APPENDIX 2
Macroinvertebrates

Abstract

This appendix reviews the available evidence concerning the potential effects of the activities associated with the Spruce No. 1 Mine on the macroinvertebrate community of receiving streams and presents survey results from streams directly affected by the Spruce No. 1 Mine, including Oldhouse Branch and Pigeonroost Branch, and comparative data from adjacent mined streams impacted by the Dal-Tex operation, including Beech Creek, Left Fork Beech Creek, Rockhouse Creek, and Spruce Fork (Figure A2.1.).

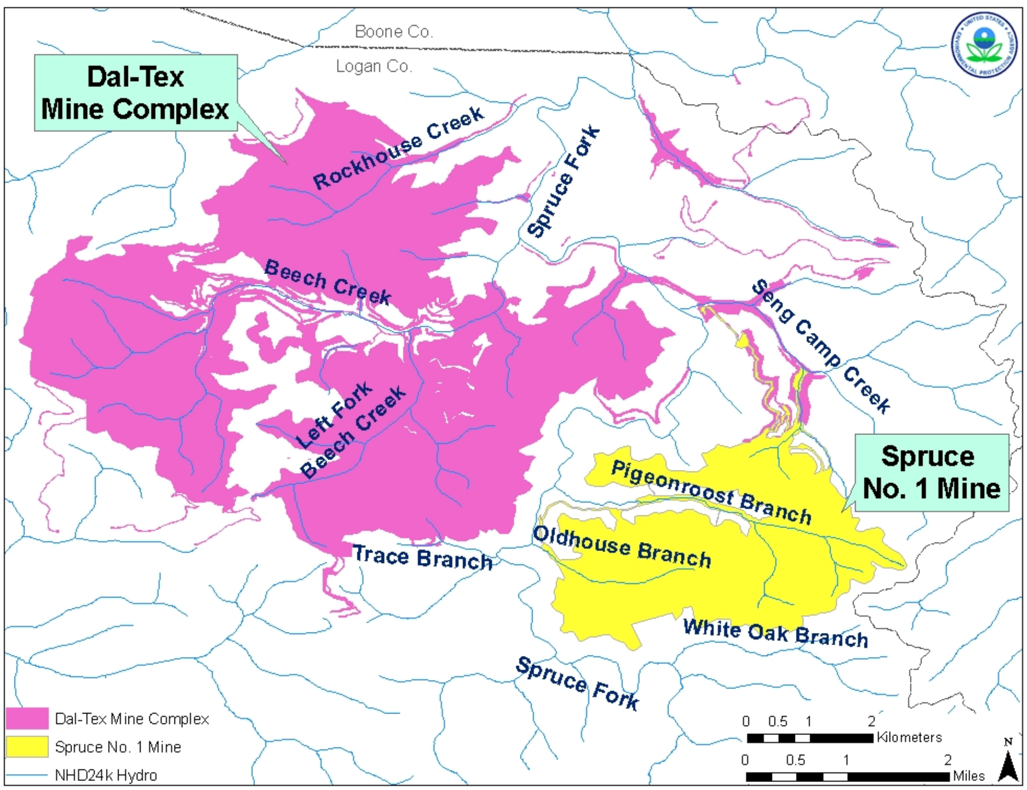


Figure A2.1. Map of Spruce No. 1 Mine area and adjacent Dal-Tex operation.

EPA conducted three different analyses. First, EPA compared benthic macroinvertebrate community composition from Pigeonroost Branch and Oldhouse Branch to benthic macroinvertebrate community composition from streams that have been impacted by Mingo Logan's Dal-Tex operation. Second, EPA used an observed/expected approach to estimate and quantify taxonomic changes following mining disturbance. Third, EPA compared WVSCI scores in Pigeonroost Branch and Oldhouse Branch with streams impacted by the Dal-Tex operation. The results showed that some naturally occurring taxa will be locally extirpated in the receiving streams and will likely be replaced by pollution-tolerant taxa if mining and filling proceed. These results are supported by the State of West Virginia's multimetric index (WVSCI), which also indicates that the magnitude and extent of degradation will increase following mining. The appendix also includes a discussion of appropriate invertebrate metrics and data collection and analysis methods and explains why EPA focuses on changes to sensitive taxa and community composition.

A2.1. Introduction

Macroinvertebrates are good indicators of ecosystem health, and are used by West Virginia and other states in the Mid-Atlantic region and across the U.S. to assess the quality of their waters. They are good indicators because they live in the water for all or most of their life cycle, can be found in all streams, are relatively stationary and cannot escape pollution. They also differ in their tolerance to the amount and types of pollution. Macroinvertebrate communities integrate the effects of stressors over time and some taxa (i.e., taxonomic category such as family, genus, or species) are considered pollution-tolerant and will survive in degraded conditions. Other taxa are pollutant-intolerant and will die when exposed to certain levels of pollution. Thus, the presence of tolerant and intolerant (i.e., sensitive) taxa informs scientists about the quality of the water.

Because of their productivity and intermediate position in the aquatic food web, macroinvertebrates in small streams and headwaters play a critical role in the delivery of energy and nutrients downstream (Vannote et al. 1980). Most macroinvertebrate taxa complete the majority of their life cycle as immature larvae in streams. The Spruce No. 1 Mine project will likely impact most of the sensitive species, as well as several common species, of mayflies (Ephemeroptera, or "E"), stoneflies (Plecoptera, or "P"), and caddisflies (Trichoptera, or "T") currently inhabiting the project area streams through direct burial, as well as chemical loading of pollutants to receiving waters. These "EPT" taxa, as a group, are often considered sensitive to pollutants. Data from other mountaintop mining/valley fill (MTM/VF) related studies (Green et al. 2000, Howard et al. 2001, Pond et al. 2008) within this subecoregion show that many of these taxa will be extirpated, that is, become locally extinct. Pond et al. (2008) reported that at least 10 different genera of mayflies were commonly extirpated from receiving streams of MTM/VF operations, as well as several common stonefly and caddisfly genera. Previous studies revealed strong negative relationships between macroinvertebrates, particularly mayflies, and surface coal mining in southern West Virginia and eastern Kentucky (Chambers & Messinger 2001, Pond 2004, Hartman et al. 2005, Merricks et al. 2007, Pond et al. 2008, Pond 2010).

In a healthy stream, one would expect to find a high diversity of benthic macroinvertebrate taxa and a large number of different taxa, including taxa that are more sensitive to stressors. Using the mayfly (Insecta: Ephemeroptera) as an example, some genera of mayfly are more sensitive than others. The presence of a large number of individuals from the more sensitive mayfly genera indicates good water quality conditions. Mayflies in particular have long been recognized as important indicators of stream ecosystem health. Mayflies are a very important part of the native organisms in Appalachian headwater streams and they routinely make up between 30%-50% of the insect assemblages in certain seasons. Numerous studies demonstrate that mayfly community structure reflects the chemical and physical environment of watercourses (e.g., Barber-James et al. 2008, Bauernfeind & Moog 2000).

Merricks et al. (2007) and Pond et al. (2008) also indicate that after several years following mining reclamation, the native sensitive animals do not recolonize the affected streams. In the highly dissected terrain of the Appalachians, headwater populations can become quickly isolated when receiving streams are cumulatively degraded by increasing human disturbance, such as mountaintop mining. However, if a network of headwater streams is intact, colonization of individual disturbed sites within the network would presumably occur faster based simply on proximity and a higher availability of colonists (Pond 2010). Thus, preserving sufficient undisturbed watersheds (such as Oldhouse and Pigeonroost) in the immediate vicinity of disturbances is crucial to maintaining regional and local macroinvertebrate biodiversity by providing refugia, a potential source for future recolonization, and to provide freshwater dilution for chemical stressors affecting Appalachian headwaters (Pond 2010).

A2.2. Comparisons of Community Compositions

Impacts of the Spruce No. 1 Mine can be predicted by comparing current conditions in the receiving streams to those in comparable nearby streams that have been exposed to similar operations, such as Mingo Logan's Dal-Tex site. Macroinvertebrate samples were collected from streams impacted by the now inactive Dal-Tex operations, including Beech Creek and Left Fork Beech Creek, and streams that would be impacted by Spruce No. 1, including Pigeonroost Branch and Oldhouse Branch, (Figure A2.1.)[1]. Equal numbers of benthic samples were collected by EPA at all locations between 1999 and 2000. Data are based upon a 1 square meter riffle sample and a 200 fixed-count sub-sample. Samples were collected using a kick-net in riffle habitats, consistent with WVDEP sampling protocols. Because only riffle habitats were sampled, these data represent an estimate of biodiversity within riffle stream habitats, and additional taxa, including crayfish and dragonflies, from other habitat types are present but seldom detected due to the nature of sampling.

Collectively, 84 distinct taxa were collected from Pigeonroost Branch and Oldhouse Branch, while only 56 were collected from both Beech Creek and Left Fork Beech Creek. In Pigeonroost Branch and Oldhouse Branch combined, 42 EPT taxa were collected, while at Beech Creek and Left Fork Beech Creek only 12 EPT were found. EPA collected 14 mayfly and 12 stonefly genera at the Spruce No. 1 Mine project area, while only two relatively opportunistic (pollution generalist) mayfly genera and three opportunistic stonefly genera were collected in streams draining the Dal-Tex mine. This direct comparison indicates that, at a minimum, 12 mayfly genera and 9 stonefly genera may be extirpated from streams that receive surface mine run-off and valley fill effluent at the Spruce No. 1 Mine site. EPA also found that caddisflies (Trichoptera) were diverse (14 total genera) in Pigeonroost Branch and Oldhouse Branch, but only 7 total genera were found in Beech Creek and Left Fork Beech Creek on the Dal-Tex mine. Overall, the difference in taxa richness of Ephemeroptera, Plecoptera and Trichoptera taxa between the mined and un-mined sites was significant.

[1] Note: EPA's macroinvertebrate data from Seng Camp was excluded because data were collected qualitatively, and thus are not comparable for most analyses.

Table A2.1. Macroinvertebrate genera identified from EPA sampling efforts at the Spruce No. 1 Mine and Dal-Tex Mine. Seng Camp data is excluded, as it was collected with a different method.

			Oldhouse +Pigeonroost	**Beech+Left Fork Beech**
Order	**Family**	**Genus**	**Spruce No. 1**	**Dal-Tex**
Oligochaeta	Oligochaeta	Oligochaeta	X	X
Nematoda	Nematoda	Nematoda		X
Proseriataoela	Plagiostomidae	*Hydrolimax*	X	
Tricladida	Planariidae	Planariidae	X	
Basommatophora	Lymnaeidae	Lymnaeidae		X
Basommatophora	Physidae	Physella		X
Basommatophora	Planorbidae	*Helisoma*		X
Coleoptera	Dryopidae	*Helichus*	X	
Coleoptera	Elmidae	*Dubiraphia*		X
Coleoptera	Elmidae	*Macronychus*		X
Coleoptera	Elmidae	*Microcylloepus*		X
Coleoptera	Elmidae	*Optioservus*	X	X
Coleoptera	Elmidae	*Oulimnius*	X	X
Coleoptera	Psephenidae	*Ectopria*	X	
Coleoptera	Psephenidae	*Psephenus*	X	X
Decapoda	Cambaridae	*Cambarus*	X	
Diptera	Ceratopogonidae	*Atrichopogon*		X
Diptera	Ceratopogonidae	*Bezzia/Palpomyia*	X	X
Diptera	Ceratopogonidae	*Dasyhelea*	X	X
Diptera	Chironomidae	*Acricotopus*		X
Diptera	Chironomidae	*Chaetocladius*	X	X
Diptera	Chironomidae	*Corynoneura*	X	X
Diptera	Chironomidae	*Cricotopus*	X	X
Diptera	Chironomidae	*Diamesa*	X	X
Diptera	Chironomidae	*Eukiefferiella*	X	X
Diptera	Chironomidae	*Metriocnemus*		X
Diptera	Chironomidae	*Micropsectra*	X	X
Diptera	Chironomidae	*Microtendipes*	X	
Diptera	Chironomidae	*Orthocladius*	X	X
Diptera	Chironomidae	*Parachaetocladius*	X	
Diptera	Chironomidae	*Parametriocnemus*	X	X
Diptera	Chironomidae	*Paraphaenocladius*		X
Diptera	Chironomidae	*Paratanytarsus*		X
Diptera	Chironomidae	*Polypedilum*	X	X
Diptera	Chironomidae	*Rheotanytarsus*	X	X
Diptera	Chironomidae	*Smittia*		X
Diptera	Chironomidae	*Stempellinella*	X	
Diptera	Chironomidae	*Stenochironomus*		X
Diptera	Chironomidae	*Stilocladius*	X	
Diptera	Chironomidae	*Sympotthastia*	X	
Diptera	Chironomidae	*Tanytarsus*	X	
Diptera	Chironomidae	*Thienemanniella*		X
Diptera	Chironomidae	*Thienemannimyia*	X	X
Diptera	Chironomidae	*Tvetenia*	X	X
Diptera	Chironomidae	*Zavrelimyia*	X	
Diptera	Empididae	*Chelifera/Metachela*	X	X
Diptera	Empididae	*Clinocera*	X	
Diptera	Empididae	*Hemerodromia*		X
Diptera	Simuliidae	*Prosimulium*	X	
Diptera	Simuliidae	*Simulium*	X	X
Diptera	Tabanidae	Tabanidae		X
Diptera	Tipulidae	*Antocha*		X
Diptera	Tipulidae	*Cryptolabis*	X	
Diptera	Tipulidae	*Dicranota*	X	

