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Ohio Environmental Protection Agency
Division of Surface Water

Biological and Water Quality Study of Salt Creek and Selected Tributaries

(Muskingum River Basin)

Ted Strickland, Governor
Lee Fisher, Lt. Governor
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Biological and Water Quality Survey of Salt Creek and Selected Tributaries (Muskingum River Basin)

2008

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prepared by

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SUMMARY

All rivers and streams in Ohio support a variety of uses such as recreation and water supply, as well as supporting aquatic life. Ohio EPA evaluates each stream to determine the appropriate use designation and to also determine if the use is meeting the goals of the federal Clean Water Act. Twenty-one sites in the Salt Creek watershed were evaluated for aquatic life and 23 sites were evaluated for recreation use potential in 2008-09 (see Figure 1 and Table 1 for sampling locations). Cutler Lake was sampled for chemistry, bacteria and fish tissue (for fish consumption).

Overall, the Salt Creek watershed met the biological goals of the Clean Water Act with 100% of the watershed in full attainment (Table 1 and Figure 1). All 21 biological sampled sites in the Salt Creek watershed were fully meeting their respective designated or recommended aquatic life use. The biological performance of twelve sample sites was very good to exceptional, and nine sample sites were performing in the good range. Most streams in the Salt Creek watershed have the potential for habitat improvements. Decreases in sand bed load from non-point sources (NPS) via improved agricultural best management practices, stabilizing banks by reducing grazing animal access to streams and increasing riparian buffer widths would help improve stream habitat. Notable conclusions and recommendations include the following:

- Buffalo Run and Kent Run are currently listed as Warmwater Habitat (WWH) streams. Biological monitoring during this study confirmed that these streams should be designated Exceptional Warmwater Habitat (EWH).
- Ten streams with an existing WWH use designation should be maintained. These streams include Salt Creek, Manns Fork, Boggs Creek, Indian Run, Williams Fork, White Eyes Creek, Pleasant Run, Little Salt Creek, Frog Run and Georges Run. Re-sampled sites on Kent Run, a tributary to Manns Fork, and Little Salt Creek met the biological goals of the Clean Water Act after resolving temporary localized issues.
- The Unnamed Tributary (UT) to Manns Fork was evaluated in this study and is not currently listed in the Ohio WQS, but meets the proposed rule for Primary Headwater Habitat Class III use designation.
- All 14 streams in the Salt Creek study area should retain the Primary Contact Recreation (PCR) use, along with the Agricultural Water Supply and Industrial Water Supply uses.

The recreation use goal of the Clean Water Act was met at 13% (three) of the sites in the Salt Creek basin and was in non-attainment at 87% (twenty) of the sites due to high bacteria (Table 5). The locations not supporting the recreation use were most likely affected by unsanitary conditions from agricultural activities, such as pasture land runoff, manure land application and unrestricted cattle access to the stream. Other sources were from sewage discharges in unsewered areas. Salt Creek has few areas with centralized municipal sewage systems.

Table 1. Salt Creek watershed (Muskingum River basin) sampling locations from the 2008 survey.

Site Number*	Location	River Mile	Drainage Area	Latitude	Longitude
1[a]	**Salt Creek** Bethel Road	25.7	2.0	40.02696774	-81.828080095
2[a]	**Salt Creek** Leachman Road	24.95	4.8	40.029854218	-81.841135855
3	**Salt Creek** Knipe Road	23.43	14.0	40.032196981	-81.866611317
4	**Salt Creek** Norfield Road	18.3	23.5	40.010170264	-81.870178435
5	**Salt Creek** U.S. Route 40	12.91	43.0	39.973532352	-81.847926857
6	**Salt Creek** State Route 146 (gage)	5.6	75.7	39.90862500	-81.860955000
7	**Salt Creek** Adj. Manns Fork Road	1.1	145	39.87402499	-81.895782988
8[a]	**Prairie Fork** Knipe Road confluence of Salt Creek	0.1	7.3	40.031966910	-81.865665079
9	**Georges Run** U.S. Route 22	1.63	5.5	39.980867744	-81.816808313
10	**Frog Run** Arch Hill Road	0.36	6.2	39.975848809	-81.852201887
11	**Little Salt Creek** Sonora Road	5.08	8.0	39.97566252	-81.905906613
12	**Little Salt Creek** Claypipe Road	0.11	14.7	39.931916138	-81.871947035
13	**White Eyes Creek** Okey Road	1.67	8.1	39.925186515	-81.840684704
14	**Buffalo Fork** Leedom Road	6.55	9.9	39.884204041	-81.784989842
15	**Buffalo Fork** Okey Road	2.13	25.6	39.903351000	-81.839368000
16	**Buffalo Fork** Farm lane of S.R. 146	0.7	27.6	39.897391000	-81.866860000
17	**Williams Fork** Pine Lake Road	0.2	6.7	39.903557266	-81.823732288
18	**Boggs Creek** Three Towers Rd and S.R. 146	4.04	10.4	39.918772433	-81.904461917
19	**Boggs Creek** Salt Creek Road	0.9	17.8	39.891391566	-81.885586512
20	**Manns Fork** Cutler Lake Road	4.2	7.8	39.847713331	-81.867200323
21	**Manns Fork** Mock Road	2.31	18.6	39.869093984	-81.863892850
22	**Kent Run** Browning Road	0.6	8.3	39.864600000	-81.855000000
23	**Pleasant Run** Clay Pike	0.1	2.3	39.92630000	-81.84240000
24	**Indian Run** Mast Road	0.1	4.2	39.89550000	-81.89800000
25[b]	**UT Manns Fork @** RM 2.3	0.1	0.46	39.87103000	-81.86153000

***The color of the site number corresponds to the narrative biological scores based on the combination and assessment of macroinvertebrate and fish data collect at that site (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, very poor do not meet the goals of WWH) and white sites were not fully biologically evaluated.**

a – Biological Integrity Equivalents (BIE) scores are based on macroinvertebrate community only (Table 11).

b – BIE based on Headwater Habitat Evaluation Index score of 76, Headwater Macroinvertebrate Field Evaluation Index score of 32 and Primary Headwater Habitat Class III determination.

