Cedar Lick Run @ CR 22A	0.10	3.50	40.363235	-80.745144
16	Barbers Hollow @ TR 166 dst. WWTP plants	0.06	3.20	40.334971	-80.713658
17	McIntyre Ck @ nr. Weems @ RR bridge	7.59	13.60	40.288300	-80.761700
18	McIntyre Ck @ TR 184	0.18	24.20	40.304200	-80.684400
19	Little McIntyre Ck. @ mouth nr. T-177	0.10	3.16	40.285693	-80.762513
20	Slab Run ust. RR trestle	0.15	1.16	40.288407	-80.743964
21	Longs Run @ CR 74 (Mingo Junc.-Goulds Rd)	0.03	3.04	40.304668	-80.684445
22	Dry Fork ust. Mine affected tributary to Dry Fork.	0.56	4.80	40.323127	-80.656163
23	Dry Fork @ Gould (Driveway Bridge)	0.28	6.60	40.319761	-80.654181
Ohio River Tributaries					
24	Croxton Run @ CR 47 (JF K Highway)	0.74	7.81	40.481347	-80.613836
25	Island Ck @ TR 373	6.28	7.31	40.437003	-80.697934
26	Island Ck @ CR 56 nr. SR 213	3.43	19.60	40.442673	-80.662272
27	Island Ck @ Costonia-Mt Tabor Rd (CR 56)	0.36	23.70	40.431548	-80.619290
28	Wills Ck adj CR 43 ust North Fork Wills Ck	2.40	5.80	40.386000	-80.665100
29	Wills Ck adj CR 43 ust US 22 nr mouth	0.70	13.90	40.382200	-80.643300
30	North Fork Wills Ck @ 7 Creeks Rd.	0.17	5.70	40.389270	-80.660052

* The color of the site number corresponds to the narrative biological score (blue is exceptional to very good (meets EWH goals), green is good to marginally good (meets WWH goals) yellow is fair, orange is poor and red is very poor (fair, poor and very poor do not meet the goals of WWH).

** For display, site number 7 combines biological narratives from two close but distinct sample sites near the mouth of Cross Creek. Fish were collected at RM 0.35 (Ohio River backwater) and macroinvertebrates were collected at RM 0.78. Narratives ranged from very good (MIwb) to marginally good (ICI).

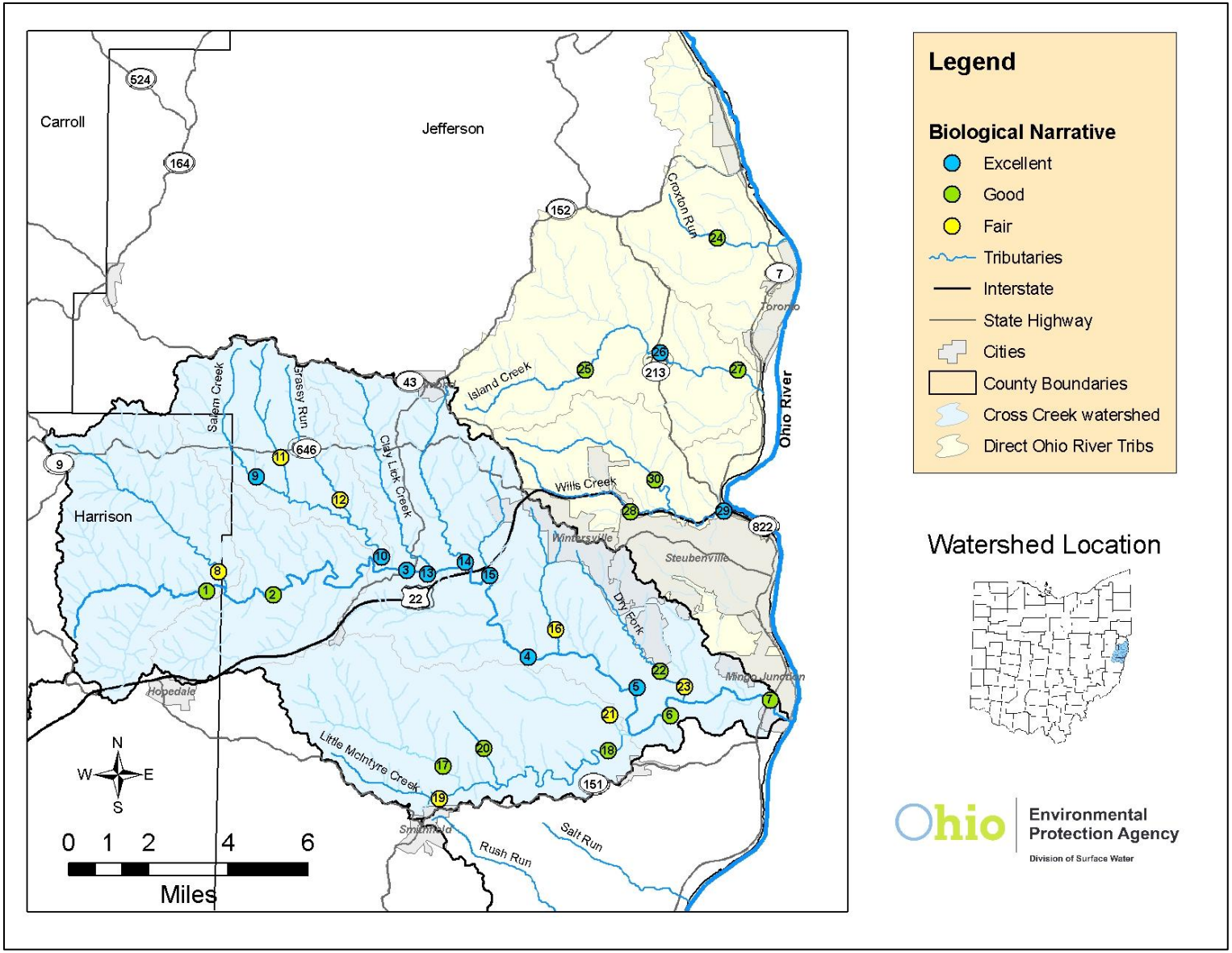

Figure 2 Map of the Cross Creek watershed and selected Ohio River tributary sampling locations and associated narrative biological community performance, 2010. The narrative colors and site numbers on the map correspond with Table 1.

Table 2. Aquatic life use attainment status for stations sampled in the Cross Creek watershed and selected direct Ohio River tributary basins including Island Creek, Croxton Run and Wills Creek watershed, 2010. The Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat of the stream to support a biotic community. The watersheds are located in the Western Allegheny Plateau (WAP) ecoregion. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted. NA is not analyzed

Stream	River Mile[A]	HUC 12 5030100	Drainage Area (mi^2)	Aquatic Life Use Designation	Aquatic Life Attainment Status[B]	IBI	MIwb[C]	ICI[D]	Stream Habitat[E]	Cause of Impairment	Source of Impairment
Cross Creek Basin											
Cross Creek	24.87	-110-01	11.80	WWH	FULL	40^{ns}	NA	MG^{ns}	79.0		
Cross Creek	22.90	-110-03	28.30	WWH	FULL	44	9.3	34^{ns}	75.5		
Cross Creek	16.2	-110-05	53.50	EWH-R	FULL	54	10.6	44^{ns}	86.0		
Cross Creek	9.72	-110-05	78.00	EWH-R	FULL	49^{ns}	10.2	42^{ns}	83.5		
Cross Creek	6.95	-110-05	88.60	WWH	FULL	49	10.9	36	73.0		
Cross Creek	4.15	-110-05	117.00	WWH	FULL	44	10.0	40	78.5		
Cross Creek	0.78	-110-05	128.00	WWH	(FULL)	--	--	32^{ns}	--		
Cross Creek	0.35	-110-05	128.00	WWH	(FULL)	40	9.4	--	52.0		
North Br. Cross Cr	0.10	-110-01	11.30	WWH	PARTIAL	42^{ns}	NA	F*	77.5	TDS	Mine Drainage
Salem Creek	4.57	-110-02	8.01	WWH	FULL	54	NA	E	77.3		
Salem Creek	0.28	-110-02	15.30	WWH	FULL	56	NA	VG	65.0		
Leas Branch	0.15	-110-02	2.72	CWH	PARTIAL	46	NA	F*	59.0	TDS	Mine Drainage
Grassy Run	0.68	-110-02	4.16	WWH-R	PARTIAL	34*	NA	VG	52.5	Siltation	Mine Drainage
Clay Lick Creek	0.03	-110-05	6.61	EWH-R	FULL	50	NA	E	70.5		
Cedar Lick Creek	0.05	-110-05	6.60	EWH,CWH-R	FULL	48	NA	48	74.0		
Cedar Lick Run	0.10	-110-05	3.50	CWH	FULL	56	NA	VG	71.0		
Barbers Hollow	0.06	-110-05	3.20	WWH	PARTIAL	40^{ns}	NA	F*	79.0	Organic enrichment	Muni. WWTP
McIntyre Creek	7.59	-110-04	13.60	WWH	FULL	47	NA	MG^{ns}	56.6		
McIntyre Creek	0.18	-110-04	24.20	WWH	FULL	40^{ns}	9.1	40	81.0		
Little McIntyre Cr	0.10	-110-04	3.16	WWH-R	--	--	--	F	--		
Slab Run	0.15	-110-04	1.16	CWH	FULL	24	NA	MG^{ns}	48.0		
Longs Run	0.03	-110-04	3.04	WWH-R	PARTIAL	56	NA	F*	82.0	TDS	Mine Drainage
Dry Fork	0.56	-110-05	4.80	CWH-R	FULL	56	NA	MG^{ns}	68.5		
Dry Fork	0.28	-110-05	6.60	CWH-R	PARTIAL	58	NA	F	66.5	TDS	Mine Drainage

Stream	River Mile[A]	HUC 12 5030100	Drainage Area (mi^2)	Aquatic Life Use Designation	Aquatic Life Attainment Status[B]	IBI	MIwb[C]	ICI[D]	Stream Habitat[E]	Cause of Impairment	Source of Impairment
Ohio River Tribs.											
Croxton Run	0.74	-110-06	7.81	CWH-R	FULL	56	NA	VG	76.5		
Island Creek	6.28	-110-07	7.31	CWH	FULL	42	NA	E	79.5		
Island Creek	3.43	-110-07	19.60	CWH	FULL	46	NA	VG	73.0		
Island Creek	0.36	-110-07	23.70	CWH	FULL	46	10.5	G	73.0		
Wills Creek	2.40	-110-09	5.80	CWH-R	FULL	40	NA	G	66.0		
Wills Creek	0.70	-110-09	13.90	CWH-R	FULL	52	NA	VG	76.5		
N. Fork Wills Creek	0.17	-110-09	5.70	CWH	FULL	42	NA	VG	66.8		

A - River Mile (RM) represents the Point of Record (POR) for the station, not the actual sampling RM.

B - Attainment is given for the proposed status when a change is recommended.

C - MIwb is not applicable to headwater streams with drainage areas ≤ 20 sq mi.

D - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

E Narrative habitat evaluations are based on QHEI scores for wading sites (Excellent >75,Good: 60-74, Fair: 45-59, Poor: 30-44, Very Poor <30) and headwater sites (Excellent >70, Good: 55-69, Fair: 43-54, Poor: 30-42, Very Poor <30).

ns - Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Index – Site Type	EWH	WWH	LRW
IBI – Headwaters/Wading	50	44	18
IBI – Boat	48	40	16
MIwb – Wading	9.4	8.4	4.5
MIwb – Boat	9.6	8.6	5.0
ICI	46	36	8

RECOMMENDATIONS

The streams in the Cross Creek study area and select direct tributaries to the Ohio River currently listed in the Ohio Water Quality Standards (WQS) are assigned one or more of the following aquatic life use designations: Warmwater Habitat (WWH), Coldwater Habitat (CWH) and Limited Resource Water (LRW). Use designations for the Cross Creek, Wills Creek, and Island Creek basins are based primarily on 1983 biological surveys conducted by Ohio EPA (Ohio EPA 1985). Some streams still retain their original 1978 WQS designations which were assigned before development of standardized approaches to the collection of instream biological data and numerical biological criteria. The most recent survey employed an extensive chemical and biological sampling effort to evaluate conditions and establish appropriate aquatic life uses throughout the study area.

Eighteen streams were evaluated for aquatic life and recreational use potential in 2010 (Table 2). Significant findings include the following:

- The **Cross Creek** mainstem is currently designated WWH. The headwaters of Cross Creek (RMs 22-25) are impacted by mine drainage and are marginally meeting WWH. The lower section of Cross Creek from RMs 9 to the mouth is also meeting WWH but is impacted by discharges from industrial facilities. The habitat scores and several of the biological scores indicate that Cross Creek is capable of supporting EWH communities particularly in the middle section of Cross Creek (RMs 17.4-9.6). This section of Cross Creek also supports a population of the eastern hellbender salamander which is state endangered and under consideration by the U.S. Fish and Wildlife Service as a potential candidate for the Federal Endangered Species Act. Cross Creek is one of two locations in the state of Ohio where juvenile eastern hellbender salamanders have been found indicating that it is a critical habitat for the future survival of the species in Ohio streams.

  It is recommended that Cross Creek retain the WWH designation in the headwaters (upstream from RM 17.4) and downstream from RM 9.6 to the mouth. The middle section of Cross Creek is recommended to be EWH (RMs 9.6-17.4 from Barber's Hollow in Fernwood to Salem Creek upstream from Broadacre) and also to be designated the Outstanding State Waters (OSW) antidegradation classification due to the presence of declining fish species, high IBI and ICI scores, habitat scores greater than 80 and the presences of the state endangered eastern hellbender salamander. Cedar Lick Creek (a tributary to Cross Creek at RM 14.5) is already designated SHQW due to the presence of declining fish species, high IBI and ICI scores and habitat scores greater than 70.

  Storm water runoff from several facilities (C&D Disposal Technologies, Crossridge Landfill and Satralloy) is negatively impacting the biological community in Cross Creek. While the biological scores were still meeting WWH, they showed a decline downstream from these facilities. C&D Disposal Technologies and Crossridge Landfill are located adjacent to each other and are operated as one facility. Both landfills have failed to meet closure requirements and the annual operating license for C&D Disposal Technologies was denied in 2012. Additionally, the site has a large 90,000 cubic yard open dump with exposed waste at the C&D Disposal Technologies portion of the facility. Leachate from the Crossridge Landfill is required by Ohio regulations to be collected and disposed of at the Jefferson County M WWTP, but the owners stopped hauling the leachate in May of 2012. As a result, leachate from the facility is collecting onsite and is potentially discharging to surface water or ground water. Ohio EPA collected leachate samples in October 2009 and found detections of numerous organic compounds including benzene, 1,1 dichloroethane, ethylbenzene,

isopropylbenzene, napthalene, toluene, 1,2,4-trimethylbenzene, vinyl chloride, o-xylene and diethylphthalate. Storm water runoff from the open dump, C&D Disposal Technologies as well as Crossridge Landfill all discharge to tributaries entering Cross Creek.

Significant amounts of hexavalent chromium and total chromium are being discharged to Cross Creek from the Satralloy facility (Table 8). Ohio EPA field staff often observed citizens swimming in Cross Creek during the 2010 survey just downstream from Satralloy at the Mingo Junction - Goulds Road bridge (TR 74). This is a well know swimming location and could be a potential area of human health exposure to hexavalent chromium and total chromium. Signs should be posted at this location to warn citizens about the potential exposure. Remediation at the Satralloy facility is underway by Cyprus Amax Minerals Company which is projected to take at least ten years to complete. During the remediation process, un-weathered portions of the waste piles will become exposed to precipitation and will likely increase the potential for additional runoff of hexavalent chromium, total chromium and other metals that may also be mixed within the waste piles. It is recommended that biological and chemical monitoring be conducted during and after the remediation of the Satralloy site to ensure that the runoff is not causing further negative impacts to the biological community of Cross Creek. It is recommended that further studies be conducted on Cross Creek to determine if remedial efforts at Satralloy and better storm water controls and proper treatment of the leachate from the landfills result in improved biological performance. If so, it may be possible to recommend that Cross Creek be upgraded to EWH. It is also recommended that ODNR evaluate mine impacts in the headwaters of Cross Creek to determine if reclamation is warranted.

