Characterization of Water Chemistry and Flow for Scarlift Sites 23-28, Shamokin Creek Watershed

by

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GEOL 305

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I have made handwritten editorial comments on this student research report.
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Introduction:

The purpose of this project was to collect water analysis data from six mine water discharges (Scarlift sites #23-#28) (Gannett Fleming Coddry and Carpenter 1972) southeast of Shamokin, Pennsylvania (Figure 1). The Shamokin Creek Watershed is severely impacted by acid mine drainage from approximately 60 mine discharges. The USGS conducted a mine drainage study of the watershed, and it collected data for most of the 60 sites. Site #23 was located and then dried during drought conditions. Also due to drought conditions, sites #24-#27 were not located until December 2001 (Kirby, pers. comm.). Site #28 is included in this study due its close proximity to the other discharges. The results of these analyses were presented to the Shamokin Creek Restoration Alliance for potential mine drainage treatment in this area.

The monitoring of these discharges is important for understanding the hydrologic conditions of the effected area and for designing treatment facilities. This project also looked for and collected data from previously unstudied discharges between sites #23 and #28 that were located during field research.

Methods:

Grab samples of the water from each discharge were taken in high-density polyethylene sample bottles as follows. After rinsing each bottle with sample solution, approximately 500mL of raw unacidified water was collected. Approximately 100mL of raw water was filtered using a 0.45 micron membrane filter, and acidified with 10 drops of HNO_3 for preservation. 100mL of raw, unfiltered water was acidified with 10 drops of HNO_3 for preservation. These samples were sent to Wilson Testing Labs in Shamokin, Pennsylvania, for metal analysis. Wilson Testing Labs analyzed acidity (as $CaCO_3$) using EPA methods. Sulfate (as SO_4) was analyzed using standard method 426C. Total aluminum was analyzed using standard method 3111D (direct nitrous oxide-acetylene flame method). Total iron and total manganese were analyzed using standard method 3111B (direct-air acetylene flame method) (Greenberg and others 1992). pH, dissolved oxygen, oxidation reduction potential, and specific conductance measurements were taken in the field using a YSI multimeter (model 600XLM-M). Discharge was measured using V-notch weirs.

Results:

Data was collected from sites 23-28 and from 3 newly discovered discharges labeled S28B, S28C, and S24B. Data was also collected within the stream ~~at~~ adjacent S28C. ~~This~~ These data ~~was~~ were labeled S28D. Results of water quality field parameters are shown in Table 1. They indicate low pH at all discharges except S23 and S24B. Results show varying DO concentrations from 2.21 to 12.97 mg/L. Concentrations of dissolved and total iron, aluminum, and manganese and total acidity as mg/L $CaCO_3$ are shown in Table 2. Results show a high concentration of iron at S23, and a relatively high concentration of aluminum at S28. Discharge data is shown in Table 3.

Discussion:

The high pH and high iron concentration observed at S23 indicates a significant amount of iron hydroxide precipitate should form. This is consistent with orange streambeds observed in the area. As observed at site S28C, the pH of the stream remains high downstream from many of the discharges; therefore, iron and aluminum from low pH discharges would also precipitate in the streambed.

The variation in DO could be the result of differences in the depths of the source of the discharges. In general, ~~deep water~~ water from deep mines sources have lower DO than near surface sources. The data suggests that S23, S24, and S26 could be deep ~~water~~ mine discharges. Discharges with high DO could be influenced by long-term exposure to the atmosphere and other oxidizing conditions; therefore, DO is not a definitive measure of depth of source water.

Low concentration of iron in all sites except S23 suggests that the only major source of iron loading to the stream is S23. High concentrations of aluminum at S28 indicate that loading from this site must be considered in determining total stream loading.

Limited temporal data is available from previous studies at these locations. However, several parameters (acidity, discharge, total iron, and pH) have been measured at various times over the past 30 years at S23 and can be compared for temporal variations. The results are shown in Figures 2-5. Because there is limited data available no definitive conclusions of temporal trends can be made. The data does suggest a general increase in iron since 1972, an increase in pH since 1999, and a decrease in acidity since 1991. Discharge was highly variable.

