SPATIAL ANALYSIS OF COAL MINING IMPACTS ON EASTERN KENTUCKY WATERSHEDS
Downstream Strategies provides science, research, and tools to organizations, businesses, and agencies. We offer clients an alternative to mainstream environmental consulting by combining sound interdisciplinary skills with a core belief in the importance of protecting the environment and linking economic development with natural resource stewardship.

The Kentucky Waterways Alliance (KWA) is a nonprofit, membership organization recognized as tax exempt under Section 501 (c)(3) of the Internal Revenue Code. KWA is a statewide organization dedicated to protecting and restoring the waters of the Commonwealth. KWA represents many members and affiliate organizations united to insure high quality water resources in Kentucky for diverse recreational activities such as swimming, boating, and fishing as well as reliable drinking water supplies and biological habitat.

This project was made possible in part by a grant from The Clean Water Network

The Clean Water Network (CWN) is a coalition of more than 1,200 public interest organizations across the country, representing more than 5 million people working together to strengthen and implement federal clean water and wetland policy.
TABLE OF CONTENTS

1. INTRODUCTION .............................................................................................................................................. 5
2. DATA ................................................................................................................................................................... 6
3. METHODS .......................................................................................................................................................... 7
4. RESULTS ............................................................................................................................................................ 8
5. RECOMMENDATIONS .................................................................................................................................. 10

APPENDIX A: DATA ............................................................................................................................................... 11
  INTRODUCTION ........................................................................................................................................................ 11
  STREAMS AND WATERSHEDS ................................................................................................................................... 11
  MINING DATA .......................................................................................................................................................... 11

APPENDIX B: METHODS ...................................................................................................................................... 13
  INTRODUCTION ........................................................................................................................................................ 13
  DATA PREPARATION FOR ANALYSIS ........................................................................................................................ 13
  INTERSECTION OF WATERSHED BOUNDARIES AND STREAMS WITH MINING DATA .................................................. 14

APPENDIX C: MAPS .............................................................................................................................................. 15
  I. Minimum and Maximum Mine Impact Area in all HUC 6 Watersheds
  II. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Upper Cumberland Watershed
  III. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Middle Ohio – Raccoon Watershed
  IV. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Licking Watershed
  V. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Kentucky Watershed
  VI. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Big Sandy Watershed
  VII. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Upper Cumberland Watershed
  VIII. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Middle Ohio – Raccoon Watershed
  IX. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Licking Watershed
  X. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Kentucky Watershed
  XI. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Big Sandy Watershed
  XII. Greater than 50% Stream Impact in HUC 14 Watershed - Estimated Maximum Impact in all HUC 6 Watersheds
LIST OF TABLES

Table 1: Summary Results by Watershed ................................................................. 8
Table 2: Summary Results by Watershed Percentage (shown as a percentage of totals) ........ 8
Table 3: Greater than 50% Impact to Streams per HUC 14 watershed .......................... 9

LIST OF FIGURES

Figure 1: Study Area ................................................................................................. 5
Figure 2: Analysis Data ............................................................................................. 6
Figure 3: Mining Impact Data in Study ..................................................................... 6
Figure 4: Impacted streams symbolized by HUC 14 boundaries in the Big Sandy Watershed ...... 7

ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUC</td>
<td>Hydrologic Unit Code</td>
</tr>
<tr>
<td>NHD</td>
<td>National Hydrography Dataset</td>
</tr>
<tr>
<td>OSM</td>
<td>Office of Surface Mining</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>KOMSL</td>
<td>Kentucky Office of Mine Safety and Licensing</td>
</tr>
<tr>
<td>KYDR</td>
<td>Kentucky Department of Revenue</td>
</tr>
<tr>
<td>KYGEONET</td>
<td>Kentucky Division of Geographic Information</td>
</tr>
<tr>
<td>PEIS</td>
<td>Programmatic Environmental Impact Statement</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

Surface coal mining has historically been and continues to be a prevalent industry in the eastern coalfields of Kentucky. Surface mining methods of coal extraction impact the land, air, water, watersheds, local communities and public health.

