Determining Water Quality Criteria for Total Dissolved Solids in Streams of Southwestern Virginia

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Project Summary

This research is being conducted for the purpose of recommending total dissolved solids (TDS) criteria for developing water quality standards with potential application to Virginia's coalfield streams. Results will be used to develop a statistical model that predicts a Virginia Stream Condition Index (VA SCI) score as a function of TDS concentrations and/or component ion contributions to TDS at locations where non-TDS anthropogenic stressor effects are not evident. The statistical model will be used to recommend a criterion that can be used to develop a TDS water quality standard that would protect aquatic life within the study region. Research methods are as follows:

1. Identify freshwater stream research sites that have elevated (i.e., above reference) TDS concentrations but appear to be otherwise relatively unaffected by non-TDS stressor effects.
2. Identify freshwater stream research sites that can serve as reference locations for assessment of TDS effects on the VA SCI.
3. At each research site, sample benthic macroinvertebrates.
4. Characterize non-TDS stressor and other benthic macroinvertebrate community influences at all research sites by sampling habitat elements and water quality.
5. Analyze data to determine a potential TDS criterion.

Progress Update

Progress since our previous report submitted in April 2010 has been on schedule and within budget. Sample processing has been completed for Fall 2009 samples. Chemical analyses for TDS, alkalinity, major ions, and trace metals have been completed. Benthic macroinvertebrate samples have been sorted and organisms have been identified. Fall 2009 VA SCI scores have been calculated for each site. Chemical and biological data for Fall 2009 are summarized herein.

Biological and chemical samples were collected from 28 sites during the Spring 2010 index period, which included three additional reference sites selected during winter 2010. Chemical

and biological analyses are ongoing for Spring 2010 samples. Spring 2010 data will be included in the final report.

Mr. Timpano has been certified in genus-level taxonomy (Eastern EPT) by the North American Benthological Society.

This report presents a summation of Fall 2009 data, activities of the past four months, and plans for the remainder of the project, to be concluded in December 2010. Earlier results were reported by Timpano et al. (2009).

Site Selection

Three additional reference sites were sampled during the Spring 2010 index period. Reference sites represent the least disturbed condition that we could locate in the Virginia coalfield region, while remaining as comparable as possible to test sites with regard to factors such as geology, topology, and hydrology. Initial candidates were selected through review of landuse data, aerial photography, as well as water quality and permit data provided by DMME. Candidate reference sites were then visited and evaluated for inclusion in the study.

Presentations

A manuscript was accepted for, and oral presentation made during, technical sessions of the 2010 National Meeting of the American Society of Mining and Reclamation (ASMR), held in Pittsburgh, Pennsylvania in June 2010. The manuscript was published in the 2010 ASMR conference proceedings. The paper presented preliminary results concerning TDS relationships to specific benthic macroinvertebrate metrics, but did not draw conclusions regarding potential VA SCI impairment thresholds or criteria. The paper is attached as an Appendix to this report.

An abstract was accepted for presentation of a poster at the 2010 meeting of the Society for Environmental Toxicology and Chemistry to be held in Portland, Oregon in November 2010. The poster will present our findings regarding TDS ionic composition as well as an analysis of biological response to TDS component ions. That abstract is also attached.

Future Plans

The plans for the next four months include finalizing analyses of chemical and biological samples from Spring 2010, data analysis, and final report preparation. The final report will contain all raw data collected during this study, as well as complete analysis of those data. The report is scheduled for submission by December 31, 2010.