Conclusions:

Based on these results, it is apparent that iron hydroxides are being precipitated into the stream. The major source of iron loading is S23, whereas both S23 and S28 are significant sources of aluminum loading. Based on DO measurements, some discharges appear to originate from deep sources, although this data is not definitive. Because temporal sampling is scattered and irregular, no concrete conclusions can be determined from temporal relationships. Further monitoring and analysis is necessary to adequately access the conditions and design proper treatment facilities.

References:

Gannet Fleming Coddry and Carpenter, Inc., 1972, *Operation Scarlift: Mine Drainage Abatement Measures for the Shamokin Creek Watershed: Report SL-113*, prepared for the PA Department of Environmental Resources.

Greenberg, A.E., Clesceri, L.S., and Eaton, A.D., eds, 1992. Standard Methods for the Examination of Water and Wastewater, American Public Health Association.

Kirby, Carl, 2002. Personal Communication. Bucknell University, Lewisburg, PA.

Table 1. Field parameters.

Sites	Date	T (^{o}C)	pH	Sp. Cond. (mS/cm)	TDS (g/L)	DO (mg/L)	DO (% saturation)	ORP
S28	04/01/02	10.45	3.24	1.012	0.657	11.08	99.6	402.1
S28B	04/01/02	10.09	3.26	0.983	0.639	9.93	88.4	442.7
S28C	04/01/02	12.71	3.91	1.018	0.662	11.15	105.3	155.4
S28D	04/01/02	12.57	6.36	1.033	0.672	12.97	122.2	77.5
S27	04/01/02	10.25	3.31	1.003	0.652	7.18	64.1	187.9
S26	04/01/02	13.31	4.14	0.519	0.337	5.18	49.6	259.7
S25	04/01/02	11.03	3.09	1.182	0.768	7.76	70.8	493.8
S24	04/01/02	11.37	3.10	1.215	0.790	4.39	44.3	483.6
S24B	04/01/02	11.86	6.45	1.060	0.689	10.64	99.4	46.7
S23	04/01/02	11.6	5.77	1.098	0.713	2.21	20.4	89.3

Table 2. Concentrations of metals and acidity (mg/L).

Sites	Acidity (as $CaCO_3$)	Fe (diss)	Al (diss)	Mn (diss)	Fe (tot)	Al (tot)	Mn (tot)	Calculated* acidity, mg/L as $CaCO_3$
S23	36.8	33.2	1.9	8.2	33.2	1.6	8.3	85
S24	84	2.9	1.2	6.1	2.6	1.2	6	64
S25	102	1.9	2.7	6	1.9	2.8	6	69
S26	84	2.5	2.3	6.4	2.2	2.3	6.4	33
S28	84	0.21	5.8	5.4	0.21	5.9	5.4	71

Table 3. Discharge measured from weirs.

Weir	h (in)	gpm
S28	3.25	43
Downstream	9.00	543
S25/26	8.50	471
S23	9.00	543

* calculated from

$$\text{Acidity, mg/L as } CaCO_3 = 50\left(\frac{2\,Fe}{56} + \frac{3\,Al}{27} + \frac{2\,Mn}{55} + 1000 \cdot 10^{-pH}\right)$$

after Hedin et al., 1994, *Passive Treatment of Coal Mine Drainage*, US Bur. Mines Info. Circ. No. 9389, US Dept. of Interior, Washington D.C.

Calculated acidities do not match well with measured acidities, suggesting a problem with either metal concentrations, or more likely, acidity measurements.

