Short title: **Community-Based Research**

An unpublished paper by Dr. Ben Stout and Janet Keating, as submitted to Appalachian Studies Association in 2012.

Abstract:

Collaboration between citizens and scientists has produced results ranging from getting fresh water supplies into impacted communities to advancing environmental legislation at the state level. Our goal is to encourage freshwater scientists to partner with community organizations and to address their needs for quality scientific evidence. Community-based participatory research is a very powerful tool for advancing environmental improvement and for producing good science. Chief advantages for scientists are 1) providing access to individual properties (water wells, springs, and streams), and 2) justification for studies that improve the competitiveness of proposal submissions to funding agencies and foundations. Primary advantages for environmental organizations are 1) providing high quality scientific data as well as expert testimony about pressing environmental concerns, supporting and underscoring citizens' claims that changes are needed, and 2) highlighting problem recognition and enhancing the competitiveness of proposals by collaborating with field and laboratory professionals, 3) developing citizen leaders who become the primary advocates for environmental policy changes, and 4) garnering significant media attention to issues, which increases the likelihood that decision-makers will act on behalf of citizens. In this paper we share experiences including successes and challenges encountered during their collaborative work with the EPA supported Community Action for a Renewed Environment Appalachian CARE Communities.

Key words: community, research, water quality, coal slurry, well water, underground injection.

Introduction

At a U.S. EPA's Community Action for a Renewed Environment (EPA CARE) National Training Workshop, Dr. Manuel Pastor (2010) made the comment in his keynote address that "Community-based participatory research produces good science." We shared that experience as part of the EPA CARE program and followed the community-based participatory research methods developed by Dr. Pastor and others (Israel, et al, 2005). Our partnerships between citizens and scientists led to community improvements and policy change.

Our partnerships grew out of an unlikely scenario. In 2004 we hosted a community meeting at the fire hall in Delbarton, West Virginia for the purpose of training citizens how to use the web-based Coal Impoundment Location and Information System (CILIS, 2013). Following a series of demonstrations and expert speakers we opened the floor to questions. Of the 20 questions asked, 19 of them were, surprisingly and essentially, "what is wrong with our water?"

Unable to use our existing federal funding to address water issues, we sought help from foundations (see CILIS, 2005). With foundation resources we were able to work with community members to sample their wells, springs, and streams to determine the source of contamination (Stout & Papillo, 2004). The damning results of the preliminary study led the Agency for Toxic Substances and Disease Registry to revise a previous finding of "no public health hazard" (ATSDR, 2004) to "Public Health Hazard for the past, present, and future"

(ATSDR, 2005). The previous ATSDR finding was based on data from a 1995 study (WV DEP, 1995). The citizens testified that their water had turned bad over the past decade.

We didn't realize at that time that we were engaging in community-based participatory research. In retrospect, we accomplished something that no regulatory agency was designed to do: we worked together with citizens in their homes to identify and solve a community-wide problem. The purpose of this paper is to describe how a partnership between citizens and scientists led to decision-making based on science that eventually led to changes in regulatory policy.

Methods

We attended our first U.S. EPA Community Action for a Renewed Environment (CARE) national training workshop in October, 2007. Attending from Wheeling Jesuit University (WJU) were the Principal Investigator, co-PI, and accountant. Also attending was a community organizer from Ohio Valley Environmental Coalition (OVEC), a partner in our EPA CARE grant. In addition to workshops and training sessions, we met with our EPA program officer and accountants. We learned about the community-based participatory research model from EPA program administrators and from the shared experiences of attendees from the other 25 EPA CARE communities.

Our early efforts involved hosting community meetings at local churches, colleges, volunteer fire departments, and residences in small isolated rural communities in southern West Virginia, USA (Figure 1). We asked citizens to list any and all of their environmental concerns. We categorized their concerns by media: air, water, and soil. We returned to the communities and asked them to prioritize their concerns. OVEC works under the assumption that community members are true "experts" and should be asked to prioritize concerns. Prioritization was done by the citizens with both WJU and OVEC acting as facilitators. The facilitators asked only that priority be given to the concerns that were a) most likely to impact community and environmental health, and b) likely to be addressed in a practical sense. The process we employed is known as the "CARE Roadmap Strategy" (U.S. EPA, June, 2008).

