Shamokin Creek Watershed Mine Drainage Overview GEOL 305

Bucknell University

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Carl Kirby

The Shamokin Creek watershed has the highest percentage of its waters degraded by AMD in PA. AMD degrades the aquatic ecosystem and impairs uses of the entire length of Shamokin Creek to its mouth 15 mi downstream from the mined part of the watershed. AMD contamination mainly results from excessive iron deposition on the streambeds or high acidity. Among the mine discharges, there is a wide range of chemistry and flow conditions. Iron concentration ranges from 0 to 90 mg/L, Mn from 0 to 7 mg/L, Al from 0 to 15 mg/L, and pH ranges from 2.8 to 7. For more information, see Cravotta, C. A. III, and Kirby, C. S., 2004, *Effects of Abandoned Coal-Mine Drainage on Streamflow and Water Quality in the Shamokin Creek Basin, Northumberland and Columbia Counties, Pennsylvania, 1999-2001*, US Geological Survey Water-Resources Investigations Report 03-4311.

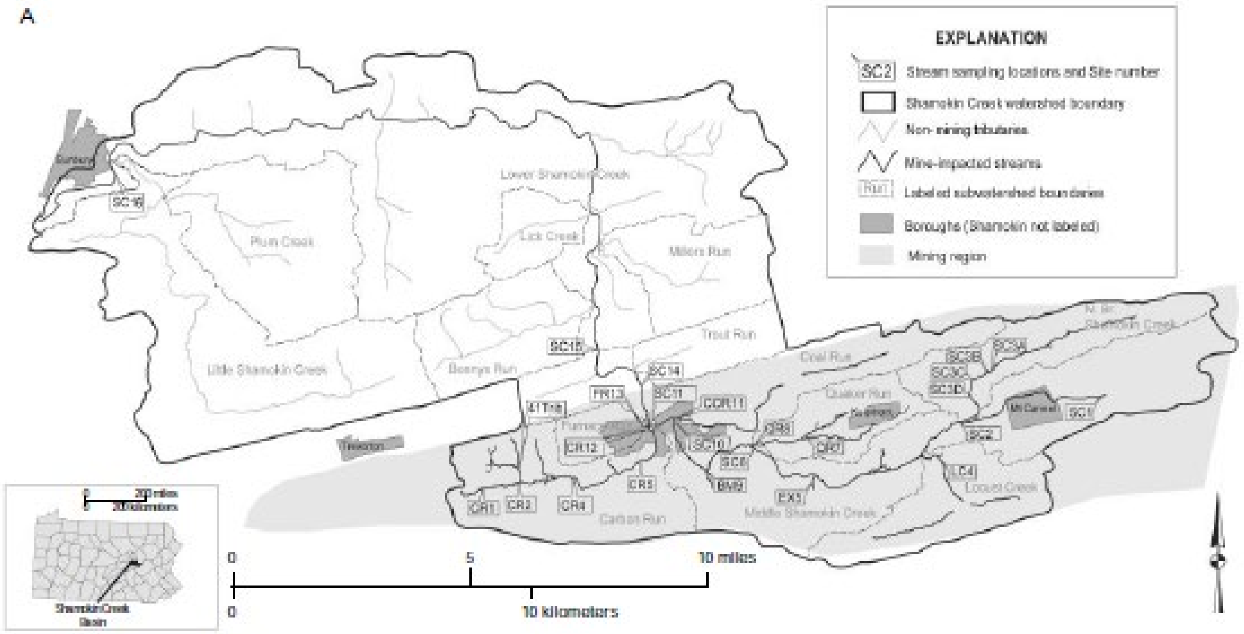
U.S. Department of the Interior
U.S. Geological Survey

Effects of Abandoned Coal-Mine Drainage on Streamflow and Water Quality in the Shamokin Creek Basin, Northumberland and Columbia Counties, Pennsylvania, 1999-2001

by Charles A. Cravotta III and Carl S. Kirby

Water-Resources Investigations Report 03-4311

Shamokin Creek Watershed & Mining Region of Watershed



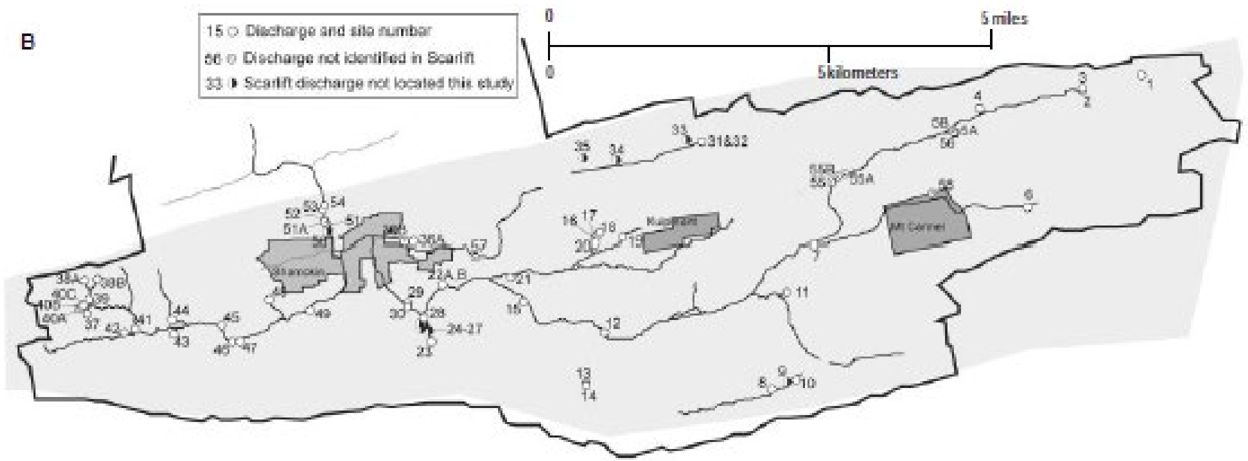


Figure 1. Shamokin Creek Basin, Pa., showing locations of municipalities, coalfield, named streams, and corresponding streamwater and mine drainage monitoring network. (A) Entire Shamokin Creek Basin, (B) Upper Shamokin Creek Basin.

