

Report

An Assessment of the Biological Integrity of the Aquatic Macroinvertebrate Communities from Intermittent Small Tributaries to Lords Brook Originating from the South Cut and South Mine of the Elizabeth Copper Mine Superfund Site.

Prepared by

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Background: Lords Brook was determined to be biologically impaired due to toxic concentrations of metals by VTDEC and placed on the “impaired” waters list in 2000. The Elizabeth Mine site was declared a superfund site in 2001. The source of the toxic metals is from the area of the mine known as the South cut, TP-4, and South mine. These areas were included in the Elizabeth Mine mitigation effort; TP-4 and much of the waste rock around the south mine has been removed. Additional mitigation is still planned to address the south cut and the residual contamination remaining at the south mine. EPA is planning to finalize the remedial design for the south cut and mine in 2014. Lords Brook itself has been considered by VTDEC as the compliance stream for the south cut and south mine areas of the Elizabeth mine. Lords Brook has met and exceeded the VTDEC biocriteria guidelines for two consecutive years 2012, and 2013, as well as in 2010. Lords Brook is now considered in very good biological condition. In assessing this stream the VTDEC has applied the biocriteria expectation of a Small High Gradient SHG stream type for macroinvertebrates and the Cold Water IBI for fish. The very small tributary streams to Lords Brook that originate from the south cut and south mine have not to this point been assessed. These very small tributaries likely become intermittent during low flow periods in dry years. Because of this there biological potential may not attain that of a perennial SHG stream type. To assess the biological condition of these streams the VTDEC also assessed an adjacent intermittent stream located within a forested watershed as a “reference” just south of the south mine in 2013. This “reference” stream will allow for a more accurate determination of the biological potential of these very small tributaries, and thus a more accurate determination of the biological condition of the tributaries directly draining the south mine sites.

Table 1, and Figure 1 describe and show the locations of the biological assessments of the small intermittent streams influenced by the south cut and south mine areas, and the “reference” stream location just south of these mine areas.

Table 1 Location of Lords Brook small intermittent tributaries, their drainage area in km², and elevation in ft. For comparison the drainage area of perennial SHG reference streams in VT.

Location	Site (RM)	Description	Latitude	Longitude	Drainage Area km ²	Elevation ft
Trib 2	0.1	Below both S.cut and S. mine, 100 m above Lords Brook confluence	43.81111	-72.3282	0.70	1100
Trib 2	0.3	Below south cut about 100m into forest, above Trib 2-Trib 1 confluence.	43.81507	-72.3352	0.13	1330
Trib 2-Trib 1	0.2	Below south mine about 100 m into forest.	43.81178	-72.3374	0.11	1376
Trib 4	0.2	“reference” 1 st tributary south of S.mine, past small camp, below S.mine road.	43.80603	-72.3422	0.13	1450
SHG	“reference”	D.A. mean 10.5 and range 0.6-95				

Figure 1: Map showing locations of small intermittent tribs to Lords Brook and the biomonitoring sites.

