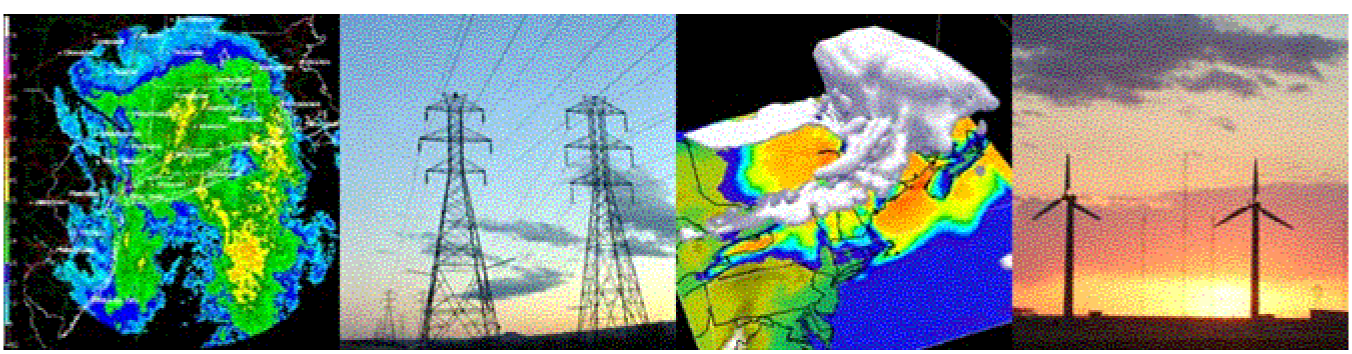
BKA Group, LLC

Effects of Terrain Modification on Local Wind Resources in the Coalfields Region of West Virginia

August 30, 2006

CONFIDENTIAL MATERIAL ENCLOSED



Prepared By:

Tony Meys
Senior Scientist
WindLogics Inc.

Patrick Heinis, M.S.
Meteorologist
WindLogics Inc.

Disclaimer: WindLogics Inc. has prepared this report based on available third party historical weather information and use of our predictive software and analysis methods. We cannot guarantee the accuracy of historical weather data. Historical weather information also does not necessarily allow accurate prediction of future weather patterns. WE ARE THEREFORE PROVIDING THIS REPORT TO YOU WITHOUT ANY EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY. Our sole responsibility is the preparation and delivery of this report. By accepting this report, you agree that our liability in any situation is limited to the amount paid for our report. In no event will we be liable for any special or consequential damages arising from use, or misuse, of our report or information in it.

Table of Contents

BKA Group, LLC
Effects of Terrain Modification on Local Wind Resources in the Coalfields Region of West Virginia

Executive Summary

1. INTRODUCTION

1.1 Study Objective
The purpose of this two-phased analysis is to gain an initial understanding of the effects that terrain modifications have on the local wind regime at 80 m above ground level (AGL). The area of study is located in southern West Virginia near the city of Whitesville. This study area (named Area 1) was selected in consultation with BKA Group, LLC in order to find the most representative region to illustrate these terrain effects. The results of the study are best used to compare the relative windiness of different areas within the prospecting domain.

1.2 Project Description
During each of the two phases of the project, the WindLogics modeling system was used to gather statistics and information covering the entire Area 1 prospecting site. Using data from the WindLogics Weather Archive, WindLogics executed detailed, twelve-month modeling processes. These complete datasets were then normalized to reflect long-term values using forty years of additional WindLogics data. Finally, these results were used to generate the conclusions and details in this report.

Phase 1 of the project called for WindLogics to perform a detailed modeling effort for Area 1 while incorporating model terrain data that encompassed year 2000 topographical detail (see Section 3.3). This topography shows the terrain as it was before mining practices had greatly altered the terrain. Within this report this phase will be referenced as Area 1A.

Phase 2 of the project called for WindLogics to perform a detailed modeling effort for Area 1 while incorporating model terrain data that encompassed year 2004 topographical detail (see Section 3.3). This topography includes areas that have been "cut down" during mining activity as well as areas that have been "filled in" with mining debris, waste, etc. Within this report this phase will be referenced as Area 1B.

2. SUMMARY OF RESULTS

2.1 Annual Wind Speed, Gross Capacity Factor and Gross Energy Production
The annual average wind speed at 80 m AGL was between 3.46 and 8.69 m/s across the area of study, corresponding to annual gross capacity factor values between 4.65 and 47.32% and annual gross energy production values between 610.70 and 6218.44 MWh for the GE 1.5SLE turbine at that hub height.

Note: All capacity factor and energy production values in this report are gross values. Net values will depend on losses from project-specific characteristics such as availability, array effects, icing, airfoil soiling, line losses, control losses and other factors.

2.3 Meteorological Overview

The wind resources in West Virginia are affected by a combination of the larger scale weather patterns and the local terrain.

During the cold season, the winds in West Virginia are driven primarily by synoptic scale weather systems (large areas of high and low pressure), which are generally steered by the upper-level, jet stream winds. These upper-level winds are generally from the west, but considerable variation in surface wind direction occurs as weather systems move through the area. During the summer, the jet stream weakens, and the weather systems have less of an impact on the wind resource. The prevailing winds are from the southwest and are driven by the circulation around the Bermuda High, which resides off the southeast coast of the United States.

The local terrain has a considerable impact on the wind resource in the region. The mountains act as a point of constriction on the flow, causing the wind to speed up at the ridge tops, but also causing the wind to slow down at upwind locations. In general, the fastest wind speeds can be found at the tops of the highest mountain ranges, which lie to the east of the modeled area. There are a number of smaller mountaintops in the modeled area, however, that likely also have locally high wind speeds. Due to the complexity of the terrain in the modeled area, it is particularly important to use fine scale modeling and tower wind measurements to characterize the wind resource.

2.4 Wind Resource Analysis – Area 1A versus 1B

The following discussion has been included to illustrate the effects that the removal of a portion of the local terrain has on the wind flow across the region. Area 1A was modeled to estimate what the wind regime would have been like before mining activity had significantly altered the terrain in the area. Figure 1 shows the topography that was included within the detailed model runs. Please note the highlighted (red circle) ridgeline and adjacent valley to the east. This ridgeline was selected for this analysis since it shows the most change between the two phases of the project. The terrain that was included within the Area 1B detailed model runs, shown in Figure 2, depicts the terrain that has been lowered due to mining practices. Note that the ridgeline that was highlighted in Figure 1 has been “cut down” by up to 120 meters while the valley directly to the east has been “filled in” by up to 65 meters (see Section 3.3 for a detailed description on how this terrain data was processed). In fact, after the terrain modifications, the area that was previously the ridgeline is at a lower elevation than the filled in valley area. Appendix A, Page 1 displays an image that shows the overall topography differences between the Area 1A and 1B model runs.