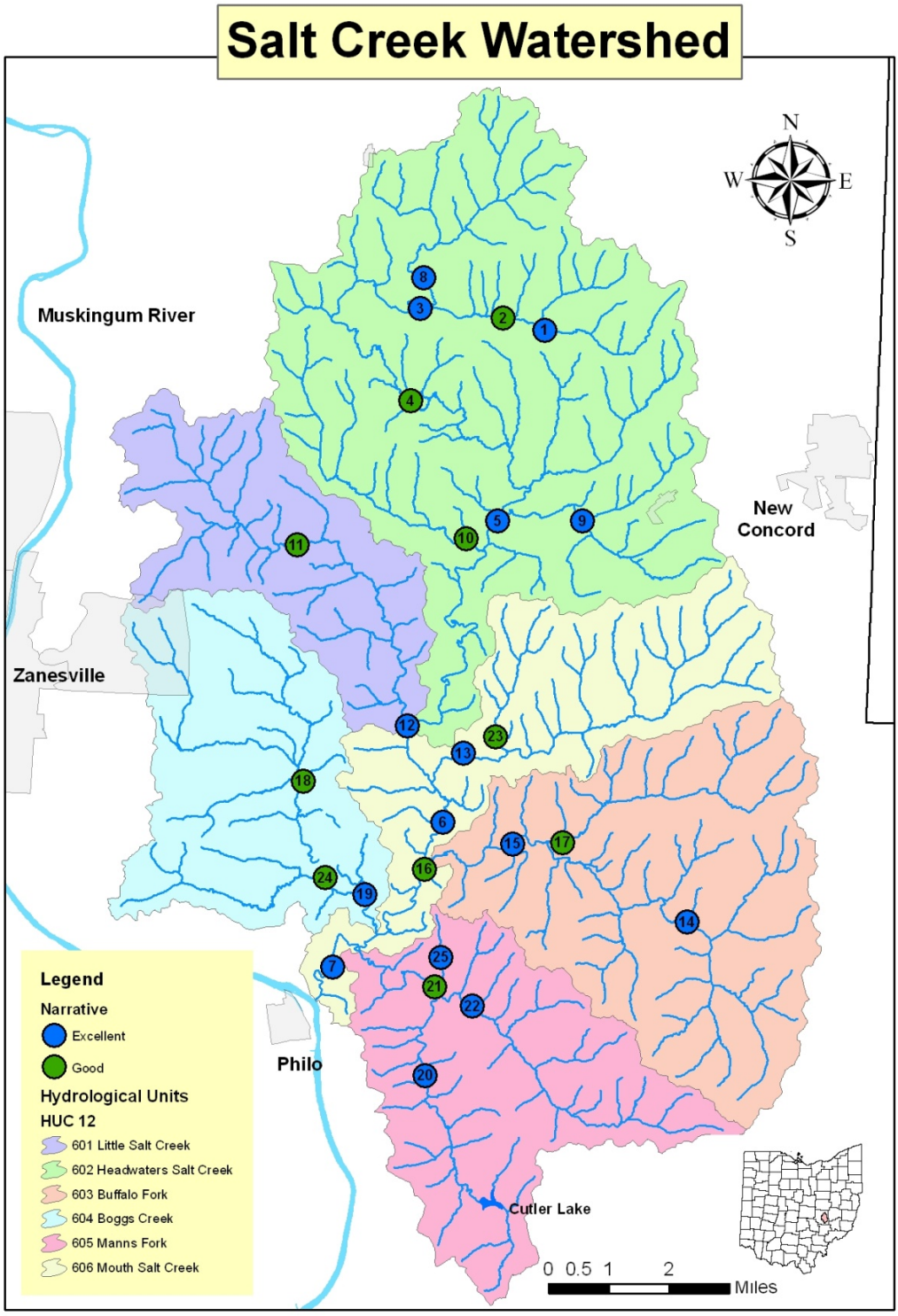

Figure 1. Salt Creek watershed (Muskingum River basin) sampling locations and biological community performance. Site numbers correspond to Table 1.

Table 2. Aquatic life use attainment status for sampling locations in the Salt Creek watershed, 2008 and 2009. *The Index of Biotic Integrity (IBI), Modified Index of Well-being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of the biological community. Stream habitat reflects the ability to support a biological community. The Salt Creek watershed is in the Western Alleghany Plateau (WAP) ecoregion. For the Aquatic Life Use Designation, R denotes a recommendation that differs from the current use designation.*

Stream	Sample Location River Mile	Sampling Type	Ecoregion	Aquatic Life Use Designation	Aquatic Life Attainment Status	IBI	MIwb	ICI[a]	Stream Habitat[b]
Salt Creek	25.7	Headwater	WAP	WWH	-	-	-	VG	-
Salt Creek	25.0	Headwater	WAP	WWH	-	-	-	G	-
Salt Creek	23.5	Headwater	WAP	WWH	FULL	50	NA	VG	44 – Fair
Salt Creek	18.3	Wading	WAP	WWH	FULL	40[ns]	9.4	VG	50 - Fair
Salt Creek	12.7	Wading	WAP	WWH	FULL	47	10.2	52	71.5 - Good
Salt Creek	5.6	Wading	WAP	WWH	FULL	46	9.8	40	67.5 - Good
Salt Creek	2.1	Wading	WAP	WWH	FULL	45	9.5	VG	59.0 – Fair
Manns Fork	4.1	Headwater	WAP	WWH	FULL	48	NA	E	81.0 - Excellent
Manns Fork	2.4	Headwater	WAP	WWH	FULL	46	NA	VG	71.5 - Good
Kent Run*	1.1	Headwater	WAP	EWH – R	FULL	52	NA	E	87.0 - Excellent
Boggs Creek	4.1	Headwater	WAP	WWH	FULL	50	NA	G	58.0 – Fair
Boggs Creek	1.0	Headwater	WAP	WWH	FULL	52	NA	44	83.5 - Excellent
Indian Run	0.1	Headwater	WAP	WWH	FULL	44	NA	MG[ns]	34.0 - Poor
Buffalo Fork	6.6	Headwater	WAP	EWH - R	FULL	50	NA	VG[ns]	76.5 - Excellent
Buffalo Fork	2.1	Wading	WAP	EWH - R	FULL	50	8.9[ns]	E	68.0 - Good
Buffalo Fork	1.5	Wading	WAP	EWH - R	FULL	52	9.6	E	74.0 - Good
Williams Fork	0.2	Headwater	WAP	WWH	FULL	46	NA	VG	70.0 - Excellent
White Eyes Creek	1.6	Headwater	WAP	WWH	FULL	48	NA	VG	81.0 - Excellent
Pleasant Run	0.1	Headwater	WAP	WWH	FULL	45	NA	VG	70.5 - Excellent
Little Salt Creek**	5.1	Headwater	WAP	WWH	FULL	40[ns]	NA	VG	57.0 – Fair
Little Salt Creek	0.1	Headwater	WAP	WWH	FULL	52	NA	VG	73.5 - Excellent
Frog Run	0.1	Headwater	WAP	WWH	FULL	46	NA	G	60.0 - Good
Georges Run	1.6	Headwater	WAP	WWH	FULL	48	NA	E	74.5 - Excellent
Prairie Fork	0.1	Headwater	WAP	WWH	-	-	-	VG	-

BIOCRITERIA		
Ecoregion	WAP	Statewide
INDEX - Site Type	WWH	EWH
IBI: Headwater/Wading	44/44	50/50
MIwb: Wading	8.4	9.4
ICI	36	46

[ns] Nonsignificant departure from biocriterion (≤4 IBI or ICI units; ≤0.5 MIwb units).
[a] Narrative evaluation used in lieu of ICI (E=Exceptional; VG=Very Good; G=Good; MG=Marginally Good).
[b] Narrative habitat evaluations are based on QHEI scores as follows: Excellent =75-100, Good = 60-74, MG = Marginally Good = 55-59, Fair = 44-54, Poor = 30-43 & Very Poor <30.

* See Macroinvertebrate and Habitat Sections.

** See Fish Community and Habitat Sections.

RECOMMENDATIONS

The streams in the Salt Creek watershed study area currently listed in the Ohio Water Quality Standards are assigned the aquatic life use designation of Warmwater Habitat (WWH) from the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. This study used biological data to evaluate and establish aquatic life uses for a number of streams in the Salt Creek watershed study area. One of the streams in the study area (UT Manns Fork) is not listed in the Ohio Water Quality Standards while Lepage Run is listed and was not evaluated.

Twenty-one sites on 12 different streams in the Salt Creek study area were evaluated for aquatic life and 23 sites for recreation use support in 2008 and 2009 (Tables 2 and 5). Significant findings include the following:

- Buffalo Fork and Kent Run are currently listed as WWH streams. Biological monitoring during this study confirmed that these streams should be designated EWH.
- Ten streams with an existing WWH use designation should be maintained. These streams include Salt Creek, Manns Fork, Boggs Creek, Indian Run, Williams Fork, White Eyes Creek, Pleasant Run, Little Salt Creek, Frog Run and Georges Run.
- UT Manns Fork was evaluated in this study and is not currently listed in the Ohio WQS. The recommended use designations are noted in Table 3.
- All 12 streams in this study should retain the PCR use, along with the Agricultural Water Supply and Industrial Water Supply uses.

The habitat quality of the Salt Creek watershed could be improved by excluding cattle access (fencing) to the streams which would also improve riparian corridors, decrease or maintain lower stream temperatures by shading the creeks, provide a leaf litter food base for aquatic insects and decrease bacterial inputs to the stream. Improved riparian corridor widths would decrease peak flow deliveries and NPS agricultural nutrient inputs. In the mainstem of Salt Creek, increased riparian corridor widths in various sampled reaches would stabilize banks, decrease down-cutting, decrease stream entrenchment, and decrease sand bedload movement within the main channel while increasing instream stability.

Specifically, cattle fencing and riparian corridor improvements would benefit the following streams:

- Frog Run near Norfield Rd., Sonora Rd., or Piper Rd.
- Georges Run and tributaries
- upper Buffalo Fork and tributaries and lower Buffalo Fork
- Williams Fork
- Indian Creek
- Boggs Creek
- Little Salt Creek
- Manns Fork near Mock Rd.