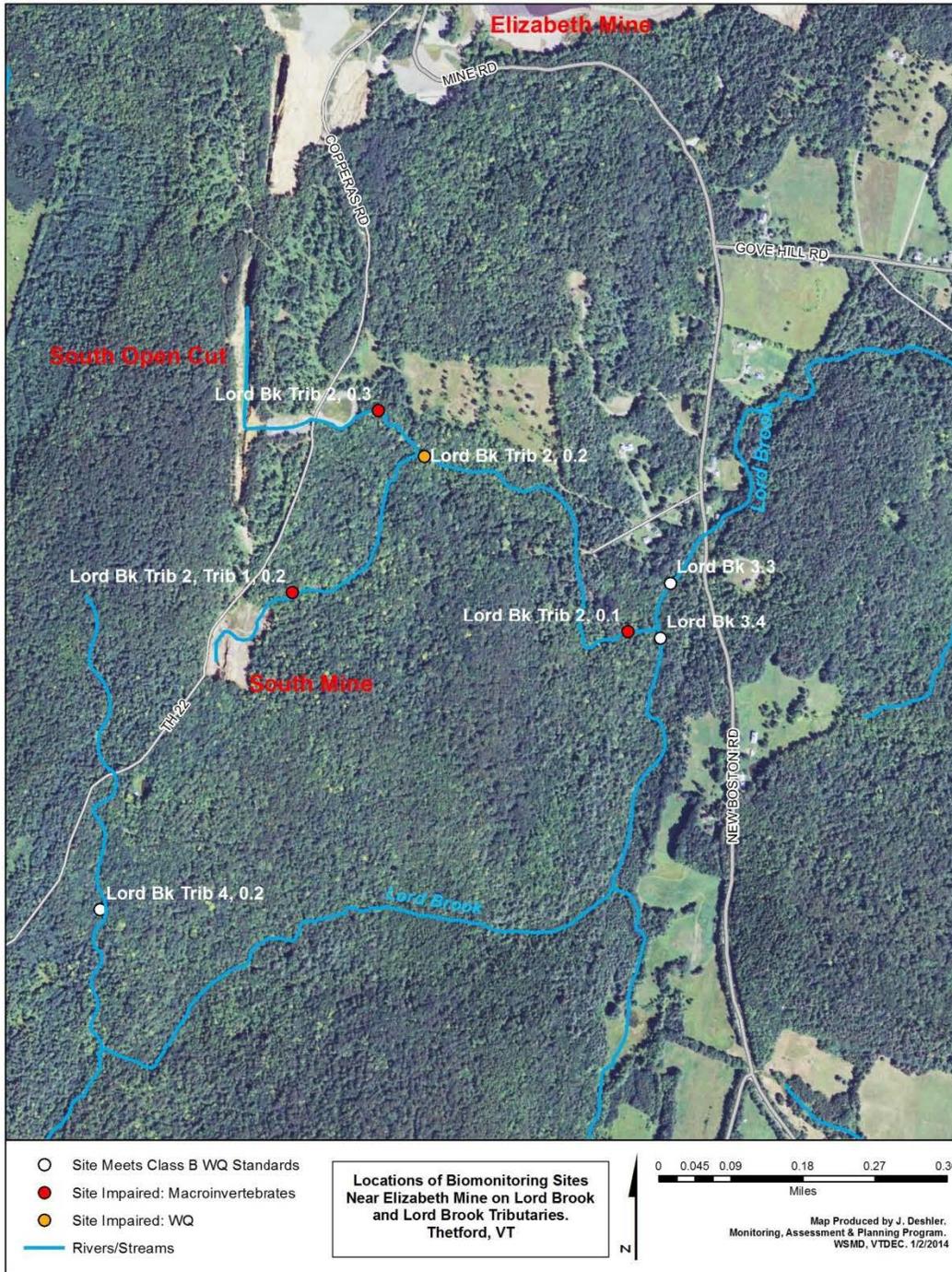


Table 2: Macroinvertebrate community metrics from very small (intermittent) headwater streams within the Lords Brook watershed. Red font indicates metric values that do not bass Class B biocriteria, blue cells denote the reference stream.

Location	RM	Assessment	Density	Richness	EPT	PMA	BI	Oligo %	EPT /EPT+C	PPCS
Lords Br Trib 2	0.1	Poor	96	17	11	71.0	2.27	0.0	0.83	0.48
Lords Br Trib 2	0.3	Very Poor	13	6	2	54.7	3.46	0.0	0.83	0.43
Lords Br Trib 2- Trib 1	0.2	Very Poor	19	7	5	47.5	1.90	0.0	0.00	0.15
Lords Br Trib 4	0.2	Excellent (Control)	1316	46	21	67.1	2.52	1.8	0.54	0.58
SHG		ref mean	1016	40	23.5	54.0	2.30	0.2	0.90	0.60
SHG		Class B	≥300	≥27	≥16	≥45	≤4.50	≤12%	≥0.45	≥.40