- Based on 1983 sampling, **Dry Fork** (Cross Creek basin) was previously designated WWH from the headwaters to RM 0.5 and LRW from RM 0.5 to the confluence with Cross Creek due to mine drainage from an unnamed tributary. While mine drainage still impacts Dry Fork, the impacts occur seasonally in the late winter or early spring when a highwall in the headwaters discharges to a tributary to Dry Fork. The discharge from the highwall is discolored red or orange due to iron precipitant which smothers aquatic life on the streambed and disrupts spring spawning. During the low flow summer period, the discharge from the highwall stops and the water quality significantly improves with no visible signs of iron laden water. As a result, the fish community exceeded the EWH biocriteria and had several species of cold water fish including longnose dace which is listed as a Species of Concern by ODNR and first collected from the Cross Creek watershed in 1983 by Ohio EPA and ODNR (Barnes 1985). TDS and conductivity were elevated impacting the macroinvertebrates which did not meet the WWH biocriteria expectations. Even though mine drainage impacts continue, the presence of good quality habitat, exceptional fish community, and cold water fish and macroinvertebrate taxa warranted a use designation change from LRW to CWH. ODNR has the ability to reclaim the highwall if they can receive approval from local landowners who have been unwilling to agree to a partnership. Since this project would dramatically improve water quality in the tributary to Dry Fork, it is recommended that work continues with the landowners to remediate this mine source and eliminate a hazardous highwall.

- **Croxton Run** is a direct Ohio River tributary currently designated as unverified (*) WWH. Physical habitat quality was adequate for support of WWH communities (QHEI=76.5) and the presence of requisite populations of cold water fish and macroinvertebrates indicated cold water potential. A CWH designation is recommended for the length of Croxton Run.

Seven additional Cross Creek watershed streams were designated CWH in the 1978 standards but assigned an "*" to denote uses were unconfirmed by biocriteria. Based on 2010 survey results, three (**Cedar Lick Run, Slab Run** and **Leas Branch**) are recommended as CWH confirmed (+), one (**Clay Lick Creek**) is recommended as EWH and three [**Grassy Run, Little McIntyre Creek** and **Longs Run** (McIntyre Creek basin)] are recommended WWH. Specific stream use justifications are as follows:

- Requisite numbers of cold water fish or macroinvertebrate taxa in **Cedar Lick Run, Slab Run** and **Leas Branch** indicate the CWH designation is appropriate and should be confirmed.

- Cold water fish and macroinvertebrate populations in **Clay Lick Creek** were insufficient to confirm the designation but biological performance was consistently exceptional, prompting a change in recommendation from CWH to EWH.

- **Grassy Run**, **Little McIntyre Creek**, and **Longs Run** lacked requisite cold water populations in 2010. Physical habitat quality in Longs Run (QHEI=82.0) was clearly adequate for support of WWH communities. Grassy Run habitats (QHEI=52.5) were more marginal but the free-flowing sample reach may have reflected localized impoundment influences from beavers or a small low-head dam located just downstream. Little McIntyre Creek's 3.2 sq mi. watershed is largely impounded by Friendship Lake but free-flowing between the dam and the mouth (RMs 0.5-0.0). A WWH re-designation is recommended for Grassy Run and Longs Run and the lower 0.5 miles of Little McIntyre Creek.

Two other Cross Creek and Wills Creek watershed streams or stream segments are verified (+) WWH but are recommended for a change to CWH or a dual, CWH/EWH designation [*i.e.,* **Wills Creek, Cedar and Lick Creek**. Specific stream use justifications are as follows:

- **Wills Creek** is a direct Ohio River tributary located immediately north of Steubenville. Physical habitat quality remains adequate for support of WWH communities (QHEI=71) but the presence of requisite populations of cold water fish and macroinvertebrates indicated cold water potential. The North Fork Wills Creek, a major tributary, is already designated CWH and the new designation would extend that classification to the mainstem. A re-designation from WWH+ to CWH is recommended for the length of Wills Creek.

- **Cedar Lick Creek** is recommended for upgrade from WWH+ to a dual, CWH/EWH designation. The collection of requisite numbers of cold water fish and macroinvertebrate taxa and consistently exceptional biological performance support the change in designation. Cedar Lick Creek should also retain the Superior High Quality Water (SHQW) antidegradation classification due to declining fish species, high IBI and ICI scores and habitat scores greater than 70.

  Township road 166 has a ford crossing over Cedar Lick Creek near the mouth. Whenever vehicles cross through the ford, silt plumes are released into Cedar Lick Creek and Cross Creek. It is recommended that the township of Cross Creek install a bridge at this location to prevent sediment plumes into the creeks. Additionally, the bridge should be constructed so that the steam isn't constricted to the point which prevents fish migration.

The Steubenville Landfill is going to build several wetland leachate collection ponds in 2013 to treat both leachate and mine drainage that is currently discharging to an **unnamed tributary to Cross Creek (RM 8.7)**. This unnamed tributary is currently designated LRW due to acid mine

drainage but was not evaluated during the 2010 survey. After construction of the wetlands, a biological and water quality survey should be conducted to determine if the mine drainage is abated and to also determine if the LRW use designation is still appropriate.

The Ohio American Energy, Inc. (North Star 1 Surface Coal Mine) was permitted by Ohio EPA in 2011 after the survey was completed in the Cross Creek watershed. It is recommended that follow-up sampling be completed in both **McIntyre Creek** and **Cross Creek** to determine if there is an impact from this surface mine operation.

Upgrades to both the Wintersville A WWTP and Jefferson County M WWTP are planned for 2013. Sampling below the plants in **Barbers Hollow** after the upgrades is recommended to determine if the biological community has recovered from the impacts of organic enrichment and solids from the WWTP discharges.

Further sampling should be conducted at the former Wheeling Pittsburgh Steel slag piles located in the lower section of Cross Creek in Cold Springs. The site is being mined and reclaimed by Phoenix Services.

Table 3. Waterbody use designation recommendations for the Cross, Creek watershed and selected direct Ohio River tributaries. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). In addition, streams **not** assessed during the 2010 survey are in small, light blue font. A plus sign (+) indicates a confirmation of an existing use and a triangle (▲) denotes a new recommended use based on the findings of this report.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Cross creek (RMs 9.6-0.0 and headwaters to RM 17.4)		+							+	+		+		
Cross Creek (RMs 17.4-9.6)			▲						+	+		+		▲ Recommend OSW
Dry fork - headwaters to unnamed tributary (RM 0.5)						▲			+	+			+	
- unnamed tributary (RM 0.5) to the mouth						▲			+	+			+	
Unnamed tributary (Dry fork RM 0.5)							+		+	+			+	Acid mine drainage
Wintersville "E" tributary (Dry fork RM 4.55)		+							+	+		+		
McIntyre creek		+							+	+		*+		
Longs run		▲							*+	*+		*+		
Polecat hollow						*			*	*		*		
Slabcamp creek						*			*	*		*		
Slab run						+			*	*		*		
Little McIntyre creek – Friendship Park Lake to mouth (RM 0.5-0.0)		▲							*+	*+		*+		
Little McIntyre creek – all other segments						*			*	*		*		
Unnamed tributary (Cross creek RM 8.7)							+		+	+		+		Acid mine drainage
Barber Hollow run		+							+	+			+	
Cedar Lick run						*+			*+	*+		*+		
Cedar Lick creek			▲			▲			+	+			+	
Clay Lick creek			▲						*+	*+		*+		
Salem creek		+							+	+		+		
Grassy run		▲							*+	*+		*+		
Leas branch						*+			*+	*+		*+		
North branch		+							+	+		+		
Wills Creek		*							*	*		*		
Permars run						+			+	+		+		
Wills creek	+					▲			+	+		+		
Rush run		*							*	*		*		
Cedar creek		*							*	*		*		
North fork						+			+	+		+		
Island creek						+			+	+		+		
Little Island creek		*							*	*		*		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Hale run		*							*	*		*		
Shelley run		*							*	*		*		
Jeddo run						+			+	+		+		
Croxton run						▲			*+	*+		*+		
Goose run						+			+	+		+		
Brimstone run		*							*	*		*		

INTRODUCTION

Ohio EPA sampled 18 streams with 31 stream locations in the Cross Creek, Island Creek, Wills Creek, and Croxton Run watersheds in 2010 using standard Ohio EPA protocols as described in Appendix Table 1. These watersheds are direct Ohio River tributaries in Jefferson and Harrison counties between Toronto and just south of Mingo Junction. (Table 1, Figure 2). The largest cities within the watersheds include Steubenville, Wintersville and Mingo Junction.

A total of 17 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the Cross Creek watershed or direct Ohio River tributaries study area. Numerous coal companies have mined in the Cross Creek and direct Ohio River tributaries with many abandoned underground and surface mines throughout the watersheds (Figure 4). Active surface mining is occurring in the headwaters of Cross Creek and in several tributaries to Cross Creek (McIntyre, Little McIntyre).

Included in this study were assessments of the biological, surface water and recreation (bacterial) condition. A total of 31 biological, 28 water chemistry,5 compliance, 35 fish tissue (from 2002-2010), and 9 bacterial stations were sampled in the study area.

Specific objectives of the evaluation were to:

- ascertain the present biological conditions in the Cross Creek watershed and direct tributaries to the Ohio River by evaluating fish and macroinvertebrate communities,
- identify the relative levels of organic, inorganic, and nutrient parameters in the sediments and surface water,
- evaluate influences from NPDES outfall discharges,
- evaluate influences from nonpoint pollution sources, particularly those associated with coal mining,
- assess physical habitat influences on stream biotic integrity,
- determine recreation water quality,
- compare present results with historical conditions, and
- determine the attainment status and recommend changes if appropriate.

The Cross Creek watershed is located in the Western Alleghany Plateau (WAP) ecoregion in Jefferson and Harrison counties. The mainstem of Cross Creek as well as North Branch Cross Creek, McIntyre Creek, Barbers Hollow, Cedar Lick Creek and Salem Creek are designated WWH in the Ohio Water Quality Standards (WQS). Many tributaries to Cross Creek were designated CWH without a use designation verification including Slab Run, Longs Run, Little McIntyre Creek, Grassy Run and Leas Branch. The lower 0.5 miles of Dry Run is designated LRW due to mine drainage. The other direct Ohio River tributaries evaluated north of Cross Creek in Jefferson County include Croxton Run, Island Creek and Wills Creek. Croxton Run, Wills Creek and North Fork Wills Creek are designated WWH and Island Creek is listed as CWH in the WQS. Wills Creek is also listed as a State Resource Water (SRW).

Some of these streams were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. This study used biological data to evaluate and establish aquatic life uses for these streams. See the recommendation section and Table 3 for use recommendation changes. All designated streams in the Cross Creek study area are currently assigned as Primary Contact Recreation (PCR) (Class B), Agricultural Water Supply

(AWS) and Industrial Water Supply (IWS). Wills Creek enters the Ohio River near the water intake for Steubenville but no streams in the survey are listed as Public Water Supply (PWS).

The findings of this evaluation may factor into regulatory actions taken by the Ohio EPA (e.g. NPDES permits, Director's Orders, or the Ohio Water Quality Standards [Ohio Administrative Code (OAC) 3745-1], and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, Total Maximum Daily Loads (TMDLs) and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] report).

RESULTS

Water Chemistry

Surface water chemistry samples were collected from the Cross Creek and direct Ohio River tributaries study area from March 2010 through April 2011 at 26 locations (Figure 1, Table 1). Chemistry was collected at all of the biological stations except for five locations which include Cross Creek at RM 0.35, Slab Run, Little McIntyre, Grassy Run and Leas Branch. Stations were established in free-flowing sections of the streams and were primarily collected from bridge crossings. Surface water samples were collected directly into appropriate containers, preserved and delivered to Ohio EPA's Environmental Services laboratory. Collected water was preserved using appropriate methods, as outlined in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 2009).

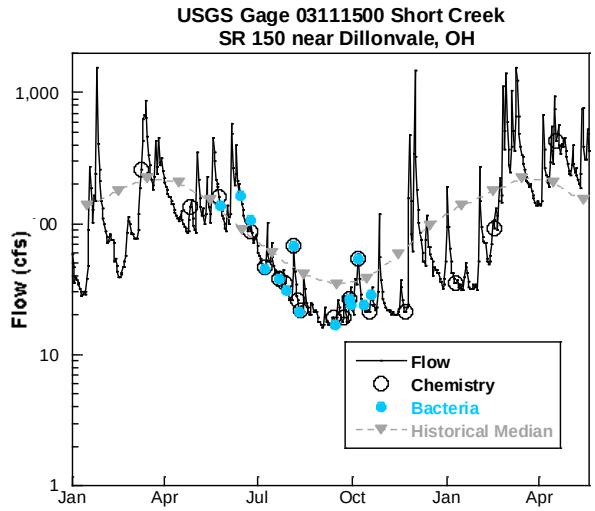

Figure 3. Flows in a nearby watershed (Short Creek) and sampling dates in the Cross Creek and selected tributaries survey, 2010.

USGS gage data from Short Creek near Dillonvale was used to show flow trends in the Cross Creek watershed during the 2010-2011 survey (Figure 3). Dates when water samples and bacteria samples were collected in the study area are noted on the graph. Flow conditions during the summer field season were typically lower than the historic median. Low flow conditions were recorded from July through November, 2010 with some rain events elevating flow above the historic median. Water samples captured a variety of flow conditions in the study area during the field season. Bacteria was collected during the 2010 recreation use season (May 1 through October 31) and was typically collected during low flows when recreation was likely to occure.

Surface water samples were analyzed for metals, nutrients, organics, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), percent D.O.saturation, and suspended and dissolved solids (Appendix Tables 2, 3, 4, 5). Parameters with results exceeding the Ohio WQS criteria are reported in Table 4. Bacteriological samples were collected from 9 locations, and the results are reported in the Recreation Use section and Appendix Table 5. Datasonde™ water quality recorders were placed at eight locations to monitor hourly levels of dissolved oxygen, pH, temperature, and conductivity (Appendix Table 4). Sediment samples were collected from 5 stream locations as well as an industrial facility (Appendix Table 6).

WQS exceedances for TDS were documented in the headwaters of Cross Creek, Dry Fork, McIntyre Creek and Longs Run (Table 4). In addition to TDS, most mine drainages had correspondingly elevated levels of manganese, sulfates and conductivity (Table 5). The sites in the headwaters of Cross Creek and McIntyre Creek, that attained biological standards despite these elevated parameters, often demonstrated marginal biological performance reflecting lingering mine drainage influences.

Dry Fork was designated LRW after the 1983 biological survey due to mine drainage. While mine drainage still impacts Dry Fork, the impacts occur only seasonally in the late winter or early spring when a highwall in the headwaters discharges to a tributary to Dry Fork. The discharge from the highwall is discolored due to iron precipitant which smothers aquatic life on the streambed and disrupts spring spawning. The appearance of the water is bright orange or red and is often described as yellow boy. During the low flow summer period, the discharge from the highwall stops and the water quality significantly improves with no visible signs of iron laden water. As a result, the fish community exceeded the EWH biocriteria and had several species of cold water fish including longnose dace which is listed as a Species of Concern by ODNR. However, TDS and conductivity were elevated and impacted the macroinvertebrates which did not meet WWH expectations.

Table 4. Exceedances of Ohio Water Quality Standards criteria (OAC3745-1) for chemical/physical parameters measured in the Cross Creek study area, 2010. Bacteria exceedances are presented in the Recreational Use Section.

Stream/RM	**Location**	**Parameter (value – ug/l unless noted)**
Cross Creek		
24.87	Cross Creek ust N. Branch TR 309	TDS (1530, 2820)
0.56	Dry Fork at CR 74	TDS (1670, 1650, 1500)
7.59	McIntyre Creek near Weems RR Bridge	TDS (1680, 1890, 1750, 1740, 1840)
0.18	McIntyre Creek TR 184	TDS (1625, 1590, 1740, 1750, 1700 ,1630, 1700, 1610, 1820, 1690, 1660, 1660)
0.03	Longs Run at CR 74	TDS (1540, 1830, 1890, 1800, 2000)

[a] Exceedance of the aquatic life Outside Mixing Zone Average water quality criterion .

