Trends in Mining Fills and Associated Stream Loss in West Virginia 1984-2009

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Abstract— In the steep slope regions of Appalachia, the volume of overburden material produced by surface mining often exceeds what can be utilized for reclamation. This condition results in the creation of permanent structures designed for the disposal of excess overburden material, which most commonly takes the form of valley fills. Valley fills bury headwater streams, and have been linked with degraded water quality and biodiversity loss in several studies. However, federal regulation does not explicitly require the compilation of mining features on watershed or regional levels, making it difficult to visualize or quantify what is happening at these scales.

To address this problem, GIS was used to compile a comprehensive database of spoil and refuse fills constructed in West Virginia as of 2009. Fills initially were identified by analyzing differences between pre- and post-mining elevation models, and supplemented with aerial photography and mining maps. Satellite and aerial photography was used to identify construction status of each fill in 1984, 1990, 1996, 2003, and 2009. This allowed an analysis of trends in fill construction to be plotted over time. A 1:24,000 scale stream network was augmented to create consistent start points for intermittent and perennial streams, based on median drainage areas calculated from field research conducted by the USGS in the state's southern coalfield. The augmented stream network was used to estimate linear stream loss due to fill construction over time.

The analysis identified 1,821 spoil fills, and 270 refuse fills, occupying a combined area of 56,780 acres, or over 88 square miles. It was estimated that the fills resulted in the loss of over 844 miles of intermittent and perennial streams. The impact was relatively concentrated—half of the stream loss occurred in 23 of 745 12-digit watersheds in the state, with stream loss exceeding 10% in fourteen of these watersheds.

Introduction

Valley fills are a central component of the debate over the environmental impact of mining operations in Appalachia. In West Virginia, there has been an ongoing effort to maintain a spatial database of valley fills digitized from thousands of permit maps. This effort has been supplemented by analyses that identified existing fills using multi-date elevation models. Both of these efforts produced data products that were limited in significant ways, making it impossible to calculate basic statistics on the number of fills, their distribution, trends over time, and the length of stream lost due to their construction.

Coincident with the preparation of this document, the EPA released a draft report on the effects of mountaintop mining and valley fills, which identified a critical need for an updated inventory of valley fills. Previously, the most comprehensive study of valley fills in West Virginia dated to 2001, conducted as part of the draft programmatic environmental impact statement arising out of the *Bragg v. Robertson* decision.

This study addresses the data gap identified in the EPA report by creating a comprehensive inventory of constructed mining fills in West Virginia. The inventory was compiled by integrating data from a variety of sources, including permit maps, satellite and aerial photography, and digital elevation models. The study benefited from a significant increase in the availability of spatial data since 2001. There are now four state-wide, high-resolution aerial photography datasets available, and an extensive inventory of Landsat TM satellite images, dating to the early 1980s, is available online for download. The state now has digital elevation data of much better quality, and often for multiple dates. Finally, the elevation grid and digital stream network used in this study to estimate stream loss are more detailed than the datasets available in 2001. Better data, combined with better information on the hydrologic characteristics of intermittent and perennial streams in the southern coalfields, produced a more accurate estimation of stream loss than could be accomplished previously.

Creating the Inventory

The objective of the compilation effort was to create a spatial database of existing fill structures in West Virginia as of the summer of 2009, which corresponded with newly available state-wide aerial photography. In addition to the 2009 photography, mining fill information was compiled and cross checked using a variety of other data sources, including thousands of georeferenced mine maps, analyses of multi-date elevation models, additional aerial photography from 1990, 1996, 2003, and 2007, Landsat satellite images from 1984 and 1990, an historical atlas of refuse dumps, and several tabular data sources.

The dataset produced by the compilation effort was organized into two feature classes, one containing spoil fills, and a second for refuse structures. Spoil fills are variously identified as valley fills, head of hollow fills, durable rock fills, excess spoil fills, or side hill fills, and are constructed primarily for the disposal of fractured overburden rock produced during mining operations. As it relates to West Virginia rules for optimizing excess spoil placement, the dataset makes no distinction between backfill area, which occurs within the mineral removal area, and excess spoil disposal areas, which lie outside the mineral removal area and are used primarily for spoil disposal. Individual fill polygons simply attempt to represent the extent of areas exhibiting a net increase in elevation due to the placement of spoil material. The second feature class was comprised of structures used for the disposal of coarse and/or fine coal refuse produced during coal preparation, including slurry impoundments.

During the compilation process, several exceptions were identified that had to be accommodated. In a few cases, it was apparent that existing spoil fills subsequently were used for deposition of refuse material. In these cases, the fills remained in the spoil feature class, and no corresponding feature was created in the refuse class. In other cases, spoil fills were constructed on top of preexisting refuse fills. In these cases, overlapping feature polygons were maintained for both types of structures. There also were several cases where spoil fills were constructed over older, smaller fills. In these cases, both fill polygons were retained. When calculating total area statistics, the intersecting area of overlapping polygons was calculated and subtracted from the appropriate totals. These areas were relatively small, totaling only about 128 acres for the entire dataset.

After identification, features in the spoil feature class were attributed to indicate their status at various time intervals, based on the interpretation of aerial or satellite images. A status of “not started”, “under construction”, or “complete” were given to each fill for the years 1984, 1990, 1996, 2003 and 2009. Fills were considered complete when overburden deposition was not apparent and the fill area appeared to be re-graded. This determination was more difficult when using satellite images for 1984 and 1990 due to the coarse resolution of the images. Determinations in these cases relied on the analyst’s experience interpreting the presence of vegetation cover on the site. Most opportunities for misclassification centered on the transition from under construction to complete. However, these categories were grouped together when calculating area and stream loss statistics, so any potential errors did not impact the results of the study.

Fill polygons were compiled from three basic sources: 1. IFSAR fills—were initially derived by comparing an elevation grid acquired using radar in 2003 with an elevation grid created from USGS hypsography data. Since the hypsography pre-dated the construction of most mining fills, elevation differences between the two datasets could be exploited to extract mining fills constructed in the interim (detailed in Shank, 2004). This analysis covered a 10-county region of southern West Virginia. Fills identified by this analysis initially were attributed to indicate whether they were complete or under construction in 2003. Fills under construction were edited, based on 2009 aerial photography, to represent their extent in 2009. 2. Permit maps—fills are routinely digitized from georeferenced maps submitted to the WVDEP. Fill polygons from this source that duplicated fills in the IFSAR dataset were deleted. The remaining fills were checked against 2009 aerial photography. Fills under construction were edited to represent the approximate extent of fill material at the time the photo was taken. Completed fills were edited in cases where the as-built fill differed significantly from the planned fill digitized from the map. 3. Interpreted from aerial photographs—Fills not captured either by the IFSAR analysis or permit maps were identified from multiple aerial photography sources dating from 1990-2009. Fill extents were approximated using aerial photography to identify the toe point and face of the fill. Topographic map contours, and occasionally visible ditch lines, were used to approximate the fill extent.