Macroinvertebrate Community Assessment Results

Lords Brook -Trib 2 RM 0.1

This is a small (0.7 km²) first order tributary and maybe intermittent during low flow years. In 2013 it is believed the stream did not become intermittent under summer low flows. The macroinvertebrate community metrics are compared to both the local “reference control” stream as well as the VTDEC SHG stream type in making an assessment of its biological condition. The abundance is very low at <100/KN. Compared to the local reference Trib 4, the abundance at this site shows a 93 percent decrease. It is also only about a third of what would be expected for a SHG stream type to meet the VTDEC Class B SHG expectation. The total species richness and EPT richness are also very low, 17 and 11 respectively. This represents about a 50-60% decrease in the total species and EPT species normally found in this type of very small stream compared to either the local reference Trib 4 or the statewide SHG mean.

Lords Brook - Trib 2 RM 0.3 and Trib 2 Trib1 RM 0.3

These locations are very small in drainage area, and are likely intermittent during low flow years, but since 2013 was a wet year they may not have gone intermittent. These streams should only be compared to the local intermittent reference stream Lords Trib 4, in determining their biological potential. As anticipated, both of these small intermittent tributaries were found to be in very poor biological condition, exhibiting an extreme departure in community metric values from Lords Trib 4. Almost no macroinvertebrates were present (<20/KN), representing very few taxa. The species richness was <10, and the EPT species was ≤5 at both sites. With less than 20 animals collected the rest of the community metrics have very little relevance in terms of an assessment. The very low density and richness is a strong indication of a toxic impact on the macroinvertebrate community at all the Lords Brook Trib 2 watershed sites.

Water Quality Parameters

Total metals samples were collected twice in 2013 under moderate base (non-runoff period) flows. These results are presented in Table 3. The “reference” tributary 4 did not show any elevated metals, and a hardness similar to Tributary 2 near its confluence with Lords Brook to just below the confluence with the two very small streams directly draining the south mine, and south cut. Of the two very small intermittent streams Tributary 2-Tributary 1 (which drains the south mine) had the highest concentrations, and acutely toxic levels of, zinc, copper and cadmium. The Tributary 2 stream, above the confluence with Tributary 2 – Tributary 1, also showed acutely toxic concentrations of copper and cadmium, while zinc was elevated but below toxic concentrations. Both copper and cadmium were also found to be at acutely toxic concentrations immediately below the confluence of these two streams, while zinc again was elevated, but below toxic concentrations at RM 0.2 on tributary 2. Tributary 2 immediately above the confluence with Lords brook only showed chronic concentrations of copper, and cadmium. Stream RM (site)

Table 3: Metals concentrations above Reportable Detection Limit (RDL) are bolded, values just below this also shown, also reported is hardness, pH and Conductivity from two baseflow events in 2013 from Lords Brook tributary sites. Shaded boxes are above acute ALS value (hardness adjusted only EPA 1998).