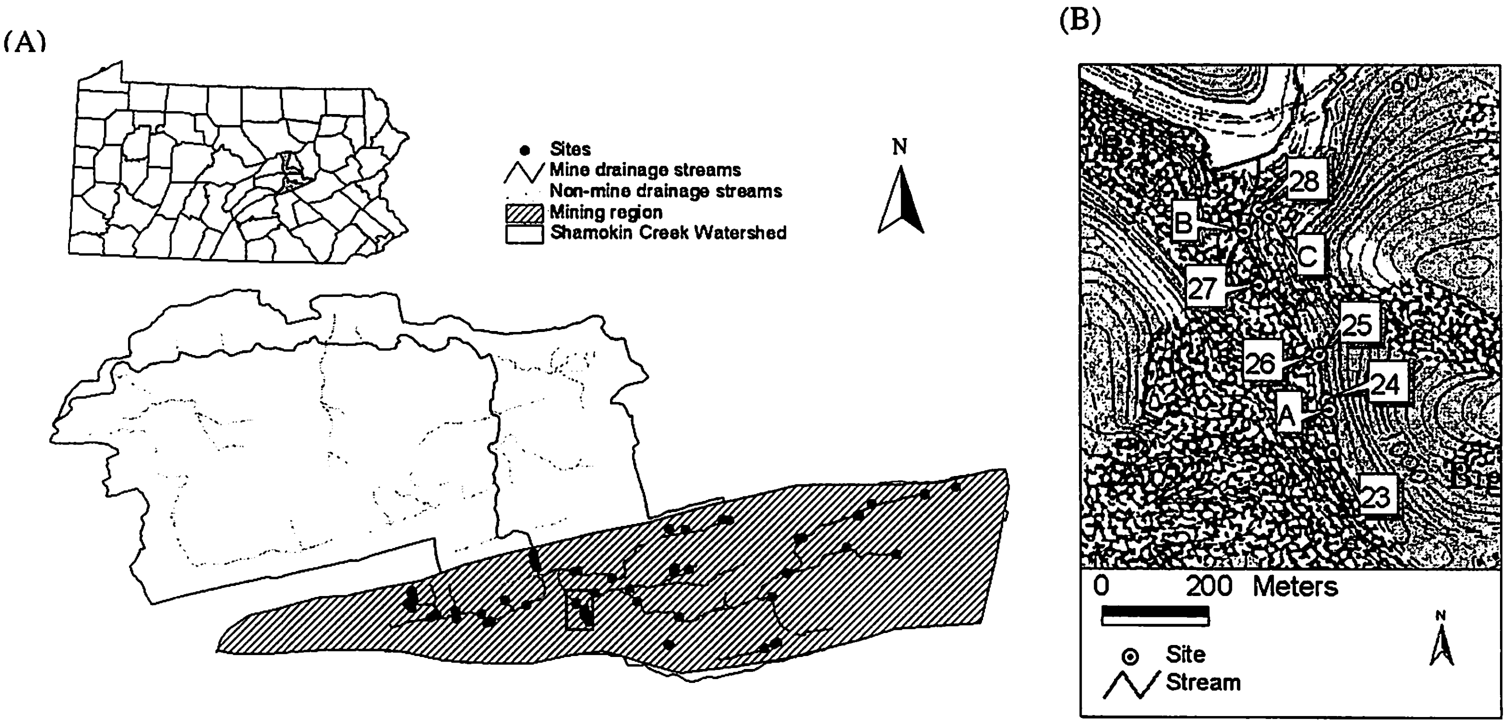

Figure 1. (A) Map of the Shamokin Creek Watershed showing all known AMD discharges. Black box indicates area of Figure 1B. (B) Map showing locations of Scarlift sites 23-28 and three newly discovered sites labeled A-C.