Fill Area Analysis Results

The data compilation effort identified 1,821 spoil fills either completed or under construction by the summer of 2009, occupying an area of 43,837 acres. A total of 270 refuse fills contributed an additional 12,943.5 acres for a total of 56,780.5 (Table 1). This represents an area of over 88 square miles, or a square measuring 9.4 miles on a side. The progression in spoil fill construction between 1984-2009 is roughly linear in terms of the cumulative area, exhibiting more than a 7-fold increase from 5,711.4 to 43,837 acres (Figure 1). The trend in the size of new fills was generally upward, with the mean size of new fills increasing from 17.3 acres in 1984 to 29.1 in 2003, before falling back slightly to 28.6 by 2009 (Figure 2).

Year	Number of fills	Discrete Area	Overlap	Total area
1984	330	5,711.4	-	5,711.4
1990	761	14,653.8	-	14,653.8
1996	1,136	24,100.4	4.4	24,096.0
2003	1,570	36,731.5	78.4	36,648.7
2009	1,821	43,919.8	-	43,837.0
refuse fills	270	12,987.6	44.1	12,943.5
spoil + refuse	2,091			56,780.5

Table 1. Area of mining fills 1984-2009, in acres.

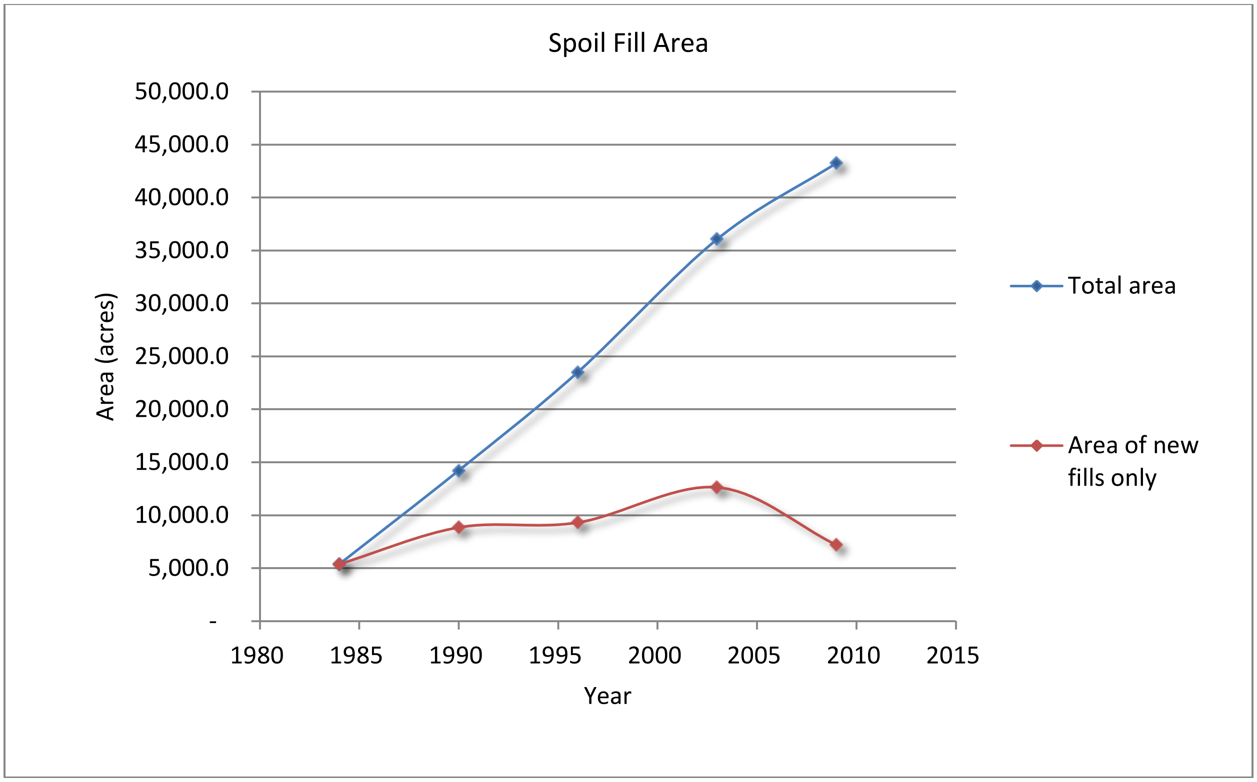

Figure 1. Area occupied by spoil fills, 1984-2009. Refuse fills are not included in the calculations.

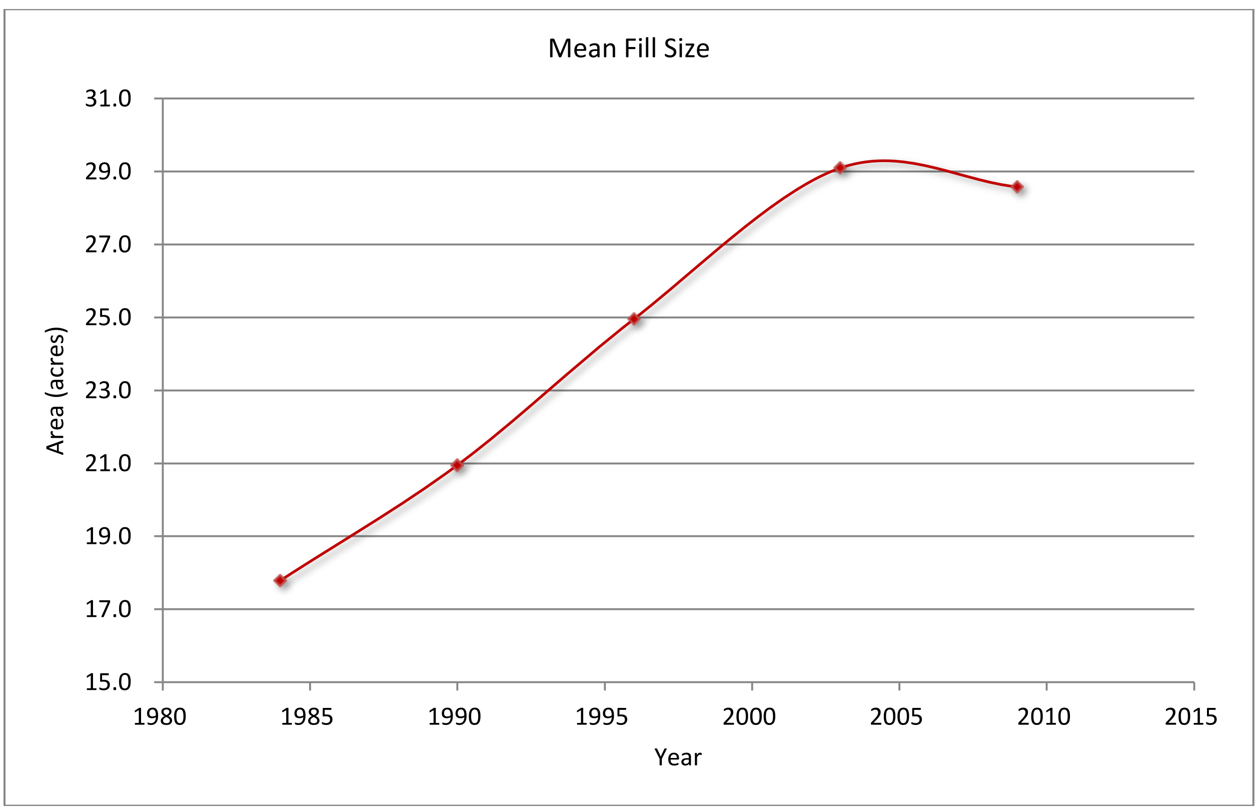

Figure 2. Trend in mean size of new fills, 1984-2009.

