

Appendix 5 Cumulative Effects

Abstract

The 404(b)(1) Guidelines, 40 CFR 230.1(c), require an analysis of the cumulative effects of each discharge of dredged or fill material on the aquatic ecosystem, in light of the cumulative impacts of known or probable impacts of other activities on that ecosystem. To evaluate the watershed-level cumulative effects of the Spruce No. 1 project in light of existing and likely future mining projects within the watershed, EPA conducted a landscape-scale analysis to predict potential increases in specific conductance (conductivity) as a result of the permitted Spruce No. 1 Mine and as a result of 100% mining of permitted projects within the Coal River sub-basin. As described in the Final Determination and Appendices 1 and 2, elevated levels of conductivity caused by surface coal mining activities result in impacts to native benthic macroinvertebrate wildlife communities and are associated with impairment of aquatic life use.

As summarized below, construction of the Spruce No. 1 Mine, as permitted, will increase the proportion of streams within the Coal River sub-basin with elevated levels of conductivity associated with impairment ($>750 \mu\text{S}/\text{cm}$ and $> 1000 \mu\text{S}/\text{cm}$). Based upon the known relationships between conductivity and aquatic life, the predicted levels of conductivity in the Spruce No. 1 Mine permit area and in downstream waters will be largely unsupportive of aquatic life if the Spruce No. 1 Mine is constructed as currently authorized. Mining activities on the Spruce No. 1 site in combination with full mining of other permitted areas within the Coal River sub-basin will even more dramatically increase conductivity levels – elevating such levels from less than $750 \mu\text{S}/\text{cm}$ to as much as $1000 \mu\text{S}/\text{cm}$ within the Little Coal River. Based on the impacts of increased conductivity levels described elsewhere in the Final Determination, EPA believes these adverse effects will cause or contribute to significant degradation within the Coal River sub-basin.

A5.1. Introduction/Background

The Section 404(b)(1) Guidelines state that “dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact either individually or in combination with known and/or probable impacts of other activities affecting the ecosystems of concern.” 40 CFR 230.1(c). Accordingly, it is appropriate to consider the project’s contribution to the cumulative effects to the aquatic ecosystem, as well as impacts from the individual project. This is consistent with the portion of the Section 404(b)(1) Guidelines (40 CFR 230.11(g)) that directs that factual findings be made regarding cumulative effects on the aquatic ecosystem. The Section 404(b)(1) Guidelines describe the factual finding that must be made with respect to cumulative effects as follows:

Determination of cumulative effects on the aquatic ecosystem.

(1) Cumulative impacts are the changes in an aquatic ecosystem that are attributable to the collective effect of a number of individual discharges of dredged or fill material. Although the impact of a particular discharge may constitute a minor change in itself, the cumulative effect of numerous such

piecemeal changes can result in a major impairment of the water resources and interfere with the productivity and water quality of existing aquatic ecosystems.

The cumulative effects on water quality and aquatic ecosystem functions from multiple mining projects have not been well studied. However, EPA has been working in partnership with USGS and West Virginia University (WVU) to develop a landscape-scale analysis to predict the magnitude of potential effects from mining projects, both individual and cumulatively. This study uses mapped landscape data and site-specific stream conductivity data collected from 73 sites to quantify the relationship between water quality parameters and the percentage of mining-related surface disturbance in the contributing watershed of a stream segment. These relationships were then used to predict conductivity at a stream segment scale throughout the Coal River sub-basin for current conditions and two future scenarios that include construction of Spruce No. 1 Mine as currently authorized¹ and complete mine-out of existing and proposed projects.

A5.2. Methods and Approach

Data Collection

The following mapped landscape data were generated from remote sensing techniques, and then used to derive regression relationships between mining activity and downstream water quality levels, as well as to develop the alternative future scenarios:

- Cumulative drainage area (km²) upstream of each stream sampling site or stream segment
- Percent Mining – the proportion of the cumulative drainage area classified as either active mines, reclaimed mine areas within permit boundaries, and reclaimed mine areas outside of permit boundaries upstream of a designated segment. The mining categories were based on interpretation of 2009 aerial photography and mine permit boundary data accessed June 2010 from the West Virginia Department of Environmental Protection (WVDEP), Division of Mining and Reclamation website.
- Permit Area – the area (km²) that is currently permitted to be mined (as per the WVDEP permit boundary data) that is upstream of a designated segment. This parameter was used to calculate future mining scenarios by distinguishing between currently mined areas in a permit area and the areas permitted but not fully mined under current conditions.
- Residential Development - structure density was calculated using total number of structures categorized by the Federal Emergency Management Agency (FEMA) as “at-risk” due to location in designated floodplain and structures within 200 m of a mapped stream segment. This data set was obtained from the West Virginia GIS Tech Center (<http://wvgis.wvu.edu/data/dataset.php?ID=230>)

In August 2010, WVU sampled pH and conductivity at 73 locations distributed throughout the Coal River watershed. All sites were at the same location or nearby to historic WVDEP sampling locations. The sites were selected to cover a full range of drainage area and structure density within the watershed, as well as the range of percent mining that encompassed the

¹ This analysis was not limited to impacts to Oldhouse Branch and Pigeonroost Branch but used the entire Spruce No. 1 Mine permit boundary to assess impacts to water quality.

expected mining levels associated with impacts to aquatic life. Although there is a temporal difference between the aerial imagery and the water quality sampling, which may add some uncertainty to the modeling, the aerial imagery is the most recent publicly available data.

Data analysis

Relationships between mining activity and water quality were analyzed in three steps. First, mapped landscape data generated from remote sensing techniques and site-specific stream data collected in August 2010 were used to determine the relationship between mining activity/residential development and downstream conductivity levels. The purposes of this analysis were to: 1) quantify the range of conductivities observed in unmined catchments; 2) examine the combined effect of residential development and mining on conductivity; and 3) quantify the relationship between percent mining and summer flow conductivity levels. Regression analyses were performed using summer conductivity as a response variable, and percent mining and percent residential development + mining as predictor variables.

Second, these regression relationships were used to identify levels of mining activity (percent mining in a watershed) associated with defined ranges of conductivity levels, classified into five types of stream condition. The five types of stream condition were based upon a specific range of conductivity associated with various levels of aquatic life impairment (USEPA 2010a). WVDEP sampling data presented here reflect sampling sites in ecoregion 69d with good habitat (total RBP scores greater than 140) and a pH greater than 6.