Sewage discharges in unsewered areas need to be inspected to determine if the septic systems are in proper operating order. Improvements in operation and maintenance and periodic inspection of home septic systems, along with the elimination of unrestricted cattle access to streams through fencing, would greatly reduce bacterial inputs to the Salt Creek watershed.

Table 3. *Waterbody use designation recommendations for Salt Creek watershed (Muskingum River basin).* *Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). A plus sign (+) indicates a new recommendation or confirmation of an existing use based on the findings of this report; ▲denotes a recommended change in use designation.*

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	
Salt Creek		*/+							*/+	*/+		*/+		
Manns Fork – at RM 6.77		*/+						º	*/+	*/+		*/+		
- all other segments		*/+							*/+	*/+		*/+		
Trib. to Manns Fork at RM 2.3									*/+	*/+		*/+		Primary Headwater Habitat Class III Pending
Kent Run		*	▲						*	*		*		
Boggs Creek		*/+							*	*		*		
Indian Run		*/+							*/+	*/+		*/+		
Buffalo Fork		*	▲						*/+	*/+		*/+		
Williams Fork		*/+							*/+	*/+		*/+		
Lepage Run		*							*	*		*		
White Eyes Creek		*/+							*/+	*/+		*/+		
Pleasant Run		*/+							*/+	*/+		*/+		
Little Salt Creek		*/+							*/+	*/+		*/+		
Frog Run		*/+												
Georges Run		*/+							*/+	*/+		*/+		
Prairie Fork		*							*/+	*/+		*/+		

INTRODUCTION

Salt Creek discharges into the Muskingum River at river mile 67.03, is 27.1 miles long and encompasses 145 square miles. Salt Creek is located within the Western Allegheny Plateau ecoregion. Land-use within the watershed is comprised of 48% agriculture and 50% forested areas. The other 2% is composed of urbanization, open water, barren, non-forested wetlands, and shrub/scrub areas. Fourteen streams within Salt Creek watershed were sampled in Muskingum County. These streams include Salt Creek, Prairie Fork, Georges Run, Frog Run, Little Salt Creek, White Eyes Creek, Pleasant Run, Buffalo Fork, Williams Fork, Boggs Creek, Indian Run, Manns Fork, Kent Run, UT to Manns Fork at RM 2.3 (Figure 2). Four facilities discharging effluent within the Salt Creek watershed have municipal or industrial National Pollutant Discharge Elimination System (NPDES) permits. These include Blue Rock State Park in Manns Fork, Ohio Department of Transportation Rest Stop Facility 5-20 in Frog Run, Muskingum County Water SE Water Treatment Plant in Indian Run and Lumi-lite Candle Co. in Georges Run (facility descriptions on page 15).

Figure 2. Salt Creek study area.

During 2008, Ohio EPA conducted a water resource assessment of fourteen streams in the Salt Creek watershed using standard Ohio EPA protocols as described in Appendix Table 13. Kent Run and Little Salt Creek (at RM 5.6) were re-sampled in 2009 after habitat impairment issued were resolved. Included in this study were assessments of the biological, surface water and recreation (bacterial) condition. A total of 21 biological, 22 water chemistry, and 23 bacterial stations were sampled in the selected tributaries to Salt Creek and the Salt Creek mainstem. 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.ohio.gov/dsw/gis/index.aspx.

Specific objectives of the evaluation were to:

- establish the present biological conditions in the selected sites in Salt Creek watershed study area by evaluating fish and macroinvertebrate communities,
- assess physical habitat influences on stream biotic integrity,
- determine recreational water quality, and
- determine the attainment status and recommend changes if appropriate.

All of the streams listed in the Ohio Water Quality Standards for the study area are assigned the Warmwater Habitat (WWH) aquatic life use designation. These streams were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. This study used biological data to evaluate and establish aquatic life uses for a number of streams in the study area.

Streams in the Salt Creek watershed are listed as Primary Contact Recreation (PCR), Agricultural Water Supply (AWS), Industrial Water Supply (IWS), and Warm Warmwater Habitat (WWH) aquatic life use designation in the Ohio WQS based on a desktop review. An unnamed tributary to Manns Fork at RM 2.3 is currently undesignated in the Ohio WQS.

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).

RESULTS

Water Chemistry

Surface water chemistry samples were collected five times from the Salt Creek study area at 22 locations (Figure 1, Table 1) between June 24 and September 24, 2008. Additionally, monthly samples were collected from two sentinel sites, Salt Creek at RM 5.6 (USGS gage station) and Buffalo Fork at RM 2.13 (Okey Road) from February through December in 2008. 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 Parts II and III of the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 2006d). 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.

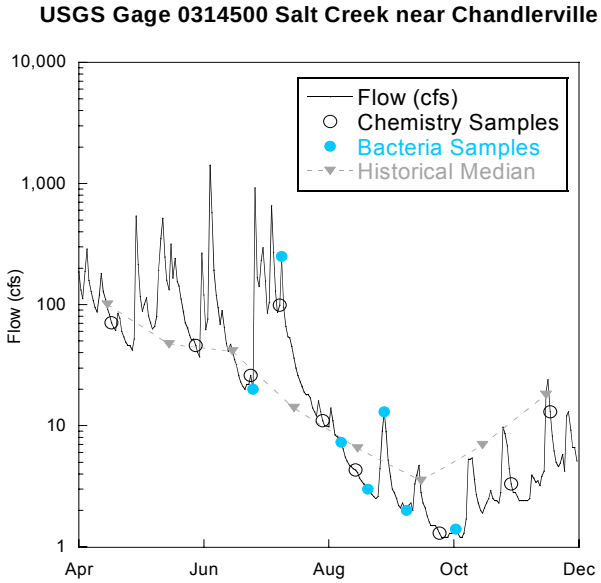

Figure 3. Flow conditions in Salt Creek near Chandlersville during the 2008 Ohio EPA survey.

A United States Geological Survey (USGS) gage station located on Salt Creek, near Chandlersville, was used to show flow trends during the 2008 sampling season (Figure 3.) Dates when water samples and bacteria samples were collected in the study area are noted on the graph. Flow conditions during the summer field season started out above the historic median and ended below the historic median at the end of the field season. Both water and bacteria samples captured a variety of flow conditions in the study area during the field season.

Water Quality
Salt Creek has good water quality with no exceedances of Ohio WQS. Some organic herbicides were detected.

Surface water samples were analyzed for metals, nutrients, bacteria, pH, temperature, conductivity, dissolved oxygen (DO), percent DO saturation, and suspended and dissolved solids (Appendix Table 1). No parameters exceeded Ohio Water Quality Standard (WQS) criteria. Bacteriological samples were collected from all 23 locations, and the results are reported in the Recreation Use section. Nutrients are shown to be elevated in some agricultural areas (Table 4).

Organic herbicides Atrazine, Metolachlor and bis(2-ethylhexyl)phthalate (DEHP) were detected at the two sentinel sampling sites. Atrazine is used as a pre- and post-emergence broadleaf and grassy weed herbicide. U.S. EPA has recently determined that Atrazine is "not likely to cause cancer in human." US EPA is currently performing an extensive study into potential hazards of Atrazine to the environment and humans. Atrazine was detected in Salt Creek at 0.52 µg/l and in Buffalo Fork at 0.33 µg/l, which is below the 3.0 µg/l Ohio WQS criterion. Metolachlor is a grass and broadleaf weed control herbicide which is commonly used in combination with other herbicides. Center of Disease Control states Metolachlor is moderately toxic to fish and U.S. EPA considers Metolachlor to be a possible human carcinogen. Metolachlor was detected in Salt Creek at 0.32 µg/l and Buffalo Fork at 0.29 µg/l. There is no WQS criterion for Metolachlor. DEHP is used in the production of PVC and is used to make plastic flexible. US EPA states DEHP is a probable human cancinogen. DEHP was detected in Salt Creek at 1.15 µg/l and in Buffalo Fork at 1.25 µg/l. The Ohio WQS criterion for DEHP is 6.0 µg/l.