Direct Stream Loss—Analysis

Estimating the total length of stream buried under fills required creating a consistent digital stream network that identified the start point of intermittent and perennial streams. This was accomplished using established surface hydrology analysis techniques. It involved embedding an existing 1:24,000 scale stream network in a 10-meter elevation grid, which then was processed to remove any sinks, calculate flow direction at each cell, then calculate flow accumulation over the entire grid.

The value of any cell in a flow accumulation grid represents the total number of cells that flow into that location. Since each grid cell used in the analysis represents an area of $100m^2$, it was easy to calculate the total area that drains to each cell. Paybins (2003) estimated the median drainage areas of intermittent and perennial streams in the mountaintop mining region of southern West Virginia, where over 95% of the fills identified by this study occur. By reclassifying the flow accumulation grid to match the median drainage of intermittent and perennial streams identified in the Paybins study, it was possible to extract a stream network with consistent start points for headwater segments. The reclassification scheme used for this study is presented in table 2. This approach is by no means perfect—variations in intermittent and perennial drainage points can vary significantly due to local conditions. However, adapting the results of actual field investigations is considered a major advance over relying on stream data derived from cartographic representations, or picking a number out of a hat.

After reclassification, the resulting grid was converted back to a vector line format that closely resembled the original 1:24,000 scale dataset, but with a more consistent representation of headwater stream segments. Figure 3 shows part of the study area with the original stream network that was based on USGS maps, while the modified stream network used to estimate stream loss is shown for the same area in figure 4. Line segments that fell within the boundaries of mining fill polygons were clipped at the polygon boundary, and the lengths of the clipped segments were summed to arrive at an estimation of the length of stream buried under fill.

The elevation grid used in the study was derived from USGS hypsography (contour) data depicted on USGS 1:24,000 scale maps. The grid proved to be a preferred source for creating the stream network for two reasons. First, the stream network that was embedded into the grid was derived from the same source—USGS 1:24,000 scale maps—so the two data sources were complementary. Second, attempts to utilize a more accurate, higher resolution grid created in 2003 could not reliably trace flow paths under existing fills that had been constructed by that date.

Stream Classification	Upstream drainage area (acres)	Flow Accumulation Grid Value	Reclassified Grid Value
No stream	< 14.5	< 587	Null
Intermittent	14.5 – 40.8	587 – 1651	1
Perennial	40.8 >	1651 >	2

Table 2. relationship between stream type, drainage area, flow accumulation grid values, and reclassification output values used in creating the modified stream network. The reclassified grid was converted to a vector stream network and used to calculate the total length of streams buried by fill.

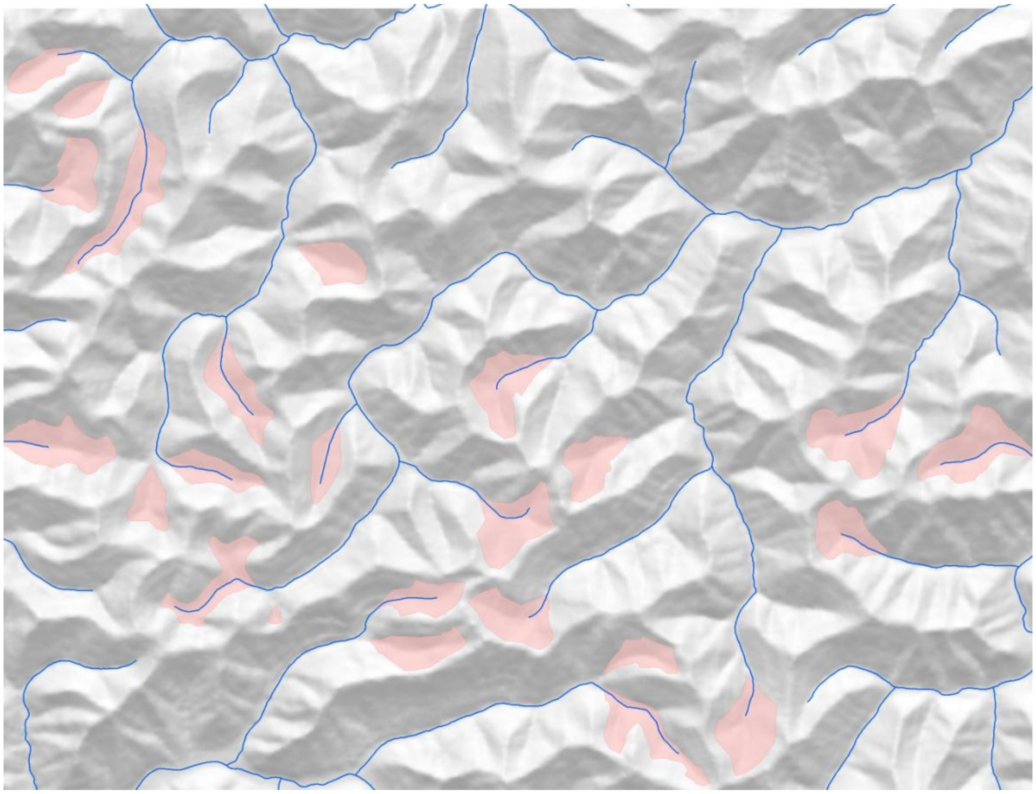

Figure 3. Streams from the original 1:24,000 scale data source. Constructed fills are shown in red.