12 Stream sites sampled this study

> 50 “legally abandoned” deep mine or spoils pile discharges of AMD; no responsible party to clean up

USGS Study:

- pH
- Redox
- DO
- flowrates
- Alk, Hot Acidity (= net acidity)
- Samples for metals
- Calc. metal and acidity loading
- Electrofishing 2 sites
- Compare to historical data
- Suggestions for treatment

4 treatment systems
1 working well (Site 15)

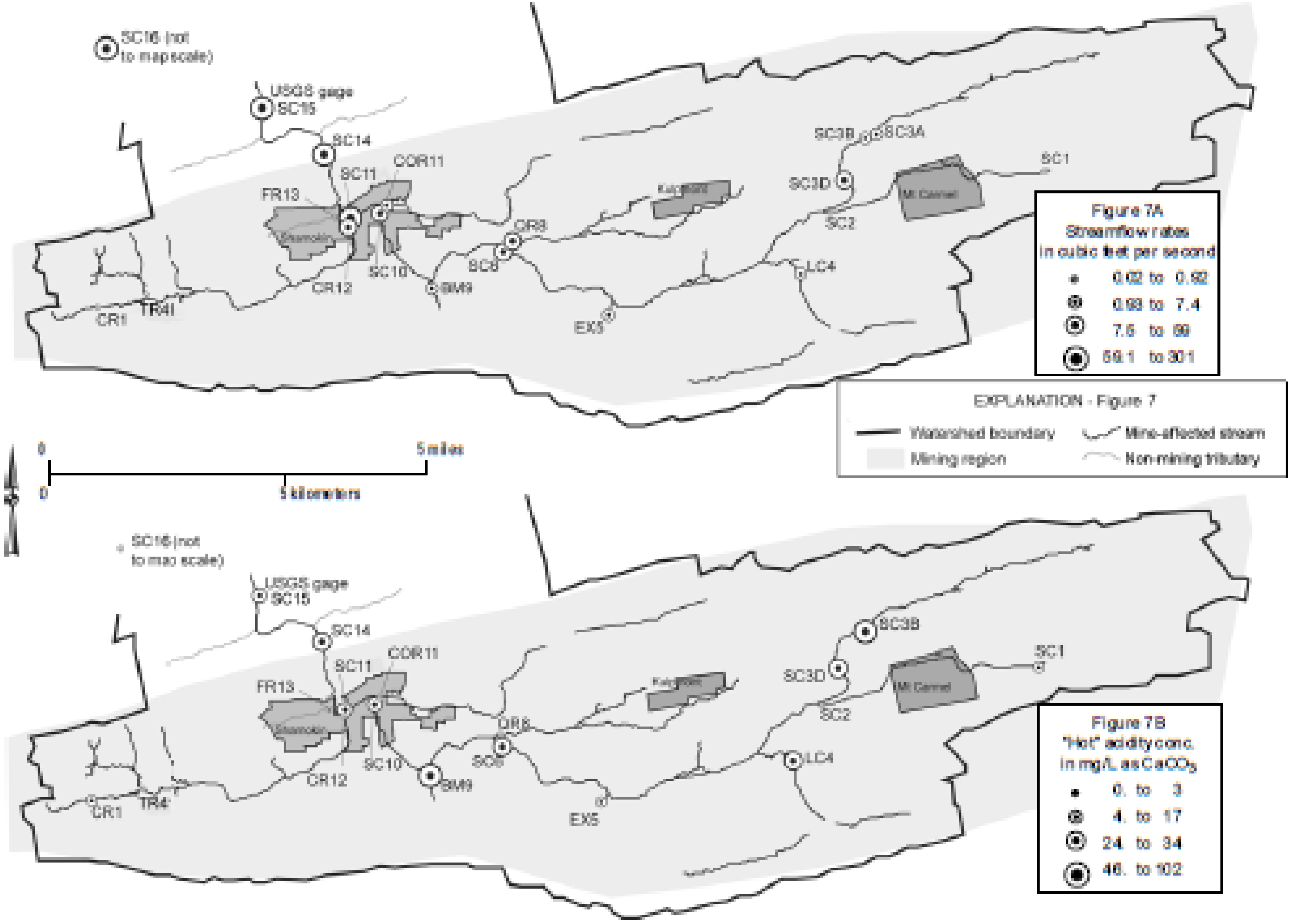


Figure 7. Maps of Shamokin Creek, Pennsylvania, showing: (A) streamflow in cubic feet per second, (B) acidity, (C) dissolved sulfate, (D) dissolved iron, (E) dissolved manganese, and (F) dissolved aluminum in the mainstem and tributaries, March 2000.

Historical (blue) and this study (black) flowrates at discontinued USGS gaging station

Two of the study flowrates were > 1 std. dev. below the 50-year average, so caution must be used when considering treatment based on mass loading.