Nutrients were measured at each water sampling location, and included ammonia-N, nitrate+nitrite-N, total phosphorus, and total Kjeldahl nitrogen (TKN). Summary statistics for nutrients measured in the Cross Creek watershed are detailed in Table 6. Nutrient levels were low at all monitoring locations in the Cross Creek and direct Ohio River tributary study area except for Barbers Hollow which had elevated total phosphorus and nitrate+nitrite-N and Clay Lick Creek which had elevated ammonia-N. Two sanitary WWTPs discharge to Barbers Hollow (Wintersville A and Jefferson County M plant). Both plants receive periodic flows above their design capacity so bypasses and sludge blowouts have caused organic enrichment in Barbers Hollow impacting the macroinvertebrate community. Even though there were elevated levels of ammonia found in Clay Lick Creek, the biological community was exceptional and the presence of cold water taxa warranted a dual use of EWH/CWH. The site on Clay Lick Creek is located downstream from a cow pasture which may cause some periodic water quality issues.

Results for DataSonde™ hourly monitoring taken over a 48 hour period on August 10-12 and September 21-23, 2010 for dissolved oxygen, temperature, pH, and conductivity at eight locations are listed in Appendix Table 4. Temperature, dissolved oxygen and pH measurements were well within acceptable environmental levels. Dissolved oxygen measurements were indicative of good water quality, with nearly all values above the average EWH (6.0 mg/l) water quality criterion with the exception of Island Creek at CR 56 (RM 0.36) which had a minimum D.O. measurement of 5.11mg/l. Nearly all sites had elevated conductivity

levels greater than reference conditions for the WAP with the highest levels in McIntyre Creek due to historic and active mining.

Table 5. Summary statistics for select mine drainage inorganic water quality parameters sampled in the Cross Creek and selected Ohio River tributaries study area, 2010. The 90th percentile value from reference sites from the Western Allegheny Plateau ecoregion is shown for comparison. Values above reference conditions or developed values are shaded.

		Iron	Manganese	Conductivity	Chloride	Sulfate	Aluminum
Units		µg/l	µg/l	umhos/cm	mg/l	mg/l	µg/l
Stream	River Mile	Mean	Mean	Mean	Mean	Mean	Mean
Cross Cr TR 309	**24.87**	166	53	1494	100.0	824	ND
Cross Cr CR 39 Unionport	**22.90**	239	56	1173	36.6	545	115
Cross Cr Broadacre SR 152	**16.20**	250	40	954	35.8	377	148
Cross Cr Fernwood CR 26	**9.72**	136	38	976	38.4	337	ND
Cross Ck @ TR 166	**6.95**	594	34	959	52.4	306	287
Cross Cr Kolmont CR 74	**4.15**	450	75	1210	37.1	560	229
Cross Ck Commercial Ave	**0.78**	470	75	1328	38.9	607	260
N BR. Cross Cr TR 309	**0.10**	258	70	1312	13.7	608	133
Salem Cr TR. 136	**4.57**	345	30	788	23.8	201	ND
Salem Cr TR 208	**0.10**	154	23	660	19.8	182	ND
Claylick Ck @ TR 166	**0.03**	461	10	396	29.9	32	207
Cedar Lick Cr TR. 166	**0.05**	56	19	701	45.9	155	ND
Cedar Lick Run CR 22A	**0.10**	116	26	956	90.9	211	ND
Barbers Hollow @ TR 166	**0.06**	78	16	972	152.0	112	100
McIntyre Cr RR bridge	**7.59**	125	153	1984	17.1	1068	ND
McIntyre Cr TR 184	**0.18**	221	141	1838	15.1	998	120
Dry Fk Gould ust AMD trib	**0.56**	444	91	1746	51.2	859	645
Dry Fk Gould dst AMD trib	**0.28**	228	61	1458	73.6	671	526
Longs Run @ CR 74	**0.03**	155	153	2012	8.7	1132	ND
Croxton Run @ CR 47	**0.74**	114	47	1074	26.3	465	ND
Island Creek @ TR 373	**6.28**	46	23	722	28.3	196	ND
Island Cr @ CR56	**3.43**	39	61	1155	23.9	518	ND
Island Cr @ Costonia Rd.	**0.36**	114	47	941	28.3	394	ND
Wills Creek CR 43	**2.4**	66	54	1496	150.8	432	ND
Wills Creek Alikanna Rd.	**0.7**	46	43	1228	102.2	368	ND
N. Fk. Wills Cr TR 383	**0.17**	33	40	973	35.1	371	ND
Reference Values: headwater/ wading		1266/ 1820	35/ 25	1019/ 791	88.2/ 55	259/ 242	750[a]

a – U.S. EPA maximum criteria.

Table 6.Summary statistics for select nutrient water quality parameters sampled in the Cross Creek and selected Ohio River tributaries 2010. The 90th percentile value from reference sites in the Western Allegheny Plateau ecoregion is shown for ammonia-N for comparison. The trophic index criteria (TIC) for nitrate+nitrite-N and total phosphorus is shown for elevated and chronic toxicity thresholds. Values above reference conditions or TIC thresholds are shaded yellow.

		Ammonia—N	Nitrate+Nitrite-N	Phosphorus-T
Stream	River Mile	Mean	Mean	Mean
Cross Cr TR 309	**24.87**	0.025	0.333	0.013
Cross Cr CR 39 Unionport	**22.9**	0.028	0.297	0.014
Cross Cr Broadacre SR 152	**16.2**	0.033	0.344	0.012
Cross Cr Fernwood CR 26	**9.72**	0.025	0.115	0.011
Cross Ck @ TR 166	**6.95**	0.025	0.492	0.074
Cross Cr Kolmont CR 74	**4.15**	0.031	0.454	0.043
Cross Ck Commercial Ave	**0.78**	0.025	0.696	0.021
N BR. Cross Cr TR 309	**0.1**	0.025	0.195	0.025
Salem Cr TR. 136	**4.57**	0.025	0.290	0.023
Salem Cr TR 208	**0.1**	0.025	0.210	0.019
Claylick Ck @ TR 166	**0.03**	0.123	0.310	0.060
Cedar Lick Cr TR. 166	**0.05**	0.025	0.288	0.014
Cedar Lick Run CR 22A	**0.1**	0.025	0.250	0.020
Barbers Hollow @ TR 166	**0.06**	0.025	7.937	0.943
McIntyre Cr RR bridge	**7.59**	0.025	0.050	0.011
McIntyre Cr TR 184	**0.18**	0.034	0.149	0.007
Dry Fk Gould ust AMD trib	**0.56**	0.025	0.196	0.013
Dry Fk Gould dst AMD trib	**0.28**	0.025	0.248	0.005
Longs Run @ CR 74	**0.03**	0.039	0.085	0.014
Croxton Run @ CR 47	**0.74**	0.0250	0.1675	0.0160
Island Creek @ TR 373	**6.28**	0.0250	0.3233	0.0100
Island Cr @ CR56	**3.43**	0.0250	0.1350	0.0115
Island Cr @ Costonia Rd.	**0.36**	0.0287	0.2742	0.0093
Wills Creek CR 43	**2.4**	0.0250	0.1475	0.0088
Wills Creek Alikanna Rd.	**0.7**	0.0250	0.1267	0.0087
N. Fk. Wills Cr TR 383	**0.17**	0.0250	0.1867	0.0167
Reference Value* or Trophic Index Criteria** (Elevated/Chronic Toxicity)		>0.06*	>1.0/>3.0**	>0.1/>0.3**

Recreation Use

Water quality criteria for determining attainment of recreation uses are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) based upon the presence or absence of bacteria indicators (*Escherichia coli*) in the water column.

Escherichia coli (*E. coli*) bacteria are microscopic organisms that are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria of human feces (Dufour, 1977), but there is currently no simple way to differentiate between human and animal sources of coliform bacteria in surface waters, although methodologies for this type of analysis are becoming more practicable. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited.

Pathogenic (disease causing) organisms are typically present in the environment in such small amounts that it is impractical to monitor them directly. Fecal indicator bacteria by themselves, including *E. coli*, are usually not pathogenic. However, some strains of *E. coli* can be pathogenic, capable of causing serious illness. Although not necessarily agents of disease, fecal indicator bacteria such as *E. coli* may indicate the potential presence of pathogenic organisms that enter the environment through the same pathways. When *E. coli* are present in high numbers in a water sample, it invariably means that the water has received fecal matter from one source or another. Swimming or other recreational-based contact with water having a high fecal coliform or *E. coli* count may result in ear, nose, and throat infections, as well as stomach upsets, skin rashes, and diarrhea. Young children, the elderly, and those with depressed immune systems are most susceptible to infection.

The streams of Cross Creek, Island Run, Croxton Run, and Wills Creek watersheds evaluated in this survey are designated as a Primary Contact Recreation (PCR) use in OAC Rule 3745-1-24. Water bodies with a designated recreational use of PCR "...are waters that, during the recreation season, are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking and SCUBA diving" [OAC 3745-1-07 (B)(4)(b)]. There are three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR Class A typically have identified public access points and support primary contact recreation. Streams designated PCR Class B support, or potentially support, occasional primary contact recreation activities. The streams evaluated for Cross Creek and selected Ohio River tributaries survey area are all designated Class B PCR waters. The *E. coli* criteria that apply to PCR B streams include a geometric mean of 161 cfu/100 ml, and a maximum value of 523 cfu/100 ml. The geometric mean is based on two or more samples and is used as the basis for determining attainment status when more than one sample is collected (Table 7).

Summarized bacteria results are listed in Table 7, and the complete dataset is reported in Appendix Table 5. Nine locations in Cross Creek, Salem Creek, McIntyre Creek, Wills Creek, Island Creek, and Croxton Run were sampled for *E. coli* six to twelve times, from May 25th to October 19th, 2010. Evaluation of *E. coli* results revealed that only one of six sites in the Cross Creek watershed met the applicable geometric mean criterion. Wills Creek, Island Creek, Croxton Run and one location on Cross Creek at Broadacre were in full attainment of the recreation use. In the Cross Creek watershed, the geometric mean ranged from 157 cfu/100ml to 1112 cfu/100ml.

The majority of sampling locations in the Cross Creek watershed are in areas without centralized sewage treatment. The non-attainment is most likely due to unsanitary conditions from poorly treated sanitary waste. The highest geometric value of 1112 cfu/100ml was found in Cross Creek in Unionport which is an unsewered community. Agricultural activities in the

watershed are somewhat sparse but it is possible that poor manure management or concentrated animal feedlots are also causing unsanitary conditions in the Cross Creek watershed.

Table 7 A summary of *E. coli* data for locations sampled in the Cross Creek watershed, Croxton Run, Island Creek and Wills Creek watersheds from May 25 through October 19, 2010. Recreation use attainment is based on comparing the geometric mean to the Primary Contact Recreation (PCR) Class B geometric mean water quality criterion of 161 cfu/100 ml (Ohio Administrative Code 3745-1-07). All values are expressed in colony forming units (cfu) per 100 ml of water. Gray shaded values exceed the applicable PCR Class B geometric mean criterion**.**

HUC-12	Location	River Mile	Maximum Value	Geometric Mean	# of samples
Cross Creek watershed					
050301011001	**Cross Cr** upstream N. BR. @ TR 309	24.87	670	**361**	6
050301011003	**Cross Cr** at CR39 Unionport Rd	22.9	4000	**1112**	12
050301011005	**Cross Cr** at Broadacre SR 152	16.2	670	157	12
050301011005	**Cross Cr** at Kolmont at CR 74	4.15	2200	**166**	12
050301011002	**Salem Cr** at TR 208	0.1	950	**232**	6
050301011004	**McIntyre Cr** at TR 184	0.18	1200	**232**	12
Misc. Direct Ohio River Tributaries					
050301011106	**Croxton Run** at CR 47 (John F Kennedy Hwy)	0.74	210	121	6
050301011107	**Island Cr** at CR56 Costonia	0.36	670	132	11
050301011109	**Wills Creek** Adj. Alikanna Rd	0.7	220	121	6

Point Source Impacts (NPDES, storm water, coal mining)

Cross Creek Watershed

The Cross Creek watershed has a total of ten individual National Pollutant Discharge Elimination System (NPDES) permitted facilities and three general NPDES permits that discharge sanitary wastewater, industrial process water, and/or industrial storm water (Figure 4, Appendix Table 12) These facilities include five active mining facilities (Hopedale Coal Mine, Ohio American Energy (North Star 1), Anthony Mining, Schaney Mining and Apex Limestone), three public sanitary waste water treatment plants (Wintersville A WWTP, Jefferson County M WWTP and Mingo Junction STP), one privately owned sanitary treatment plant (Granatir Apartments) and three industrial facilities (Mingo Junction LLC Steel Works (formerly Wheeling Pittsburgh Steel), Crossridge Landfill and Steubenville Landfill). CD& Disposal Technologies and Cyprus Amax Minerals Co. (formerly Satralloy) also have general industrial storm water permits.

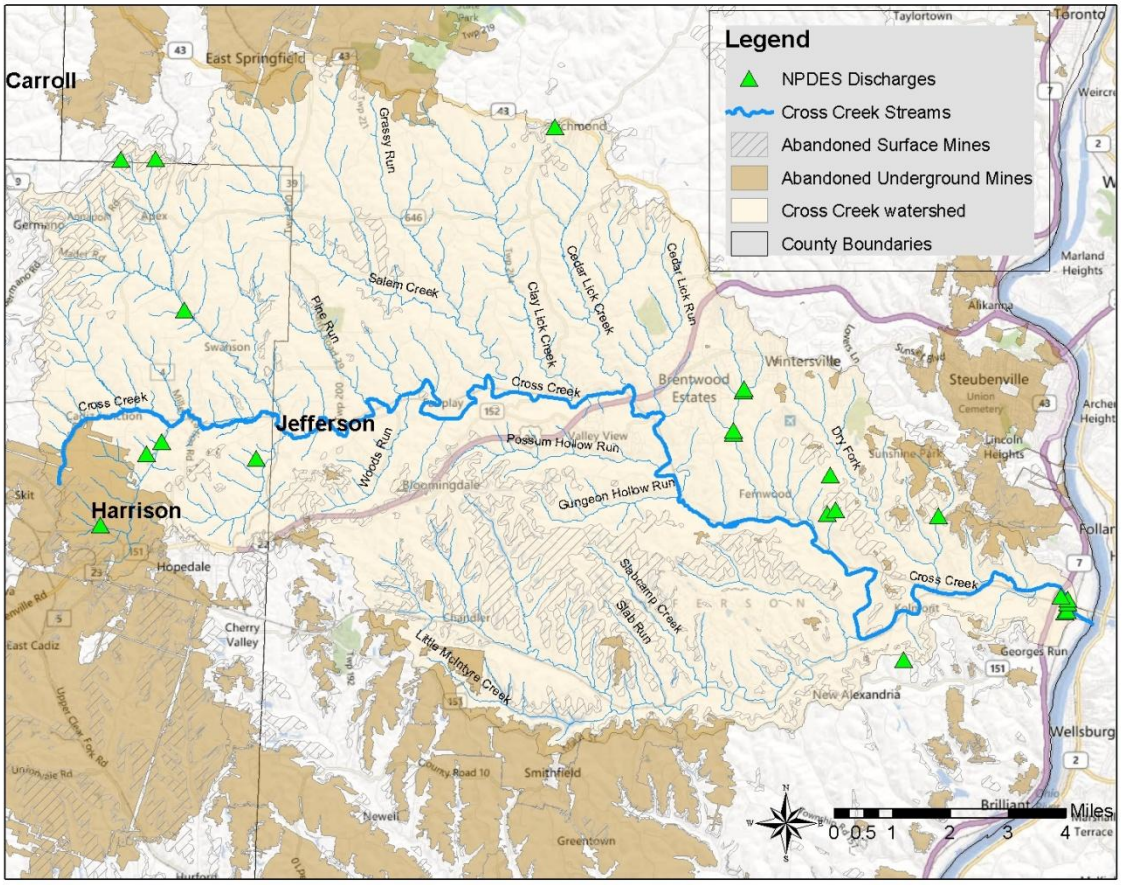

Figure 4. Abandoned underground and surface mines as well as NPDES permitted outfalls in the Cross Creek watershed (Jefferson and Harrison Counties).