Order	Family	Genus	Spruce No. 1	Dal-Tex
Diptera	Tipulidae	*Hexatoma*	X	
Diptera	Tipulidae	*Limnophila*	X	
Diptera	Tipulidae	*Limonia*	X	X
Diptera	Tipulidae	*Pseudolimnophila*	X	
Diptera	Tipulidae	*Tipula*	X	X
Ephemeroptera	Ameletidae	*Ameletus*	X	
Ephemeroptera	Baetidae	*Acentrella*	X	
Ephemeroptera	Baetidae	*Baetis*	X	X
Ephemeroptera	Baetiscidae	*Baetisca*	X	
Ephemeroptera	Ephemerellidae	*Drunella*	X	
Ephemeroptera	Ephemerellidae	*Ephemerella*	X	
Ephemeroptera	Ephemerellidae	*Eurylophella*	X	
Ephemeroptera	Ephemeridae	*Ephemera*	X	
Ephemeroptera	Heptageniidae	*Cinygmula*	X	
Ephemeroptera	Heptageniidae	*Epeorus*	X	
Ephemeroptera	Heptageniidae	*Stenacron*	X	
Ephemeroptera	Heptageniidae	*Maccaffertium/ Stenonema*	X	
Ephemeroptera	Isonychiidae	*Isonychia*	X	X
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*	X	
Megaloptera	Corydalidae	*Corydalus*		X
Megaloptera	Corydalidae	*Nigronia*	X	X
Odonata	Aeshnidae	*Boyeria*		X
Odonata	Gomphidae	*Lanthus*	X	X
Plecoptera	Capniidae	Capniidae	X	
Plecoptera	Chloroperlidae	*Haploperla*	X	
Plecoptera	Leuctridae	*Leuctra*	X	
Plecoptera	Nemouridae	*Amphinemura*	X	X
Plecoptera	Nemouridae	*Ostrocerca*	X	
Plecoptera	Nemouridae	*Prostoia*		X
Plecoptera	Peltoperlidae	*Peltoperla*	X	
Plecoptera	Perlidae	*Acroneuria*	X	
Plecoptera	Perlodidae	*Isoperla*	X	
Plecoptera	Perlodidae	*Remenus*	X	
Plecoptera	Perlodidae	*Yugus*	X	
Plecoptera	Pteronarcyidae	*Pteronarcys*	X	
Plecoptera	Taeniopterygidae	*Taenionema*	X	
Plecoptera	Taeniopterygidae	*Taeniopteryx*	X	X
Trichoptera	Glossosomatidae	*Agapetus*	X	
Trichoptera	Glossosomatidae	*Glossosoma*	X	
Trichoptera	Goeridae	*Goera*	X	
Trichoptera	Hydropsychidae	*Ceratopsyche*	X	
Trichoptera	Hydropsychidae	*Cheumatopsyche*	X	X
Trichoptera	Hydropsychidae	*Diplectrona*	X	X
Trichoptera	Hydropsychidae	*Hydropsyche*	X	X
Trichoptera	Hydroptilidae	*Hydroptila*		X
Trichoptera	Limnephilidae	*Pycnopsyche/ Hydatophylax*	X	
Trichoptera	Philopotamidae	*Chimarra*	X	X
Trichoptera	Philopotamidae	*Dolophilodes*	X	
Trichoptera	Polycentropodidae	*Polycentropus*	X	
Trichoptera	Psychomyiidae	*Psychomyia*	X	X
Trichoptera	Rhyacophilidae	*Rhyacophila*	X	X
Trichoptera	Uenoidae	*Neophylax*	X	
		Total Distinct Taxa	**84**	**56**
		Total EPT Taxa	**42**	**12**

At Beech Creek and Left Fork Beech Creek, several tolerant taxa were found that were not found in the Spruce project area (Table 1), indicating altered environmental conditions (i.e., atypical of Appalachian headwater streams) foster the invasion of these tolerant taxa. These taxa include highly tolerant snails that typically do not occupy healthy headwater streams in the Appalachians (Lymnaeidae, *Physella, Helisoma*), as well as tolerant beetles and fly larvae.

Mayfly data from EPA, WVDEP, and the applicant's consultants (Sturm Environmental Services, BMI, Inc.) reveal that collectively, Pigeonroost Branch and Oldhouse Branch contain a high number of sensitive mayfly taxa and individuals. A total of 19 taxa (Table A2.2.) have been identified from these two headwater streams indicating these systems offer high water quality and optimal habitat. Many of these mayfly genera have not been collected in Spruce Fork, making these headwater streams distinctive in the permit area.[2] This list represents only an estimate of mayfly richness in these streams; several other genera have been found by WVDEP in other Spruce Fork tributaries and are potentially present in the project area.

Table A2.2. Presence/absence of mayfly genera in the permit area.[3] Frequency of occurrence below MTM/VF is presented for comparison and is based upon 20 similar West Virginia MTM/VF sites (Pond et al. 2008). NA indicates that the taxon was not collected in Pond et al. (2008) study.

Order	Family	Genus	Oldhouse	Pigeon-roost	Frequency of Occurrence Below MTM/VF >500 µS/cm
Ephemeroptera	Ameletidae	*Ameletus*	X	X	10%
Ephemeroptera	Baetidae	*Acentrella*	X	X	15%
Ephemeroptera	Baetidae	*Baetis*	X	X	35%
Ephemeroptera	Baetidae	*Diphetor*		X	0%
Ephemeroptera	Baetiscidae	*Baetisca*		X	NA
Ephemeroptera	Ephemerellidae	*Attanella*		X	NA
Ephemeroptera	Ephemerellidae	*Dannella*		X	NA
Ephemeroptera	Ephemerellidae	*Drunella*	X	X	0%
Ephemeroptera	Ephemerellidae	*Ephemerella*	X	X	15%
Ephemeroptera	Ephemerellidae	*Eurylophella*	X	X	0%
Ephemeroptera	Ephemeridae	*Ephemera*	X	X	0%
Ephemeroptera	Heptageniidae	*Cinygmula*	X	X	0%
Ephemeroptera	Heptageniidae	*Epeorus*	X	X	0%
Ephemeroptera	Heptageniidae	*Heptagenia*		X	NA
Ephemeroptera	Heptageniidae	*Maccaffertium*	X	X	0%
Ephemeroptera	Heptageniidae	*Stenacron*	X		0%
Ephemeroptera	Isonychiidae	*Isonychia*		X	0%
Ephemeroptera	Leptophlebiidae	*Choroterpes*	X		NA
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*	X		0%

[2] The few taxa shared with Spruce Fork are generally non-sensitive such as *Baetisca*, *Baetis*, and *Isonychia*.
[3] *Siphlonurus* and *Pseudocloeon* were identified by the permitee's consultant, Sturm Environmental Services, but have been excluded from this list, as they were likely erroneous identifications. *Siphlonurus* is exceedingly rare in this ecoregion and can be confused with *Ameletus*, a much more common inhabitant. EPA believes the identification may have been in error. Also, older taxonomic sources placed *Pseudocloeon* as *Acentrella* (formerly of the genus *Baetis*), and was eventually placed in the genus *Labiobaetis*. This genus does not frequent headwater streams like Oldhouse Branch and Pigeonroost Branch. It is most probable that previous records of *Pseudocloeon* are, in fact, *Acentrella*.

Oldhouse Branch and Pigeonroost Branch represent an exceptionally high quality resource within the Spruce Fork watershed, providing refugia for aquatic life and potential sources for recolonizing nearby waters, which are experiencing significant stream degradation. As many as 9 mayfly taxa have been collected by EPA in Oldhouse Branch in any one season-specific sample (based on a random subsample of 200 organisms), with an average of 7 genera across multiple samples. This former observation ranks in the 95th percentile of 937 samples taken by WVDEP in the Central Appalachian ecoregion (also based on 200 organism subsamples). These data are significant and indicate that only 5% or less of the total number of streams in this ecoregion have more mayfly taxa than Oldhouse Branch. On a statewide scale (greater than 4000 samples), Oldhouse ranks in the 90th percentile. Pigeonroost Branch contained 8 genera in a season-specific sample, ranking it among the 90th percentile in the Central Appalachians and 83rd percentile statewide for single-sample observations indicating that these streams are refugia for aquatic life and potential sources for recolonizing nearby waters, and an exceptional, high quality resource within the Spruce Fork watershed which is experiencing significant stream impairment.

A recent study (Pond et al. 2008) found that mayfly richness is significantly reduced to a few or zero genera when conductivity exceeds 500 µS/cm below mining operations in West Virginia that are similar to the Spruce No. 1 Mine. Many of the individual mayfly genera present in Pigeonroost Branch and Oldhouse Branch are found infrequently or are absent from MTM streams having conductivity levels greater than 500 µS/cm. The same mining-induced pattern was documented in the eastern Kentucky coalfields (Pond 2010).

Stonefly data compiled from EPA, WVDEP, and the applicant's consulting firms show that Oldhouse Branch and Pigeonroost Branch collectively yielded 16 genera of stoneflies (Table A2.3.). Oldhouse Branch and Pigeonroost Branch both had 11 total stonefly genera. A single collection in Oldhouse Branch by EPA (in the Spring of 2000) had 9 genera of stoneflies, which ranks greater than the 98th percentile of all Central Appalachian streams sampled by WVDEP (937 samples). This means that only 2% of stream samples in this ecoregion had more stonefly taxa than Oldhouse within a single sampling event. This makes Oldhouse Branch remarkably diverse and distinctive in a watershed that is highly impaired. Pigeonroost Branch had 6 stonefly genera in any one season-specific sample (Spring 2000), ranking it at the 83rd percentile among 937 Central Appalachian streams. Similar to mayflies described above, stonefly survey data showed that stonefly richness is significantly reduced when conductivity exceeds 500 µS/cm in mining operations similar to Spruce No. 1.

Table A2.3. Presence/absence of stonefly genera in the permit area.[4] Frequency of occurrence below MTM/VF is presented for comparison and is based upon 20 similar West Virginia MTM/VF sites (Pond et al. 2008). NA indicates that the taxon was not collected in Pond et al. (2008) study.