Table 4. Summary statistics for select nutrient water quality parameters sampled in the Salt Creek study area, 2008. The 90th percentile value from reference sites from the Western Allegheny Plateau ecoregion is shown for comparison. Values above reference conditions are shaded yellow. All result reported below are mg/l

			Ammonia—N 0.06 (Headwater) 0.06 (Wadeable)		Nitrate+Nitrite-N 0.606 (Headwater) 1.054 (Wadeable)		Phosphorus-T 0.09 (Headwater) 0.11 (Wadeable)	
Stream	**River Mile**	**Type**	Mean	Median	Mean	Median	Mean	Median
Salt Creek	25.7	HW	0.025	0.025	1.148	1.41	0.0304	0.32
Salt Creek	24.95	HW	0.363	0.071	0.896	0.87	0.065	0.06
Salt Creek	23.43	HW	0.0358	0.025	0.843	0.835	0.038	0.0365
Salt Creek	18.3	W	0.0302	0.025	0.93	0.95	0.0224	0.024
Salt Creek	12.91	W	0.03	0.025	0.646	0.59	0.025	0.021
Salt Creek	5.6	W	0.025	0.025	0.549	0.435	0.015	0.0155
Salt Creek	1.1	W	0.037	0.025	0.444	0.39	0.0178	0.0165
Prairie Fork	0.1	HW	0.098	0.054	0.838	0.89	0.268	0.026
Georges Run	1.63	HW	0.025	0.025	0.166	0.05	0.036	0.038
Frog Run	0.36	HW	0.025	0.025	1.353	1.31	0.043	0.039
Little Salt Creek	5.08	HW	0.0308	0.025	0.393	0.46	0.019	0.021
Little Salt Creek	0.11	HW	0.025	0.025	0.396	0.45	0.0208	0.017
White Eyes Creek	1.67	HW	0.025	0.025	0.0995	0.085	0.009	0.0075
Buffalo Fork	6.55	HW	0.0302	0.025	0.0525	0.05	0.0075	0.005
Buffalo Fork	2.13	W	0.025	0.025	0.147	0.12	0.0237	0.015
Buffalo Fork	0.7	W	0.025	0.025	0.1	0.05	0.05	0.024
Williams Fork	0.2	HW	0.025	0.025	0.104	0.05	0.0118	0.011
Boggs Creek	4.04	HW	0.0544	0.06	0.31	0.26	0.016	0.015
Boggs Creek	0.9	HW	0.025	0.025	0.32	.034	0.013	0.011
Manns Fork	4.2	HW	0.025	0.025	0.06	0.05	0.0094	0.011
Manns Fork	2.31	HW	0.025	0.025	0.13	0.17	0.0074	0.005
Kent Run	0.6	HW	0.025	0.025	0.058	0.05	0.0107	0.005

Recreational Use

Water quality criteria for determining attainment of the recreation use 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 feasible. 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 every type of pathogen. Fecal indicator bacteria, including *E. coli*, by themselves 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 *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.

Bacteria

Elevated bacteria counts were found throughout the watershed. Sewage discharges in unsewered areas, inadequate manure management and unrestricted cattle access to streams are the most likely sources of bacteria.

Streams in the Salt Creek watershed (Muskingum River basin) are designated Primary Contact Recreation (PCR) in OAC Rule 3745-1-24. Water bodies with a designated recreation 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 B support, or potentially support, occasional primary contact recreation activities. The Salt Creek study area is all designated Class B PCR waters. The *E. coli* criteria that apply to PCR Class B streams include a geometric mean of <161 colony forming units (cfu)/100. The geometric mean is based on two or more samples and issued as the basis for determining attainment status (Table 5).

Summarized bacteria results are listed in Table 5, and the complete data set is reported in Appendix Table 2. Downloadable bacteria results are also available from the Ohio EPA GIS interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx. Twenty-three locations in the Salt Creek study area were tested for *E. coli* levels four to eight times, from June 25th – October 10th, 2008. Evaluation of *E. coli* results revealed that 20 of the 23 locations sampled failed to the attain applicable geometric mean criterion indicating an impairment of the recreation use at these locations. The locations not attaining the recreational use were most likely due to unsanitary conditions from failing home sewage treatment systems (HSTS) and/or agricultural activities such as pasture land runoff and manure land application.

Manns Fork at RM 4.2, Kent Run and UT to Manns Fork were the only locations meeting the Class B use criterion. Manns Fork at RM 4.2 and Kent Run have very low developed land-use and are heavily forested. Manns Fork's headwaters begin in Blue Rock State Park. Buffalo Fork, Williams Fork, White Eyes Creek and Boggs Creek all have large amounts of agricultural use in the lowlands and small housing lots along the major roads which are the mostly likely sources of bacteria.

The middle segment of Salt Creek and all of Little Salt Creek fall along the Interstate 70 corridor which has the largest amount of development, including light industry as well as residential developments. Currently only the Zanesville Municipal Airport and the Eastpointe Business Park, along State Route 40, are served by sanitary sewers. The areas along I-70 and County Road 52 are having sewers installed in 2010. This will only resolve the sanitary sewer needs of homes within that corridor.

Figure 4. Typical, unrestricted cattle access to stream.

The headwaters of the Salt Creek watershed are dominated by pasture, hay and row crop land-use along with large forested areas. Cattle were observed in the stream on numerous occasions during the sampling season. Lowland flood plain areas, where row crops were cultivated, have reduced or eliminated wooded or vegetated riparian zones along the stream bank. Pasture land runoff and application of manure to harvested crop fields in late August 2008 were the most likely reason that bacteria levels were so elevated.

Table 5. A summary of E. coli data for the 23 locations in the Salt Creek basin, June 25tth – October 10nd, 2008. Attainment based on comparing the geometric mean, when more than one sample collected, to the Primary Contact Recreation (PCR) criteria of the proposed standard (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 proposed PCR criteria.

Site #	Location	River Mile	Recreation Use	# of Samples	Geometric Mean	Maximum Value*	Recreational Attainment Status	Source(s) of Bacteria[a]
1	Salt Creek	25.7	PCR Class B	8	657	2900	**NON**	A, UCA
2	Salt Creek	24.95	PCR Class B	7	7397	54000	**NON**	A, UCA
3	Salt Creek	23.43	PCR Class B	8	690	7300	**NON**	A
4	Salt Creek	18.3	PCR Class B	8	684	11000	**NON**	A
5	Salt Creek	12.91	PCR Class B	7	567	22000	**NON**	A, SD
6	Salt Creek	5.6	PCR Class B	8	352	48500	**NON**	A, SD
7	Salt Creek	1.1	PCR Class B	8	163	4900	**NON**	A SD
8	Prairie Fork	0.1	PCR Class B	5	1596	15000	**NON**	A
9	Georges Run	1.63	PCR Class B	5	786	1300	**NON**	A
10	Frog Run	0.36	PCR Class B	5	1612	48000	**NON**	A
11	Little Salt Creek	5.08	PCR Class B	5	408	4700	**NON**	A, SD
12	Little Salt Creek	0.11	PCR Class B	8	576	5300	**NON**	A, SD
13	White Eyes Creek	1.67	PCR Class B	5	310	3500	**NON**	A, SD
14	Buffalo Fork	6.55	PCR Class B	5	242	1700	**NON**	A, SD
15	Buffalo Fork	2.13	PCR Class B	8	207	28000	**NON**	A, SD
16	Buffalo Fork	0.7	PCR Class B	5	629	6300	**NON**	A, SD
17	Williams Fork	0.2	PCR Class B	5	487	3700	**NON**	A SD
18	Boggs Creek	4.04	PCR Class B	5	1455	3500	**NON**	A, UCA, SD
19	Boggs Creek	0.9	PCR Class B	5	1168	7000	**NON**	A, SD
20	Manns Fork	4.2	PCR Class B	5	139	320	FULL	
21	Manns Fork	2.31	PCR Class B	5	373	1600	**NON**	A, SD
22	Kent Run	0.6	PCR Class B	5	56	1100	FULL	
23	UT Manns Fork	0.18	PCR Class B	4	116	810	FULL	

a A – Agricultural practices such as inadequate manure management. UCA – Unrestricted cattle access to stream. SD - Sewage discharges in unsewered areas with inadequate or failing septic systems.