We used community-prioritized concerns to identify the type of expertise needed to solve the citizen's most pressing concerns. We developed relationships with academic and government researchers one at a time by first visiting with them followed by inviting them to meet with our communities. We later linked researchers with community members at follow-up meetings designed to develop action plans for improving the environment and community health. Four years later we hosted an "Appalachian Summit" (EKU, 2011) where we reconvened 56 scientists and community leaders for the purpose of developing a more comprehensive action plan (Russell & Ashley, 2011) to move beyond our EPA CARE funding cycle.

During the CARE process we also conducted studies using standard methods (Clesceri, *et al*, 1999) for analyzing water and the liquid constituents of coal slurry. In approaching community household water supplies we first conducted preliminary studies (*e.g.* Stout & Papillo, 2004). If conditions warranted, we approached foundations for funding more detailed and inclusive house-to-house studies (*e.g.* CILIS, 2005). We used those results to intrigue and engage scientists from the multiple disciplines that were necessary to identify a complex environmental and community health problem.

Results

Community needs

In 2008 we hosted 7 community meetings in southern West Virginia (Figure 1) attended by an average of 19 citizens. The meetings were planned and discussions were facilitated by an OVEC community organizer. Interestingly, children were also in attendance at 5 of the meetings. No research collaborators attended community meetings early in the CARE Roadmap process.

At five community meetings 125 environment and health concerns were expressed. Water quality was the environmental media of primary concern (Figure 2). Soils were of lesser concern but often expressed because of residents' knowledge of midnight dumping and illegal landfills. Health and safety concerns were often accompanied by concerns for air and water pollution, particularly from coal slurry and dust associated with blasting at large area surface mines. Economic concerns were rarely expressed.

The most pressing concern expressed by communities was for their household water supplies. Most of the homes in the rural, widely separated communities used groundwater from deep wells, shallow dug wells, and springs. Concerns about surface water were often related to "blackwater" events involving the illegal release of coal slurry into local rivers and streams. The second most pressing concern was the chemical makeup of coal slurry.

The Appalachian CARE community leadership convened a meeting with scientific experts and community leaders at a centralized location. After hearing from the experts the citizens confirmed their most pressing environmental and health concerns. Three questions emerged as the greatest concerns where practical solutions for improvement might be applied: 1) what is the quality of the water supply, 2) what are the chemical constituents of coal slurry, and 3) are these chemicals harmful to human health?

In seeking further expertise to answer these questions both OVEC and WJU met separately with researchers from U.S. Geological Survey, Virginia Tech, Eastern Kentucky University, West Virginia University, and Marshall University. The areas of expertise sought included organic chemistry, community health, hydrology, sociology, geography, and environmental engineering. From these efforts we built a partnership of citizens and scientists working closely together to solve problems.

<u>Water quality studies</u>

A preliminary study was conducted in response to citizens concerns at the Delbarton meeting. Primary drinking water standards (U.S. EPA, 2013) were exceeded 13 times in samples from 15 private wells near Williamson, West Virginia (Stout & Papillo, 2004). The lead standard (15ppb) was exceeded in over one half of the wells. Primary standards were also exceeded for barium, beryllium, and selenium. Only one well met secondary drinking water standards.

A repeat sampling of 5 wells was conducted during high flow conditions based on the Williamson U.S. Geological Survey Tug Fork River gauging station (Table 1). Citizens termed the high flow condition a "blackwater" event given the color of the water in their wells. Whereas arsenic was detecting in one well during low flow, arsenic was detected in 4 of the 5 wells during high flow. On the other hand vanadium (unregulated) had been detected in 3 of the 5 wells during low flow, but was below detection limits during high flow. Other changes in elemental composition were likewise baffling.