- Type 1– summer conductivity likely to be less than 300 $\mu\text{S}/\text{cm}$. This corresponds to the conductivity level expected to result in the extirpation of less than 5% of the native taxa normally found in healthy wadeable Appalachian streams (USEPA 2010a). WVDEP sampling sites (n=204) with conductivity less than 300 $\mu\text{S}/\text{cm}$, have WVSCI scores less than 68² only 15% of the time. Based on the available scientific literature, EPA believes this level of conductivity will largely protect aquatic life.
- Type 2 – summer conductivity likely to be 300 - 499 $\mu\text{S}/\text{cm}$, which will likely result in the loss of 15% of the native taxa normally found in healthy wadeable Appalachian streams (USEPA 2010a). WVDEP sampling sites (n=64) with conductivity 300 - 499 $\mu\text{S}/\text{cm}$ have WVSCI scores less than 68 approximately 42% of the time. Based on the available scientific literature, EPA believes these elevated levels of conductivity begin to have an increasingly adverse effect on aquatic life.
- Type 3 – summer conductivity likely to be 500 - 749 $\mu\text{S}/\text{cm}$, which will likely result in the loss of 25% of the native taxa normally found in healthy wadeable Appalachian streams. This conductivity level is approximately equal to a total dissolved solids (TDS) measurement of 500 mg/L, which is the secondary TDS standard for drinking water. WVDEP sampling sites (n=73) with conductivity 500 - 749 $\mu\text{S}/\text{cm}$ have WVSCI scores less than 68 approximately 51% of the time. Conductivity levels greater than 500 $\mu\text{S}/\text{cm}$ have been shown to cause degraded biological condition in wadeable streams (Pond et al. 2008).

² Currently, WVDEP uses WVSCI scores greater than 68 to indicate full support of aquatic life use.

- Type 4 – summer conductivity likely to be 750 - 999 $\mu\text{S}/\text{cm}$, which will likely result in the loss of 30% of the native taxa normally found in healthy wadeable Appalachian streams. WVDEP sampling sites (n=26) with conductivity 750 - 999 $\mu\text{S}/\text{cm}$ have WVSCI scores less than 68 approximately 69% of the time.
- Type 5 – summer conductivity likely to be 1000 $\mu\text{S}/\text{cm}$ or higher, which will likely result in the loss of greater than 30% of the native taxa normally found in healthy wadeable Appalachian streams. WVDEP sampling sites (n=32) with conductivity greater than or equal to 1000 $\mu\text{S}/\text{cm}$ have WVSCI scores less than 68 approximately 78% of the time.

Third, a stream segment level watershed network (based on stream reach segments, 1:24k NHD) modeling system was constructed to estimate downstream chemical response to mining activities upstream within the Coal River sub-basin (Figure A5.1.). The percent mining levels associated with stream condition type were utilized in an alternative futures analysis to quantify changes in summer stream conductivity levels and stream condition under a range of mine development scenarios. Scenarios in our analysis included:

- Scenario 1 – Current conditions based on percent mining and stream condition types derived from 2009 and 2010 data
- Scenario 2 – 100% of the Spruce No. 1 permit area mined as currently authorized, with current conditions assumed in the remainder of the Coal River sub-basin
- Scenario 3 – 100% of total permitted area mined in the Coal River sub-basin (this assumes that the entire permitted area will be mined)³

For each scenario we calculated the number of stream segments and length of stream (km) that could be classified into each stream condition type described above (i.e., Types 1-5). We also constructed a series of alternative scenario maps to depict spatially explicit responses to the three mine development scenarios. To test the fit of our model, we performed a regression analysis of the 73 measured stream segments with the Scenario 1 modeled values for those segments.

³ EPA makes no determination at this time regarding whether these other mines comply with the 404(b)(1) Guidelines or may result in unacceptable adverse impact under § 404(c).

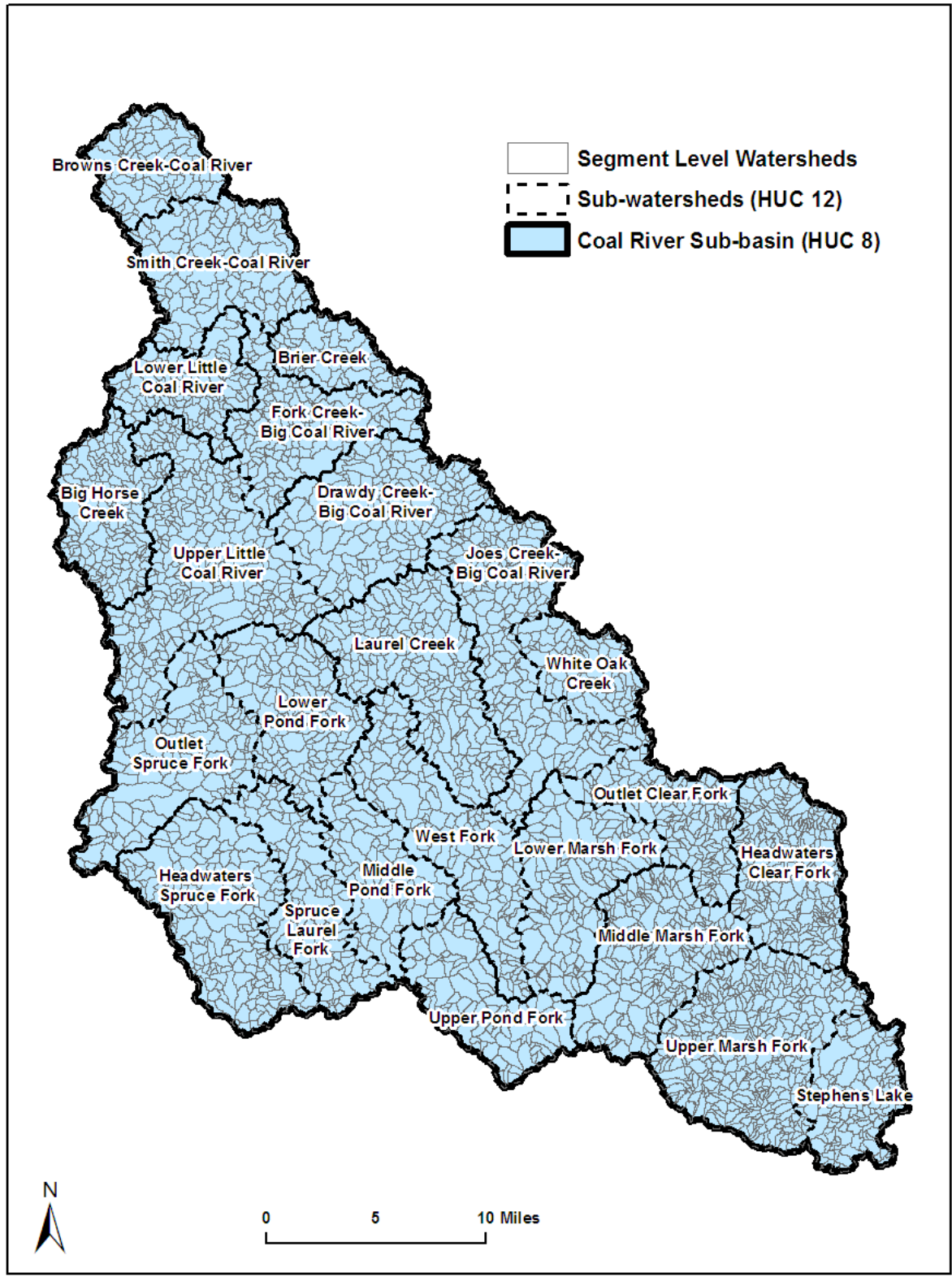


Figure A5.1. Coal River sub-basin (HUC 8) and the 24 sub-watersheds (HUC 12) outlined in dashed black line within the sub-basin. Outlined in gray are the 4229 segment level watersheds for each stream reach segment (1:24k NHD) used in the cumulative watershed modeling system to estimate downstream chemical response to mining activities upstream within the Coal River sub-basin.