Mining began in Jefferson County in 1800 and has continued to the present (Crowell, 1995). Abandoned underground mines are found in the fringes of the headwaters (Grassy Fork, Salem Creek), McIntyre Creek, and in the lower section of the watershed from northern tributaries that drain the land from Wintersville and Mingo Junction (Figure 4). At least twenty-two companies

operated surface mines that are now abandoned in the headwaters of Cross Creek, North Branch Cross Creek, Pine Run, Salem Creek, McIntyre Creek, and the Dry Fork sub-watersheds. Numerous mine drainage seeps continue to discharge to the Cross Creek watershed from these abandoned unreclaimed mines. There are four active coal mines that discharge process water to tributaries to Cross Creek which include Hopedale Mining, Schaney Mining and Anthony Mining in the headwaters and North Star 1 in the lower section of Cross Creek near Kolmont which is operated by Murray Energy/Ohio American Energy.

Hopedale Mining, LLC (Ohio EPA Permit # 0IL00093 outfall 009 and 010)
The Hopedale Mining, LLC is a coal mining preparation plant located at Township Roads 176 & 171, one mile northwest of Hopedale, in Harrison County. Hopedale Mining LLC outfall 009 is a discharge from a settling pond that includes coal refuse area storm water, deep mine water and coal preparation plant process water. Outfall 010 is sewage treatment plant effluent. Both 009 and 010 discharge to an unnamed tributary to upper Cross Creek (tributary enters Cross Creek at RM 27.4)

Apex Environmental, LLC (Ohio EPA Permit # 0II00022 outfall 007)
Apex Environmental, LLC (formerly owned by Krulock Coal Company) is located at Amsterdam Road, in the community of Amsterdam in Jefferson county and discharges to both the Yellow Creek watershed (unnamed tributary to Goose Creek) and the Cross Creek watershed (North Branch of Cross Creek). Most of the final outfalls discharge to Goose Creek in the Yellow Creek watershed but outfall 007 discharges to the North Branch of Cross Creek and consists of effluent from a sedimentation pond. Apex Environmental, LLC reported no flows from outfall 007 between 2007 and 2012.

Wintersville A WWTP (Ohio EPA Permit # 0PB00066 outfall 001)
The Wintersville A WWTP is located at 160 Rear Marshall Road, in the community of Wintersville in Jefferson County and discharges to Barbers Hollow (trib to Cross Creek at RM 9.60). The Wintersville A WWTP is a publicly owned treatment works providing wastewater treatment for the City of Wintersville and residents of Jefferson County outside of the city limits. The population served by this treatment plant is estimated at 4,567 people. The design flow is 0.54 MGD with an annual average flow of 0.425 MGD for 2007-2012. The plant was constructed in 1990 and the last major modifications to the plant occurred in 2001. Current treatment includes communition, flow equalization, activated sludge-conventional, chlorination

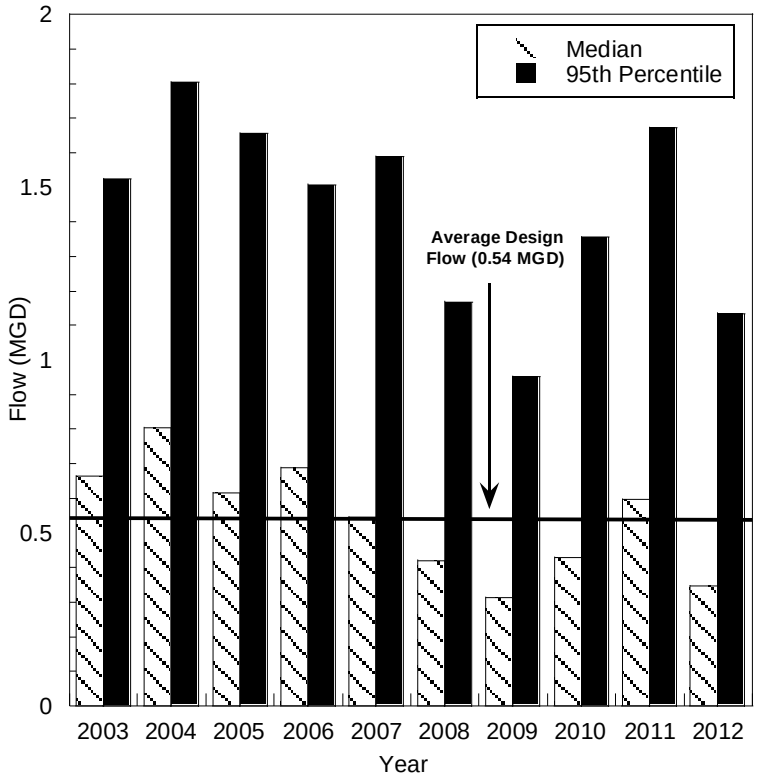

Figure 5. Annual median and 95th percentile effluent flows for the Wintersville WWTP, 2003 - 2012.

and dechlorination. Additionally, Wintersville A WWTP has a permitted bypass from the overflow of their aerated equalization tank that is treated with chlorine for disinfection. Wintersville A WWTP has been issued a Permit To Install (PTI) for a WWTP improvement project which will add grit removal, screening, digester, revamp clarifiers and UV treatment and should also prevent bottlenecks at the plant reducing bypasses. Construction for these improvements began in 2012.

Wintersville A WWTP is required to submit monthly operating reports (MORs) to Ohio EPA as part of their permit requirements. Annual median and 95th percentile data collected by Wintersville A WWTP show that median plant performance has been fairly consistent from 2007 to 2012 for ammonia and CBOD5. Median flows remained consistent but exceeded the design flow of 0.54 MGD in both 2007 and 2011. The 95th percentile flows exceeded the design flow every year from 1995 to 2012 with the highest flows at 1.799 MGD in 2004 (Figure 5). Six bypasses were reported for 2010 and nine bypasses were reported for 2011.

Ohio EPA conducted a compliance sampling inspection at the Wintersville A WWTP on March 13-14, 2011 from outfall 001. The results from the composite sample found no permit limit exceedances, however, nitrate+nitrite-N values were elevated with a result of 7.52 mg/l as well as elevated total dissolved solids (1100 mg/l). The Wintersville A WWTP has issues with telescoping valves plugging which leads to solids washouts. During the 2010 biological survey, the macroinvertebrates were found to be impaired downstream from the WWTP due to organic enrichment from the combined discharges of the Wintersville A and Jefferson M WWTP.

Jefferson M WWTP (Ohio EPA Permit # 0PH00000 outfall 001) The Jefferson M WWTP is located on Evergreen Terrace, in the community of Wintersville, in Jefferson County and discharges to Barbers Hollow (Cross Creek tributary) just downstream from the Wintersville A WWTP. Jefferson M WWTP is a publicly owned treatment works providing wastewater treatment for residents of Jefferson County outside of the Wintersville and Stuebenville city limits. The population served by this treatment plant is estimated at 5,840 people. The design flow is 0.42 MGD with an annual average flow of 0.519 MGD for 2007-2012. The plant was constructed in 1991. Current treatment includes flow equalization, primary sedimentation, oxygen ditch, secondary clarification, chlorination and dechlorination.

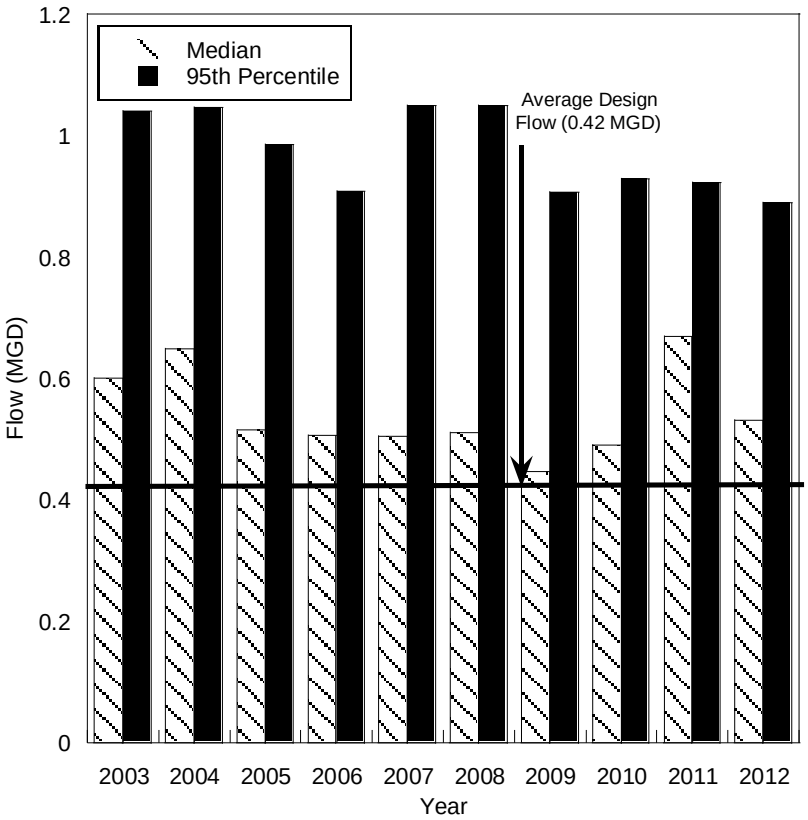

Figure 6. Annual median and 95th percentile effluent flows for the Jefferson M WWTP, 2003 - 2012.

Similar to the Wintersville A WWTP, Jefferson M WWTP has a permitted bypass from the overflow of their aerated equalization tank that is treated with chlorine for disinfection. The Jefferson M Plant is conducting a study for clarifier upgrades and potential plant expansion.

The Jefferson M WWTP is required to submit MORs to Ohio EPA as part of their permit requirements. Annual median and 95th percentile data collected by Jefferson M WWTP show that median plant performance has been fairly consistent from 2007 to 2012 with ammonia and cBOD5 below permit limits. Median and 95th percentile flows have consistently exceeded the design flow of 0.42 MGD from 2003-2012 (Figure 6).

Ohio EPA conducted a compliance sampling inspection at the Jefferson M WWTP on March 13-14, 2011 from outfall 001. The results from the composite sample found no permit limit exceedances, however, nitrate+nitrite-N values were elevated with a result of 7.26 mg/l and TKN at 1.22 mg/l. During the 2010 biological survey, the macroinvertebrates were found to be impaired downstream from the Jefferson M WWTP due to organic enrichment from both the Jefferson County M WWTP and Wintersville A WWTP.

Steubenville Landfill, Inc. (Ohio EPA Permit# 0IN00277)
The Steubenville Landfill is a closed landfill located on Fernwood Road just south of Wintersville in Jefferson County. Leachate seeps from the landfill discharge to a tributary to Cross Creek that enter at RM 8.7. To control these discharges, the Steubenville Landfill received a PTI from Ohio EPA in February 2013 to construct two wetland treatment systems which will treat leachate as well as mine drainage from historic mine discharges. The proposed wetlands will be constructed by the summer of 2013 and monitoring from the two outfalls (001 and 002) will begin.

C&D Disposal Technologies LLC
Crossridge Landfill, Inc. (Ohio EPA Permit# 0IN00106)
C&D Disposal Technologies and Crossridge Landfill are technically two separate landfills but are owned and operated by one owner. Both landfills are located adjacent to each other at the southwest of the intersection of County Road 26 and Township Road 174 in Cross Creek Township within Jefferson County. Discharges from the landfills go to an unnamed tributary to Cross Creek (enters at RM 8.5) and Dry Run which enters Cross Creek at RM 7.9. The Crossridge Landfill has two permitted outfalls. Outfall 001 is final effluent from a sediment pond at the south end of the landfill area and outfall 002 is from a sediment pond in the southeast section of the landfill. The Crossridge Landfill stopped receiving waste in 1990, but has failed to meet closure requirements in accordance of Ohio law. Ohio EPA and the Jefferson County Health Department are working with the owners of the landfill to properly close the landfill by installing a final cap system over the entire waste disposal area of approximately 9 acres. Leachate from the Crossridge Landfill is supposed to be collected and disposed of at the Jefferson County M WWTP, but the owners stopped hauling the leachate in May of 2012. As a result, leachate from the facility is collecting onsite and is potentially discharging to Cross Creek or into the groundwater. Ohio EPA collected leachate samples in October 2009 and found detections of numerous organic compounds including benzene, 1,1 dichloroethane, ethylbenzene, isopropylbenzene, napthalene, toluene, 1,2,4-trimethylbenzene, vinyl chloride, o-xylene and diethylphthalate as well as highly elevated ammonia (80.1 mg/l) and various metals (aluminum, arsenic, iron, barium, chromium, copper, lead, manganese, strontium, selenium and nickel).

C&D Disposal Technologies is a construction and demolition debris landfill that accepted out of state waste, mostly from the east coast, by railroad car (Figure 7). The annual license for C&D Disposal Technologies from the Jefferson County Health Department was denied in 2012 but the facility continued to accept waste without a license. Acceptance of waste ceased near the end of 2012. Additionally, the site has a large 90,000 cubic yard open dump with exposed waste at the C&D Disposal Technologies portion of the facility. Storm water runoff from the open dump, C&D Disposal Technologies as well as Crossridge Landfill all discharge to tributaries entering Cross Creek.

During the 2010 survey, sediment plumes were observed in Cross Creek just downstream from the Crossridge Landfill and C&D Disposal Technologies. In addition to the construction and demolition debris waste disposal activities, active logging was occurring on site which created noticeable sediment runoff. A compliance sample was conducted in 2011 at several storm water ponds and tributaries to Cross Creek after a rain event. Much of the observed storm water flowing from the property bypasses the ponds and discharges directly to the tributaries to Cross Creek. WQS criteria exceedances (outside mixing zone average) were found in the tributaries for barium, cobalt, copper, iron, lead, nickel, vanadium and zinc.

Figure 7. C&D Disposal rail line adjacent to a tributary to Cross Creek.

Satralloy – Cyprus Amax Minerals (Ohio EPA Industrial Storm Water Permit 0GR00401)
The Satralloy plant was constructed in 1957 and was used for smelting chromium ore. The arc furnaces operated at this 333 acre facility were taken out of production in 1982. From 1982 to approximately 1992 a chromium recovery facility (Satra Concentrates) attempted to recover useable chromium from the acres of slag and waste present at the site. The buildings are contaminated with asbestos and dust containing chromium and there are approximately 50 acres of waste and slag piles containing varying concentrations of chromium. A byproduct of the chromium smelting process is the formation of hexavalent chromium, a known cancer causing chemical. Cyprus Amax Minerals Company, who was connected to the original owner and operator of the site (Vanadium Corporation of America), has agreed to investigate and remediate the site pursuant to a Judicial Consent Order Preliminary Injunction. In the near term, this remediation will include the demolition of all of the plant buildings and the processing of on-site waste piles to reclaim chromium. The investigation and cleanup is projected to take ten or more years. The property was bought by Cyprus Amax Minerals in 2010.

Satralloy did have an NPDES permit with Ohio EPA but the permit was revoked in 1996 after the facility was closed and the new owner and operator refused to continue the required monitoring. Several areas discharge from the property directly to Cross Creek from RMs 7.72 to 4.71 (Figure 8). Hexavalent chromium and chromium samples were collected from Satralloy by

Ohio EPA on April 11, 2011 and showed exceedances of the WQS criterion for hexavalent chromium (see Figure 8 and Table 8 for sampling locations and Table 8 for sampling results). Elevated levels of total chromium, total dissolved solids (TDS) and pH were above the WQS criterion for the Outside Mixing Zone Average (OMZA) (Table 8). Additional samples, collected by the Cyprus Amax Minerals Company on June 7, 2011 and May 8, 2012, also exceeded the WQS criterion for hexavalent chromium. Chromium was also detected in one fish tissue sample collected downstream from Satralloy (see Fish Tissue section). During the Ohio EPA 2010 survey, field staff often observed citizens swimming in Cross Creek just downstream from Satralloy at the Mingo Junction - Goulds Road bridge (TR 74). This is a well know swimming location and could be a potential area of human health exposure to hexavalent chromium and total chromium. Runoff laden with chromium is expected to worsen as Cyprus Amax Minerals Company begins demolition of the buildings and reclaiming the waste and slag piles. During the remediation of the site, it is recommended that biological and chemical monitoring be conducted to ensure that the runoff is not causing further negative impacts to the biological community of Cross Creek or increasing human health exposure.