Parameter	RDL	units	Trib 2 0.1		Trib 2 0.2	Trib 2 0.3		Trib 2-Trib 1 0.2		Trib 4 0.2
			6/21	9/23	6/21	6/21	9/23	6/21	9/23	9/23
Aluminum	<50	ug/L	<50	<50	<50	<50	<50	<50	<50	47
Zinc	<50	ug/L	<50	<50	79.4	61.0	54.8	493.2	1302.0	<50
Arsenic	<1	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Sodium	<0.05	mg/L	1.3	1.5	1.5	1.9	2.1	1.4	1.7	1.1
Magnesium	<0.01	mg/L	2.8	4.0	4.5	6.9	7.4	5.9	9.3	1.7
Potassium	<0.05	mg/L	2.0	2.2	2.8	4.6	4.4	2.3	2.7	1.8
Calcium	<0.05	mg/L	19.0	26.5	27.1	44.0	49.1	30.8	42.7	16.6
Chromium	<5	ug/L	4.9	<5	<5	<5	<5	<5	<5	<5
Manganese	<5	ug/L	<5	<5	15.8	149.8	250.0	308.0	604.1	10.7
Iron	<50	ug/L	<50	<50	<50	62.9	102.2	67.6	167.1	60.7
Nickel	<5	ug/L	5.2	<5	6.9	14.6	10.2	22.5	39.7	<5
Copper	<10	ug/L	9.0	<10	24.7	70.6	40.1	94.2	478.4	<10
Cadmium	<1	ug/L	<1	<1	<1	<1	<1	2.9	6.3	<1
Lead	<1	ug/L	<1	<1	<1	<1	<1	<1	<1	<1
Hardness	<1	mg/L	59.3	82.4	86.2	138.1	153.6	101.1	144.0	48.5
pH	field	STD U	7.53	7.45	7.34	6.97	7.11	7.06	7.16	7.54
Conductivity	field	uohms	143.0	194.0	190.0	306.0	343.0	214.0	325.0	91.8

General water quality parameters from the tributary streams are presented in table 4. All streams were within an acceptable ALS pH range, ranging between 6.97 to 7.54. Conductivity and sulfate followed the same pattern as metals concentrations, with the very small tributary streams directly below south mine and south cut over 300 uohms, and the control stream less than 100 uohms. Alkalinity on the other hand was lowest (<20 mg/l) and very similar in the mine draining streams, and highest (40 mg/l) in the reference control stream. Chloride was below detection < 2mg/l in all the tributary streams. The above patterns show that acidic, sulfate and dissolved metals are reacting with the relatively strong alkalinity in the area (40mg/l reference stream) and lowering it. The nutrient concentrations of nitrogen and phosphorus are low in all the streams. A slightly higher turbidity in the tributary stream immediately below the south mine may indicate the metals are bound to fines or dissolved organic particles in this stream.

Table 4: Water quality parameters for Lords Brook Tributary streams in 2013. RDL = reportable detection limit for a parameter.

Stream RM (SITE)			Trib 2 0.1	Trib 2 0.3	Trib 2-Trib 1 0.2	Trib 4 0.2
Parameter	RDL	units	9/23	9/23	9/23	9/23
pH	field	STD U	7.45	7.11	7.16	7.54
Conductivity	field	uohms	194	343	325	92
Color	<2.5	PCo U	2.5	2.5	2.5	10
Alkalinity	1	mg/L	17.5	13.0	14.0	40.0
Chloride	2	mg/L	<2	<2	<2	<2
Sulfate	0.5	mg/l	66	134	122	6
Nitrate + Nitrite	0.05	mg/L	<0.05	<0.05	<0.05	<0.05
Total Nitrogen	0.1	mg/L	<0.1	<0.1	<0.1	<0.1
Phosphorus	5	ug/L	<5	7.47	7.45	13.70
Turbidity	0.2	NTU	<0.2	0.46	1.48	0.76

Table 5 and Figure 2 below show a very similar size and habitat, between the “reference” control and mine drainage tributary stream reaches. All stream reaches directly below the mine sites were only about a ½ meter wide within channel and all had a lot of organic leaf litter and woody debris. All sites were located within fully forested areas, had complete canopies dominated by hardwoods, and immediate riparian forest well over 25m wide. The photos also show that the flow level reflects a moderate base flow for the streams. The presence of the *Trichoptera Homoplectra sp* within the two upper Trib 2 streams that drain the mine is a strong indicator that the streams are likely intermittent. Other taxa that indicate small cold spring feed systems are the *Trichoptera Parapsyche sp* and *Diplectrona sp* and the, *Diptera Pedicia sp* and *Stilocladius sp*. Also of note was that the salamander *Eurycea bislineata* was common in Trib 4 the local reference control, and not observed at any of the mine drainage tributary reaches. A list of all taxa, their abundance and percent composition from the streams is presented in Table 6.