A5.3. Results and Discussion

Results indicate significant and strong quantitative relationships exist between mining activities in a watershed and downstream conductivity levels (Figure A5.2.) (See also USEPA 2010a, Appendices A and F). Residential development and mining influenced conductivity, although the relationship with residential development was not as strong as mining. The majority of development only sites had stream conductivity less than 500 $\mu\text{S}/\text{cm}$, with mining only (i.e. no development) sites measuring higher than 800 $\mu\text{S}/\text{cm}$. The two regression curves, combined mining + development and mining only, were similar and both had large explanatory power (R^2). Despite the greater explanatory power of the combined mining + development model, the mining only regression was used to identify percent mining thresholds related to the five types of stream condition described in the methods section because it provided more conservative estimates of conductivity for a given percent mining.

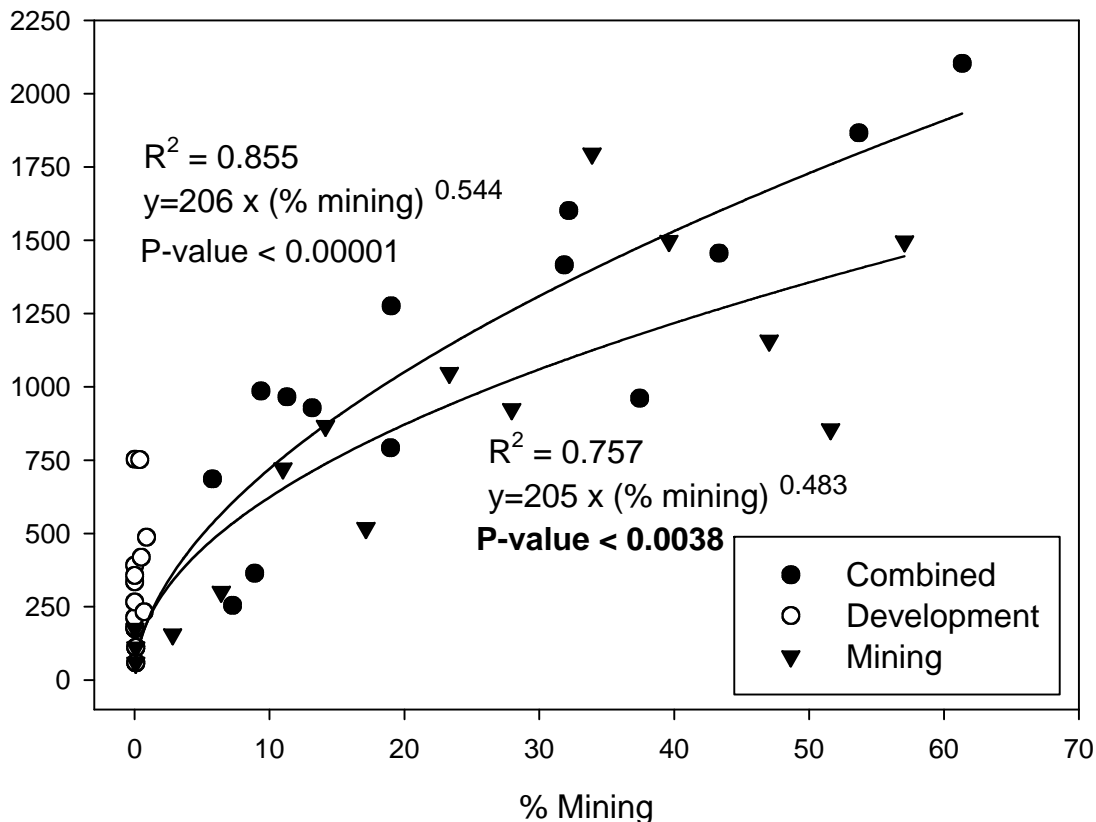


Figure A5.2. Examination of the relationship between percent mining, residential development and 2010 summer conductivity. The lower regression line is for mined sites only, and the upper line is for sites that have combined mining and development impacts.

Based upon the mining-only regression relationship with conductivity, the levels of mining activity (percent mining in a watershed) associated with the five types of stream condition are:

- Type 1 (conductivity less than 300 $\mu\text{S}/\text{cm}$) streams are associated with less than 3% of the watershed impacted by mining.
- Type 2 (conductivity 300 – 499 $\mu\text{S}/\text{cm}$) streams are associated with greater than 3% but less than 7% of the watershed impacted by mining.

- Type 3 (conductivity 500 – 749 $\mu\text{S}/\text{cm}$) streams are associated with greater than 7% but less than 15% of the watershed impacted by mining.
- Type 4 (conductivity 750 – 999 $\mu\text{S}/\text{cm}$) streams are associated with greater than 15% but less than 27% of the watershed impacted by mining.
- Type 5 (conductivity greater than or equal to 1000 $\mu\text{S}/\text{cm}$) streams are associated with greater than 27% of the watershed impacted by mining.

The watershed network modeling predictions, and associated alternate futures scenarios, are consistent with the empirical relationship between mining and conductivity levels. In a comparison of modeled and empirical conductivity measurements from 73 stream segments, the model provided good estimates of conductivity ($R^2 = 0.6859$, $p\text{-value} < 0.001$) though they tended to be conservative (Figure A5.3.). However, the conductivity levels predicted under Scenario 1 are generally consistent with the current levels reported in Appendix 1, based on the WVDEP dataset. Also, the conductivity predictions under Scenario 2 are consistent with the maximum post-mining conductivity levels in the Spruce Fork main stem reported in Appendix 1, which were based on the watershed-weighted deterministic model and baseline conductivity data (see Appendix 1 Table A1.4.).

