HAUL ROADS: POST-MINING MANAGEMENT PROBLEMS[1]

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Abstract. Monitoring stations were installed in three small watersheds in the Cumberland Mountains and three in the Cumberland Plateau of east Tennessee to evaluate the effects of surface mining on water quality. Each set had a recently mined, old mined and unmined watershed. Stream flow and concentration levels for 5 water quality parameters, collected every four weeks from 1981 through 1984, were evaluated.

Differences in water quality were found between mined and unmined watersheds, with mined ones generally having generally higher levels of minerals and greater turbidity. However, one unmined watershed yielded poorer water quality than its old mined counterpart water for most of the parameters tested, apparently due to an unpaved road. Water quality of one new mine also continued to deteriorate following mining due to controlled road use, trash dumping and poor reclamation.

Key Words: water quality, surface mining, haul roads, mined watersheds.

Introduction

Surface mining for coal has been practiced for over two hundred years in the United States. The first operations were very small and made use of exposed or thinly covered deposits. At first, manual labor was used and later, draft animals removed the overlying materials on deeper coal beds, having but small limited environmental impact. Today, entire drainages are altered and exposed spoil materials are sometimes highly toxic, causing water contamination. Thousands of miles of streams have been affected in this manner in the Appalachian region (Seitz 1981). Most monitoring stations have been in large watersheds with many land uses, making it very difficult to attribute water problems specifically to surface mining. For this study, monitoring stations were established on small watersheds in an effort to overcome this problem.

The initial objective of the work was to compare unmined, old mined and newly mined watersheds to determine differences in water quality and quantity. The work also revealed some interesting data relating to haul-roads which are reported here.

Methods and Materials

In late 1980 and early 1981, stream flow and precipitation monitoring equipment was installed at the confluences of six watersheds in the coal region of eastern Tennessee. Each site selected represented either an "old mined," "newly mined" or an unmined condition. All watersheds are between 80 and 260 acres in size.

Unmined watersheds were not to have roads or cuts that exposed bare ground and were not to have been farmed, disturbed or developed. Old vegetated logging roads and skid trails were allowed.

Old mined watersheds should have had 10 to 100 percent of their area disturbed by surface mining before January 1972, with no surface mining or reclamation after that date. Whenever possible, watersheds were selected in which only one coal

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seam had been mined.

Newly mined watersheds were to have had no mining until after January 1972. From 10 to 100 percent of the area could be disturbed by surface mining and active mines were permitted. Areas with old mines that were worked before 1972 were permitted, provided that all areas previously mined were reworked after January 1972. Watersheds with only one coal seam or those that had only one seam mined were selected when possible.

The average yearly temperature is around 14 degrees Celcius with winter temperatures averaging four degrees C. and summer temperatures averaging 25. Precipitation averages 50 to 55 inches annually and is disturbed fairly evenly throughout the year, although there is a greater frequency of large scale storms in the winter and early spring. Thunderstorms and showers sometimes produce high rates of precipitation during midsummer. Winds average five to seven miles per hour.

A rainfall and stream flow monitoring station was installed at each watershed. Precipitation was monitored with a Remote Recording Rain Cage which continuously measures one-hundredth inch increments using a tilting bucket. A battery powered Model 101 Datapod by Omnidata accumulated the data. These instruments were located in an open area where no objects could hinder precipitation freefall.

A trapezoidal venturi flume stream flow gauge was constructed at the mouth of each watershed. A stilling well with a float was used to measure water levels. Data were collected with a battery powered recorder at five minute intervals on punched paper strip charts.

Each site was visited every four weeks. Water samples were collected at each site during the visit, but only if water was flowing through the flume. After all sites were visited, the water samples, charts, data storage modules and data sheets were sent to the Northeastern Forest Experiment Station in Berea, Kentucky, for processing. Water samples were analyzed for 33 elements and properties (Dyer 1982), of which 5 are reported here.

Proc X11, from the Econmetrics and Time Series (SAS 1984) program package, was used to test for seasonal significance of fluctuations in stream water quality indicators.

The General Linear Model (Proc GLM in SAS 1985) was used to test for correlations between stream flow, date, watershed and water quality. Based on past experience, data were converted to logarithmic values to adjust for increases in variability of water quality data over time.

