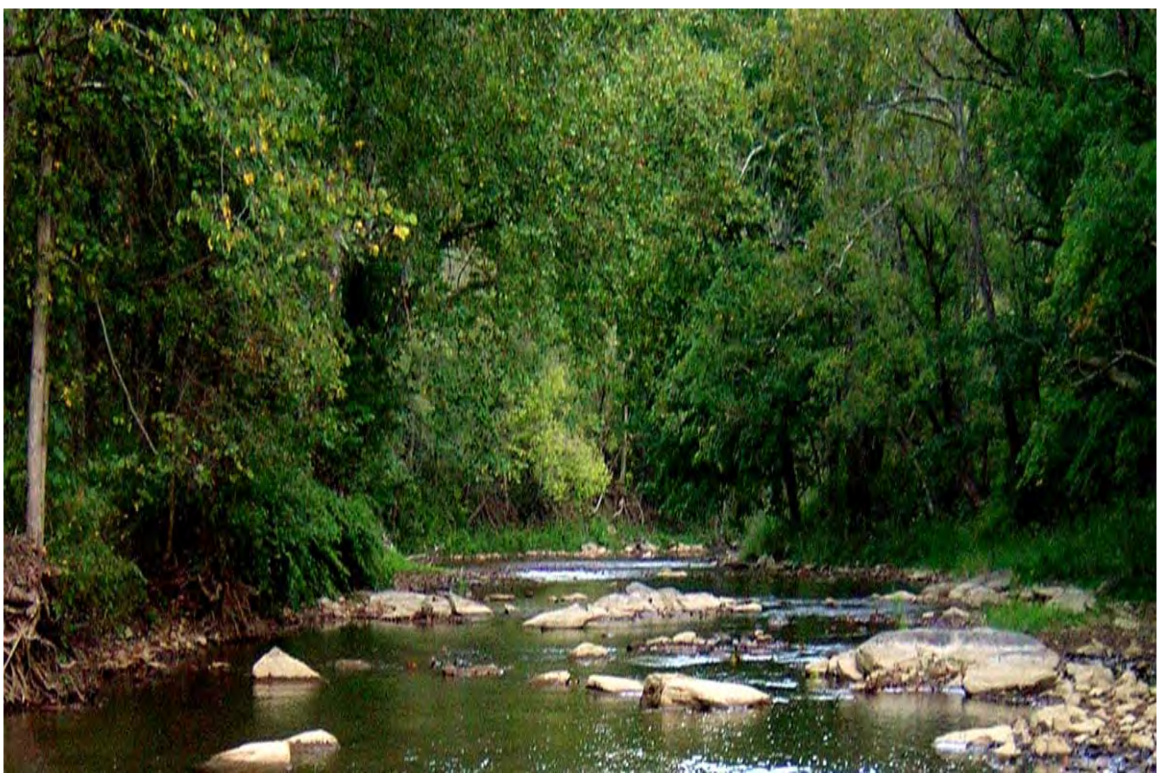
Biological and Water Quality Study of Short Creek and Selected Ohio River Tributaries 2010

Jefferson, Belmont and Harrison Counties, Ohio



OHIO EPA Technical Report EAS/2013-02-03

Division of Surface Water

March 3, 2014

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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 selected 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.

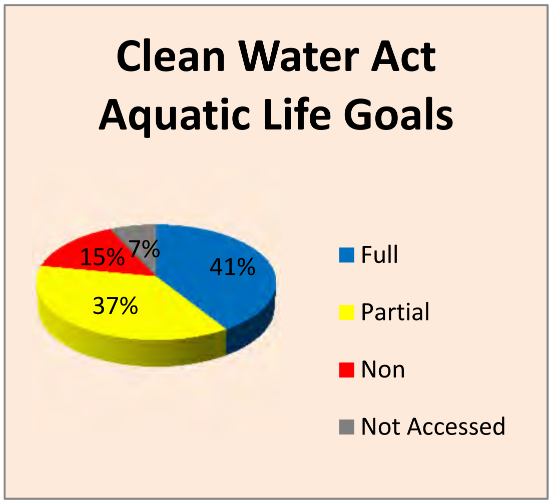


Figure1. Aquatic life use attainment in Short Creek watershed and direct Ohio River tributaries, 2010.

In 2010, 27 sites from 15 streams in the Short Creek, Salt Creek, Rush Run, Deep Run and Glenns Run watersheds were assessed for aquatic life (see Figure 5 and Table 1 for sampling locations). Located in extreme eastern Ohio in southern Jefferson, eastern Harrison and northern Belmont counties, these streams are direct Ohio River tributaries.

Of the 27 biological samples collected, 11 sites (41%) were fully meeting the designated or recommended aquatic life use, 10 (37%) were in partial attainment, and 4 (15%) were in non-attainment. In addition, attainment at two sites (7%) was listed as unknown due to insufficient data. All of the impairment was manifest at smaller, headwater sampling sites (<20 mi^2). However, even larger, attaining streams in heavily mined basins tended to support more marginal quality communities indicative of lingering mine drainage influences.

The overwhelming source of biological impairment in the study area was associated with active and abandoned mine runoff and abandoned mine drainage in the form of alkaline mine drainage and their related constituents, total dissolved solids (TDS), metals, and siltation (often composed of sand). Additionally, 3 of the 15 impaired sites were impaired due to agricultural activities, failing home sewage systems and the Cadiz wastewater treatment plant.

Water Quality Standard (WQS) exceedances for TDS were documented at 63% of all Short Creek and Ohio River tributary chemical sites and 50% of the impaired sites. In addition to TDS, most mine drainages had correspondingly elevated levels of sulfates and conductivity. Those sites that attained biological standards, despite these elevated parameters, often demonstrated marginal biological performance.

Coal mining is widespread throughout the Short Creek and Ohio River tributary watersheds with both surface and underground mining. An important factor in the coal mines is the location, or height, of the mined coal seams in relation to the adjacent receiving streams. The elevation of exploited coal gradually shifts from “below grade” to “above grade” in a west to east direction across the watersheds. Land disturbance at “above grade” mines is situated upgrade from the receiving streams, allowing unrestricted runoff to flow directly to the affected waters. Below grade mines are positioned below the stream channels so runoff cannot simply flow off-site, by gravity, to adjacent water courses.

On the positive side, most mine influenced drainages benefitted from a mixed limestone geo-type and high stream buffering capacity which spared the affected sites from *extremely* severe acidic mine water generation and its impacts (*e.g.,* extremely low pH levels or highly toxic heavy metals concentrations). Physical habitat quality was also adequate throughout most of the study area to support WWH communities; Qualitative Habitat Evaluation Index (QHEI) scores averaged 65.5 at mine impaired sites. The combination of optimal buffering capacity, widespread reclamation of both historic and active mines and gob piles (uncovered coal waste piles), natural attenuation of the damaged landscape, strong base flow, and good habitat quality contributed to less severe biological impacts. As a testament to the improving conditions, two sensitive and previously unrecorded fish species, bluebreast darter and longnose dace, were found in the Short Creek watershed and Glenns Run which is a direct tributary to the Ohio River. These fish are highly sensitive to siltation, and their presence is a strong indicator of reduced silt runoff, reflecting a gradual return to gravelly substrates and a healing of the watersheds.

As a result of the 2010 survey findings, and in all streams evaluated, the minimum aquatic life use designation recommendation was Warmwater Habitat (WWH). All other Modified Warmwater Habitat (MWH) and Limited Warmwater Habitat (LWH) streams were upgraded to WWH. Affected streams included Short Creek, Middle Fork Short Creek, Piney Fork, Little Short Creek, and Coal Run (all WWH). This did not mean the upgraded streams were unaffected, or even unimpaired, by mining. Simply, physical habitat quality, background watershed geology, and recovery trends in both the landscape and water courses were considered positive enough to justify the upgraded uses.

Eleven locations in the Short 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 2 of 11 locations attained the applicable geometric mean criterion, and thus were in full attainment of the designated recreation use. Nine of the eleven sites were impacted by sanitary waste from failing home sewage treatment systems or poor agricultural activities such as cattle with free access to the creek.

On-going sedimentation issues from active surface mining in the Salt Run watershed were observed by field staff during the 2010 survey (Figure 2). Instream habitat was covered by a gray cementitious silt downstream from the active mining. The substrates were extensively covered and compacted resulting in a QHEI score of 40.5. The heavy silt runoff from the active mine and haul road impacted the macroinvertebrates as well, which scored a “fair” narrative with tolerant species predominating the collection.

Figure 2. Salt Run downstream from mine and along haul road, 2010.

In general, mine drainage on the east and west side of the Flushing Escarpment are alkaline and not acidic mine drainage as is seen in the mid-section of Ohio’s mine fields. But in the North Fork Short Creek, an old coal cleaning facility’s spoil pile was reclaimed to reduce erosion (see Point Source Impacts below). The reclamation covered the spoil with a soil cover but rain water infiltrates the covered spoil and has a discharge with a pH of 2.38 while the upstream pH of North Fork Short Creek is 7.77. The mine spoil is composed of mostly waste mining material without the alkaline producing rock that usually produces a buffer. The North Fork Short Creek does not recover its true alkaline condition until the lower section where the pH is in the 8.0 to 8.4 range. The reclaimed facility does have mine drainage treatment currently for past mine operations, but the newly developed seepage is not directed to the treatment facility. This mine drainage can be seen a mile downstream at Unionvale (Figure 3). The mine drain and metal flocculants had an impact on the macroinvertebrates which scored a "fair" narrative with a third of the taxa being tolerant species.

Figure 3. Iron laden mine drainage in North Fork Short Creek at RM 6.21, Unionvale, 2010.

Acidic mine drainage is not required for the development of the ubiquitous orange stream coloration as seen in North Fork Short Creek. Additionally, not all mine drainage is constantly discharging throughout the year. In Glenns Run, a reclaimed abandoned mine site periodically discharges alkaline mine drainage with the orange iron color. Similar to the North Fork Short Creek, the mine drainage has affected the macroinvertebrate community which scored a "fair" narrative. In 2010 ODNR-MRM sampled fish at RM 2.5 to determine if the mine seeps discharging to the stream had an impact on the stream (ODNR 2010). Only four species of fish were collected at this location while 17 species including two sensitive species, longnose dace and bluebreast darter, were collected in the lower section of the stream (RM 0.1). The additional species present in the lower reach (RM 0.1) likely move into the Ohio River from Glenns Run to avoid the periodic iron laden alkaline mine drainage slugs from RM 2.1 (Figure 4).

Figure 4. Reclaimed abandon mine drainage swale into Glenns Run, 2010.

Ohio EPA has conducted limited historical sampling in the Short Creek study area with the only two biological stations sampled in Short Creek in 1993 at RM 9.0 and RM 18.0. Over that period of 17 years, the upper most site improved from an IBI of 32 to 46 and the site near RM 9.0 improved from an IBI of 38 to an IBI of 49. The 2010 results are evidence of an improving trend.

Based on qualitative narrative evaluations and ICI scores, 18 (64%) of 28 Short Creek and Ohio River tributary macroinvertebrate samples were in the marginally good to exceptional range, thereby meeting or exceeding minimum WWH performance levels. Highest quality sites were generally found in the larger drainage area streams with good flow regimes. As a rule, remaining lower quality sites that fell in the fair to very poor ranges were from small, largely mined, headwater drainages (< 20 mi^2). Mine drainage impacts were most often reflected by low taxa richness and low numbers of pollution sensitive and EPT (*i.e.,* Ephemeroptera, Plecoptera and Trichoptera) taxa. Mayflies (Ephemeroptera) appeared particularly sensitive to mine drainage and TDS (Figure 16) and, with the exceptions of a few, relatively tolerant varieties, were largely absent from impacted sites. In contrast to the headwaters, macroinvertebrates from all mainstem sites met WWH expectations. Still, the mainstem collections reflected continued or residual mine drainage influences in Short Creek.

Two of the seven sanitary waste water treatment plants (WWTPs) account for most of the effluent violations and impact on the biology in the study area. The villages of Adena and Cadiz have old WWTPs that are currently under Director's Final Findings and Orders to correct plant and operation deficiencies. Four individual and seventeen general National Pollutant Discharge Elimination System (NPDES) permitted facilities operate in the study area.

Table 1. Short Creek and direct Ohio River tributaries sampling locations, 2010.

Site Number*	Stream Name /Location	River Mile	Drainage Area	Latitude	Longitude
Short Creek Basin					
1	Short Cr. at CR 10 (Mill St) dst. North Fork	19.37	64.00	40.219200	-80.872800
2	Short Cr. at CR 7 ust. Long Run	12.68	76.20	40.199174	-80.810559
3	Short Cr. dst. Dillonvale WWTP ust. Piney Fk.	8.84	87.00	40.201300	-80.767300
4	Short Cr. at SR 150 nr. USGS Gage	4.96	123.00	40.193300	-80.734400
5	South Fk. Short Cr. at TR 83 (Greaves Rd)	1.13	14.01	40.203612	-80.901059
6	Middle Fork Short Cr. at Fox's Bottom Rd; 2nd crossing	5.35	15.80	40.239400	-80.955800
7	Middle Fork Short Cr. at CR 41	0.23	24.00	40.213038	-80.891039
8	Liming Cr. at TR 76 (Jackson Rd)	0.15	4.71	40.245521	-80.968926
9	Sally Buffalo Cr. just ust. Cadiz WWTP	0.17	9.92	40.242798	-80.971755
10**	Cadiz WWTP	0.10	9.92	40.243100	-80.970000
11	North Fk. Short Cr. at CR 12 (Unionvale Rd)	6.21	11.00	40.272759	-80.926421
12	North Fk. Short Cr. at Nagy Lane from CR 10	0.09	18.01	40.220743	-80.872937
13	Long Run at CR 7 (Dillonvale-Long Run Rd)	0.26	6.50	40.197326	-80.814539
14	Piney Fork at TR 192 ust L. Piney Fork	10.51	7.64	40.279113	-80.853833
15	Piney Fork at SR 150	0.35	22.40	40.205000	-80.766100
16	Dry Fork at SR 150	0.15	8.50	40.210953	-80.758329
17	Little Short Cr. at TR 472 ust. Parkers Run	4.99	11.00	40.151409	-80.767506
18	Little Short Cr. at TR 113	0.08	17.60	40.184504	-80.708465
19	Coal Run at mouth (mine road off SR 647)	0.15	2.00	40.150200	-80.795360
Direct Ohio River Tributaries					
20	Salt Run adj TR 157 (church bridge crossing)	0.60	4.02	40.249041	-80.663961
21	Rush Run adj. CR 17 (Rush Run Road)	2.71	8.45	40.23301	-80.70191
22	Rush Run adj CR 17 (Rush Run Road)	0.65	12.01	40.223611	-80.672462
23	Deep Run adj Deep Run Rd ust. abandoned mine drainage	2.40	2.48	40.145820	-80.734870
24	Deep Run adj Deep Run Rd dst. abandoned mine drainage	1.55	3.1	40.152048	-80.731395
25	Deep Run at Deep Run Rd at RR Trestle	0.25	4.11	40.150130	-80.710820
26	Glenns Run at CR 4 ust. Patton Run	2.9	6.17	40.108560	-80.745610
27***	Glenns Run at CR 4 dst. Patton Run & acid seep	2.15	7.6	40.113597	-80.74445
28	Glenns Run at CR 4 (Glenns Run Rd)	0.1	10.70	40.117515	-80.710518

* 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).