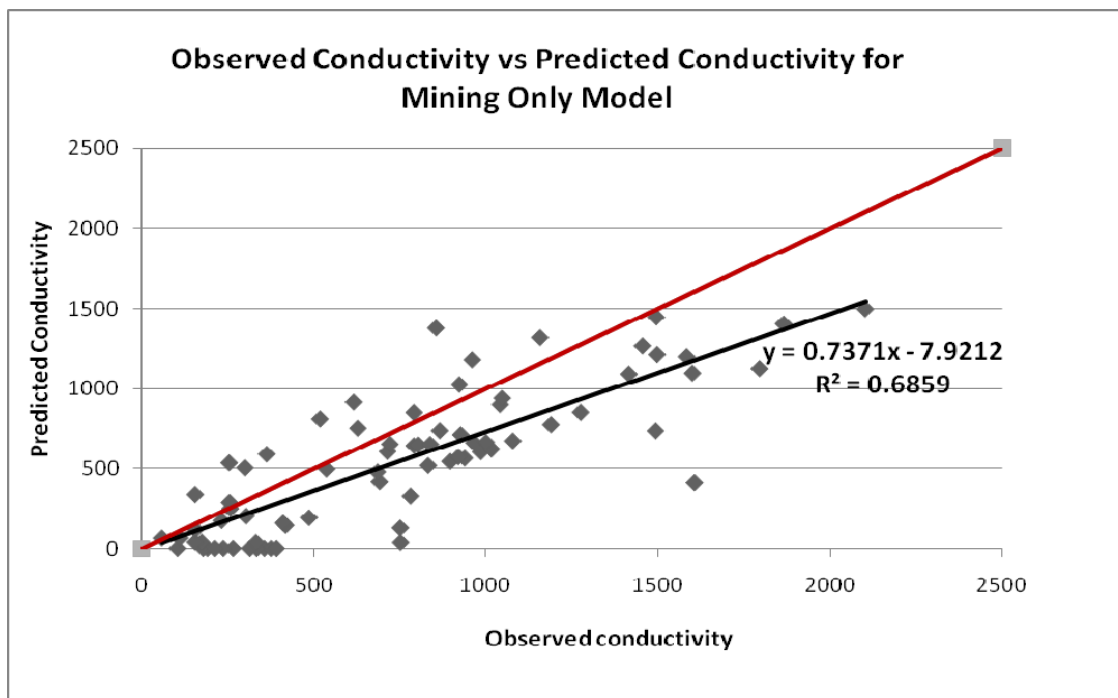


Figure A5.3. Comparison of modeled and empirical conductivity measurements from 73 stream segments.

In the alternative future analysis, EPA found that under Scenario 1 (current conditions), summer conductivity was estimated to be below 300 $\mu\text{S}/\text{cm}$ (Type 1) in 5.3% of stream length within the Spruce No. 1 project area and downstream to the mouth of the Coal River (Table A5.1.). Under this scenario, 2.2% of the stream length within or downstream of the Spruce No. 1 site was estimated to have conductivity greater than 1000 $\mu\text{S}/\text{cm}$ (Type 5). The majority of stream miles within the Headwaters Spruce Fork sub-watershed (HUC 12), Little Coal River watershed (HUC 10), and Coal River sub-basin (HUC 8) currently fall within the conductivity range of 500 - 749

μS/cm (Type 3, Figure A5.4.), a level that is consistent with degraded biological condition in wadeable streams (Pond et al. 2008).

Table A5.1. Summary of stream segments within the Coal River sub-basin that are expected to be directly affected by the Spruce No. 1 Mine. The table presents stream length and percentages of stream length within each stream condition category.

Stream Type	Conductivity	Stream Length (km)		% Stream Length	
		Scenario 1: Current Conditions	Scenario 2: After Spruce	Scenario 1: Current Conditions	Scenario 2: After Spruce
Type 1	<300	7.4	0.0	5.3	0.0
Type 2	300-499	6.9	3.1	4.9	2.2
Type 3	500-749	96.9	78.7	69.5	56.4
Type 4	750-999	25.2	27.4	18.1	19.6
Type 5	≥1000	3.1	30.3	2.2	21.7

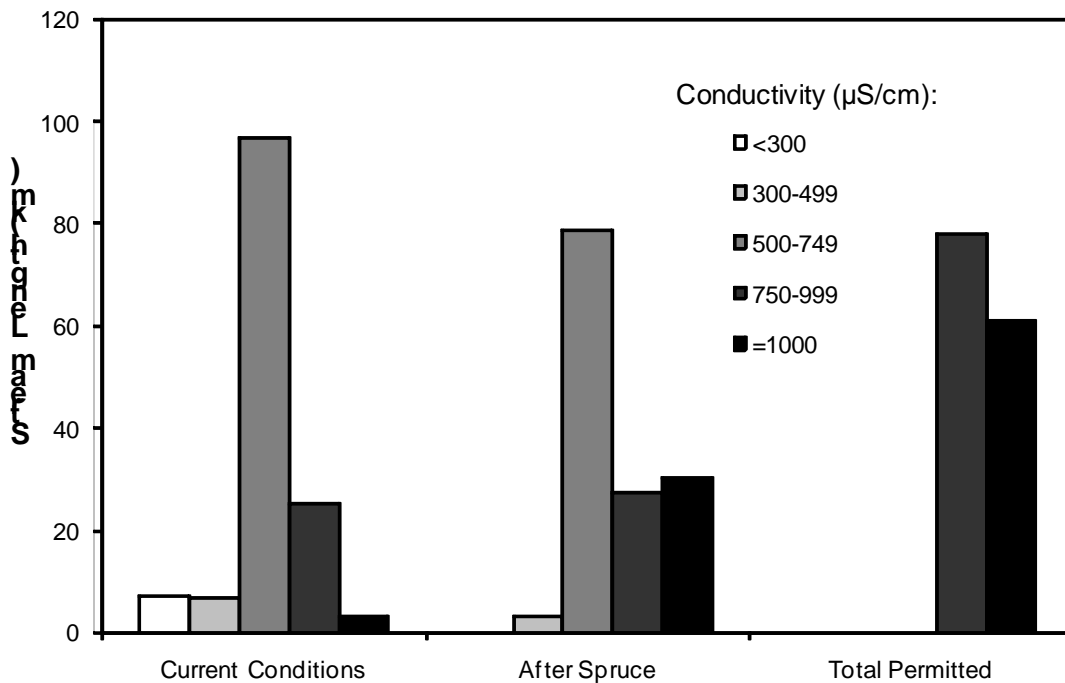


Figure A5.4. Stream length in each conductivity condition type estimated given each of the mining scenarios.

Under Scenario 2 (Spruce No. 1 Mine is constructed as permitted), this analysis shows that there will be no stream segments with conductivity less than 300 μS/cm (Type 1) downstream of the Spruce site in the Coal River sub-basin (Table A5.1.), and only an estimated 2.2% of stream length will have conductivity levels below 500 μS/cm (Type 2). Furthermore, 21.7% of stream length within the Coal River sub-basin is projected to have conductivity greater than 1000 μS/cm (Type 5). If the Spruce No. 1 Mine is constructed as permitted, the summer conductivity levels in the main stem of Spruce Fork immediately downstream of the project area will increase to greater than 1000 μS/cm (Type 5) for approximately 9.2 km (5.7 miles) downstream, and will increase to conductivity values between 750 – 999 μS/cm (Type 4) for the remaining 19 km (11.8 mi) of the Spruce Fork main stem before its confluence with Little Coal Creek (Table

A5.2., Figure A5.5.). Based upon the known relationships between conductivity and aquatic life (see Section V.D.1.b. and Appendix 1), the predicted levels of conductivity in the Spruce No. 1 Mine permit area and in downstream waters, will be largely unsupportive of aquatic life if the Spruce No. 1 mine is constructed as currently authorized.