Reference::

A. Timpano, S. Schoenholtz, D. Soucek, C. Zipper. 2009. Effects of Total Dissolved Solids in Streams of Southwestern Virginia. p. 82-94, in: 2009 Powell River Project Research and Education Program Reports. http://www.cses.vt.edu/PRP/Reports_09/Reports_09.html

Data Summary – Fall 2009

Table A-1. Site Information - Fall 2009

Stream	Station ID	Type	Order	Dominant Geology	County	Lat	Long
Burns Creek (ref)	BUR	Ref	2	Lee	Wise	36.929	-82.535
Clear Creek (ref)	CLE	Ref	2	Mississippian	Wise	36.929	-82.589
Eastland Creek (Ref)	EAS	Ref	1	Mississippian	Wise	36.917	-82.593
Birchfield Creek	BIR	Test	2	Wise	Wise	37.036	-82.575
Callahan Creek West Fork	CAW	Test	1	Wise	Wise	36.980	-82.797
Fawn Branch	FAW	Test	1	Wise	Lee	36.811	-83.080
Fryingpan Creek	FRY	Test	2	Norton	Dickenson	37.060	-82.218
Fryingpan Creek Right Fork	RFF	Test	2	Norton	Dickenson	37.060	-82.220
Gin Creek	GIN	Test	3	Wise	Lee	36.836	-83.055
Grape Branch	GRA	Test	2	Norton	Buchanan	37.257	-82.007
Hurricane Fork	HUR	Test	2	Norton	Buchanan	37.400	-82.067
Jess Fork	JES	Test	2	Wise	Buchanan	37.295	-82.219
Laurel Branch	LAB	Test	2	Norton	Russell	37.014	-82.205
Laurel Fork	LAU	Test	2	Wise	Wise	36.874	-82.825
Mill Branch Left Fork	MIL	Test	2	Wise	Wise	36.927	-82.747
Powell River	POW	Test	1	Wise	Wise	37.013	-82.697
Race Fork UT	RAC	Test	1	Norton	Buchanan	37.427	-82.050
Roll Pone Branch	ROL	Test	1	Norton	Russell	37.014	-82.195
Spring Branch	SPR	Test	1	Norton	Buchanan	37.434	-82.046
Cane Branch	CAN	Test	1	Wise	Dickenson	37.160	-82.547
Kelly Branch	KEL	Test	2	Wise	Wise	36.935	-82.792
Kelly Branch UT	KUT	Test	1	Wise	Wise	36.936	-82.792
Richey Branch	RIC	Test	2	Wise	Wise	37.036	-82.546
Richey Branch UT	RUT	Test	1	Wise	Wise	37.037	-82.544
Spruce Pine Creek	SPC	Test	2	Norton	Buchanan	37.261	-81.922

Table A-2. Field Physicochemical Parameters - Fall 2009

Stream	Temp (°C)	pH (SU)	D.O. (mg/L)	Cond. (µS/cm)
Burns Creek (ref)	13.62	6.5	8.36	21
Clear Creek (ref)	13.81	7.25	8.39	20
Eastland Creek (ref)	13.79	7.15	7.69	22
Birchfield Creek	14.38	7.67	8.45	647
Callahan Creek West Fork	7.81	7.31	10.75	292
Cane Branch	10.01	7.96	9.13	1462
Fawn Branch	9.55	7.49	8.52	281
Fryingpan Creek	13.08	7.62	9.05	402
Fryingpan Creek Right Fork	12.9	7.41	8.37	340
Gin Creek	11.14	8.07	9.21	656
Grape Branch	8.35	7.27	10.12	339
Hurricane Fork	7.31	7.21	11.06	383
Jess Fork	6.74	7.22	11.35	682
Kelly Branch	11.67	7.3	9.34	873
Kelly Branch UT	12.71	7.96	9.69	1366
Laurel Branch	13.01	7.63	9.19	784
Laurel Fork	7.04	7.23	10.15	20
Mill Branch Left Fork	15.00	7.37	8.42	845
Powell River	15.08	7.46	8.93	1087
Race Fork UT	9.31	7.25	9.69	450
Richey Branch	13.49	7.93	8.49	1670
Richey Branch UT	12.85	7.63	8.77	545
Roll Pone Branch	12.97	7.2	8.77	652
Spring Branch	7.68	7.3	10.69	274
Spruce Pine Creek	9.01	7.79	10.05	468