The Mountaintop Mining/Valley Fills in Appalachia: Final Programmatic Environmental Impact Statement (PEIS) concluded that mountaintop mining and valley fill operations have significantly impacted eastern Kentucky’s waterways and landscape. Kentucky has the distinction of having 60% of the direct stream impacts associated with mountaintop mining and valley fill operations in Appalachia. When the valley fill inventory is evaluated in terms of calculated miles of streams buried under valley fills, generally headwater streams; Kentucky again has the distinction of having the most in Appalachia. The miles of headwater streams being filled in Kentucky are approximately 1.5 times greater than any other state in Appalachia. As continuous Integrated Reports to Congress on Water Quality in Kentucky clearly indicate, Kentucky has not adequately protected the water resources of eastern Kentucky from the degrading impacts associated with mountaintop coal mining operations.

When overburden is cleared or the surface is impacted in order to extract coal, those impacts to the watershed can be calculated based on area and proximity to certain sensitive features. Using publicly accessible data, this report uses GIS to model, quantify, and report those impacts.

Figure 1: Study Area
2. DATA

Figure 2: Analysis Data

Stream networks and Hydrologic Unit Code (HUC) 14 boundaries have been drawn from the National Hydrography Dataset (NHD). The above graphics illustrate these data layers for the Big Sandy watershed. Surface mining data, shown in the third graphic, has been compiled by combining geographic information system (GIS) datasets from three agencies: the federal Office of Surface Mining (OSM), the Kentucky Office of Mine Safety and Licensing (KOMSL), and the Kentucky Department of Revenue (KYDR).

Figure 3: Mining Impact Data in Study
3. METHODS

Using these data layers, GIS software (ARCMAP 9.2, ESRI) was used to calculate the minimum and maximum cumulative impacts of past and present surface mining on streams and land at various watershed scales. The following two graphics, for example, use color shading to illustrate the percent of impacted stream length and the percent of impacted land area for each HUC 14 subwatershed in the Big Sandy watershed.

Percent of stream impacts was calculated based on the total length of streams within each HUC 14 subwatershed. In addition, total acreage within a HUC 14 watershed boundary was also calculated, therefore determining percentage of impacted areas. This method of analysis presents a cumulative effect of stream and land impacts within a given watershed.

More detailed information on data sources and analysis techniques are outlined in the Data and Methods section of the Appendix.

Figure 4: Impacted streams symbolized by HUC 14 boundaries in the Big Sandy Watershed
4. RESULTS

The tables listed below identify the impacts to streams and land. Each major (HUC 6) watershed is listed in a table by the minimum and the maximum amount of impact. Maps provided in Appendix C display a variety of ways to graphical depict the impacts and results.

Table 1: Summary Results by Watershed

<table>
<thead>
<tr>
<th>HUC 6 Watershed (with HUC 6 ID Number)</th>
<th>Minimum Impact Area (Acres)</th>
<th>Maximum Impact Area (Acres)</th>
<th>Minimum Stream Impact (Miles)</th>
<th>Maximum Stream Impact (Miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Sandy-Guyandotte-050702</td>
<td>71,289</td>
<td>227,221</td>
<td>41</td>
<td>72</td>
</tr>
<tr>
<td>Cumberland-051301</td>
<td>26,963</td>
<td>126,905</td>
<td>23</td>
<td>51</td>
</tr>
<tr>
<td>Licking-051001</td>
<td>4,335</td>
<td>13,219</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Kentucky-051002</td>
<td>84,179</td>
<td>225,460</td>
<td>46</td>
<td>80</td>
</tr>
<tr>
<td>Middle Ohio-050901</td>
<td>4,530</td>
<td>4,725</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 2: Summary Results by Watershed Percentage (shown as a percentage of totals)

<table>
<thead>
<tr>
<th>HUC 6 Watershed</th>
<th>Minimum Impact Area</th>
<th>Maximum Impact Area</th>
<th>Minimum Stream Impact</th>
<th>Maximum Stream Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Sandy-Guyandotte-050702</td>
<td>4.9%</td>
<td>15.5%</td>
<td>1.0%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Cumberland-051301</td>
<td>0.8%</td>
<td>3.8%</td>
<td>0.3%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Licking-051001</td>
<td>0.2%</td>
<td>0.7%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Kentucky-051002</td>
<td>3.5%</td>
<td>9.5%</td>
<td>0.6%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Middle Ohio-050901</td>
<td>0.6%</td>
<td>0.6%</td>
<td>0.2%</td>
<td>0.2%</td>
</tr>
</tbody>
</table>
Listed in the following table are the HUC 14 subwatersheds within the larger HUC 8 and HUC 6 watersheds that have a greater than 50% impact to streams based on the maximum mine impact dataset. Also listed in the table are the minimum and maximum surface impacts to each subwatershed. The table illustrates the correlation between the data quality and the impact results. Cells highlighted in red are greater than 50% impacted by the maximum mine impact and the minimum impact is within 30% of the maximum impact. This correlation helps define the potential for actual impact to land and streams. Conversely, the data illustrate the discrepancies between the minimum and maximum impact data sets. For example, Stonecoal Branch has a maximum land impact of 94.1%, but only a 2.2% minimum impact. The overview highlights the limitations of the data analysis and the need for refined mining information and spatial data.

