Downstream Impacts of Surface Mining And Valley Fill Construction

by

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Abstract Pen Coal Corporation has been conducting a detailed monitoring program on Trough Fork watershed to determine the downstream impact of mining operations. This program involves the monitoring of both water chemistry and benthic macroinvertebrates at upstream and downstream locations during the spring and fall since 1995. The study was initiated prior to any mining activity, and will continue through the completion of mining and reclamation activities. This report is a summary of the data gathered as of the fall of 1998.

Key Words: Watershed, Perennial Stream, Intermittent Stream, Water Chemistry, Benthic Macroinvertebrates, Valley Fill, Wildlife Habitat.

Note:

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3) Publication in this proceedings does not prevent authors from publishing their manuscripts, whole or in part, in other publication outlets.

Introduction

Pen Coal Corporation has extensive mining operations located near Dunlow, in southern Wayne County, West Virginia. The operations consist of an active underground mine in the Coalburg Seam, two active underground mines and two active surface mines in the 5-Block seam, a preparation plant, a refuse fill, and an impoundment. Each of these operations are located in the watershed of the East Fork of Twelvepole Creek.

Mining operations began at the Honey Branch Surface Mine in September 1987. This operation consisted of contour mining and valley fill construction associated with the Coalburg seam. During the summer of 1988 Pen Coal began mining operations at the Frank Branch Surface Mine that involved contour mining and point removal with valley fill construction associated with the 5-Block seam.

The mining operations involving the 5-Block seam have continued to expand to involve the drainage areas of Kiah Creek and Trough Fork, which are also tributaries of the East Fork of Twelvepole Creek.

Some minor water quality problems were detected during 1990, which were easily treated and corrected. As mining progressed northward, the elevation of the 5-Block seam has continued to drop closer to drainage. This created some operational problems due to the lack of available valley fill areas. This also caused an increase in the quantity of surface water which entered the mining area. During 1993, the water quality problem associated with the surface mining of the 5-Block seam became more pronounced, and required a more intensive effort to control and abate. Pen Coal began an extensive "Water Quality Improvement Plan" in February 1994 to determine the most cost effective method for treatment of the existing problems and methods to prevent or minimize future problems.

As part of the "Water Quality Improvement Plan", Pen Coal began an extensive benthic macroinvertebrate monitoring program in the affected watersheds during the fall of 1995. The Trough Fork watershed was undisturbed during the fall of 1995, but mining was projected for the area, therefore Trough Fork was included in the monitoring program. This monitoring has continued each spring and fall since that time.

Statement of Purpose

The purpose of this paper is to share the data that Pen Coal Corporation has gathered with the coal mining industry and other interested parties. The writers would like to specifically address the following points of significance:

- The most dramatic change which occurs during surface mining with valley fill construction is the disturbance and associated change in land configuration and vegetation.
- The chemical composition (quality) and volume of the water downstream from these operations do change. These changes will be discussed in more detail.
- The benthic macroinvertebrate communities that exist downstream of these operations do change as a result of the changes in the chemical and physical characteristics of the receiving streams.

Surface Impacts

Trough Fork is a first order stream which has a watershed of approximately 2,882 acres. Pen Coal's currently permitted mining activities will impact approximately 580 acres, or 20% of the Trough Fork watershed.

Trough Fork has approximately 16,200 linear feet of peramial stream with approximately 44,400 linear feet of intermittent tributaries (Based on USGS topographic mapping). The value of these intermittent tributaries is an item that is currently under hot debate. The mining activities by Pen Coal will directly impact approximately 19,800 linear feet of these tributaries either by direct mineral removal, or by valley fill construction. This amounts to about 44% of the intermittent tributaries of Trough Fork. Only one of these individual tributaries, Vance Branch, exceeded 250 acres.

The post-mining configuration of the reclaimed mine sites will consist of six valley fills of various sizes, eighteen ponds, approximately 40,000 linear feet of sediment or diversion channels, and approximately 575 acres of regraded land. This land will then be rcvegetated with various grasses, legumes, shrubs and trees to enhance wildlife habitat. This is what will replace the pre-mining site that originally consisted of 580 acres of unmanaged forestland and 19,800 linear feet of intermittent streams.