Order	Family	Genus	Oldhouse	Pigeonroost	Frequency of Occurrence Below MTM/VF >500 µS/cm
Plecoptera	Capniidae	*Allocapnia*	X	X	0%
Plecoptera	Chloroperlidae	*Alloperla*		X	0%
Plecoptera	Chloroperlidae	*Haploperla*	X		10%
Plecoptera	Chloroperlidae	*Sweltsa*	X		0%
Plecoptera	Leuctridae	*Leuctra*	X	X	20%
Plecoptera	Nemouridae	*Amphinemura*	X	X	80%
Plecoptera	Nemouridae	*Ostrocerca*	X	X	0%
Plecoptera	Nemouridae	*Paranemoura*		X	NA
Plecoptera	Peltoperlidae	*Peltoperla*	X		10%
Plecoptera	Perlidae	*Acroneuria*	X	X	10%
Plecoptera	Perlodidae	*Isoperla*	X		25%
Plecoptera	Perlodidae	*Remenus*		X	5%
Plecoptera	Perlodidae	*Yugus*	X		0%
Plecoptera	Pteronarcyidae	*Pteronarcys*	X	X	5%
Plecoptera	Taeniopterygidae	*Taenionema*		X	0%
Plecoptera	Taeniopterygidae	*Taeniopteryx*		X	5%

Most of the benthic wildlife taxa naturally occurring in Oldhouse Branch and Pigeonroost Branch headwaters will not survive in the erosion control ditches proposed for mitigating the loss of headwater streams due to extreme chemical conditions, temperature extremes, and the overall lack of a lotic flow regime found in other examples of these ditches (Kirk 1999a, Green et al. 2000, Gingerich 2009). Based on the results shown in Table A2.1. and A2.2., some of the most sensitive, but naturally ubiquitous mayfly genera are extremely unlikely to survive in these ditches because of these water quality conditions, and therefore are likely be extirpated from the project site during and after mining activities. These genera include:

- Dark Red Quill (*Cinygmula subaequalis*)
- Little Maryatts (*Epeorus* spp.)
- Blue Winged Olives (*Drunella* spp.)
- Sulphurs (*Ephemerella* spp.)
- Blue Quills (*Paraleptohlebia* spp.)
- Brown Duns (*Ameletus* spp.)

[4] *Podmosta, Paraleuctra, Megaleuctra,*and *Beloneuria* were reported by the permittee's consultant, Sturm Env. Services, but have been excluded from this list, as they were likely erroneous identifications. *Podmosta* is primarily a western U.S. genus, with only one species that occurs in eastern Canada. Also, *Megaleuctra* (while this would be an important, rare sighting) occurs in the eastern part of the state and is not recorded from this ecoregion. Similarly, *Beloneuria* is not known to occur in this ecoregion, but can be confused with the more common *Acroneuria* in early life stages. While *Paraleuctra* can occur in the study area, this genus is most often captured as adults while nymphs are exceedingly rare in benthic samples. We conservatively excluded this genus from the list of stonefly genera found within the Spruce No. 1 Mine project area.

Stoneflies predicted to be extirpated from the project site during and after mining activities include:

- Sallflies: *Alloperla*, *Haploperla brevis*, and *Sweltsa* spp.
- Salmonfly: *Pteronarcys proteus*
- Browns and Yellows: *Yugus kirchneri*, *Remenus bilobatus*

Populations of other stoneflies such as the Tiny Winter Blacks (*Leuctra* spp.) will be severely reduced. Likewise, populations of other taxa, including caddisflies, will likely be affected. For example, several caddisfly genera present in Spruce No. 1 Mine streams are expected to be affected by the authorized project based on their absence from Beech Creek and Left Fork Beech Creek at the Dal-Tex site. The Little Black Caddisfly (*Agapetus*), the Little Black Short-horned Sedge (*Glossosoma*), the Autumn Mottled Sedge (*Neophylax*), the Little Gray Sedge (*Goera*), and Evening Sedge (*Dolophilodes*) have all been extirpated from Dal-Tex streams. Since these data reflect genus-level information, it is unknown whether sensitive species within other genera could also be severely affected or extirpated.

In summary, Pigeonroost Branch and Oldhouse Branch currently have high taxonomic richness of mayflies and stoneflies. In contrast, many of these taxa have been extirpated in Beech Creek and Left Fork Beech Creek at the Dal-Tex site, indicating the potential for significant effects on these wildlife taxa following mine construction. Similar patterns of taxonomic loss were observed at 20 other West Virginia sites downstream of MTM/VF when conductivity was greater than 500 µS/cm, and these effects on wildlife taxa and their habitat will likely occur following the Spruce No. 1 Mine operations.

A2.3. Observed/Expected Index: A Measure of Biological Impairment

To supplement multi metric index information provided later in this appendix (Section A2.4), EPA applied another accepted and peer reviewed approach, called an Observed/Expected index (O/E) (Hawkins 2006b, Van Sickle et al. 2005) to estimate and quantify the taxonomic changes in streams impacted from mining activities in the Spruce Fork watershed. This index follows the premise behind the River Invertebrate Prediction and Classification System (RIVPACS), which models physical or geographic attributes of reference sites in order to predict expected reference taxa (Clarke et al 2003).

A2.3.1. Deriving the Observed/Expected Index

O/E measures how far a stream assemblage has departed from reference condition (i.e., biological integrity). O/E ratios represent the number of the expected taxa that are observed in a sample, compared to the number expected in the sample (Figure A2.2.). Our analysis estimated the number of expected taxa using a set of relatively homogeneous reference sites (i.e., a null model). Setting expectations using a null model is appropriate when working in areas with relatively similar physical and regional characteristics that may have influence on the macroinvertebrate community (e.g., geology, stream slope, natural substrate, season and climate). Because taxa expectations are based on those collected at least-disturbed reference sites, and observations are constrained to those reference site taxa, O/E is an excellent measure of biological integrity. O/E quantifies a fundamental component of ecological capital, one of three general indicators identified as critical to monitor by the National Research Council (NRC 2000; as cited in Hawkins 2006).

O versus E as a Measure of Biological Integrity

$$\frac{O}{E} = \frac{\text{the set of native taxa expected at a site that are actually observed.}}{\text{the set of native taxa expected to occur at a site in the absence of human-caused stress.}}$$

The deviation of O from E is a measure of compositional similarity and thus a community-level measure of biological integrity.

Figure A2.2. Measure of biological integrity; O vs. E (Hawkins 2006b).

EPA developed two separate O/E models; one model for spring (March-May) and one model for summer (June-Sept). Genus-level null models were developed using WVDEP reference sites from ecoregions 67 and 69 (Ridge and Valley and the Central Appalachians), which together form the Mountain Bioregion. The spring null model was developed using 128 WVDEP reference sites sampled in the spring (median catchment area ~1.3 square miles), and the summer null model was developed using 181 reference sites sampled in the summer (median catchment area ~2.0 square miles). Macroinvertebrate assemblages in these two ecoregions are highly similar.

For the West Virginia null models, EPA first calculated the probability of capture (Pc) as the proportion of a taxon's occurrence at all mountain reference sites (combined ecoregions 67 and 69), within spring and summer samples separately. We did this for all non-chironomid taxa. (Chironomidae taxa were excluded because WVDNR does not require Chironomidae taxa to be identified at a genus level). The Pc's of all taxa with a Pc greater than 0.1 were then summed to yield the *Expected* number of taxa at a site for the given season (Table A2.4.). Taxa with Pc less than 0.1 were excluded since these taxa are rarely observed (including uncommon sensitive and tolerant taxa, infrequent taxa, or sporadically occurring taxa). Van Sickle et al. (2007) showed increased sensitivity of O/E indices when Pc excluded rarely observed taxa. Using Pc of greater than 0.1 provides a compromise of including most common taxa in the reference taxa pool. Actual taxa collected at test sites (*Observed*), constrained by those reference condition taxa that might be expected, are then compared to what was expected to occur (based on reference condition) and reported as a ratio (O/E).

Table A2.4. Probability of capture (Pc) of taxa for West Virginia null model for streams in Mountain Spring and Mountain Summer region of WV. The sum of the Pc is the *Expected* number of taxa used in the O/E index. Only taxa collected greater than 0.10 of sites are included.

Genus	MT Spring	Genus	MT Summer
Leuctra	0.94	Leuctra	0.94
Paraleptophlebia	0.92	Baetis	0.89
Amphinemura	0.89	Paraleptophlebia	0.83
Epeorus	0.88	Dolophilodes	0.83
Ephemerella	0.88	Rhyacophila	0.65
Baetis	0.81	Maccaffertium/Stenonema	0.65
Diplectrona	0.80	Diplectrona	0.64
Rhyacophila	0.75	Hexatoma	0.58
Hexatoma	0.62	Acroneuria	0.57
Haploperla	0.57	Epeorus	0.57
Isoperla	0.57	Ceratopsyche	0.52
Cinygmula	0.55	Cheumatopsyche	0.52
Oulimnius	0.54	Pteronarcys	0.49
Dolophilodes	0.51	Dicranota	0.45
Acroneuria	0.50	Oulimnius	0.45
Maccaffertium/Stenonema	0.50	Simulium	0.45
Sweltsa	0.46	Cambarus	0.43
Polycentropus	0.45	Optioservus	0.41
Cambarus	0.44	Sweltsa	0.41
Pteronarcys	0.43	Polycentropus	0.39
Drunella	0.40	Acentrella	0.38
Dicranota	0.40	Drunella	0.37
Neophylax	0.40	Glossosoma	0.37
Prosimulium	0.38	Nigronia	0.35
Simulium	0.37	Amphinemura	0.32
Lepidostoma	0.37	Ectopria	0.31
Ameletus	0.34	Tallaperla	0.31
Yugus	0.34	Leucrocuta	0.30
Cheumatopsyche	0.31	Psephenus	0.28
Antocha	0.26	Ephemerella	0.26
Ceratopsyche	0.25	Hydropsyche	0.26
Bezzia/Palpomyia	0.25	Isonychia	0.25
Acentrella	0.23	Isoperla	0.24
Optioservus	0.23	Diphetor	0.23
Wormaldia	0.22	Gammarus	0.23
Tipula	0.22	Peltoperla	0.22
Leucrocuta	0.20	Antocha	0.22
Peltoperla	0.20	Lepidostoma	0.21
Diphetor	0.19	Yugus	0.19
Gammarus	0.19	Bezzia/Palpomyia	0.18
Nigronia	0.19	Plauditus	0.18
Ectopria	0.18	Stenacron	0.17
Hydropsyche	0.18	Tipula	0.17
Stenacron	0.15	Haploperla	0.16
Ephemera	0.14	Dixa	0.15
Pseudolimnophila	0.14	Stenelmis	0.15
Chelifera	0.13	Heptagenia	0.14
Isonychia	0.13	Ephemera	0.13
Blepharicera	0.13	Malirekus	0.12
Tallaperla	0.12	Eurylophella	0.12
Pycnopsyche	0.11	Wormaldia	0.11
Sum of Probability of Capture	20.37	Sum of Probability of Capture	18.72

A site that is a perfect match to the richness of expected indigenous taxa will score 1.0, while downward deviation from 1.0 indicates increasing loss of expected taxa compared to regional reference (e.g., a score of 0.50 indicates a 50% loss of the expected taxa). Upward deviation (greater than 1.0) indicates that more taxa were collected than expected. When a taxon is observed at a test site, that taxon is counted as 1 for the observed score, so if the Pc is less than 1 for that taxon, this can lead to O/E scores greater than 1. For example, for the stonefly *Leuctra*, the Pc of capture is 0.94, so its tally for E is only 0.94, but if the taxa is observed at a site, its tally for O is 1.

The standard deviation of reference O/E scores provides a measure of precision; the spring and summer null models both had a SD of 0.19 and represents the upper bound of precision compared to a full predictive model (Van Sickle et al. 2005). These West Virginia null model standard deviations (0.19) are reasonable, since other full RIVPACS-type models often yield standard deviations of ~0.15. We chose the 5th percentile of reference site O/E scores as an impairment threshold to correspond to WVDEP's bio-assessment threshold for aquatic life use impairment. This O/E 5th percentile was 0.64, indicating for purposes of this model that a loss of 36% expected taxa reflects an impairment of in-stream biota. Van Sickle et al. (2005) cautioned that null models are conservative estimates of impairment and that streams could be misclassified as unimpaired, when in fact, they are impaired. In our models, this conservatism is reflected in the interpretation that more than 1/3 (36%) of the taxa are lost before aquatic life-use impairment is detected by the O/E score. This percentage of taxa loss is greater than what EPA expects to be associated with aquatic life-use impairment based on field sampling, as described elsewhere in these technical appendices.