Table 3: Greater than 50% Impact to Streams per HUC 14 watershed

<table>
<thead>
<tr>
<th>HUC 6 Watershed</th>
<th>HUC 8 Watershed</th>
<th>HUC 14 Watershed</th>
<th>Minimum Impact Area</th>
<th>Maximum Impact Area</th>
<th>Minimum Stream Impact</th>
<th>Maximum Stream Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Sandy</td>
<td>Tug, Kentucky, Virginia, West Virginia.</td>
<td>Left Fork of Petercavé Fork</td>
<td>25.1%</td>
<td>72.7%</td>
<td>92.1%</td>
<td>92.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pawpaw Creek</td>
<td>7.2%</td>
<td>79.7%</td>
<td>37.3%</td>
<td>68.1%</td>
</tr>
<tr>
<td></td>
<td>Upper Levisa, Kentucky, Virginia.</td>
<td>Grape Branch</td>
<td>26.8%</td>
<td>48.9%</td>
<td>52.7%</td>
<td>63.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Doty Branch</td>
<td>2.2%</td>
<td>83.8%</td>
<td>0.0%</td>
<td>55.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long Branch</td>
<td>69.9%</td>
<td>72.2%</td>
<td>75.0%</td>
<td>75.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stonecoal Branch</td>
<td>2.2%</td>
<td>94.1%</td>
<td>0.0%</td>
<td>56.6%</td>
</tr>
<tr>
<td>Kentucky</td>
<td>North Fork Kentucky, Kentucky.</td>
<td>Hurricane Branch</td>
<td>43.9%</td>
<td>83.5%</td>
<td>49.4%</td>
<td>67.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Left Fork of Elk Fork</td>
<td>9.3%</td>
<td>82.7%</td>
<td>0.0%</td>
<td>50.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Little Creek</td>
<td>3.8%</td>
<td>94.6%</td>
<td>16.4%</td>
<td>54.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quillen Fork</td>
<td>0.3%</td>
<td>97.5%</td>
<td>0.0%</td>
<td>69.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Right Fork of Clover Fork</td>
<td>20.4%</td>
<td>73.6%</td>
<td>64.1%</td>
<td>64.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Left Fork of Lewis Creek</td>
<td>32.2%</td>
<td>80.5%</td>
<td>25.0%</td>
<td>53.2%</td>
</tr>
<tr>
<td>Upper Cumberland</td>
<td>Upper Cumberland. Kentucky, Tennessee.</td>
<td>Gap Branch</td>
<td>0.0%</td>
<td>85.8%</td>
<td>0.0%</td>
<td>68.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Right Fork of Cranks Creek</td>
<td>0.0%</td>
<td>94.7%</td>
<td>0.0%</td>
<td>51.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wieser Branch</td>
<td>0.7%</td>
<td>69.6%</td>
<td>3.8%</td>
<td>50.5%</td>
</tr>
</tbody>
</table>
5. RECOMMENDATIONS

This analysis was performed in the eastern coalfields of Kentucky to gain a greater understanding of the amount of surface damage and stream impacts that are caused by surface mining activities. The analysis utilized the best publicly available data. Data gaps, lack of detailed metadata, and spatial accuracy are all data limitations that can have an undesired affect on analysis results.

The data provide an overview of community impacts of surface mining in the eastern coalfields of Kentucky. The power of this research lies within the detailed examination of resources in a given watershed. In addition to the data tables and maps provided in this report, geo-spatial data has been generated to provide the ability to analyze impacts within specific streams and watersheds in the future.
APPENDIX A: DATA

Introduction

The data used in this analysis came from varying sources, from the federal to the state level. All the datasets were created by the given government agency, as detailed in the following sections. No data were created or digitized for the purpose of this analysis.