Methods

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected following a modified Rapid Bioassessment Protocol III (EPA/440/4-89/001) at both an upstream (BM-005) station and a downstream (BM-006) station on Trough Fork in October and April since 1995 (Figure 1). An Elfis-RutterTm Portable Invertebrate Box Sampler (PEBS) with a sample area of 0. 1 rn~ was utilized in the both the riffle habitats and in a slower run/pool habitat for a total of three replicates per station. A standard kick-net seine (sample area = 1.0 m^2) was also utilized at each station, but in a run/pool habitat Invertebrate samples were preserved in 10% formalin, picked under n-dcroscopes, and detrital material was checked a second time to insure that no individuals were missed. All macroinvertebrates were indentified to lowest practical taxonomic level, enumerated, and several metrics were calculated using the data.

Water Chemsitry

Water samples were collected in October and April since 1995 at both the upstream (BM-005) site and the downstream (BM-006) site (Figure 1), appropriately preserved, and transported to R-E.I. Consultant's laboratory for analysis. 'Me Water Quality Parameters measured for each sampling site are listed below:

Flow	Sulfates
pH	Sodium
Conductivity	Aluminum
TDS	Calcium
TSS	Iron
Hardness	Magnesium
Alkalinity	Manganese
Acidity	Chlorides

Parameters analyzed in-the-field were pK conductivity, dissolved oxygen, water temperature, and stream flows. These parameters are good indicators of the water quality of a particular station, and when used in conjunction with the macroinvertebrate data, can indicate any changes which occur as one progresses downstream.

Some of the individual parameters are described in more detail as to their role in evaluating water quality below:

Flow:

The flow is an indicator of the surface and groundwater discharges in the watershed-

pH:

The pH is a measure of the hydrogen ion concentration and is preferred to be in the 6.5 to 8.5 range in natural waters.

Conductivity:

The conductivity is the ability of a solution to conduct electrical current The conductivity is directly related to the amount of materials dissolved in the water.

TDS:

The TDS (rotal Dissolved Solids) is a measure of the amount of dissolved materials in the water is directly related to the conductivity, and generally preferred to be less than 1000 mg(l.

TSS:

The TSS (rotal Suspended Solids) is a measure of the undissolved solids which are suspended in the water. Any land disturbance can lead to increases in TSS-

Hardness:

The hardness is typically a measure of the amount of calcium, magnesium and iron in the water. The hardness typically increases as the concentration of these elements increase.

Alkalinity:

The capacity of water to accept hydrogen ions is called alkalinity. This is important in the chemistry and biology of natural waters. Alkalinity serves as a pH buffer and reservoir for inorganic carbon, thus helping to determine the ability of water to support algal growth and other aquatic life. Alkalinity can be used as a measure of water fertility. It is important to distinguish between an elevated pH and high alkalinity, the difference is pH is an intensity factor while alkalinity is a capacity factor.

Acidity:

The capacity of water to neutralize OF is referred to as acidity. The acidity in natural waters generally results from the presence of weak acids such as C02 and acidic metal ions, particularly Fe3+.

Sulfate:

The sulfate content of natural waters in the Appalachian region is typically low in undisturbed watersheds (10 to 50 mgtl). When surface disturbance occurs, such as mining or highway construction, and sulfide bearing rock is exposed to weathering, sulfate concentrations typically increase in the watersheds. Sulfate concentrations in the 300 to 400 mg/l range can give water a bitter taste an concentrations of 600 to 1000 mg/l has laxative effect.

Sodium:

The sodium concentration of natural waters in the Appalachian region is typically very low and increases area usually attributed to human activities such as highway salting, water treatment or oil and gas production.

Aluminum:

The aluminum concentrations in naftu-A waters is typically attributed to suspended clay particles or to dissolved aluminum if severe acid mine drainage is encountered.

Calcium:

The most common cation in most freshwater systems is calcium and often has the most influence on aquatic chemistry. Calcium is a key element in many geochemical processes and minerals constitute the primary sources of the calcium ion in water.