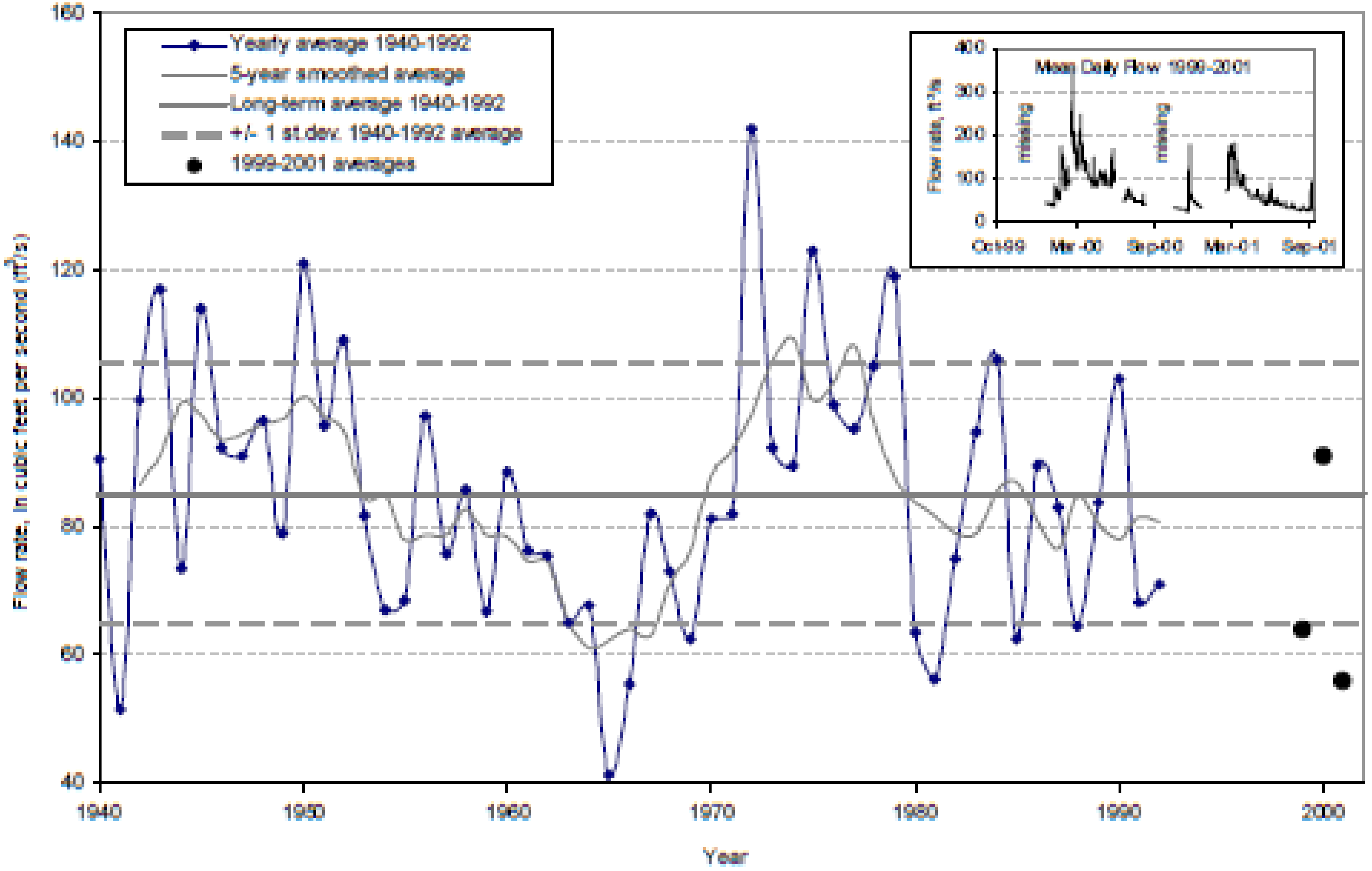


Figure 8. Historical (1940-1992) and recent (1999-2001) streamflow data for Shamokin Creek near Shamokin, Pennsylvania (SC15; USGS station 01554500). Daily mean values were used to generate the hydrographs and to compute the mean and standard deviation (st.dev.) of the long-term average streamflow.

Ranked remediation strategies

Table 7. Rankings and possible remedial alternatives for abandoned mine drainage (AMD) in Shamokin Creek Basin, Pennsylvania

[AMD rank based on instantaneous dissolved metals, net-alkalinity, or sulfate loading during March 14-16, 2000. Remedial alternatives identified in order of preference; any treatment design would require additional data and specific analysis; VFCW, vertical-flow compost wetland; ALD, anoxic limestone drain; OLD, flushable oxic limestone drain; OLC, open limestone channel; ft^3/s, cubic feet per second; L/min, liters per minute; mg/L, milligrams per liter; --, no data; =, equal to; <, less than; ≤, less than or equal to; >, greater than; ≥, greater than or equal to. *Discharges ranked 43rd are not distinguished from one another by rank because of insufficient data.

SCRA Site Identification Number[a]	AMD Metals Rank[b]	Net Alkalinity Rank	Sulfate Rank	Percentage Dissolved Fe, Al, and Mn load	Cumulative Percentage Fe, Al, and Mn load	Principal Characteristics[c]	Remedial Alternatives[d]: Remove Culm bank	VFCW	ALD	OLD	OLC	Aerobic Pond(s)	Active Treatment	Comments	Wetland Area, acres[e]
19	1	4	1	23.5	23.5	Very large flow; high Fe, Mn; moderate Al; net acidic; suboxic.							1	Passive methods difficult because of physical layout. Consider active treatment using heterogeneous catalysis of iron oxidation by ferric hydroxide. Additional alkalinity needed to balance acidity and facilitate iron oxidation. Potentially could be treated passively south of Route 61.	17.8
12	2	2	3	17.1	40.6	Very large flow; high Fe, Mn; moderate Al; net acidic; oxic.						?	?	Consider *in-situ* alkaline addition to present pond (requires introduction of dissolved oxygen into strip pit) or active treatment. PaDEP BAMR considering filling pit to eliminate physical hazard at County's request. (Additional water chemistry and survey data available from C. Kirby in Dept. of Geology, Bucknell University.)	13.1
49	3	43*	2	12.6	53.2	Large flow; high Fe, Mn; moderate Al; net acidic?; anoxic.			1			1	2	May be able to introduce limestone into present pump slope or mine pool through borehole; water must be routed across Carbon Run to ponds. Consider active treatment with no alkaline addition, but using heterogeneous catalysis of iron oxidation by ferric hydroxide. Diminished source of metals during low-flow conditions.	10.0
53	4	1	4	12.3	65.5	Very large flow; very high Fe, Mn; very high Al; net		?				?	1	Discharges from culvert under Route 61 immediately into Shamokin Creek; no area for treatment unless discharge relocated. Large flow, high concentrations of	8.8