** Only water chemistry was collected at this sampling location.

*** Based on macroinvertebrate sample only.

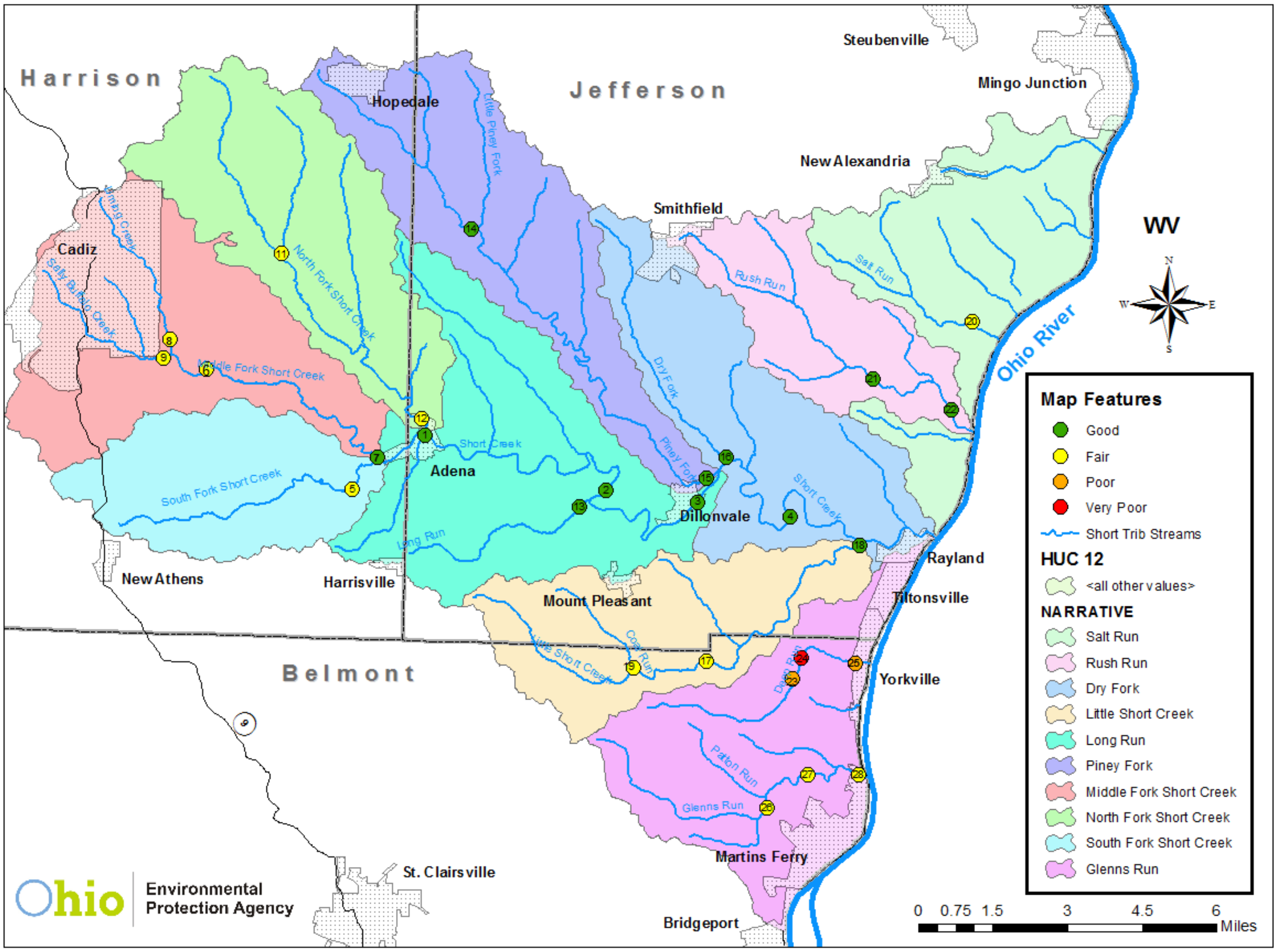


Figure 5. Map of Short Creek watershed and direct Ohio River tributaries sampling locations and associated narrative biological community performance, 2010. The narrative colors and site numbers on the map correspond with Table 1 biological sampling sites.

Table 2. Aquatic life use attainment status for stations sampled in the Short Creek watershed and direct Ohio River tributaries, 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 Short Creek and selected Ohio River tributaries 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 = not applicable.

Stream	River Mile[a]	HUC 12 5030100	Drainage Area (Mi^2)	Aquatic Life Use Designation[b]	Aquatic Life Attainment Status[c]	IBI	MIwb[d]	ICI[e]	Stream Habitat	Cause of Impairment	Source of Impairment
Short Creek Basin											
Short Creek	19.37	-602-05	64.0^{W}	WWH-R	FULL	46	9.2	42	75.0	*Note: TDS exceedances throughout Short Cr.*	
Short Creek	12.68	-602-05	76.2^{W}	WWH-R	FULL	50	9.1	32^{ns}	77.5		
Short Creek	8.84	-602-05	8.84^{W}	WWH-R	FULL	49	9.3	42	54.0		
Short Creek	4.96	-602-07	123.0^{W}	WWH-R	FULL	50	8.95	44	88.5		
S. Fk. Short Creek	1.13	-602-01	14.01^{H}	WWH	PARTIAL	44	NA	F*	80.0	TDS	Abandoned mine drainage
M. Fk. Short Creek	5.35	-602-02	15.8^{H}	WWH-R	PARTIAL	42^{ns}	NA	F*	69.5	TDS, Organic Enrich.	Abandoned mine drainage, Municipal WWTP
M. Fk. Short Creek	0.23	-602-02	24.0^{W}	WWH-R	FULL	42^{ns}	8.0^{ns}	34^{ns}	60.8		
Sally Buffalo Creek	0.17	-602-02	9.92^{H}	WWH-R	PARTIAL	40^{ns}	NA	F*	68.8	TDS	Abandoned mine drainage
Liming Creek	0.15	-602-02	4.71^{H}	WWH-R	NON	38*	NA	F*	75.0	TDS, Org. Enrich.	Abandoned mine drainage, Unrestricted Livestock
N. Fk Short Creek	6.21	-602-03	11.0^{H}	WWH	PARTIAL	44	NA	F*	76.0	TDS, Metals	Abandoned mine drainage
N. Fk. Short Creek	0.09	-602-03	18.01^{H}	WWH	PARTIAL	44	NA	F*	68.5	TDS	Abandoned mine drainage
Long Run	0.26	-602-05	6.5^{H}	WWH	FULL	42^{ns}	NA	MG^{ns}	61.5		
Piney Fork	10.51	-602-04	7.64^{H}	WWH-R	FULL	44	NA	MG^{ns}	73.0		
Piney Fork	0.35	-602-04	22.4^{W}	WWH-R	FULL	46	8.2^{ns}	48	71.3		
Dry Fork	0.15	-602-07	8.5^{H}	WWH	FULL	46	NA	MG^{ns}	67.5		
Little Short Creek	4.99	-602-06	11.0^{H}	WWH-R	PARTIAL	34*	NA	G	85.8	Metals	Abandoned mine drainage
Little Short Creek	0.08	-602-06	17.6^{H}	WWH-R	FULL	56	NA	MG^{ns}	78.0		
Coal Run	0.20	-602-06	2.0^{H}	WWH-R	PARTIAL	34*	NA	G	62.8	Metals	Abandoned mine drainage
Direct Ohio River Tributaries											
Salt Run	0.60	-612-02	4.02^{H}	WWH	NON	32*	NA	F*	40.5	TDS, Siltation	Surface Mining

Stream	River Mile[a]	HUC 12 5030100	Drainage Area (Mi^2)	Aquatic Life Use Designation[b]	Aquatic Life Attainment Status[c]	IBI	MIwb[d]	ICI[e]	Stream Habitat	Cause of Impairment	Source of Impairment
Rush Run	2.71	-612-01	8.45[H]	WWH	PARTIAL	30*	NA	G	64.5	TDS, Org. Enrichment	Abandoned mine drainage, Septic Tanks
Rush Run (2010 /11 macroinvertebrates)	0.65	-612-01	12.01[H]	WWH	FULL	52	NA	F*/MG[ns]	77.3		
Deep Run	2.40	-612-04	2.48[H]	WWH	NON	22*	NA	MG[ns]	50.8	TDS, Metals	Abandoned mine drainage
Deep Run	1.55	-612-04	3.1[H]	WWH	--	--	--	VP*	--		
Deep Run	0.25	-612-04	4.11[H]	WWH	NON	34*	NA	P*	47.0	TDS, Metals	Abandoned mine drainage
Glenns Run	2.90	-612-04	6.17[H]	WWH	PARTIAL	30*	NA	MG[ns]	66.5	Metals	Abandoned mine drainage
Glenns Run	2.50	-612-04	7.60[H]	WWH	N/A	---	---	F*	68.8	Comment: Macroinvertebrate community negatively influenced by mine drainage flocculants.	
Glenns Run	0.10	-612-04	10.7[H]	WWH	PARTIAL	52	NA	F*	58.3	TDS, Metals	Abandoned mine drainage

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

b - Recommended (R) new or change in aquatic life use designation.

c - Attainment is given for the proposed status when a change is recommended (R).

d - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

e - 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.

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.

W - Wading site.

H - Headwater site.

Biological Criteria Western Allegheny Plateau				
Index – Site Type	**EWH**	**WWH**	**MWH[1]**	**LRW**
IBI – Headwaters	50	44	24	18
IBI – Wading	50	44	24	18
MIwb – Wading	9.4	8.4	6.2	4.5
ICI	46	36	30	8

RECOMMENDATIONS

The streams in the Short Creek and Ohio River tributaries study area currently listed in the Ohio Water Quality Standards (WQS) are assigned one or more of the following aquatic life use designations: Limited Warmwater Habitat (LWH) and Modified Warmwater Habitat (MWH), which are all related to excessive mine drainage, and Warmwater Habitat (WWH). Because of the dearth of historical sampling data, most 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. In fact, only 2 of the 14 streams evaluated in 2010 (14%) had verified aquatic life use designations based on biological data. The two were Middle Fork Short Creek and Sally Buffalo Creek. 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.

Fifteen streams in the Short Creek and Ohio River tributary study area were evaluated for aquatic life and recreational use potential in 2010 (Table 3). As a result of the 2010 survey findings, the minimum aquatic life use designation recommended was WWH for all Short Creek and Ohio River tributary streams. All segments currently listed as MWH and LWH were recommended for upgrade to WWH. Those streams included Short Creek, Middle Fork Short Creek, Piney Fork, Little Short Creek, and Coal Run. Significant findings include the following.

- Mine influenced stream re-designations were based on numerous factors related to biological, chemical, and physical habitat quality, watershed geology, and recovery patterns in both the landscape and water courses. The upgraded mine affected use recommendations do not mean streams were unaffected, or even unimpaired by mining. Rather, physical habitat quality, background watershed geology, and recovery trends in both the landscape and water courses were often positive enough to justify an upgrade in stream potential. More detailed justifications include but were not limited to the following.

    - Full biological attainment of the recommended, upgraded use in all or portions of the mine affected streams [*e.g.,* Short Creek, Middle Fork Short Creek (RM 0.23), Little Short Creek (RM 0.08) and Piney Fork]. Full attainment was often documented despite obvious physical indications of mine drainage and WQS exceedances for mine drainage parameters.

    - If not in full attainment, documentation of consistent partial attainment (*i.e.,* fair to good or better biological performance) at numerous locations. These results show at least one organism group met WWH standards and impacts to the other organism group were not severe (*i.e.,* not poor or very poor). Examples include partial WWH attainment in Little Short Creek, Coal Run and Sally Buffalo Creek.

    - One indication of improving quality in mine influenced streams is the presence of six declining fish species (OAC 3745-1-05 Table 5-2): the bluebreast darter (also listed as a threatened species, Table 5-3), river chub, variegate darter, rosyface shiner, mimic shiner and southern redbelly dace. These fish were previously unrecorded species, along with the pollution sensitive longnose dace, found in Short Creek. Longnose dace were also collected in Rush Run and Glenns Run. Additionally, bluebreast darters were also collected in Glenns Run. The darters are very sensitive to siltation and their presence was a strong indicator of reduced silt runoff and gradual healing of the watersheds.

- o The presence of good or exceptional physical stream habitats (based on QHEI scores), adequate for support of WWH communities.

- o The presence of adequate stream buffering capacity associated with a mixed limestone geo-type. The enhanced buffering tends to temper potential impacts often associated with acid mine drainage.

- o The presence of extensive or ongoing mine and gob pile reclamation efforts by the Ohio Department of Natural Resources – Mineral Resource Management (ODNR-MRM) and mining companies over the past 30 years. Reclamation activity is widespread throughout the study area but this work has been particularly intensive in the Short Creek basin. Flood plain relief grading on gob areas adjacent to Piney Creek and underground mine entrance closures have reduced mine drainage runoff and discharges.

- o The presence of fully attaining WWH communities in similar sized streams within the other 2010 study areas (*e.g.,* Cross Creek and Island Creek) show the potential endpoint for the Short Creek watershed (Figure 16). Biological collections showed that typical, natural stream channels in the Short Creek study area are largely capable of supporting WWH communities. These higher quality streams were unimpaired but contained varying degrees of historic coal mining activity and displayed lingering traces of mine drainage.

o More detailed justifications for each mine affected MWH and LWH aquatic life use re-designations are as follows.

- o **Short Creek:** Short Creek is currently listed as LWH with an exemption for TDS due to mining history. Despite chronic TDS exceedances, biological communities met minimum WWH standards at all Ohio EPA monitoring stations. Supplemental ODNR fish sampling near significant abandoned mine drainage discharges points to localized "*hot spots"* but in general, biological performance throughout Short Creek was good and within WWH standards. Mainstem QHEIs averaged 77, clearly adequate to support WWH communities. Vast areas of historically mined lands in the basin have been reclaimed and ODNR- MRM has been particularly active in gob pile remediation over the last quarter century. New collection records for pollution and silt intolerant bluebreast and variegated darters in lower Short Creek suggests improving conditions and gradual healing of the disturbed landscape. For these reasons, the WWH designation is considered appropriate.

- o **Middle Fork Short Creek** is a confirmed (+), MWH–Mine Affected stream that drains the largely mined and reclaimed Short Creek headwaters around Cadiz. An upgrade to WWH is recommended based on full attainment of the Middle Fork near the mouth and the presence of adequate physical habitat quality (Avg. QHEI=65). The stream is physically and chemically similar to other reclaimed headwater streams in the Cadiz area (*e.g.,* Liming Creek, South Fork, Sally Buffalo Creek, and North Fork). Chronically elevated TDS concentrations contribute to marginal biological performance along with the poor condition and operation of the Cadiz WWTP. However, most mine reclamation measures were historically instituted to prevent soil loss and property damage, not to improve stream water quality. Improvements to the Cadiz WWTP are scheduled in the near future (See NPDES section below).

- **Sally Buffalo Creek** is a confirmed (+), MWH–Mine Affected stream that drains the largely mined and reclaimed Short Creek headwaters around Cadiz. An upgrade to WWH is recommended based on physical habitat quality (QHEI=68.8) adequate to support WWH. Biological performance was in the fair to marginally good range (partial WWH attainment) but in line with other mined streams in the Cadiz area. Sally Buffalo Creek is physically and chemically similar to other headwater streams in the Cadiz area (*e.g.,* Liming Creek, South Fork, Middle Fork, and North Fork). Chronically elevated TDS concentrations contribute to marginal biological performance.

- **Piney Fork:** Piney Fork is currently listed as LWH with an exemption for TDS due to its mining history. Biological communities in the marginally good to exceptional range fully achieved the recommended WWH use at each sample site. QHEIs averaged 72, also clearly adequate to support WWH communities. Despite the LWH exemption, no TDS exceedances were encountered during the 2010 survey, an indication of minimal mining influences due to past reclamation efforts.

- **Little Short Creek:** Little Short Creek is currently listed as LWH with an exemption for TDS due to its mining history. Physical habitat quality (mean QHEI=81.75) was adequate to support WWH and biological performance met WWH standards at one of two monitoring stations. In 2010 ODNR-MRM sampled fish at RM 3.5 to determine if an abandoned mine drainage discharge was impacting the stream (ODNR 2010). The results suggests a localized hot spot near a large abandoned mine drainage discharge with mostly tolerant fish being found along with a southern redbelly dace. Continued monitoring of this site may help in determining its reclamation potential. Slight impairment to fish communities in the upper headwaters appeared the result of occasional slugs of mine runoff and metals following rain events. However, the overall quality of Little Short Creek was generally good and compatible with WWH expectations. An upgrade to WWH is recommended.