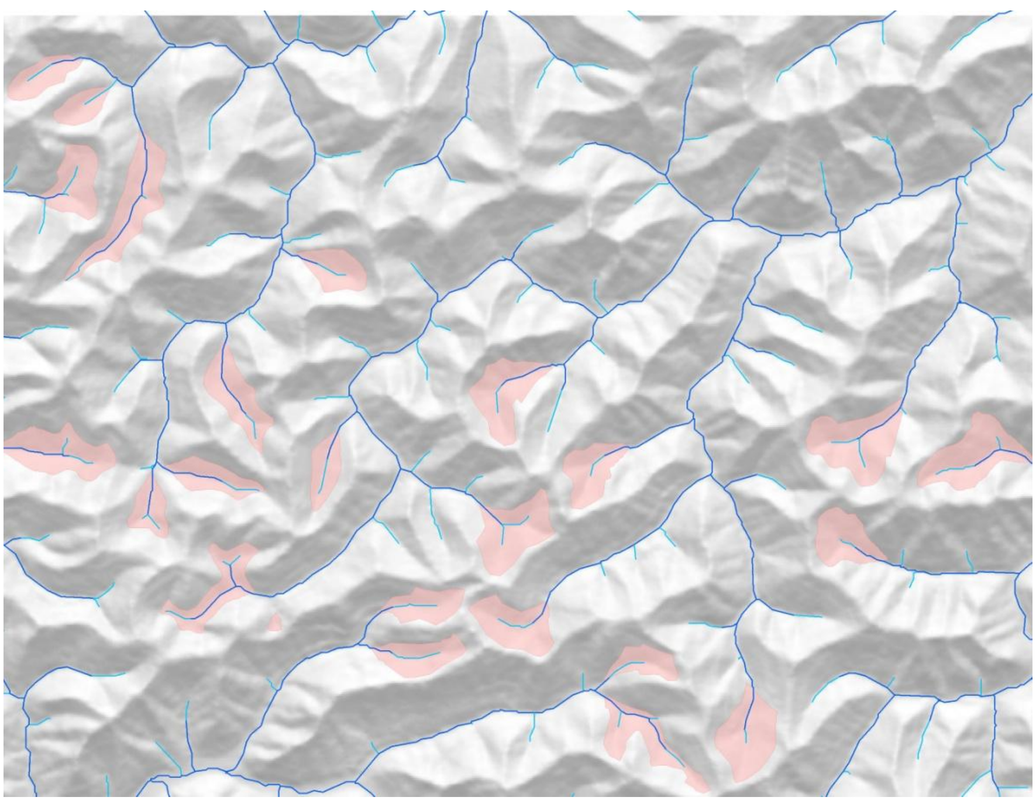

Figure 4. Modified stream network used for estimating stream loss, showing distinction between intermittent and perennial reaches.

Direct Stream Loss--Results

Stream loss statistics are presented in table 3. Direct stream loss for all types of mining fills totaled 699.8 miles, comprised of 272.7 miles of intermittent, and 427.1 miles of perennial streams (table 3). Over 94% of the stream loss occurred in the southern coal field. Figure 5 depicts stream loss due to spoil fills from 1984-2009. By 2009, spoil fills had buried over 7 times the total calculated for 1984, a factor that correlates with the increase in total fill area.

Table 3 includes additional estimates for isolated stream segments that occur above existing fills. It is arguable that these stream fragments should be included in estimates of stream loss because they no longer perform the same ecological functions as they did previously. The estimates in table 3 were derived from examining sections of stream that fell within the drainage area of an existing fill, and fell within a known permit boundary. While this analysis is not definitive, it suggests that an additional 145 miles of streams may fit within this category.

The trend in direct stream loss from spoil fills is presented in figure 6. The rate of stream loss accelerated for each sample period until 2003, before a significant decline. In the period 1996-2003, stream loss reached a peak of over 154 miles, or a rate of about 22 miles/year. In the following time period from 2003-2009, stream losses dropped to less than 87 miles, or approximately 14.5 miles/year . This rate is the lowest of any time period since 1984, and represents a reduction of over 34% from the peak period ending in 2003.

	south			north			combined		
	intermittent	perennial	total	intermittent	perennial	total	intermittent	perennial	total
spoil fills, 1984	30.3	32.9	63.3	2.1	1.3	3.4	32.5	34.2	66.7
spoil fills, 1990	45.5	57.7	103.2	0.4	1.0	1.5	45.9	58.8	104.7
spoil fills, 1996	45.7	64.9	110.5	1.3	0.6	1.9	46.9	65.5	112.4
spoil fills, 2003	62.6	89.9	152.6	0.5	1.2	1.7	63.2	91.1	154.3
spoil fills, 2009	36.2	50.6	86.8	0.1	0.0	0.1	36.3	50.6	86.9
spoil fills, total	220.4	296.1	516.5	4.4	4.2	8.6	224.8	300.3	525.0
refuse fill total	36.9	109.8	146.6	11.2	18.1	29.3	48.1	127.8	175.9
overlap adjustment	*0.2*	*1.0*	*1.1*	-	-	-	*0.2*	*1.0*	*1.1*
total streams under fills	257.1	404.9	661.9	15.6	22.3	37.9	272.7	427.1	699.8
streams above fill drainage	*72.3*	*63.8*	*136.1*	*4.4*	*4.5*	*8.9*	*76.8*	*68.2*	*145.0*
total stream loss, including streams above fills	***329.4***	***468.6***	***798.0***	***20.1***	***26.7***	***46.8***	***349.5***	***495.4***	***844.8***

Table 3. Stream length buried under mining fills (in miles) 1984-2009. The overlap adjustment accounts for overlapping fills built at different times on the same location. Calculations for streams above a fill only include stream segments within the drainage area of an existing fill that also occur within a mine permit boundary.