News of the findings and subsequent testimony of the citizens in West Virginia state legislative hearings (Sludge Safety Project, 2006) lead to 1) the community being buoyed to the top of the list for obtaining funding for a new municipal water supply, 2) the researchers obtaining additional funding for a more detailed study, and 3) other communities coming forward to ask for the support.

Coal slurry analysis

The community's number 2 concern was "what is in coal slurry?" Collaborative scientists were unable to locate any reliable information on the chemical constituents of coal slurry, the volumes of coal slurry being disposed of, or the location of coal slurry impoundments and underground injection systems. Communities, consisting of volunteers, interns, and hourly staff went through underground injection permit files to ascertain where coal slurry was being injected underground in West Virginia (Figure 3). A total of 649 injection points were "known, suspected, or proposed" according to 2008 permit files (Sludge Safety Project, 2009b).

Collaborative scientists calculated the total amount, 110,770,367,742 gallons, of coal slurry permitted in 2008 in the 126 active coal slurry impoundments in West Virginia listed on the Coal Impoundment Location and Information System (CILIS, 2008a). They also used a database of well-documented coal slurry impoundment spills that occurred between 1974 and 2008 (CILIS, 2008b) and from this tallied 666,992,700 gallons spilled into waters of the U.S. from the 40 of the 65 spills where spill volumes had been estimated by regulatory agencies.

Scientists following the recommendations of the National Academy of Scientists (NAS, 2002) collected coal slurry samples from a variety of active and abandoned operations and analyzed heavy metal concentrations in the liquid fraction of 19 coal slurry samples from a variety of sources (Table 2). Some of the samples were split samples analyzed by both the West Virginia Department of Environmental Protection (2008) and by university researcher collaborators (Sludge Safety Project, 2009a). To our knowledge Table 2 represents the first published data on heavy metals in the liquid fraction of coal slurry.

According to the provisions of the Groundwater Protection Act, coal slurry must meet drinking water standards in order to be legally discharged underground. Eight of the 19 samples (42%) did not meet primary drinking water standards. Standards for antimony, arsenic beryllium, lead and selenium were exceeded in at least one sample, with antimony (4) and lead (3) most frequently exceeded. Standards for barium, chromium, and mercury were never exceeded.

Two (9%) of the 19 samples met both primary and secondary drinking water standards. Manganese most frequently exceeded the secondary standard (53%), followed by aluminum (26%) and iron (21%). Copper, silver, and zinc never exceeded the secondary standard. Clearly, coal slurry does not consistently meet the primary drinking water standards necessary to be legally injected underground.

Discussion

Blackwater events

In retrospect it is obvious what citizens mean by "blackwater" events. At the first meeting in Delbarton the black and red stained water carried by citizens in Mason jars is the result of excessive levels of iron and manganese in their well water. Blackwater events in major river systems are undoubtedly due to high levels of manganese and suspended clay particles from coal cleaning facilities located on the floodplains of the rivers. The greatest danger, however, is for the presence of elements of primary concern in that they have known consequences for human and environmental health. When dissolved in water, those elements are odorless, colorless, and tasteless. Thus the citizens are unaware of the presence of the most dangerous elements in their drinking water until less harmfulelements such as iron and manganese accompany them. This represents a significant human exposure pathway that remains understudied.

Improvement strategy

Testimony by 3 collaborative researchers during West Virginia state legislative hearings (Sludge Safety Project, 2006; 2009a; 2009c) confirmed the presence of heavy metals in water samples taken from communities and supported citizens' testimony that coal slurry was seeping into their drinking water. Citizens became energized and engaged because researchers were acting on community concerns and supporting their claims as they pressed for in-depth studies of the impacts of coal sludge (slurry) on the environment and human health. Buoyed by water quality analysis (Stout & Papillo, 2004) and the support of another CARE collaborator, the Sludge Safety Project, citizens continued to press their state representatives for replacement water (Sludge Safety Project, 2013). Three such systems were enabled by the citizen/scientist collaborative Appalachian CARE communities. The condition of well water in the community of Prenter, West Virginia brought national attention to the issues (Duhigg, 2009).