- **Coal Run:** Coal Run is a small, largely reclaimed stream in the headwaters of Little Short Creek and currently listed as LWH-TDS exempt. Physical habitat quality (QHEI=62.8) was adequate to support WWH communities; biological performance was fair to good and in partial attainment of WWH. Despite the TDS exemption, TDS concentrations were not particularly elevated. Slight impairment to fish communities appeared to be the result of occasional slugs of mine runoff and metals following rain events. An upgrade to WWH is recommended.

- Eight additional survey streams were designated WWH in the 1978 standards but were unconfirmed by biocriteria. Based on 2010 survey results, all eight are recommended for WWH. More detailed use justifications are as follows.

    - **South Fork Short Creek** drains the largely mined and reclaimed Short Creek headwaters around Cadiz. Physical habitat quality (QHEI=80) was clearly adequate to support WWH communities while biological performance in the fair to marginally good range (partial attainment) was in line with other streams in the area. South Fork Short Creek is physically and chemically similar to other mine influenced headwater streams in the Cadiz area (e.g., Liming Creek, Sally Buffalo Creek, Middle

Fork, and North Fork). Chronically elevated TDS concentrations contributed to marginal biological performance. Based on 2010 sampling, the current WWH use should be retained.

- **North Fork Short Creek** is a reclaimed and actively mined tributary to Short Creek in the headwaters near Cadiz. Physical habitat quality was adequate to support WWH communities (mean QHEI=72.5) but biological communities were in partial attainment, due to mine drainage. The stream is physically and chemically similar to other headwater streams in the Cadiz area (*e.g.,* Liming Creek, South Fork, and Middle Fork). Chronically elevated TDS concentrations contribute to the marginal biological performance. However, most mine reclamation measures were historically instituted to prevent soil loss and property damage, not to improve stream water quality (see Point Source Impacts section Hopedale Mining, LLC). Based on 2010 sampling, the current WWH use should be retained.

- **Dry Fork** and **Long Run** are Short Creek tributaries with good physical habitat quality (QHEIs > 60) and in full attainment of WWH. Based on 2010 sampling, the current WWH use should be retained for both.

- **Glenns Run, Deep Run**, **Rush Run, and Salt Run** are small, direct Ohio River tributaries with natural stream channels and each reflected varying degrees of impact from mining. Average QHEI scores for the four watersheds (60) were adequate to support WWH although the two Deep Run sites were marginal (Avg. QHEI=49). Small stream size, high gradient, and cascading, boulder strewn channel in upper Deep Run contributed to the lower habitat score but this should not preclude WWH or prompt a downgraded use. Full attainment of WWH in Rush Run is evidence of WWH potential among these small drainages that line the Ohio River north of Bridgeport. Unlike some Ohio River tributaries in the East Liverpool and Wellsville areas, the lower reaches of these streams had not been cut off and culverted under the SR 7 highway that runs adjacent to the Ohio River. As such, undeterred fish passage and unrestricted re-colonization potential is the standard. The collection of bluebreast darters and longnose dace (species of concern) in Glenns Run and longnose dace in Rush Run were likely due to re-establishment of populations via the Ohio River.

- One stream (**Liming Creek**) was unlisted and undesignated in the WQS. It is recommended for WWH.

  - **Liming Creek** is a tributary of Middle Fork Short Creek. The physical habitat quality (QHEI=75) of Liming Creek was adequate to support WWH. Biological communities were in the fair range (non-attainment of WWH) but the creek is physically and chemically similar to other mine influenced headwater streams in the Cadiz area (e.g., Middle Fork, South Fork, North Fork and Sally Buffalo Creek). Chronically elevated TDS concentrations contribute to marginal biological performance. However, most mine reclamation measures were historically instituted to prevent soil loss and property damage, not improve stream water quality.

- All 15 streams in this study should retain the Primary Contact Recreation Class B use, along with the Agricultural Water Supply and Industrial Water Supply uses.

Table 3. *Waterbody use designation recommendations for the Short Creek watershed and direct Ohio River tributaries, 2010. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). In addition, steams **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	
Glenns run		*+							*+	*+		*+		
Nixon run		*							*	*		*		
Patton run		*							*	*		*		
Buckeye run		*							*	*		*		
Patton run		*							*	*		*		
Deep run		*+							*+	*+		*+		
Short creek		▲							*+	*+		*+		
Williamson run		*							*	*		*		
Little Short creek		▲							*+	*+		*+		
Parkers run		*							*	*		*		
Coal run		▲							*+	*+		*+		
Jug run		*							*	*		*		
Dry fork		*+							*+	*+		*+		
Piney fork		▲							*+	*+		*+		
Cabbage fork		*							*	*		*		
Henderson creek		*							*	*		*		
Thompson creek		*							*	*		*		
Little Piney fork		*							*	*		*		
Harrah run		*							*	*		*		
Long run		*+							*+	*+		*+		
Perrin run		*								*		*		
Goose run		*							*	*		*		
North fork		*+							*+	*+		*+		
Coal run		*							*	*		*		
Flag run		*							*	*		*		
Skelley creek		*							*	*		*		
Flag run		*							*	*		*		
Middle fork		▲							+	+		+		
Sally Buffalo creek (Middle fork RM 6.33)		▲							+	+		+		
Liming Creek		▲							+	+		+		
South fork		*+							*+	*+		*+		
Little Rush run		*							*	*		*		
Rush run		*+							*+	*+		*+		
Blues run		*							*	*		*		
Salt run		*+							*+	*+		*+		

INTRODUCTION

Twenty-six stream sampling locations were evaluated in the Short Creek and several Ohio River tributaries watersheds located in Jefferson, Belmont and Harrison Counties in 2010. The sampling survey included 18 stations along the lengths of Short Creek and its major tributaries and nine stations on direct Ohio River tributaries between Martins Ferry and Mingo Junction, Ohio (Figure 6). A full list of the sampling sites is found in Table 1.

Figure 6. Short Creek watershed and direct Ohio River tributaries, 2010.

A total of 13 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the Short Creek watershed or direct Ohio River tributaries study area.

During 2010, Ohio EPA conducted a water resource assessment of 15 streams in the Short Creek watershed and direct Ohio River tributaries study area using standard Ohio EPA protocols as described in Appendix Table A1. Included in this study were assessments of the biological, surface water and recreation (bacterial) condition. A total of 27 biological, 25 water chemistry, 3 fish tissue, and 11 bacterial stations were sampled in the study area. All of the biological, chemical and bacteria results can be downloaded from the Ohio EPA GIS interactive maps at the following link: http://www.epa.state.oh.us/dsw/gis/index.aspx.

Specific objectives of the evaluation were to:

- ascertain the present biological conditions in the Short 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 use potential,
- compare present results with historical conditions, and
- determine the attainment status of designated beneficial uses and recommend changes if appropriate.

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 [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).

STUDY AREA DESCRIPTION

The Short Creek and the Ohio River tributaries watersheds are in the Western Allegheny Plateau (WAP) ecoregion. The study area is located on the east side of the Flushing Escarpment. The Flushing Escarpment is a drainage divide in eastern Ohio (ODNR 2003). This divide is a long ridge that stretches in a north-northeast direction where all eastward streams flow to the Ohio River and westward streams flow into the Muskingum River watershed. The eastern flowing streams have a high gradient and are unglaciated while westward streams have a low gradient and have been influenced by past glaciations. The deep cut valleys have no glacial outwash substrates. Short Creek is 29.4 miles long and has a drainage area of 148 mi^2.

The other Ohio River tributaries (Salt, Rush, Deep and Glenns Run) have a combined drainage area of 36 mi^2. The geologic setting is the Carboniferous Pennsylvanian Period rock with shale, sandstone and limestone (lower portion of the unit). Intermixed in these rock units are different layers of bituminous coal. Over 30% of the Short Creek watershed has been surface mined and 33% has been underground mined. The study area is 56.8% forest, 26.7% agriculture, 11.6% developed areas and 5% open water, wetlands and grasslands (Figure 7). Agricultural activities take place in the few areas where there are wide stream valleys and, in many cases, on old strip mine land on ridge tops. The heaviest development is along the Ohio River in the cities of Martins Ferry, Yorkville and Tiltonsville. The villages of Adena, Cadiz and Dillionvale also are well developed, but on a much smaller scale. Adena and Dillionvale are located in the Short Creek valley while Cadiz is located on a ridge top.

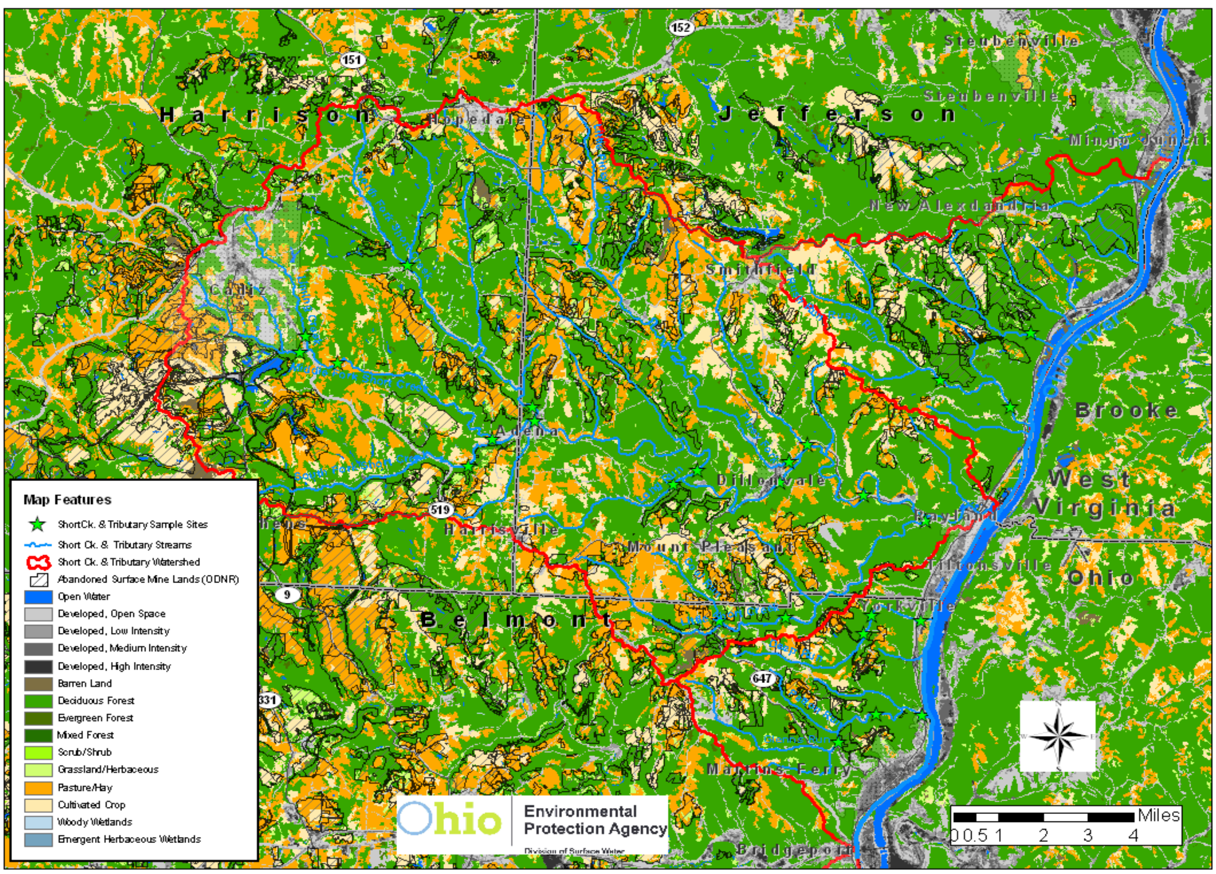


Figure 7. Land use in the Short Creek watershed and direct Ohio River tributaries, 2010.

RESULTS

Water Chemistry

Surface water chemistry samples were collected from 26 sampling locations (Figure 5, Table 1) in the Short Creek and selected Ohio River tributaries study area from March 2010 through April 2011. Stations were established in free-flowing sections of the stream 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). Interactive maps of surface water chemical data, downloadable to excel files, are available at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx .

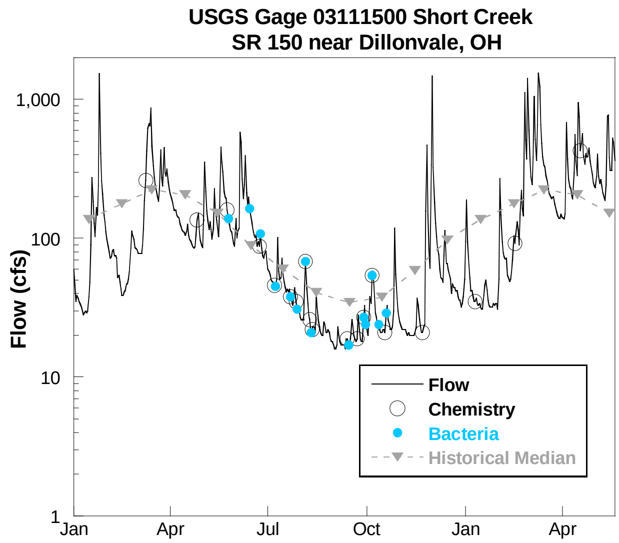


Figure 8. Flow conditions and days with grab chemical and bacterial samples in the Short Creek and selected Ohio River tributaries study area, 2010-2011.

USGS gage data from Short Creek near Dillonvale was used to show flow trends in the study area during the 2010-2011 survey (Figure 8). 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 were typically collected during lower flows.

Surface water samples were analyzed for metals, nutrients, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), percent D.O. saturation, and suspended and dissolved solids (Appendix Table A2). Parameters which were in exceedance of the Ohio WQS criteria are reported in Table 4. Bacteriological samples were collected from 11 locations, and the results are reported in the Recreation Use section. Datasonde® water quality recorders were placed at 12 locations twice to monitor hourly levels of dissolved oxygen, pH, temperature, and conductivity over a 2-day period (Appendix Table A3).

Metals were measured for seventeen different parameters (Appendix Table A2). Iron exceedances were found in the upper portion of Glenns Run at RM 1.9 downstream from an abandoned mine drainage discharge (Table 4). Average iron and manganese values above reference conditions were also found at this location on Glenns Run, at RM 6.21 North Fork Short Creek (see NPDES section) and at RM 0.25 on Deep Run (Table 5). These three sites are associated with previous coal mining activities that are ubiquitous throughout the study area. Eighteen other locations were above reference values for manganese alone. No other metals were above reference values.

The Water Quality Standards criterion for total dissolved solids (TDS) was exceeded at 17 sampling sites 76 times (Table 4), ranging between the WQS of 1500 mg/l and 3070 mg/l. The prevalence of TDS in the study area is a direct result of present and past mining. The high TDS is caused by rain water seeping through the large disturbed surface mine areas or the rain water that percolates through the fractured bedrock into the underground mine and is discharged to the stream. As the rain water moves through these features, it dissolves minerals and salts which comprise the TDS constituents. The high TDS level in the water column creates a salty (brackish) environment which has impaired the macroinvertebrate community (see Macroinvertebrate Community section below). Coal mining appears to be the main contributor to the high TDS levels. Figure 16 shows TDS increasing in a north to south direction and this corresponds with the amount of coal mining which also increases in the same north to south direction. The dissolved solids also impact the habitat by forming a cementitious crust on substrates and cementing the substrates together.

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 a select number of Short Creek and Ohio River tributary sites are detailed in Table 6. Many sampling locations had values at or near the detection limits of the testing method. Nutrient levels were low at all but three monitoring locations in the Short Creek and direct Ohio River tributary study area. Short Creek at RM 8.84 had elevated nitrate+nitrite-N directly below the Dillionvale WWTP. Additionally, sites below the Village of Cadiz's main sewer line and WWTP had elevated nutrients. Liming Creek had ammonia and phosphorus above reference and threshold values. Liming Creek has one of Cadiz's main sewer lines running through and along the stream and this sewer has had numerous overflows (see NPDES section below). Middle Fork Short Creek at RM 5.35 is below both the Cadiz WWTP on Sally Buffalo Creek and Liming Creek. This site had elevated ammonia-N, nitrate+nitrite-N and total phosphorus; all attributed to the main sewer line overflows and the WWTP. No nutrients were detected above the reference or threshold on Sally Buffalo Creek above the Cadiz discharge point (Table 6). The Cadiz WWTP, Sally Buffalo Creek at RM 0.10, reported effluent results over the NPDES permit limit during the study period: 7 times for ammonia, 18 times for total suspended solids and 24 times for carbonaceous biochemical oxygen demand. The poor quality of the effluent from the Cadiz WWTP contributes to the marginally good fish narrative, and fair macroinvertebrate narrative at the Middle Fork Short Creek (RM 5.35) site at Fox's Bottom Road.