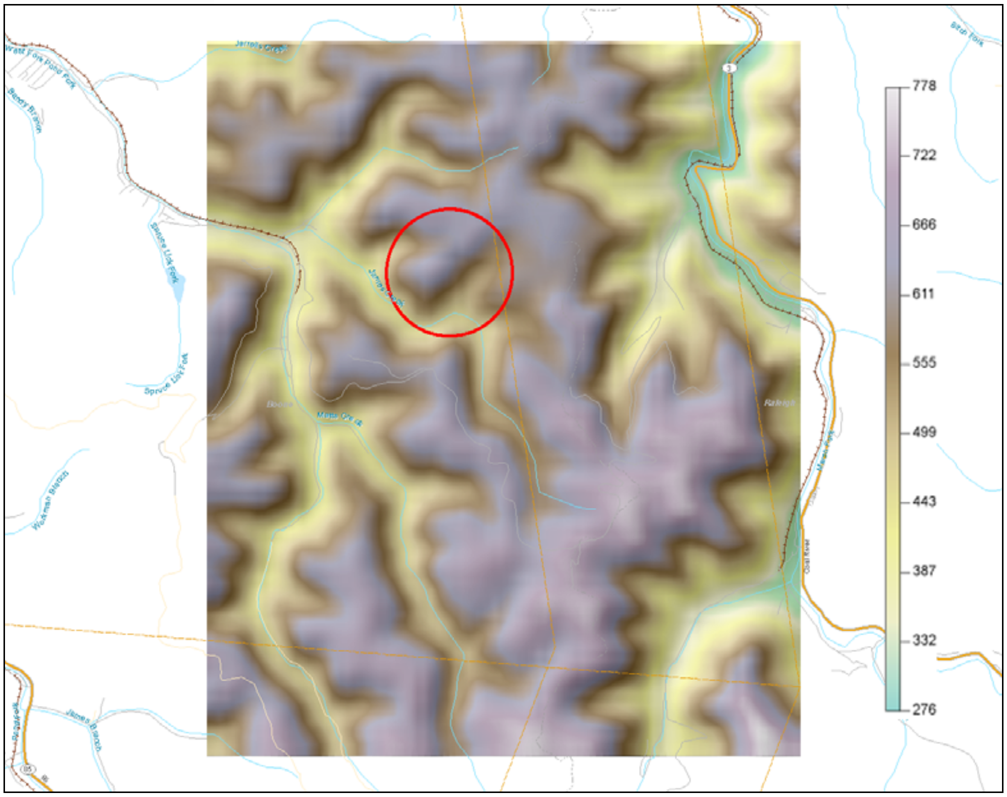


Figure 1: Area 1A terrain with highlighted ridgeline and valley. Terrain data processed based on data from 2000.

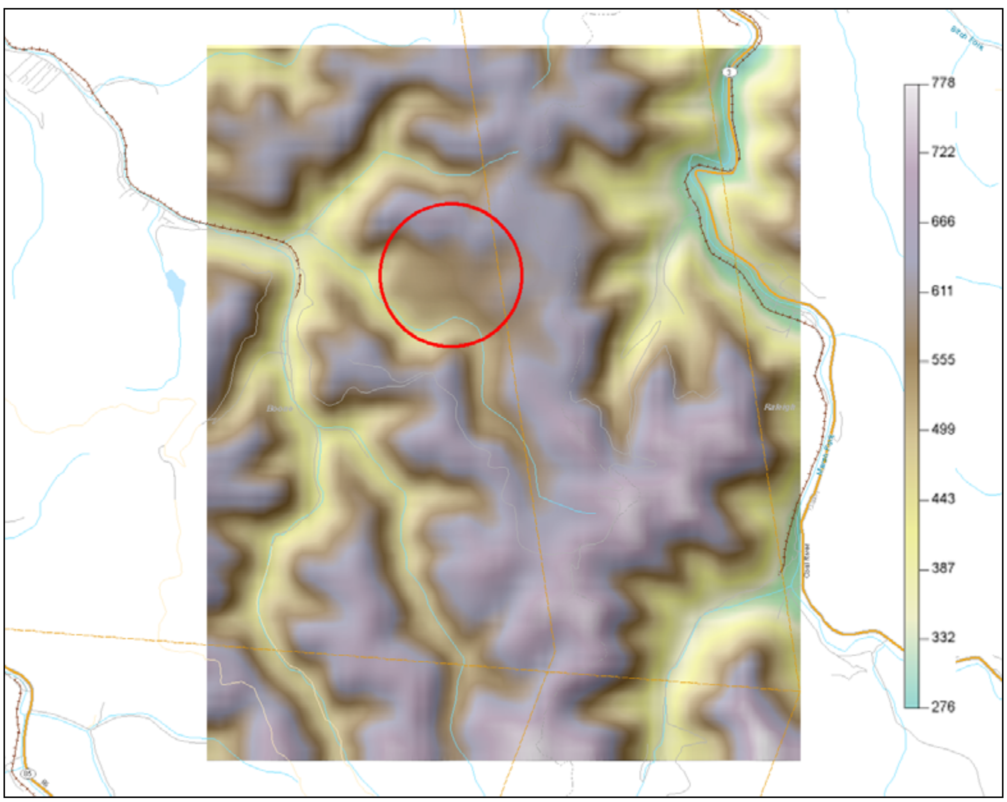


Figure 2: Area 1B terrain with highlighted ridgeline and valley. The ridgeline has been lowered while the valley to the east has been filled. Terrain data processed based on data from 2004.

The annual wind speed maps for this highlighted ridgeline show a noteworthy drop in the 80 m wind speeds in conjunction with the drop in elevation. Wind speeds on top of this ridgeline for Area 1A run between 6.6 and 7.3 m/s while the winds in the adjacent valley range from 5.0 to 5.9 m/s annually (see Figure 3). When looking at the same area for Area 1B, a large drop in wind speed is observed. The ridgeline that has been “cut down” now has wind speed values of about 6.1 m/s or about 1.2 m/s (16%) slower than the speeds shown in Area 1A (see Figure 4). The valley to the east shows an increase in wind speed values ranging from 5.9 to 6.3 m/s. The fact that the speed in the valley area is now greater than that associated with the ridgeline area is consistent with fact that the “valley” area now has a higher elevation than the former ridgeline. See Appendix A, Page 2 for an image that illustrates the overall wind speed differences between Area 1A and 1B.

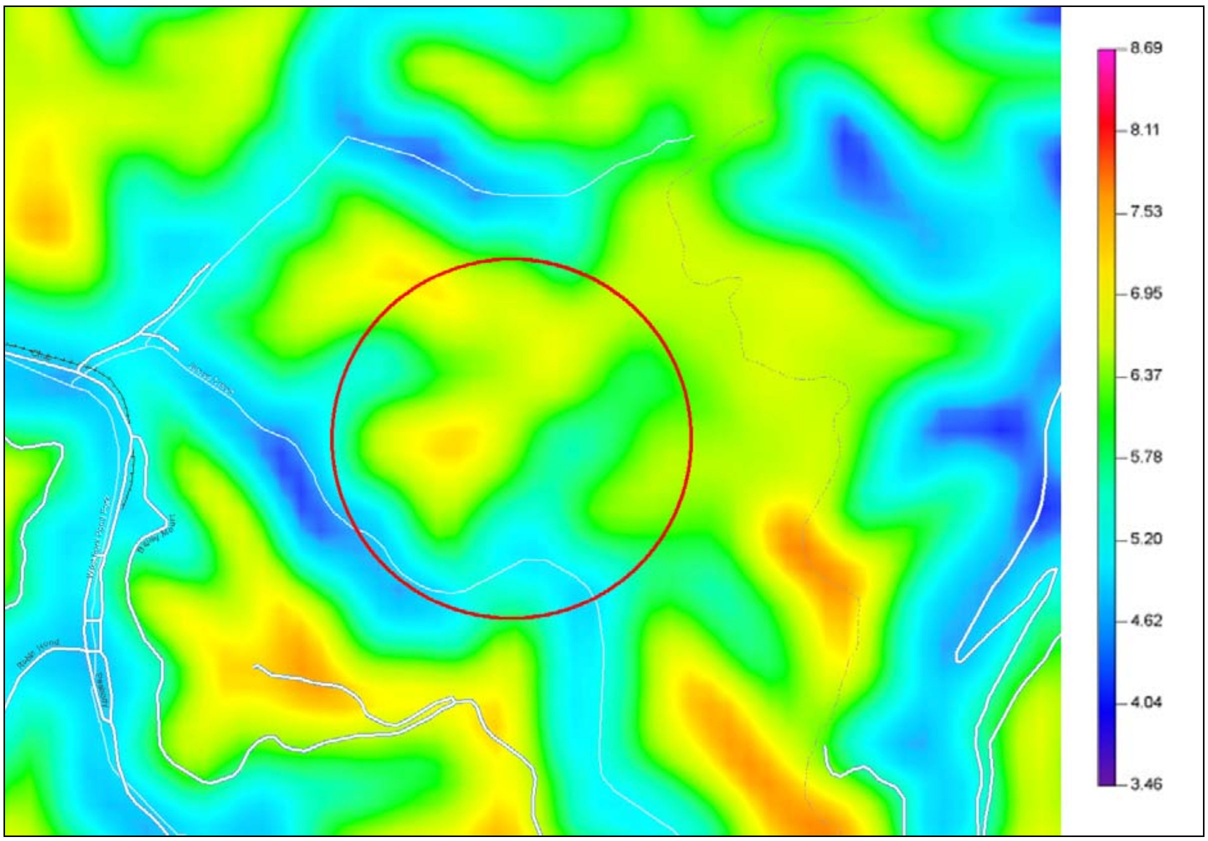


Figure 3: Area 1A ridgeline and valley wind speeds.