A2.3.2. O/E Comparisons in Spruce No. 1 Mine streams vs. Dal-Tex streams

EPA compared benthic assemblages in streams in the Spruce No. 1 Mine project area (Pigeonroost Branch, Oldhouse Branch, and White Oak Branch) to streams at adjacent mining operations including Dal-Tex (Left Fork Beech Creek and Beech Creek) and Rockhouse Creek using the West Virginia null model of O/E (after Van Sickle et al. 2005). Note that Seng Camp Creek was not included in this analysis because we did not have a sample collected with quantitatively comparable methods. The O/E index results indicate that streams with adjacent fills receiving drainage from MTM/VF operations and the macroinvertebrate communities within those streams are consistently degraded (Tables A2.5. and A2.6.), based upon the O/E threshold value of 0.64.

The West Virginia null model indicates that macroinvertebrate assemblages in Pigeonroost Branch, Oldhouse Branch and the upstream White Oak Branch are comparable to WVDEP mountain ecoregion reference sites and that there is adverse impact (O/E less than 0.64) to streams receiving drainage from MTM/VF operations in West Virginia, including streams adjacent to the Spruce mine area (Table A2.5.). The O/E scores for Pigeonroost Branch, Oldhouse Branch and White Oak Branch were consistently high, ranging from 0.68 to 1.18. In contrast, the O/E scores in Beech Creek and Left Fork of Beech Creek, both of which have been impacted by mining operations, were consistently below the impact threshold (O/E less than 0.64), ranging from 0.20 to 0.53. Standard deviation for Spruce No. 1 Mine streams had similar or better precision to the WVDEP reference model, while the standard deviation for Dal-Tex streams was very low, indicating that all observations consistently show less taxa.

Table A2.5. Summary of West Virginia O/E null model results for the Spruce No. 1 Mine project area (EPA data). The 5th percentile biological degradation threshold is 0.64. An O/E score of ~1.0 means that the number of Observed native taxa is equivalent to the Expected number of native taxa.

Mean (SD) O/E			
	Spruce No. 1	**Dal-Tex**	
	Pigeonroost, Oldhouse, White Oak	Beech, LF Beech	Rockhouse
Spring	0.98 (0.20); n=9	0.26 (0.06);n=5	0.31 (0.10); n=3
Summer	0.85 (0.15); n=2	0.32 (0.08); n=2	0.38 (0.08); n=2

The model indicates that Spruce No. 1 Mine sites are comparable to unimpaired WVDEP mountain ecoregion reference sites. On average, Spruce No. 1 Mine sites scored 0.98 in summer and 0.85 in spring, indicating they have approximately 2% and 15% fewer taxa, respectively, than the average WVDEP mountain reference sites. In contrast, Dal-Tex sites scored, on average, 0.26 in the summer and 0.32 in the spring, indicating they support approximately 74% and 68% fewer taxa, respectively, than the average WVDEP mountain reference sites. Thus, past mining by Mingo Logan Coal Co. has led to the estimated extirpation of ~70% of the native expected taxa in streams draining their adjacent Dal-Tex mine operation. This finding is significant, and supports the conclusion that conditions in Pigeonroost Branch and Oldhouse Branch will follow this pattern of genus-level extirpation and aquatic life use degradation if the project commences as currently authorized.

Table A2.6. Null model O/E scores for EPA and WVDEP data for Spruce No. 1 Mine project area and immediately adjacent valley filled streams.

EPA Data-Spring

Station ID	Type	Stream Name	Date	Observed	Expected	O/E
KC-00046-1.1	Adjacent Fills	Rockhouse Creek	4/21/1999	7	20.37	0.34
KC-00046-1.1	Adjacent Fills	Rockhouse Creek	4/25/2000	8	20.37	0.39
KC-00046-1.1	Adjacent Fills	Rockhouse Creek (Replicate)	4/25/2000	4	20.37	0.20
KC-00047-2	Adjacent Fills	Beech Creek	4/21/1999	6	20.37	0.29
KC-00047-2	Adjacent Fills	Beech Creek	4/27/2000	5	20.37	0.25
KC-00047-2	Adjacent Fills	Beech Creek (Replicate)	4/27/2000	4	20.37	0.20
KC-00049-0.2	Adjacent Fills	Left Fork/Beech Creek	4/21/1999	7	20.37	0.34
KC-00049-0.2	Adjacent Fills	Left Fork/Beech Creek	4/25/2000	4	20.37	0.20
KC-00054-0.9	Spruce No. 1	Pigeonroost Branch	4/22/1999	24	20.37	1.18
KC-00054-0.9	Spruce No. 1	Pigeonroost Branch	4/25/2000	14	20.37	0.69
KC-00055-0.4	Spruce No. 1	Oldhouse Branch	4/22/1999	19	20.37	0.93
KC-00055-0.4	Spruce No. 1	Oldhouse Branch	4/25/2000	14	20.37	0.69
OECA 14	Spruce No. 1	Oldhouse Branch	3/14/2007	24	20.37	1.18
KC-00061-0.4	Spruce No. 1	White Oak Branch	4/22/1999	21	20.37	1.03
KC-00061-0.4	Spruce No. 1	White Oak Branch (Replicate)	4/22/1999	24	20.37	1.18
KC-00061-0.4	Spruce No. 1	White Oak Branch	4/25/2000	16	20.37	0.79
OECA 13	Spruce No. 1	White Oak Branch	3/14/2007	23	20.37	1.13

EPA Data-Summer

Station ID	Type	Stream Name	Date	Observed	Expected	O/E
KC-00046-1.1	Adjacent Fills	Rockhouse Creek	7/29/1999	6	18.72	0.32
KC-00047-2	Adjacent Fills	Beech Creek	7/29/1999	7	18.72	0.37
KC-00049-0.2	Adjacent Fills	Left Fork/Beech Creek	7/29/1999	5	18.72	0.27
KC-00055-0.4	Spruce No. 1	Oldhouse Branch	7/29/1999	14	18.72	0.75
KC-00054-0.9	Spruce No. 1	Pigeonroost Branch	7/29/1999	18	18.72	0.96

WVDEP Data-Summer

Station ID	Type	Stream Name	Date	Observed	Expected	O/E
KC-00046-0	Adjacent Fills	Rockhouse Creek	8/6/2002	7	18.72	0.37
KC-00046-0.8	Adjacent Fills	Rockhouse Creek	8/6/2002	9	18.72	0.48
KC-00047-0	Adjacent Fills	Beech Creek	8/6/2002	10	18.72	0.53
KC-00047-0	Adjacent Fills	Beech Creek	8/6/2002	7	18.72	0.37
KC-00047-1.7	Adjacent Fills	Beech Creek	8/7/2002	10	18.72	0.53
KC-00049-0.2	Adjacent Fills	Left Fork/Beech Creek	8/7/2002	5	18.72	0.26
KC-00054-0.8	Spruce No. 1	Pigeonroost Branch	8/6/2002	13	18.72	0.69
KC-00061-0.5	Spruce No. 1	White Oak Branch	7/10/2000	14	18.72	0.75

A2.3.3. O/E Relationships to Stressors

Using the West Virginia spring null model applied to genus-level data from Pond et al. (2008), O/E scores were negatively correlated ($r^2 = 0.63$) to conductivity, which explained more than twice the variance as RBP habitat scores ($r^2 = 0.28$)), confirming that conductivity is an excellent predictor of native taxa loss from Appalachian streams (Figure A2.3.). Also, nearly all sites with medium and high levels of specific conductance had O/E scores below the 5th percentile impairment threshold (Figure A2.4.). All sites in Pond et al. (2008) were located upstream of any residences, and thus mining was the sole or dominant land use. The majority (85%) of mined sites assessed in Pond et al. (2008) having conductivity greater than 500 µS/cm, were impaired, based upon an impairment threshold equal to the 5th percentile of the 128 WVDEP spring reference sites and a value roughly equal to 1.96 standard deviation of reference O/E.

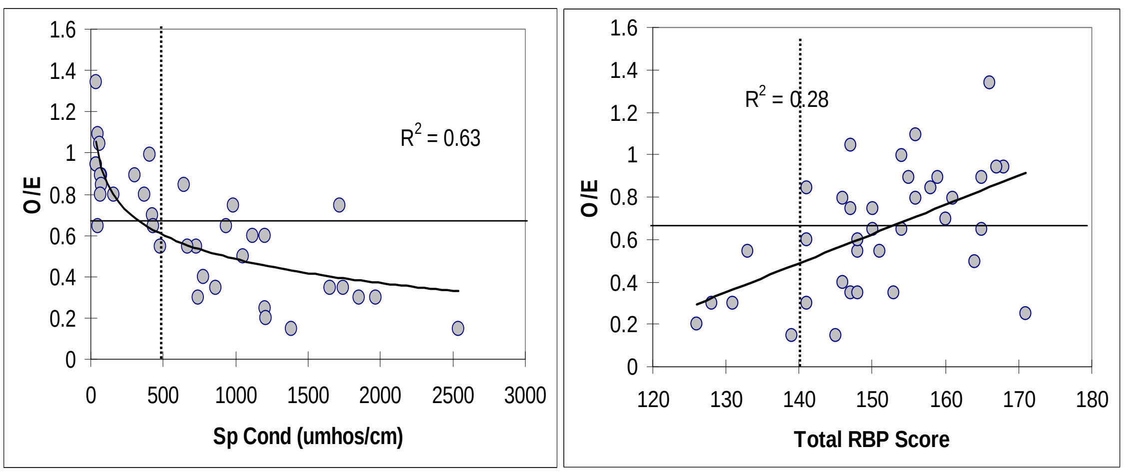


Figure A2.3. Relationship between Spring O/E null model, specific conductance (logarithmic fit), and RBP Habitat scores (linear fit) applied to data from Pond et al. (2008). Vertical dashed lines indicate 500 µS/cm threshold and 140 RBP score threshold for WVDEP reference screening criteria. Solid horizontal lines represent the 5th percentile impairment threshold (0.64).

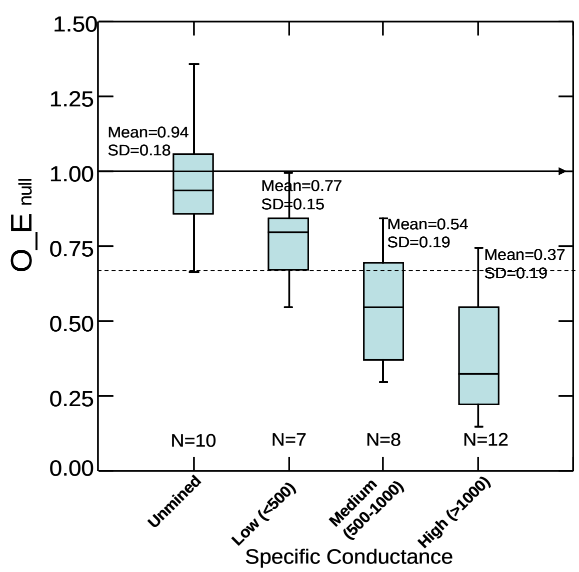


Figure A2.4. Boxplot of O/E scores along generalized specific conductance categories. Data are from Pond et al. (2008). Dashed line indicates 5th percentile impairment threshold (0.64).

In an effort to assess the influence of abiotic stressors on O/E score variation, a multiple regression analysis was performed on several habitat metrics plus conductivity, temperature, and pH across the 37-site dataset from Pond et al. (2008). Three separate regression models were run (Table A2.7.). O/E scores were normally distributed but logarithmic transformations were applied to abiotic parameters to satisfy assumptions of normality. The analysis shows that conductivity was the only metric significantly correlated with O/E values. Regression coefficients were not significant for sediment deposition, substrate embeddedness, channel alteration, riparian zone width, pH, or temperature. In fact, habitat offered little explanatory value in O/E variation. While EPA acknowledges habitat can strongly affect native wildlife assemblages, these additional analyses support previous results (Pond et al. 2008) that the variable water quality gradient (measured as conductivity) across watersheds with and without mountaintop mining strongly structured wildlife communities. These data suggest that similar water chemistry induced patterns of taxa loss will occur downstream of Spruce No. 1 Mine following the project.