Table 5: Physical habitat observations for Lords Brook tributary streams for 2013.

Stream and riparian habitat Observations	Lord Brook Trib 2	Lord Brook Trib 2	Lord Brook Trib 2-Trib 1	Lord Brook Trib 4
Site	0.1	0.3	0.2	0.2
Date	9/23/2013	9/23/2013	9/23/2013	9/23/2013
Bank Stability	Fair	Fair	Fair	V.G.
Ledge %	0	0	10	10
Boulder %	25	0	0	0
Cobble %	40	30	5	10
Coarse Gravel %	20	20	0	10
Gravel %	10	30	10	10
Silt %	0	10	40	25
Silt Rating (0-5)	3	4	5	5
CPOM Rating (0-5)	5	5	5	5
Large Woody Debris	10	40	10	10
Bank Full Width (m)	3	2	1	1
Wetted Width (m)	1	0.5	0.5	0.5
Softwood %	75	0	2	0
Hardwood %	25	100	98	100
Canopy %	90	100	100	100
Moss % cover	5	0	0	10

In conclusion: The very small tributary streams that directly drain the south cut and south mine (Tributary 2 0.3, and Tributary 2-Trib 1 0.2 are in very poor biological condition due to acutely toxic levels of zinc, copper and cadmium. Tributary 2 0.1 (just above the confluence with Lords Brook) is also in poor biological condition, only slightly better than the tribs above. This stream reach showed chronic levels of copper and cadmium. Tributary 2 at this location RM 0.1 is more likely to be perennial than the

two very small tributaries that directly drain the south mine above, however it too may also become intermittent in very dry years. The control Tributary 4 showed that all of these very small streams that drain the south mine, when perennial, should have a lot greater macroinvertebrate abundance and species richness, and should have salamanders present.

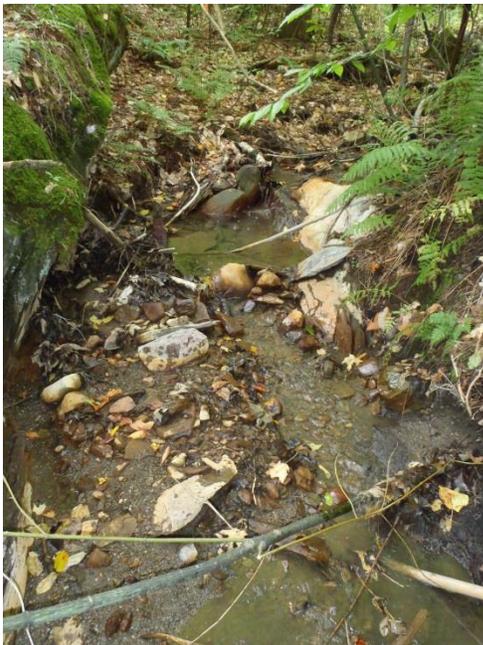
Figure 2 Photographs of stream channels of tributaries of Lords Brook



1-Trib 4 0.2 reference stream



2 - Trib 2 0.1 immediatley above Lords Brook



3-Trib 2 0.3 below s.cut



4- Trib 2- trib 1 0.2 below s mine

Table 6: A list of the macroinvertebrate species their density and composition.