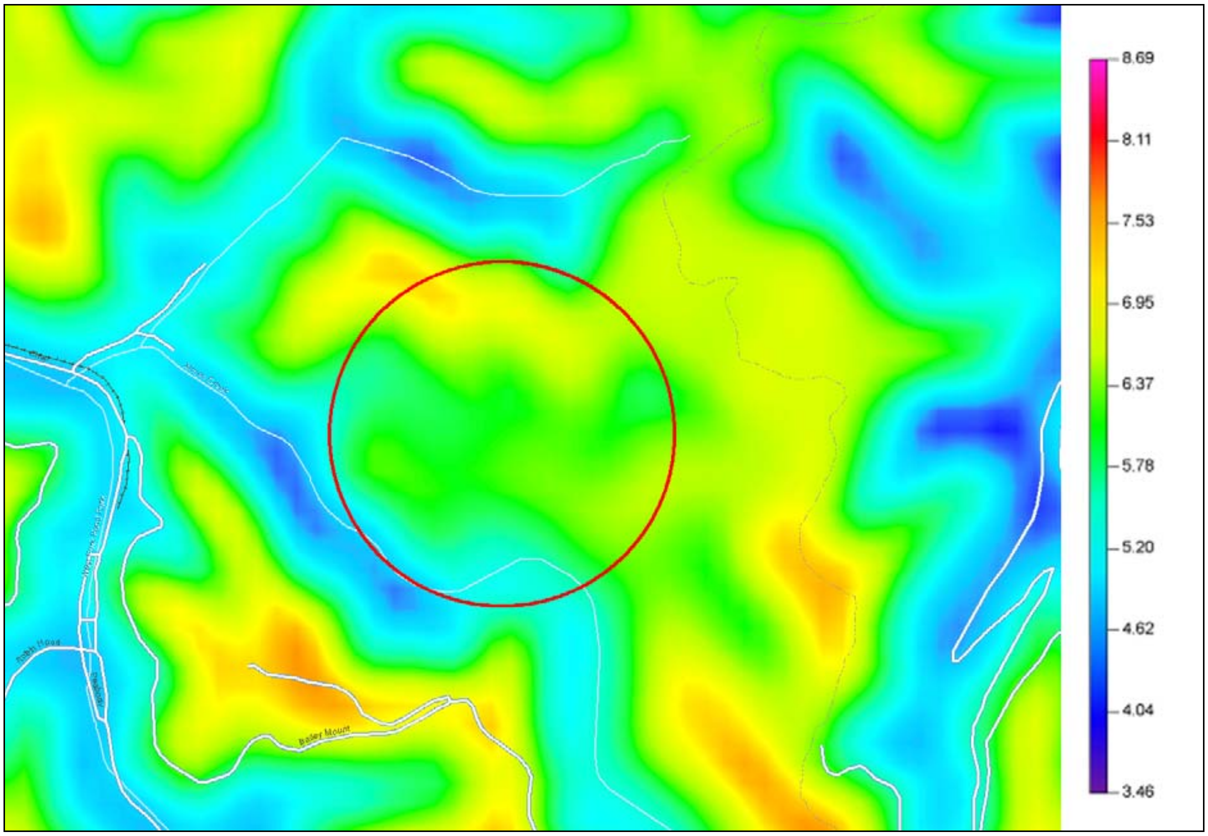


Figure 4: Area 1B "cut down" ridgeline and "filled in" valley wind speeds.

This example illustrates that the modification of the local terrain, due to mining activity, may have an impact on the wind regime in the area. The ridge that was lowered showed a 16% decrease in the 80 m wind speed values while the valley that was filled observed about an 11% increase in wind speed.

3. METHODOLOGY AND DATA

3.1 Methodology Overview

The WindLogics Weather Data archive and modeling system were used to model the wind activity of the site and generate statistics of the study region.

3.1.1 Mesoscale Modeling

The WindLogics data archives were used as input to the MM5 mesoscale modeling system with an inner grid resolution of 2 km (see Appendix B, Page 1).

3.1.2 Windfield Modeling – Area 1A

The output from the MM5 modeling was used as input to the detailed windfield modeling system consisting of a grid with a resolution of 90 m (see Appendix B, Page 2). Area 1A utilized a combination of SRTM (Shuttle Rader Topography Mission) and USGS NED (United States Geological Survey National Elevation Dataset) terrain data as its baseline topography data (see Section 3.3).

3.1.3 Windfield Modeling – Area 1B

The output from the MM5 modeling was used as input to the detailed windfield modeling system consisting of a grid with a resolution of 90 m (see Appendix B, Page 3). Area 1B utilized USGS NED terrain data as its baseline topography data (see Section 3.3).

Hourly time series were run for the entire period and statistics were accumulated on a monthly and annual basis. The results were then normalized to long-term climatic means using forty years of data from the WindLogics NCEP/NCAR Reanalysis data archive (see Section 3.6 for the long-term normalization description).

3.2 Turbine Model & Power Curve

The gross energy production results were calculated for the GE 1.5SLE turbine. The WindLogics modeling system calculates energy production using time-dependent air density and hourly wind speed values produced from the models.
Please note also:

1) The power curve used in this study was created from documentation supplied by GE (See Appendix C).
2) The standard GE power curve used in the study was modified on an hour-by-hour basis according to the air density values.
3) The WindLogics modeling process uses the standard GE power curve at 1.225 kg/m^3. Energy production is calculated using the actual air density (from the modeling process) at the site/point location for each hour in order to adjust the wind speed that is applied to the power curve for that hour.
4) The formula for the air density adjusted wind speed is: $WS*(AD/1.225)^{(1/3)}$, where WS is the modeled wind speed and AD is the modeled air density at that hour.

3.3 Topography Data Processing

In an effort to most realistically capture the effects of mining on the windiness of the area, an effort was made to use real terrain data that captured the physical landscape at two different stages of mining activity. The most available elevation datasets captured at two different time intervals in the U.S. are the SRTM dataset and the NED dataset.

The Shuttle Rader Topography Mission dataset is a global dataset that was collected over a span of 11 days in February of 2000. The data were collected by using radar interferometry from an orbiting space shuttle. This dataset has a horizontal resolution of roughly 90 meters and is vertically accurate to within 10 meters of actual terrain.

The NED dataset covers the entire continental U.S. It has been continuously maintained from 1925 to the present with updates as local survey crews and photo interpreters in various areas of the U.S. make their work available. According to the changes listed by the USGS, the last updates in West Virginia occurred in 2004. This does not necessarily imply that the NED data used in this study was current as of 2004. However, since it was apparent that mining related activity was visible in the terrain that was not in the 2000 SRTM dataset, we can safely assume that the changes made to the landscape took place over some period between 2000 and 2004. NED data has a resolution of 30 m and is vertically accurate to within 7 meters of actual terrain elevations.

To decide on an area of focus for this study, a large portion of the state of West Virginia was examined. Two criteria where necessary; 1) The focus area should show discernable and significant change to the landscape due to mining over the time period captured between the source dates of the SRTM dataset (2000) and NED dataset (~2004), and 2) The focus area should have annual average wind speeds larger than those of most of the surrounding region.