Table A2.7. Multiple regression statistics for O/E scores and abiotic variables (Full Model, Specific Conductivity Model, and Specific Conductivity + RBP Habitat Model).

Full model		log Sp. Cond		log Sp Cond + logHabitat	
Regression Statistics		*Regression Statistics*		*Regression Statistics*	
Multiple R	0.84	Multiple R	0.79	Multiple R	0.80
R Square	0.71	R Square	0.63	R Square	0.65
Adjusted R Square	0.63	Adjusted R Square	0.61	Adjusted R Square	0.62
Standard Error	0.18	Standard Error	0.18	Standard Error	0.18
Observations	37	Observations	37	Observations	37

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	2.1805	0.3115	9.9263	0.0000
Residual	29	0.9100	0.0314		
Total	36	3.0905			

Full model	*Coefficients*	*St. Error*	*t Stat*	*P-value*
Intercept	0.23	0.82	0.28	0.78
log Cond	-0.29	0.07	-4.34	0.00
logEmbed	0.14	0.26	0.56	0.58
logChanAlt	0.59	0.51	1.15	0.26
logSedDep	0.45	0.27	1.65	0.11
logRiparian	-0.07	0.33	-0.23	0.82
logTemp	0.26	0.33	0.79	0.44
pH	-0.05	0.05	-0.97	0.34

A2.4. Bioassessments Using WVDEP's WVSCI

States routinely use macroinvertebrate assemblage data to assess their narrative water quality standards and to determine support of aquatic life uses. WVDEP uses a family-level multi metric index called the West Virginia Stream Condition Index (WVSCI).[5]

[5] For more information on the WVSCI, see http://www.dep.wv.gov/WWE/watershed/bio_fish/Pages/Bio_Fish.aspx

The WVSCI uses six (6) component metrics to summarize and analyze family-level macroinvertebrate taxa lists. The six metrics are total number of EPT taxa (Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies)), total number of taxa, % of organisms that are EPT, % of organisms that are Chironomidae (midges), the % of organisms in the top two dominant taxa, and the Hilsenhoff Biotic Index. All metrics are computed at the family-level with a 200 fixed-count subsample. The metrics are scored against Best Standard Values (BSVs) for the entire dataset, as a % of the BSV and normalized to a score of 100. The average of all six metrics makes up the final WVSCI score. The lower the score, the more degraded the macroinvertebrate assemblage.

Examination of the West Virginia dataset has shown that the family-level metrics used by WVDEP generally underestimate degradation of the macroinvertebrate community impairment of aquatic life uses as compared to more sensitive genus-level indices due to the coarse level of taxonomy. Despite this lower sensitivity, bioassessments using WVSCI have documented adverse impacts to aquatic life due to mining in streams on mined sites near the project area.

Currently, WVDEP uses WVSCI index scores greater than 68 to indicate full support of the aquatic life use. This score represents the 5th percentile of the range of scores of the 107 reference site scores used in the 2000 report (Gerritsen et al. 2000). Since 2000, WVDEP has sampled hundreds of new reference sites. There are now 394 statewide reference sites available in the WVDEP dataset. A WVSCI score of 72 represents the 5th percentile of all currently available reference sites and is considered for informational purposes as part of a weight of evidence approach.

EPA sampled several streams within the Spruce Fork watershed for the Mountaintop Mining/Valley Fill Programmatic Environmental Impact Study (MTM/VF PEIS) (Green et al. 2000; Bryant et al. 2002). Unmined streams within and near the project area, including White Oak Branch, Oldhouse Branch, and Pigeonroost Branch generally scored above the 68 threshold index value, indicating they were high quality streams that fully support the aquatic life use (Table A2.8.). The streams located in the historically mountaintop mined areas located nearby (Rockhouse Branch, Beech Creek, and the Left Fork of Beech Creek) generally scored below the 68 threshold index value, indicating they do not fully support aquatic life use. It is likely that the aquatic life use in streams on the project area (i.e., Oldhouse Branch and Pigeonroost Branch) will be similarly degraded if the project commences as currently authorized.

Table A2.8. WVSCI scores for EPA sites on and near the project area (Green et al. 2000). *Note: Pigeonroost Branch has some limited historic mining (no valley fills) in the headwaters region of the watershed. ** indicates Drought/ Low Flow Conditions - Unable to Collect a Representative Sample;

Stream Classification	Stream Name	Spring 1999	Summer 1999	Fall 1999	Winter 2000	Spring 2000
Unmined	White Oak Branch	87	**	**	67.8	90.2
Unmined	Oldhouse Branch	94.9	78.6	**	91.4	90.2
Mined*	Pigeonroost Branch	86.5	80.8	88.8	94.2	82.6
Filled	Rockhouse Creek	48.2	54.7	69.4	50.6	51.6
Filled	Beech Creek	55.9	48.6	58.3	48.7	48.6
Filled	Left Fork of Beech Creek	56.4	59.8	**	**	37.6

Water quality data from the benthic macroinvertebrate sites on streams within the Spruce No. 1 Mine project area and the nearby mined streams indicate water quality degradation at the mined sites compared to the unmined sites (Table A2.9.). Average measurements of alkalinity, calcium, sulfate and Total Dissolved Solids were substantially higher in mined sites than the unmined streams within the project area. The MTM/VF PEIS found that the changes in macroinvertebrate assemblages and WVSCI scores were strongly correlated with water quality changes. Again, these data indicate that the water quality in streams on the mine area will likely be degraded in a similar fashion, and will likely result in degradation of the aquatic life use in the mined tributaries. The project will also contribute increased loadings of pollutants to downstream waters in Spruce Fork. See Appendix 1 for further detailed findings on water chemistry impacts.

Table A2.9. Average water quality at EPA sites on and near the project area: August 2000 to February 2001 (Bryant et al. 2002)

Site Description (Category)	Alkalinity (mg/L)	Calcium (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)
White Oak Branch (Unmined)	34.7	11.8	21.6	78.7
Oldhouse Branch (Unmined)	21.7	9.6	18.1	55.7
Rockhouse Creek (Fills)	255	108.1	415.8	848.7
Beech Creek (Fills)	172.8	84.9	350.7	679.3
Left Fork Beech Creek (Fills)	501.8	269	1110.7	2071.7
Range of Increase (Mined/Unmined)	5x to 23x	7x to 28x	16x to 61x	8x to 37x

Construction of valley fills, sediment ponds, and other discharges into Pigeonroost Branch and Oldhouse Branch as authorized by the Spruce No. 1 Mine will likely contribute increased loadings of pollutants to downstream receiving waters within the Spruce Fork sub-watershed and Coal River sub-basin, further exacerbating biological impairments. EPA analyzed data collected by WVDEP from a subset of sites in the Spruce Fork, Pond Fork, and Little Coal watersheds. Most of these data were collected in the summer of 2002, but a few samples were collected in the fall of 1997, the spring of 2005 and the spring of 2008. WVDEP data from the Spruce Fork, Pond Fork and Little Coal River watersheds indicate that nearby Dal-Tex mined streams, as well as the main stem of Spruce Fork, Pond Fork and the Little Coal River currently do not fully support aquatic life use (Table A2.10.). Note that the WVDEP data indicate a lower WVSCI scores for Pigeonroost Branch than the scores in the EPA dataset. This lower score is likely because the WVDEP sample was taken further downstream in the watershed, and downstream of a house where immediate riparian and channel impacts were obvious.

Table A2.10. WVSCI scores for WVDEP sites on Spruce Fork, Pond Fork and Little Coal River. NA= no biological sample from these sites, but water chemistry data reported in Appendix 1.

Stream Name (mile point)	WVSCI	Consistent with 5th percentile of all currently available candidate reference sites (WVSCI>72)
Tributaries to Spruce Fork draining Spruce No.1- unmined[6]		
Seng Camp Creek (at mouth)	73.8	X
Pigeonroost Branch (mile 0.8)	62.9	
Oldhouse Branch (at mouth)	NA	
White Oak Branch (mile 0.5)	86.5	X
Tributaries to Spruce Fork draining nearby mined areas		
Rockhouse Creek (mile 0.8)	52.9	
Beech Creek (at mouth)	58.8	
Left Fork Beech Creek	23.4	
Trace Branch	NA	
Spruce Fork main stem sites		
Spruce Fork (mile 0.3)	73.1	X
Spruce Fork (mile 0.5)	69.3	
Spruce Fork (mile 4.6)	72.5	X
Spruce Fork (mile 6)	61.4	
Spruce Fork (mile 9.6)	41.4	
Spruce Fork (mile 11.4)	65.0	
Spruce Fork (mile 14.4)	69.5	
Spruce Fork (mile 17.2)	67.9	
Spruce Fork (mile 18.1)	67.1	
Spruce Fork (mile 18.5)	53.8	
Spruce Fork (mile 18.6)	NA	
Spruce Fork (mile 23.7)	69.0	
Pond Fork mainstem sites		
Pond Fork (mile 0.3)	68.1	
Pond Fork (mile 0.4)	73.1	X
Pond Fork (mile 4.9)	64.3	
Pond Fork (mile 6.3)	64.7	
Pond Fork mile 9.0)	66.8	
Pond Fork (mile 12.6)	NA	
Pond Fork (mile 15.8)	64.1	
Pond Fork (mile 21.6)	61.3	
Pond Fork (mile 24.4)	59.1	
Pond Fork (mile 26.6)	72.2	X
Pond Fork (mile 32.3)	57.5	
Little Coal mainstem sites		
Little Coal River (mile 0.2)	NA	
Little Coal River (mile 3.6)	73.9	X
Little Coal River (mile 4.7)	NA	
Little Coal River (mile 10.2)	NA	
Little Coal River (mile 16.5)	NA	
Little Coal River (mile 17)	65.2	
Little Coal River (mile 17.2)	64.5	
Little Coal River (mile 17.8)	NA	
Little Coal River (mile 21.7)	66.8	

[6] Seng Camp Creek is approx. at Spruce Fork RM 17.5
Pigeonroost Branch is approx. at Spruce Fork RM 20.8
Oldhouse Branch is approx. at Spruce Fork RM 21.5
White Oak Branch is approx. at Spruce Fork RM 24.6

Little Coal River (mile 25.2)	NA

Overall, these WVDEP data from the Spruce Fork, Pond Fork and Little Coal River watersheds indicate that aquatic life use is adversely impacted not only in the nearby mined streams, but further downstream on the main stem of Spruce Fork, Pond Fork and the Little Coal River. The impairment in the main stem of Spruce Fork, Pond Fork, and the Little Coal are likely due to a combination of stressors, including mining and residential stressors (WVDEP 1997a). Because these downstream waters have existing biological impairments, increased loading of pollutants from this project will likely further reduce the ability of these waters to support aquatic life use.

A2.5. Comparison of Biological Responses to Impoundments versus Mining

The construction and operation of in-stream mining impoundments can also affect downstream communities, most notably by altering natural food sources, temperature regimes, and flow regimes. Using data collected for the PEIS in WV, Armstead et al. (2004) found that the “most significant changes in stream biological community are the shifts in the functional feeding groups toward more filter feeding organisms and the reduction of the mayfly community in [valley] fill and fill/residentially influenced sites.” Their analysis showed that scrapers (algal grazers) and shredders (which feed upon fallen leaves), most of which are mayflies and stoneflies, were strongly reduced below valley fills in the winter and spring, respectively. Armstead et al. (2004) believed that **“**the changes in community structure may result from the presence of ponds and changes in temperature regimes.” The authors further stated that “the reduced mayfly populations in the fill and fill/residentially influenced sites are not uncommon in areas with mining influence or below impoundments.”