Iron:

The iron concentrations in natural waters in the Appalachian region vary greatly. The sources of iron can range from suspended iron clay minerals to dissolved iron from natural seeps or discharges from manniade disturbances such as mining or construction activities.

MaMsium:

Probably the second most common cation in most freshwater, magnesium behaves similar to calcium and is usually associated with calcium concentrations and contributes to hardness.

Manganese:

The manganese concentrations in natural waters in the Appalachian region vary. The sources are typically the result of weathering of sedimentary rocks. The concentrations can increase dramatically when large quantities of rock are exposed to weathering such as surface mining or highway construction.

Chlorides:

The chloride concentrations are typically low in natural waters in the Appalachian region but may increase as a result of highway de-icing or oil and gas production.

Results

Benthic Macroinvertebrates

In general, the total number of bentluc macroinvertebrate individuals has increased dramatically at the upstream (BM-005) site since pre-mining conditions in October 1995 from 193 individuals in April 1996 to 1,009 individuals in October 1998 (Tables 3 and 4). In addition, taxa richness has increased slightly at the upstream stations since October 1995. The number of Ephemeroptera, Plecopetera, and Trichoptera (EPT) groups has also slightly increased since pre-mining conditions in October 1995. A trend in the benthic community's tolerance is hard to distinguish at the upstream site, but a slight negative trend towards a more tolerant community is somewhat evident from the increasing Hilsenhoff Biotic Index (HBI) as well as the relative percentages within the three tolerance groups. The decreasing Diversity and Evenness measures also indicate a slightly less diverse and less equitable community at the upstream site since October 1995 (Tables 3 and 4).

In general, the total number of benthic macroinvertebrate individuals has most likely increased at the downstream station (BM-006) since pre-mining conditions in October 1995 from 496 individuals in October 1995 to 2,777 individuals in October 1998. Taxa richness may have increased slightly at the downstream station. Number of EPT taxa has probably remained unchanged at the downstream station

(Tables 3 and 4). The macroinvertebrate community, however, has depicted a negative trend in the tolerance as indicated by the increasing HBI, and by the changes of percentages within the three tolerance groups. The decreasing Diversity and Evenness measures also indicate a somewhat less diverse and less equitable population Of aquatic macroinvertebrates at the downstream station since October 1995.

Water Chemistry

In general, all parameters analyzed have remained relatively unchanged at the upstream (BM-005) site since pre-mining samples were collected in October 1995 (Fables I and 2). However, at the downstream site (BM-006), several parameters have increased since premining conditions in October 1995. These include conductivity, TDS, TSS, hardness, alkalinity, sulfates, sodium, calcium, and magnesium. Those parameters which have exhibited dramatic increases at the downstream site are conductivity (64 mmhos in April 1996 to 1061 mmhos in October 1998), TDS 64 mg/1 in April 1996 to 727 mg/l in October 1998), hardness (22.4 mg/I in April 1996 to 303 mg/I in April 1998), alkalinity (20.9 mg/1 in April 1996 to 137 mg1I in October 1998), sulfates (15.3 mg/l in April 1996 to 354 mg/l in October 1998), sodium (1.05 mg11 in April 1996 to 141 mg/I in October 1998), calcium (4.44 mg/I in April 1996 to 80.2 mg/I in April 1998), and magnesium (2.74 mg/l in April 1996 to 30.3 mg/ I in October 1998).

Discussion

The most significant change in water quality was the sulfate concentrations which were most likely attributed to the oxidation of sulfide bearing overburden exposed during the mining operations. Some water treatment have occurred during these operations to neutralize the acidity produced by the oxidation of pyritic overburden. The treatment chemicals utilized were calcium oxide and sodium hydroxide which most likely contributed to the dramatic increases which also were observed in the calcium and sodium concentrations at the downstream sampling site. There was also an increase in magnesium which was probably also attributed to the weathering of magnesium bearing clays. The other increases such as conductivity, TDS, hardness, and alkalinity are directly related to the previously discussed increases in sulfate, calcium, sodium, and magnesium.