DataSonde® hourly monitoring results for dissolved oxygen, temperature, pH, and conductivity at twelve locations are listed in Appendix Table A3. The results from the sonde location at Middle Fork Short Creek RM 5.35 show a D.O. swing of 7 mg/l through each 24-hr period and during each 2-day sample period in October and September, 2010. This D.O. swing is attributed to excessive nutrients causing nuisance algae noticed during chemistry sampling, and the excessive pondweed (*Potamogeton*), noted during the Qualitative Habitat Evaluation Index assessment. Additionally, this site is affected by supersaturated D.O. conditions. When the percent saturation of dissolved oxygen reaches 115% to 125% its affects can be lethal to fish (Tchobanoglous and Schroeder,1987). Twice during the sampling period the D.O. percent saturation reached over 130% (Figure 9). The same water quality result occurred at the downstream sonde site below the Village of Adena's WWTP on Short Creek RM18.75. D.O. percent saturation reached 159.3% and was above 125% three times during the sampling period. D.O. ranged from 7.2 mg/l to 13.5 mg/l. This site was not evaluated for biological, habitat and chemical quality, but, as was seen below Cadiz WWTP, the same biological response could be expected. The DataSonde® results at Glenns Run (RM 0.1) for conductivity ranged from 3680 to 3930 mS/cm for 18-hr monitoring period. These were the highest DataSonde® conductivity readings within the study area and indicated a high TDS condition.

Temperature and pH measurements were indicative of good water quality at all sonde sites. Dissolved oxygen and conductivity measurements were well within acceptable environmental levels at the remaining sonde sites.

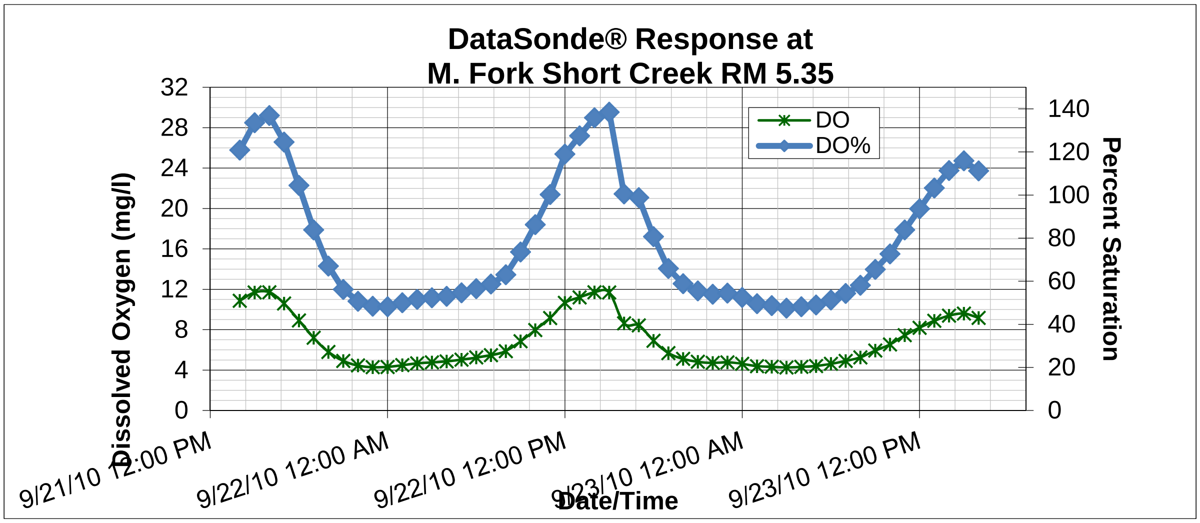


Figure 9. Diurnal fluctuations of D.O. and percent saturation recorded with DataSonde®.

Table 4. Exceedances of Ohio Water Quality Standards criteria (OAC3745-1) for chemical/physical parameters measured in Short Creek watershed and direct Ohio River tributaries, 2010. Bacteria exceedances are presented in the Recreation Use Section.

Stream/RM	Location	Parameter (value – mg/l unless noted)
Short Creek		
19.37	Short Cr. Adena CR 10	TDS[a] (1650, 1770, 2130, 2000, 1970, 2060, 2170, 2240, 1960, 2220, 2180)
18.4	Short Cr. Dst Adena WWTP	TDS (2090)
12.68	Short Cr. Dillonvale CR 7	TDS (1840, 1730, 1820, 1990)
8.84	Short Cr. dst. Dillionvale WWTP	TDS (1700, 1650, 1710, 1775, 1910, 1585)
4.96	Short Cr. USGS gage - SR 150	TDS (1530, 1510, 1550, 1640, 1650, 1600, 1750)
0.26	Long Run Dillionvale CR 7	TDS (2010)
0.15	Liming Cr. TR 76	TDS (1510, 1520)
5.35	Middle Fk. Short Cr. dst. Cadiz WWTP	TDS (1690, 1720, 1870, 1840, 1780, 1850, 1910)
0.23	Middle Fk. Short Cr. CR 41 Adena	TDS (1670, 1950, 1950, 2100, 1990)
1.13	South Fk. Short Cr. TR 83	TDS (2590, 2900, 2840, 2800, 3070)
0.17	Sally Buffalo Cr. ust Cadiz WWTP	TDS (1710, 1920, 1970, 2110, 2240, 2210)
6.21	N. Fk. Short Cr. Nagy Lane in Adena	TDS (1820, 1500, 1750, 2000)
0.09	N. Fk Short Cr. CR 12 Unionvale	TDS (1570, 1530, 1620)
Misc. Direct Ohio River Tribs		
1.9	Glenns Run ust. Treadle Run	Iron[b] (28600, 14800 µg/l), TDS (1670, 1770)
0.1	Glenns Run Glenns Run Rd. near mouth	TDS (1540, 1640, 1740, 2580, 2320, 1770, 1930, 2110, 1820)
0.25	Deep Run at Deep Run Rd - RR	TDS (1820)
0.6	Salt Run TR 157 dst. American Energy	TDS (1500, 1660)

a - Exceedance of the aquatic life Outside Mixing Zone Average water quality criterion .
b - Exceedance of the statewide water quality criteria for the protection of agricultural uses.

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

		Iron	Manganese	Conductivity	Sodium	Sulfate
Units		µg/l	µg/l	umhos/cm	mg/l	mg/l
Stream	River Mile	Mean	Mean	Mean	Mean	Mean
Long Run at CR 74	**0.03**	155	153	2012	13	1132
Short Cr. CR 10 at Adena	**19.37**	298	160	2065	65	1196
Short Cr. dst. WWTP Adena	**18.4**	838	188	2340	89	1290
Short Cr. at CR 7	**12.68**	377	144	1988	69	1111
Short Creek DST. Dillonvale WWTP	**8.84**	297	126	1950	93	1038
Short Cr. at SR 150 Gage	**4.96**	457	105	1697	81	862
S. Fk Short Cr. at TR 83	**1.13**	104	254	2930	117	1866
M. Fk. Short Cr. dst Cadiz WWTP	**5.35**	282	134	1954	89	1097
M. Fk Short Cr. CR 41	**0.23**	140	153	2115	68	1226
Sally Buffalo Cr. ust. Cadiz WWTP	**0.17**	171	157	2199	95	1328
Liming Ck at TR 76 (Jackson Rd)	**0.15**	284	84	1606	62	613
N. Fk Short Cr. at CR 12	**6.21**	1641	130	1830	30	1068
N. Fk Short Cr. at Nagy Ln in Adena	**0.09**	128	117	1683	20	940
Long Run at CR 7	**0.26**	303	50	1640	147	760
Piney Fork at TR 192	**10.51**	202	95	1453	20	666
Piney Fk at ST. RT. 150	**0.35**	294	67	1244	51	534
Dry Fk near mouth	**0.15**	243	44	1118	115	337
L. Short Ck at TR 472	**4.99**	825	39	940	53	220
Little Short Cr. at TR 113	**0.08**	185	41	1301	123	510
Glenns Run ust. Treadle Run	**1.9**	9040	141	1304	161	425
Glenns Run near mouth	**0.10**	291	33	2062	301	839
Deep Run at Deep Run Rd	**0.25**	1275	46	1656	109	719
Salt Run at TR 157	**0.6**	295	22	1769	97	864
Reference Values: headwater/ wading		1266/ 1820	35/ 25	1019/ 791	86/ 45	259/ 242

Table 6. Summary statistics for select nutrient water quality parameters sampled in the Short Creek and direct Ohio River tributaries, 2010. The 90th percentile value from reference sites from the Western Allegheny Plateau ecoregion is shown for comparison. Values above reference values are shaded.

		Ammonia-N	Nitrate-Nitrite-N	Phosphorus-T
Units		Mg/l	Mg/l	Mg/l
Stream	River Mile	Mean	Mean	Mean
Short Cr. CR 10 at Adena[1]	**19.37**	0.034	0.225	0.0125
Short Cr. at CR 7	**12.68**	0.025	0.086	0.0062
Short Creek dst. Dillonvale WWTP	**8.84**	0.025	1.82	0.093
Short Cr. At SR 150 Gage[1]	**4.96**	0.034	0.28	0.007
Sally Buffalo Cr ust. Cadiz WWTP	**0.17**	0.025	0.113	0.009
Cadiz WWTP to Sally B. Cr.	**0.10**	8.31	3.80	2.03
M. Fk. Short Cr. dst. Cadiz WWTP	**5.35**	0.22	1.30	0.238
M. Fk Short Cr .CR 41	**0.23**	0.025	0.423	0.0434
Liming Cr. at TR 76 (Jackson Rd)	**0.15**	0.14	0.046	0.287
Piney Fk at ST. RT. 150	**0.35**	0.025	0.182	0.008
Little Short Cr. at TR 113[1]	**0.08**	0.029	0.175	0.02
Glenns Run near mouth	**0.25**	0.025	0.293	0.0098
Rush Run at Rush Run Road	**0.25**	0.025	0.1025	0.005
Salt Run TR 157	**0.6**	0.025	0.07	0.014
Reference Values: headwater/ wading)		0.060/0.060	0.606/1.054	0.090/0.110

1 - Sites sampled 13 times during the study

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 in the Short Creek watershed and direct Ohio River tributaries 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 in the Short Creek watershed and selected Ohio River tributaries are 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.

Summarized bacteria results are listed in Table 7, and the complete dataset is reported in Appendix Table A4. Downloadable bacteria results are also available from the Ohio EPA GIS interactive maps at the following link: http://wwwapp.epa.ohio.gov/dsw/gis/wq/index.php.

Eleven locations in the study area were sampled for *E. coli* six to eleven times, from June 14th to October 19th, 2010. Evaluation of *E. coli* results revealed that 2 of the 11 locations attained the applicable geometric mean criterion, and thus were in full attainment of the recreation use. Nine sites exceeded the bacteria criterion, with a geometric mean ranging from 237 cfu/100ml to 660 cfu/100ml. The majority of sampling locations in the Short Creek watershed and selected Ohio River tributaries study area are in areas without centralized sewage treatment. The non-attainment is most likely due to unsanitary conditions from poorly treated sanitary waste and/or livestock operations.

The highest geometric value of 660 cfu/100ml was found near the mouth of Rush Run. This area is not on central sewers and has numerous houses along the creek on small home lots. The small size of the residential lots does not allow for adequate on-site sanitary sewage treatment such as a leach field. This situation was common in all the Ohio River tributaries in the study area.

In Short Creek, the same housing condition existed outside of the villages where homes were crowded along the narrow stream valley. The Short Creek watershed also has some wide valleys that are dominated by agricultural activities. The ridge tops in the upper watershed where strip mining had occurred are now large pasture or hay production areas. Runoff from these operations is another likely source of bacteria.

South Fork Short Creek and Little Short Creek both have little residential or agricultural activity compared to the above areas sampled. As such, it is not unexpected that the assigned PCR Class B use would be achieved.

Table 7. Summary of E. coli data for locations sampled in the Short Creek watershed and direct Ohio River tributaries, June 14 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	Stream/Location	River Mile	Maximum Value	Geometric Mean	# of samples
Short Creek					
050301060205	Short Cr. at Adena CR 10	19.37	2700	**530**	10
050301060205	Short Cr. dst. Dillonvale WWTP	8.84	1100	**287**	6
050301060207	Short Cr. USGS Gage at SR 150	4.96	970	**240**	11
050301060201	S. Fk Short Cr. at TR 83 (Greaves Rd)	1.13	200	140	6
050301060202	M. Fk Short Cr. at Adena at CR 41	0.23	2700	**441**	6
050301060203	N. Fk Short Cr. at Nagy Ln CR 10 in Adena	0.09	640	**462**	6
050301060204	Piney Fork at Dillonvale SR 150	0.35	2300	**466**	6
050301060206	Little Short Cr. at Mt. Pleasant Rd (TR 113)	0.08	460	146	10
Ohio River Tributaries					
050301061201	Rush Run adj CR 17 (Rush Run Road)	0.65	4000	**660**	6
050301061202	Salt Run adj TR 157 (church bridge crossing)	0.6	490	**237**	6
050301061204	Glenns Run at CR4 (Glenns Run Rd)	0.1	2100	**279**	11

Point Source Impacts (NPDES, storm water, mining)

The Short Creek watershed and direct Ohio River tributaries study area have a total of thirteen National Pollutant Discharge Elimination System (NPDES) permitted facilities that discharge waste water from a sanitary wastewater plant, industrial process water, and/or industrial storm water (Figure10). These facilities include five active mining facilities (Anthony Mining, Hopedale Mining LLC, Ohio American Energy, Inc., DTE Dickerson LLC and CONSOL), seven public sanitary waste water treatment plants (Adena WWTP, Buckeye Local School District WWTP, Cadiz WWTP, Dillonvale-Mt. Pleasant Sewer District WWTP, Hopedale WWTP, Smithfield WWTP and Yorkville STP), and two proposed industrial facilities for the Harrison Ethanol confined animal feeding operation (CAFO). A summary of the facilities' effluent results are in Appendix Table A5.

Mining in the area began in 1800 and has continued until the present (Crowell, 1995). Abandoned underground mines are found throughout Short Creek and the Ohio River tributaries (Figure 10). Abandoned surface mines are common as well. From 1968 thru the present there have been at least 49 different coal companies mining in the study area. There are currently 17 active NPDES permitted facilities in the study area for storm water related to coal surface mining activities covered under the General NPDES permit pre-fix OHM. The general permitted surface coal mine must control storm water and monitor for mining related contaminates.