While impacts to aquatic communities can occur directly as a result of in-stream impoundments, it does not appear from the data that impoundments are the primary causes of aquatic life impairment below valley fills. Filter feeders generally increase below impoundments. However, long after mine ponds have been removed, chemically tolerant filter feeding caddisflies persist and dominate the samples. In contrast to Armstead et al. 2004’s claim that the presence of mining sediment ponds causes the impact to aquatic wildlife via alteration of the hydrological regime and changes in food resources, EPA data show that communities below all mining sediment control ponds (n=21) respond strongly to a specific conductance gradient. Additionally, EPA established that there was a poor correlation between total habitat score and conductivity (Figure A2.5.) at the impounded mine sites (n=21) using data from Pond et al. (2008). In the 500 to 1000 µS/cm range, 6 out of 7 sites had good habitat quality (greater than 140; based on WVDEP reference screening criteria). In the 1000 to 2500 µS/cm range, 7 out of 9 sites had acceptable total habitat scores. These results indicate that habitat was not limiting at the majority of the mined sites sampled by EPA.

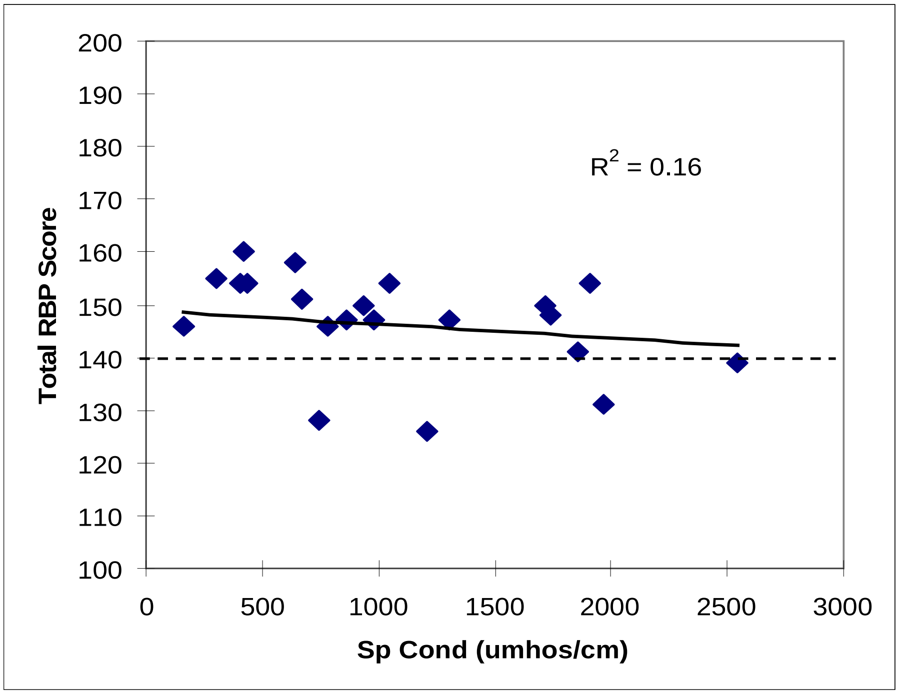


Figure A2.5. Relationship between RBP habitat score and specific conductance obtained from receiving streams of mine site impoundments, indicating a poor correlation. Data from Pond et al. (2008). Dashed line demarcates criterion required for WVDEP reference site candidacy.

Even when sediment ponds were removed as a variable by examining only sites below ponds, conductivity explained 80% of the variance associated with mayfly generic richness (Figure A2.6.). Conductivity significantly accounted for 37% of total taxa richness variance and 52% of the variation in and EPT richness below impoundments. If the macroinvertebrate responses were caused solely by the presence of up-stream sediment ponds, the relationship with conductivity would be insignificant. Instead, the loss of taxa is strongly and significantly related to conductivity. EPA found that when ponds had been removed during reclamation, degraded communities persisted and were dominated by tolerant organisms, indicating that the impoundment was not the main reason for impaired biological communities. Significant degradation of water quality is much more strongly correlated with the adverse impact on macroinvertebrate community structure below mountaintop mining operations with valley fills, such as the Spruce No. 1 Mine, than the presence of sediment ponds.

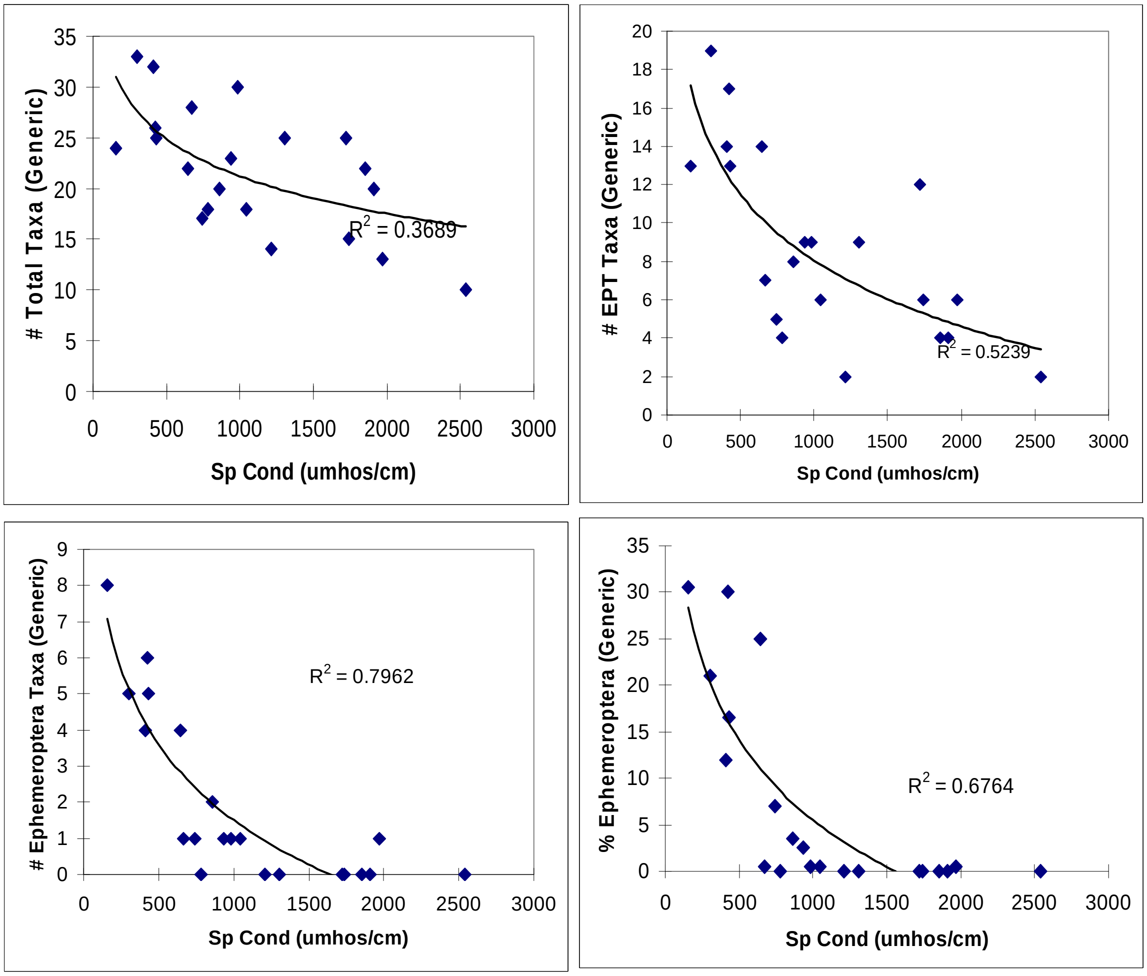


Figure A2.6. Relationships between conductivity and macroinvertebrate metrics (Total Generic Richness, EPT Generic Richness, Ephemeroptera Generic Richness, and % Ephemeroptera Abundance) for mine site receiving streams located below in-stream impoundments (EPA data).

Armstead et al. (2004) concluded that impoundments, not degradation of water quality, caused the shift in functional feeding groups downstream of valley fills. Similar to Armstead et al. (2004), EPA found that functional feeding groups (based on WVDEP group designations) also shift in relation to mining impacts. However, EPA believes the shift is more related to water quality. In mined sites, the percentage of scrapers (herbivorous grazers) was significantly reduced, while collector-filterers significantly increased (Table A2.11; data from pond et al. 2008). This analysis confirms that not only was community structure affected, but functional feeding group composition was also significantly altered below mountaintop mining operations with valley fills.

Further analysis of functional feeding groups (Table A2.12.) revealed categorical dose-response for unmined, low (<500), medium (500-1000), and high (>1000) conductivity. Functional feeding group richness for scrapers, shredders, and collector-gatherers was higher at unmined sites and declined with increasing conductivity category. When “low” mining sites were combined with unmined (n=17; <500 µS/cm) and compared to combined “medium” and “high” mining sites (n=20; >500 µS/cm), there were significant alterations of trophic composition with genus-level scraper richness, shredder richness, collector-gatherer richness, %scraper abundance, and %collector-filterer abundance. Several FFG metrics were strongly correlated to specific conductance (Table A2.12.).

Table A2.11. Mean richness and relative abundance of functional feeding groups at unmined and mined sites (data from Pond et al. 2008). P-values for Mann-Whitney U-tests are shown below.

Mann-Whitney U-Test			
FFG (Richness)	Unmined	Mined	*P*
# Collector-Gatherer Genera	**10.5**	**8.2**	**0.03**
# Scraper Genera	**7.4**	**2.3**	**<0.0001**
# Collector-Filterer Genera	3.0	4.1	0.07
# Predator Genera	**7.2**	**4.4**	**0.01**
# Shredder Genera	**4.5**	**2.8**	**0.02**
# Piercer-Herbivore Genera	0.1	0.0	0.46

FFG (Rel. Abundance)	Unmined	Mined	*P*
% Collector-Gatherers	29.5	32.0	0.61
% Scrapers	**29.1**	**5.4**	**<0.0001**
% Collector-Filterers	**7.7**	**27.3**	**0.004**
% Predators	8.4	6.8	0.19
% Shredders	24.8	28.3	0.72
% Piercer-Herbivores	0.1	0.1	0.91

Table A2.12. Mean richness and relative abundance of functional feeding groups among conductivity categories (data from Pond et al. 2008). Additional comparisons of sites (<500 µS/cm and >500 µS/cm) include P-values for Mann-Whitney U-tests shown. Spearman correlations of functional feeding groups with conductivity are also shown. Bold values are significant (p<0.05).

FFG (Richness)	Unmined	Low	Medium	High	Combined Unmined + Mined (low)	Combined Mined (Medium+ High)	Mann-Whitney U-test	*P*	Correlation to Conductivity: Spearman *r*
# Scraper Genera	**7.4**	**5.0**	**2.1**	**0.9**	**6.4**	**1.4**	**333.5**	**0.000**	**-0.85**
# Shredder Genera	**4.5**	**3.4**	**2.0**	**2.0**	**4.1**	**2.6**	**244.0**	**0.021**	**-0.50**
# Coll-Gatherer Genera	**10.5**	**9.1**	**7.3**	**7.3**	**9.9**	**7.9**	**240.0**	**0.031**	**-0.48**
# Coll-Filterer Genera	3.0	4.7	3.6	3.6	3.7	3.9	143.0	0.389	0.10
# Predator Genera	7.2	4.7	3.7	3.7	6.2	4.3	232.0	0.057	**-0.44**
# Piercer-Herb Genera	0.1	0.0	0.0	0.1	0.1	0.1	171.5	0.907	-0.03

FFG (Rel. Abundance)	Unmined	Low	Medium	High	Combined Unmined +Mined (low)	Combined Mined (Medium+ High)	Mann-Whitney U-test	*P*	Correlation to Conductivity: Spearman *r*
% Scraper	**29.1**	**7.6**	**9.1**	**1.6**	**18.4**	**5.4**	**304.0**	**0.000**	**-0.79**
% Shredder	24.8	43.0	28.8	19.3	33.9	24.1	224.5	0.097	-0.23
% Coll-Gatherer	29.5	28.5	32.3	33.7	29.0	33.0	149.0	0.437	0.04
% Coll-Filterer	**7.7**	**14.6**	**17.5**	**41.2**	**11.2**	**29.4**	**78.5**	**0.005**	**0.60**
% Predator	8.4	6.0	11.9	3.9	7.2	7.9	199.0	0.376	-0.40
% Piercer-Herbivores	0.1	0.0	0.0	0.2	0.1	0.1	167.0	0.920	0.01

To test whether collector-filterers are solely related to impoundment as proposed by Armstead et al. (2004, 2006), we compared the relative abundances at EPA sampled mined sites below sediment ponds along the conductivity gradient. As in the above analysis of community metrics, Figure A2.7. shows that despite impoundments being present at all sites, the percentage of collector-filterers showed a strong response to conductivity. Low collector-filterer abundance was present at the more dilute impounded sites, and increased with rising conductivity. At these 21 sites, conductivity was not significantly related to distance below impoundments (ranging from 0.05 to 1.63 km; r^2=0.14, p=0.98).[7] This provides evidence that water quality has a greater effect on macroinvertebrate communities than habitat changes from impoundments below mountaintop mining operations with valley fills. Further, these water quality changes can affect trophic (feeding) group composition.