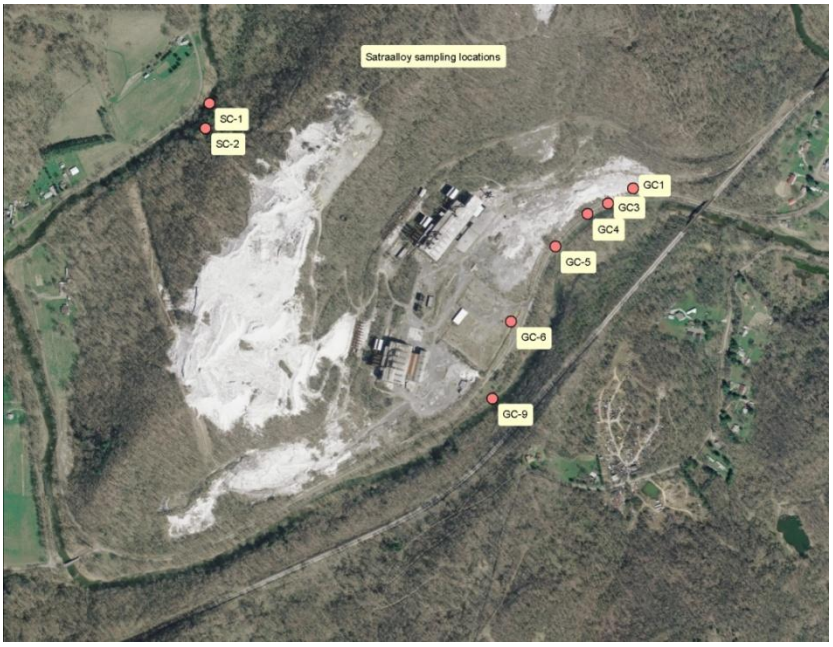

Figure 8. (Top) Storm water sampling locations at Satralloy collected in 2011 and 2012 (see Table 8 for sampling results). (Bottom) discharges to Cross Creek from Satralloy at RM 7.72

Table 8. Satralloy discharges to Cross Creek sampled by Ohio EPA on April 11, 2011. NA is not analyzed.

		Site Location: **Satralloy discharges to Cross Creek** Samples collected by Ohio EPA 04/11/2011			
Parameter	Units	**SC1** RM 7.72	**GC-3** RM 4.68	**GC-5** oufall 002 RM 4.75	**GC-4** RM 4.71
Acidity	mg/L	<5	<5	<5	<5
Alkalinity	mg/L	111	927	55	140
Aluminum	ug/L	<200	<200	<200	<200
Ammonia	mg/L	0.056	0.378	<0.05	<0.05
Arsenic	ug/L	<2	<2	<2	<2
Barium	ug/L	27	74	27	42
Cadmium	ug/L	<0.2	<0.2	<0.2	<0.2
Calcium	mg/L	51	666	219	436
Chloride	mg/L	<5	23.9	<5	8.4
Chromium	ug/L	54.3	752	281	634
COD	mg/L	<20	<20	<20	<20
Conductivity	umhos/cm	380	4890	1200	1800
Copper	ug/L	<2	<2	<2	<2
Hardness, Total	mg/L	169	1660	798	1090
Hexavalent Chromium	ug/L	59	752	271	620
Iron	ug/L	<50	244	53	<50
Lead	ug/L	<2	<2	<2	<2
Magnesium	mg/L	10	<1	61	<1
Manganese	ug/L	<10	<10	<10	<10
Mercury	ug/L	NA	NA	NA	NA
Nickel	ug/L	<2	16.8	4.9	9.5
Nitrate+nitrite	mg/L	0.23	<0.1	0.25	0.19
Nitrite	mg/L	0.033	0.04	0.062	0.077
Potassium	mg/L	9	6	4	5
Selenium	ug/L	<2	<2	<2	<2
Sodium	mg/L	8	34	13	24
Strontium	ug/L	1050	2430	695	1200
Sulfate	mg/L	37.3	477	629	789
TKN	mg/L	<0.2	0.49	0.23	<0.2
Total Dissolved Solids	mg/L	168	1710	984	1300
Total Phosphorus	mg/L	<0.01	0.197	<0.01	<0.01
Total Suspended Solids	mg/L	74	<5	20	<5
Zinc	ug/L	<10	<10	<10	<10
Field Measurements					
Temperature	°C	19.41	12.16	12.73	16.56
Conductivity	µmhos/cm	414.9	5013	1213.4	1825.6
Dissolved Oxygen	mg/L	8.07	10.18	9.81	7.77
D.O. Saturation	%	87.8	96.4	92.9	80.1
pH	S.U.	11.19	12.6	9.3	11.36

Ohio American Energy, Inc. North Star 1 Surface Coal Mine (OEPA Permit # 0IL00155)
The North Star 1 Mine is located in Cross Creek Township adjacent to Scott Featner Road near New Alexandria within Jefferson County and discharges to unnamed tributaries to McIntyre Creek and Cross Creek. Outfalls 001, 002, 003 and 004 are discharges from settling ponds going to a tributary to Cross Creek that enters at RM 4.5 just upstream from Kolmont. Outfall 005 is a settling pond that discharges to a tributary to Cross Creek that enters at RM 5.3 upstream from Satralloy and outfalls 006 and 007 are discharges from settling ponds going to tributaries of McIntyre Creek at RMs 0.1 and 0.5 respectively. This permit was issued by Ohio EPA in 2011 after the completion of the survey in 2010 so the effects of the mining operation are unknown.

Sisters of Reparation
The Sisters of Reparation is a Catholic nunnery located in Steubenville in the headwaters of Dry Fork (Cross Creek). There are several underground abandoned mines and surface mines located in this area. An exposed highwall is located on the property of the Sisters of Reparation along with a large pond that fills seasonally with iron laden mine water (Figure 9). Another pond to the southeast also contributes iron and aluminum to the tributary to Dry Fork. Typically the pond fills up in the winter and spring then overflows and discharges mine water during spring rain events. The Ohio Department of Natural Resources Division of Mineral Resources Management has approached the Sisters of Reparation several times about reclaiming this highwall to stop the mine drainage and eliminate the safety hazard. However, at this time the Sisters of Reparation do not want to allow a reclamation project on their property. This project could significantly improve the water quality of Dry Fork if and when the Sisters of Reparation agree to cooperate.

Figure 9. Aerial photograph of a pond located on the property of the Sisters of Reparation. The pond fills with iron laden mine water then discharges to a tributary to Dry Fork in the Cross Creek watershed.

Granatir Apartments WWTP (Ohio EPA permit # 0PW00011)
Granatir Apartments is an extended aeration sewage treatment plant that discharges to an unnamed tributary to Dry Fork adjacent to Goulds Rd. (CR 28). The design flow of the plant is 6000 gallons per day. Average flows for the past 5 years have ranged from 3000 to 5000 gallons per day.

Rocky's Junk Yard
Rocky's Junk Yard is located on CR 74 adjacent to the lower section of Cross Creek just south of Mingo Junction. The Rocky's Junk Yard has a significant amount of cars located in the Cross Creek floodplain. Additionally, the material that the cars are sitting on is disposed slag from Wheeling Pittsburg Steel (now called Mingo Junction LLC Steel Works). During rain events or flooding, runoff from Rocky's Junk Yard could discharge contaminants into Cross Creek. Rocky's Junk Yard does not have a storm water permit from Ohio EPA.

Mingo Junction LLC Steel Works (formerly Wheeling Pittsburgh) Ohio EPA permit # 0ID00034 outfall 011, 019, 020

Most of the process water for Mingo Junction LLC Steel Works is discharged to the Ohio River; however, there are three outfalls that discharge to the lower section of Cross Creek which include non-contact cooling water from the hot strip mill, floor drains and storm water runoff. These discharges enter Cross Creek downstream from Commercial Avenue in the Ohio River backwater section of Cross Creek.

The former Wheeling Pittsburgh Steel company disposed slag piles over an area of 23.8 acres located on TR 167a in Cold Springs just south of Mingo Junction. An unnamed tributary drains from this location and enters Cross Creek at RM 1.2 upstream from Commercial Avenue. The water that drains the slag pile is typically milky white and has very high pH (Figure 10). Sediment samples were collected from the Cold Springs slag pile in 2011 (Appendix Table 6). polychlorinated biphenyl (PCBs) were detected (220 ug/kg) as well as numerous metals. This area is currently being mined and reprocessed by Phoenix Services with the hopes of redevelopment.

Figure 10. RG Steel slag pile (lower) and drainage from slag pile (upper)

Mingo Junction STP (Ohio EPA Permit # 0PD00010)

The Mingo Junction Sanitary Treatment Plant (STP) is located at Erie Avenue in Mingo Junction with an outfall to Cross Creek at RM 0.5. Additionally, the Mingo Junction STP has seven Combined Sewer Overflow (CSO) stations located at Lower Church Hill Road, Upper Church Hill Road, Lincoln Ave., North Hill, Commercial Ave., McAlister Ave. and Aracoma Ave. The Mingo Junction STP has a Long Term Control Plan to eliminate the CSOs with an estimated completion date of 2017. Mingo Junction has eliminated one CSO and also has modified some of the weirs to prevent dry weather discharges.

Ohio River Tributaries (Island Creek, Wills Creek, Croxton Run)

The northern direct Ohio River tributaries have a total of two individual NPDES permitted facilities and two general NPDES permits that discharge sanitary wastewater, industrial process water, and/or industrial storm water. These facilities include one active mining facility (Valley Mining Pleasant Hill), one industrial facility (Richmond Mill Inc.) and two sanitary WWTPs (Ridgeland Subdivision WWTP and Franciscan Sisters Third Order Regular (TOR)).

Richmond Mill Inc. Fly Ash Site II (Ohio EPA Permit # 0IN00113)
Richmond Mill Inc. Fly Ash Site II (formerly owned by the Anthony Mining Company) is located at 16479 State Route 152, in Knoxville within Jefferson County and has three outfalls that discharges to the Croxton Run watershed.

Ridgeland Subdivision WWTP (Ohio EPA Permit # 0PG00053)
The Ridgeland Subdivision wastewater treatment works is located near the intersection of Northeast Ridgeland Drive and County Road 46 in Island Creek Township, within Jefferson County and discharges to the Croxton Run watershed via an unnamed tributary to Wildcat Hollow.

Franciscan Sisters TOR (Ohio EPA Permit # 0GS00007)
The Franciscan Sisters TOR has a sanitary treatment plant that discharges to the Croxton Run watershed via an unnamed tributary to Wildcat Hollow. The treatment plant is located at 170 Little Church Road in Island Township within Jefferson County.

Valley Mining Pleasant Hills (Ohio EPA Permit # 0GM00402)
Valley Mining Pleasant Hills has a general NPDES permit for coal surface mining. The operation is located at 5027 CR 45 in Island Township within Jefferson County. Drainage from outfall 001 discharges to the headwaters of Island Creek.

Sediment

Surficial sediment samples were collected at five locations in Cross Creek, McIntyre Creek and Island Creek by the Ohio EPA on August 3 and November 22, 2010. Sampling locations were co-located with biological sampling sites. Samples were analyzed for total analyte list inorganics (metals) and total phosphorus. Specific chemical parameters tested and results are listed in Appendix Table 6. Sediment data were evaluated using Ohio Sediment Reference Values (Ohio EPA 2008), along with guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et.al*. 2000) and the Persaud et. al. 1993 phosphorus guidelines (LEL= 600 mg/kg, and SEL = 2000 mg/kg). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed.

Sediment samples were conservatively sampled by focusing on depositional areas of fine grain material (silts and clays). These areas typically are represented by higher contaminant levels, compared to coarse sands and gravels. Fine grained depositional areas were not a predominant substrate type at all five sites with less than 6% of the sample comprised of fine grained silt or clay.

No elevated metals were found in the most upstream section of Cross Creek at Unionport (Table 9). Island Creek had one elevated metal (nickel) above the TEC level and elevated phosphorus. The highest metal levels were found in McIntyre Creek which is a heavily mined subwatershed of Cross Creek and in Cross Creek at Kolmont downstream from McIntyre Creek and Satralloy. Arsenic exceeded PEC levels in McIntyre Creek which suggest toxic sediment levels. Also in McIntyre Creek, cadmium, calcium and strontium were above TEC levels and copper, nickel and zinc exceeded the SRV levels. Cross Creek at Broadacre and Kolmont had arsenic, nickel and zinc above the TEC levels and iron elevated above the SRV levels. Cross Creek at Kolmont also had cadmium, calcium, and manganese above the SRV levels.

The biology does not seem to be affected in Cross Creek, McIntyre Creek and Island Creek with both fish and macroinvertebrates meeting WWH. The sparse deposits of fine grained material in Cross Creek, McIntyre Creek and Island Creek contributed to low exposure levels of potential sediment contaminants to biological communities.

Table 9..Chemical parameters measured above screening levels in samples collected by Ohio EPA from surficial sediments in Cross Creek, McIntyre Creek and Island Creek, 2010. Contamination levels were determined for parameters using Ohio Sediment Reference Values (SRVs) and consensus-based sediment quality guidelines (MacDonald, et.al. 2000). Shaded numbers indicate values above the following: SRVs (blue),Threshold Effect Concentration –TEC (yellow) and Probable Effect Concentration – PEC (red). Sampling locations are indicated by river mile (RM).

Parameter	Cross Creek Unionport RM 22.9	Cross Creek Broadacre RM 16.4	Cross Creek Kolmont RM 6.4	Island Creek CR 56 RM 0.36	McIntyre Creek TR184 RM 0.18
Aluminum	6020	7780	23400	12800	12300
Ammonia	43	89	NA	32	89
Arsenic	6.96	13.7	12.6	9.36**J**	15.3
Barium	58.9	83.8	219	128**J**	130
Cadmium	0.355	0.592	0.948	0.495	0.895
Calcium	5330	12400	58800	8960	93200
Chromium	9.78	13.2	28.7	25.3**J**	22.3
Copper	15.1	17.5	22.4	19.4**J**	56.2
Iron	24100	52900	64700	41100	43300
Lead	30.4	20.1	25.1	21	30.2
Magnesium	1600	2750	14100	4330	6770
Manganese	979	1520	2280	963	1750
Nickel	16	22.9	35.9	26.2**J**	42.7
Potassium	ND	ND	2670	1830	ND
Selenium	ND	ND	ND	ND	ND
Sodium	ND	ND	ND	ND	ND
Strontium	23	34	172	44	339
Zinc	69.4	339	143	112	263
Total Phosphorus	391	656	NA	704	757

J - Estimated result. Result is less than RL.

ND - not detected at or above the method detection limit

NA – Not Analyzed

Fish Tissue

Ohio's Fish Consumption Advisory Program (FCA) was reorganized in 1993 as a cooperative effort amongst the Department of Health, Department of Natural Resources, and the Ohio EPA. This multi-agency approach has produced a broad consistent fish tissue contaminant database from all of the State's waters. Concurrently, the Great Lakes Governors Association, U.S. EPA, and Ohio's FCA have improved data evaluation and risk communication. The Ohio FCA website provides further information: http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

Fish tissue in 22 samples comprised by 60 fish either singularly or combined was collected in 2002, 2009 and 2010 from the Cross Creek study area. Table 10 summarizes the concentrations of detected metals from these fish. In 2010, 28 fish from the Satralloy vicinity were specifically evaluated in 10 tissue samples for the presence of chromium. Table 11 presents the results for this subset analysis. Table 12 lists the detected organic compounds present in the 22 samples. Results for other typical tissue parameters not presented in these tables were less than the method detection limits. These analytes, specific FCA guidance, and contaminant thresholds are discussed in: *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program.*
http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure.pdf

The ubiquitous presence of mercury has resulted in a statewide recommendation to restrict fish consumption based on location and species specific risk. Broadly, it's prudent to eat most fish about 52 times annually (once a week). While yellow perch, crappie and sunfish may be consumed more often, the mercury contamination in other species could exceed the amount most people would normally metabolize and eliminate. In places where the amount of species specific mercury contamination is excessive, advisories are issued to limit consumption accordingly. Thus, a monthly advisory suggests certain fish from particular water bodies should be eaten less frequently than the weekly recommendation would suggest.

Channel catfish, freshwater drum, and smallmouth bass from Cross Creek were determined to have higher mercury concentrations than appropriate for weekly meals. Limiting consumption of these species to about 12 times annually is recommended. Cross Creek channel catfish also exhibited elevated amounts of PCB contamination. The monthly advisory suggests limiting catfish meals for this reason as well.