Aerial Pictures – headwaters toward mouth


Scarlift Site 1, 2, 3
Origin of N. Br.
Shamokin Creek
waste rock piles
oxidizing environment
pH 3
high Fe, Mn, Al
clear water


Scarlift Site 1, 2, 3
Origin of N. Br.
Shamokin Creek
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clear water

Headwaters – surface mine discharges

Brad Jordan at Scarlift Site 2 discharge
From a large aerated spoils pile

- pH 3
- high Fe, Al, Mn
- net acidic
- clear water

Headwaters – surface mine & deep mine discharges

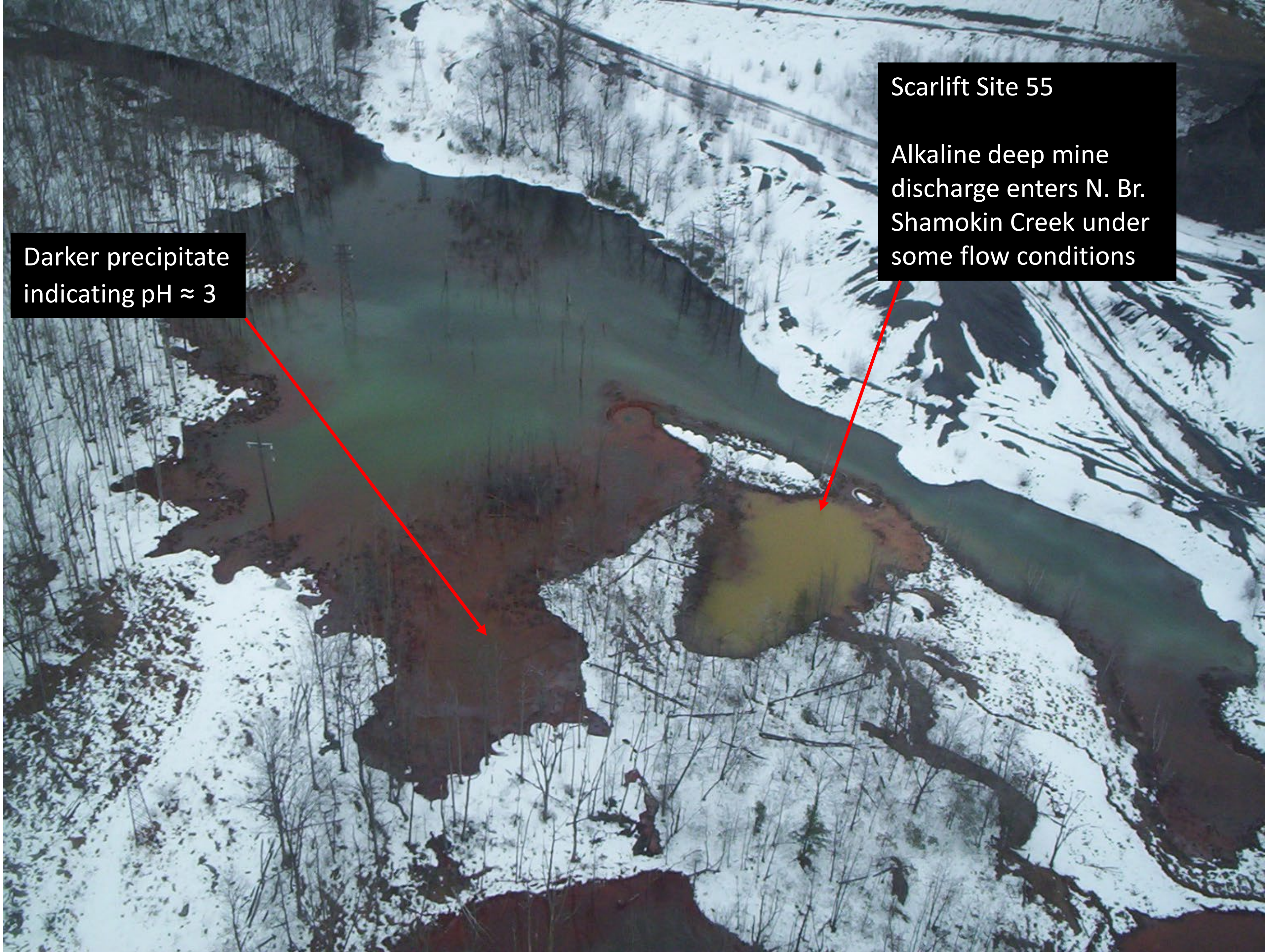
Scarlift Site 4
Luxuriant algae growth – not much living to eat it
From deep mine & spoils pile

- pH 3.5
- high Fe, Al, Mn
- net acidic
- clear water

Scarlift Site 4
Origin of N. Br. Shamokin Creek

- waste rock piles
- mixed oxidizing/reducing environment
- pH 3.7
- High Fe, Mn, Al