Location	Site	Order	Family	Genus	Species	Density/KN	% Comp
Lord Brook Trib 2	0.1	COLEOPTERA	DRYOPIDAE	HELICHUS	basilus	1.0	1.0
		COLEOPTERA	CURCULIONIDAE	N/A	unid	1.0	1.0
		DIPTERA	CHIRONOMIDAE	BRILLIA	sp	7.0	7.3
		DIPTERA	CHIRONOMIDAE	THIENEMANNIMYIA GROUP	group	8.0	8.3
		DIPTERA	TIPULIDAE	DICRANOTA	sp	2.0	2.1
		DIPTERA	TIPULIDAE	TIPULA	sp	4.0	4.2
		EPEMEROPTERA	BAETIDAE	BAETIS	tricaudatus	1.0	1.0
		EPEMEROPTERA	BAETIDAE	PLAUDITUS	sp	1.0	1.0
		TRICHOPTERA	HYDROPSYCHIDAE	DIPLECTRONA	modesta	16.0	16.7
		TRICHOPTERA	HYDROPSYCHIDAE	CERATOPSYCHE	ventura	22.0	22.9
		TRICHOPTERA	LEPIDOSTOMATIDAE	LEPIDOSTOMA	sp	5.0	5.2
		TRICHOPTERA	LIMNEPHILIDAE	N/A	imm	3.0	3.1
		TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA	sp a	1.0	1.0
		TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA	nigrita	2.0	2.1
		TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA	carolina group	3.0	3.1
		PLECOPTERA	CHLOROPERLIDAE	SWELTSA	sp	12.0	12.5
PLECOPTERA	PERLODIDAE	MALIREKUS	iroquois	7.0	7.3		
Lord Brook Trib 2	0.3	COLEOPTERA	ELMIDAE	OULIMNIUS	latiusculus	1.0	7.7
		DIPTERA	CHIRONOMIDAE	BRILLIA	sp	1.0	7.7
		DIPTERA	TIPULIDAE	DICRANOTA	sp	1.0	7.7
		DIPTERA	TIPULIDAE	TIPULA	sp	5.0	38.5
		TRICHOPTERA	HYDROPSYCHIDAE	HOMOPLECTRA	sp	3.0	23.1
		TRICHOPTERA	PHRYGANEIDAE	OLIGOSTOMIS	sp	2.0	15.4
Lord Brook Trib 2-Trib 1	0.2	DIPTERA	TIPULIDAE	TIPULA	sp	5.0	26.3
		TRICHOPTERA	HYDROPSYCHIDAE	HOMOPLECTRA	sp	7.0	36.8
		TRICHOPTERA	HYDROPSYCHIDAE	DIPLECTRONA	modesta	1.0	5.3
		TRICHOPTERA	HYDROPSYCHIDAE	CERATOPSYCHE	morosa	1.0	5.3
		TRICHOPTERA	HYDROPSYCHIDAE	PARAPSYCHE	apicalis	1.0	5.3
		TRICHOPTERA	LIMNEPHILIDAE	N/A	imm	3.0	15.8
		LEPIDOPTERA	CRAMBIDAE	CRAMBUS	sp	1.0	5.3
Lord Brook Trib 4 0.2	0.2	COLEOPTERA	ELMIDAE	OULIMNIUS	latiusculus	20.0	1.5
		COLEOPTERA	DYTISCIDAE	AGABUS	sp	0.0	0.0
		COLEOPTERA	HYDROPHILIDAE	ANACAENA	limbata	20.0	1.5
		COLEOPTERA	HYDROPHILIDAE	TROPISTERNUS	sp	0.0	0.0
		DIPTERA	CERATOPOGONIDAE	CERATOPOGON	sp	16.0	1.2
		DIPTERA	CERATOPOGONIDAE	BEZZIA/PALPOMYIA	group	40.0	3.0
		DIPTERA	CHIRONOMIDAE	MICROPSECTRA	sp	52.0	4.0
		DIPTERA	CHIRONOMIDAE	CHAETOCLADIUS	sp	4.0	0.3
		DIPTERA	CHIRONOMIDAE	CORYNONEURA	sp	24.0	1.8