ArcGIS raster processing methods were used to determine changes in the landscape. Using grid math, the SRTM data was subtracted from the NED dataset. The resulting output showed negative and positive changes in the elevation. The most significant changes in the landscape were compared against available polygon datasets that show permitted mining areas to verify that the changes shown were most likely due to mining activity. It should be noted that for the areas chosen it is only safe to assume that during the period between 2000 and 2004 *some* mining activity occurred. It is unknown if mining began before 2000 or if mining continued after 2004. In other words, the potential change in the landscape due to mining could be greater than what was observed. This methodology only captured a snapshot of that activity over a four-year period.

Once a candidate location was chosen, preparatory raster processing of the elevation datasets for input to the wind model was done. Because the SRTM dataset and the NED dataset are somewhat different, we decided to limit the scope of the observed changes in elevation to only those areas known to be mining areas during the time span captured. We used the NED dataset as a base since it is slightly more accurate. First, the NED data was generalized from a resolution of 30 m to 90 m to match the resolution of the SRTM data. For model run 1A, data in the NED was replaced with data from SRTM for only those areas inside the above-mentioned mining polygons to represent the terrain prior to 2000 (see Appendix A, Page 1). The original, unaltered, re-scaled (to 90 m resolution) NED data was used as input for model run 1B.

3.4 Vegetative and Land Cover Data

1) WindLogics took into account several sources (satellite imagery, USGS land cover information, etc.) to assess the overall land cover of the region.
2) The land cover over the area is a mixture of dense trees and coal mining areas. A displacement height of 15 m was used for areas of deciduous forest. The displacement height was zero for all other categories.

3.5 WindLogics Archive Data for Detailed Analysis

The continuous modeling process used data from the WindLogics North American Archive, consisting of hour-by-hour assimilated weather data at a 20 km horizontal spacing between grid point columns. This data is a physics-based assimilation from many sources, both direct measurement and remote sensing (e.g. satellite) sources, and was initially created by The National Centers for Environmental Prediction (NCEP) as a starting point for their Rapid Update Cycle forecast model. It is a complete, physically-consistent matrix of the atmospheric conditions and includes wind, temperature, pressure and many other weather variables. WindLogics has collected and organized this data and now has more than six years of this North American data online.

3.6 WindLogics Weather Archive for Long-Term Normalization

WindLogics also has an online archive of more than 55 years of worldwide weather data used for normalizing the results of the mesoscale modeling to reflect long-term values and for studying the inter-annual variation of the wind resource. The National Centers for Environmental Prediction (NCEP) and National Center for Atmospheric Research (NCAR) have cooperated in this “Global Reanalysis” project to produce a retroactive record of atmospheric weather data fields in support of the needs of the research and climate monitoring communities. This effort involved the recovery of land surface, ship, rawinsonde, aircraft, satellite and other data; ensuring strict quality control of all data; and assimilating all data with a data assimilation system that is kept unchanged over the complete period. Most data fields are saved four times per day (every 6 hours) and the horizontal resolution is approximately 210 km. WindLogics has developed special technology to maintain this complete dataset online and obtain wind data from the archive at turbine hub height over the entire planet.

By characterizing the model year wind resource difference with the long-term average (forty year) at Reanalysis grid points adjacent to the study location, a ratio is obtained that is applied to the results from the WindLogics modeling process. For example, if the nearby Reanalysis grid point exhibited 5% faster monthly wind speeds (based on the model year) than the long term (forty year) average, the WindLogics modeled wind speeds over the entire grid would be decreased by 5% to adjust to the long term average.

MAP IMAGES

Extended Legend - United States Data

Appearance of base data on any map is dependent on the scale specified in each item's title and / or whether or not that data layer was specifically included in any particular map. Specific data layers may be excluded from individual maps to maintain readability of the map.

WindLogics Data Archive Points (All Scales)
- WindLogics Data Archive Points

METAR Stations (All Scales)
- METAR Stations

Transmission Lines (All Scales)

Kilovolts
- 115 - 243
- 345 - 372
- 500

Airports (1:1,500,000 - 1:200,001)
- Airport Area

Airports (>= 1:200,000)
- Runway
- Airport Area

State Boundaries (1:25,000,000 - 1:1,500,001)
- State Boundaries

State Boundaries (>= 1:500,000)
- State Boundary
- International
- Shore

County Boundaries (1:25,000,000 - 1:1,500,001)
- County Boundaries

County Boundaries (>= 1:1,500,001)
- County Boundary

Freeway System (1:50,000,000 - 1:1,500,001)
- Freeway System

Roadways (1:1,500,000 - 1:20,001)
- Limited Access
- Highway
- Major Road
- Local Road
- Minor Road
- Other Road
- Ramp
- Ferry
- Pedestrian Way

Streets (>= 1:20,000)
- Limited Access
- Highway
- Major Road
- Local Road
- Minor Road
- Other Road
- Ramp
- Ferry
- Pedestrian Way

Water (1:10,000,000 - 1:200,001)
- Lake
- Swamp or Marsh
- Reservoir
- Stream
- Glacier
- Bay or Estuary or Ocean
- Lake Intermittent
- Lake Dry
- Reservoir Intermittent
- Canal

Water (>= 1:200,000)
- Lake / Pond
- Stream / River
- Artifical Basins
- Wash
- Playa
- Glacier
- Canal / Ditch
- Complex Channels

Rivers (>= 1:1,500,000)
- Stream
- Intermittent Stream
- Canal
- Dam

National Parks (1:20,000,000 - 1:1,500,001)
- National Parks
- National Forests

Parks (>= 1:1,500,001)
- National Park or Forest
- State Park or Forest
- Local Park or Recreation Area

Landmarks (1:1,500,000 - 1:200,001)
- Military Installation

Landmarks (>= 1:200,000)
- Educational Institution
- Golf Course
- Cemetery
- Military Installation
- Stadium or Arena
- Federal or State Prison
- Amusement Center
- Government Center

Urban Areas (1:10,000,000 - 1:1,500,001)

POPULATION
- <= 100,000
- 100,001 - 500,000
- 500,001 - 1,000,000
- 1,000,001 - 5,000,000
- >= 5,000,001

Urban Areas (1:1,500,000 - 1:200,001)

POPULATION
- 700 - 242,000
- 242,000 - 1,009,000
- 1,009,000 - 2,986,000
- 2,986,000 - 8,299,000
- 8,299,000 - 17,340,000

Places (>= 1:200,000)