Table A-3. Rapid Bioassessment Protocol Habitat Scores - Fall 2009

Stream	Substrate/Cover	Embeddedness	Velocity/Depth	Sediment Dep.	Flow	Channel Alt.	Riffle Freq.	Bank Stability L	Bank Stability R	Veg. Protection L	Veg. Protection R	Rip. Veg. Width L	Rip. Veg. Width R	Total
Burns Creek (ref)	19	18	17	17	18	20	17	9	10	10	10	10	10	**185**
Clear Creek (ref)	19	17	19	16	20	20	20	9	10	10	10	10	10	**190**
Eastland Creek (ref)	19	17	17	17	17	20	20	9	9	10	10	10	10	**185**
Birchfield Creek	16	13	15	12	18	20	18	7	7	8	8	10	8	**160**
Callahan Creek West Fork	16	13	16	13	18	20	18	9	9	10	10	10	10	**172**
Fawn Branch	17	13	16	13	18	20	18	9	9	9	9	10	9	**170**
Fryingpan Creek	18	15	16	14	17	20	19	9	9	10	10	10	10	**177**
Fryingpan Creek Right Fork	18	16	16	14	15	20	18	8	8	10	10	10	9	**172**
Gin Creek	16	12	16	12	18	20	18	8	8	8	8	10	7	**161**
Grape Branch	17	14	16	13	18	20	16	9	9	9	9	10	10	**170**
Hurricane Fork	16	11	15	11	15	20	18	8	8	9	9	10	10	**160**
Jess Fork	15	12	15	11	18	20	17	7	7	7	7	9	7	**152**
Laurel Branch	16	13	15	12	20	20	16	8	8	8	6	10	6	**158**
Laurel Fork	20	15	17	14	20	20	19	9	9	10	10	10	10	**183**
Mill Branch Left Fork	17	13	13	12	16	20	18	8	7	10	10	10	9	**163**
Powell River	19	15	15	14	20	20	20	7	9	10	10	10	10	**179**
Race Fork UT	18	13	14	12	16	20	18	8	8	9	9	10	10	**165**
Roll Pone Branch	17	12	15	12	16	20	19	8	8	9	9	10	10	**165**
Spring Branch	17	13	16	12	17	20	17	7	8	7	8	10	10	**162**
Cane Branch	17	14	17	13	18	20	17	7	7	8	8	10	10	**166**
Kelly Branch	17	13	18	12	20	20	17	10	10	10	9	10	10	**176**
Kelly Branch UT	18	16	17	14	18	20	19	6	6	9	9	10	10	**172**
Richey Branch	17	14	17	13	18	20	17	7	7	9	9	10	10	**168**
Richey Branch UT	17	13	17	12	18	20	17	6	6	10	10	10	10	**166**
Spruce Pine Creek	17	15	17	13	17	20	18	10	10	10	10	10	10	**177**

Table A-4. Total Dissolved Solids, Anions, and Alkalinity - Fall 2009

Stream	TDS (mg/L)	Anions (mg/L)		Alkalinity (mg/L as $CaCO_3$)		
		Cl^-	SO_4^{2-}	Total	CO_3^{2-}	HCO_3^-
Burns Creek (ref)	12	2.0	4.2	1.2		1.2
Clear Creek (ref)	14	0.5	3.1	6.3		6.3
Eastland Creek (ref)	10	0.4	2.8	8.0		8.0
Birchfield Creek	410	8.7	220.7	120.1		120.1
Callahan Creek West Fork	187	0.7	88.2	68.4		68.4
Cane Branch	1108	5.1	679.4	202.0		202.0
Fawn Branch	164	2.2	67.4	81.5		81.5
Fryingpan Creek	263	11.2	100.9	93.1		93.1
Fryingpan Creek Right Fork	218	5.9	76.7	90.5		90.5
Gin Creek	411	8.5	112.9	232.9	3.4	229.5
Grape Branch	202	4.2	119.7	51.6		51.6
Hurricane Fork	258	1.1	166.5	34.2		34.2
Jess Fork	493	1.1	340.4	49.3		49.3
Kelly Branch	615	1.8	412.7	88.0		88.0
Kelly Branch UT	1021	1.9	629.3	173.1		173.1
Laurel Branch	553	3.9	282.7	124.7		124.7
Laurel Fork	33	0.5	4.3	6.0		6.0
Mill Branch Left Fork	588	1.1	350.8	133.6		133.6
Powell River	751	0.5	477.2	126.7		126.7
Race Fork UT	273	1.1	163.0	81.4		81.4
Richey Branch	1378	5.8	849.0	190.8		190.8
Richey Branch UT	388	4.6	219.4	75.1		75.1
Roll Pone Branch	462	3.2	272.4	83.4		83.4
Spring Branch	156	0.8	92.3	53.3		53.3
Spruce Pine Creek	281	3.4	108.2	142.9		142.9