The "Estimate" option in the Proc GLM program (SAS 1985) was used to compare watersheds with different mining conditions. Both "newly mined" and "old mined" conditions were compared with the unmined condition for the two groups.

Final analyses were made to test for significant differences in water quality over time and for these, Proc GLM "Estimate" statements (SAS 1985) were used.

Results and Discussion

With the exception of Davis Creek, the new mountain watershed, TDS levels do not pose major problems (Figure 1). This unmined-mountain watershed had averaged over three times the suggested standard and the concentration is still increasing. Note should be made of two aspects of TDS. First, the rhythmic annual cycles in concentration changes, with low concentrations appearing in February in mountain streams, appearing several months later, March and April, in the plateau watersheds. In the mountain watersheds, TDS levels are significantly higher ($P = .01$) in the newly mined stream than in unmined one. The unpaved road passing through this watershed seems to be the cause of this anamoly.

The newly mined mountain watershed yielded concentrations of sodium that were three to four times greater than standards which have been set and in addition there was a significant increase during the study period (Fig. 2). High levels of sodium in the unmined mountain watershed are probably due to the road through the area. Peak values for this highly mobile element appear in August and September, which coincides with a period of low water yield.

Although water quality standards have not been set, magnesium concentrations showed large variations between study areas and over time (Figure 3). The new mountain mine had the highest values and with highly significant increase during the study period.

Although water quality standards are not available, calcium concentrations varied greatly between the study areas and over time (Figure 4). Davis Creek, the "new" mountain mined watershed, had the highest concentrations and showed a highly significant increase during the study period. Denny Cove, the new plateau mine, was next highest in 1981, but by 1984 was comparable to the unmined mountain watershed.

Sulfate is a problem on only one of the study areas, Davis Creek (Fig. 5). Concentrations averaged over four times the recommended levels.

This study was begun with the intent of studying the effects of strip mining on yield and quality of water issuing from mined watersheds. We have found, however, that the effects of road building and trash dumping, as well as the natural variability of every watershed which can be expected in almost any field experiment, may heavily mask experimental results of watershed studies. This problem could largely be overcome by concommitant sampling of streams above roads and strip mines as well as below them. If water quality is the only matter of concern, such a sampling scheme might render the use of unmined controls unneccessary.

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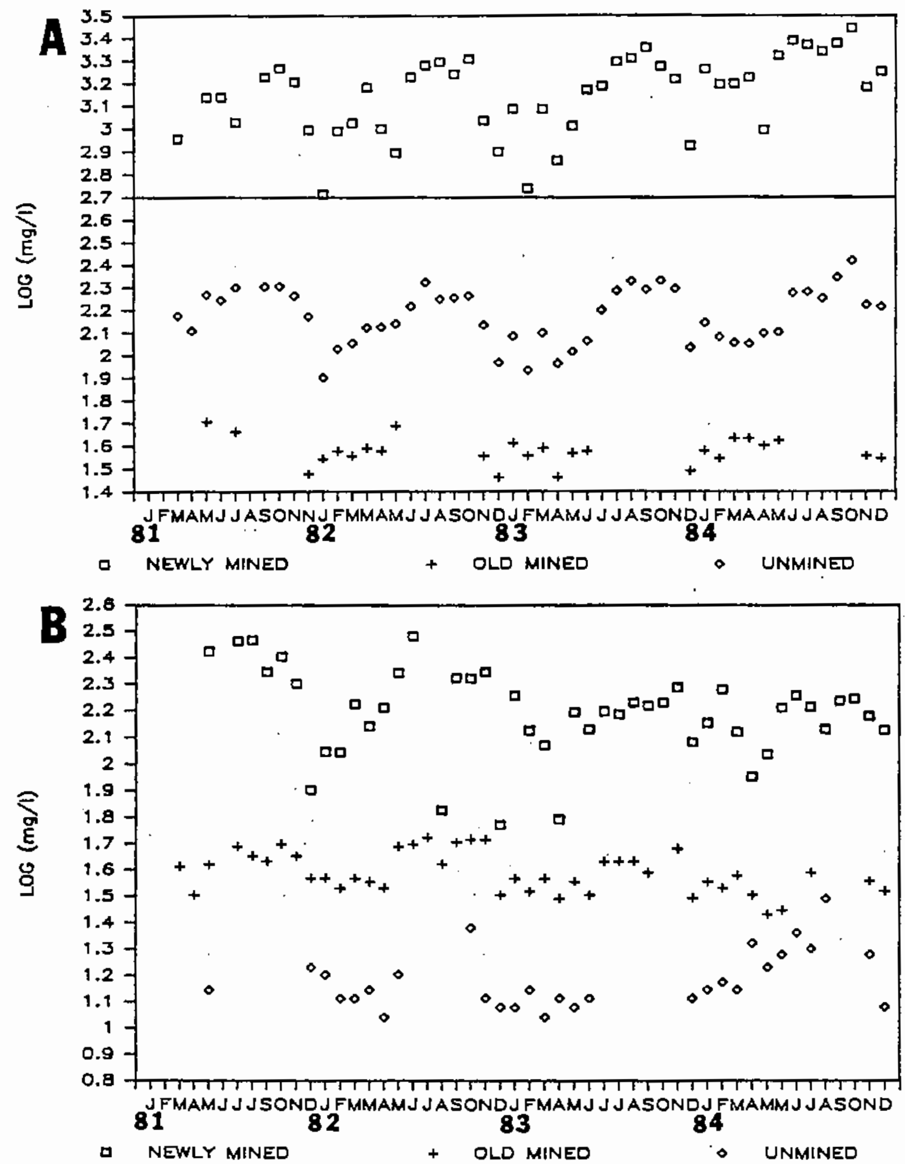