POPULATION
- 0 - 55,000
- 55,000 - 362,000
- 362,000 - 1,518,000
- 1,518,000 - 3,695,000
- 3,695,000 - 8,008,000

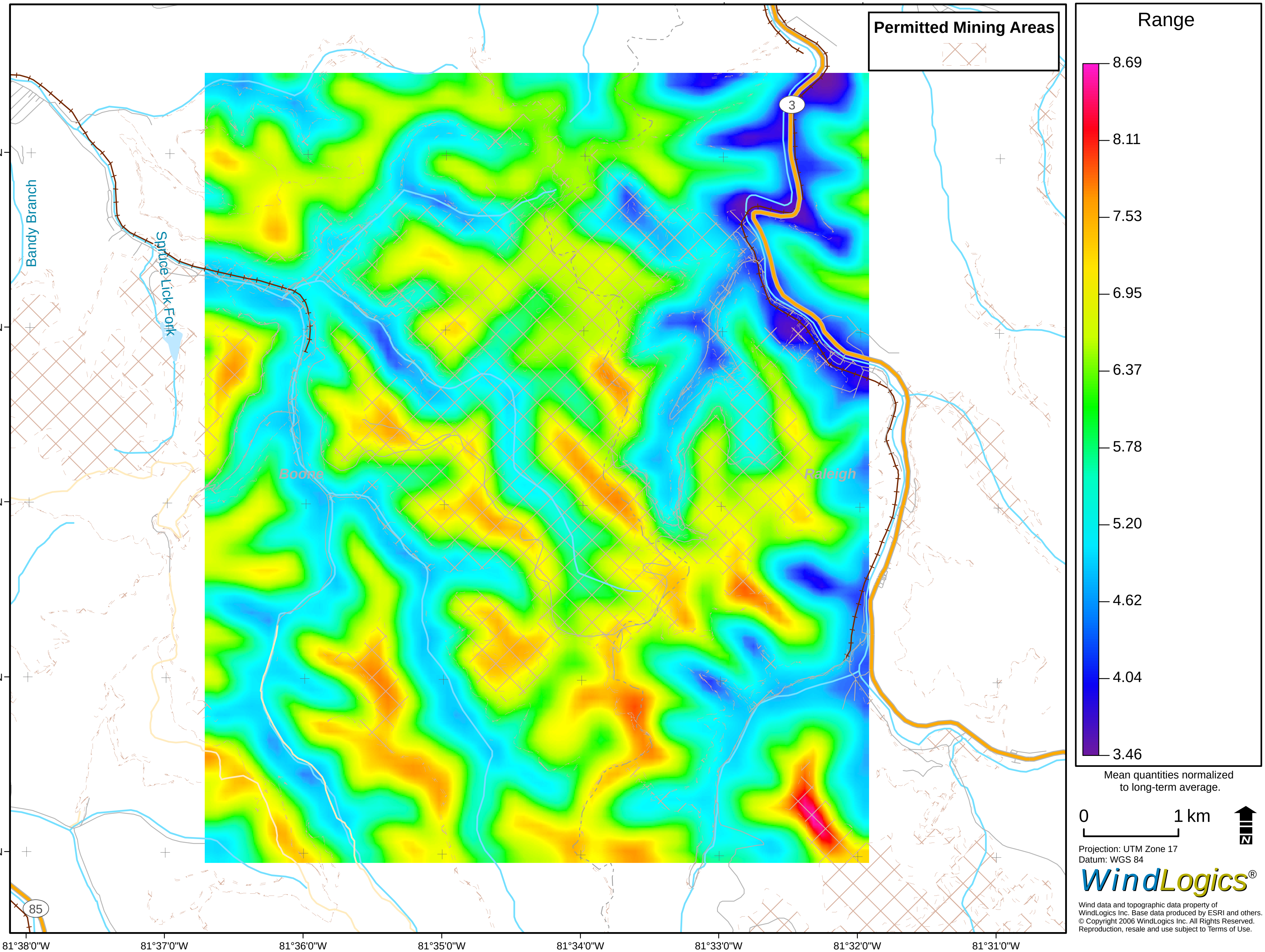
SECTION 1

MAPS OF NORMALIZED ANNUAL WIND SPEED AVERAGES (in m/s)

80 METERS

BKA Group, LLC - West Virginia Coalfields, Area 1A

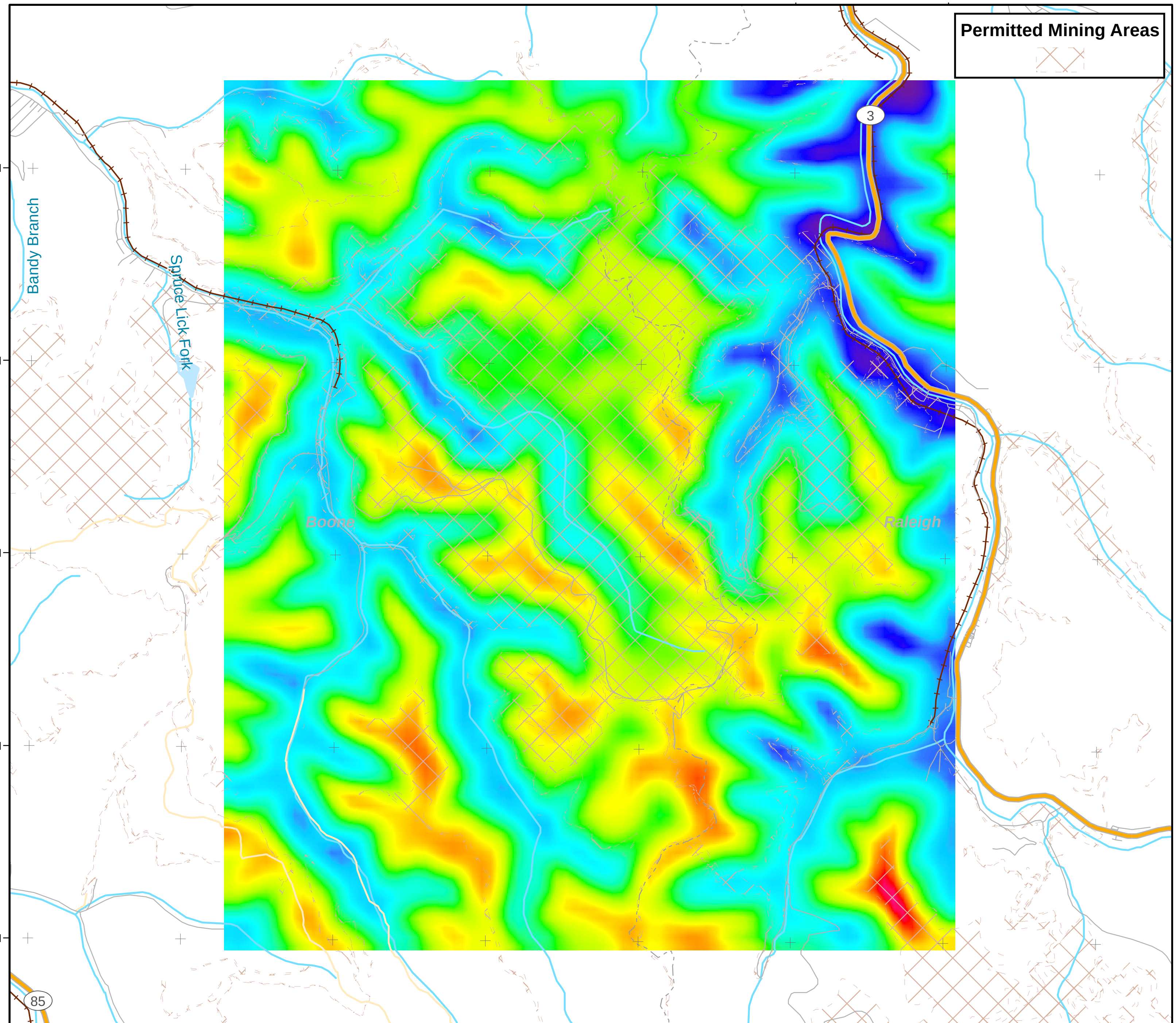
80 m Wind Speed (m/s) - Annual



Wind data and topographic data property of WindLogics Inc. Base data produced by ESRI and others.

BKA Group, LLC - West Virginia Coalfields, Area 1B

80 m Wind Speed (m/s) - Annual



Mean quantities normalized to long-term average.

Projection: UTM Zone 17
Datum: WGS 84

WindLogics®

SECTION 2

MAPS OF
NORMALIZED ANNUAL
GROSS ENERGY PRODUCTION (in MWh)