Table A-5. Major Cations - Fall 2009

Stream	Major Cations (mg/L)			
	K	Na	Ca	Mg
Burns Creek (ref)	0.3	1.7	1.2	0.5
Clear Creek (ref)	0.4	0.6	2.1	0.6
Eastland Creek (ref)	0.4	0.6	2.8	0.7
Birchfield Creek	4.2	19.4	63.2	46.3
Callahan Creek West Fork	2.1	6.8	33.1	14.9
Cane Branch	7.4	76.8	141.8	97.0
Fawn Branch	2.2	10.9	29.9	13.7
Fryingpan Creek	2.4	27.0	37.2	18.0
Fryingpan Creek Right Fork	2.4	29.1	29.0	11.9
Gin Creek	3.7	117.1	28.7	11.8
Grape Branch	2.0	21.0	32.1	13.3
Hurricane Fork	2.5	7.7	36.0	27.3
Jess Fork	3.3	9.9	81.6	45.2
Kelly Branch	4.9	14.1	100.3	59.6
Kelly Branch UT	7.6	55.3	151.8	82.4
Laurel Branch	4.3	46.5	82.0	41.9
Laurel Fork	0.6	0.7	1.5	1.1
Mill Branch Left Fork	5.1	15.2	104.4	49.6
Powell River	4.5	9.7	122.7	72.0
Race Fork UT	2.5	20.7	46.4	23.8
Richey Branch	6.5	14.6	183.9	160.6
Richey Branch UT	4.2	5.5	46.4	50.1
Roll Pone Branch	3.9	16.0	76.5	39.6
Spring Branch	1.9	3.8	27.6	18.3
Spruce Pine Creek	1.9	53.8	37.0	15.7

Table A-6. Trace Metals - Fall 2009

Stream	Trace Metals (µg/L)					
	Al	Cu	Fe	Mn	Se	Zn
Burns Creek (ref)	11.3	< 12.9	< 64.9	6.7	< 16.1	18.1
Clear Creek (ref)	35.1	< 12.9	< 64.9	12.2	< 16.1	10.9
Eastland Creek (ref)	< 8.6	< 12.9	< 64.9	5.1	< 16.1	10.3
Birchfield Creek	< 8.6	< 12.9	< 64.9	32.9	< 16.1	12.0
Callahan Creek West Fork	9.4	< 12.9	< 64.9	6.3	< 16.1	12.6
Cane Branch	25.8	< 12.9	< 64.9	86.7	< 16.1	10.3
Fawn Branch	< 8.6	< 12.9	< 64.9	8.1	< 16.1	12.8
Fryingpan Creek	< 8.6	< 12.9	< 64.9	6.6	< 16.1	10.0
Fryingpan Creek Right Fork	< 8.6	< 12.9	< 64.9	10.4	< 16.1	10.2
Gin Creek	< 8.6	< 12.9	64.9	7.4	< 16.1	13.7
Grape Branch	< 8.6	< 12.9	< 64.9	6.3	< 16.1	11.4
Hurricane Fork	8.7	< 12.9	< 64.9	17.2	< 16.1	11.6
Jess Fork	20.0	< 12.9	< 64.9	12.7	< 16.1	16.7
Kelly Branch	< 8.6	< 12.9	< 64.9	9.5	< 16.1	10.6
Kelly Branch UT	17.2	< 12.9	< 64.9	12.2	22.9	11.3
Laurel Branch	< 8.6	< 12.9	< 64.9	11.2	14.6	11.1
Laurel Fork	12.4	< 12.9	80.8	10.6	< 16.1	15.9
Mill Branch Left Fork	15.3	< 12.9	71.3	93.0	17.2	13.5
Powell River	11.4	< 12.9	< 64.9	14.1	16.6	17.4
Race Fork UT	< 8.6	< 12.9	< 64.9	6.5	< 16.1	11.3
Richey Branch	36.4	< 12.9	< 64.9	19.7	< 16.1	10.2
Richey Branch UT	9.9	< 12.9	< 64.9	11.7	< 16.1	10.5
Roll Pone Branch	< 8.6	< 12.9	< 64.9	5.8	< 16.1	11.1
Spring Branch	30.7	< 12.9	69.9	8.7	< 16.1	10.8
Spruce Pine Creek	< 8.6	< 12.9	< 64.9	14.7	< 16.1	10.7