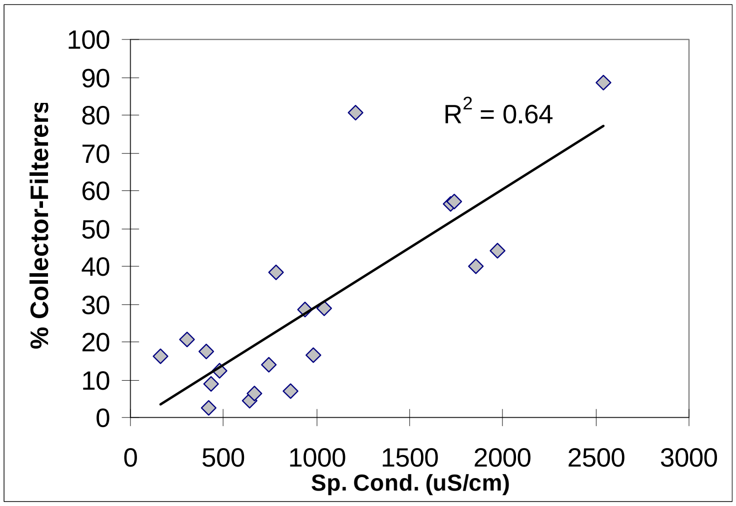


Figure A2.7. Relationship between relative abundance of collector-filterers and conductivity for only those mine site receiving streams located below in-stream impoundments.

A2.6. Appropriateness of data sets and analyses

In order to be used as a basis for quantitative scientific analyses, datasets must conform to a minimum standard of quality, where the sampling design and data analysis techniques are both appropriate and properly implemented, and results are appropriately interpreted. Previous reports presented by the U.S. Army Corps of Engineers (USACE) utilized datasets that inappropriately collected and analyzed data, and as such, should not be considered reliable. In the USACE's evaluation of comments submitted by EPA for the Spruce No. 1 mine (USACE Memorandum for the Record dated September 30, 2009), the Huntington District cited three studies they believe contradict the conclusions of Pond et al. (2008).[8] One of these studies (Hartman et al. 2005) actually shows strong significant effects on macroinvertebrates, contrary to the USACE interpretation of the results. With respect to the other two studies, EPA has reviewed actual or similar industry datasets that Armstead et al. (2006) and the USACE relied upon, and has found that the majority of the data are of poor quality, with low taxonomic precision and quality assurance, and with many errors in metric and index calculations. Sample sites are often pseudo-replicated and effects of natural variation such as seasonality and stream size are uncontrolled. Samples are often collected out of the April-October index period and the

---

[7] However, at all 27 mined sites used in Pond et al. (2008), conductivity was weakly but significantly related to distance from valley fills (r^2=0.23, p=0.009).

[8] Unlike Pond et al (2008), to EPA's knowledge 2 of the 3 studies have been neither peer-reviewed nor published.

WVSCI is used inappropriately. Therefore we believe the conclusions in the Armstead et al. (2006) report and the USACE memorandum are unreliable.

A2.7. EPA's Focus on Sensitive Taxa

EPA's analyses focus on the effects of mining on sensitive taxa because these taxa reflect unimpaired conditions, as found at regional reference sites. To the extent sensitive taxa make up the majority of the native wildlife expected in natural streams across the ecoregion (and which WVDEP has designated as reference quality streams), then it is appropriate to consider those sensitive taxa. Many of the sensitive taxa that EPA is concerned about are naturally ubiquitous in those healthy streams that exist across the region. These species are not rare or insignificant contributors to these streams. Therefore, when results show that nearly all of these sensitive animals are extirpated below mined streams, like those downstream of Dal-Tex mine, there is a significant deviation from natural or baseline conditions. While it is true that sensitive taxa can be affected by any land use disturbance or other permitted activity, the preponderance of evidence points to declines and extirpation of both sensitive and common native taxa downstream of MTM/VF operations similar to the Spruce No. 1 Mine.

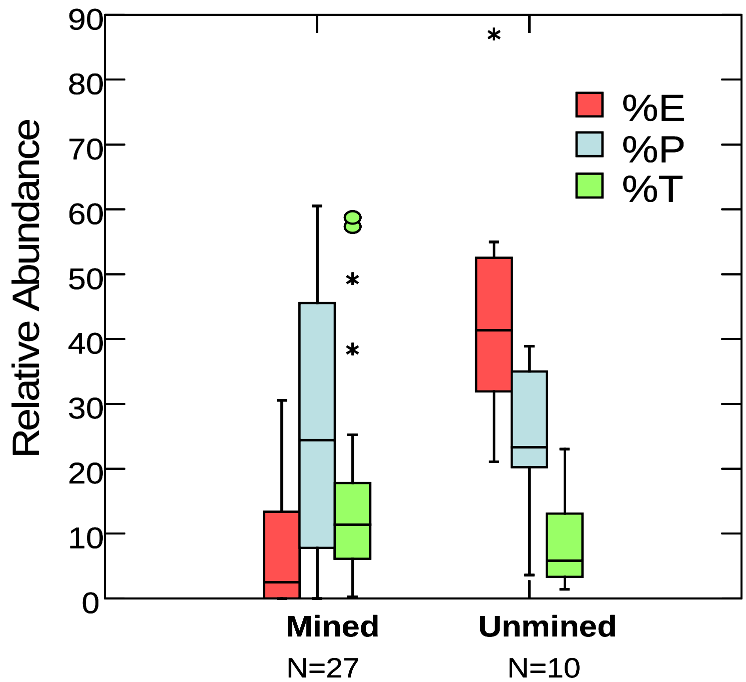
Shifts in community structure are indicators of adverse effects not only to macroinvertebrate communities, but also to broader ecosystem functions, including organic matter transport, productivity in streams and food web interactions. Data from Hartman et al (2005), and Pond et al. (2008) showed significant "shifts", among other strong evidence, to demonstrate impairment downstream of MTM/VF. Furthermore, WVDEP has acknowledged that a "shift" in the macroinvertebrate community can constitute impairment, stating in their published 2008 and 2010 Integrated List Reports, "A "shift" in the benthic macroinvertebrate community of a stream can constitute biological impairment pursuant to 47CSR2 – 3.2.i, and the WVSCI (recognized as a "best science method" in the MTM/VF EIS) provides a sound scientific basis for assessment."

Pond et al. (2008) not only found more than "diminished numbers of certain genera of mayflies," but reported strong evidence of (1) impacts to many other forms of benthic wildlife (including stoneflies and caddisflies), (2) impacts based on 15 out of 17 different community metrics tested, and (3) impacts based on the WVSCI. The published Pond et al. article found many EPT taxa were extirpated or severely reduced downstream of mountaintop mining operations. The authors do mention significant "shifts" in composition, but actually point to the WVSCI scores (and for comparison, the more accurate genus-level metrics) as indicating probable "violations of narrative standards". Declining WVSCI scores are in direct response to these "shifts". Hence, "shifts" in community structure can indicate that benthic populations are harmed and eradicated downstream of mining operations.

A2.7.1. Aggregate %EPT Abundance Metric vs. EPT Generic Richness and Components

EPA uses Ephemeroptera richness (as well as Plecoptera and Trichoptera richness) to detect impact from mining instead of %EPT abundance metric because the commonly used %EPT (relative abundance of mayflies plus stoneflies plus caddisflies) metric can often be one of the most misleading benthic metrics used in headwater streams of the Appalachian coalfields. Relative abundance metrics can mask significant and ecologically important shifts in species composition if there are increases in tolerant taxa while sensitive taxa decline. Specifically some of the tolerant, component genera of EPT increase in abundance following disturbance and dominate streams influenced by chemical or habitat stress, while the more sensitive members of these orders decline or are extirpated. Hence, while the %EPT metric indicates that a high percentage of the individuals in the sample belong to those orders, it does not reveal that the more sensitive genera have been extirpated and the remaining individuals at mined sites are largely tolerant or facultative members of those orders. EPA found that two components of %EPT (%P and %T) showed no significant difference between unmined and mined streams in West Virginia due to the presence of tolerant genera within those generally sensitive orders. It is important to note that in streams with discharges of severely degraded water (e.g., conductivity greater than 2000 µS/cm), even the more tolerant species can be harmed.

In headwater streams, %EPT is not an effective indicator of impairment because several pollution tolerant taxa belonging to the orders Ephemeroptera (e.g., *Baetis, Plauditus, Caenis, Isonychia*), Plecoptera (e.g., *Amphinemura, Allocapnia, Taeniopteryx*) and Trichoptera (mostly Hydropsychidae, Hydroptilidae, and the philopotamid, *Chimarra*) are typically not present or naturally abundant in these streams. These taxa have life history strategies and physiological adaptations that allow them to become dominant in streams under increasing chemical or habitat stress. The occurrence of these tolerant taxa within the generally sensitive EPT orders, results in a metric that cannot consistently distinguish effects due to environmental stressors. To demonstrate this, Figure A2.8. shows the distribution of the three component orders of %EPT across mined and unmined streams from Pond et al. (2008). Mann-Whitney U-tests (SYSTAT v. 13) were performed to determine differences in mean relative abundance of %E, %P, and %T between the two categories (Mined and Unmined). There was no significant difference between mined and unmined sites for both %P and %T. On average, %T was greater at mined sites and was attributed to increases in tolerant hydropsychids, hydroptilids, and/or philopotamids. % P was often dominated at mined sites by the facultative nemourid, *Amphinemura,* while many sensitive stoneflies typical of unmined sites were extirpated. This is such a commonly recognized issue that some states (e.g., PA and VA) have excluded more tolerant and ubiquitous genera or families such as *Baetis* and Hydropsychidae before calculating %EPT.



	WVDEP REF (n=128)	Unmined (n=10)	Mined (n=27)	Mann-Whitney U-test (p-value)
% E	36.1	44.1	7.4	5.5 (p<0.000)
% P	23.0	24.3	27.4	144.0 (p=0.76)
% T	11.4	8.5	16.2	174.0 (p=0.18)

Figure A2.8: Boxplot comparison of relative abundance of EPT component insect orders across mined and unmined sites (EPA data from Pond et al. 2008). Mean values (including WVDEP Reference sites from Mountain Spring bioregion) and Mann-Whitney U-tests results included (table insert).

For example, hydropsychid caddisflies can account for greater than 90% of the total sample abundance and is a common biological signature in streams draining some MTM/VF operations. This dominance indicates severe water quality degradation, but these caddisflies can tolerate these degraded conditions, even when coated in oxides of Mn and Fe precipitate, and calcium minerals (Figure A2.9.). In an unnamed tributary to Leatherwood Creek (Clay Co., WV), the hydropsychids *Hydropsyche* and *Cheumatopsyche* comprised *90*.7% of the sample, and the WVSCI score was still moderate (47.4) despite only having 4 total genera (3 hydropsychid genera, one orthoclad midge) in the 200 organism subsample.