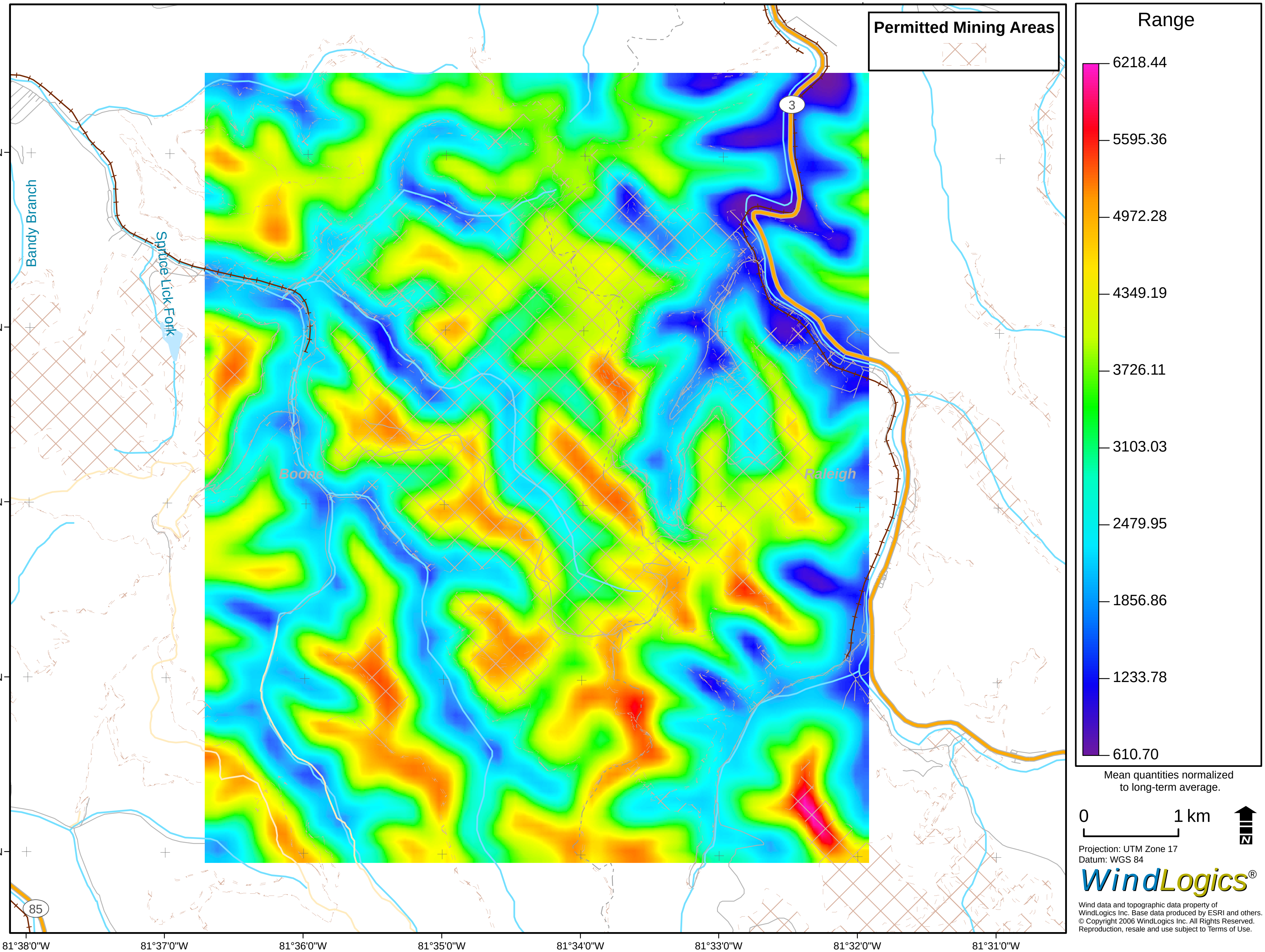
80 METERS

GE 1.5SLE TURBINE

WindLogics, Inc.
1217 Bandana Blvd. N., St. Paul, MN 55108 Tel: 651.556-4200 Fax: 651.556-4210
www.windlogics.com

BKA Group, LLC - West Virginia Coalfields, Area 1A

80 m Energy Production (MWh) GE 1.5SLE - Annual



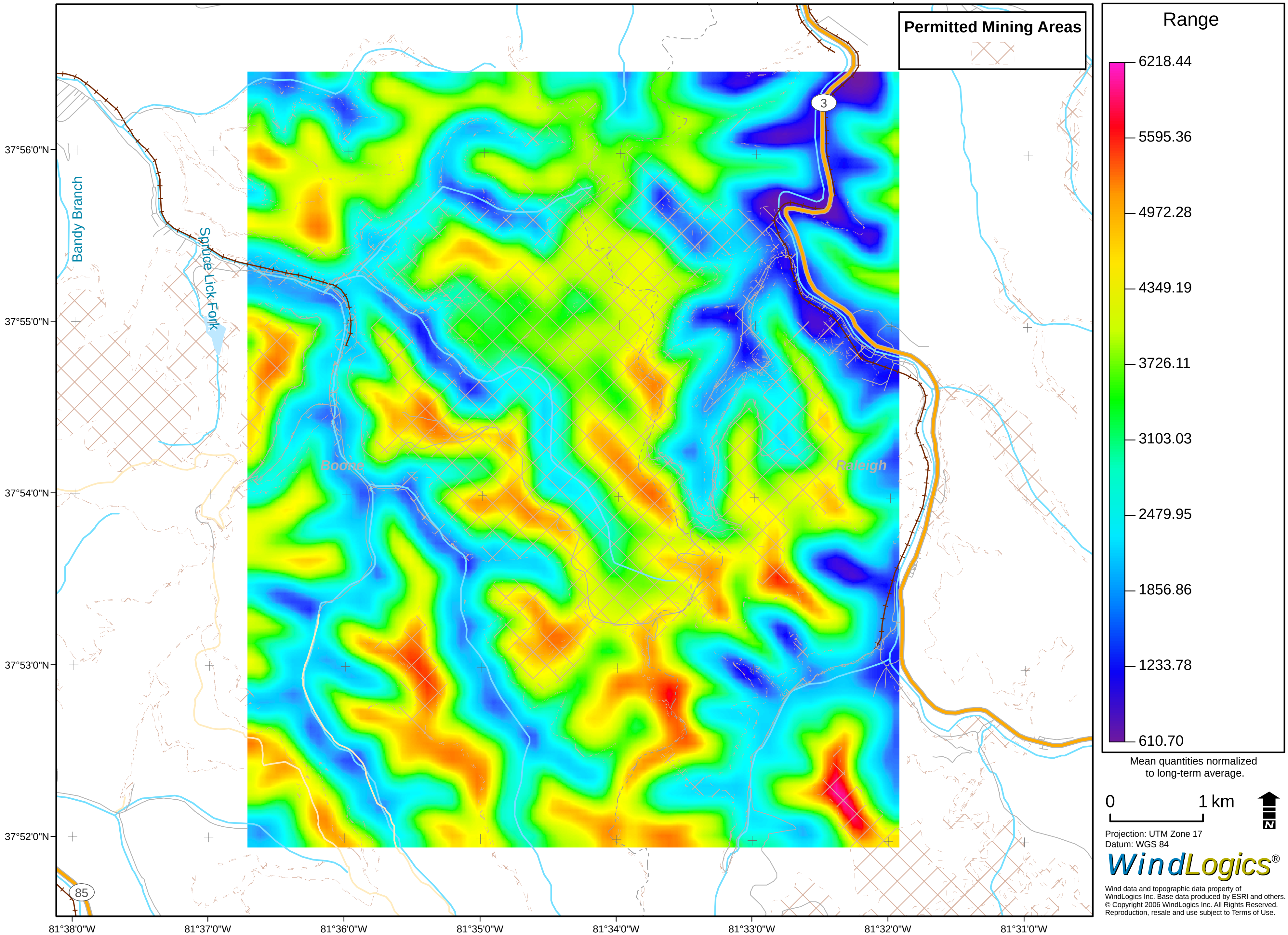
Mean quantities normalized to long-term average.