**Not used to determine recreation use.*

Effluent Dischargers

A total of four National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge either sanitary wastewater, industrial process water, and/or industrial storm water into the Salt Creek Watershed within Muskingum County. Included in this list are two publicly owned sanitary wastewater plants and two industrial wastewater plants. The two sanitary wastewater dischargers consist of the Blue Rock State Park facility which discharges treated sanitary waste as well as water treatment plant backwash to Manns Fork and the ODOT Rest Stop facility 5-20 which discharges to Frog Run. The two industrial dischargers are the Muskingum County Water Treatment Plant SE facility which discharges filter backwash water to an Unnamed Tributary to Indian Run and the Lumi-Lite Candle Company which discharges industrial process water to an unnamed tributary to Georges Run. Each facility is required to monitor their discharges according to sampling and monitoring conditions specified in their NPDES permit and report results to the Ohio EPA on a Discharge Monitoring Report (DMR). Summarized effluent results are listed in Appendix Table 7.

Blue Rock State Park (Ohio EPA Permit # 0PP00088*AD)
Blue Rock State Park located at 7924 Cutler Lake Road consists of two primitive campground areas as well as a beach house facility located near Cutler Lake with full restroom facilities. The sanitary wastewater generated at the beach house receives treatment from an extended aeration wastewater treatment plant with an average daily design flow of 3,000 gallons per day. The treated effluent undergoes primary settling and secondary treatment prior to being disinfected and discharged to Manns Fork downstream of the lake spillway. In addition to the sanitary wastewater discharge the state park also has a permitted water treatment plant filter backwash discharge listed as Outfall 002 in their permit. The park provides drinking water treatment of the lake water for use at the park which produces a wastewater. The industrial wastewater discharge consists of a routine filter backwash which undergoes treatment through surface sand filters prior to discharge to Manns Fork. A three year facility DMR review is shown in Appendix Table 7.

ODOT Rest Stop facility 5-20 (Ohio EPA Permit # 0PP00052*CD)
Located along the westbound lane of Interstate 70 approximately four miles west of Norwich is the ODOT Rest Stop Facility 5-20. The rest stop consists of two full service restrooms which discharge sanitary wastewater to an extended aeration package plant with an average daily design flow of 10,000 gallons per day. The sanitary waste receives primary, secondary and tertiary treatment through an initial trash trap, aeration basins with clarifiers and surface sand filters. Following the tertiary treatment from the sand filters the treated effluent is disinfected in the months of May through October with ultraviolet radiation and discharged to Frog Run. A five year facility DMR review is shown in Appendix Table 7.

Muskingum County Water SE Water Treatment Plant (Ohio EPA Permit # 0IY00041*CD)
The Muskingum County Water Treatment Plant located at 3830 Wayne Ridge Road provides treatment of drinking water through softening and filtration with sand filters. The sand filters are backwashed on a routine basis and the backwash water is de-chlorinated and filtered prior to discharge to an unnamed tributary to Indian Run. A five year facility DMR review is shown in Appendix Table 7.

Lumi-Lite Candle Company (Ohio EPA Permit # 0IM00021*AD)
The Lumi-Lite Candle Company located at 102 Sundale Road near Norwich, Ohio is a warehouse and manufacturing facility for scented candles and home fragrances. The candle manufacturing facility began operations in the early 1960's and manufactures a variety of scented candles under various names. The facility produces little process wastewater which is combined with sanitary wastewater and treated by the 5,000 gallons per day extended aeration treatment plant. The wastewater is discharged to an unnamed tributary to Georges Run. The sanitary waste undergoes primary, secondary, and tertiary treatment through settling, aeration, sand filtration, and disinfection prior to discharge. Due to the minimal wastewater discharge, the facility was granted authorization in June 2009 to discharge treated wastewater under conditions specified in the general small sanitary discharge permit 0GS00045*AG. A five year facility DMR review is shown in Appendix Table 7.

Sediment Quality

Sediment samples were collected from two locations in the Salt Creek study area by the Ohio EPA on July 28, 2008. Samples were analyzed for metals, semi-volatile organic compounds, organochlorinated pesticides, PCBs, nutrients, and particle size. Specific chemical parameters tested and results are listed in Appendix Table 4. Sediment data were evaluated using guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et.al*. 2000), and *Ohio Specific Sediment Reference Values (SRVs)* for metals (Ohio EPA 2003). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed, and is comparable to background conditions. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed.

Sediment Organic Chemicals

NONE DETECTED

(PCBs, pesticides, semivolatile organics)

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 sands and gravels. All sediment sampling occurred in areas along the stream bank, which were represented by sparse deposits of fine grained material. These nearbank areas comprised only a small fraction of the bottom substrates of the streams surveyed. Bottom substrates at sediment sites were dominated by sand and gravel material. Organic chemical parameters were tested at both sampling locations (Table 6). All organic chemicals were reported as not detected. (Select metals and nutrients are presented in Table 6 and all are below reference concentrations.)

Table 6. Chemical parameters detected in sediment samples collected in the Salt Creek study area, 2008. Results are reported in mg/kg dry weight. Contamination levels were determined for parameters using consensus-based sediment quality guidelines (MacDonald et.al. 2000). Sediment reference values are listed in the Ohio EPA Ecological Risk Assessment Guidance (2003).

Parameter	Salt Creek	Buffalo Fork
	RM 5.6	RM 2.73
Arsenic	4.85	8.23
Cadmium	0.150	0.140
Chromium	11.9	14.7
Copper	11.3	13.7
Lead	12	15.4
Nickel	15.2	18.3
Aluminum	6720	7490
Iron	19900	33000
Zinc	52.4	55.7
Ammonia	70	55
Total Phosphorus	384	420

Cutler Lake

Cutler Lake is located within the 322 acre Blue Rock State Park. The 15 acre lake was constructed in 1938 and is an impoundment of Mann's Fork Salt Creek, with a maximum depth of 15 feet. The lake has a swimming beach and one boat launch; no gasoline boat engines are allowed. The lake serves as a source of drinking water for the Blue Rock State Park. The primary land use of the watershed is forested with some pasture or grassland.

Fish Consumption Advisory
No specific fish advisory for Cutler Lake.
Statewide fish advisory of one fish meal per week.

Water chemistry samples and bacteria samples were collected four times in 2008 and 2009. Sediment samples were collected once in 2008. In 2008, three fish tissue samples were collected and analyzed for fish consumption advisory determination. Sediment was analyzed for metals, nutrients and organic compounds. No sediment analytes were above levels of concern. No exceedances of the proposed Lake Habitat base aquatic life criteria for arsenic, cadmium, chromium, copper, lead, nickel, selenium and zinc were found. All bacteria samples for Cutler Lake were below the PCR Class A recreation use standards (<126 colony forming units) (Table 7). Sampling results can be found in Appendix 6.

The proposed Lake Habitat base aquatic life criteria show that the Secchi disc readings for 4 of 8 samples were below the minimum value of 2.16 meters. The chlorophyll-a median of 12.65 µg/l exceeded the Western Allegheny Plateau (WAP) target of 6.2 µg/l. The total nitrogen median value of 500 µg/l exceeded the WAP target of 350 µg/l. The total phosphorus median value of 24.5 µg/l exceeded the WAP target of 14.5 µg/l. Dissolved oxygen concentrations for 5 of 8 samples (profiles) were below the 6.0 mg/l criterion above the thermocline (metalimnion). Ammonia met the WQS criterion on all dates. Results of the Lake Habitat use parameters are presented in Table 7. There are no fish consumption advisories specifically for Cutler Lake but there is a statewide fish consumption advisory of one fish meal per week. No additional advisories are recommended for Cutler Lake (Table 8).

Table7. Cutler Lake - Lake Habitat Use and PCR Class A attainment status.

Tiered Aquatic Life Criteria							Recreation Use
Parameter	Secchi depth meter(s)	Chlorophyll a µg/l	Total Nitrogen µg/l	Total Phosphorus µg/l	D.O	Nh3 mg/l	*e. coli*
Criteria	2.16 minimum	6.2 median	350 median	14 median	Impaired	temperature dependent	126 cfu/100ml.
6/10/2008	0.76	11.4	0.1	19	yes	<0.05	---
7/14/2008	0.98	6.5	480	28	no	<0.05	10
8/5/2008	1.12	13.2	520	17	yes	<0.05	30
8/21/2008	------	---	---	---	---	---	10
8/27/2008	0.72	10.9	540	21	yes	<0.05	10
6/15/2009	1	13.9	370	11	no	<0.05	20
7/13/2009	1.09	14.5	860	1470	no	<0.05	<10
8/6/2009	1.38	12.1	440	58	yes	<0.05	10
9/1/2009	0.72	14.3	680	120	yes	<0.05	<10
Median	---	12.65	500	24.5	---	---	---
Narrative	watch list	impaired	watch list	watch list	impaired	meets standard	meets standard

Table 8. Results of fish tissue analysis on selected fish fillets collected from Cutler Lake, 2008.