It is generally known that the white heaps and hills of waste spoil at the former Satralloy property contain hazardous substances including hexavalent chromium. The obvious possibility of chromium transport through storm water runoff or aerial deposition from the Satralloy site warranted specific analysis for this metal in fish tissue as part of the overall 2010 study. Detection of chromium is unusual unless it has an anthropogenic origin. Most research related to chromium effects is based on human contact through manufacturing or exposures related to waste disposal. Different degradation states are known to be carcinogenic or to have other toxic effects. Information about chromium and biological effects in natural environments is less certain and complicated by many factors including the accuracy of testing methodology. The US Fish and Wildlife Service has summarized much of the salient information in *Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review* (Eisler 1986).

Among the 28 fish analyzed in 10 tissue samples in the vicinity of Satralloy, chromium was detected in a composite evaluation of three white suckers. This finding is consistent with similar observations of higher concentrations in lower trophic levels (Eisler 1986). Otherwise, beyond the fundamental point that chromium should not be present, further inferences about this detection and amount are speculative. The uncertainty regarding chromium and environmental exposure should be cause for concern and further investigation. The 2010 fish tissue detection near the former

Satralloy facility indicates that hazardous substances are migrating from the location. More effective containment and remediation are recommended.

In addition to consumption advisories, fish tissue data supports assessment of the non-drinking water human health use. "Section E: Evaluating Beneficial Use: Human Health (Fish Contaminants)" of the 2012 Ohio EPA *Integrated Report* (http://epa.ohio.gov/portals/35/tmdl/2012IntReport/IR12SectionEfinal.pdf) explains the rationale used to characterize this attainment status. Table 13 includes the calculation procedure that determined three study area assessment units are impaired due to PCB contamination. The same calculation for mercury is shown to illustrate the difference between this use expectation and that of the FCA procedure.

Polychlorinated biphenyls (PCBs) have been illegal to manufacture in the U.S. since 1979 and worldwide since 2001. The persistence of these carcinogens in the environment challenges contemporary source location. The frequent detection of PCBs in study area fish tissue reflects the regions' industrial heritage and calls for vigilance in the proper disposal of these toxins.

Table 10. Metals concentrations (mg/kg) in fish tissue samples collected from Cross, Creek, 2002-2010. Values preceded by a less than sign (<) indicate results were below the method detection limit. Comparative values under each analyte are Ohio adopted triggers. **Bold** values exceed the unrestricted consumption risk trigger (biweekly for mercury), ***bold italicized*** values exceed the weekly consumption risk trigger. **Yellow** and ***red*** highlighted mean values support respective consumption advisories. Sample types are: SFF=skin off fillet, SFFC= skin off fillet composite, SOFC= skin on fillet composite.

Species			Location	Arsenic	Cadmium	Lead	Mercury	Selenium
n/type	Year	RM	Cross Creek	**0.150/ *0.656***	**0.500/ *2.188***	**0.086/ *0.375***	**0.110/ *0.220***	**2.500/ *10.938***
Channel catfish								
1/SFF	2009	13.6	Reeds Mill Rd.	<0.099	<0.0040	<0.040	***0.487***	0.160
2/SFFC	2009	3.9	Dst. Satralloy	<0.098	<0.0039	<0.039	***0.239***	0.260
2/SOFC	2010	1.3	CR 74	<0.050	0.0043	0.071	0.109	0.286
			Mean values	--	0.0028	0.037	***0.278***	0.235
Carp								
3/SOFC	2002	13.6	Reeds Mill Rd.	<0.036	<0.0040	0.078	**0.188**	0.301
2/SFFC	2009	13.6	Reeds Mill Rd.	<0.099	<0.0040	<0.040	0.104	0.416
3/SOFC	2002	4.2	Dst. Satralloy	<0.035	0.0055	0.065	**0.176**	0.247
3/SFFC	2009	3.9	Dst. Satralloy	<0.100	<0.0040	<0.040	**0.171**	0.636
			Mean values	--	0.0029	0.046	**0.160**	0.400
Freshwater drum								
2/SFFC	2010	4.9	Dst. Satralloy	0.092	<0.0039	<0.039	***0.263***	0.666
3/SFFC	2009	3.9	Dst. Satralloy	0.118	<0.0040	<0.040	***0.531***	0.531
2/SFFC	2010	1.3	CR 74	0.108	<0.0040	<0.040	**0.195**	0.527
			Mean values	0.106	--	--	***0.330***	0.575
White sucker								
3/SFFC	2010	4.9	Dst. Satralloy	<0.050	<0.0040	<0.040	0.059	0.530
Yellow bullhead								
2/SFFC	2009	13.6	Reeds Mill Rd.	<0.099	<0.0040	<0.040	**0.142**	0.284
Flathead catfish								
1/SFF	2010	1.3	CR 74	<0.050	<0.0040	0.048	**0.112**	0.322
Rock Bass								
4/SFFC	2009	13.6	Reeds Mill Rd.	<0.100	<0.0040	<0.040	***0.286***	0.394
5/SOFC	2010	4.9	Dst. Satralloy	0.052	<0.0040	0.054	**0.129**	0.472
2/SFFC	2009	3.9	Dst. Satralloy	<0.098	<0.0039	<0.039	**0.205**	0.420
			Mean values	0.051	--	0.031	**0.207**	0.429
Sauger								
3/SFFC	2010	4.9	Dst. Satralloy	<0.049	<0.0040	<0.039	**0.187**	0.412
Smallmouth bass								
4/SFFC	2009	13.6	Reeds Mill Rd.	<0.098	<0.0039	<0.039	***0.330***	0.430
5/SFFC	2010	4.9	Dst. Satralloy	0.085	<0.0040	<0.040	**0.182**	0.536
2/SFFC	2010	4.9	Dst. Satralloy	0.087	<0.0040	<0.040	**0.218**	0.537
3/SFFC	2009	3.9	Dst. Satralloy	0.115	<0.0040	**0.201**	***0.270***	0.534
3/SFFC	2010	1.3	CR 74	0.138	<0.0040	<0.040	**0.168**	0.526
			Mean values	0.095	--	0.056	***0.234***	0.513

Table 11 Chromium concentrations (mg/kg) in fish tissue samples collected from Cross Creek in the Satralloy vicinity, 2010. Values preceded by a less than sign (<) indicate results were below the method detection limit. No detection is expected. Detections are likely indicative of runoff or aerial depositions from Satralloy. Sample types are: SFF=skin off fillet, SFFC= skin off fillet composite, SOFC= skin on fillet composite.

Cross Creek				
Species n/type	Year	RM	Location	Chromium *Value*
Channel catfish				
2/SOFC	2010	1.3	CR 74	<0.40
Freshwater drum				
2/SFFC	2010	4.9	Dst. Satralloy	<0.39
2/SFFC	2010	1.3	CR 74	<0.40
White sucker				
3/SFFC	2010	4.9	Dst. Satralloy	***0.48***
Flathead catfish				
1/SFF	2010	1.3	CR 74	<0.40
Rock Bass				
5/SOFC	2010	4.9	Dst. Satralloy	<0.40
Sauger				
3/SFFC	2010	4.9	Dst. Satralloy	<0.39
Smallmouth bass				
5/SFFC	2010	4.9	Dst. Satralloy	<0.40
2/SFFC	2010	4.9	Dst. Satralloy	<0.40
3/SFFC	2010	1.3	CR 74	<0.40

Table 12 Organic compounds (mg/kg) in fish tissue samples collected from Cross Creek 2002-2010. Values preceded by a less than sign (<) indicate results were below the method detection limit. Comparative values under each analyte are Ohio adopted recommendations. **Bold** values exceed the unrestricted consumption risk trigger, ***bold italicized*** values exceed the weekly consumption risk trigger. **Yellow** and ***red*** highlighted mean values support respective consumption advisories. Sample types are: SFF=skin off fillet, SFFC= skin off fillet composite, SOFC= skin on fillet composite.

Species			Location	PCB Aroclors		Total PCBs	Total DDT
n/type	Year	RM	Cross Creek	1254	1260	**0.050/ *0.220***	**0.500/ *2.188***
Channel catfish							
1/SFF	2009	13.6	Reeds Mill Rd.	<0.050	***0.339***	**0.364**	<0.010
2/SFFC	2009	3.9	Dst. Satralloy	**0.134**	***0.564***	**0.698**	0.017
2/SOFC	2010	1.3	CR 74	**0.180**	***0.269***	**0.449**	<0.010
			Mean values			**0.504**	0.009
Carp							
3/SOFC	2002	13.6	Reeds Mill Rd.	<0.050	**0.102**	**0.127**	0.014
2/SFFC	2009	13.6	Reeds Mill Rd.	<0.050	<0.050	0.050	<0.010
3/SOFC	2002	4.2	Dst. Satralloy	**0.142**	***0.337***	**0.479**	0.012
3/SFFC	2009	3.9	Dst. Satralloy	<0.050	**0.090**	**0.115**	<0.010
			Mean values			**0.193**	0.009
Freshwater drum							
2/SFFC	2010	4.9	Dst. Satralloy	**0.064**	**0.065**	**0.129**	<0.010
3/SFFC	2009	3.9	Dst. Satralloy	<0.050	**0.050**	**0.075**	<0.010
2/SFFC	2010	1.3	CR 74	**0.057**	<0.050	**0.082**	<0.010
			Mean values			**0.095**	--
White sucker							
3/SFFC	2010	4.9	Dst. Satralloy	<0.050	**0.095**	--	<0.010
Yellow bullhead							
2/SFFC	2009	13.6	Reeds Mill Rd.	<0.050	<0.050	--	<0.010
Flathead catfish							
1/SFF	2010	1.3	CR 74	**0.101**	**0.094**	**0.195**	<0.010
Rock Bass							
4/SFFC	2009	13.6	Reeds Mill Rd.	<0.050	<0.050	--	<0.010
5/SOFC	2010	4.9	Dst. Satralloy	<0.050	<0.050	--	<0.010
2/SFFC	2009	3.9	Dst. Satralloy	<0.050	<0.050	--	<0.010
Sauger							
3/SFFC	2010	4.9	Dst. Satralloy	<0.050	<0.050	--	<0.010
Smallmouth bass							
4/SFFC	2009	13.6	Reeds Mill Rd.	<0.050	<0.050	--	<0.010
5/SFFC	2010	4.9	Dst. Satralloy	<0.050	<0.050	--	<0.010
2/SFFC	2010	4.9	Dst. Satralloy	<0.050	<0.050	--	<0.010
3/SFFC	2009	3.9	Dst. Satralloy	<0.050	<0.050	--	<0.010
3/SFFC	2010	1.3	CR 74	<0.050	<0.050	--	<0.010

Table 13 Non-drinking water human health use attainment status based on fish tissue samples collected from Cross, Creek, 2002-2010. **Bold** values (mg/kg) in the heading are parameter specific criterion. ***Red bold*** highlighted values violate the criteria and signify impairment. Values preceded by a less than sign (<) indicate results were below the method detection limit. Sample types are: SFF=skin off fillet, SFFC= skin off fillet composite, SOFC= skin on fillet composite.

Species			**Trophic Level**	Mercury		PCB Aroclors		Total	
n/type	Year	RM	Location		**1.0**	1254	1260	PCBs	**0.054**
Channel catfish			**3**						
1/SFF	2009	13.6	Reeds Mill Rd.	0.487		<0.050	0.339	0.364	
2/SFFC	2009	3.9	Dst. Satralloy	0.239		0.134	0.564	0.698	
2/SOFC	2010	1.3	CR 74	0.109		0.180	0.269	0.449	
			Geometric mean	0.233				0.485	
Carp			**3**						
3/SOFC	2002	13.6	Reeds Mill Rd.	0.188		<0.050	0.102	0.127	
2/SFFC	2009	13.6	Reeds Mill Rd.	0.104		<0.050	<0.050	0.050	
3/SOFC	2002	4.2	Dst. Satralloy	0.176		0.142	0.337	0.479	
3/SFFC	2009	3.9	Dst. Satralloy	0.171		<0.050	0.090	0.115	
			Geometric mean	0.156				0.137	
Freshwater drum			**3**						
2/SFFC	2010	4.9	Dst. Satralloy	0.263		0.064	0.065	0.129	
3/SFFC	2009	3.9	Dst. Satralloy	0.531		<0.050	0.050	0.075	
2/SFFC	2010	1.3	CR 74	0.195		0.057	<0.050	0.082	
			Geometric mean	0.301				0.093	
White sucker			**3**						
3/SFFC	2010	4.9	Dst. Satralloy	0.059		<0.050	0.095	0.120	
Yellow bullhead			**3**						
2/SFFC	2009	13.6	Reeds Mill Rd.	0.142		<0.050	<0.050	0.050	
Flathead catfish			**4**						
1/SFF	2010	1.3	CR 74	0.112		0.101	0.094	0.195	
Rock Bass			**4**						
4/SFFC	2009	13.6	Reeds Mill Rd.	0.286		<0.050	<0.050		
5/SOFC	2010	4.9	Dst. Satralloy	0.129		<0.050	<0.050		
2/SFFC	2009	3.9	Dst. Satralloy	0.205		<0.050	<0.050		
			Geometric mean	0.196				0.050	
Sauger			**4**						
3/SFFC	2010	4.9	Dst. Satralloy	0.187		<0.050	<0.050	0.050	
Smallmouth bass			**4**						
4/SFFC	2009	13.6	Reeds Mill Rd.	0.330		<0.050	<0.050		
5/SFFC	2010	4.9	Dst. Satralloy	0.182		<0.050	<0.050		
2/SFFC	2010	4.9	Dst. Satralloy	0.218		<0.050	<0.050		
3/SFFC	2009	3.9	Dst. Satralloy	0.270		<0.050	<0.050		
3/SFFC	2010	1.3	CR 74	0.168		<0.050	<0.050		
			Geometric mean	0.226				0.050	
			Mean 3 value (11.8)	0.178	2.103			0.177	2.089
			Mean 4 value (5.7)	0.180	1.027			0.086	0.492
			Sum		3.130				2.580
			Divided by /17.5		0.178				**0.147**

Stream Physical Habitat

Study area stream habitat conditions were assessed at 22 fish sampling sites in the Cross Creek basin and 7 sites in the direct Ohio River tributaries (Island Creek, Croxton Run and Wills Creek) in 2010 (Appendix Table 7). Based on the functional ability to support fish, each site's substrate, instream cover, and channel characteristics were graded and composited using the Qualitative Habitat Evaluation Index (QHEI). Generally, QHEI scores above 60 are typical of good habitat conditions associated with WWH aquatic communities. QHEI scores less than 45 are consistent with poor habitat conditions associated with the MWH aquatic life use, while QHEI values above 75 are typical of exceptional habitat conditions correlated with an EWH aquatic life use and potential to support exceptional biological communities. QHEI scores are most meaningful when considered in aggregate groups. For instance, an average of several QHEI scores from a river reach or the trend among many small streams in close proximity is more informative than relying on any single location QHEI score. It is unlikely for any site with particularly good or poor habitat to exert the same extreme influences on its resident aquatic community. Instead, aquatic assemblages at unique habitat locations tend to reflect the wider ambient condition.

Good habitat conditions were routine across the study area with most sites in the 70s which is considered excellent (Table 14). The few sites where habitat was subpar were impacted by historic or active coal mining. Otherwise, habitat conditions were sufficient to support aquatic communities representative of or exceeding WWH expectations throughout the study area.

Cross Creek had very good habitat conditions (QHEI $\bar{x}$=75.4, n=7) with high gradients, a wide array of substrates, deep pools, well defined riffles, and good availability of several cover types. These frequently encountered features and the comparable QHEI scores suggest any differences in aquatic community performance between sites are unlikely to be attributed to exclusive habitat factors. The lowest QHEI score on Cross Creek was 52 near the mouth in an area impounded by the Ohio River backwaters. As a result, the habitat score was fair with no riffles and a heavy sediment bedload.

Mine runoff and associated sedimentation were evident at some locations within the Cross Creek basin. Grassy Run (QHEI =52.5) and Leas Branch (QHEI =59.0) had limited flow and an abundance of silty fine substrates. Slab Run had better flow, but it is a primary headwater stream with a small drainage area (1.16 sq mi) and is isolated from downstream receiving waters by culverts and step pools (QHEI =48.0). The QHEI was developed for larger streams with a drainage area greater than 10 sq mi so it would be more appropriate to evaluate Slab Run using the Headwater Habitat Evaluation Index (HHEI) (OEPA 2012a).