Location	Site	Order	Family	Genus	Species	Density/KN	% Comp
Lord Brook Trib 4 0.2		DIPTERA	CHIRONOMIDAE	HELENIELLA	sp	44.0	3.3
		DIPTERA	CHIRONOMIDAE	PARAMETRIOCNEMUS	sp	168.0	12.8
		DIPTERA	CHIRONOMIDAE	RHEOCRICOTOPUS	sp	4.0	0.3
		DIPTERA	CHIRONOMIDAE	TVETENIA	paucunca	52.0	4.0
		DIPTERA	CHIRONOMIDAE	STILOCLADIUS	sp	4.0	0.3
		DIPTERA	CHIRONOMIDAE	BRUNDINIELLA	sp	12.0	0.9
		DIPTERA	CHIRONOMIDAE	ZAVRELIMYIA	sp	12.0	0.9
		DIPTERA	CHIRONOMIDAE	THIENEMANNIMYIA GROUP	group	120.0	9.1
		DIPTERA	DIXIDAE	DIXA	sp	12.0	0.9
		DIPTERA	TIPULIDAE	DICRANOTA	sp	48.0	3.6
		DIPTERA	TIPULIDAE	HEXATOMA	sp	40.0	3.0
		DIPTERA	TIPULIDAE	PEDICIA	sp	4.0	0.3
		DIPTERA	TIPULIDAE	TIPULA	sp	4.0	0.3
		DIPTERA	TIPULIDAE	MOLOPHILUS	sp	4.0	0.3
		EPEMEROPTERA	EPEMERELLIDAE	EURYLOPHELLA	funeralis	28.0	2.1
		EPEMEROPTERA	LEPTOPHLEBIIDAE	PARALEPTOPHLEBIA	sp	4.0	0.3
		TRICHOPTERA	HYDROPSYCHIDAE	DIPLECTRONA	modesta	40.0	3.0
		TRICHOPTERA	HYDROPSYCHIDAE	PARAPSYCHE	apicalis	32.0	2.4
		TRICHOPTERA	LEPIDOSTOMATIDAE	LEPIDOSTOMA	sp	44.0	3.3
		TRICHOPTERA	LIMNEPHILIDAE	N/A	imm	8.0	0.6
		TRICHOPTERA	LIMNEPHILIDAE	HYDATOPHYLAX	sp	8.0	0.6
		TRICHOPTERA	ODONTOCERIDAE	PSILOTRETA	sp	16.0	1.2
		TRICHOPTERA	PHILOPOTAMIDAE	N/A	imm	20.0	1.5
		TRICHOPTERA	PHILOPOTAMIDAE	DOLOPHILODES	sp	4.0	0.3
		TRICHOPTERA	PHILOPOTAMIDAE	WORMALDIA	sp	88.0	6.7
		TRICHOPTERA	PHRYGANEIDAE	N/A	imm	16.0	1.2
		TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA	sp	12.0	0.9
		TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA	nigrita	16.0	1.2
		TRICHOPTERA	RHYACOPHILIDAE	RHYACOPHILA	carolina group	16.0	1.2
PLECOPTERA	CAPNIIDAE	N/A	imm	4.0	0.3		
PLECOPTERA	CHLOROPERLIDAE	SWELTSA	sp	88.0	6.7		
PLECOPTERA	LEUCTRIDAE	N/A	imm	56.0	4.3		
PLECOPTERA	NEMOURIDAE	SOYEDINA	sp	44.0	3.3		
PLECOPTERA	PERLODIDAE	ISOPERLA	sp	32.0	2.4		
PLECOPTERA	PERLODIDAE	MALIREKUS	iroquois	4.0	0.3		
ODONATA	GOMPHIDAE	N/A	imm	4.0	0.3		
BIVALVIA	SPHAERIIDAE	PISIDIUM	casertanum	4.0	0.3		
OLIGOCHAETA	LUMBRICULIDAE	N/A	unid	20.0	1.5		
OLIGOCHAETA	ENCHYTRAEIDAE	N/A	unid	4.0	0.3		
CAUDATA	PLETHODONTIDAE	EURYCEA	bislineata	common	common		