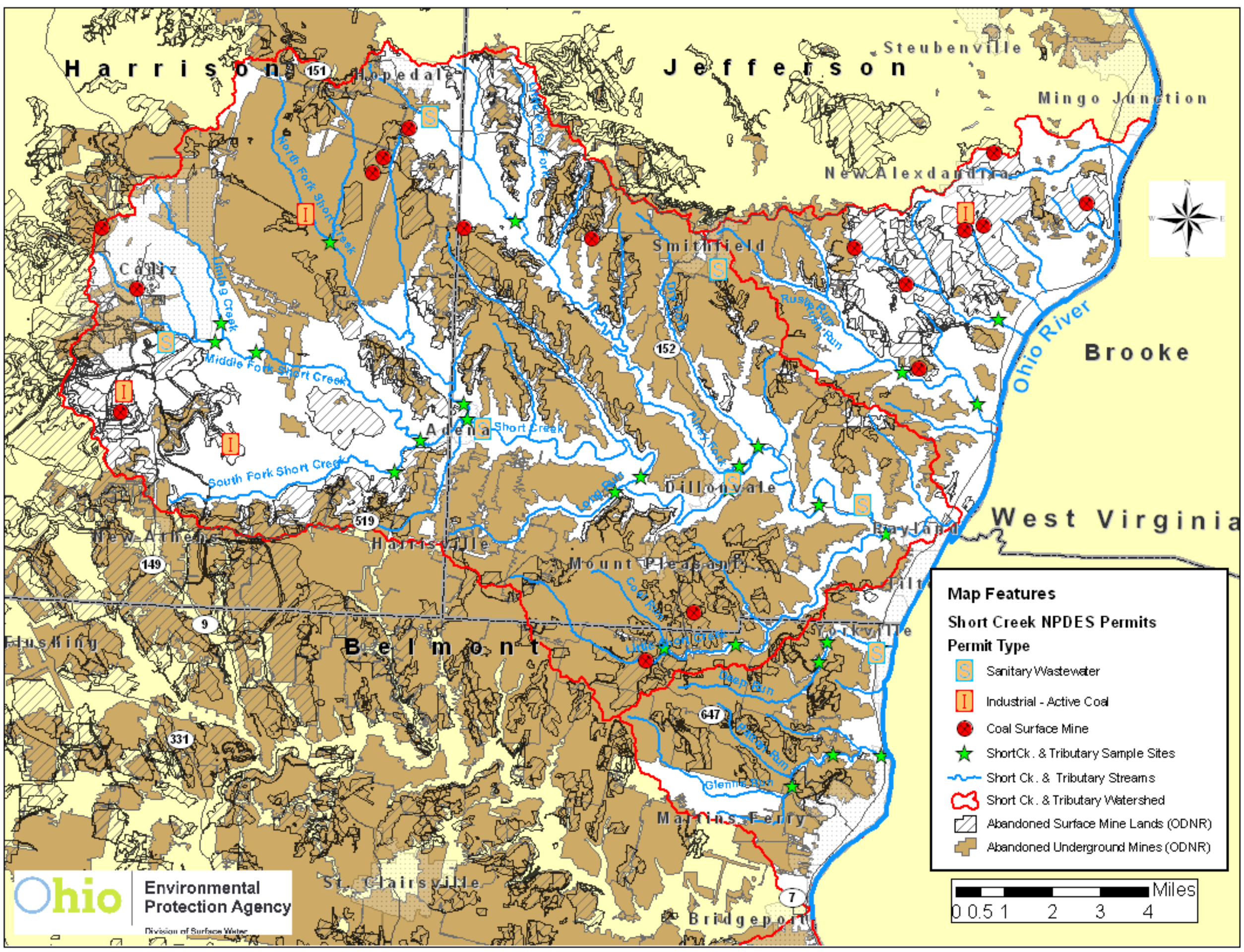


Figure 10. Active NPDES permitted facilities and previous coal mining in Short Creek watershed and direct Ohio River tributaries, 2010.

Hopedale Mining, LLC – Cadiz Portal (Ohio EPA Permit # 0IL00092; outfalls 001, 002, 004, 006 and 007)

The Hopedale Mining, LLC – Cadiz Portal is a reclaimed coal preparation plant, rail loading facility and deep mine portal complex located along Old Hopedale Road (CR5) and Upper Clearfork Road (CR 13), ¾ of a mile northwest of Unionvale, in Harrison County. Hopedale Mining LLC outfalls 001, 002, 006 and 007 are discharges from a settling pond that include storm water from a reclaimed coal refuse area and preparation plant. Outfall 004 is sewage treatment plant effluent. Outfalls 004, 006 and 007 all discharge to unnamed tributaries of North Fork Short Creek. Outfalls 001 and 002 discharge to North Fork Short Creek at approximately RM 7.0. The underground mine is currently not in operation but the surface effects continue to produce contaminated storm water. The map below (Figure 12) shows the location of an acid mine drainage seep that is not part of the treatment system located at outfalls 001 and 002. The acidic seep is from a covered coarse refuse disposal area and discharges to an unnamed tributary of the North Fork Short Creek shown in Figure 11.

Figure 11. Mine seep tributary to N.F. Short Creek.

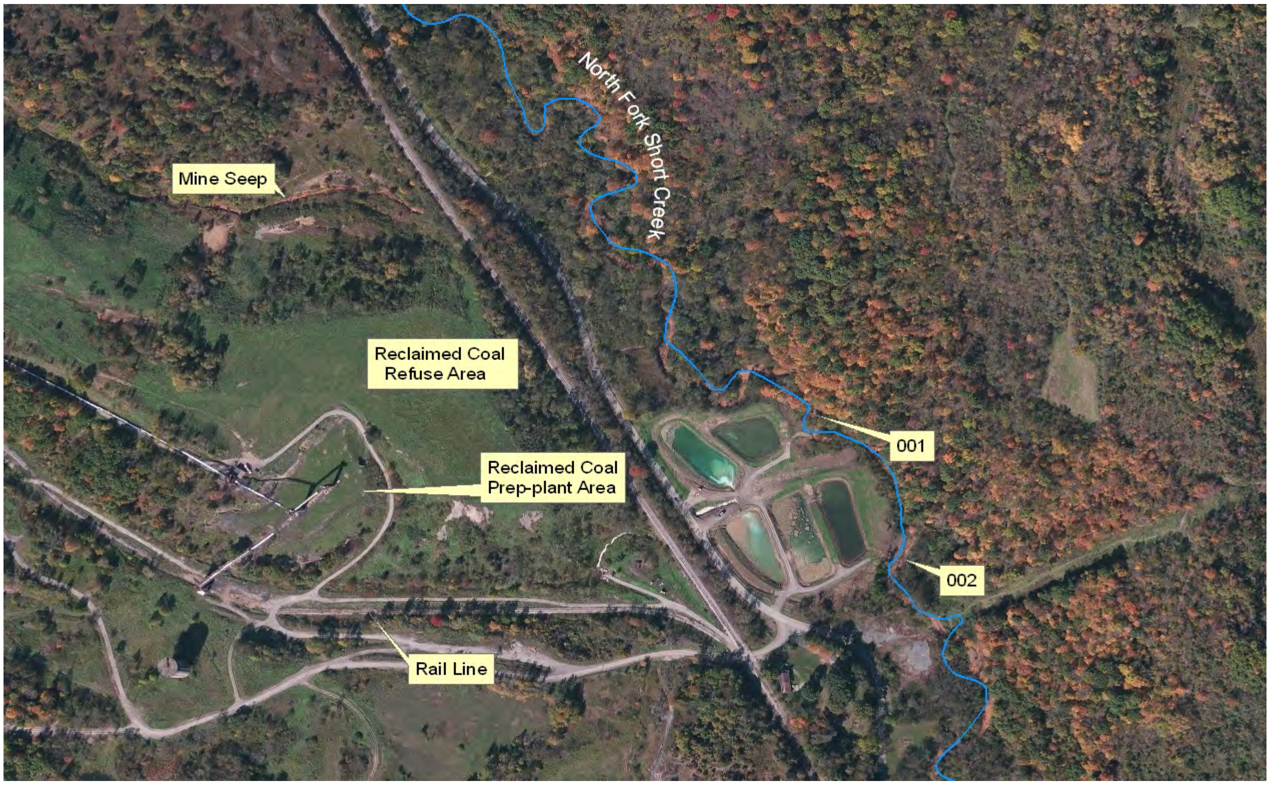


Figure 12. Hopedale Mining and Nemls Mine No. 1 prep-plant restoration area with treatment ponds 001, 002 and untreated acid mine drainage seep.

A portion of the mine site's waste was created prior to the 1977 Surface Mining Control and Reclamation Act at the Nelms Mine No. 1 which required reclamation, so that portion was reclaimed with Abandon Mine Lands (AML) funds. The AML reclamation's primary goal was to reduce erosion. ODNR-MRM is studying the Short Creek watershed to determine which AML sites can be reclaimed to also improve water quality. Hopedale Mine site is part of ODNR-MRM's study area.

Table 8. Samples collected by Ohio EPA on June 6, 2011 at the Hopedale Mine on North Fork Short Creek.

Parameter	Unit	N. Fk. ust Hopedale Seep	Seep to Trib to N. Fk	Trib to N. Fork ust. 001	Hopedale Mine pond 001	N. Fk dst. pond 001	Hopedale Mine pond 002	N. Fk. dst. Hopedale	Target Values
Acidity	mg/L	<5.0	9740	185	<5.0	<5.0	<5.0	<5.0	-67[a]
Alkalinity	mg/L	148	<5.0	<5.0	39	298	38.2	44.6	110[f]
Aluminum	ug/L	<200	379,000	23,000	779	112,000	533	4,520	750[b]
Ammonia	mg/L	<0.050	10.6	0.531	0.514	2.69	0.141	0.145	1.0[d]
Arsenic	ug/L	<2.0	1250	22.7	<2.0	3.3	<2.0	3.4	100[d]
Copper	ug/L	<2.0	151	26.5	7.3	98.6	5	6.8	30[d]
Hardness, T	mg/L	545	1690	1140	893	1250	733	823	209[f]
Iron	ug/L	135	2,260,000	76,000	80	6,990	60	16,600	5,000[e]
Manganese	ug/L	149	20,300	2,190	228	4,550	120	977	248[f]
Nickel	ug/L	3.8	1740	88	7.2	291	6.6	32.8	200[d]
Selenium	ug/L	<2.0	17.4	2.1	4.6	6.3	3.6	<2.0	50[d]
Sodium	mg/L	14	37	23	287	413	193	34	19[f]
Sulfate	mg/L	449	9,420	1,440	1,580	2,040	1,170	826	2238[c]
TDS	mg/L	858	14,200	2,110	2,290	2,770	1,730	1,270	1,500[d]
T Phoshorus	mg/L	<0.010	7.53	0.252	<0.010	0.205	<0.010	0.028	1.0[d]
Zinc	ug/L	<10	6910	286	<10	846	<10	78	25,000[d]
Field Parameters									
Temperature	°C	18.98	19.06	24.79	24.09	18.98	25.96	22.5	---
Conductivity	µmhos/cm	1049	8764	1897	2644	3308	2011	1451	540[f]
Dissolved Oxygen	mg/L	7.81	3.14	7.53	7.75	7.67	6.83	6.82	4[d]
D.O. Saturation	%	84.4	34.9	103.4	93	83.5	84.5	79.1	---
pH	S.U.	7.77	2.38	7.96	8.25	8.12	8.29	6.33	6.5-9[d]

a – Ohio EPA 2005, target value
b – US EPA 2009
c – IDEM 1996
d – OAC 3745 - OMZA - DO is minimum value
e - OAC 3745 - Agriculture OMZA
f – Ohio EPA 1999

The table above shows the chemistry results from the mine seep sampling that occurred on June 6, 2011. The iron measurement from the abandoned mine drainage, "seep to trib", site listed in Table 8 is the highest value recorded in Ohio in the last 14 years. The seep affects the mainstem sampling location located one mile downstream. Outfall 001 had one pH limit violation below the 6.0 limit. Outfall 006 had total suspended solids and manganese exceedances a total of five times over the January 2006 thru November 2012 review period.

DTE Dickerson LLC – Georgetown Prep-plant Area (Ohio EPA Permit # 0IL00149; outfall 003)
DTE Dickerson LLC – Georgetown Prep-plant Area is a secondary coal reprocessing facility with a slurry impoundment discharge to an unnamed tributary of South Fork Short Creek at RM 4.3. The facility is located 2.4 miles northeast of New Athens along Georgetown Road (CR 41), Harrison County. The impoundment receives process wastewater and storm water runoff from

the prep-plant area. No limit exceedances were reported for the April 2010 thru December 2012 reporting period.

CONSOL Energy Inc. – Oak Park Mine No. 7 (Ohio EPA Permit # 0IL000036; outfall 001)
CONSOL – Oak Park Mine No.7 is located at 79285 Cadiz-New Athens Road (SR 9), Harrison County. This is a support facility (with a sewage treatment plant) for the CONSOL, Mahoning Valley surface mine and Oak Park Mine No. 7, which are in the process of being reclaimed. The support facility services a small number of employees. The sewage treatment plant discharges to an unnamed tributary of Sally Buffalo Creek at RM 0.6.

Ohio American Energy Inc. – Riddles Run Refuse Disposal & Coal Processing Plant (Ohio EPA Permit # 0IL00146; outfalls 001, 002 and 003)
Ohio American Energy – Riddles Run facility is located along Riddles Run Road (TR 163) 0.8 miles south of New Alexander, Jefferson County. The facility consists of a coal prep-plant and coarse refuse disposal area. Storm water from the coarse refuse disposal area discharges from outfall 001 and coal prep-plant process water are discharged from treatment ponds (002 and 003) to Riddles Run at RM 2.5.

The prep-plant outfall 001 had 20 daily minimum pH violations and one iron daily maximum violation for the December 2008 thru November 2012 review period. The prep-plant outfall also monitors total dissolved solids (TDS), chlorides and sulfates. The TDS results for this time period had 36 exceedances of the 1500 mg/l Water Quality Standards (WQS) criterion. Additionally, the sulfates ranged from 53 to 2335 mg/l (with 510 mg/l being the next lowest reported value). The median reference site value for sulfate is 75.0 within the WAP ecoregion (Ohio EPA 1999). Storm water outfall 002 had 1 minimum and 6 maximum pH violations and 2 manganese violations for the review period.

Village of Yorkville – Yorkville Sewage Treatment Plant (Ohio EPA Permit # 0PB00052; outfall 001)
The Yorkville STP is located at 1001 Market Street and Deep Run Road, Belmont County. The STP services a population of 1875 and treats only domestic wastewater. The treatment plant consists of secondary treatment activated sludge, extended aeration and disinfection. The plant is designed to treat 0.424 MGD. Five percent of the sewage collection system is combined storm water and sewage; the rest is sanitary sewage only. The plant discharges to Deep Run at RM 0.3 prior to entering the Ohio River. The STP is required to reduce inflow and infiltration in the collection system. The STP had 3 total suspended solids (TSS) and 2 $CBOD_5$ violations for the review period.

On May 13, 2010 Severstal Wheeling Inc. (SWI) – Yorkville Plant released 500 gallons of ferrous chloride solution and hydrochloric acid (pickling acid) to the Yorkville STP. The release was through an unknown sanitary sewer connection. SWI enlisted the services of several remediation contractors to remove and dispose of the contaminated material from the STP. Approximately 150,000 gallons of lime-stabilized wastewater and 135 tons of contaminated soil and sludge were removed from the STP for off-site treatment. No effluent limit exceedances were reported.

Buckeye Local School District – High School (Ohio EPA Permit # 0PT00023; outfall 001)
Buckeye Local High School is located on State Route 150 near Connorville, Jefferson County. The WWTP consists of tertiary treatment extended aeration and disinfection. The plant is designed to treat 0.015 MGD. The plant discharges to Short Creek at RM 2.9. The plant reported two NPDES permit limit violations for chlorine and ammonia from January 2006 thru November 2012.

Dillonvale – Mt. Pleasant Sewer District – WWTP (Ohio EPA Permit # 0PQ00007; outfall 001) The Sewer District WWTP is located at 19 Township Road 1197, Dillonvale, Jefferson County. The District has 1586 service connections and the collection system is 100% separate. The treatment plant consists of secondary treatment activated sludge, extended aeration and disinfection. The plant is designed to treat 0.34 MGD. The plant discharges to Short Creek at RM 8.9. No violations were recorded during the January 2006 thru December 2012 review period.

Village of Adena – Sewage Treatment Facility (Ohio EPA Permit # 0PB00056; outfall 001) The Adena STP is located on Smithfield Township Road 122, Adena, Jefferson County. The STP services a population of 815 and the collection system is 100% separate. The treatment plant consists of secondary treatment activated sludge, extended aeration and disinfection. The plant is designed to treat 0.128 MGD. The plant discharges to Short Creek at RM 19.0. The plant has had 31 TSS and 18 $CBOD_5$ permit limit violations. High influent flows are common at the WWTP with the design flow being exceeded 251 times in 2009, 195 times in 2010, 312 times in 2011 and 168 times in 2012. On August 2nd, 2011 Ohio EPA issued Director's Final Findings and Orders (DFF&Os) to the Village of Adena. The DFF&Os require improvement projects to reduce the main influent pump station bypasses and control inflow and infiltration in the sanitary sewer system. The improvements at the WWTP include replacing the clarifier to increase its treatment capacity and upgrade pumps to improve control of plant solids. These projects were to go to bid in early 2013.