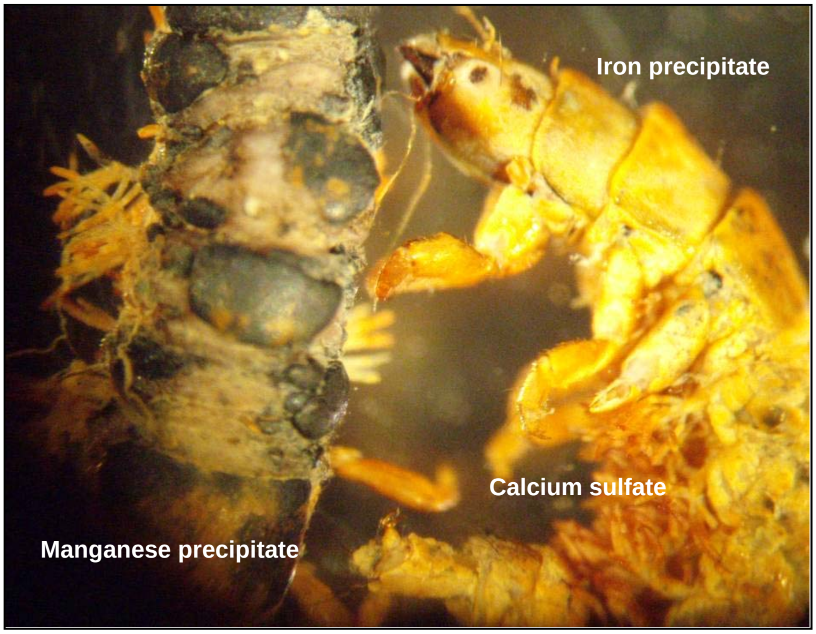


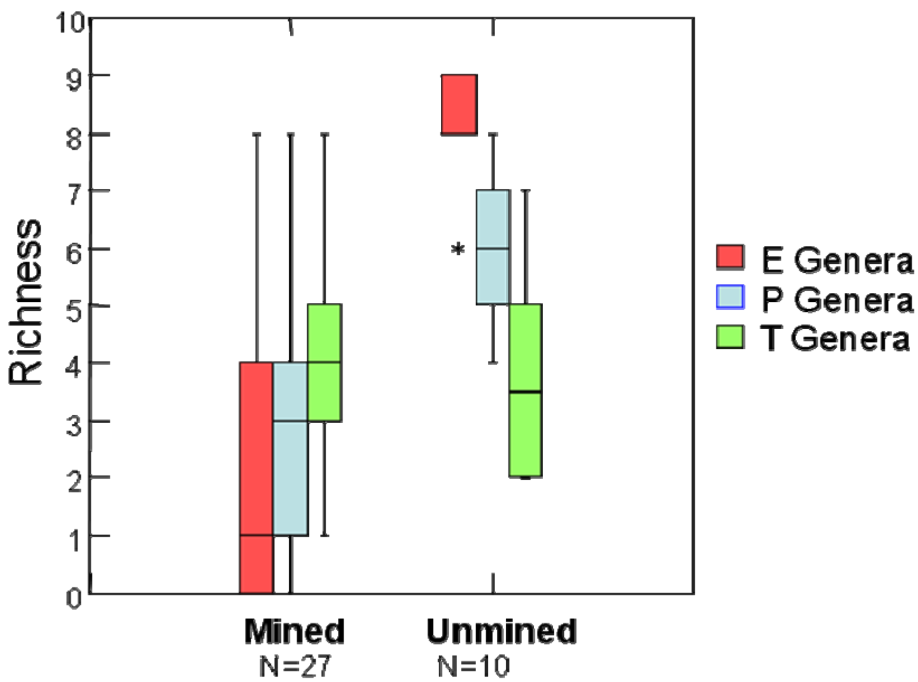
Figure A2.9. ***Hydropsyche*** **and** ***Cheumatopsyche*** **(shown) are tolerant of poor water quality resulting in heavy coatings of oxides of Mn, Fe, and possibly Ca-carbonate-sulfate based minerals. On the left, black manganese oxide concretions are shown in several locations on the insect's body surface. On the right, the normally thin white, filamentous gills of this hydropsychid are heavily thickened by mineral precipitates.**

Seasonality alone can influence %EPT abundance; for example, a December sample from a headwater reference site (Twin Branch) in Mingo County, WV, yielded 94% EPT individuals where 92% was comprised of a single winter stonefly, *Allocapnia*. Twin Branch had a WVSCI score of 65.2. In a mined stream in Nicholas Co. (Neff Fork), *Allocapnia+Taeniopteryx* made up 73% of the EPT found in a Novemeber 1999 sample (WVSCI=90.5). Diapausing, early instar Winter Stonefly nymphs (*Allocapnia* and *Taeniopteryx*) migrate up from deep hyporheic sediments in early fall (i.e., at the time of leaf fall and cooler stream temperatures). Predictably, massive populations (often >1000/m^2) inhabit the riffles of Central Appalachian streams only from mid-October to late-December. They are ubiquitous colonizers and tolerant of highly adverse conditions including total dissolved solids. In these examples, the %EPT metric is providing a false positive signal, indicating a high proportion of the sample is composed of nominally sensitive EPT individuals, while in fact only a single tolerant caddisfly or winter stonefly is present, and most taxa were extirpated at the site. While some WVSCI scores are low enough to indicate impairment, other scores can be high enough for %EPT to obscure any relationships (i.e., correlations and regression-type analyses) between biological response metrics and stressors.

The inability of this metric to detect wholesale changes in the invertebrate community from a diverse, sensitive assemblage to one dominated by tolerant individuals of a few taxa makes it an inappropriate metric to elucidate water quality effects on macroinvertebrate communities. Further, a reliance on %EPT can lead to misinterpretation of biological condition or stressor-relationships. Because genus-level taxonomic data and genus-based community metrics allow for the detection of shifts in community composition, they are a more accurate way of assessing ecological impacts and should be used, where available, and limitations of the accuracy and variability of certain metrics (e.g. %EPT) must be understood.

A2.7.2. EPT Genus Richness is a Better Indicator to Protect Native Aquatic Diversity

EPT genus-level richness is a much more accurate and sensitive metric than %EPT, as it can detect shifts in community composition, rather than just the relative abundance of one to a few tolerant genera (e.g., *Baetis*, *Amphinemura*, *Cheumatopsyche*). While EPT richness is a much more appropriate measure in these streams, it can still, on occasion, give false-positives of acceptable stream quality because it aggregates across multiple taxa with varying responses to disturbance. For example, caddisfly richness was not significantly sensitive to mining influence in Pond et al. (2008), whereas stonefly and mayfly richness was significantly altered at mined sites (Figure A2.10.). So, by using EPT as an aggregate metric, a false positive assessment could occur when the diversity of mayflies and stoneflies are affected, but not caddisflies.



	WVDEP REF (n=128)	Pond, 2008 Unmined (n=10)	Pond, 2008 Mined (n=27)	Mann-Whitney U-test (p-value)
E Richness	7.3	8.1	2.1	4.5 (p<0.000)
P Richness	6.1	5.8	2.7	13.1 (p<0.000)
T Richness	4.7	3.7	4.0	149.0 (p=0.62)

Figure A2.10. Box plot comparison of richness of EPT component insect orders across mined, unmined (from Pond et al. 2008), and WVDEP Reference sites (Mountain Spring bioregion), with mean values and Mann-Whitney U-tests results included (table insert). Where Mined sites contained high E and P richness, conductivity was always less than 500 µS/cm.

In the case of the Spruce No. 1 Mine streams, however, caddisflies were relatively diverse (14 total genera) compared with streams draining Dal-Tex (7 total genera). This represents a meaningful shift in the abundance of these taxa, and suggests that the effects of mining on these streams – an effect noted repeatedly within other elements of the Final Determination and these appendices – can be detected using this aggregate metric. Conditions in mined streams near Spruce No. 1 Mine exhibit significant reductions in E, P, and T taxa richness (Figure A2.11.). By using number of genera rather than the percentage of assemblage, it is clear that both the number of E and P taxa are significantly different in mined and unmined sites, but there is a greater effect on E richness. These changes in taxa richness lead to different and less diverse aquatic communities.

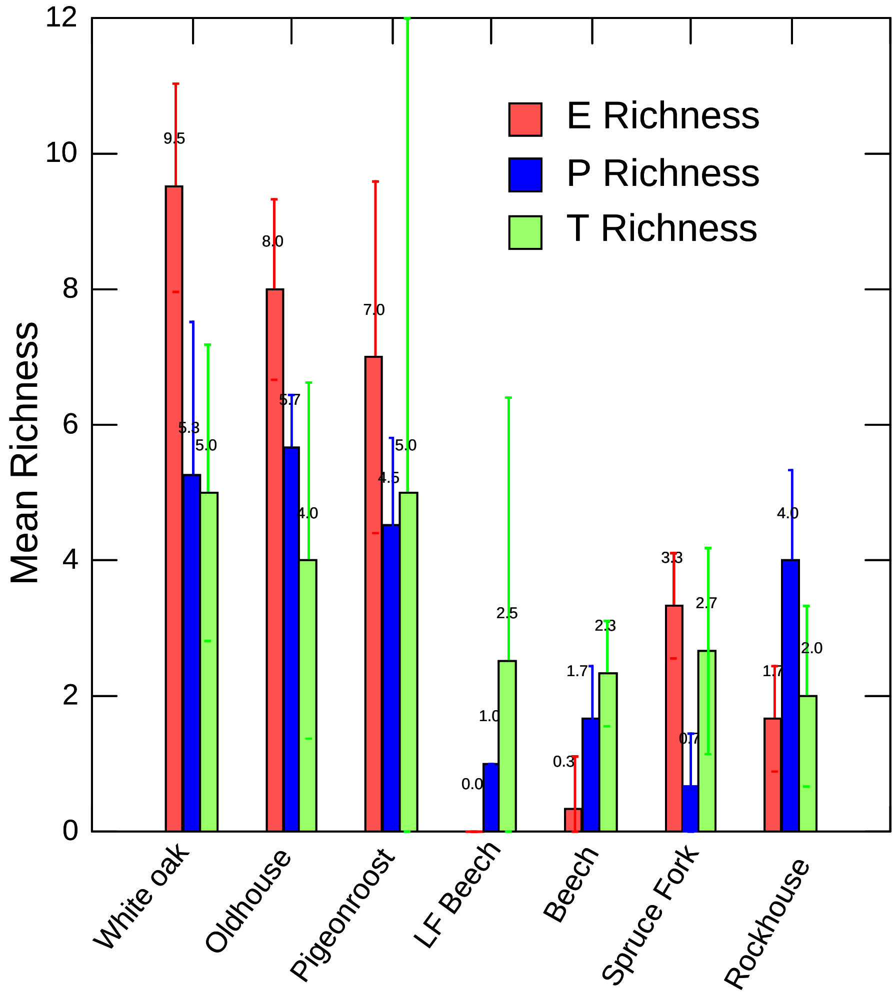


Figure A2.11. Mean richness (whisker = standard deviation) of E, P, and T genera in streams draining Spruce No. 1 Mine area, and adjacent mined streams at Dal-Tex, Rockhouse, and mainstem Spruce Fork near White Oak. Data are based on 1 m^2 riffle samples and 200 fixed-count subsamples (EPA data from PEIS (1999-2000, supplemented in 2007)).

A2.5.3. Use of Total Abundance or Density as Response Metrics

EPA does not believe that total macroinvertebrate abundance or density are appropriate metrics to determine effects, as the response of these metrics can be highly variable, and an increase in these metrics is not always "beneficial" to a healthy aquatic wildlife community. While certain pollutants can sharply decrease invertebrate abundance (e.g., sediment), it is well known that this measure is highly variable across both impacted sites and undisturbed sites and has been shown to be unreliable for impact assessment. In fact, it has been known for decades that higher densities often result from a pollution signature (Hynes 1970). For example, discharges from improperly operated sewage treatment plants or confined animal feeding operations can release organic waste providing an abundance of food for some tolerant, opportunistic macroinvertebrates (e.g., tolerant worms, midgeflies, and hydropsychid caddisflies). This increased abundance can result from discharges having excess nutrients, organic wastes, or other pollutants. Arguing that this overabundance represents a healthy aquatic community is flawed. In the same way, concluding that coal mining is not adverse because it in some limited cases increases "total" abundance below the mine operation (at the expense and demise of sensitive, indigenous taxa) is flawed and does not acknowledge the importance of a diverse macroinvertebrate community characteristic of healthy Appalachian headwater streams like those affected by the Spruce No. 1 project.