Figure 1. Periodic total dissolved solid (TDS) levels from 1981 through 1984. A. Cumberland Mountain streams: newly mined (Davis Creek), old mined (Crooked Fork) and unmined (Lake City). B. Cumberland Plateau streams: newly mined (Denny Cove), old mined (Corn Branch) and unmined (Suzanne Creek).

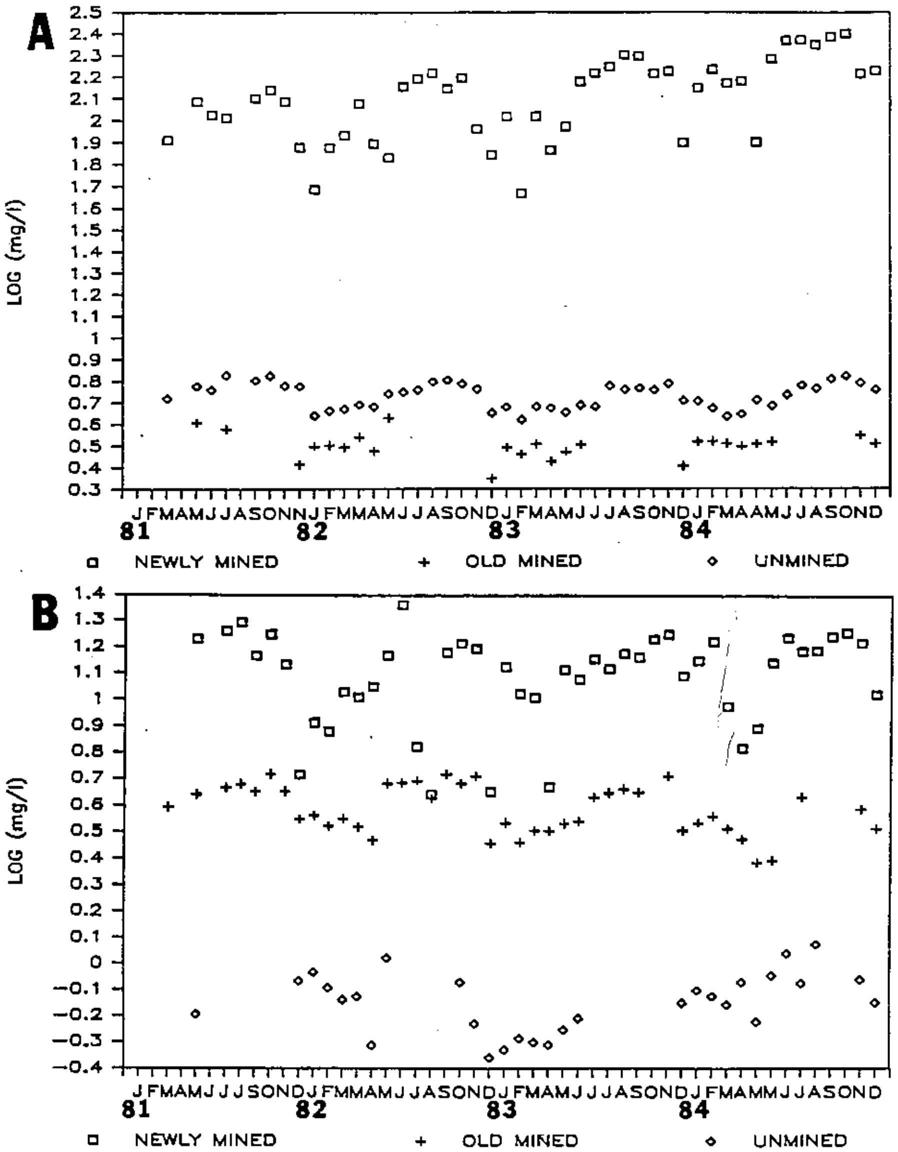

Figure 3. Periodic magnesium levels from 1981 through 1984. A. Cumberland Mountains streams: newly mined (Davis Creek), old mined (Crooked Fork) and unmined (Lake City). B. Cumberland Plateau streams: newly mined (Denny Cove), old mined (Corn Branch) and unmined (Suzanne Creek).