Under Scenario 3 (other permitted mine areas are fully mined, in addition to Spruce No. 1), the cumulative effect of all currently permitted mine areas will likely result in substantially higher conductivities in the Little Coal and Coal Rivers. Calculation of full mining of all permitted mine areas produced significant increases in expected stream conductivity levels in the Coal River sub-basin (Figure A5.6.). Under this scenario, percent mining is predicted to increase by 16% within the Outlet Spruce Fork sub-watershed, compared with current conditions (Table A5.3.). Under this scenario, it is likely that conductivity will increase from below 750 $\mu\text{S}/\text{cm}$ to greater than 1000 $\mu\text{S}/\text{cm}$ (Type 5) at the mouth of Spruce Fork.

Within the larger Lower Little Coal River watershed, Scenario 3 predicts an increase in percent mining by 11.2% over current conditions (Table A5.3.). This will likely elevate conductivity from below 750 $\mu\text{S}/\text{cm}$ to as much as 1000 $\mu\text{S}/\text{cm}$ within the Little Coal River. At the broadest scale analyzed, percent mining is predicted to increase by 9.3% in the Coal River sub-basin with full construction of all permitted mines. This will likely elevate conductivity from below 750 $\mu\text{S}/\text{cm}$ to as much as 1000 $\mu\text{S}/\text{cm}$ within the Coal River sub-basin (Table A5.2.).

Elevated conductivity levels, at levels predicted to occur under the above scenarios, have been associated with impairment of aquatic life. At conductivity levels greater than 500 $\mu\text{S}/\text{cm}$ (i.e., stream condition Types 3, 4 and 5), a loss of greater than 25% of the native taxa normally found in healthy wadeable Appalachian streams can be anticipated, and it is likely that these streams will not be fully support of aquatic life use (USEPA 2010a). At the watershed scale, shifts in macroinvertebrate communities, and subsequent loss of these organisms as food sources to higher trophic levels, will potentially result in cascading ecosystem changes downstream. Combined with likely increased levels of selenium and other mining-related pollutants (as described in Appendices 1, 2, and 4), EPA believes these adverse effects will cause or contribute to significant degradation within the Coal River sub-basin.

Table A5.2. Percent mining for scenarios coded based upon stream condition type (Table A5.1.). Asterisks indicate reach segments within the Spruce No. 1 Mine permit boundary. Bold font indicates the mouth of a multi-reach tributary. The mouth of Spruce Fork, Little Coal, and Coal River are outlined in red.

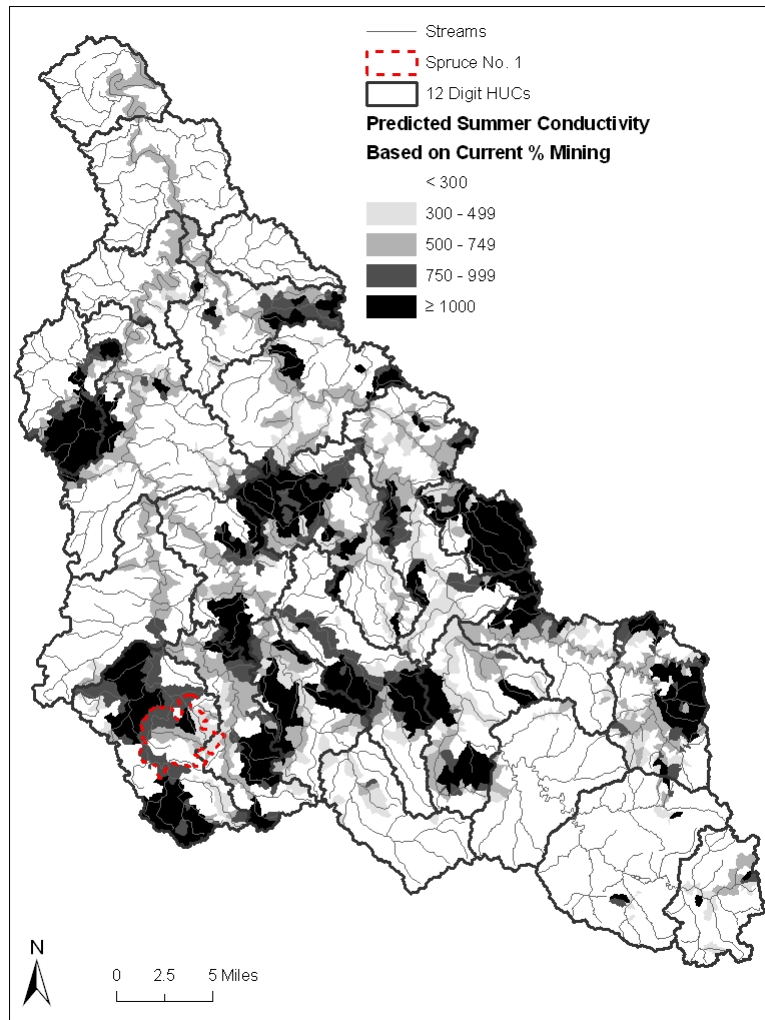
Segment Name	Cum. Drainage Area (km ²)	Stream Segment Length (km)	% Permit Area in Drainage Area	Percent Mining		
				Scenario 1	Scenario 2	Scenario 3
* UNT/UNT RM 0.26/RF RM 0.63/Seng Camp Creek	0.2	0.4	99.7	92.5	100	99.7
* UNT/UNT RM 0.77/Pigeonroost Branch RM 1.74	0.2	0.2	100	0.3	100	100
* UNT/UNT RM 0.27/Pigeonroost Branch RM 2.30	0.3	0.4	78.8	12.4	81.1	78.8
* UNT/Pigeonroost Branch RM 1.74	0.3	0.4	100	0.2	100	100
* UNT/Spruce Fork RM 19.18	0.4	0.6	49.5	17.8	67.3	49.5
* UNT/White Oak Branch RM 1.14	0.4	0.9	77.8	0	77.9	77.8
* UNT/Pigeonroost Branch RM 2.30	0.4	0.6	90.1	3.1	89.8	90.1
* UNT/Right Fork RM 0.63/Seng Camp Creek	0.7	0.4	98.6	87	100	98.6
* Pigeonroost Branch	0.7	1.1	99	12.2	100	99
* UNT/Pigeonroost Branch RM 2.30	0.8	0.4	88.5	5.5	89.1	88.5
* Right Fork/Seng Camp Creek	0.8	1.3	99	28.4	100	99
* White Oak Branch	1.3	0.5	3.5	0	3.4	23.5
* UNT/Pigeonroost Branch RM 1.74	1.3	1.3	100	0.2	100	100
* UNT/Seng Camp Creek RM 2.57	1.4	1.6	33.1	4.5	9.3	33.1
* Pigeonroost Branch	2	1	95.1	10.5	95.7	95.1
* Right Fork/Seng Camp Creek	2.1	1	90.2	51.4	93	90.2
* Oldhouse Branch	2.4	2.3	91.6	2.7	94.3	91.6
* Trough Fork	2.5	2.3	23.7	3.1	3.4	23.7
* White Oak Branch	3.2	1.8	45.1	0	41.5	45.1
* Seng Camp Creek	3.9	1.7	34.8	6.7	10.4	34.8
* Pigeonroost Branch	6	2.8	88.3	7.3	92.3	88.3
* Seng Camp Creek	7.4	0.3	29.3	4.8	6.9	29.3
* Seng Camp Creek	10.7	1.2	42.6	16.8	26.4	42.6
Seng Camp Creek DS Spruce 1	13.2	0.9	42.9	17.2	25	42.9
* Spruce Fork	44	2.1	35.5	19.2	22.8	36
* Spruce Fork	44.8	0.3	34.9	18.9	22.4	35.4
* Spruce Fork	54.2	2.3	36.4	15.7	18.9	36.8
* Spruce Fork	55.9	0.5	36.7	16.3	19.4	37.1
* Spruce Fork	59	1	38.9	15.8	22.6	39.2
* Spruce Fork	68	3	43.3	15.4	29.1	43.6
* Spruce Fork	69.5	1.2	43	15.3	29.2	43.3
Spruce Fork DS Spruce 1, US Seng Camp	71.1	1.2	42.5	15.1	28.6	42.8
Spruce Fork DS Seng Camp	85.1	1	42.4	15.4	28	42.7
Spruce Fork	86.6	0.4	43	15.9	28.2	43.2
Spruce Fork	88.5	1.7	42.1	15.5	27.6	42.4
Spruce Fork	113.8	0.7	50.1	20.7	30.1	50.3
Spruce Fork	116.6	2.2	49.5	20.6	29.7	49.7
Spruce Fork	124.8	1.2	48.9	23.4	32	51.3
Spruce Fork (outflow Headwater Spruce HUC 12)	131.4	0.8	46.7	22.4	30.5	49
Spruce Fork	214.9	0.7	38.3	18.2	23.2	40.1
Spruce Fork	216.7	0.6	38	18.1	23	39.7
Spruce Fork	220.6	1.6	37.3	17.8	22.6	39
Spruce Fork	271.1	2	30.7	14.5	18.5	32.1
Spruce Fork	279.2	1.7	29.8	14.1	17.9	31.1
Spruce Fork	292.4	1.8	28.4	13.5	17.1	29.7