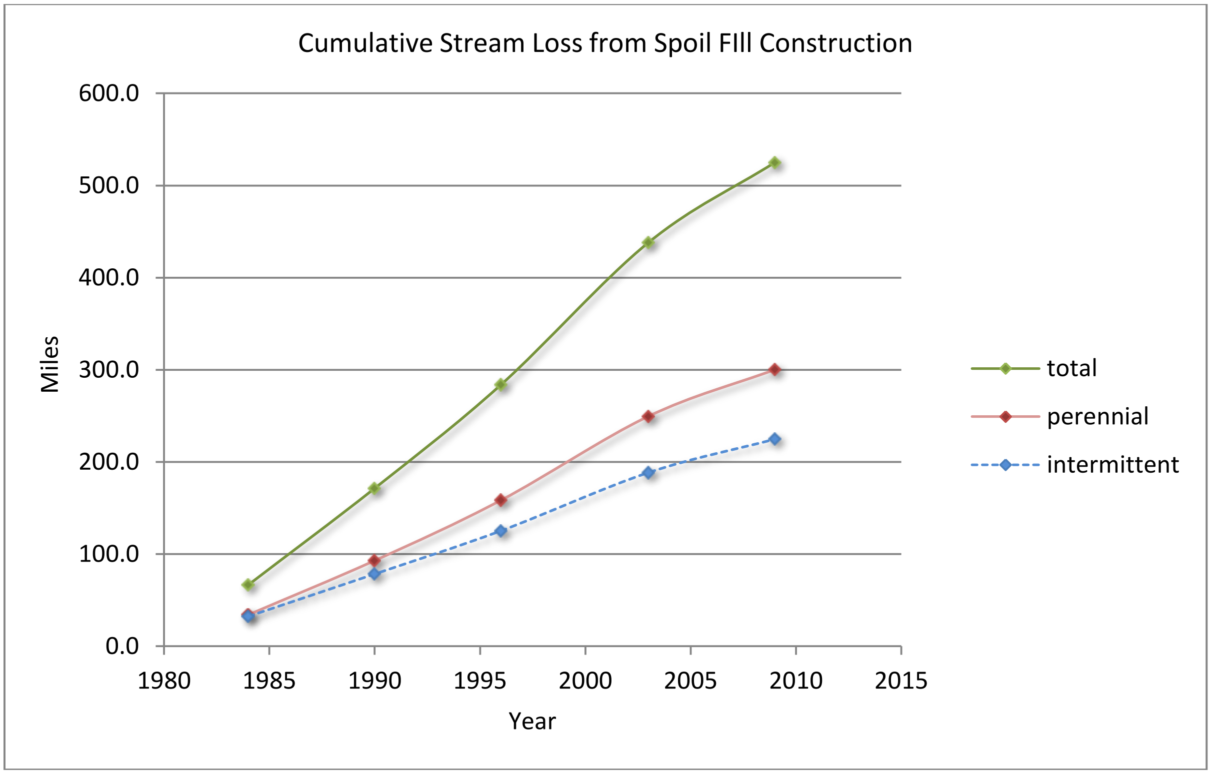

Figure 5. Cumulative stream loss due to spoil fill construction reached 525 miles by 2009. This does not include refuse fills, which contributed an additional 175 miles.

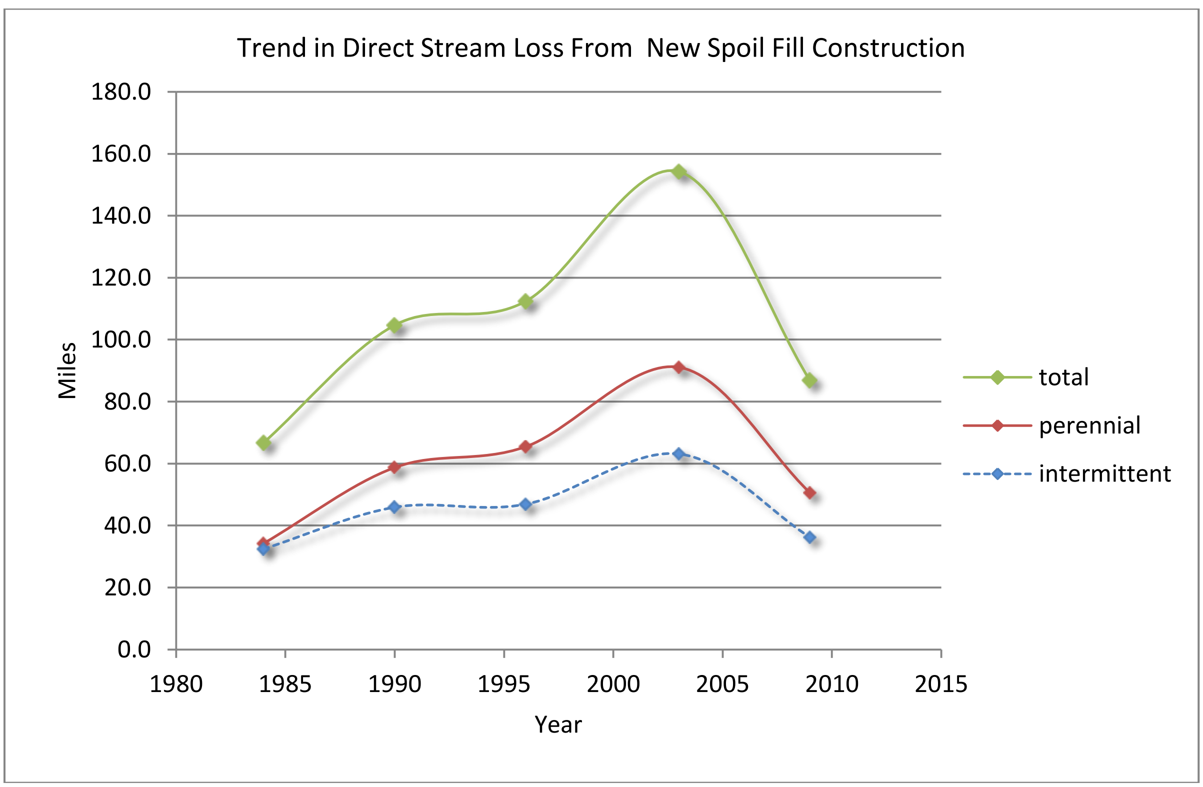

Figure 6. Direct stream loss from new fills started since the previous sample year. Stream loss appears to have significantly decreased in 2009, relative to 2003 totals.

Stream loss was measured in 169 of the 745 12-digit watersheds that make up the West Virginia drainage network, though only 106 of these watersheds suffered losses exceeding one mile. Stream losses were concentrated— the top twelve watersheds accounted for one third of the total stream loss, and over half the stream loss was borne by just 23 watersheds. Stream loss exceeded 10% in fourteen watersheds, all located in the southern coalfield (table 4). Most impacted were White Oak Creek (30.4%), Twentymile Creek (22.5%), and Ben Creek (19.5%).

Figure 7 shows the locations of watersheds with the highest percentage of streams loss. These watersheds often were associated with large surface mine complexes, including Catenary Coal's Kayford Mountain Operations (White Oak Creek), Fola Coal and Alex Energy (Twenty Mile Creek), and the Hobet 21 area (Ballard Fork and Big Horse Creek).

HUC	Name	Total Streams (mi)			Loss Under Fill			Percent Loss		
		intermittent	perennial	total	intermittent	perennial	total	intermittent	perennial	total
050500090601	White Oak Creek	16.7	47.8	64.4	5.7	13.9	19.6	34.3%	29.0%	30.4%
050500050701	Headwaters Twentymile Creek	34.8	81.8	116.6	10.1	16.1	26.2	29.0%	19.7%	22.5%
050702010302	Ben Creek	27.5	54.6	82.1	7.7	8.3	16.0	28.2%	15.1%	19.5%
050500060303	Smithers Creek	19.9	43.5	63.5	4.6	5.6	10.2	23.0%	12.8%	16.0%
050701020302	Ballard Fork-Mud River	46.3	95.0	141.4	8.2	14.3	22.6	17.8%	15.1%	16.0%
050701010507	Rum Creek-Guyandotte River	44.3	104.7	149.1	7.4	14.4	21.8	16.6%	13.8%	14.6%
050500090403	Middle Pond Fork	27.4	66.9	94.3	3.7	9.9	13.6	13.4%	14.8%	14.4%
050500090302	Headwaters Spruce Fork	49.3	124.4	173.7	6.4	16.1	22.4	12.9%	12.9%	12.9%
050500090501	Big Horse Creek	34.4	78.2	112.7	6.1	8.3	14.3	17.7%	10.5%	12.7%
050500060201	Headwaters Cabin Creek	32.8	79.7	112.6	4.8	8.5	13.3	14.7%	10.6%	11.8%
050901020201	Kiah Creek	33.4	77.7	111.2	6.0	5.9	11.9	18.0%	7.6%	10.7%
050500090402	West Fork	41.4	99.6	140.9	3.4	11.2	14.6	8.2%	11.2%	10.4%
050500070502	Lilly Fork	34.4	68.4	102.8	3.3	7.2	10.5	9.5%	10.5%	10.2%
050500070901	Leatherwood Creek-Elk River	54.4	114.5	169.0	6.4	10.6	16.9	11.7%	9.2%	10.0%

Table 4. Watersheds with more than 10% total stream loss by mining fills as of 2009.