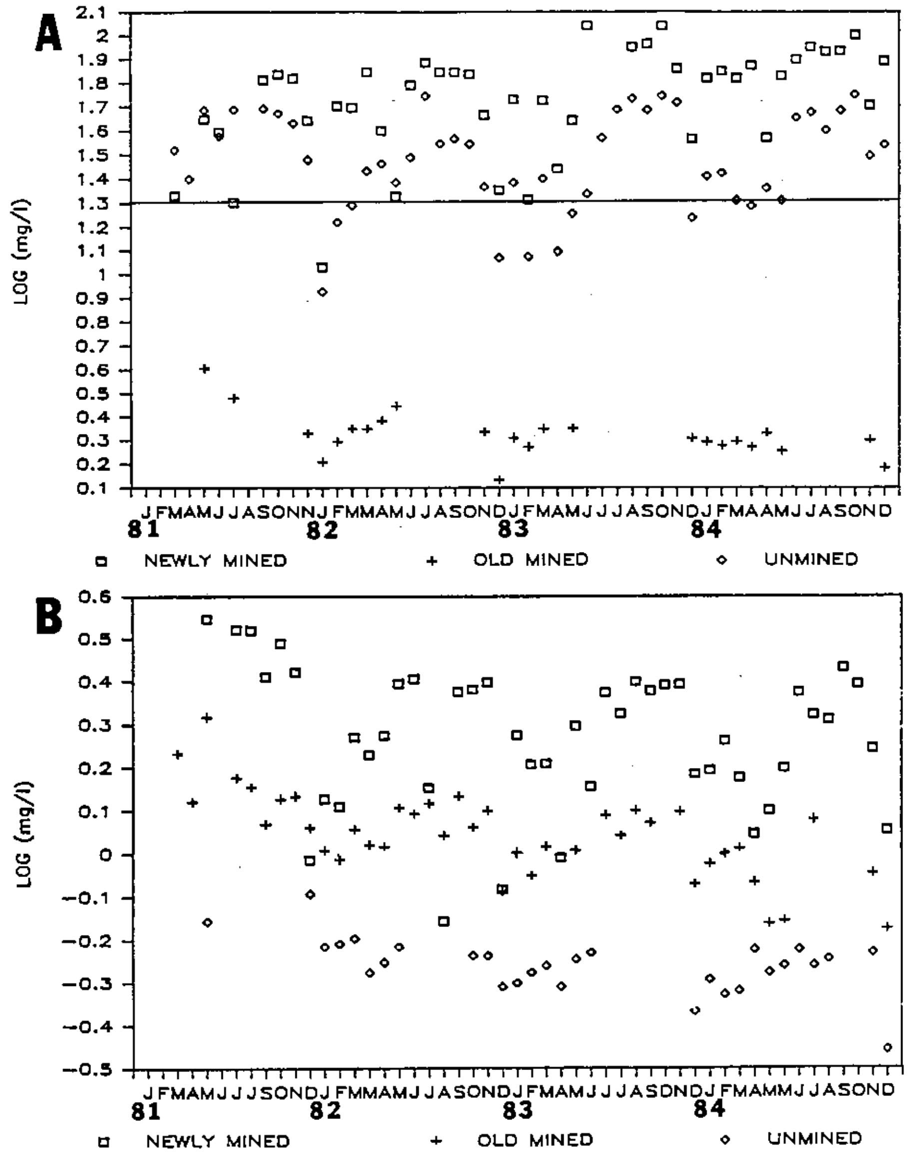

Figure 2. Periodic sodium levels from 1981 through 1984. A. Cumberland Mountains streams: newly mined (Davis Creek), old mined (Crooked Fork) and unmined (Lake City). B. Cumberland Plateau streams: newly mined (Denny Cove), old mined (Corn Branch) and unmined (Suzanne Creek).