Segment Name	Cum. Drainage Area (km ²)	Stream Segment Length (km)	% Permit Area in Drainage Area	Percent Mining		
				Scenario 1	Scenario 2	Scenario 3
Spruce Fork	299.7	2	27.8	13.2	16.7	29
Spruce Fork	305.4	0.8	28.2	12.9	16.4	29.5
Spruce Fork	306.8	1.1	28.1	12.9	16.4	29.4
Spruce Fork	309.6	0.4	27.9	12.8	16.2	29.1
Spruce Fork	310.6	1	27.8	12.8	16.2	29
Spruce Fork	311.3	0.5	27.7	12.7	16.2	29
Spruce Fork	312.5	0.2	27.6	12.7	16.1	28.9
Spruce Fork	312.8	0.4	27.6	12.7	16.1	28.9
Spruce Fork	312.9	0.1	27.6	12.7	16.1	28.8
Spruce Fork	313	0.2	27.6	12.7	16.1	28.8
Spruce Fork	316.7	1.1	27.3	12.5	15.9	28.5
Spruce Fork	319.7	1.2	27	12.4	15.7	28.2
Spruce Fork	320	0.4	27	12.4	15.7	28.2
Spruce Fork (outlet Spruce Fork HUC12)	321.7	1.3	26.8	12.3	15.6	28.1
Little Coal River	684.5	1.3	25.9	12.1	13.7	26.7
Little Coal River	687.3	0.9	25.8	12.1	13.6	26.6
Little Coal River	688	0.2	25.8	12	13.6	26.6
Little Coal River	692.5	1.1	25.6	12	13.5	26.4
Little Coal River	695	0.7	25.5	11.9	13.5	26.3
Little Coal River	726.4	0.5	24.4	11.4	12.9	25.1
Little Coal River	727.2	0.5	24.4	11.4	12.9	25.1
Little Coal River	727.9	0.2	24.4	11.4	12.9	25.1
Little Coal River	728.3	0.5	24.3	11.4	12.8	25.1
Little Coal River	743.6	1	24	11.3	12.7	24.7
Little Coal River	744.4	0.7	24	11.2	12.7	24.7
Little Coal River	745	0.5	24	11.2	12.7	24.7
Little Coal River	780	1	23	10.8	12.2	23.7
Little Coal River	780.9	0.6	23	10.8	12.2	23.7
Little Coal River	785.7	1.1	23.2	11	12.4	23.9
Little Coal River	787.2	0.2	23.1	11	12.4	23.8
Little Coal River	788.1	0.7	23.1	11	12.3	23.8
Little Coal River	790.4	1.6	23	11	12.3	23.7
Little Coal River	807.8	0.6	22.7	10.8	12.1	23.3
Little Coal River	810.3	1.3	22.7	10.7	12.1	23.3
Little Coal River	810.9	0.5	22.7	10.7	12	23.4
Little Coal River	811.7	0.4	22.7	10.7	12	23.3
Little Coal River	831.7	1.2	22.6	10.7	12	23.3
Little Coal River	832.2	1	22.6	10.7	12	23.2
Little Coal River	908.5	0.9	22.8	11.4	12.6	23.4
Little Coal River	913.4	0.4	22.7	11.3	12.5	23.3
Little Coal River	914.1	0.6	22.7	11.3	12.5	23.3
Little Coal River	915.1	0.6	22.7	11.3	12.5	23.3
Little Coal River	916.9	2.2	22.6	11.3	12.4	23.2
Little Coal River (outflow HUC12)	919.9	2.2	22.6	11.2	12.4	23.2
Little Coal River	930	0.7	22.3	11.1	12.3	23
Little Coal River	930.6	0.4	22.3	11.1	12.3	23
Little Coal River	932.7	1.8	22.3	11.1	12.3	22.9