Fish Tissue Analysis					
Species	**Inches**	**# Samples**	**Arsenic** (mg/kg)	**Mercury** (mg/kg)	**Selenium** (mg/kg)
Channel Catfish	16	1	0.037	0.126	0.268
Largemouth Bass	16	1	0.075	0.463	0.442
Redear Sunfish	7	1	0.088	0.311	0.869

Stream Physical Habitat

Figure 5. Williams Fork off Pine Lake Road at RM 0.2.

Stream habitat was evaluated at 21 fish sampling locations (Appendix Table 8). Within the Salt Creek study area, good to excellent stream habitat was recorded at 17 sites (81%), and fair habitat was noted at 3 locations (14%) (Table 9). Indian Run scored a 34.0 which is the in poor range. The average QHEI score for all sites combined was 67.0, consistent with good overall habitat quality. Many of the stream sites were predominated by high quality substrates, including gravel, sand, and cobble. Three stream sites (Boggs Creek at mouth, Williams Creek and Indian Run) were predominated by bedrock substrate. Moderate to extensive embeddedness of the bottom substrates occurred at 16 of the 21 fish sites (76%). Sand dominated the embedded material throughout the study area. Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded, compacted, or covered by fine sand and silt. Extensive embeddedness is detrimental to bottom spawning fish and can impair macroinvertebrate communities.

Physical Habitat Summary

Good to Excellent 81%
Fair 14%

The upper portion of Salt Creek has more agricultural land than forested areas. Many of the stream reaches monitored had little or no riparian corridor remaining. Cattle access to the streams was observed at numerous sites. Indian Run flows through an open pasture and had black manure pooled in the stream along with the lowest habitat score in the watershed. The upper portion of Little Salt Creek had storm water runoff via newly cleared (now impervious) acreage causing flashy flows with erosion, sedimentation and embedded conditions from the Eastpointe Business Park. The sedimentation affected the fish community in 2008. Storm water controls are now in place and the fish community improved in 2009. The lower portion of Salt Creek has more wooded areas, but agriculture dominates the wide stream valleys. Kent Run's streambed was actively mined for gravel during the 2008 sampling season which had a negative impact on the macroinvertebrate community. The landowner said he removed sand and gravel sporadically (once or twice a year) and would cease his instream mining. In 2009 the macroinvertebrate community had recovered and Kent run is now recommended EWH.

Table 9. Stream physical habitat (QHEI) summarized results for the Salt Creek study area, 2008.

Stream	River Mile	Location	QHEI	Comments
EXCELLENT				
Manns Fork	4.3	Cutler Lake Road	81.0	
Manns Fork	2.3	Mock Road	71.5	Nuisance algae, some embedded substrates
Kent Run	1.2	Browning Road	87.0	Instream gravel mining
Boggs Creek	0.9	Salt Creek Road	83.5	Nuisance algae
Buffalo Fork	6.5	Leedom Road	76.5	
Williams Creek	0.2	Pine Lake Road	70.0	Possible enrichment issues
White Eyes Creek	1.7	Okey Road	81.0	
Pleasant Run	0.1	Clay Pike	70.5	
Little Salt Creek	0.1	Claypipe Road	73.5	Moderate sand embeddedness, coal fines
Georges Run	1.8	U.S. Route 22	74.5	
GOOD				
Salt Creek	12.8	U.S. Route 40	71.0	
Salt Creek	5.6	State Route 146 (gage)	67.5	Unstable sand load, coal fines
Boggs Creek	4.1	Three Towers Road	58.0	Compacted sands and gravel
Buffalo Fork	2.1	Okey Road	68.0	Heavy sand and silt bedload
Buffalo Fork	1.5	Farm lane off S.R. 146	74.0	
Little Salt Creek	5.1/5.6	Sonora Road	57/63.5	Heavy silt bedload
Frog Run	0.1	Arch Hill Road	60.0	
FAIR				
Salt Creek	23.5	Knipe Road	44.0	Heavy sand load, little functional cover
Salt Creek	18.3	Norfield Road	50.0	Heavy sand load, historic channelization
Salt Creek	2.1	Adj. Manns Fork Road	59.0	Heavy unstable sand load, coal fines
POOR				
Indian Run	0.1	Adj. Mast Road	34.0	Open cattle pasture

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

Fish Community

A total of 45,005 fish representing 59 species (+ one hybrid) was collected from the Salt Creek watershed (Muskingum River basin) study area between June and October, 2008-09. Relative numbers and species collected per location are presented in Appendix Table 9. Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb) metric scores are presented in Appendix Table 10. Sampling locations were evaluated using Warmwater Habitat (WWH) or Exceptional Warmwater Habitat (EWH) biocriteria based on the current or recommended aquatic life use where applicable. A summary of the fish data are presented in Table 10. Salt Creek watershed 2008-09 biological and habitat data are available on Ohio EPA interactive maps at the following link: http://wwwapp.epa.ohio.gov/dsw/gis/bio/index.php

Fish Biocriteria
Full Attainment

Salt Creek Watershed: 100%

Sites sampled in the Salt Creek watershed during 2008-09 achieved the applicable WWH or EWH fish biocriterion at all 21 locations (100%) (Table 10). Six of fifteen headwater sample sites (40 %) scored an IBI $\geq$ 50 (exceptional), and IBI scores $\geq$ 46 (very good–exceptional) were recorded at 13 of 15 sites (86.7%). An IBI of 45 (good quality) was documented at Pleasant Run. In 2008 an IBI score of 38 was found in Little Salt Creek at RM 5.1. After stormwater improvements were put in place, the IBI score improved to 42 in 2009 (sample taken at RM 5.6). A mean IBI score of 40 (Table 2) for both (2008-2009) samples (marginally good) met the WWH biocriterion score (Table 11).

Eight of ten wading sites scored an IBI or MIwb in the very good to exceptional ranges (IBI$\geq$ 46, MIwb>8.9). A marginally good IBI of 40 in Salt Creek at RM 18.3 was a decrease in quality from the upstream Salt Creek headwater site (RM 23.5) IBI score of 50. Past channelization effects were still evident and the number of modified physical stream attributes increased and ratio of modified to warmwater attributes increased to 4.5 from 3.0. Open pastures and agriculture NPS inputs increased tolerant fish percentages and decreased the top carnivore and insectivore percentage scores at RM 18.3. Salt Creek at RM 2.1 (downstream from Manns Fork) decreased slightly from very good to exceptional fish scores (IBI / MIwb) to good to very good fish scores (Table 10). Kent Run and Buffalo Fork both met or exceeded the EWH biocriterion. The IBI and MIwb scores were exceptional in 5 of 6 samples.

The lower Salt Creek mainstem sites (RMs 12.8-2.1) supported the highest number of fish species (35-38) in the survey. The highest number of lithophils and darters were found in the lower reaches of Salt Creek – with eight darter species at RMs 5.6 and 2.1 and 15 lithophilic species at RM 5.6. The highest number of sucker species and carnivores were also collected in lower Salt Creek.

Rare (R) and intolerant (I) fish collected in the Salt Creek watershed included the northern madtom (R), the slenderhead darter (R), and Eastern sand darter (R). These species, along with trout-perch, sand shiners, mimic shiners (I), and ghost shiners, were collected in lower Salt Creek (and other locations), where abundant, clean, sand and gravel bottoms occurred. Other fish species collected which are sensitive to water pollution included golden redhorse, silver redhorse, smallmouth redhorse, northern hog sucker, silver shiner, rosyface shiner, rainbow darter, logperch, and banded darter (I). Least brook lamprey, partial to cool, sandy streams, were collected in two smaller headwater streams. The cold water (CW) Southern red belly dace (SRBD) was collected at several headwater stream sample sites, and both the CW SRBD and CW redside dace were collected in Kent Run. Mottled sculpin, redside dace and SRBD are indicative of a cold water stream. Rare, CW, and pollution sensitive fish comprised 17.3 percent of the fish community.