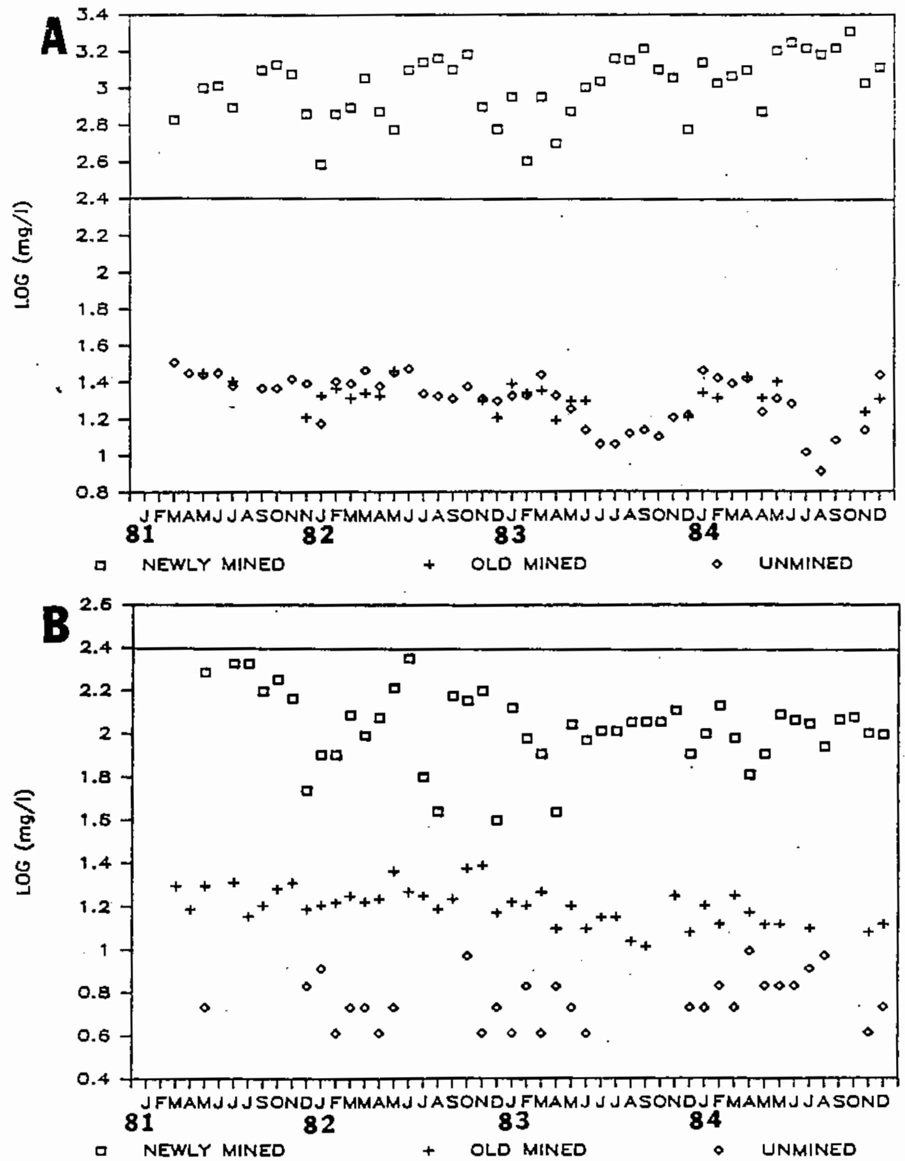

Figure 5. Periodic sulfate levels from 1981 through 1984. A. Cumberland Mountains streams: newly mined (Davis Creek), old mined (Crooked Fork) and unmined (Lake City). B. Cumberland Plateau streams: newly mined (Denny Cove), old mined (Corn Branch) and unmined (Suzanne Creek).