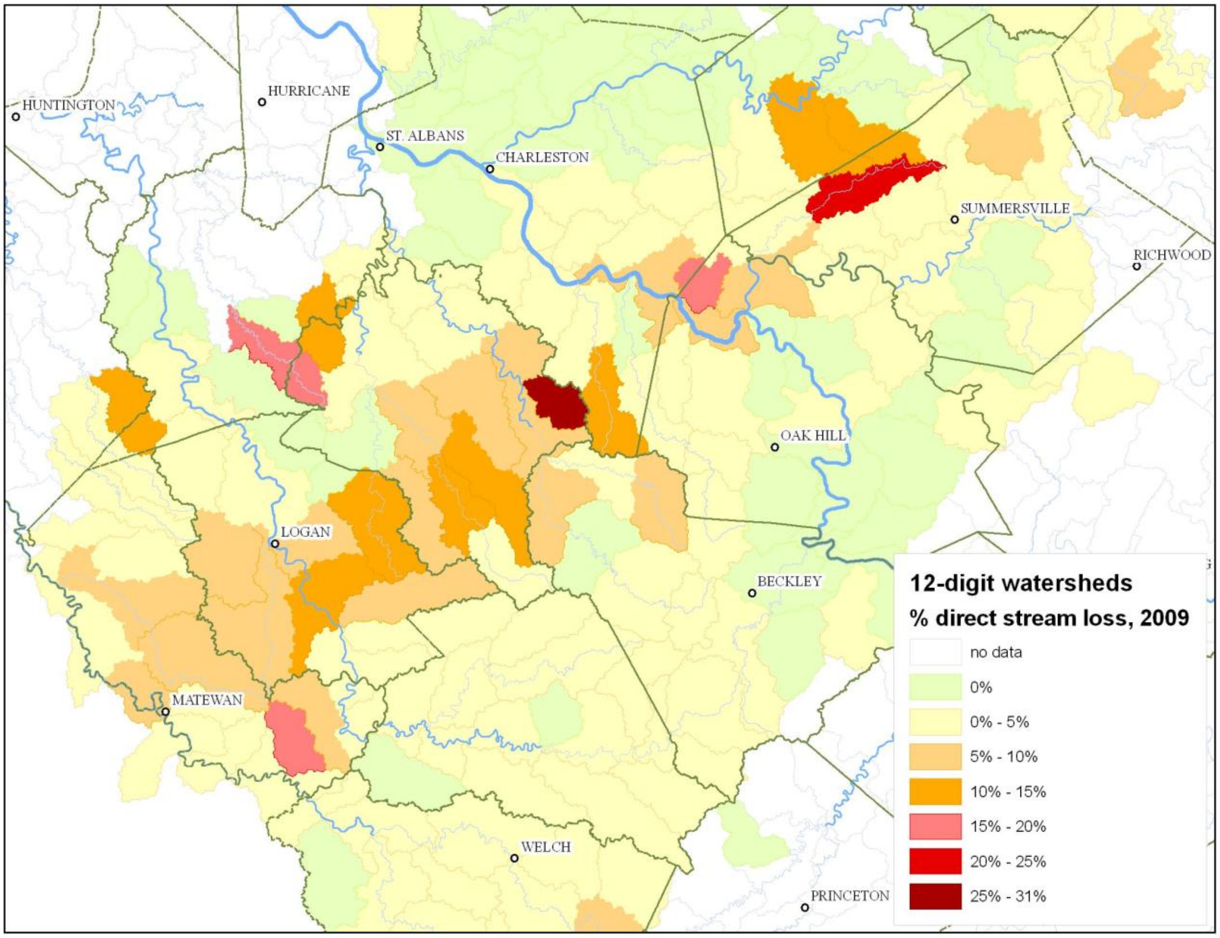

Figure 7. Watersheds most impacted by direct stream loss from mining fills.

Data Quality

The fill inventory used for this analysis represents the best available source. It's constituent parts were built from countless hours of digitizing and analysis. Compiling and cross checking the final inventory required over 120 hours to complete, before any analysis could be conducted. Even so, the data on which this analysis is permeated with errors of many different kinds—a legacy of the lineage from which it was derived. Individual fill polygons are intended to capture general locations and extents of features on the ground; they are not produced by methods of survey and are of limited usefulness for investigations of individual structures. The scale of error is appropriately measured in meters, not centimeters. In the author's judgment, these error sources do not significantly impact regional analyses such as the one presented here, but could lead to problems if the data were used in inappropriate ways. With this in mind, some of the recognized error sources associated with the dataset are enumerated below:

1) Some small number of fills may have been omitted. These fills likely are old and small, associated with operations for which a map is not available, and not easily picked up by airphoto interpretation. In some cases, visual evidence was not conclusive enough to warrant inclusion in the database.

2) Fills delineated from the analysis of elevation models may have imperfect boundaries arising from errors in the elevation models from which they were derived.

3) The boundaries of fills digitized from aerial photographs could be subject to interpretation, and often relied on pre-mining contours to suggest the extent of a valley fill above the toe.

4) Fills digitized from permit maps can contain errors that include: 1) error in the map source itself, 2) error introduced by scanning and georeferencing, 3) error contributed by imperfect digitizing.

5) Fills digitized from permit maps can be subject to interpretation when their extent was not clearly indicated. In these cases, contours or drainage ditches were sometimes used to interpret the fill extent.

6) Fills in adjacent valleys sometimes converge to a single point downstream, or sometimes diverge into opposite drainages. While technically a single connected fill, these structures usually were split into two fill polygons. This affects the total fill count by a small amount, but does not affect area or length of stream calculations.

7) The status of fills depicted on satellite images in 1984 and 1990 could be difficult to determine due to the limited resolution of the images. This problem was minimized by examining images from other dates, and examining the issue date of the associated permit, where available. Also, the status of each fill was compared across all dates to ensure logical consistency.