Figure 13. Manhole overflow due to high flows, near Liming Creek.

Village of Cadiz – Cadiz WWTP (Ohio EPA Permit # 0PB00009; outfall 001)
The Cadiz WWTP is located at Country Club Road and US 250 in Cadiz, Harrison County. The WWTP services a population of 3,300 and the collection system is 100% separate. The treatment plant consists of an Imhoff tank, two trickling filters and clarifier then disinfection. The plant is designed to treat 0.60 MGD. The plant was built in 1939 and the last upgrade/improvement was made in 1988. The plant discharges to Sally Buffalo Creek at RM 0.15. The WWTP has had the following effluent permit violations for the January 2006 through December 2012 review period: 2 fecal coliform; 86 ammonia, 119 $CBOD_5$, 75 TSS, 5 oil and grease and 5 pH. High influent flows are common at the WWTP with the design flow being exceeded 43 times in 2009, 125 times in 2010, 252 times in 2011 and 99 times in 2012.


Figure 14. Solids discharge from the Cadiz WWTP outfall 001, Sally Buffalo Creek.

In June 2012, the Ohio EPA issued DFF&Os to the Village of Cadiz restricting new sanitary sewer connections. The DFF&Os additionally require the Village to rehabilitate or replace the three main trunk sewers (including the Liming Run line) that convey the sewage from the Village to the WWTP within 18 months of the DFF&Os. The Village must make improvements to or replace the WWTP by May 2018. Replacing trunk sewers will reduce high flow to the WWTP and eliminate manhole overflows (Figure 13). Cadiz is currently replacing the Liming Run (south) trunk line and has permits to replace the other two trunk sewers.

On October 18th, 2010 the Cadiz WWTP was discharging solids through outfall 001 (Figure 14). Total suspended solids and $CBOD_5$ limit violations were reported this week and month. On November 2–3, 2010 Ohio EPA collected a composite sample from the Cadiz WWTP. Both TSS and ammonia exceeded the permit limit with TSS levels of 19 mg/L and ammonia at 11.6 mg/L.

Village of Hopedale – Hopedale WWTP (Ohio EPA Permit # 0PB00018; outfall 001)
The Hopedale WWTP is located at State Route 150 in Hopedale, Harrison County. The WWTP services a population of 925 and the collection system is 100% separate. The treatment plant consists of tertiary treatment, extended aeration and disinfection. The plant is designed to treat 0.125 MGD. The plant discharges to Piney Fork at RM 13.7. The plant has had 40 TSS permit limit violations from January 2006 thru November 2012.

Village of Smithfield – Smithfield WWTP (Ohio EPA Permit # 0PA00053: outfall 001)
The Smithfield WWTP is located at 378 Sherwood Avenue in Smithfield, Jefferson County. The WWTP services a population of 1500 and the collection system is 100% separate. The treatment plant consists of tertiary treatment, extended aeration and disinfection. The plant is designed to treat 0.110 MGD. The plant discharges to Crow Hollow at RM 3.3 which is a tributary to Dry Fork. The WWTP has reported the following effluent permit violations: 167 for ammonia, 41 for $CBOD_5$ and 166 for TSS from January 2006 thru November 2012. Flows at the WWTP have been mistakenly reported higher than they actually were in the past; thus some loading violations may be in error.

Harrison Ethanol LLC – Concentrated Animal Feeding Operation and Ethanol Production Facility (Ohio EPA Permit Numbers 0IK00011 and 0IN00253)
The proposed Harrison Ethanol complex is located less than a mile south of Cadiz and is in the Sally Buffalo Creek watershed. Currently, Harrison Ethanol's two facilities have not been built and put into production, although the facilities do have active permits. The Harrison Ethanol complex proposes to have a CAFO that will house 2,000 mature dairy cows and 10,000 non-dairy cows. The facility will generate 52 million gallons of manure, litter and wastewater annually. The NPDES permit requires a manure management plan and storm water pollution prevention plan (SWPPP) which prohibit contaminated storm water from the CAFO operation and require notifying Ohio EPA of any such discharge. Harrison Ethanol will take the corn and convert it into mash, which will be fermented and the alcohol distilled to produce up to 26 million gallons of fuel-grade ethanol. Spent distiller's dried grains and distiller's solubles will be sold as animal feed and the cattle manure will be used to produce methane at the facility to run electrical generators. Membrane Biological Reactor effluent will be discharged from outfall 001 into the CONSOL Reservoir and will be monitored for nutrients, bacteria and $CBOD_5$. The other two outfalls will be comprised of facility storm water. This facility will also be covered by a SWPPP.

Sediment

Surficial sediment samples were collected at two Short Creek locations and one Little Short Creek and Glenns Run location by the Ohio EPA on August 3-4, 2010. Sampling locations were co-located with chemical and 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 A6. Sediment data were evaluated using Ohio Sediment Reference Values (SRV) (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 (lowest effect level = 600 mg/kg, and severe effect level = 2000 mg/kg). The consensus-based sediment guidelines define two levels of eco-toxic 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 (Ohio EPA 2010).

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 four sites with an average of 8% of the sample comprised of fine grained silt or clay.

Arsenic, nickel and zinc were above TEC levels at all four sampling locations. Arsenic is a commonly occurring element found in some sedimentary rocks (such as limestone and sandstone) and coal. Nickel is found in sandstones and clays and also in industrial air emissions from power plant and metal industries while zinc is found in some coals as zinc sulfide and air emissions. Manganese exceeded the PEC at all four sites and iron was above the SRV at the two tributary sites. Iron and manganese are typical coal mining elements. The high levels of metals in the sediment may be a result of a highly disturbed geological setting resulting from the extensive coal mining in the study area. Large areas have been strip mined leaving the surface with large piles of waste coal, soils and broken rock through which rainwater seeps through leaching salts, minerals and metals into the streams. Underground mine voids fill with water which percolates through the fractured overburden carrying the same salts, minerals and metals into the streams. These constituents then settle out into the sediments which can be detrimental to the aquatic life that is in close proximity to the sediment.

Calcium ranged between 12 to 47 percent above the SRV level. Calcium is a main component in cement. In a stream environment it can form a cementitious crust on substrates which is detrimental to macroinvertebrates (see Stream Physical Habitat section below).

The sparse deposits of fine grained material in the sediment had higher than normal levels of metals and minerals. These constituents contributed to the exposure of sediment contaminants to biological communities and further degraded stream physical habitat. These and other factors may have contributed to the impaired biological communities from Little Short Creek and Glenns Run sampling sites.

Table 9. Chemical parameters measured above screening levels in samples collected by Ohio EPA from surficial sediments in Short Creek, Little Short Creek and Glenns Run, 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 (orange), Threshold Effect Concentration –TEC (yellow) and Probable Effect Concentration – PEC (red). Sampling locations are indicated by river mile (RM).

Parameter	Short Creek USGS Gage RM 4.9	Short Creek in Adena RM 19.7	Little Short Creek TR 113 RM 0.1	Glenns Run CR 4 RM 0.1	Reference Values
Aluminum	14200	17300	15800	9190	53000
Ammonia	230	170	110	39	N/A
Arsenic	13.2	15	16.6	16.2	9.79
Barium	144	177	174	220	360
Cadmium	0.997	1.04	0.923	0.651	0.99
Calcium	94100	143000	57700	217000	27000
Chromium	15.7	280	16.2	13.3	43.4
Copper	30.9	36.8	23.5	37.4J	31.6
Iron	47300	48700	56400	115000	51000
Lead	21.3	33	23.5	21.3J	35.8
Magnesium	5880	14100	5610	6220	9900
Manganese	1210	2840	1190	1980	1100
Nickel	42.8	43.5	34.9	30.6	22.7
Potassium	2820	3420	2000	1650	14000
Selenium	2.82	3.42	1.75	1.65	2.6
Sodium	7040	8550	4370	4130	N/A
Strontium	377	629	174	456	250
Zinc	187	168	147	139	121
Total Phosphorus	308	375	777	686	N/A

J - Estimated result. Result is less than reporting limit (RL).

Fish Tissue Assessment

Ohio's Sports Fish Consumption Advisory (SFCA) program was reorganized in 1993 as a cooperative effort amongst the Departments of Health, 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, US EPA, and Ohio's SFCA program have improved data evaluation and risk communication. The SFCA program website provides further information:
http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

Fish tissue in 12 samples comprised by 19 fish either singularly or combined was collected from Short Creek in 2009 and 2010. Table 10 summarizes the concentrations of detected metals from these fish. Table 11 lists the detected organic compounds present in the 12 samples. Results for other typical tissue parameters not presented in these tables were less than the method detection limits. These analytes, specific SFCA guidance, and contaminant thresholds are discussed in: *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program* (2010,
http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure.pdf).

The ubiquitous presence of mercury has resulted in a statewide recommendation to monitor fish consumption based on location and species specific risk. Broadly, it's prudent to eat most fish no more than 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. Data for any single species are insufficient for species-specific advisories. Therefore, the statewide advisories should continue to be applied (Table 10).

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. The one HUC12 within the study area which was determined to have a human health impairment due to PCBs based on the assessment of fish tissue data at Short Creek RM 3.0 is named 'Dry Fork-Short Creek (05030106 02 07) (Table 12). The same calculation for mercury is shown to illustrate the difference between this use expectation and that of the SFCA 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. Due to limited data, no advisories are recommended at this time, although levels of PCBs were in the one meal a month category for both channel catfish and smallmouth bass (Table 11).

Table 10. Metals concentrations (mg/kg) in fish tissue samples collected from Short Creek, 2009-2010. Values preceded by a less than sign (<) indicate results were below the method detection limit. Comparative values under each analyte are Ohio adopted triggers. Sample types are: SFF=skin off fillet, SFFC= skin off fillet composite, SOFC= skin on fillet composite. Data for any single species are insufficient for species-specific advisories. Therefore, the statewide advisories should continue to be applied.

Species				Arsenic	Cadmium	Lead	Mercury	Selenium
n/type	Year	RM	Location	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	3.0	SR 150	<0.099	0.0043	<0.040	0.067	0.198
Carp								
1/SFF	2009	3.0	SR 150	<0.098	0.0051	0.854	0.145	0.690
Freshwater drum								
2/SFFC	2009	3.0	SR 150	<0.099	<0.0040	<0.040	0.081	0.773
Rock Bass								
2/SFFC	2009	3.0	SR 150	<0.098	<0.0039	<0.039	0.061	0.584
Sauger								
2/SOFC	2010	8.7	Dst. Dillonville	<0.050	<0.0040	<0.040	0.210	0.561
Smallmouth bass								
3/SOFC	2010	8.7	Dst. Dillonville	0.079	<0.0040	<0.040	0.232	0.649
1/SFF	2009	3.0	SR 150	0.136	<0.0040	<0.040	0.233	0.639

Table 11. Organic compounds (mg/kg) in fish tissue samples collected from Short Creek, 2009-2010. 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. Data for any single species are insufficient for species-specific advisories. Therefore, the statewide advisories should continue to be applied. Sample types are: SFF=skin off fillet, SFFC= skin off fillet composite, SOFC= skin on fillet composite.

Species				PCB Aroclors PCB		Total PCBs	Total DDT
n/type	Year	RM	Location	1254	1260	**0.050/ *0.220***	**0.500/ *2.188***
Channel catfish							
1/SFF	2009	3.0	SR 150	<0.050	***0.626***	***0.626***	<0.010
Carp							
1/SFF	2009	3.0	SR 150	<0.050	<0.050	--	<0.010
Freshwater drum							
2/SFFC	2009	3.0	SR 150	<0.050	<0.050	--	<0.010
Rock Bass							
2/SFFC	2009	3.0	SR 150	<0.050	<0.050	--	<0.010
Sauger							
2/SOFC	2010	8.7	Dst. Dillonville	<0.050	<0.050	--	<0.010
Smallmouth bass							
3/SOFC	2010	8.7	Dst. Dillonville	<0.050	<0.050	--	<0.010
1/SFF	2009	3.0	SR 150	**0.079**	**0.146**	***0.225***	<0.010

Table 12. Non-drinking water human health use attainment status based on fish tissue samples collected from Short Creek, 2009. ***Red bold*** *highlighted values violate the criteria and signify impairment for the Dry Fork-Short Creek (05030106 02 07) assessment. 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 PCBs**	
n/type	Year	RM	Location			1254	1260		
Channel catfish			**3**						
1/SFF	2009	3.0	SR 150	0.067		<0.050	0.626	0.651	
Carp			**3**						
1/SFF	2009	3.0	SR 150	0.145		<0.050	<0.050	0.050	
Freshwater drum			**3**						
2/SFFC	2009	3.0	SR 150	0.081		<0.050	<0.050	0.050	
Rock Bass			**4**						
2/SFFC	2009	3.0	SR 150	0.061		<0.050	<0.050	0.050	
Smallmouth bass			**4**						
1/SFF	2009	3.0	SR 150	0.233		0.079	0.146	0.225	
			Mean 3 value (11.8)	0.098	1.152			0.250	2.954
			Mean 4 value (5.7)	0.147	0.838			0.138	0.784
				Sum	1.990				3.738
				Divided by /17.5	0.114				**0.214****

* - A value of 1.0 mg/kg mercury or greater is the criteria used to determine impairment .
** - A value of 0.054 mg/kg PCB or greater is the criteria used to determine impairment.
*** - The one HUC12 which was determined to have a human health impairment due to PCBs based on the assessment of fish tissue data at Short Creek RM 3.0 is named 'Dry Fork-Short Creek (05030106 02 07).

Stream Physical Habitat

Short Creek Watershed

Stream habitat was evaluated at 18 fish sampling locations in the Short Creek watershed during 2010 (Table 13, Appendix Table A7). Four of these stations were located on the Short Creek mainstem, where habitat quality was excellent at three sites and fair at one. The average Qualitative Habitat Evaluation Index (QHEI) score for all Short Creek watershed sites was 72.3, consistent with good overall habitat quality. Watershed sites were predominated by limestone bedrock, gravel, sand and coal fines substrates, with lesser amounts of cobble, and boulders. Moderate embeddedness of the bottom substrates occurred at 3 of the 4 fish sites in Short Creek proper. Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine sand and silt. Extensive amounts are detrimental to bottom spawning fish and can impair macroinvertebrate populations.

Throughout these heavily mined watersheds, some substrates were "concreted" together with orange sand and were very difficult to pry apart. Mineral deposits on the substrates are a result of mineral rich water where extensive mining has occurred. The mineral deposits create a cementitious covering on the substrates and further reduce the pore space between substrates (Figure 15). Orange staining and “concreted” substrate, sand and silt are indicative of past coal mining activity during which time companies did little to reduce runoff and erosion of mining sites and provided little to no vegetative cover after mining. Ohio Department of Natural Resources – Mineral Resources Management has reclaimed previously barren areas and covered or capped gob piles (a source of coal fines) over the last decade to eliminate these sources of fine material. In spite of these apparent limitations, natural channel quality, abundant instream cover, wide to moderate riparian zones and little to no bank erosion problems within Short Creek contribute to habitat quality that can support good biological communities.

Ohio River Tributaries

Five of the eight direct Ohio River tributary sampling locations (2 sites on Rush Run, 3 sites on Glenns Run) were represented by good to excellent physical habitat, with QHEI scores ranging from 58.3 to 77.3 (Table 13, Appendix Table A7). These smaller streams had high gradients and a lot of the same better attributes noted at larger stream locations except flow was more variable. The overall QHEI average score was 59.2 due to fair to poor scores in Deep Run and Salt Run, the latter which had the lowest QHEI score of 40.5. An abundance of silt, sand and muck were the common cover on substrates in these two extensively mined watersheds. Active surface mining in Salt Run and untreated abandoned mining drainage in Deep Run have severely impacted the water chemistry and contributed to the massive amounts of fine bed load materials.