Croxton Run, Island Creek, and Wills Creek were smaller streams with high gradients and many of the high quality attributes noted at larger stream locations except flow was more variable. Even though these streams had a smaller drainage area, habitat scores were good to excellent ranging from 66.0 to 79.5.

Table 14. Stream physical habitat quality as scored by the Qualitative Habitat Evaluation Index(QHEI) at sites in the Cross Creek watershed and direct Ohio River Tributaries study area, 2010.

Stream	River Mile	Location	QHEI	Comments
Cross Creek Watershed				
Cross Creek	24.9	TR 309 ust N. Br. Cross Ck	79.0	Moderate silt level, Moderate embeddedness
Cross Creek	22.9	CR 39 (Unionport Rd)	7.5.	Moderate silt level, no fast current
Cross Creek	15.2	Broadacre (SR 152)	86.0	extensive instream cover
Cross Creek	10.1	CR 26 (Bloomingdale – Fernwood)	83.5	Moderate silt level
Cross Creek	7.0	TR 166 ford Dst Landfills	73.0	Moderate silt level
Cross Creek	4.2	CR 74 (Mingo Junction - Goulds Rd)	78.5	Moderate silt level
Cross Creek	0.4	Commercial Ave. impounded area	52.0	Sparse cover, moderate silt, poor development
N. Br. Cross Creek	0.2	Adj TR 309	77.5	Heavy silt layer/moderate embeddedness
Cedar Lick Run	0.3	CR 22A	71.0	extensive instream cover
Salem Creek	4.5	TR 136	77.3	No fast current, moderate embeddedness
Salem Creek	0.1	Private Drive nr. mouth	65.0	No sinuosity, sparse cover,
Leas Branch	0.2	@ T-136	59.0	Moderate to Sparse cover, max depth < 40cm
Grassy Run	0.8	T-205, ust. Seminary pond	52.5	No Sinuosity, sparse cover, moderate silt levels
Clay Lick Creek	0.6	TR 166	70.5	No fast current, moderate embeddedness
Cedar Lick Creek	0.1	TR 166	74.0	Moderate silt and embeddedness, no fast current
Cedar Lick Run	0.1	CR 22A	71.0	Extensive to Moderate cover
Barbers Hollow	0.1	TR 166 dst. WWTP plants	79.0	Heavy silt layer/ extensive instream cover
McIntyre Creek	7.6	CR 74 (Mingo Junc.-Goulds Rd)	56.6	Mod to sparse cover
McIntyre Creek	0.5	McIntyre Ck @ TR 184	81.0	Mod-extensive instream cover
Slab Run	0.2	RR trestle	48.0	Sparse cover, max depth < 40cm Drainage area is 1.2 sq mi- HHEI should be used.
Longs Run	0.1	CR 74 (Mingo Junc.-Goulds Rd)	82.0	Mod-extensive instream cover
Dry Fork	0.6	UST mining tributary	68.5	Moderate to Sparse cover, max depth < 40cm
Dry Fork	0.3	Gould (Driveway Bridge)	66.5	Extensive to Moderate cover, no sinuosity
Direct Ohio River Tributaries				
Croxton Run	0.5	CR 47 (JF K Highway	78.5	Mod-extensive instream cover
Island Creek	6.3	TR 373	79.5	Mod-extensive instream cover
Island Creek	3.2	CR 56 nr. SR 213	73.0	Mod-extensive instream cover
Island Creek	0.3	Costonia-Mt Tabor Rd (CR 56)	73.0	Mod-extensive instream cover, no fast channel
Wills Creek	2.4	43 ust North Fork Wills Ck	66.0	Moderate to Sparse cover, max depth < 40cm
Wills Creek	0.7	CR 43 ust US 22 nr mouth	76.5	Mod-extensive instream cover
N. Fk Wills Creek	0.2	7 Creeks Rd	66.8	Moderate cover

General narrative ranges assigned to QHEI scores.			
Narrative Rating		QHEI Range	
		Headwaters (≤20 sq mi)	Larger Streams
Excellent		≥70	≥75
Good		55 to 69	60 to 74
Fair		43 to 54	45 to 59

Fish Community

A total of 34,891 fish representing 49 species were collected from the Cross Creek watershed study area between June and September, 2010. In the direct Ohio River tributaries (Island Creek, Wills Creek, Croxton Run) a total of 8,974 fish representing 29 species were collected in 2010. Relative numbers and species collected per location are presented in Appendix Table 8 and IBI and MIwb scores are presented in Appendix Table 9. Sampling locations were evaluated using Warmwater Habitat or Exceptional Warmwater Habitat biocriteria, along with Coldwater Habitat narrative benchmarks.

All the sites on the mainstem of Cross Creek met WWH. In 2010, the average IBI and MIwb scores for the seven mainstem Cross Creek sites were 45.5 and 10.6, respectively. Both averages were improved over those from 1983 (44 and 7.9, respectively) but the MIwb improved significantly. Most of the historic mining in Cross Creek occurred on the fringes of the watershed and the coal seams are positioned below grade so mine drainage typically doesn't freely flow into Cross Creek. Additionally, Jefferson and Harrison counties are underlain by a mixed limestone geo-type which buffers the streams against water quality impacts commonly associated with mine drainage thereby preventing severe acidic or low pH impacts and highly toxic heavy metals concentrations. Compared to the watersheds just south of Cross Creek, the prevalence of both surface and underground mining, and the magnitude of instream impacts, tends to be more significant in the Short Creek and Wheeling Creek basins.

Commensurate diversity improvements and increasing carnivore abundance further validated this positive trend. In 1983, smallmouth bass were only present in half of the samples and only represented by one or two individuals when present. Altogether, 14 smallmouth bass were collected in 1983. In 2010, smallmouth bass were only absent at the most upstream site. Otherwise, 207 were present among ten samples. In total, 48 rock bass were among 16 of 18 samples collected in 1983. All 2010 samples included rock bass (76 total, 11 samples). No sauger were found in 1983, but 14 were present at three 2010 sites. Similarly, two walleye and a saugeye were noted in 2010, but not previously.

Considering that the 2010 biological fish scores ranged from good to exceptional, it's apparent that Cross Creek has tremendous assimilative capacity. The confluence of Cross Creek with the Ohio River flows through a gauntlet of industrial and commercial land use. Upstream from the steel mill, slag piles, and railroad terminal, Cross Creek's north bank is flanked by one of Ohio's largest auto salvage yards with several similar recycling ventures nearby. Further upstream centered near RM 5.3, three miles of Cross Creek receive direct runoff from the former Satralloy property. The white patches seen in aerial photography are hillsides smothered in chromium laced hazardous waste (Figure 8). The waste piles began accumulating in the 1960s as a byproduct of chromium ore smelting. Beginning around the next bend upstream, one and a half miles of Cross Creek is frequently pulsed with silty runoff from a construction and demolition landfill (C&D Disposal Technologies). A railroad siding adjacent to Cross Creek's north bank is used to transfer waste to trucks (Figure 7). The trash is then dumped atop a former strip mine. The barren areas south and west, and Fernwood State Forest itself, were all former strip mine sites. Historic mining seeps are present throughout the watershed affecting the headwaters as well as tributaries such as McIntyre Creek and Dry Run.

Storm water runoff in the steep Cross Creek watershed is rapid and erosive. In 2010, distinctively tinged storm water associated with each of these industries was observed discoloring Cross Creek. Opaque white plumes were noted from the Satralloy location. Deeply dark water came from hillside salvage lots. Orange hues were telltales of coal spoils. Gray tones emanated along the steel mill and rail road reach. But most pervasive was the light brown characteristic of the construction and demolition landfill. The continuous stain from this operation lingered long after storm runoff from other facilities ceased. Cross Creek substrates were silt covered in a three mile reach next to and downstream from the landfill. Turbidity in this area prevented fish sampling efforts when adjacent reaches were clear.

Figure 11 illustrates the co-occurrence of IBI scores and the component lithophil metric values at Cross Creek sites sampled in 2010 (blue), 2006 (purple), and 1983 (red) The dashed lines show IBI scores meet the WWH criterion (IBI=44) or were within an acceptable range of achievement (IBI≥40, gray shaded region). Solid lines above or within the lower gray shaded region portray the difference between percentages of lithophils earning a 5 or 3 toward the cumulative IBI score. Lithophilic fish need clean, well swept substrates to broadcast eggs, for subsequent hatching and fry survivability, and because less silty conditions improve foraging prospects. Variable lithophil abundance reflects changing substrate quality. In all surveys, lithophils declined downstream from the construction and demolition landfill. The downstream persistence of fewer lithophils in 2010 could be due to cumulative aggradation. Three consultant sampled sites bracketed the Satralloy facility in 2006. The provided data mimics the longer linear trends of the Ohio EPA surveys but registered higher IBI scores and lithophil percentages. This data supports the supposition that Cross Creek merits EWH designation. It also draws attention to the fact that only a few IBI points separate WWH and EWH performance.

The state endangered eastern hellbender salamander is endemic to this reach of Cross Creek. Hellbenders reside under large rock slab habitats that are free from siltation. Excessive silt deposits can fill in the spaces under the rock slabs and limit critical habitat for the hellbenders. Additionally, excessive siltation and turbidity can limit feeding and reproduction. Efforts should be made to reduce siltation sources particularly from the CD&D Technologies landfill which is also negatively affecting the fish and macroinvertebrate communities.

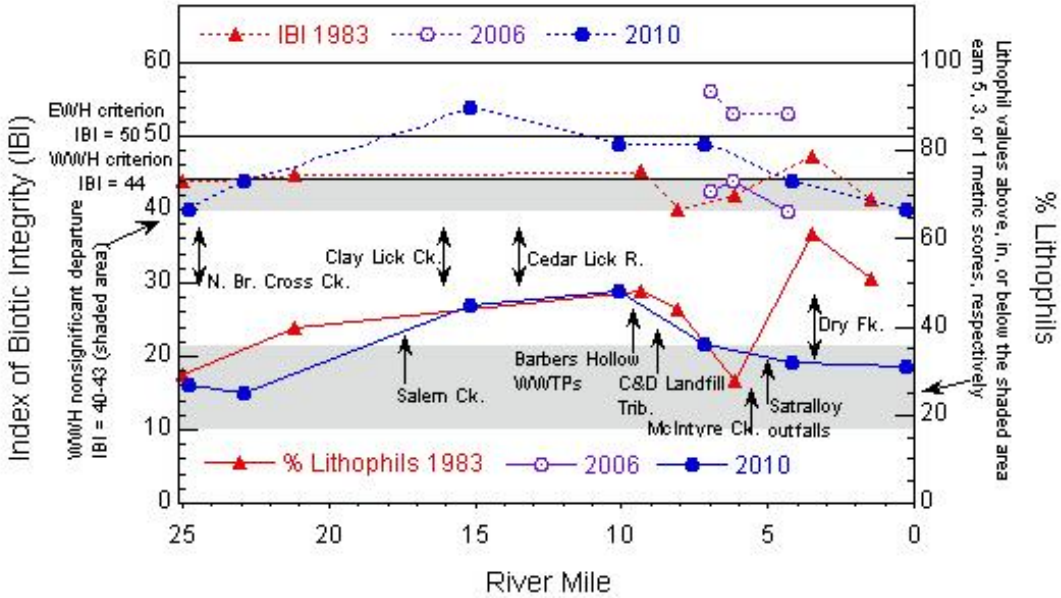

Figure 11. Comparison of IBI scores (left y axis) with the percentage of lithophilic fish (right y axis) in Cross Creek, 1983-2010. Declines downstream from the C&D Landfill implicate it as a source of excessive sediment pollution.

Macroinvertebrate Community

Macroinvertebrates were sampled at 30 locations in the Cross Creek, Island Creek, Wills Creek and Croxton Run watersheds (Figure 2). Qualitative sampling was conducted at all sampling sites while quantitative, Hester/Dendy artificial substrate samplers were retrieved from 8 sites. Artificial substrate sampling was largely restricted to drainages greater than 20 sq mi and regional reference sites. A summary of the macroinvertebrate data are presented in Table 15 while raw macroinvertebrate data are presented in Appendix Table 10 and ICI metric scores are in Appendix Table 11. Sampling locations were evaluated using the WWH or EWH biocriterion based on the current or recommended aquatic life use designation along with CWH narrative benchmarks where applicable.

All 7 (100%) of the mainstem Cross Creek sites met the WWH biocriterion with scores ranging from marginally good to very good (Table 15). However, a gradual upstream to downstream decline in ICI scores and macroinvertebrate quality was noted, beginning primarily downstream from Barbers Hollow (RM 9.6) and the C&D Disposal Technologies landfill (RM 8.38) at station RM 6.8. The increased siltation and murky, discolored water observed at RM 6.8 points to inputs from the landfill tributary more than Barbers Hollow. Declines in quality continued at station RMs 4.6 and 0.8, located successively downstream from McIntyre Creek (RM 5.55), Satralloy (RMs 4.7-4.9), mine runoff via Dry Fork, runoff from waste slag piles in Cold Springs and a large auto salvage yard adjacent to the most downstream site. Unregulated runoff from Satralloy was also observed upstream from McIntyre Creek near RM 6.3. Sensitive taxa include *pollution intolerant* and *moderately pollution intolerant* macroinvertebrates based on analysis of the Ohio EPA historical sampling database (Ohio EPA file data).The declining trend in lower Cross Creek was also reflected, and even more pronounced, in qualitative EPT richness and sensitive taxa richness (Table 15).

Based on qualitative narrative evaluations and ICI scores, 9 of the 16 (56%) Cross Creek tributary sites were in the marginally good to exceptional range, thereby meeting or exceeding minimum WWH performance levels. The remaining lower quality sites that fell in the fair ranges were from small, largely mined, headwater drainages (< 20 sq. mi.) and accounted for 44% (n=7) of impaired sites. In contrast, all larger drainages with associated ICI scores met WWH expectations, but most mainstem collections reflected continued or residual mine drainage influences. All 7 sites (100%) in the Wills Creek, Island Creek and Croxton Run watersheds were meeting or exceeding the WWH expectations ranging from good to exceptional.

The watersheds just south of the Cross Creek survey area were also sampled in 2010. These watersheds included Wheeling Creek, Short Creek, Rush Run, Glenns Run, Deep Run and Salt Run. Collectively these watersheds along with Cross Creek, Island Run, Croxton Run and Wills Creek are called the Central Ohio River Tributaries (CORT) in the Ohio WQS (OAC 3745-1-13). Compared with Cross Creek and absent stream size, lower performing sites were not evenly distributed over the study area. Rather, macroinvertebrate performance tended to transition from higher to lower quality in a north to south direction, from one basin to the next. As evidence, the percentage of fully meeting sites shifted from 100% (Island Run, Croxton Run and Will Creek watersheds), to 70% (Cross Creek watershed), to 67% (Short Creek watershed), to 56% (Rush Run, Glenns Run, Salt Run and Deep Run) to a low of 44% in the southernmost, Wheeling Creek watershed.

The trend of shifting macroinvertebrate quality across all the basins corresponded with shifts in land use, abandoned coal mines and chemical water quality. Historic and active coal mining

increased along with elevated concentrations of mine drainage parameters in roughly the same, north to south direction across the CORT study area. The trend is illustrated in Figure 12, which displays the strong negative correlations between intolerant mayfly taxa richness (a surrogate for higher macroinvertebrate quality) and elevated total dissolved solids (TDS) levels from each sample site. While mayflies are considered sensitive to TDS as a group, several common, facultative varieties were routinely encountered at many mine-influenced CORT sites. However, intolerant mayflies were typically absent or rare in mine impacted streams and appeared particularly sensitive to mine drainage.