A desirable increase that occurred, however, was the increase in allcalunty which was originally in the 20 m&/I range. This increase in allmMty to the 60 to 100 mgtl range should provide a much more fertile aquatic habitat.

Another change which was observed has been the increase in base flow at the downstream sampling point when compared with the upstream sampling point during low flow conditions which are typical during the October sampling. These have been confirmed on numerous occasions by visual observations. Even though these flows are small, they are very critical to aquatic life. These increases in flows can more easily guarantee year round flows which then make a difference between a stream containing rich populations of benthic macroinvertebrates and fish, to streams completely drying up in the dryer seasons, which is obviously devastating to aquatic life.

As stated previously, many of the water chemistry parameters have increased several fold at the downstream site since pre-mining conditions existed in October 1995. It is interesting to note that although mining activities commenced in February 1996, changes in water chemistry were not observed until the October 1996 sampling event.

These increases in water chemistry constituents, however, were not observable in the aquatic macroinvertebrate data until possibly the April 1997 sampling event, but definitely by the October 1997 sampling event. The only observable negative trend at the downstream station has been the shift in community structure from a more pollution sensitive, more diverse, and more evenly distributed community to one which is more pollution tolerant less diverse, and less evenly distributed. Nevertheless, total abundances of benthic macroinvertebrates has continued to increase, and taxa richness has probably increased slightly at the downstream station since mining activities commenced in February 1996.

Conclusions

Even though many individual water chemistry constituents of the water quality at Trough Fork's downstream site have continued to escalate, the catastrophic results once predicted within the benthic macroinvertebrate communities have not been observed. The changes in water chemistry would probably have occurred even if valley fills had not been constructed due to hydrologic interactions with the backfilled and regraded areas at the coal seam elevation and higher. The increases in dissolved solids occurred as a result of the unavoidable increased weathering of exposed rock during mining. Pen Coal will continue to study the Trough Fork watershed through the completion of mining and reclamation activities to determine the long-term impacts that the mining operation has on the watershed. Since Pen Coal began mining in the East Fork of Twelvepole Creek watershed in 1987, 70% of its thirteen surface mine permits involved mining and valley fill construction in watershed greater than 250 acres. Ile changes proposed by the various Regulatory Agencies regarding mining and valley fills in watersheds greater than 250 acres could significantly impact future mining operations for the entire coal industry. A careful review of existing data should be undertaken and thoroughly evaluated by proven scientific methods.