Table 10. Fish community summaries based on pulsed D.C. electrofishing sampling conducted by Ohio EPA in the Salt Creek watershed from June – October, 2008-09. Relative numbers and weight are per 0.3 km for wading and headwater sites. NA= not applicable.

Stream	River Mile	Sampling Method	Fish Species (Total)	Relative Number	Relative Weight (kg)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation
Salt Creek 2009	23.5	Headwater	23	5183	NA	44.0	**50**	NA	Exceptional (E)
Salt Creek 2009	18.3	Wading	26	2879	10.49	50.0	**40**^{ns}	9.4	Marginally Good ^{ns}/ E
Salt Creek	12.8	Wading	38	1775	21.72	71.0	**47**	**10.25**	Very Good / Exceptional
Salt Creek	5.6	Wading	35	2113	12.57	67.5	**46**	**9.85**	Very Good / Exceptional
Salt Creek	2.1	Wading	36	4005	10.32	59.0	**45**	**9.25**	Good / Very Good
Manns Fork	4.3	Headwater	19	870	NA	81.0	**48**	NA	Very Good
Manns Fork	2.3	Headwater	22	2498	NA	71.5	**46**	NA	Very Good
Kent Run	1.2	Headwater	16	1502	NA	87.0	**52**	NA	Exceptional
Boggs Creek	4.1	Headwater	21	2770	NA	58.0	**50**	NA	Exceptional
Boggs Creek	0.9	Headwater	30	5056	NA	83.5	**52**	NA	Exceptional
Indian Run	0.1	Headwater	21	4802	NA	34.0	**44**	NA	Very Good
Buffalo Fork	6.5	Headwater	18	762	NA	76.5	**50**	NA	Exceptional
Buffalo Fork	2.1	Wading	26	720	4.51	68.0	**50**	**8.9**^{ns}	Exceptional / Very Good ^{ns}
Buffalo Fork	1.5	Wading	26	1704	10.85	74.0	**52**	**9.6**	Exceptional
Williams Fork	0.2	Headwater	15	4506	NA	70.0	**46**	NA	Very Good
White Eyes Creek	1.7	Headwater	18	1398	NA	81.0	**48**	NA	Very Good
Pleasant Run	0.1	Headwater	20	1921	NA	70.5	**45**	NA	Good
Little Salt Creek 2009	5.6	Headwater	14	1374	NA	63.5	**42**^{ns}	NA	Marginally Good ^{ns}
Little Salt Creek 2008	5.1	Headwater	15	3582	NA	57.0	**38***	NA	Fair*
Little Salt Creek 2008	0.1	Headwater	24	3407	NA	73.5	**52**	NA	Exceptional
Frog Run	0.1	Headwater	22	4912	NA	60.0	**46**	NA	Very Good
Georges Run	1.8	Headwater	20	7388	NA	74.5	**48**	NA	Very Good

The color of corresponds to the narrative habitat score (blue is exceptional-very good, green is good-marginally good, yellow is fair, and red is poor-very poor).

^{ns} Nonsignificant departure from biocriterion (≤4 IBI or ICI units; ≤0.5 MIwb units).
* Significant departure from biocriterion (>4 IBI or ICI units; >0.5 MIwb units).

Biocriteria for WAP Ecoregion		
INDEX - Site Type	WWH	EWH
IBI: Headwater/Wading	44	50
MIwb: Wading	8.4	9.4

Macroinvertebrate Community

The macroinvertebrate communities from 27 locations in the Salt Creek study area were sampled in 2008-09. Qualitative, multi-habitat samples were collected from all sampling locations. Quantitative samples using artificial substrates were collected at four sites: two in lower Salt Creek with one each in lower Manns Fork and Boggs Creek. A total of 247 different taxa were collected throughout the survey. A summary of the macroinvertebrate data are presented in Table 11. The macroinvertebrate raw data are presented in Appendix Tables 11 and 12. Sampling locations were evaluated using Warmwater Habitat or Exceptional Warmwater Habitat biocriteria based on current or recommended aquatic life uses.

Salt Creek watershed tributary sites sampled during 2008-09 achieved the applicable WWH or EWH macroinvertebrate biocriterion at 27 of the 27 sites evaluated (100%). Buffalo Fork and Kent Run sites met EWH expectations, with narrative ratings of very good to exceptional.

Macroinvertebrate Biocriteria Full Attainment
Salt Creek Watershed: 100%

The highest qualitative EPT (Ephemeroptera/ Plecoptera/Trichoptera) taxa totals were collected from Georges Run and Salt Creek (RM 12.7) with 20 and 19, respectively. The highest qualitative and quantitative sensitive taxa totals were also from the Salt Creek sample site at RM 12.7 – 29 and 40 sensitive taxa, respectively. At the Kent Run and Buffalo Fork sites, the number of EPT taxa ranged from 16 to 23 with a median of 20 (Table 11). There were 15 to 28 sensitive taxa with a median total of 23. Among the EWH designated sample sites, Kent Run had the highest number of EPT taxa with 23 at RM 0.8, and there was a maximum of 28 sensitive taxa at the Buffalo Fork site (RM 0.8).

Several common sensitive or high quality taxa were collected from the Salt Creek watershed streams, and 19 of 27 sample sites with narratively assessed as very good or exceptional. Sensitive mayflies collected included the following intolerant (I) taxa: *Diphetor hageni*, *Acerpenna macdunnoughi*, *Plauditus* spp., *Pseudocloeon* spp., Leucrocuta and Nixe sp.. A few moderately intolerant (MI) mayflies collected included *Paracloeodes fleeki*, *Macaffertium* spp., *Procloeon* spp, and *Isonychia* sp.. Various sensitive stoneflies collected included the perlid stoneflies *Acroneuria* spp.(MI), *Agnetina flavescens* (I), and *Neoperla clymene complex* (I). *Neophylax* sp.(I), *Pycnopsyche* sp. (MI) and *Triaenodes melaca* (MI) were among the sensitive caddisflies collected. The sensitive hydropsychid, caddisflies hydropsyche *dicantha* and *Ceratopsyche morosa gr.*, and the MI riffle beetle, *Optioservus fastiditus*, were also collected at several sites. Sensitive midges, including *Cladotanytarsus vanderwulpi* group Types I & 3, *Labrundinia pilosella*, *Thienemanniella taurocapita*, and *Tvetenia bavarica* were collected at various high quality Salt Creek sample sites. Two MI mussel species were collected in Little Salt Creek and/or Buffalo Fork– the white heelsplitter (*Lasmigona complanata*) and the fatmucket (*Lampsilis radiata luteola*).

Cold ground water inputs supplemented water quality at many sites, as 13 of 26 sample sites had at least two to three cold water (CW) taxa. Some CW taxa collected included the stonefly *Leuctra* sp., the dragonfly *Boyeria grafiana*, the fishfly *Nigronia fasciatus*, the caddisfly *Ceratopsyche slossonae*, and the true flies (*Zavrelimyia* sp. *Parametriocnemus* sp., *Polypedilum (P.) aviceps* and *Paratanytarsus n. sp.*

Table 11. Summary of macroinvertebrate data collected from natural substrates (qualitative sampling) and/or quantitative samples in the Salt Creek watershed study area, June – October, 2008 and 2009.