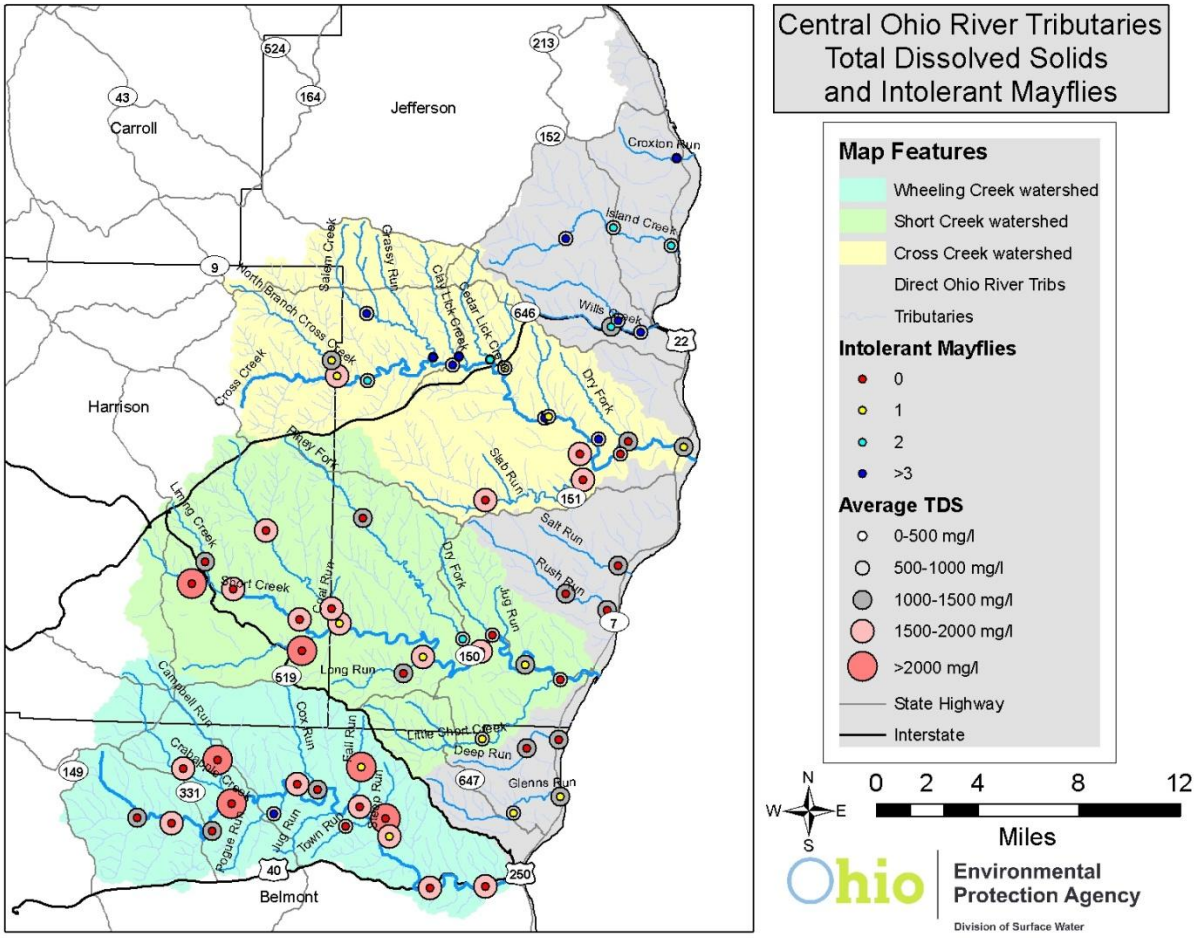

Figure 12. Number of sensitive mayfly taxa compared to the presence of TDS in the CORT study area, 2010.

In the Cross Creek basin, streams impacted by mining included the North Branch Cross Creek, Leas Branch, Dry Fork, lower McIntyre Creek and its tributaries, Little McIntyre Creek, Slab Run and Longs Run. Taken as a whole, the macroinvertebrates showed a consistent mine impairment "fingerprint" at mine influenced streams, both in the Cross Creek basin and throughout the CORT study area.

Besides mining, impairment at some Cross Creek basin sites may be related to other or additional causes. Little McIntyre Creek was extensively mined and reclaimed but the basin is largely impounded by Friendship Lake; collections at the mouth appeared more influenced by low habitat quality and surrounding wetlands. Barbers Hollow was un-mined but its lower quality was attributed to organic enrichment from the Jefferson M WWTP and Wintersville A WWTP.

Macroinvertebrate Trends

Cross Creek Mainstem

In 1983, selected Cross Creek mainstem sites were sampled in the headwaters between RMs 25 and 21 and at multiple sites in the lower 10 river miles. Because 1983 sampling was limited to qualitative collections, comparisons to 2010 qualitative data were used for trend assessment. With few exceptions, Cross Creek macroinvertebrate quality has remained relatively consistent over the past 27 years (Figure 13). Both surveys determined that Cross Creek met minimum WWH standards based on qualitative results in 1983 and ICI scoring in 2010. However, certain aspects of benthic communities in both studies showed areas of improvement and decline that were generally consistent over time. At similar sampling stations, lower quality headwater communities gradually improved with increased distance downstream, then showed gradual decline at consecutive sites over the lower nine miles of the mainstem.

To varying degrees, this declining trend was evident in the numbers of EPT taxa, sensitive taxa, and, more specifically, the number of sensitive mayfly taxa collected from the natural substrates (Figure 13). As a group, the sensitive mayflies would be among the most intolerant to elevated TDS and mining impacts. Both surveys showed the highest numbers of these taxa beginning at RM 9.7 (upstream Barbers Hollow) and lowest richness in the lower five miles of the creek, downstream from McIntyre Creek and Satralloy. While not all sample locations lined up precisely, 2010 data also documented mainstem improvements, both upstream at RM 9.7 and downstream between Barbers Hollow and McIntyre Creek. One confounding factor is that the 1983 site at RM 6.1 was potentially downstream from some Satralloy drainage. Higher quality 2010 collections from RM 6.8 were upstream from all Satralloy influences.

Cross Creek Tributaries

North Branch Cross Creek sampling ranged from good (1983) to fair (2010) over the same period. A comparison of the results indicated many components of the 1983 collections were lower than in 2010 (e.g., total taxa, sensitive taxa) so differences between surveys may be more related to the narrative assigned, not significant changes in stream quality. Barbers Hollow at the mouth (RM 0.1) has remained “Fair” downstream from the Jefferson County M WWTP in both 1983 and 2010. A substantial drop in tolerant taxa (from 13 to 5) and an increase in sensitive taxa were indications of improvement below the plant. However, the continued presence of large numbers of enrichment tolerant sludge worms (Class Oligochaeta) suggested organic enrichment or solids problems associated with the WWTP.

Sampling at the mouth of Salem Creek has revealed consistent quality and exceptional (1983) to very good (2010) conditions. Cedar Lick Creek sampling near the mouth has maintained very good to exceptional quality on three occasions between 1983 and 2010. In addition to EWH potential, sampling since 1996 has also indicated CWH potential.

Dry Fork (Cross Creek basin) sites bracketed an unnamed mine drainage tributary (RM 0.50) that historically suffered severe impacts from mine drainage. Dry Fork collections in 1983 dropped from “Low Fair” to “Poor” downstream from the tributary. In contrast, 2010 samples shifted to “Good” and “Fair” at sites bracketing the tributary, yielding much higher numbers of total and sensitive taxa along with healthier population densities. While the lower reach of Dry Fork remains impaired, conditions were dramatically improved over the nearly lifeless stream (7 total taxa) found in 1983.

Resampling of two 1983 McIntyre Creek sites in 2010 indicated continued marginal achievement of WWH standards, despite significant historic mining activity and elevated levels of TDS. 2010 collections reflected minimal change in the macroinvertebrates over time.

Ohio River Basin Tributaries: Wills Creek basin, Island Creek

Wills Creek basin sampling in 1983 indicated at least marginally good water quality and CWH potential. Duplicate 2010 sampling in Wills Creek and the North Fork Wills Creek showed consistent improvement and strong indications of cold water conditions. Total, sensitive, and EPT taxa richness approximately doubled at each site, pointing to gradual improvements in the watershed over time. Like the Wills Creek basin, Island Creek sampling between 1983 and 2010 also indicated steady or improving quality and CWH potential.

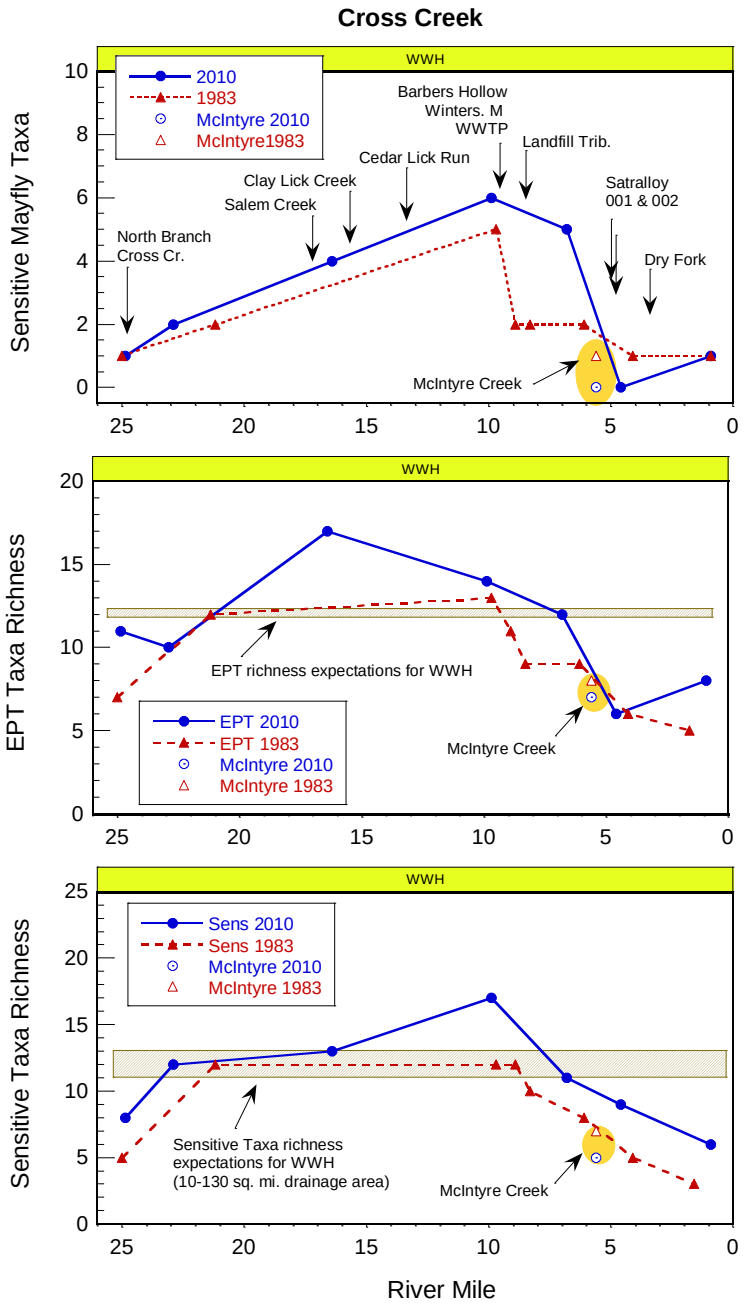

Figure 13. Trends in sensitive taxa, EPT taxa, and sensitive mayfly taxa richness from macroinvertebrate collections in the Cross Creek mainstem and lower McIntyre Creek, 1983-2010.

Table 15. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in Cross Creek basin and direct Ohio River tributaries (Island Run, Croxton Run and Will Creek basins) July to October, 2010.

River	RM[a]	D.A.[b]	Qual[c] Taxa	Sens.[d] Taxa Ql./Total	EPT Taxa Ql./Total	Density[e] Ql. or Qt.	ICI	Predominant Populations on the Natural Substrates (Tolerance Categories = sensitive, facultative, tolerant)[d]
Cross Creek	24.87	11.8	50	8	11	Mod.	--	Baetid mayflies, net-spinning caddisflies (sens.–facultative)
Cross Creek	22.90	28.3	53	12 / 13	10 / 10	536	34[ns]	Baetid & square-gill mayflies, tanytarsini midges (facultative)
Cross Creek	16.40	53.5	58	13 / 17	17 / 18	912	44	Mayflies and caddisflies (sensitive-facultative)
Cross Creek	9.9	78.0	42	17 / 20	14 / 16	300	42	Baetid mayflies, caddisflies (sensitive-facultative)
Cross Creek	6.80	88.1	39	11 / 16	12 / 13	312	36	Baetid and flat-headed mayfllies (sensitive-facultative)
Cross Creek	4.6	117	35	6 / 11	6 / 8	1,031	40	Net-spinning caddisflies (facultative)
Cross Creek	0.90	127.0	41	6 / 9	8 / 11	358	32[ns]	Scuds, square-gill mayflies (facultative)
North Br. Cross Cr	0.10	11.3	55	7	7	Mod.	--	Net-spinning caddisflies (sensitive.-facultative), blackflies (fac.)
Salem Creek	4.57	5.9	62	17	17	High	--	Baetid mayflies, net-spinning caddisflies (sens.-facultative)
Salem Creek	0.10	15.3	42	15	16	Mod.	--	Baetid, brush legged, flat-headed mayflies (sens.-facultative)
Leas Branch	0.15	2.7	39	7	6	Mod.	--	Net-spinning caddisflies (facultative)
Grassy Run	0.68	4.2	64	12	17	Mod.	--	Baetid mayflies, tanytarsini midges (facultative), net-spinning caddisflies (sens.-facultative)
Clay Lick Creek	0.60	6.4	49	18	18	Mod.	--	Baetid mayflies (facultative), brush legged mayflies (sensitive)
Cedar Lick Creek	0.3	6.3	46	15 / 19	15 / 17	601	48	Stoneflies (sensitive), baetid mayflies (facultative), net-spinning caddisflies (sensitive-facultative)
Cedar Lick Run	0.10	3.5	28	15	13	Mod.	--	Stoneflies (sensitive), baetid mayflies (sensitive-facultative)
Barbers Hollow	0.10	3.2	30	5	8	High	--	Baetid mayflies (facultative), sludge worms (tolerant)
McIntyre Creek	7.59	13.6	45	7	12	Low	--	Net-spinning caddisflies (facultative)
McIntyre Creek	1.00	23.6	33	5 / 9	7 / 9	349	40	Net-spinning caddisflies (facultative)
Little McIntyre Cr.	0.10	3.2	28	3	6	Low	--	Fingernet caddisflies (sensitive)
Slab Run	0.15	1.2	28	7	6	High	--	Scuds (facultative)
Longs Run	0.10	3.0	25	6	6	Low	--	Net-spinning caddisflies (facultative), stoneflies (sens.)
Dry Fk (Cross trib.)	0.56	4.8	30	8	7	Low	--	Net-spinning caddisflies (sensitive-facultative), scuds (fac.)
Dry Fk (Cross trib.)	0.28	6.6	26	7	6	Low	--	Net-spinning caddisflies (sensitive-facultative), scuds (fac.)
Croxton Run	0.74	7.8	46	14	11	Mod.	--	Stoneflies, baetid mayflies, net-spinning caddisflies (sensitive)
Island Creek	6.28	7.3	56	21	19	High	--	Stoneflies, baetid mayflies (sensitive), scuds (facultative)
Island Creek	3.43	19.6	59	14	14	Mod.	--	Stoneflies (sensitive), blackflies (facultative)
Wills Creek	0.70	13.9	58	15	14	High	--	Baetid mayflies (fac.), net-spinning caddisflies (sens- fac.)
North Fork Wills Cr	0.50	5.6	42	14	15	Mod.	--	Stoneflies (sens.), net-spinning caddisflies, mayflies (sens- fac.)
Wills Creek	2.40	5.8	48	12	10	Mod.	--	Net-spinning caddisflies (sensitive-facultative), scuds (fac.)
Island Creek	0.30	23.7	46	10	14	High	--	Baetid mayflies (facultative)

Table 15 continued.

[a] RM = River Mile

[b] D.A. = Drainage Area in square miles

[c] Ql.: Qualitative sample collected from the natural substrates.

[d] Tolerance descriptors are derived from Ohio EPA macroinvertebrate taxa tolerance categories. "Sensitive" includes *Intolerant* and *Moderately Intolerant* taxa. "Tolerant" includes taxa listed as *Very Tolerant*, *Tolerant*, and *Moderately Tolerant*.

[e] Ql. = Qualitative sample. Qualitative sample relative density: Low, Mod. = Moderate, High;
Qt. = Quantitative sample collected on Hester-Dendy artificial substrates; Quantitative density is expressed in organisms per square foot.

General narrative ranges	
Excellent/Very Good	
Good/Marginally Good	
Fair	

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