Emboldened by their success in 2007, the Sludge Safety Project argued for and achieved passage of Senate Continuing Resolution 15 (SCR 15, 2007). The resolution mandated "a comprehensive environmental study of the injection of coal preparation plant slurry into underground mines" (WV DEP, 2008), and a community health assessment (Ducatman, et al, 2010). Following testimony by both citizens and scientists no new permits for underground injection of coal slurry in West Virginia have been issued since 2007. Importantly, the West Virginia Department of Environmental Protection issued a moratorium on new underground injection permits for coal slurry which continues to remain in effect (WSAZTV, 2009).

Prioritized lists of citizens' environment and health concerns are powerful tools for leveraging researcher collaborations and funding. The 28 academic and government researchers collaborating with the Appalachian CARE communities are currently engaged in millions of dollars worth of research from state, federal, and foundation sources. Current research to improve the environment and community health in the region spans multiple disciplines and media including soil, water, and air. The Appalachian CARE Communities were recognized by the U.S. EPA for their ability to leverage academic resources, and in the words of one community member "CARE has given us a voice" (US EPA, June 2010).

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List of figures

Fig. 1

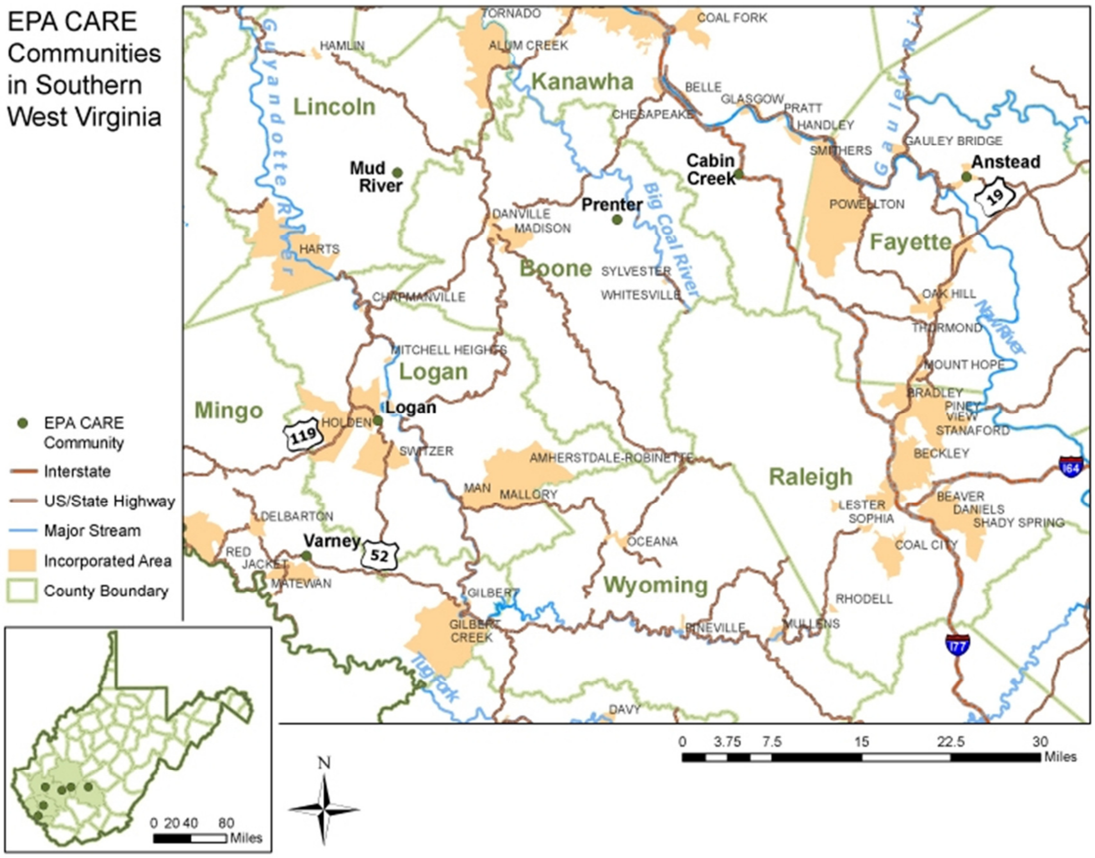
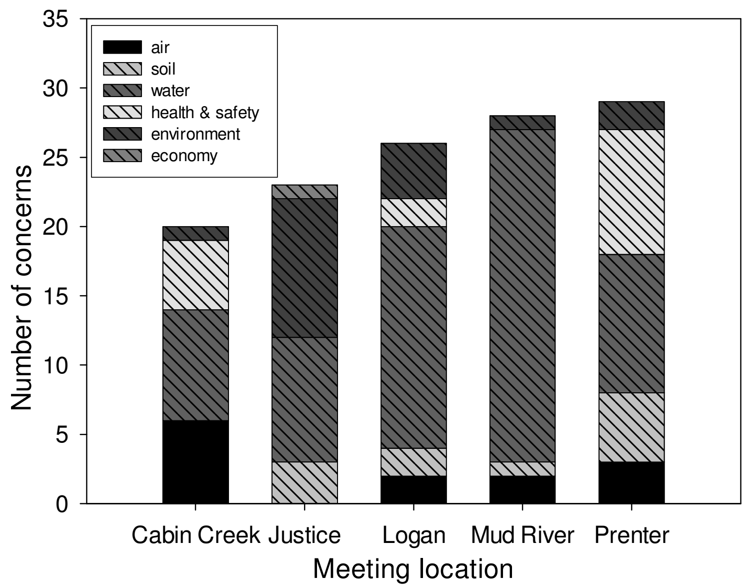
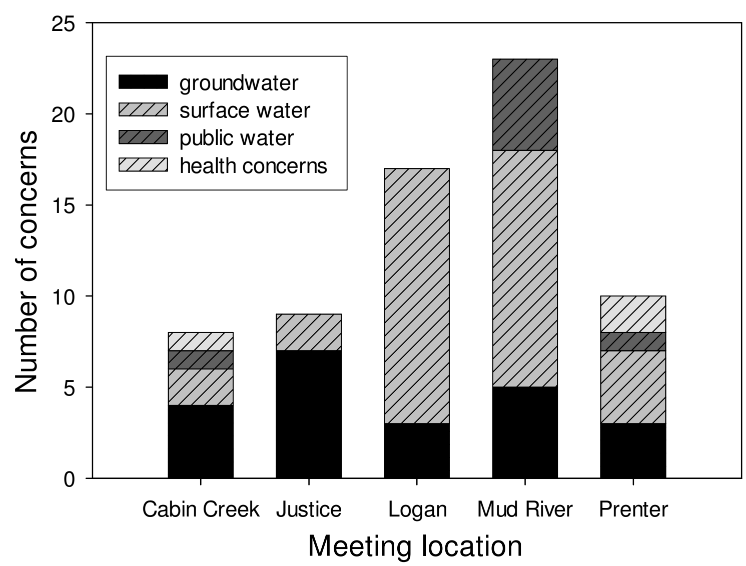

EPA CARE Communities in Southern West Virginia
EPA CARE Community
Interstate
US/State Highway
Major Stream
Incorporated Area
County Boundary
Lincoln
Kanawha
Boone
Logan
Mingo
Fayette
Raleigh
Wyoming
Mud River
Prenter
Cabin Creek
Anstead
Logan
Varney
Guyandotte River
Big Coal River
Gauley River
New River
Tug Fork
TORNADO
HAMLIN
ALUM CREEK
COAL FORK
BELLE
GLASGOW
PRATT
HANDLEY
CHESAPEAKE
SMITHERS
GAULEY BRIDGE
POWELLTON
DANVILLE
MADISON
HARTS
SYLVESTER
WHITESVILLE
CHAPMANVILLE
OAK HILL
THURMOND
MITCHELL HEIGHTS
MOUNT HOPE
BRADLEY
PINEY VIEW
STANAFORD
HOLDEN
SWITZER
BECKLEY
AMHERSTDALE-ROBINETTE
MAN
MALLORY
BEAVER
DANIELS
SHADY SPRING
LESTER
SOPHIA
DELBARTON
OCEANA
COAL CITY
RED JACKET
MATEWAN
GILBERT
RHODELL
GILBERT CREEK
PINEVILLE
MULLENS
DAVY
119
52
19
64
77
0 3.75 7.5 15 22.5 30 Miles
0 20 40 80 Miles
N