Projection: UTM Zone 17
Datum: WGS 84

WindLogics®

BKA Group, LLC - West Virginia Coalfields, Area 1B

80 m Energy Production (MWh) GE 1.5SLE - Annual



SECTION 3

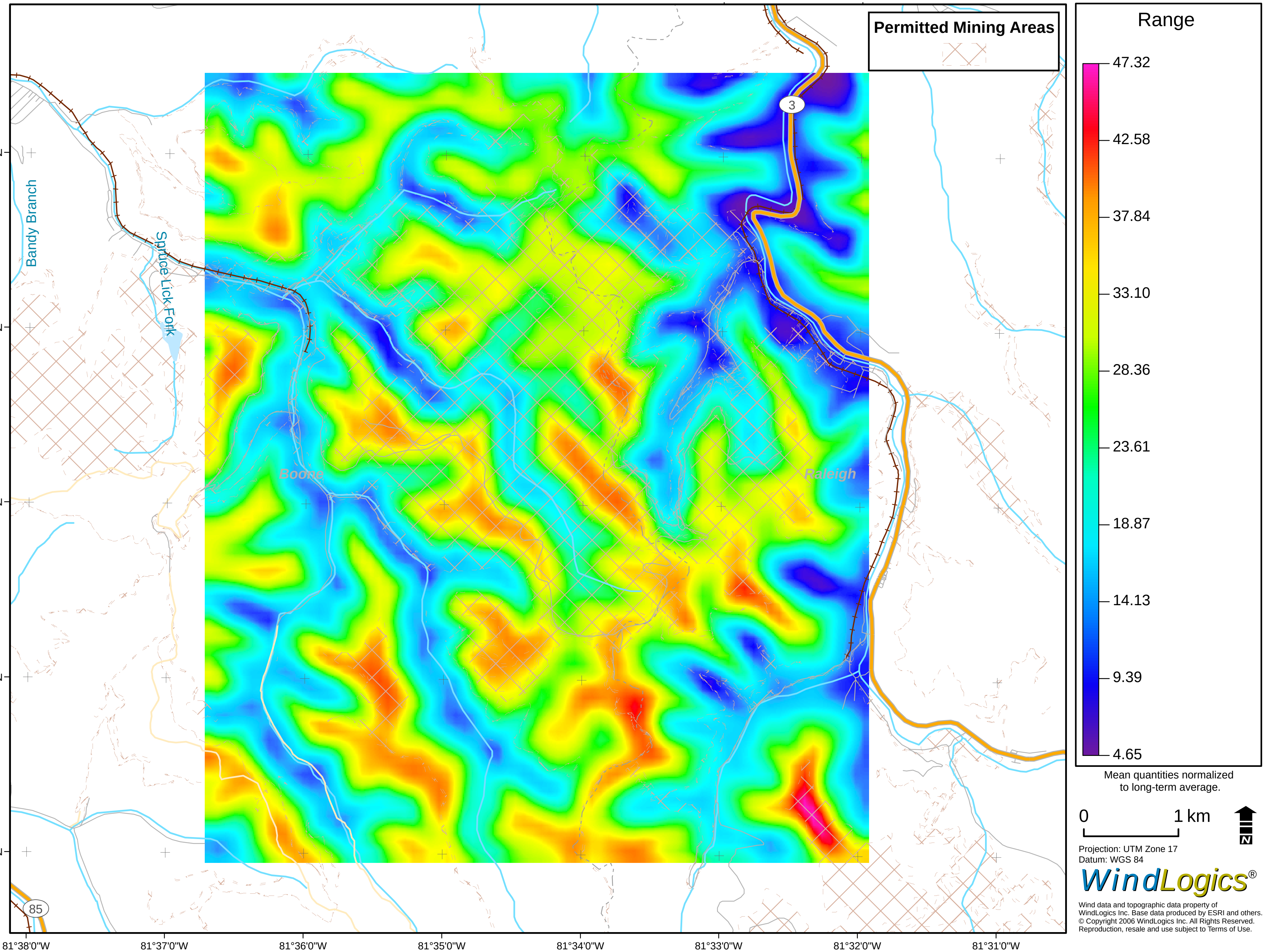
MAPS OF
NORMALIZED ANNUAL
GROSS CAPACITY FACTOR (in %)

80 METERS

GE 1.5SLE TURBINE

BKA Group, LLC - West Virginia Coalfields, Area 1A

80 m Capacity Factor (%) GE 1.5SLE - Annual



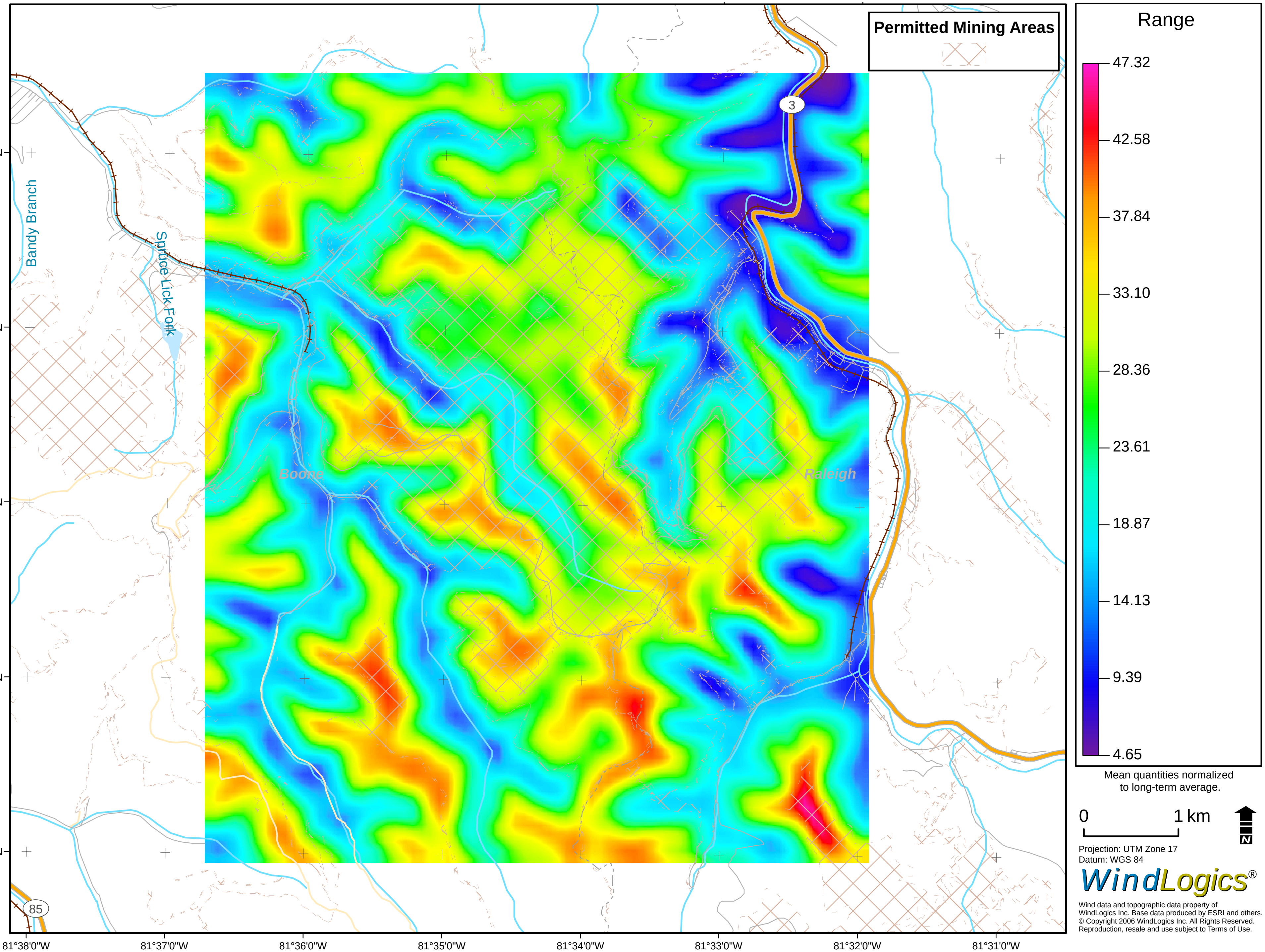
Mean quantities normalized to long-term average.

Projection: UTM Zone 17
Datum: WGS 84

WindLogics®

BKA Group, LLC - West Virginia Coalfields, Area 1B

80 m Capacity Factor (%) GE 1.5SLE - Annual



Mean quantities normalized to long-term average.