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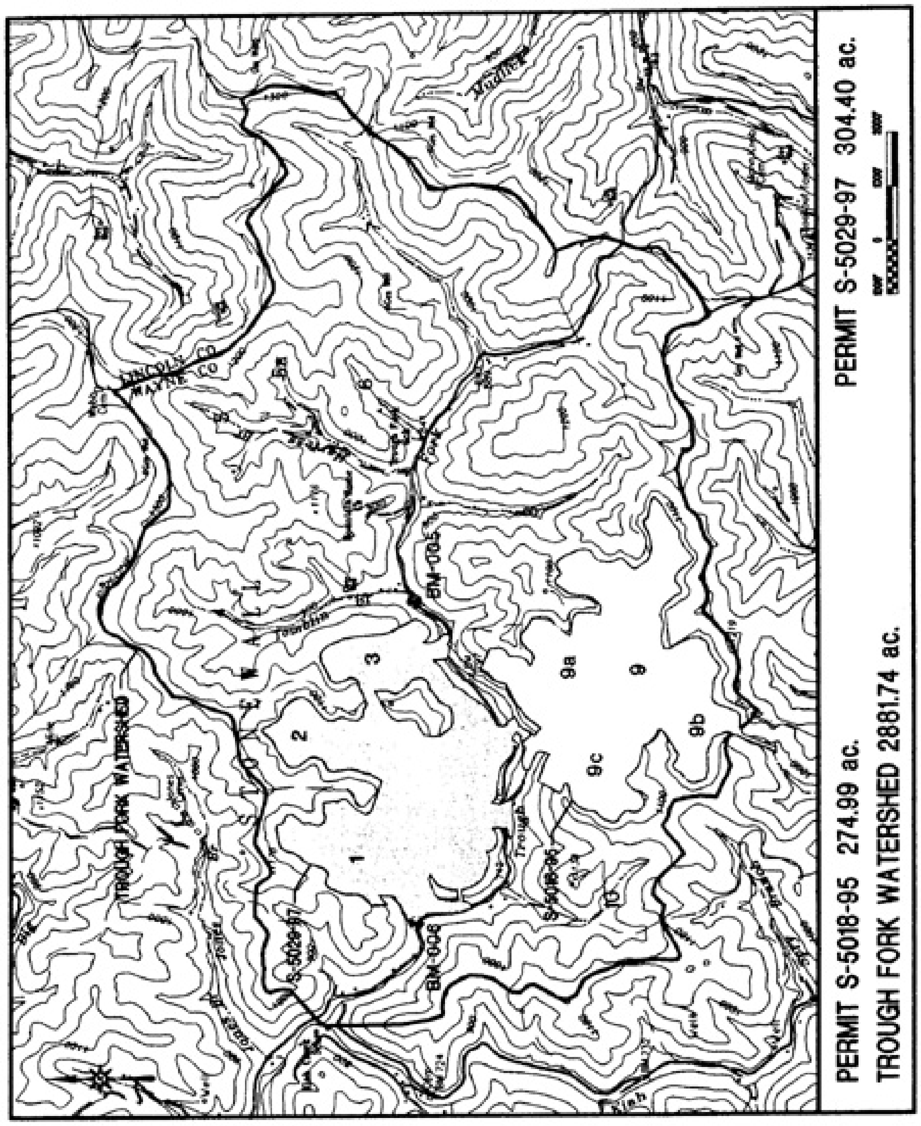

FIGURE 1. Trough Fork Station Locations.

Table 1. Selected water quality parameters of Stations BM-005 (Upstream) and BM-006 (Downstream) on Trough Fork; October data 1995 - 1998.

	OCT 1995		OCT 1996		OCT 1997		OCT 1998	
	BM-005	-006	-005	-006	-005	-006	-005	-006
Flow (ft3/sec)	0.2	0.2	3.2	4.7	0.02	0.14	0.05	0.31
pH (SU)	6.53	6.08	7.21	7.12	7.55	7.60	6.69	7.47
Conductivity (Amhos)	93	176	65	242	124	469	105	1061
Total Dissolved Solids (mgA)	60	107	32	122	79	577	61	727
Total Suspended Solids (mg/1)	5	2	<1.0	1.0	1	4	<1.0	2
Hardness (mg/1)	35.8	67.3	24.2	116.1	43	349	48	254
Alkalinity (mg/1)	21.8	24.0	11.3	36.9	33.1	106.0	37	137
Acidity (mg/1)	<1.0	<1.0	<1.0	<1.0	11.5	15.5	<1.0	<1.0
Sulfates (mg/1)	12.1	41.4	12.8	60.1	20.3	282.0	14.5	354
Total Sodium (m94)	1.86	4.90	1.35	2.59	2.96	12.0	2.70	141
Total Aluminum (m8A)	<0.10	<0.10	<0.10	<0.10	<0. 10	<0.10	0.051	0.038

Total Calcium (mg/1)	7.82	14.2	5.62	30.6	9.84	86.3	11.3	51.9
Total iron (mg/l)	0.32	0.10	<0.10	<0.10	0.140	0.106	0.183	0.186
Total Magnesium (mg/1)	3,96	7.74	2.48	9.63	4.46	32.5	4.81	30.3
Total Manganese (mg/l)	<0.05	<0.05	<0.05	0.15	0.034	0.049	0.032	0.121
Chlorides (mg/1)	---	---	---	---	2.1	2.9	3.9	4.6

Table 2. Selected water quality parameters of Stations BM-005 (Upstream) and BM-006 (Downstream) on Trough Fork; April data 1996 - 1998.