Figure 15 Mineral deposits on substrates create a concrete-like structure, typical in mineral rich mine water.

Table 13. Stream physical habitat summarized results as measured by the Qualitative Habitat Evaluation Index (QHEI) for the Short Creek watershed and direct Ohio River tributaries, 2010.

Stream Name /Location	River Mile	QHEI	Narrative Evaluation	Comments
Short Creek Watershed				
Short Creek	18.90	75.0	Excellent	Sandstone gravel; coal fines
Short Creek	12.68	77.5	Excellent	Sand/silt smoothers gravel; coal fines
Short Creek	8.84	54.0	Fair	Excessive sand/silt; coal fines
Short Creek	4.96	88.5	Excellent	Boulder/cobble; coal fines
South Fork Short Creek	1.13	80.0	Excellent	Gravel/sand; moderate silt
Middle Fork Short Creek	5.35	69.5	Good	Gravel/sand; moderately heavy silt
Middle Fork Short Creek	0.23	68.8	Good	Nutrients – algae
Sally Buffalo Creek	0.17	68.8	Good	Outfall smelly – gray colored substrate
Liming Creek	0.15	75.0	Excellent	Dark organic sediments
North Fork Short Creek	6.21	76.0	Excellent	Mine impacted appearance – iron//sulfur colors
North Fork Short Creek	0.09	68.5	Good	Moderate silt and embeddedness
Long Run	0.26	61.5	Good	Moderate silt and embeddedness
Piney Fork	10.51	73.0	Excellent	Moderate silt; nice riparian
Piney Fork	0.35	71.3	Excellent	Gravel/sand; normal silt and embeddedness
Dry Fork	0.15	67.5	Good	Moderate silt and embeddedness
Little Short Creek	4.99	85.8	Excellent	Cobble; wide forested riparian
Little Short Creek	0.08	78.0	Excellent	Cobble/gravel; Normal silt and embeddedness
Coal Run	0.15	62.8	Good	Bedrock' very little flow
Direct Ohio River Tributaries				
Salt Run	0.60	40.5	Poor	Odd gray cementitious silt appears to bind substrates together; extensively covered and compacted.
Rush Run	2.80	64.5	Good	Moderate silt and embeddedness; rural ditch
Rush Run	0.65	77.3	Excellent	Cobble/gravel; sewage smell
Deep Run	2.40	50.8	Fair	Moderate silt ; attached algae
Deep Run	0.25	47.0	Fair	Orange sediment is covering substrates
Glenns Run	2.90	66.5	Good	Bedrock; high gradient; some algae
Glenns Run	2.50	68.8	Good	Boulder/Slabs/Cobble; discoloration
Glenns Run Rd)	0.10	58.3	Good	Boulders – substrates stained orange; heavy sand

General narrative ranges assigned to QHEI		
Narrative Rating		QHEI Range
		Headwaters/Wading
Excellent		$\geq$70
Good		55 to 69
Fair		43 to 54
Poor		30 to 43

Fish Community

A total of 18,084 fish representing 49 species were collected from the Short Creek watershed and 5,315 fish representing 24 species of fish in the direct Ohio River tributaries were collected between August and September, 2010. Relative numbers and species collected per location are presented in Appendix Table A8 and Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb) scores are presented in Appendix Table A9. Sampling locations were evaluated using Warmwater Habitat (WWH) biocriteria. A summary of the fish data are presented in Table 15.

Short Creek Watershed
The Short Creek mainstem sites sampled during 2010 met the WWH fish biocriteria at all four sampling sites. The historical trends of Short Creek for MIwb and IBI reflect a significant improvement compared to 1993 with an MIwb average improving to 9.14 and an IBI average improving to 48.75 (Table 14). Over the 17 year period between surveys of Short Creek, substantial improvement has occurred in the fish community. Commensurate diversity improvements and increasing carnivore abundance further validated this positive trend. In 1993, green sunfish were the only carnivore present at the upper Short Creek site. In 2010, smallmouth and largemouth bass, bluegill and green sunfish were present. The lower Short Creek site went from 4 carnivore species present to 9 carnivore species present in 2010.

Table14. Average IBI and MIwb scores for Short Creek from 1993 and 2010.

Year	IBI	MIwb
2010	48.75	9.14
1993	35.0	6.89

In addition to the improvement in carnivore species, other new species were collected in 2010 adding to the recognition that the water quality in Short Creek has improved. The intolerant black redhorse and the moderately intolerant golden redhorse were present at the lower Short Creek site in 2010, but were absent in 1993. River chub, silver shiner, rosyface shiner, and mimic shiner were collected in the 2010 Short Creek watershed. Likewise, stonecat madtoms, bluebreast darters and variegate darters add to the class of intolerant species that were not present in prior surveys. Beyond these pollution sensitive species, channel catfish, yellow bullhead, mottled sculpin, and logperch were also first collected in 2010.

Orangethroat darters were found in eight Short Creek tributary streams while a single (intolerant) longnose dace, an Ohio Species of Concern (ODNR 2012), was noted in Little Short Creek. In total, Little Short Creek harbored 22 fish species at RM 0.1 (Table 15). This headwater site had the best IBI score (56) in the Short Creek watershed. With very good QHEI values ($\bar{x}$=81.5, n=2), Little Short Creek had the best consistent habitat quality in the watershed as well. It was also one of the streams inhabited by orangethroat darters. The RM 0.1 site is impacted from an abandoned mine discharge at RM 3.5. This is revealed in the marginally good macroinvertebrate score which can be directly attributed to a large abandoned mine drainage contributor at RM 3.5.

Middle Fork Short Creek and Sally Buffalo Creek were sampled in 1985 resulting in an IBI of 24 and 22, respectively. While locations in 1985 were different than the 2010 sites, both streams reflected a significant increase in IBI scores. The 2010 IBI scores for both Middle Fork Short Creek sampling locations were 42; the IBI score of the Sally Buffalo Creek sampling location, upstream from the Cadiz WWTP, was 40.

Compared to the other streams evaluated in the 2010 Central Ohio River Tributaries (CORT) survey, the Cross Creek watershed, directly north of the Short Creek watershed, lacks both extensive surface and underground mining, and therefore does not have the magnitude of instream impacts that tend to be more significant in the mined watersheds of Short Creek and Wheeling Creek, directly to the south (Ohio EPA 2010b and 2013). Similar to Short Creek, Cross Creek fish communities achieved biocriteria at 100% of the mainstem sampling sites; direct Ohio River tributaries to the north of Cross Creek performed equally well with 90% of sites achieving the fish biocriteria. Additionally, the streams in Jefferson and Belmont counties benefit from a mixed limestone geo-type which buffers mine drainage preventing severe acidic or low pH impacts and the highly toxic heavy metals concentrations found in acid mine drainage. This alkaline mine drainage is typically high in dissolved solids which does impact the streams aquatic communities, particularly the macroinvertebrates.

Ohio River Tributaries

Eight sites on four direct tributary streams to the Ohio River had fish community assessments completed in 2010. Two of the eight sites were fully achieving the IBI biocriterion. The mouth of both Rush Run (RM 0.65) and Glenns Run (RM 0.10) had IBI scores of 52. Both Glenns Run and Rush Run had longnose dace collected in 2010 and bluebreast darters were collected in Glenns Run in 2011 and 2012 during follow-up sampling. In Glenns Run, the high IBI score and intolerant species suggest that the fish are able to repopulate the stream from the Ohio River after periodic abandoned mine drainage impacts that occasionally affect the stream (observed during winter chemical sampling). Again, the abandoned mine drainage disproportionally affected the macroinvertebrate community as seen by the fair narrative score in Glenns Run. On-going surface mining and the associated heavy siltation in the Salt Run watershed has inhibited the Ohio River recruitment reducing the IBI to 32. Deep Run had the lowest IBI score of 22 in the entire study area and is affected by both mine drainage and poor habitat.

Table 15. Fish community summaries based on pulsed D.C. electrofishing sampling conducted by Ohio EPA in the Short Creek watershed and direct Ohio River tributaries, 2010. Relative numbers and weighs are per 0.3 km for wading and headwater sites. NA= not applicable.

Stream	River Mile	Sample Type	Fish Species (Total)	Relative Number	Relative Weight (kg)	IBI	MIwb	QHEI	Narrative Evaluation
Short Creek Watershed									
Short Creek	18.90	Wading	21	1,667	44.31	46	9.2	75.0	Very Good
Short Creek	12.68	Wading	31	500	47.56	50	9.1	77.5	Exceptional
Short Creek	8.84	Wading	24	324	94.18	49	9.3	54.0	Very Good
Short Creek	4.96	Wading	31	1,089	20.49	50	8.95	88.5	Exceptional
S. Fk. Short Creek	1.13	HW	10	510	NA	44	NA	80.0	Good
M. Fk. Short Creek	5.35	HW	15	1,472	NA	42ns	NA	69.5	Marginally Good
M. Fk. Short Creek	0.23	Wading	14	2,938	NA	42ns	8.0ns	60.8	Marginally Good
Sally Buffalo Creek	0.17	HW	11	602	NA	40ns	NA	68.8	Marginally Good
Liming Creek	0.15	HW	13	2,492	NA	38*	NA	75.0	Fair
N. Fk Short Creek	6.21	HW	14	1,652	NA	44	NA	76.0	Good
N. Fk. Short Creek	0.09	HW	16	1,030	NA	44	NA	68.5	Good
Long Run	0.26	HW	12	1,572	NA	42ns	NA	61.5	Marginally Good
Piney Fork	10.51	HW	9	2,818	NA	44	NA	73.0	Good
Piney Fork	0.35	Wading	21	1,066	7.59	46	8.2ns	71.3	Very Good
Dry Fork	0.15	HW	14	688	NA	46	NA	67.5	Very Good
Little Short Creek	4.99	HW	11	4,038	NA	34*	NA	85.8	Fair
Little Short Creek	0.08	HW	22	1,442	NA	56	NA	78.0	Exceptional
Coal Run	0.20	HW	7	2,608	NA	34*	NA	62.8	Fair
Direct Ohio River Tributaries									
Salt Run	0.60	HW	5	891	NA	32*	NA	40.5	Fair
Rush Run	2.71	HW	7	2,374	NA	30*	NA	64.5	Fair
Rush Run	0.65	HW	24	2,050	NA	52	NA	77.3	Exceptional
Deep Run	2.40	HW	2	588	NA	<u>22</u>*	NA	50.8	Poor
Deep Run	0.25	HW	7	965	NA	34*	NA	47.0	Fair
Glenns Run	2.90	HW	4	2,072	NA	30*	NA	66.5	Fair
Glenns Run	0.10	HW	17	1,266	NA	52	NA	58.3	Exceptional

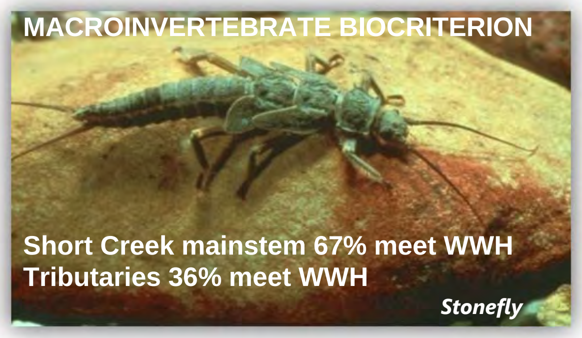
ns Nonsignificant departure from biocriterion (<u><</u>4 IBI units; <u><</u>0.5 MIwb units).
* Significant departure from biocriterion (>4 IBI units; >0.5 MIwb units). Poor and very poor results are underlined.
HW - Headwater

BIOCRITERIA	
INDEX - Site Type	WWH
IBI: Headwater/Wading	44/ 44
MIwb: Wading	8.4

General narrative ranges assigned to IBI scores		
Narrative Rating		IBI Range Headwaters/Wading
Excellent – Very Good	(blue)	60 to 49
Good – Marginally Good	(green)	45 to 40
Fair	(yellow)	39 to 28
Poor to Very Poor	(red)	27 to 12

Macroinvertebrate Community

Macroinvertebrates were sampled at 18 locations in the Short Creek watershed. Additional sampling at nine sites was conducted in several adjacent, direct Oho River tributaries including Salt, Deep, Rush (resampled in 2011) and Glenns runs (Figures 5 and 16). Qualitative sampling was conducted at all sampling sites while quantitative, Hester/Dendy artificial substrate samplers were retrieved from 6 sites. Artificial substrate sampling was largely restricted to drainages >20 mi^2. A summary of the macroinvertebrate data are presented in Table 16 while raw macroinvertebrate data are presented in Appendix Tables A10 and A11.



Based on qualitative narrative evaluations and Invertebrate Community Index (ICI) scores, 16 of 28 study area samples (57%) were in the marginally good to exceptional range, thereby meeting or exceeding minimum WWH performance levels. As a rule, remaining lower quality sites that fell in the fair to very poor ranges were from small, largely mined, headwater drainages (<20 mi^2) and accounted for 60% (n=15) of impaired sites. In contrast, all larger drainages with associated ICI scores met WWH expectations. Still the mainstem collections reflected continued or residual mine drainage influences in Short Creek.

In comparing the Short Creek watershed to the other watersheds (Cross and Wheeling creeks) sampled during the 2010 Central Ohio River Tributaries survey (for watershed reports, see http://epa.ohio.gov/dsw/tmdl/OhioRiverTributariesEast.aspx) and absent stream size, lower performing sites were not evenly distributed. 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 in the CORT survey area shifted from 100% (northern Ohio River tributaries, *e.g.* Island Creek), to 70% (Cross Creek), to 67% (Short Creek), to 56% (southern Ohio River tributaries, *e.g.* Salt, Rush Deep and Glenns runs) to a low of 44% in the southernmost, Wheeling Creek watershed. The trend of shifting macroinvertebrate quality across the 2010 CORT basins corresponded with shifts in land use 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 three CORT basins.

The trend is illustrated in Figure 16, a map which displays the strong negative correlations between intolerant mayfly taxa richness (a surrogate for higher macroinvertebrate quality) and elevated 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 sites. However, intolerant mayflies were typically absent or rare in mine impacted streams and appeared particularly sensitive to abandoned mine drainage as is shown in Figure 16 and, the lower Piney Creek site had some of the lowest average TDS in the Short Creek watershed and direct Ohio River tributaries study area.