Fig. 2

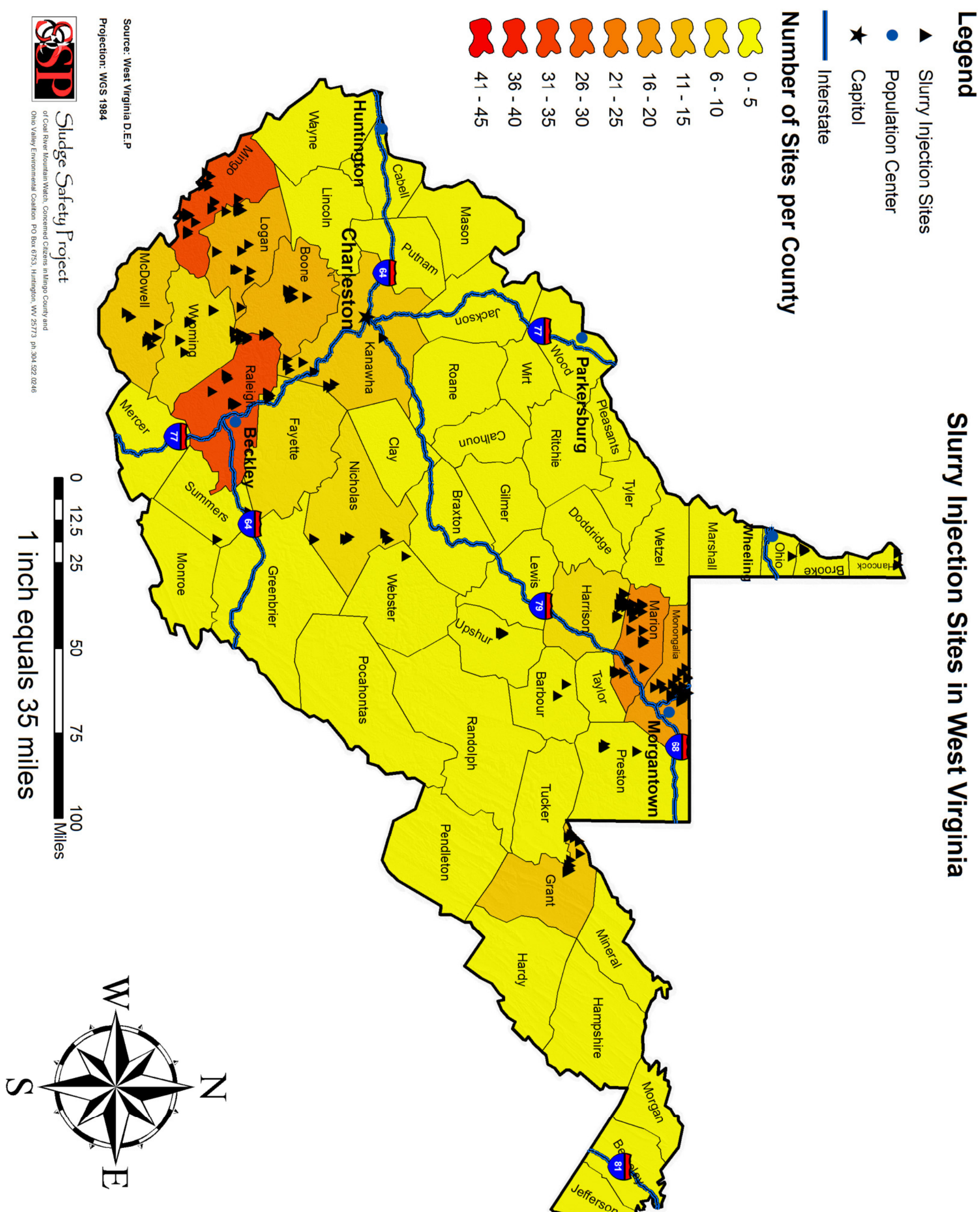


35
30
25
20
15
10
5
0
Number of concerns
air
soil
water
health & safety
environment
economy
Cabin Creek
Justice
Logan
Mud River
Prenter
Meeting location



25
20
15
10
5
0
Number of concerns
groundwater
surface water
public water
health concerns
Cabin Creek
Justice
Logan
Mud River
Prenter
Meeting location

Fig. 3



Slurry Injection Sites in West Virginia
Legend
Slurry Injection Sites
Population Center
Capitol
Interstate
Number of Sites per County
0 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 30
31 - 35
36 - 40
41 - 45
Source: West Virginia D.E.P
Projection: WGS 1984
SSP
Sludge Safety Project
Huntington
Charleston
Parkersburg
Beckley
Morgantown
Wheeling
Hancock
Brooke
Ohio
Marshall
Wetzel
Tyler
Pleasants
Wood
Jackson
Mason
Cabell
Wayne
Lincoln
Putnam
Kanawha
Roane
Wirt
Ritchie
Calhoun
Doddridge
Gilmer
Braxton
Clay
Lewis
Harrison
Marion
Monongalia
Taylor
Barbour
Preston
Tucker
Upshur
Webster
Nicholas
Fayette
Boone
Logan
Mingo
McDowell
Wyoming
Raleigh
Mercer
Summers
Monroe
Greenbrier
Pocahontas
Randolph
Pendleton
Grant
Mineral
Hardy
Hampshire
Morgan
Berkeley
Jefferson
64
77
79
68
81
0
12.5
25
50
75
100
Miles
1 inch equals 35 miles
N
S
E
W