Streams and Watersheds

A. Streams. Streams used for the GIS analysis from the USGS National Hydrography High Resolution Dataset (NHD) ([http://nhd.usgs.gov/](http://nhd.usgs.gov/)) on March 25, 2008. Stream data were extracted from this dataset, using 1:24,000 or 1:12,000-scale data (the NHD flowline component of the dataset). NHD standards can be found at [http://mapping.usgs.gov/standards/](http://mapping.usgs.gov/standards/). Streams were then clipped based on watershed and subwatershed boundaries. No other modifications were made to the stream data. The data reported here include intermittent and perennial streams as well as NHD “connector” and NHD “artificial path” segments.

B. Watersheds. The watershed boundaries were downloaded from the Kentucky Division of Geographic Information (KYGEONET) ([http://kygeonet.ky.gov/](http://kygeonet.ky.gov/)) on March 25, 2008. The HUC 14 watershed boundaries were extracted from the HUC 14 data layer in the KYGEONET geodatabase.

Mining Data

A. Mined Out Areas. Composite Mined Out Areas in NAD83 Single Zone State Plane (KY1Z) were downloaded from the Kentucky Mine Mapping Information System (KYMMIS) ([http://minemaps.ky.gov/ftpdownload.htm?image.x=59&image.y=34](http://minemaps.ky.gov/ftpdownload.htm?image.x=59&image.y=34)) on March 25, 2008. The metadata that accompanied the dataset are limited. According to KOMSL staff, the data was created from existing mine maps scanned and georeferenced by the KOMSL office, then sent to KYDR, where that staff digitized the GIS data and made it available to the public via the KYMMIS website. Only mined areas have been digitized, broken down by the type of mining activity: surface, auger, or underground. The data type field also lists a significant amount of unknown mining types; according to the KYDMP, no effort by the KYMMIS, KOMSL or the KYDR is being made to update the unknown status. This dataset was created to show areas that have been mined, so exploration opportunities can be investigated in the future.

1. Mined Out Areas from surface mines (not including Unknown type of mining). As stated above the Mined Out Areas dataset lists several types of mining activities. For analysis purposes, a subset of these data that includes only the surface and auger mining activities were created. This dataset represents the minimum amount of surface mining activity from this dataset that would have taken place.
2. **Mined Out Areas from surface mines (including Unknown type of mining).** A second subset of data was created that includes the surface, auger, and unknown mining activities. This dataset represents the maximum amount of surface mining activity from this dataset that would have taken place.

**B. Valley Fill Areas.** After discussions with KOMSL staff on November 9, 2007, this project was directed to the regional Office of Surface Mining (OSM) in Lexington, Kentucky. The OSM had additional valley fill data that were used in various reports. On November 10, 2007, OSM supplied the data via a mailed CD. These valley fills are all known to be associated with surface mines. The data are digitized polygons of valley fill areas in Kentucky. OSM staff stated that the data was used in the “Mountaintop Mining/Valley Fills in Appalachia: Final Programmatic Environmental Impact Statement (Final PEIS)” report. ([http://www.epa.gov/region3/mntn/index.htm](http://www.epa.gov/region3/mntn/index.htm)).
APPENDIX B: METHODS

Introduction

The methods described here utilized ArcGIS standard toolsets. These toolsets and models are listed in this section and help explain the processes with which the analysis was undertaken.

Data Preparation for Analysis

The data that were used for the analysis were reformatte to ensure quality reporting. The preparation and data reformattion are listed below.

A. **Mining data.** As stated earlier, the mined out datasets had a type field which indicated mining activity status for each digitized polygon. The type field was queried to exclude any underground mining activity. However, there are a significant amount of “unknown” data types. Two datasets were created from the single data source. In addition, the valley fill data were merged with the mined out areas data set to create a single data set of surface mining activity. Listed below are the final two datasets used in the analysis.

1. **Mining impact minimum**: This dataset combines the mined out areas from surface mining (not including unknown type of mining) dataset with the valley fill areas dataset. This dataset represents the minimum amount of surface mining activity that would have taken place in the watershed.

2. **Mining impact areas maximum**: This dataset combines the mined out areas from surface mining (not including unknown type of mining) dataset with the valley fill areas dataset. This dataset represents the maximum amount of surface mining activity that would have taken place in the watershed.