Scarlift Site 5
N. Br. Shamokin Creek
waste rock piles
Intermediate redox
pH 4
High Fe, Mn, Al
Shamokin Creek


Scarlift Site 55
Alkaline deep mine discharge enters N. Br. Shamokin Creek under some flow conditions
Darker precipitate indicating pH ≈ 3

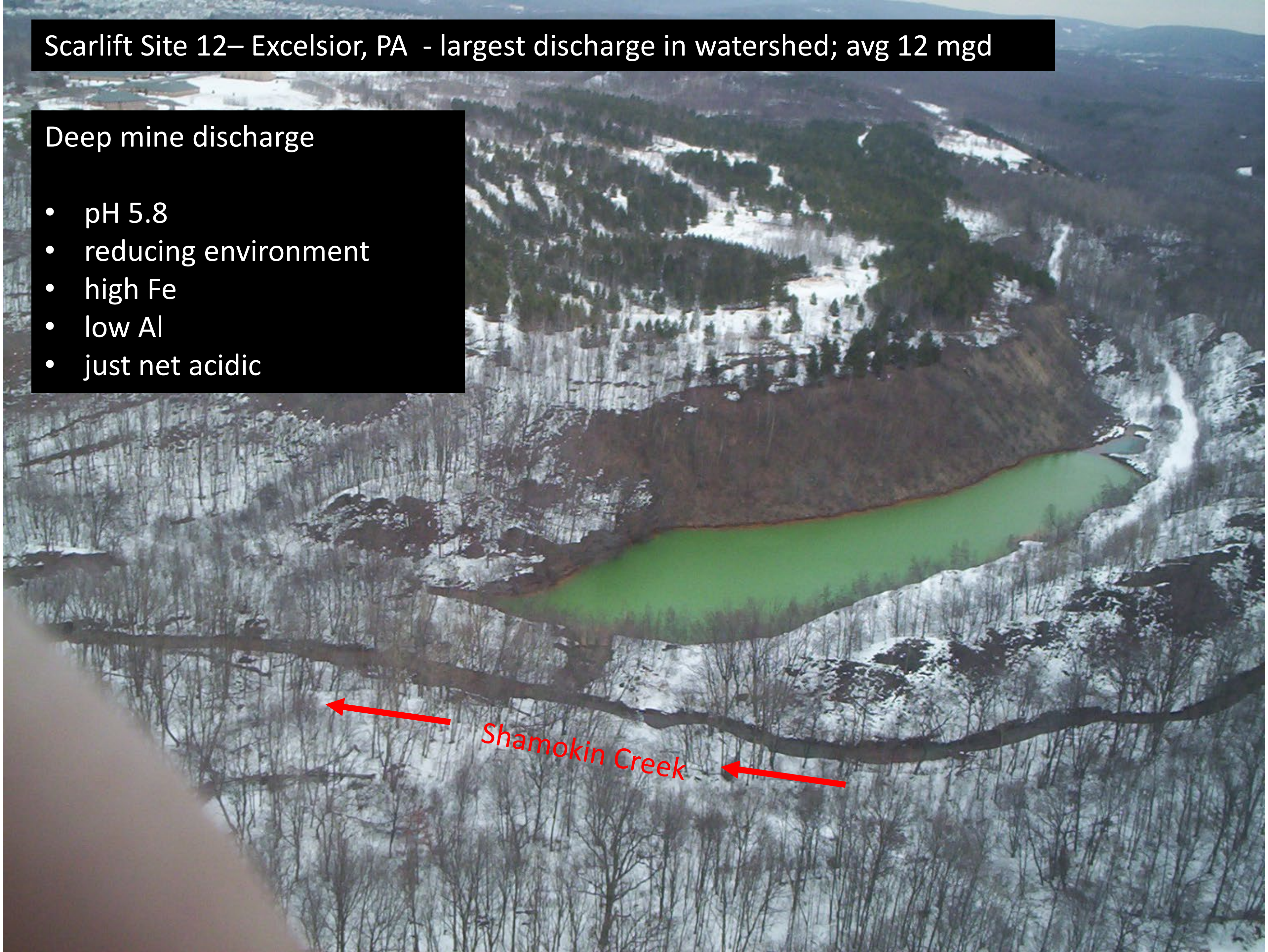
Waste rock piles produce

- oxidizing conditions
- low pH
- high metals

Scarlift Site 12– Excelsior, PA - largest discharge in watershed; avg 12 mgd

Deep mine discharge

- pH 5.8
- reducing environment
- high Fe
- low Al
- just net acidic




Scarlift Site 23
• pH 3.5
• high Fe, Al
• net acidic