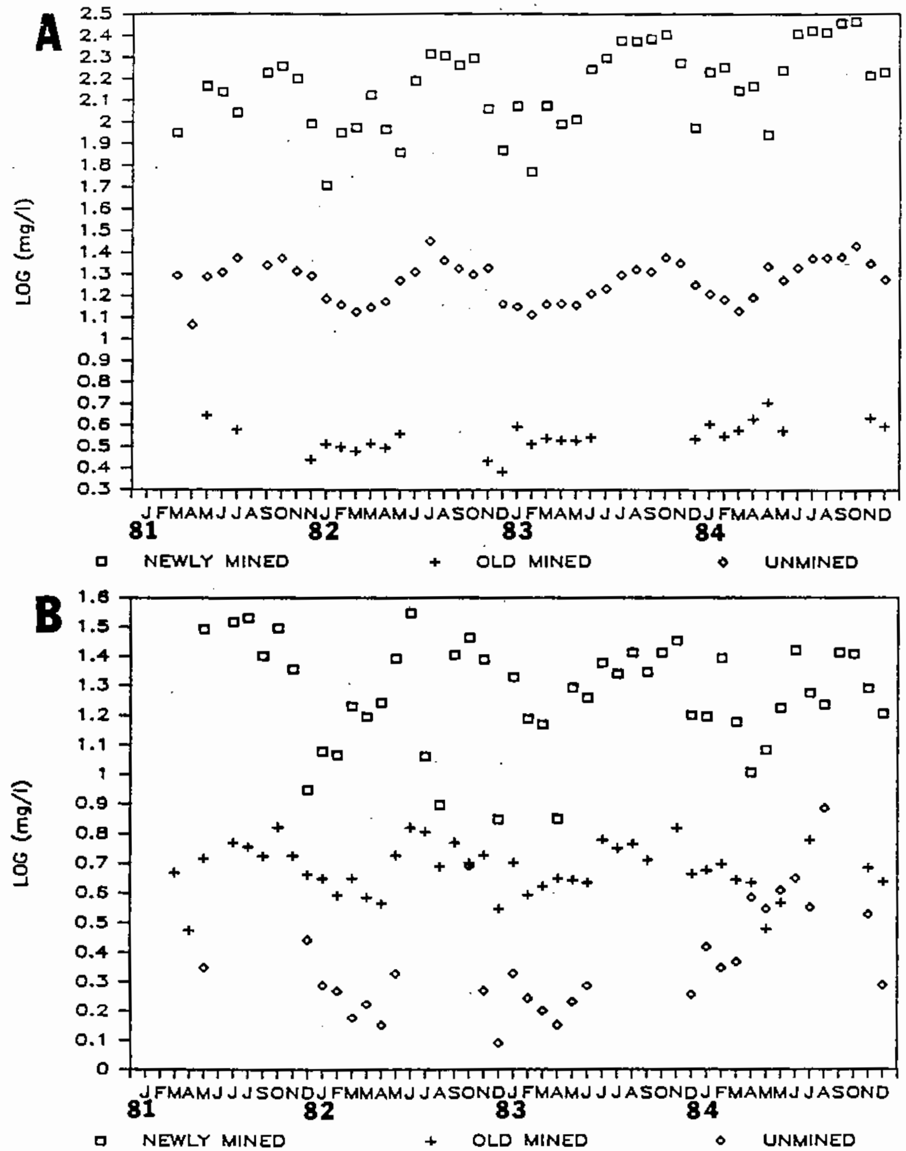

Figure 4. Periodic calcium levels from 1981 through 1984. A. Cumberland Mountains streams: newly mined (Davis Creek), old mined (Crooked Fork) and unmined (Lake City). B. Cumberland Plateau streams: newly mined (Denny Cove), old mined (Corn Branch) and unmined (Suzanne Creek).