8) Calculations of total area at various dates includes fills under construction. However, the area used in the calculation represents the area of the completed fill. In some cases, a fill under construction at a particular date may not have reached its terminal point downstream, resulting in a slight overestimate of the total area estimated for a particular date.

9) Calculations of stream loss only include stream segments directly under (and above) the fill, though it could be argued that stream loss should be extended to the downstream pond below the toe of a valley fill.

References

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Shank, Michael, 2004. "Development of a Mining Fill Inventory from Multi-Date Elevation Data" Presented at the Advanced Integration of Geospatial Technologies in Mining and Reclamation Conference, December 7-9, 2004, Atlanta Ga.

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Appendix A 12-digit watersheds with over 1 percent direct stream loss from mining fill construction

	HUC_12	HU_12_NAME	streams in HUC (miles)			stream loss (miles)			percent loss		
			i	p	total	i	p	total	i	p	total
1	050500090601	White Oak Creek	16.7	47.8	64.4	5.7	13.9	19.6	34.3%	29.0%	30.4%
2	050500050701	Headwaters Twentymile Creek	34.8	81.8	116.6	10.1	16.1	26.2	29.0%	19.7%	22.5%
3	050702010302	Ben Creek	27.5	54.6	82.1	7.7	8.3	16.0	28.0%	15.3%	19.5%
4	050500060303	Smithers Creek	19.9	43.5	63.5	4.6	5.6	10.2	23.0%	12.8%	16.0%
5	050701020302	Ballard Fork-Mud River	46.3	95.0	141.4	8.2	14.3	22.6	17.8%	15.1%	16.0%
6	050701010507	Rum Creek-Guyandotte River	44.3	104.7	149.1	7.4	14.4	21.8	16.6%	13.8%	14.6%
7	050500090403	Middle Pond Fork	27.4	66.9	94.3	3.7	9.9	13.6	13.4%	14.8%	14.4%
8	050500090302	Headwaters Spruce Fork	49.3	124.4	173.7	6.4	16.1	22.4	12.9%	12.9%	12.9%
9	050500090501	Big Horse Creek	34.4	78.2	112.7	6.1	8.3	14.3	17.7%	10.5%	12.7%
10	050500060201	Headwaters Cabin Creek	32.8	79.7	112.6	4.8	8.5	13.3	14.7%	10.6%	11.8%
11	050901020201	Kiah Creek	33.4	77.7	111.2	6.0	5.9	11.9	18.0%	7.6%	10.7%
12	050500090402	West Fork	41.4	99.6	140.9	3.4	11.2	14.6	8.2%	11.2%	10.4%
13	050500070502	Lilly Fork	34.4	68.4	102.8	3.3	7.2	10.5	9.5%	10.5%	10.2%
14	050500070901	Leatherwood Creek-Elk River	54.4	114.5	169.0	6.4	10.6	16.9	11.7%	9.2%	10.0%
15	050701010402	Island Creek	63.6	141.5	205.0	7.9	11.3	19.2	12.5%	8.0%	9.4%
16	050702010401	Headwaters Pigeon Creek	58.8	135.6	194.5	6.5	11.6	18.1	11.1%	8.6%	9.3%
17	050500090602	Laurel Creek	46.4	124.5	170.9	6.3	9.6	15.9	13.6%	7.7%	9.3%
18	050500090404	Lower Pond Fork	36.2	82.6	118.7	3.3	7.7	11.0	9.3%	9.3%	9.3%
19	050500090301	Spruce Laurel Fork	28.2	80.2	108.4	3.6	6.4	9.9	12.6%	7.9%	9.2%
20	050701010505	Buffalo Creek	42.9	106.6	149.6	4.3	9.2	13.6	10.1%	8.7%	9.1%
21	050500090101	Headwaters Clear Fork	62.9	84.9	147.8	6.6	6.7	13.3	10.5%	7.9%	9.0%
22	050500090204	Lower Marsh Fork	37.3	89.3	126.6	2.0	9.1	11.1	5.3%	10.2%	8.8%
23	050500060304	Boomer Branch-Kanawha River	27.9	49.6	77.5	2.0	4.1	6.1	7.3%	8.2%	7.9%
24	050701010508	Dingess Run-Guyandotte River	31.2	75.7	106.9	2.2	5.8	8.0	7.0%	7.7%	7.5%
25	050500060306	Hughes Creek-Kanawha River	44.5	93.9	138.4	3.6	6.0	9.6	8.0%	6.4%	6.9%
26	050701010502	Gilbert Creek	33.2	70.1	103.3	2.8	4.3	7.0	8.3%	6.1%	6.8%
27	050701010401	Copperas Mine Fork	46.2	110.3	156.5	5.2	4.1	9.3	11.2%	3.7%	6.0%
28	050500070201	Headwaters Laurel Creek	33.3	71.9	105.2	2.9	3.3	6.2	8.7%	4.6%	5.9%
29	050702010403	Outlet Pigeon Creek	46.2	125.0	171.2	3.2	6.8	10.0	6.9%	5.4%	5.8%
30	050702010312	Sycamore Creek-Tug Fork	25.3	54.3	79.6	2.2	2.4	4.6	8.7%	4.4%	5.8%
31	050500050809	Rich Creek-Gauley River	38.5	89.6	128.1	2.0	5.2	7.2	5.2%	5.8%	5.6%
32	050702010201	South Fork Tug Fork-Tug Fork	63.3	100.8	164.1	3.4	5.7	9.1	5.3%	5.7%	5.5%
33	050500050802	Headwaters Muddlety Creek	46.2	88.3	134.5	2.9	4.4	7.3	6.2%	5.0%	5.4%
34	050500090603	Joes Creek-Big Coal River	53.9	128.9	182.8	2.7	6.5	9.2	5.0%	5.0%	5.0%
35	050901020101	Upper West Fork Twelvepole Creek	45.5	114.3	159.8	4.5	3.4	7.8	9.9%	2.9%	4.9%
36	050500090401	Upper Pond Fork	32.4	71.8	104.3	0.4	4.6	5.0	1.1%	6.4%	4.8%
37	050702010402	Laurel Fork	31.1	79.2	110.2	2.0	3.2	5.2	6.5%	4.1%	4.7%
38	050500050807	Outlet Peters Creek	34.7	54.5	89.2	1.9	1.8	3.8	5.6%	3.4%	4.3%