Scarlift Site 21 – Ranshaw, PA - deep mine discharge

15 ft down into the borehole

Site 21 discharge flowing into Carbon Run

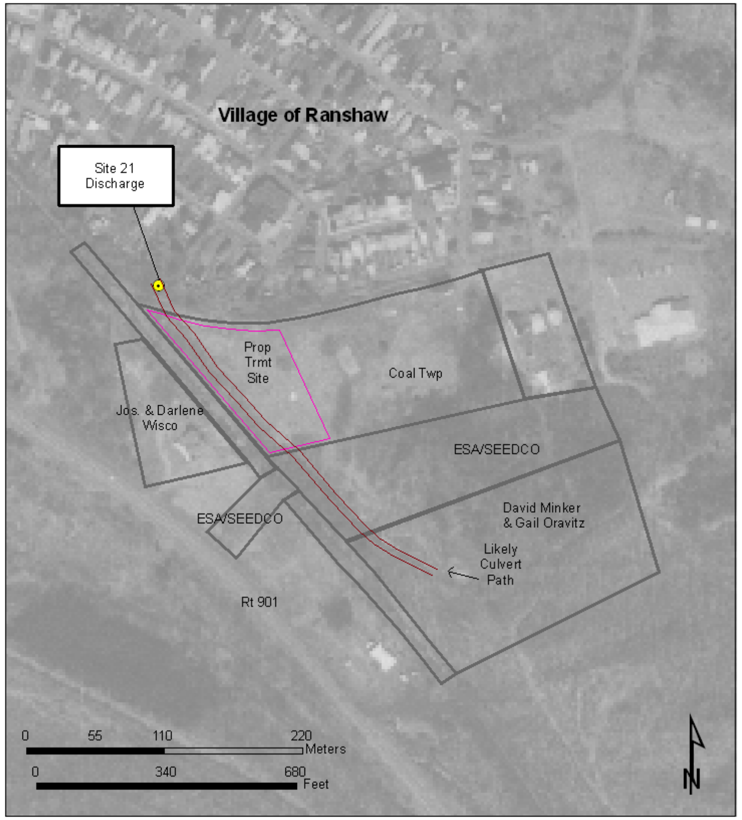
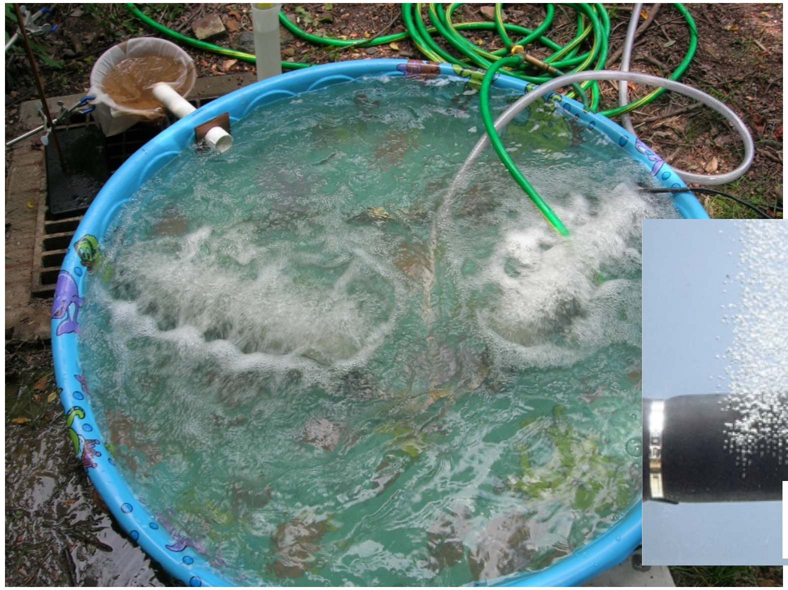


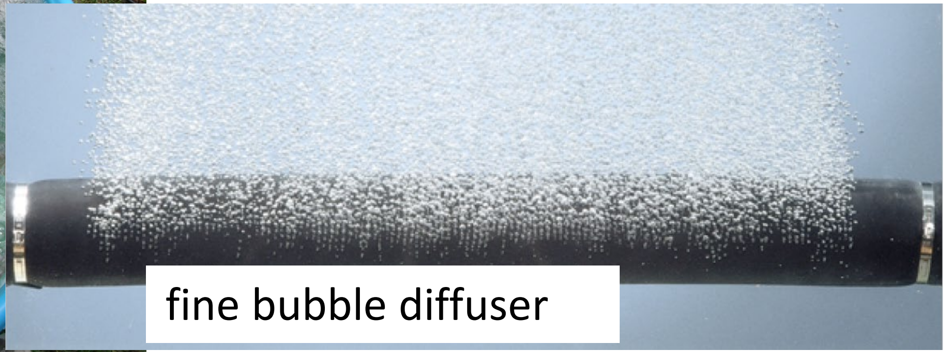
Figure 1. Aerial photograph with land ownsership near proposed Site 21 treament.

- 0.5 cfs
- pH 6.1
- high Fe
- low Al
- net alkaline

Scarlift Site 21 – Ranshaw, PA – Fe(II) oxidation rate experiments – stage 2

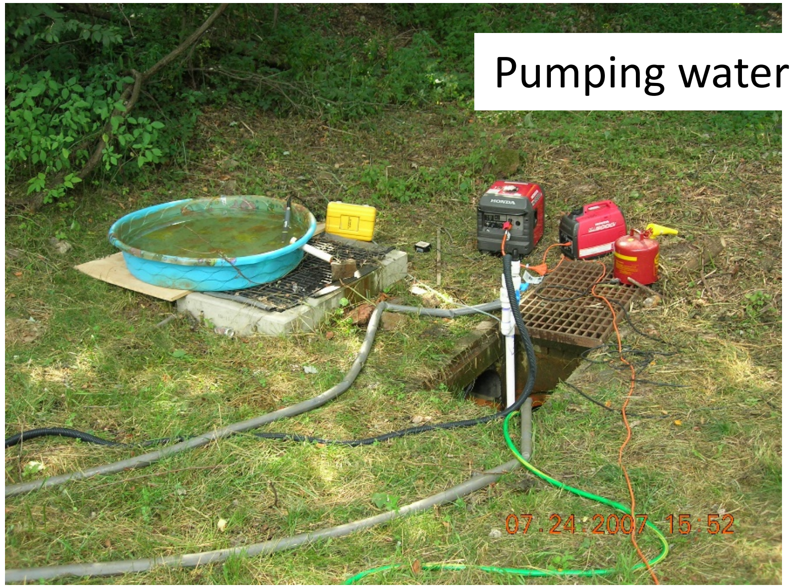
Could be treated with aeration alone; would require pumping and area to capture solids; no limestone needed