![Mined out areas minimum](#)

![Raw Data](#)

![Mined out areas maximum](#)

Yellow: Mined out areas excluding unknowns and underground types
Orange: Mined out areas including unknowns and excluding underground
Green: Valley fill data
3. Streams and watersheds. The data were reviewed to ensure a broad level of quality assurance and to make the analysis easier for reporting. To ensure that each reach is unique and no miscalculation of reach length occurred, the length field was dissolved so that each reach code was unique to the dataset. A recalculation of stream length and watershed area was completed to ensure a consistency of measurement with the analysis.

Intersection of Watershed Boundaries and Streams with Mining Data

A. Stream impacts. Impacts were calculated by intersecting the two mining data sets with the stream network. The resulting intersected dataset provided stream impact length, which was used to derive the percentage of impacted reaches and the ability to summarize the data by HUC 14 subwatershed areas.

B. Land impacts. Impacts were calculated by intersecting the two mining data sets with the HUC 14 boundaries. The resulting intersected dataset provided land acreage impact, which was used to derive percentage of surface impact to HUC 14 subwatershed areas.
APPENDIX C: MAPS

I. Minimum and Maximum Mine Impact Area in all HUC 6 Watersheds

II. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Upper Cumberland Watershed

III. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Middle Ohio – Raccoon Watershed

IV. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Licking Watershed

V. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Kentucky Watershed

VI. Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Big Sandy Watershed

VII. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Upper Cumberland Watershed

VIII. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Middle Ohio – Raccoon Watershed

IX. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Licking Watershed

X. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Kentucky Watershed

XI. Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed) in the Big Sandy Watershed

XII. Greater than 50% Stream Impact in HUC 14 Watershed - Estimated Maximum Impact in all HUC 6 Watersheds
Middle Ohio-Raccoon Watershed

Eastern Coalfields of Kentucky Mine Impact Analysis

Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed)

Percent of Stream Impacts
- Less than 1% - 3%
- 4% - 10%
- 11% - 23%
- 24% - 46%
- 47% - 92%
- No Impact

HUC 6 Boundary
HUC 14 Boundary

*Refer to supplementary report for data source and explanation

Prepared by Downstream Strategies - GIS Solutions
Kentucky Watershed

Eastern Coalfields of Kentucky Mine Impact Analysis

Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed)

*Refer to supplementary report for data source and explanation

Prepared by Downstream Strategies - GIS Solutions
Big Sandy Watershed

Estimated Maximum Impact to Streams (Percent Impact in HUC 14 Watershed)

*Refer to supplementary report for data source and explanation

Percent of Stream Impacts:
- Less than 1% - 3%
- 4% - 10%
- 11% - 23%
- 24% - 46%
- 47% - 92%
- No Impact

HUC 6 Boundary
HUC 14 Boundary

Prepared by Downstream Strategies - GIS Solutions
Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed)

- Less than 1% - 4%
- 5% - 11%
- 12% - 22%
- 23% - 40%
- 41% - 92%
- No Impact

*Refer to supplementary report for data source and explanation.

Prepared by Downstream Strategies - GIS Solutions
Kentucky Watershed

Eastern Coalfields of Kentucky Mine Impact Analysis

Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed)

Percent of Stream Impacts:
- Less than 1% - 4%
- 5% - 11%
- 12% - 22%
- 23% - 40%
- 41% - 92%
- No Impact

HUC 6 Boundary
HUC 14 Boundary

Prepared by Downstream Strategies - GIS Solutions

*Refer to supplementary report for data source and explanation
Big Sandy Watershed

Eastern Coalfields of Kentucky Mine Impact Analysis

Estimated Minimum Impact to Streams (Percent Impact in HUC 14 Watershed)

Percent of Stream Impacts

- Less than 1% - 4%
- 5% - 11%
- 12% - 22%
- 23% - 40%
- 41% - 92%
- No Impact

HUC 6 Boundary

HUC 14 Boundary

Prepared by Downstream Strategies - GIS Solutions

*Refer to supplementary report for data source and explanation
Upper Cumberland Watershed

Eastern Coalfields of Kentucky Mine Impact Analysis

Greater than 50% Stream Impact in HUC 14 Watershed - Estimated Maximum Impact

HUC 14 Boundaries Greater than 50% Impacted

HUC 6 Boundary

HUC 14 Boundary

*Refer to supplementary report for data source and explanation

Prepared by Downstream Strategies - GIS Solutions