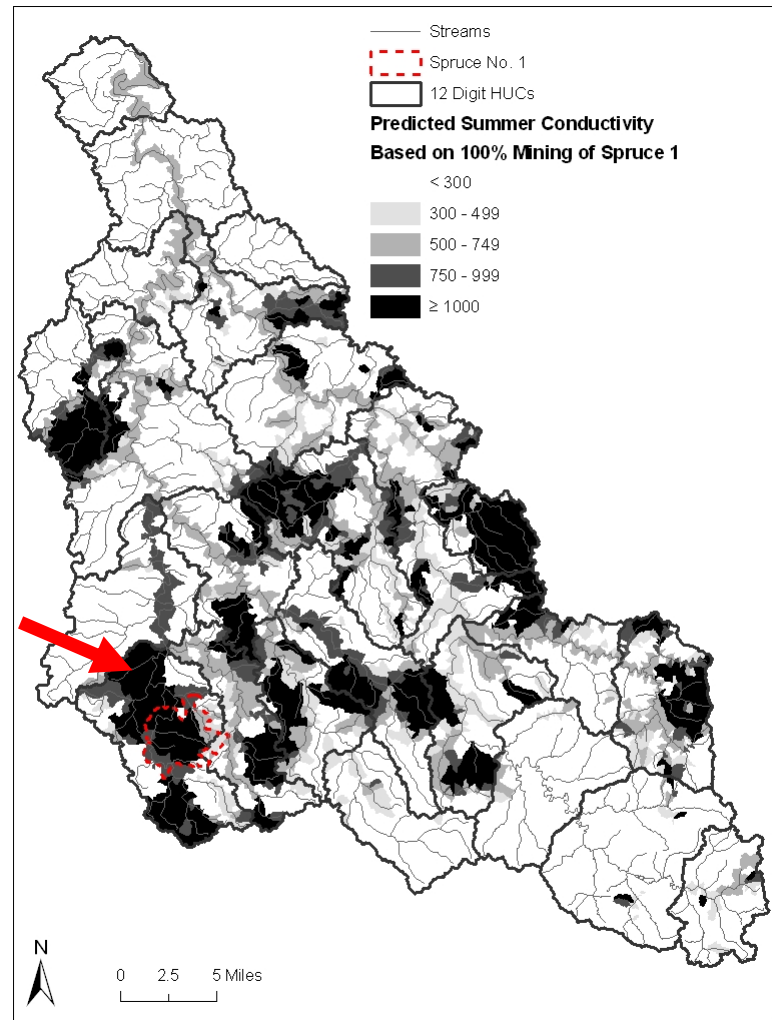
Segment Name	Cum. Drainage Area (km ²)	Stream Segment Length (km)	% Permit Area in Drainage	Percent Mining		
				Scenario 1	Scenario 2	Scenario 3
Little Coal River	939.2	0.9	22.3	11	12.2	22.9
Little Coal River	967	0.8	21.6	10.7	11.8	22.2
Little Coal River	968	0.5	21.6	10.7	11.8	22.2
Little Coal River	969.2	0.9	21.6	10.7	11.8	22.2
Little Coal River	970.4	0.3	21.6	10.7	11.8	22.1
Little Coal River	974.3	3.4	21.5	10.7	11.8	22.1
Little Coal River	974.6	0.2	21.5	10.7	11.8	22.1
Little Coal River	975.7	1.3	21.4	10.7	11.7	22
Little Coal River	978.9	0.5	21.4	10.6	11.7	22
Little Coal River	979.5	0.3	21.4	10.6	11.7	22
Little Coal River	980.3	1.3	21.3	10.6	11.7	21.9
Little Coal River	982	0.2	21.3	10.6	11.7	21.9
Little Coal River	983.2	1	21.3	10.6	11.7	21.9
Little Coal River	985.6	2	21.2	10.5	11.6	21.8
Little Coal River	989.3	1.7	21.2	10.5	11.6	21.7
Little Coal River	991.7	1.4	21.1	10.5	11.6	21.7
Coal River	2146.7	0.4	19	9.4	9.9	19.5
Coal River	2148.6	1.1	19	9.4	9.9	19.5
Coal River	2164.5	1.6	18.9	9.3	9.8	19.3
Coal River	2174.3	0.4	18.8	9.3	9.8	19.2
Coal River	2196.2	0.3	18.6	9.2	9.7	19
Coal River	2197.9	1.2	18.6	9.2	9.7	19
Coal River	2199.2	0.9	18.6	9.2	9.7	19
Coal River	2202.1	2.4	18.5	9.2	9.7	19
Coal River	2203.5	0.2	18.5	9.2	9.7	19
Coal River	2215.3	0.8	18.4	9.1	9.6	18.9
Coal River	2217.5	0.8	18.4	9.1	9.6	18.9
Coal River	2218.8	1.1	18.4	9.1	9.6	18.8
Coal River	2219.9	1	18.4	9.1	9.6	18.8
Coal River	2230.6	1	18.3	9.1	9.5	18.7
Coal River	2249.7	0.5	18.1	9	9.5	18.6
Coal River	2251.4	0.2	18.1	9	9.5	18.6
Coal River	2253.2	2	18.1	9	9.4	18.6
Coal River	2254.8	2.2	18.1	9	9.4	18.5
Coal River	2255.5	0.5	18.1	9	9.4	18.5
Coal River	2285.2	1.6	17.9	8.8	9.3	18.3
Coal River	2286.9	1.8	17.8	8.8	9.3	18.3
Coal River	2287.8	0.3	17.8	8.8	9.3	18.3
Coal River	2290.2	3.2	17.8	8.8	9.3	18.3
Coal River	2292.2	1.5	17.8	8.8	9.3	18.2
Coal River	2296	2.8	17.8	8.8	9.3	18.2
Coal River	2307.5	0.8	17.7	8.8	9.2	18.1

Table A5.3. Percent mining and predicted conductivity for the scenarios at the outflow of 12-Digit HUCs (nested within 10-Digit HUCs) within the Coal River sub-basin. The Spruce No. 1 Mine is to be located in the Headwaters Spruce Fork sub-watershed (HUC 12). Table is color-coded for stream condition type (Table A5.1)

HUC 12	HUC 12 Name	Cumulative Drainage Area (km ²)	Percent Mining		
			Scenario 1	Scenario 2	Scenario 3
50500090101	Headwaters Clear Fork	85.5	12.2	12.2	24.3
50500090102	Outlet Clear Fork	164.2	9.6	9.6	28.1
50500090201	Stephens Lake	47.9	3.2	3.2	5.1
50500090202	Upper Marsh Fork	159.2	1.5	1.5	2.4
50500090203	Middle Marsh Fork	302.2	1.1	1.1	2.3
50500090204	Lower Marsh Fork	422.9	4.4	4.4	8.1
50500090301	Spruce Laurel Fork	82.8	11.8	11.8	26.3
50500090302	Headwaters Spruce Fork	131.4	22.4	30.5	49
50500090303	Outlet Spruce Fork	326.5	12.1	15.4	27.6
50500090401	Upper Pond Fork	69.2	3.1	3.1	8.2
50500090402	West Fork	110.5	14.8	14.8	34.6
50500090403	Middle Pond Fork	156	9.6	9.6	21.9
50500090404	Lower Pond Fork	357.3	12.1	12.1	25.9
50500090501	Big Horse Creek	75.9	18.8	18.8	25.7
50500090502	Upper Little Coal River	919.9	11.2	12.4	23.2
50500090503	Lower Little Coal River	991.7	10.5	11.6	21.7
50500090601	White Oak Creek	49.6	39.8	39.8	57.1
50500090602	Laurel Creek	128.8	16	16	32.7
50500090603	Joes Creek-Big Coal River	902.5	9.3	9.3	19.2
50500090604	Drawdy Creek-Big Coal River	1010.4	8.9	8.9	18.4
50500090605	Brier Creek	41.2	0.3	0.3	3.9
50500090606	Fork Creek-Big Coal River	1154.9	8.5	8.5	17.6
50500090607	Smith Creek-Coal River	2230.6	9.1	9.5	18.7
50500090608	Browns Creek-Coal River (outlet)	2307.5	8.8	9.2	18.1



(a)



(b)

Figure A5.5.: Predicted summer conductivity under (a) Scenario 1 (Current conditions) and (b) Scenario 2 (Full construction of the Spruce No. 1 Mine). Arrows highlight areas of change.