Table 1. Comparison of well water chemistry (*u*g/l) during low flow (base flow, February 25 & 26, 2004) versus high flow (blackwater, April 16, 2004) conditions (n.d.=not detected).

		well		well		well		well		well	
source wells		4819		4852		4836		4845		4802	
well depth (feet)		220		55		78		189		100	
location in hollow		middle		head		bottom		middle		bottom	
water hardness in mg/l		120	72	70	68	185	164	301	247	158	136
Primary (enforceable) standards						flow condition					
	standard	low	high	low	high	low	high	low	high	low	high
Arsenic	10	n.d.	340	n.d.	44	n.d.	n.d.	3	8	n.d.	4
Barium	2,000	400	500	500	500	100	200	100	400	200	200
Beryllium	4	n.d.	n.d.	n.d.	n.d	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cadmium	5	n.d.	n.d.	n.d.	n.d	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Chromium	100	n.d.	4	n.d.	2	9	6	7	8	6	4
Lead	15	n.d.	n.d.	n.d.	9	20	10	23	22	6	10
Selenium	50	n.d.	n.d.	n.d.	n.d.	65	n.d.	n.d.	n.d.	n.d.	n.d.
Secondary (recommended) standards											
Aluminum	200	50	40	n.d.	30	60	170	50	70	60	70
Copper	1,300	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	131	n.d.	n.d.

Table 2. Concentration (ug/l) of heavy metals that are regulated by EPA Primary Drinking Water Standards in 19 samples of the soluble (liquids, filtered) fraction of coal slurry samples.