	APR 1996		APR 1997		APR 1998	
	BM-005	-006	-005	-006	-005	-006
Flow (Osec)	1.6	4.8	1.3	5.0	3.75	8.66
pH (SU)	7.75	7.69	7.29	7.35	6.92	6.54
Conductivity (Amhos)	58	64	67	221	53.6	611
Total Dissolved Solids (mg/l)	54	64	49	129	31	407
Total Suspended Solids (mg/l)	<1.0	15	5	5	<1.0	9
Hardness (mg/1)	19.9	22.4	25.8	99.2	20.4	303
Alkalinity (mg/1)	22.6	20.9	9.0	27.9	11.7	66.4
Acidity (mg/1)	19.8	19.3	<1.0	<1.0	<1.0	<1.0
Sulfates (mg1l)	13.6	15.3	15.8	55.7	14.6	214
Total Sodium (mg/l)	1.08	1.05	1.27	2.36	1.06	3.48
Total Aluminum (mg/1)	0.19	0.60	0.052	0.064	0.224	0.127
Total Calcium (mg/1)	4.09	4.44	5,52	25.2	4.36	80.2
Total Iron (mg/1)	0.19	0.72	0.089	0.107	0.240	1.03
Total Magnesium (mg/1)	2.35	2.74	2.92	8.82	2.32	24.9
Total Manganese (mg/1)	<0.05	0.06	0.005	0.236	<0.05	2.33
Chlorides (mg/1)	---	---	1.6	1.8	<1.0	1.3

Table 3. Selected metrics of Stations BM-005 (Upstream) and BM-006 (Downstream) on Trough Fork, October data 1995 - 1998.

OCT 1995 OCT 1996 OCT 1997 OCT 1998

	BM-005	-006	-005	-006	-005	-006	-005	-006
Total Individuals Collected	220	496	1519	2277	907	308	1009	2777
Taxa, Richness	20	16	23	20	19	15	21	20

% Sensitive Abundance	18%	29%	58%	45%	10%	48%	17%	11%
(Taxa)	(6)	(7)	(7)	(8)	(6)	(5)	(7)	(5)
% Facultative Abundance	51%	43%	24%	31%	37%	8%	7%	7%
(Taxa)	(5)	(5)	(12)	(7)	(7)	(6)	(8)	(6)
% Tolerant Abundance	30%	28%	17%	23%	53%	43%	76%	83%
(Taxa)	(4)	(4)	(4)	(4)	(6)	(4)	(6)	(9)
# of EPT Taxa	9	9	16	12	10	9	11	6
Hilsenhoff Biotic Index (HBI)	4.44	4.08	3.80	4.59	4.58	4.73	5.40	5.65
Simpson's Diversity Index	0.84	0.86	0.90	0.90	0.79	0.76	0.69	0.47
Shannon-Wiener Diversity Index	3.21	3.06	3.81	3.60	2.90	2.66	2.43	1.64
Shannon-Weiner Evenness	0.79	0.76	0.84	0.83	0.68	0.68	0.55	0.38

Table 4. Selected metrics of Stations BM-005 (Upstream) and BM-006 (Downstream) on Trough Fork, April data 1996-1998.

	APR 1996		APR 1997		APR 1998	
	BM-005	-006	-005	-006	-005	-006
Total Individuals Collected	193	651	398	328	676	1303
Taxa. Richness	21	26	24	26	27	30
% Sensitive Abundance	16%	45%	27%	27%	12%	22%
(Taxa)	(6)	(13)	(5)	(6)	(7)	(6)
% Facultative Abundance	45%	37%	53%	34%	35%	50%
(Taxa)	(11)	(9)	(13)	(13)	(12)	(17)
% Tolerant Abundance	39%	18%	20%	39%	53%	28%
(Taxa)	(4)	(4)	(6)	(7)	(7)	(7)
# of EPT Taxa,	14	19	17	16	17	19
Hilsenhoff Biotic Index (HBI)	3.77	3.57	3.28	4.14	4.91	4.79
Simpson's Diversity Index	0.81	0.87	0.88	0.82	0.76	0.86
Shannon-weiner Diversity index	3.17	3.48	3.39	3.27	3.08	3.13
Shannon-Weiner Evenness	0.72	0.74	0.74	0.71	0.65	0.64