Scarlift Site 21 – Ranshaw, PA – Fe(II) oxidation rate experiments – stage 3

fine bubble diffuser



Pumping water to reactor

Scarlift Site 19

Scarlift Site 20 6/27/2006 flooding

SCRA-installed weirs

Scarlift Site 49 (pump slope) - Sept 9, 2011

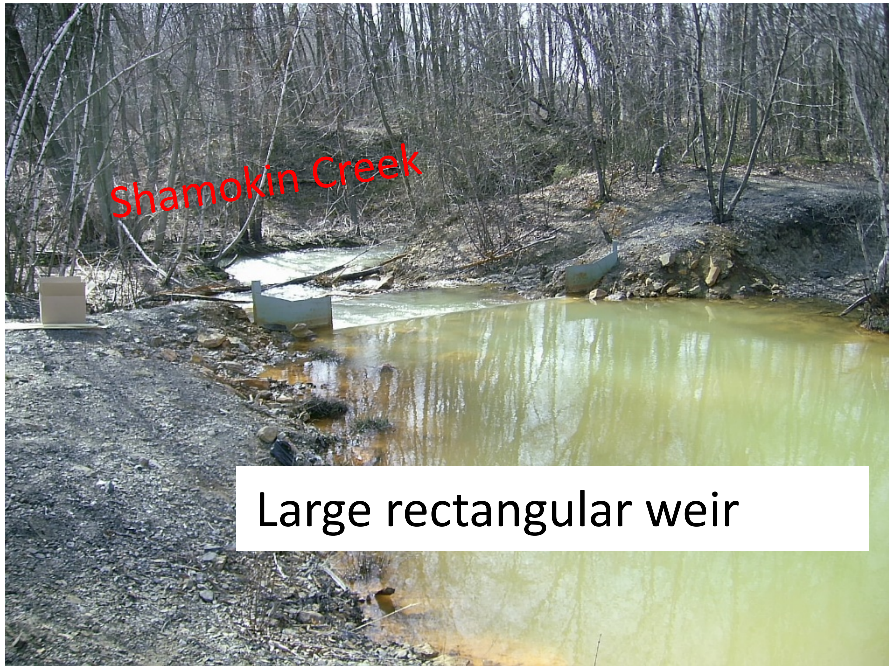
Scarlift Site 36 – 0 (usually) to 2 mgd flow
Double V-notch weir for flowrate measurement

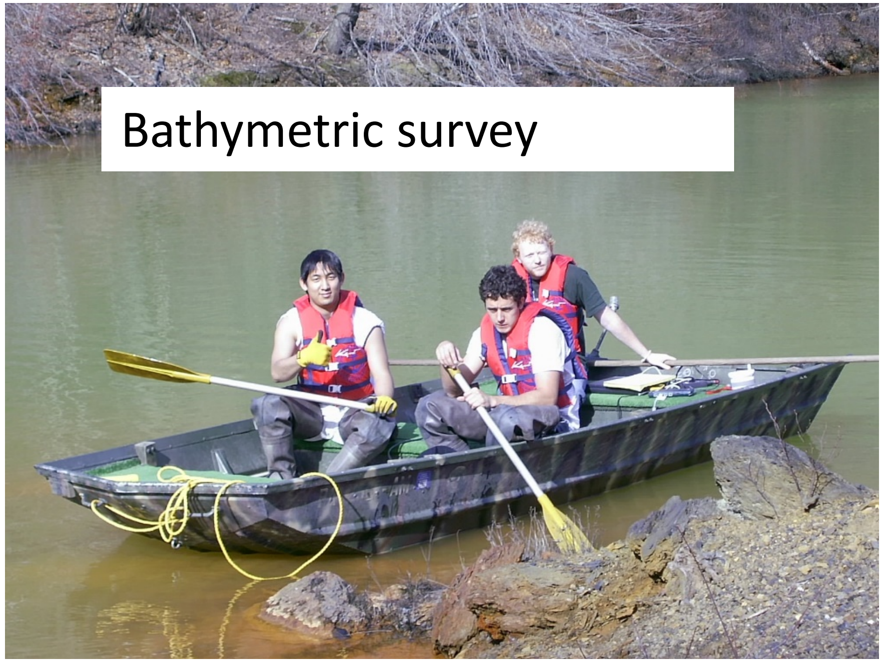
Scarlift Site 23 – Ranshaw, PA

6/27/2006 flooding

Scarlift Site 49 – pump slope

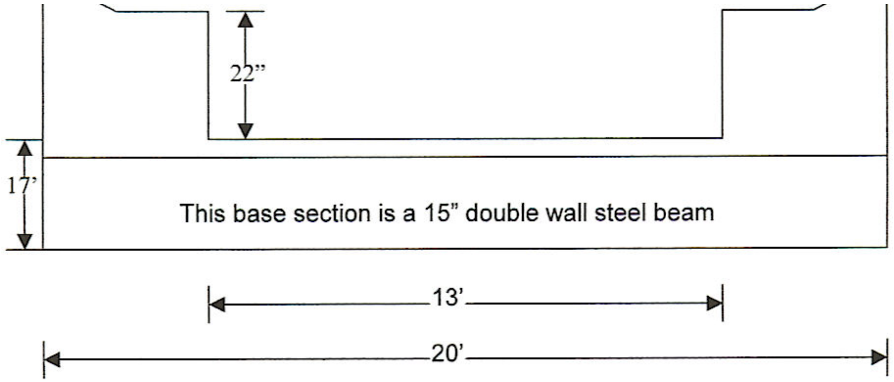
Scarlift Site 12– Excelsior, PA - largest discharge in watershed; avg 12 mgd