Element	Sb	As	Ba	Be	Cd	Cr	Pb	Hg	Se	Tl
EPA standard	6	10	2000	4	5	100	15	2	50	2
sample 1	9.7	1.2	33.3	0.0	0.0	0.0	0.0	0.0	12.5	0.0
sample 2	5.7	4.2	97.4	0.0	0.0	0.0	0.0	0.0	26.8	0.3
sample 3	1.4	4.6	54.6	0.0	0.0	0.0	29.2	0.0	4.5	0.0
sample 4	14.6	10.4	243.0	0.0	0.0	27.2	76.2	0.0	22.4	0.0
sample 5	22.0	3.9	80.9	0.2	0.0	1.3	0.0	0.0	8.2	0.0
sample 6	6.9	0.0	67.7	0.0	0.0	0.0	0.0	0.0	2.4	0.0
sample 7	0.4	0.0	52.3	0.0	0.0	0.0	0.0	0.0	5.7	0.2
sample 8	2.1	1.5	137.7	0.0	0.0	1.5	0.0	0.0	4.0	0.0
sample 9		1.5	210.6	0.0	0.0	0.0	0.0	0.0	2.1	0.0
sample 10	2.4	2.3	25.7	0.0	0.0	0.0	1.5	0.0	1.6	0.0
sample 11	0.0	0.0	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sample 12	1.2	0.0	62.6	0.0	0.0	0.0	0.0	0.0	6.4	0.0
sample 13	2.2	3.6	97.3	0.0	0.0	0.0	5.1	0.0	8.3	0.0
sample 14	0.0	0.0	32.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sample 15	3.1	68.7	0.0	12.2	5.2	74.2	10.1	0.0	14.5	0.0
sample 16	0.0	0.0	102.1	0.0	0.0	0.0	1.0	0.0	6.5	0.0
sample 17	0.0	0.0	68.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sample 18	0.0	7.4	43.5	0.0	0.0	0.0	0.0	0.0	370.3	0.0
sample 19	0.0	0.0	25.5	15.5	22.8	0.0	761.0	0.0	2.4	1.0
minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maximum	22.0	68.7	243.0	15.5	22.8	74.2	761.0	0.0	370.3	1.0
mean	4.0	5.8	76.6	1.5	1.5	5.5	46.5	0.0	26.2	0.1
median	1.7	1.5	62.6	0.0	0.0	0.0	0.0	0.0	5.7	0.0

Table 3. Concentration (ug/l) of heavy metals that are regulated by EPA Secondary Drinking Water Standards in 19 samples of the soluble (liquids, filtered) fraction of coal slurry samples.

Element	Al	Cu	Fe	Mn	Ag	Zn
standard	200	1300	300	50	100	5000
sample 1	60.5	1.7	193.9	29.0	0.0	3.6
sample 2	150.0	1.6	0.0	86.0	0.0	0.0
sample 3	8.8	129.9	28.5	13.1	0.0	134.7
sample 4	29.0	24.8	68.0	21.0	0.0	19.0
sample 5	195.0	1.2	0.0	14.1	0.0	16.0
sample 6	532.0	2.1	0.0	133.0	0.0	0.0
sample 7	509.0	1.5	30.0	921.0	0.6	32.0
sample 8	22.2	0.0	128.7	75.2	0.0	1.6
sample 9	196.9	3.0	328.9	100.0	0.0	7.0
sample 10	19.9	2.6	116.5	0.0	0.0	13.3
sample 11	142.6	3.8	52.4	1,034.8	0.0	68.8
sample 12	18.7	2.2	87.1	0.0	0.0	4.4
sample 13	383.7	39.1	322.2	2.3	0.0	29.3
sample 14	10.2	3.7	125.7	65.0	0.0	4.1
sample 15	50,881.3	174.7	328,541.1	972.0	0.0	329.4
sample 16	90.8	5.8	304.0	2.6	1.1	8.1
sample 17	15.8	3.8	53.1	2,639.0	0.0	6.9
sample 18	22.2	2.5	133.7	0.0	0.0	3.9
sample 19	2,018.0	52.0	203.4	966.4	0.0	
minimum	8.8	0.0	0.0	0.0	0.0	0.0
maximum	50,881.3	174.7	328,541.1	2,639.0	1.1	329.4
mean	2,910.9	24.0	17,406.2	372.3	0.1	37.9
median	90.8	3.0	116.5	65.0	0.0	7.6