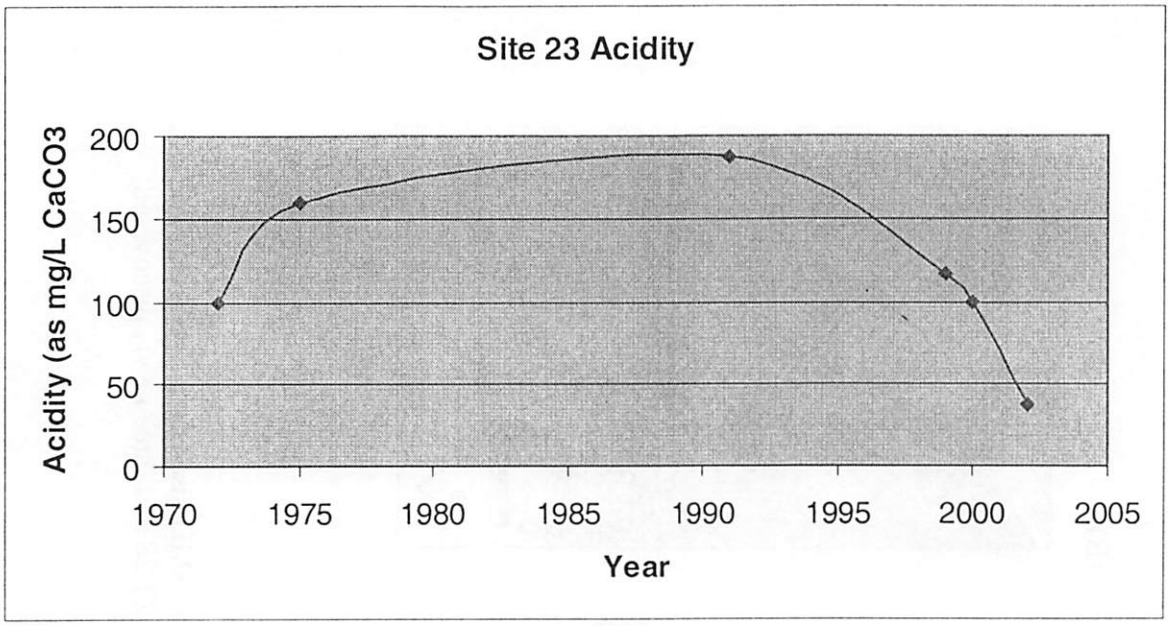

Figure 2 Temporal variations in acidity at Site 23

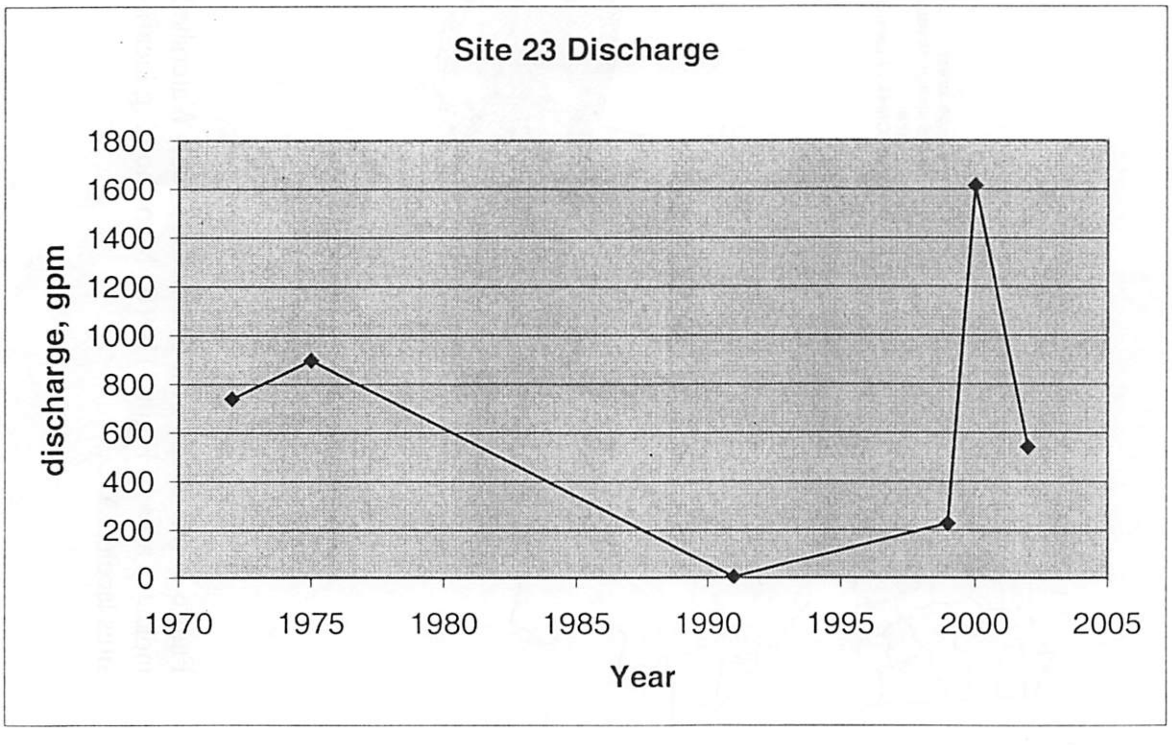

Figure 3 Temporal variations in discharge at Site 23