Table A-7. Virginia SCI Metrics and Final Score (100 organism sample) – Fall 2009

Stream	# Taxa	# EPT Taxa	% E	% PT-Hyd.	% Scrapers	% Chiron.	% 2 Dom.	HBI	SCI Score
Burns Creek (ref)	15	8	7.5	34.0	4.7	16.0	51.9	4.2	62.1
Clear Creek (ref)	20	16	31.0	19.0	22.4	15.5	40.5	4.2	74.3
Eastland Creek (ref)	15	11	17.4	22.7	10.6	3.8	60.6	4.3	64.8
Birchfield Creek	9	5	0.0	76.0	0.0	1.0	82.7	2.2	51.3
Callahan Creek West Fork	17	12	19.8	42.6	17.8	9.9	38.6	3.2	77.8
Fawn Branch	17	12	30.1	56.6	9.7	6.2	54.0	2.1	75.7
Fryingpan Creek	15	12	0.9	60.4	9.0	9.0	71.2	3.0	65.0
Fryingpan Creek Right Fork	9	5	0.0	83.3	1.9	7.4	86.1	1.9	50.3
Gin Creek	11	7	1.8	56.0	0.9	8.3	83.5	3.2	54.2
Grape Branch	13	9	1.9	41.3	1.0	14.4	67.3	4.2	58.1
Hurricane Fork	23	16	9.0	49.5	6.3	9.9	43.2	3.4	74.5
Jess Fork	11	8	2.6	17.9	0.0	23.9	73.5	5.2	45.2
Laurel Branch	13	7	5.0	37.1	1.4	11.4	68.6	4.0	57.0
Laurel Fork	13	11	18.5	48.1	11.1	8.3	58.3	3.4	70.1
Mill Branch Left Fork	11	5	0.0	25.5	0.0	11.8	75.5	4.8	45.9
Powell River	11	5	0.0	62.7	4.9	9.8	57.8	2.5	57.0
Race Fork UT	16	9	0.0	45.5	2.0	21.8	47.5	4.0	62.7
Roll Pone Branch	11	8	2.5	67.8	0.0	4.2	86.4	2.6	55.3
Spring Branch	16	9	19.0	39.0	7.0	18.0	40.0	3.9	69.7
Cane Branch	8	2	0.0	62.0	0.0	7.4	86.1	2.9	45.9
Kelly Branch	11	6	0.0	58.0	2.0	4.0	68.0	2.8	56.3
Kelly Branch UT	12	5	0.0	16.5	1.9	14.6	76.7	5.2	42.4
Richey Branch	11	6	0.0	51.8	1.8	2.7	86.4	3.3	52.9
Richey Branch UT	15	8	1.0	46.7	8.6	7.6	62.9	3.3	63.0
Spruce Pine Creek	14	8	8.7	24.3	14.8	4.3	69.6	4.5	58.5