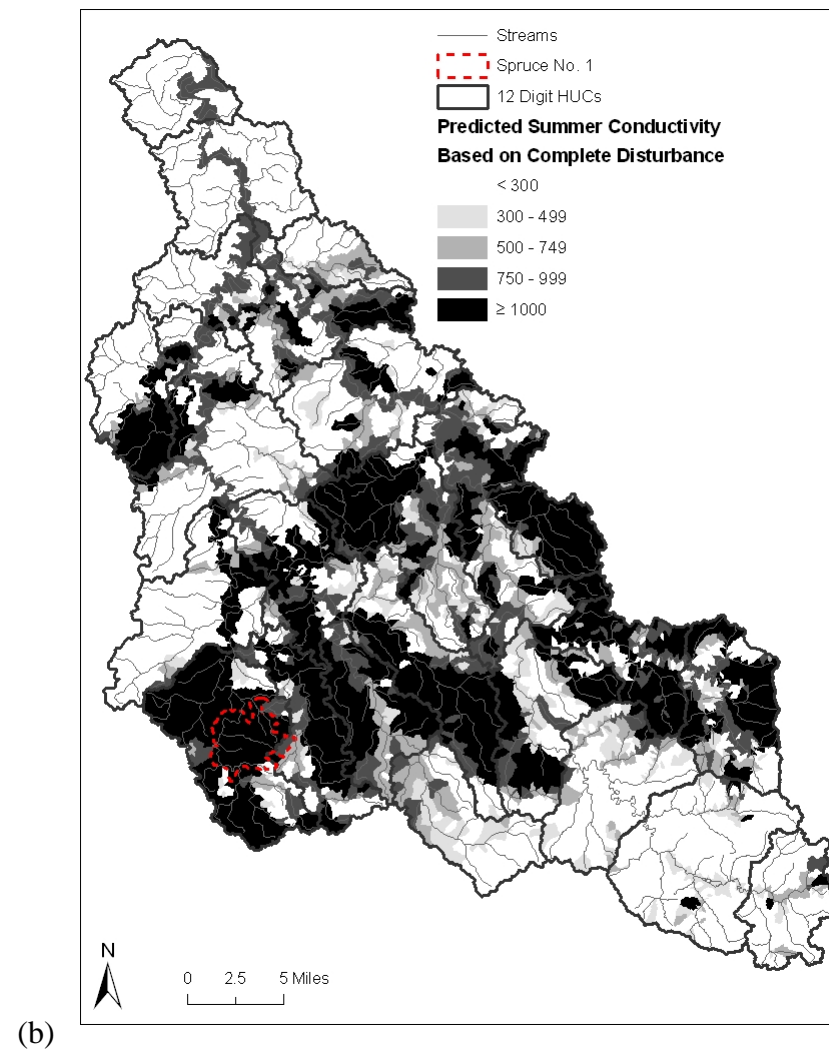
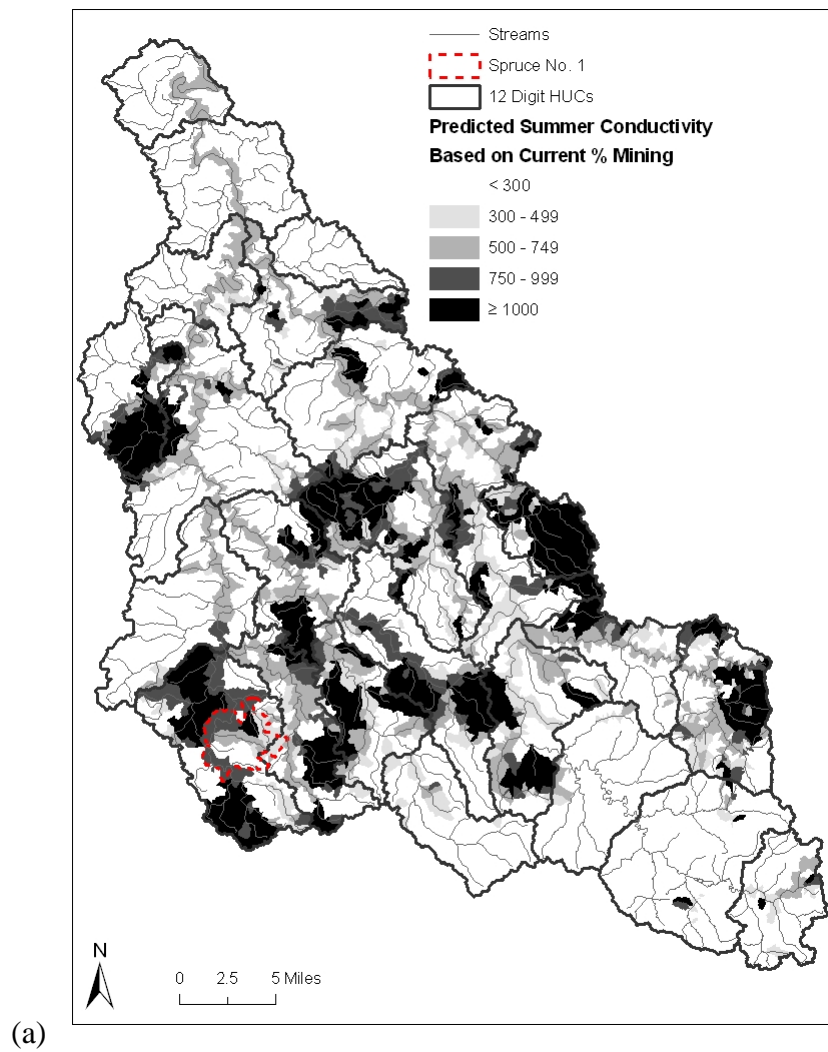


Figure A5.6. Predicted summer conductivity under (a) Scenario 1 (Current conditions) and (b) Scenario 3 (Complete mining of all permitted areas). There are numerous areas of change in Scenario 3.