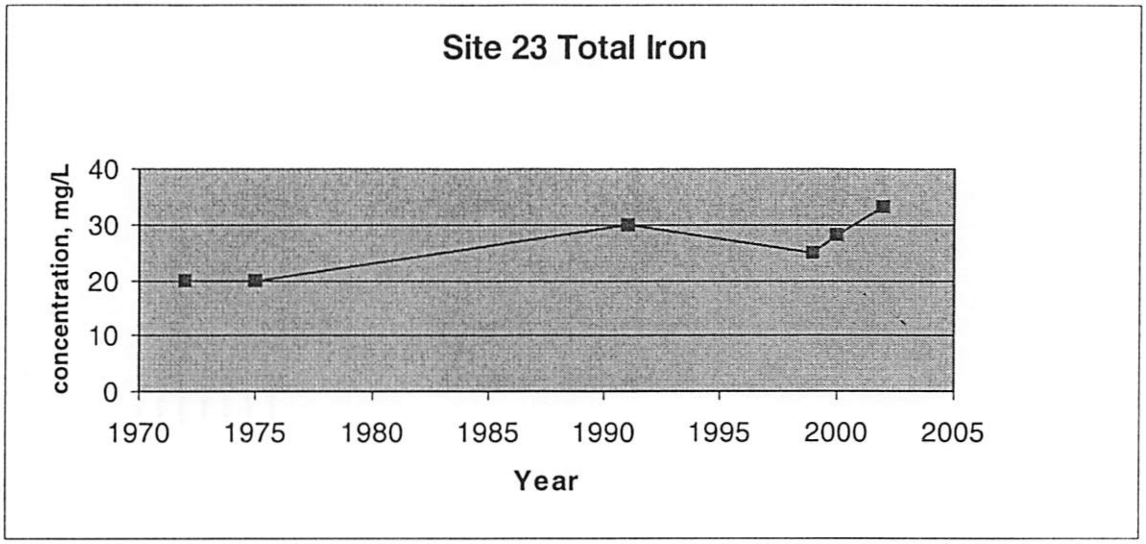

Figure 4 Temporal variations in total iron at Site 23

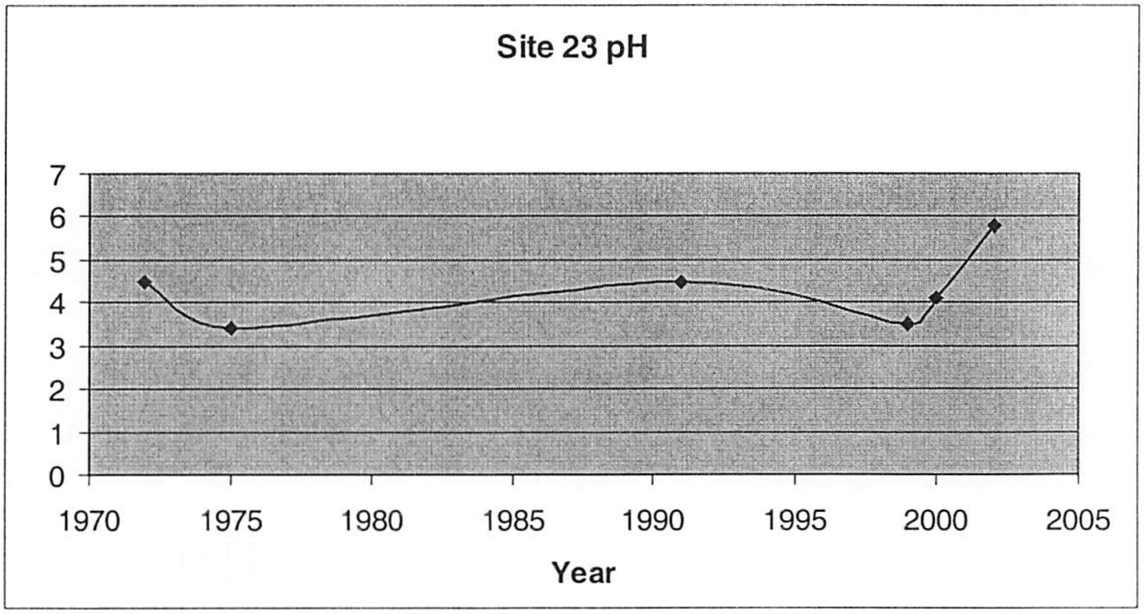

Figure 5 Temporal variations in pH at Site 23