	HUC_12	HU_12_NAME	streams in HUC (miles)			streams loss (miles)			percent loss		
			i	p	total	i	p	total	i	p	total
39	050702010204	Sandlick Creek-Tug Fork	60.7	99.0	159.7	3.7	2.9	6.6	6.1%	2.9%	4.1%
40	050701010302	Pinnacle Creek	69.6	143.6	213.2	4.2	4.6	8.8	6.1%	3.2%	4.1%
41	050901020202	Upper East Fork Twelvepole Creek	60.4	136.4	196.7	3.8	4.3	8.0	6.2%	3.1%	4.1%
42	050702010203	Outlet Elkhorn Creek	46.1	81.7	127.9	2.4	2.7	5.1	5.2%	3.3%	4.0%
43	050500050801	Big Beaver Creek	61.9	99.6	161.5	4.0	2.4	6.4	6.5%	2.4%	4.0%
44	050702010601	Marrowbone Creek	23.0	55.1	78.1	1.6	1.4	3.0	6.9%	2.6%	3.9%
45	050500050702	Outlet Twentymile Creek	56.8	130.7	187.5	3.4	3.8	7.1	5.9%	2.9%	3.8%
46	050500090102	Outlet Clear Fork	38.6	62.6	101.2	1.4	2.4	3.8	3.6%	3.9%	3.8%
47	050702010308	Beech Creek-Tug Fork	33.6	63.6	97.2	1.7	1.7	3.5	5.2%	2.7%	3.6%
48	050701010202	Headwaters Clear Fork	50.1	88.1	138.1	1.7	3.3	4.9	3.3%	3.7%	3.6%
49	050500070401	Upper Birch River	53.9	113.2	167.1	2.0	3.7	5.7	3.8%	3.2%	3.4%
50	050500060202	Outlet Cabin Creek	36.9	91.0	127.9	1.9	2.3	4.2	5.1%	2.5%	3.3%
51	050500070202	Outlet Laurel Creek	36.9	87.4	124.3	1.5	2.3	3.8	4.0%	2.6%	3.0%
52	050500090606	Fork Creek-Big Coal River	34.3	86.7	121.1	1.3	2.3	3.7	3.8%	2.7%	3.0%
53	050701010503	Big Cub Creek-Guyandotte River	57.8	115.4	173.2	2.4	2.9	5.2	4.1%	2.5%	3.0%
54	050701010305	Indian Creek	50.5	107.5	158.0	3.2	1.5	4.7	6.4%	1.4%	3.0%
55	050500060103	Long Branch-Paint Creek	38.3	80.8	119.1	0.9	2.6	3.5	2.4%	3.2%	3.0%
56	050701010506	Elk Creek-Guyandotte River	53.2	102.4	155.6	1.5	3.0	4.5	2.9%	2.9%	2.9%
57	050701010504	Huff Creek	56.3	121.5	177.8	2.2	2.9	5.1	4.0%	2.3%	2.9%
58	050500060404	Campbells Creek	45.4	95.3	140.7	2.2	1.8	4.0	4.8%	1.9%	2.9%
59	050702010506	Miller Creek-Tug Fork	55.6	133.6	189.3	2.1	3.2	5.3	3.7%	2.4%	2.8%
60	050500060403	Fields Creek-Kanawha River	31.3	80.7	112.1	1.2	1.9	3.0	3.7%	2.3%	2.7%
61	050200030308	Scotts Run-Monongahela River	43.2	84.2	127.4	1.0	2.4	3.4	2.3%	2.9%	2.7%
62	050702010101	Big Creek	46.7	79.5	126.1	1.5	1.9	3.3	3.1%	2.3%	2.6%
63	050702010311	Mate Creek	19.9	37.1	57.0	0.6	0.9	1.5	3.2%	2.3%	2.6%
64	050500090604	Drawdy Creek-Big Coal River	39.7	112.6	152.2	1.5	2.5	4.0	3.8%	2.2%	2.6%
65	050500060402	Lens Creek	18.7	46.3	65.0	0.9	0.7	1.6	5.0%	1.5%	2.5%
66	050701010203	Outlet Clear Fork	51.5	82.7	134.2	1.7	1.7	3.4	3.2%	2.0%	2.5%
67	050500090502	Upper Little Coal River	69.1	160.3	229.4	2.6	2.8	5.4	3.8%	1.7%	2.4%
68	050701010303	Cabin Creek-Guyandotte River	40.3	88.3	128.6	0.4	2.6	3.0	1.1%	2.9%	2.3%
69	050500060302	Armstrong Creek	22.5	49.7	72.2	0.3	1.2	1.5	1.4%	2.4%	2.1%
70	050702010303	Long Branch-Tug Fork	39.4	85.2	124.5	1.2	1.2	2.4	3.0%	1.4%	1.9%
71	050200050104	Miracle Run	23.3	57.8	81.1	0.4	1.1	1.5	1.6%	2.0%	1.9%
72	050702010310	Blackberry Creek-Tug Fork	39.3	91.1	130.5	1.1	1.3	2.4	2.7%	1.5%	1.8%
73	050200030301	Paw Paw Creek	40.2	103.5	143.7	0.8	1.7	2.5	2.0%	1.7%	1.8%
74	050200010705	Hackers Creek-Tygart Valley River	39.7	78.5	118.2	0.5	1.4	2.0	1.3%	1.8%	1.7%
75	050702010208	Horse Creek-Tug Fork	47.8	90.9	138.7	0.5	1.7	2.2	1.1%	1.9%	1.6%
76	050500060305	Kellys Creek	29.7	56.8	86.5	0.4	1.0	1.4	1.4%	1.7%	1.6%
77	050500060101	Packs Branch-Paint Creek	81.3	110.3	191.5	1.9	1.1	3.0	2.3%	1.0%	1.6%

	HUC_12	HU_12_NAME	streams in HUC (miles)			streams loss (miles)			percent loss		
			i	p	total	i	p	total	i	p	total
78	050200030309	West Run-Monongahela River	45.9	91.7	137.6	1.1	1.0	2.1	2.4%	1.1%	1.6%
79	050701010201	Laurel Fork	81.8	135.4	217.2	1.6	1.7	3.4	2.0%	1.3%	1.5%
80	050702010301	Bull Creek-Tug Fork	29.3	52.2	81.5	0.8	0.4	1.2	2.7%	0.8%	1.5%
81	050500060102	Plum Orchard Lake-Paint Creek	44.8	54.8	99.5	1.0	0.4	1.4	2.2%	0.7%	1.4%
82	050500070501	Headwaters Buffalo Creek	40.1	97.3	137.4	1.1	0.7	1.8	2.8%	0.7%	1.3%
83	050500090503	Lower Little Coal River	27.1	62.5	89.6	0.3	0.8	1.2	1.3%	1.3%	1.3%
84	050500090201	Stephens Lake	39.5	61.0	100.5	0.8	0.5	1.2	2.0%	0.8%	1.2%
85	050701010101	Tommy Creek	71.1	135.5	206.6	1.1	1.4	2.5	1.6%	1.0%	1.2%
86	050701010306	Turkey Creek-Guyandotte River	48.5	114.2	162.6	0.6	1.3	1.9	1.3%	1.1%	1.2%
87	050500050804	Panther Creek-Gauley River	63.0	113.4	176.3	1.0	1.0	2.0	1.5%	0.9%	1.1%
88	050500060401	Witcher Creek	23.8	50.5	74.3	0.3	0.5	0.8	1.3%	1.1%	1.1%