Another indicator of macroinvertebrate performance was reflected in the qualitative EPT and sensitive taxa richness attributes. Sensitive taxa include *intolerant* and *moderately intolerant* varieties assigned based on analysis of the Ohio EPA historical sampling database. These results are presented by basin in Figure 17. As displayed, water quality impacts in the Short Creek watershed yielded greater numbers of these positive stream quality indicators. In contrast, decreasing richness and correspondingly lower biological performance are evident in the direct

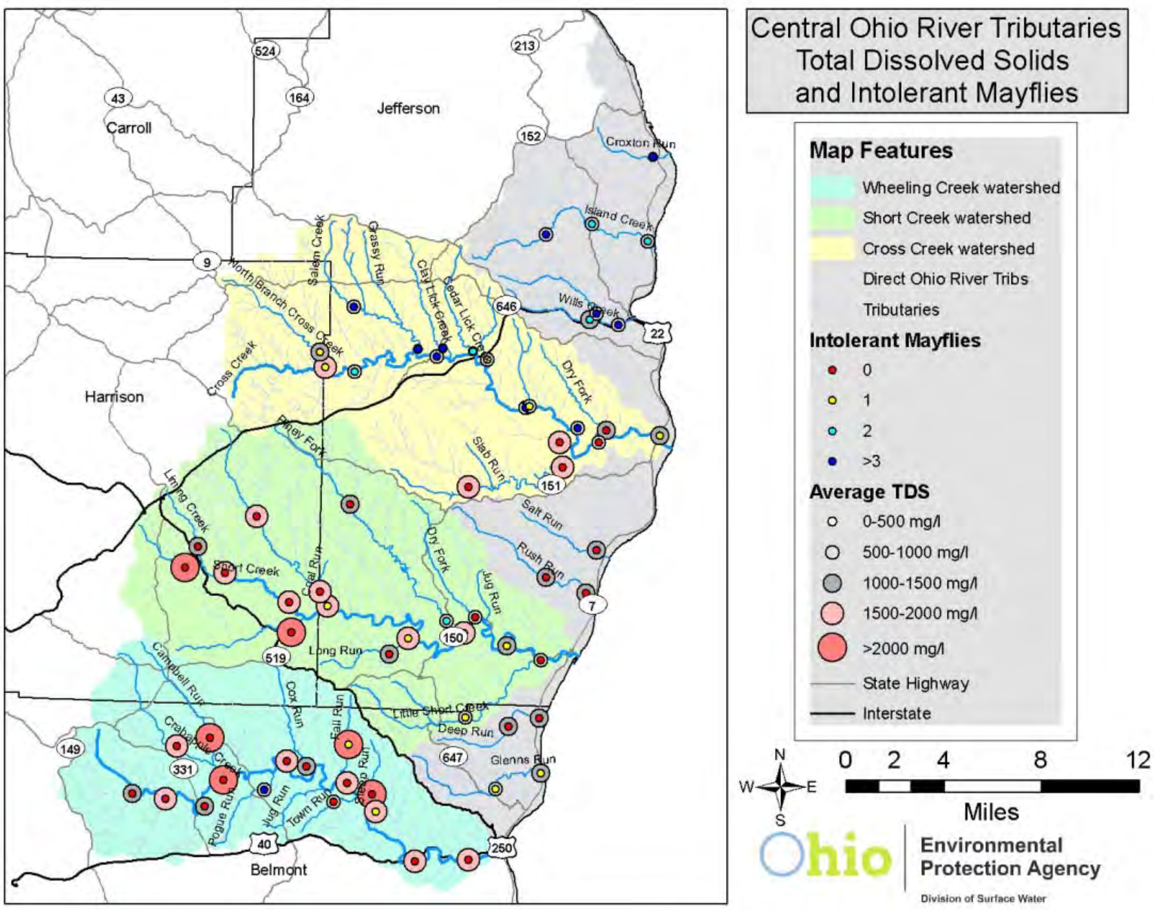


Figure 16. Numbers of Intolerant (i.e., pollution sensitive) mayfly taxa and associated ranges of TDS at CORT survey sites as a whole in comparison to the Short Creek watershed and direct Ohio River tributaries study areas, 2010.

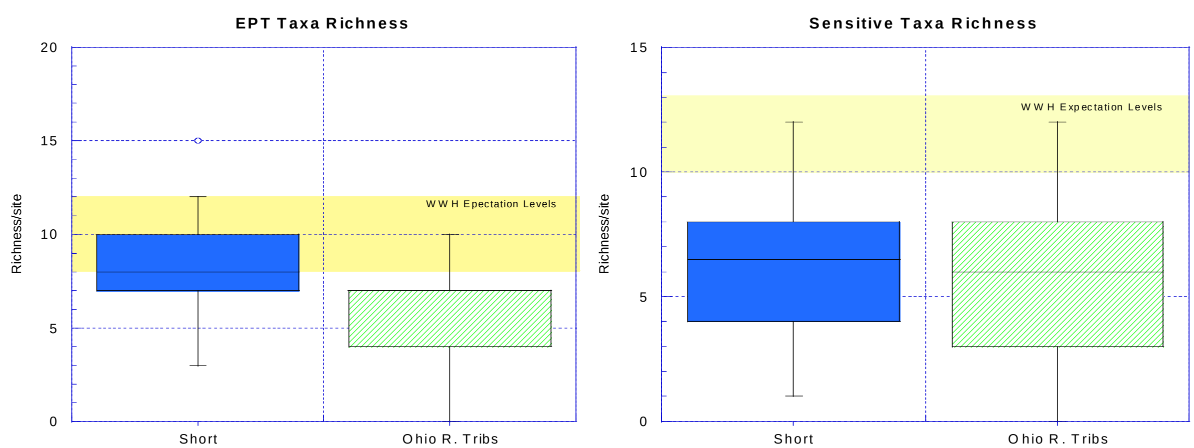


Figure 17. Qualitative EPT and sensitive taxa (includes intolerant and moderately intolerant) richness at Short Creek watershed and direct Ohio River tributaries sampling locations, 2010.

Ohio River tributaries. Again, this trend follows the pattern of active and previous coal mining activities in the study area.

With few exceptions, macroinvertebrate impairments at all Short Creek watershed and direct Ohio River tributary sites were related to mining. Middle Fork Short Creek at RM 6.3 had low numbers of sensitive and EPT taxa, in line with other mine influenced tributary sites in the Short Creek headwaters near Cadiz. However, the site was also located 0.72 miles downstream from the Cadiz WWTP and the strong odor of sewage, coupled with a predominance of enrichment tolerant flatworms and midges, reflected impacts from the plant.

Salt Run, a small, direct Ohio River tributary, drains a large area of active mining and the channel lies directly adjacent to an over widened haul road used by large mining trucks. During rainfall events, the creek receives a heavy load of fine silts from road runoff (Figure 18, left photo). Coincidentally, all stream substrates were covered with a similar layer of fine, light silt and the corresponding macroinvertebrate collections were fair (Table 16). The waters of Deep Run at RM 1.55 (Figure 18, right photo), and Glenns Run (RM 2.15) were discolored orange and fouled by mine drainage flocculants. These were among the most severely impacted stream sites in the survey, ranging from very poor to fair macroinvertebrate quality.

Figure 18. Mine haul road runoff in Salt Creek (RM 0.6) following a rainfall event (left photo) and mine drainage in Deep Run (RM 1.55; right photo).

Mainstem Sampling Results for Short Creek

In contrast to qualitative collections from smaller, mine influenced tributaries, all quantitative sites along the Short Creek mainstem exceeded or nearly exceeded the WWH biocriterion (Figure 19). While these ICI scores were sufficient to meet WWH, most mainstem collections still reflected background mining or other negative influences within the study area. For example, mainstem ICI metric scores were persistently low for mayfly richness and mayfly percentage (Appendix Table A9) and these organisms are considered largely sensitive to mining impacts. In contrast, caddisfly and tanytarsini midge metric scores from the same sites were consistently higher. Like mayflies, caddisfly and tanytarsini midge populations are also considered positive water quality indicators. However, as a group, they are considered more tolerant of TDS and mining than mayflies (Pond et al., 2007). This trend was evident in the study area where collections of facultative, net-spinning caddisflies (*i.e.,* the genera *Cheumatopsyche*, and *Hydropsyche*) consistently predominated natural substrate collections at both mine influenced mainstem sites and all but the most severely mine-impacted tributaries. In addition, two common and facultative midges of the tribe Tanytarsini (*i.e.,* the genera *Rheotanytarsus* and *Tanytarsus*) regularly predominated artificial substrate collections at mine influenced sites. These larger stream reaches included all of Short Creek. Each site had

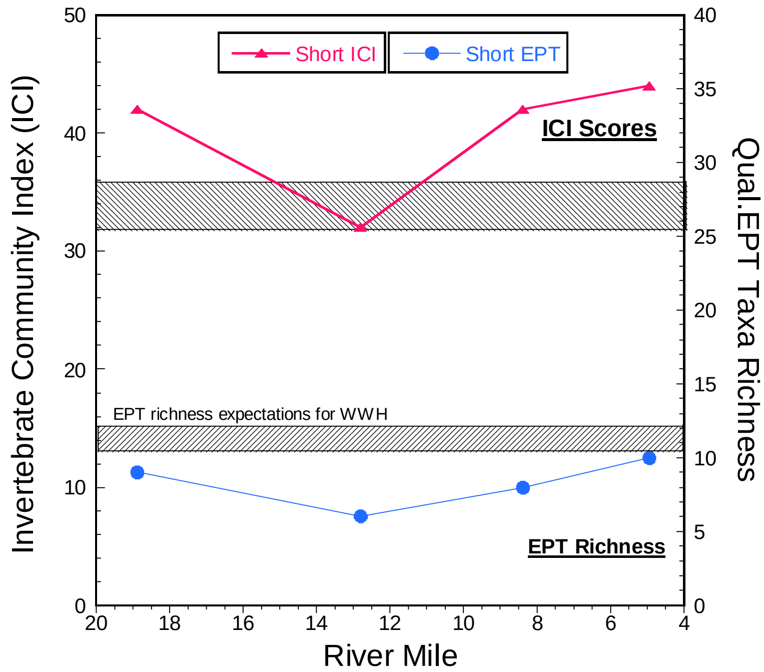


Figure 19. ICI scores (Y1 axis) and EPT taxa richness (Y2 axis) from Short Creek mainstem sites, 2010. Upper diagonal shading denotes minimum WWH ICI scoring range (Y1 axis). Lower diagonal shading marks approximate level for EPT taxa richness expectations for WWH communities based on most recent Ohio EPA state collection data.

comparatively low numbers of EPT taxa, sensitive taxa, and sensitive mayfly taxa. Taken as a whole, the results suggest persistent, though not severe, mine drainage influences throughout the study area.

The fact that many mainstem ICI scores met WWH criteria, despite widespread mining activity and elevated TDS, could be related to a couple of factors. First, the artificial substrate habitat provided clean substrates in optimal current, a benefit to colonizing populations. In contrast natural substrates at mined sites were often lower quality containing loose sands, depositional silts, coal fines, mineral precipitates (*e.g.,* sulfides) or legacy contaminates (*e.g.,* “red dog” foundry sands). Second, the enhanced buffering capacity encountered in Short Creek streams tends to mitigate or dampen the effects of elevated mining parameters on biological communities. These two factors could have had a tendency to influence the final ICI scores in the mined streams, defining somewhat better than anticipated stream quality.

Based on ICI scores for Short Creek, macroinvertebrates ranged from very good to marginally good at four sites along the approximate 19 mile length (Figure 19; Table 16). As can be seen in Figure 17 or Table 16, qualitative EPT and sensitive taxa richness were relatively low in Short Creek, despite ICI scores that met the WWH biocriterion. As discussed previously, the marginal performance was attributed to background mining influences and elevated TDS. No past comparison with current data could be made since no historical macroinvertebrate sampling has been collected by Ohio EPA in the Short Creek watershed.

Table 16 Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Short Creek watershed and direct Ohio River tributaries, July to October, 2010 and July 2011[#].

River	River Mile	Narrative Evalaution	Qual[a] Taxa	Sens.[b] Taxa Ql./Total	EPT Taxa Ql./Total	Density[c] Ql. or Qt.	ICI	Predominant Populations on the Natural Substrates (Tolerance Categories = sensitive, facultative, tolerant)[d]
Short Creek Watershed								
Short Creek	18.90	**Very Good**	51	7 / 7	9 / 10	516	42	Net-spinning caddisflies, midges (facultative)
Short Creek	12.80	M. Good	35	6 / 6	6 / 7	455	32[ns]	Net-spinning caddisflies (facultative)
Short Creek	8.40	**Very Good**	49	8 / 11	8 / 10	396	42	Net-spinning caddisflies (facultative)
Short Creek	4.96	**Very Good**	44	8 / 9	10 / 12	625	44	Net-spinning (facultative) and fingernet caddisflies (sensitive)
South Fork Short Creek	1.13	Fair	29	7	7	Low-Mod.	--	Net-spinning (facultative) and fingernet caddisflies (sensitive)
Middle Fork Short Creek	5.35	Fair	30	1	3	Mod.	--	Flatworms (facultative), midges (facultative-tolerant)
Middle Fork Short Creek	1.60	M. Good	28	4 / 4	5 / 6	226	34[ns]	Net-spinning caddisflies, midges (facultative-tolerant)
Sally Buffalo Creek	0.17	Fair	33	2	3	Low	--	Fingernet caddsflies (sensitive)
Liming Creek	0.15	Fair	45	1	7	Mod.	--	Net-spinning caddisflies (facultative), midges (facultative-tolerant)
North Fork Short Creek	6.21	Fair	30	2	7	Low	--	Net-spinning (facultative) and fingernet (sensitive) caddisflies
North Fork Short Creek	0.60	Fair	34	7	7	Low	--	Net-spinning caddisflies (facultative)
Long Run	0.26	M. Good	42	8	8	Low-Mod.	--	Net-spinning caddisflies, scuds (facultative)
Piney Fork	10.51	M. Good	33	6	9	Mod.	--	Net-spinning caddisflies and riffle beetles (facultative),
Piney Fork	0.35	Exceptional	23	4 / 7	8 / 12	242	48	Baetid mayflies, net-spinning caddisflies (facultative)
Dry Fork	0.15	M. Good	36	6	11	Low	--	Baetid mayflies and net-spinning caddisflies (facultative)
Little Short Creek	4.99	Good	48	12	15	Mod.	--	Net-spinning caddisflies, baetid mayflies, (facultative)
Little Short Creek	0.08	M. Good	34	7	12	Low	--	Net-spinning caddisflies, baetid mayflies (facultative), fingernet caddisflies (sensitive)
Coal Run	0.15	Good	56	11	12	High	--	Net-spinning caddisflies (sens- fac.), baetid mayflies (facultative)

River	River Mile	Narrative Evalaution	Qual[a] Taxa	Sens. [b] Taxa Ql./Total	EPT Taxa Ql./Total	Density [c] Ql. or Qt.	ICI	Predominant Populations on the Natural Substrates (Tolerance Categories = sensitive, facultative, tolerant)[d]
Ohio River Tributaries								
Salt Run	0.60	Fair	35	6	5	Low-Mod.	--	Scuds (facultative)
Rush Run	2.80	Good	35	12	10	--	--	Scuds (fac.), stoneflies (sens.), Net-spinning caddis.(sens.-fac.)
Rush Run (2011)	1.00	M. Good	41	10	9	Low	--	Net-spinning caddisflies (sensitive-facultative), scuds (fac.), stoneflies (sensitive)
Rush Run (2010)	1.00	Fair	33	6	7	Low-Mod.	--	Net-spinning caddisflies, flat-headed mayflies (facultative)
Deep Run	2.40	M. Good	27	8	7	High	--	Scuds (facultative)
Deep Run	1.55	V. Poor	2	0	0	None	--	None
Deep Run	0.25	Poor	13	1	0	Low	--	Scuds (facultative)
Glenns Run	2.70	M. Good	40	6	10	High	--	Net-spinning caddisflies (sensitive.-facultative), baetid mayflies (facultative), water pennies (sensitive)
Glenns Run	2.15	Fair	16	4	4	Low	--	Riffle beetles (facultative)
Glenns Run	0.10	Fair	29	3	7	Low	--	Net-spinning caddisflies (facultative)

\# One site resampled in July 2011.

a Ql.: Qualitative sample collected from the natural substrates.

b 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.

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

ns nonsignificant departure of ecoregional biocriterion (≤4 ICI units).

ACKNOWLEDGEMENTS

The following Ohio EPA staff provided technical expertise for this project:

Report preparation and analysis	Jack Freda, Kelly Capuzzi, Randy Spencer and Brian Alsdorf
Data support	Dennis Mishne and Bryan Schmucker
Reviewers	Kelly Capuzzi, Mike Bolton, Jeff DeShon, Holly Tucker, Joann Montgomery, Aaron Pennnington, Tim Campbell and Dan Messerly
Stream sampling	Macroinvertebrates – Jack Freda Fish – Brian Alsdorf, Ben Rich, Kelly Capuzzi, Randy Spencer and Gregg Sablak. Chemistry – Randy Spencer, Kelly Capuzzi, Joann Montgomery and Dan Imhoff Modeling - Dale White and Paul Gledhill

We would also like to thank Chad Kinney, Mike Mozena, Dylan Pendleton and Tamara Richards with ODNR-MRM for their assistance with field reconnaissance and data collection. Seasonal college interns who assisted with field data collection include Audra Sabo, Nicole Smith, Amelia Hettinger, Lynn Parkins, Christopher Stephan, Andrew Butler, Caleb Shields, Nicholas Hardesty, April Denega, Brie Elking, Lindsey Boaz, Josh Griffin, Matt Lane, Claire Westervelt and Mike Taricska.

The Ohio EPA appreciates the numerous property owners who allowed field staff access to the project area.

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