- 7 cfs
- pH 5.8
- reducing conditions
- high Fe
- low Al
- just net acidic

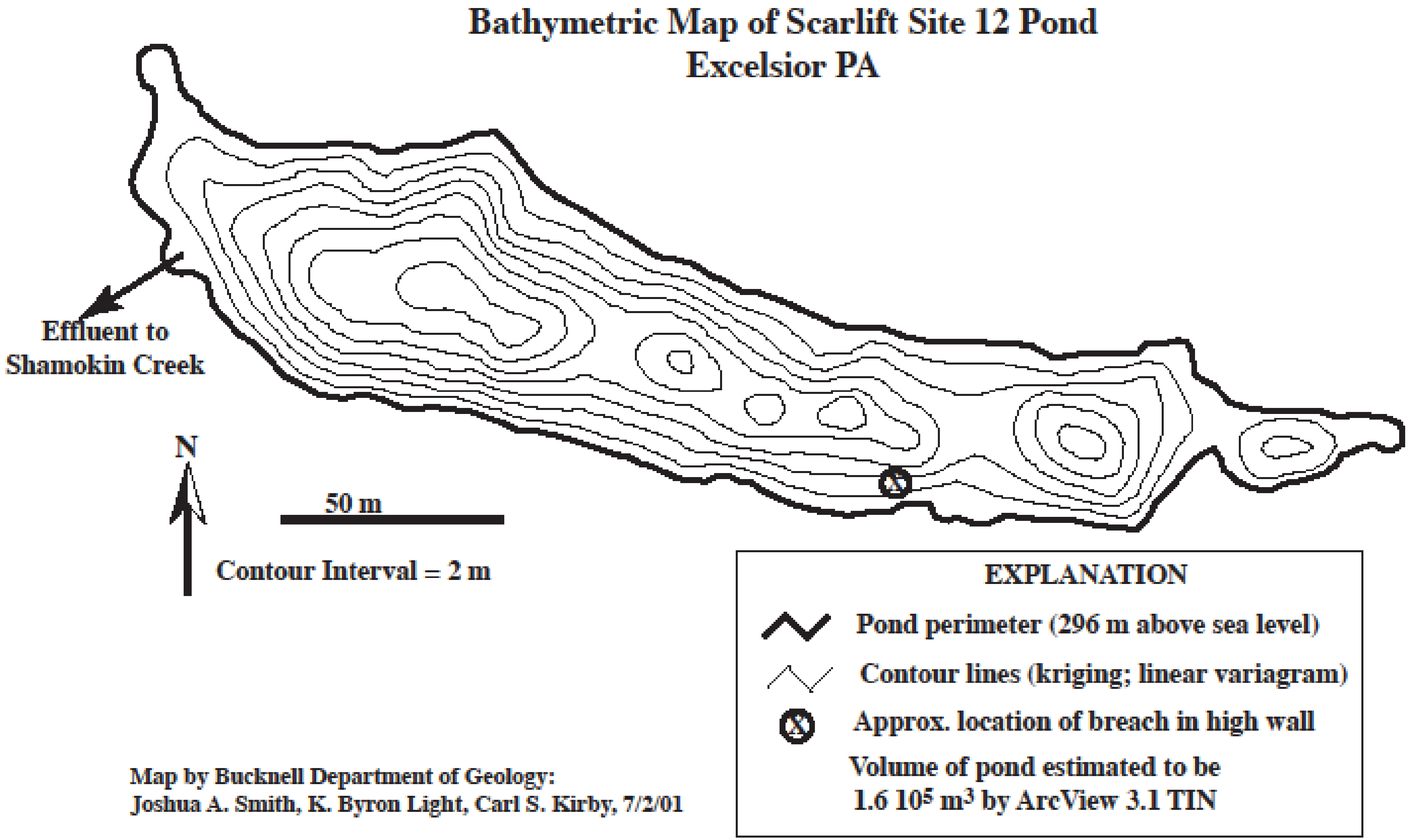
Scarlift Site 12– Excelsior, PA - largest discharge in watershed; avg 12 mgd



The lip of the weir is a 2" x ¼" angle iron that was ground to a sharper point.

Site 12 (Excelsior) discharge weir

Scarlift Site 12– Excelsior, PA - largest discharge in watershed; avg 12 mgd



Scarlift Site 51 just upstream of Shamokin Creek near spoils pile north of Shamokin

- 1 cfs
- pH 5
- high Fe, Al, Mn
- net acidic

Scarlift Site 23 – Double v-notch weir replacing damaged upstream wooden weir

Metal V-notch weir damaged 6/27/06 flood

Scarlift Site 49 (pump slope leading to deep mine)
just upstream of Carbon Run

Scarlift Site 49 (pump slope) - building a rectangular weir for flowrate

Ashland Borehole discharge – south of Shamokin Creek watershed – quite artesian

Headwaters area

Remining (removal of spoils to burn producing electricity) removes pyrtitic material, helps prevent AMD

Shamokin Creek 10 miles downstream of the last mine discharge. Color changes often from clear to red depending on rainfall in particular parts of the watershed. The pH ranges from 4 to 6.

Site 42 treatment system Vertical flow wetland
Now that’s dedication to research!

USGS electrofishing Shamokin Creek 2002
downstream of the last mine discharge

6 species, several individuals

Catfish and suckers

Shamokin Creek Restoration Alliance
Typical of watershed groups, about 200 members, but about 2 to 5 people do most of the volunteer work

Shamokin Creek Restoration Alliance
SCRA