Stream	River Mile	Data Codes	Qual./ Total Taxa	CW Taxa	Qual./Total EPT[a] Taxa	Ql./Tot Sens. Taxa	Rel. Density (#/ ft.^{2})	Predominant Organisms	ICI	Narrative Evaluation
Prairie Fork	0.1	X19	52	1	17	20	Moderate	Rheo.& Polypedilum midges (MI,F), baetids (F,MI,I), hydropsychids (F,MI), heptageneids (MI,F)	NA	Very Good
Salt Creek	25.7	X19	54	3	14	22	Mod.-Low	Hydropsychids (F), midges (F,MI,MT), elmids (F,MI), & heptageneids (F,MI)	NA	Very Good
Salt Creek	25.0	X19	56	3	12	13	Mod.-High	*Rheotanytarsus* sp. (MI), *Polypedilum* midges (F,MI,CW), hydropsychids (F), *Stenacron* sp.	NA	Good
Salt Creek	23.5		40	2	13	18	Moderate	Mayflies (I,MI,F) and hydropsychids (MI,F)	NA	Very Good
Salt Creek	18.3		58	2	16	25	Mod.-High	*Isonychia* (MI), hydropsychids (MI,F), midges *Rheotanytarsus* & *Polypedilum* midges.(MI,F)	NA	Very Good
Salt Creek	12.7	X15	47/86	2	19/23	29/40	Mod./716	*Tanytarsini* midges (MI), M. vicarium (MI), *C. morosa gr.*(MI), *Isonychia* (MI), bryozoa (F)	52	Exceptional
Salt Creek	5.6		43/63	1	15/21	23/34	Mod.-High/ 482	Hydropsychids (F,MI), *Rheo*. & tanypode midges (MI,F), *Isonychia* (MI), *Hemerodromia*	40	Good
Salt Creek	2.1	X13	44	0	16	19	Moderate	Hydropsychids (F,MI), *Rheo*. midges (MI), *Isonychia* & *Tricorythodes* sp. mayflies (MI)	NA	Very Good
Manns Fork	4.1	X19	52	1	18	19	Moderate	*Rheo*. midges & others (MI,F,MT,T), baetids (MI,F), hydropsychids (MI,F)	NA	Exceptional
Manns Fork	2.4	X15	45/65	2	16/18	13/25	Low-Mod./326	*Rheo*. midges (MI), baetid mayflies (MI,F), hydropsychids (MI,F), crayfish (F)	40[b]	Very Good
Beaver Creek (Trib. to Manns Fork @-RM 2.3)	0.1	X29	28	1	10	20	Moderate	Baetid (F,MI,I)& *Caenis* (F) mayflies, crayfish, *Chimarra* & hydropsychid caddisflies (MI,F)	NA	Good
Kent Run	1.1	X19	40	2	13	13	Mod.-Low	Hydropsychids (F,MI), *Rheo*. midges (MI), stoneflies (MI), *S. femoratum* (F)	NA	Good*
Kent Run (2009)[c]	1.1	X19	54	3	21	20	Mod.-Low	Baetids (F,MI,I), hydroptilids (F), *Nyctiophylax* & hydropsychid caddisflies (MI,F)	NA	Exceptional
Kent Run (2009)[c]	0.8	X19	47	1	23	23	Mod.-Low	Baetids (F,MI,I), heptageneids (F,MI,I), stoneflies (MI,I)	NA	Exceptional
Boggs Creek	4.1		59	0	11	15	Low	*Rheotany*. & others (F,MI,MT,T), F&MI baetids	NA	Good
Boggs Creek	1.0	X15	53/69	0	15/18	1	Mod.-High/ 315	Baetids (F,MI), hydropsychids (MI,F), Tanytarsini & other midges (F,MI,MT), F *Stenacron*	44	Very Good
Indian Run	0.1	X19	64	1	11	14	Moderate	*Rheo*., *Stictochironomus*, *Chironomus*(MI,F,T) hydropsychids & riffle beetles (F)	NA	Marginally Good[ns]
Buffalo Fork	6.6	X19	52	2	16	15	Moderate	*Rheo*. & *C. morosa gr*. (MI), baetids (F,MI,I)	NA	Very Good[ns]

Table 11 continued.

Stream	River Mile	Data Codes	Qual./ Total Taxa	CW Taxa	Qual./Total EPT[a] Taxa	Ql./Tot Sens. Taxa	Rel. Density (#/ ft.^{2})	Predominant Organisms	**ICI**	Narrative Evaluation
Buffalo Fork	2.1		59	0	20	27	Moderate	*Rheotanytarsus* sp. (MI), hydropsychids (F,MI), heptageneid mayflies (F,MI)	NA	Exceptional
Buffalo Fork	0.8		58	0	20	28	Mod.-High	*Rheotanytarsus* sp. (MI), hydropsychids(F,MI) heptageneids (F,MI), *Chimarra* (MI)	NA	Exceptional
Williams Fork	0.2	X19	46	1	18	16	Mod.-High	*Rheo*. midges (MI), hydropsychids(F,MI), Caenis (F), baetids & heptageneids (F,MI)	NA	Very Good
White Eyes Creek	1.6		50	1	16	19	Mod.-Low	Midges (MI,F,T), hydropsychids (F,MI), heptageneids (F,MI), *Acroneuria frisoni* (MI)	NA	Very Good
Pleasant Run	0.1	X19	45	1	17	14	Moderate	*Rheo*. midges, baetids & *Isonychia* (F,MI),elmids(F,MI)	NA	Very Good
Little Salt Creek	5.1	X19	69	2	16	27	Mod.-High	*Rheo*. midges (MI), baetids & hydropsychids (F,MI)	NA	Very Good
Little Salt Creek	0.1		50	3	15	22	Mod.-High	Elmids (F,MI), hydropsychids(F,MI), *Rheo*. midges(MI)	NA	Very Good
Frog Run	0.1	X19	64	3	14	25	Mod.-High	*Rheo*. & other midges (MI,F,MT), *C. morosa gr*. (MI)	NA	Good
Georges Run	1.6	X19	58	3	20	22	Mod.-High	Hydropsychids (MI,F), *Rheo*. midges (MI), hydroptilids	NA	Exceptional

Biocriteria for WAP Ecoregion		
INDEX – Site Type	WWH	EWH
ICI	36 (good)	46 (exceptional)

[a] EPT = total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa richness.
[b] Narrative evaluation used in lieu of ICI score to assess biological quality. ICI results were influenced by low flow conditions.
[c] 2009 follow-up samples after resolving local gravel extraction issue.
[ns] nonsignificant departure from biocriterion or narrative ranges.
* Significant departure from biocriterion (>4 ICI units) or narrative ranges.

WATERSHED ASSESSMENTS UNITS

The Salt Creek watershed study area is comprised of five 12-digit Hydrologic Unit Code (HUC12) watersheds. Data from individual sampling locations in a HUC12 assessment unit are accumulated and analyzed; summary information for each Salt Creek watershed assessment unit (WAU) is presented in this section. The sampling site scores calculated for headwater and wading sites were averaged to determine the intermediate score. The intermediate score was averaged with the principle sites score for an overall measure of aquatic life attainment in the HUC 12 watershed. Data used in this analysis were collected in 2008 and 2009 (Sites sampled a second time in 2009 overrode the earlier assessment, as issues were resolved). All stream samples sites within the Salt Creek watershed study area supported fis and macroinvertebrate communities in full attainment of designated or recommended aquatic life uses and reflected a condition consistent with the Clean Water Act biological integrity goal (Table 12).

Table 12. Results for the Salt Creek watersheds using the HUC12 aquatic life use assessment methodology.

		Headwater Site Assessment (<20mi^2)			Wading Site Assessment (≥20 to <50mi^2)				Principle Site Assessment (≥50 to <500 mi^2)			HUC 12 Assessment Unit Score[b]
HUC 12 WATERSHED	Drainage Area sq. mi.	Total Sites	#Sites Full Attainment	Score	Total Sites	#Sites Full Attainment	Score	Intermediate Score[a]	Total Sites	#Sites Full Attainment	Score	
050400040601 – Little Salt Cr.	14.7	2	2	100.0	0	NA	NA	100.0	0	NA	NA	100.0
050400040602 – Headwaters Salt Creek	46.1	3	3	100.0	2	2	100.0	100.0	0	NA	NA	100.0
050400040603 – Buffalo Fork	27.6	2	2	100.0	2	2	100.0	100.0	0	NA	NA	100.0
050400040604 – Boggs Creek	18.2	3	3	100.0	0	NA[c]	NA	100.0	0	NA	NA	100.0
050400040605 – Manns Fork Salt Creek	19.8	4	4	100.0	0	NA	NA	100.0	0	NA	NA	100.0
050400040606 – Mouth Salt Creek	18.5	3	3	100.0	0	NA	NA	100.0	2	2	100.0	100.0

[a] – Average of headwater and wading scores.
[b] – Average of intermediate and principle sites scores.
[c] – NA = Not applicable. No sampling sites in the noted assessment size.

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*Some of the references not in the report can be found in the Appendix Table 11 which includes Methods, Biosurvey Background Information, and Notice to Users.