Projection: UTM Zone 17
Datum: WGS 84

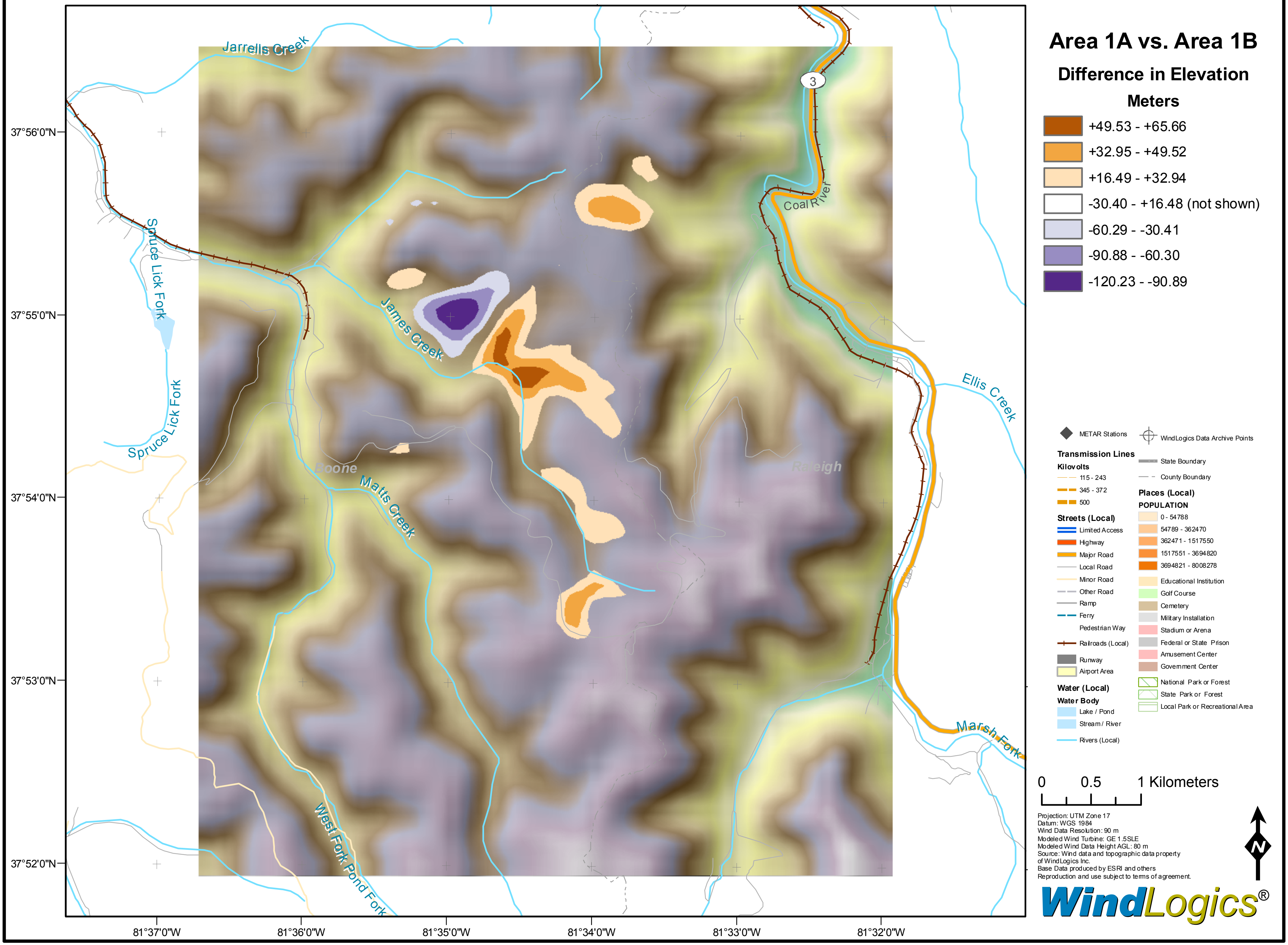
WindLogics®

APPENDIX A

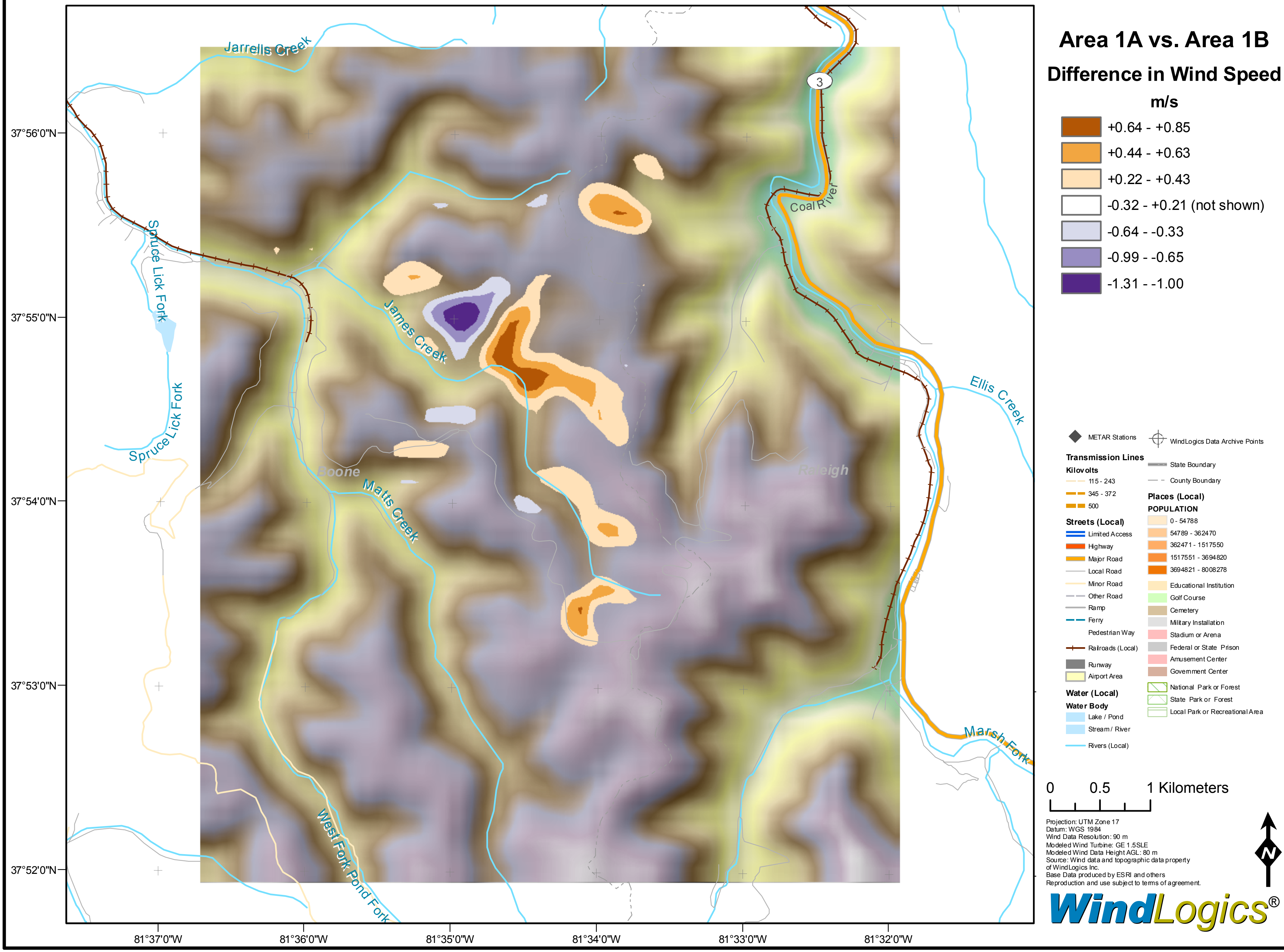
SUPPORTING IMAGES

WindLogics Inc.
1217 Bandana Blvd. N., St. Paul, MN 55108 Tel: 651.556-4200 Fax: 651.556-4210
www.windlogics.com

BKA Group, LLC - West Virginia Coalfields - Mining Activity Effects



BKA Group, LLC - West Virginia Coalfields - Mining Activity Effects

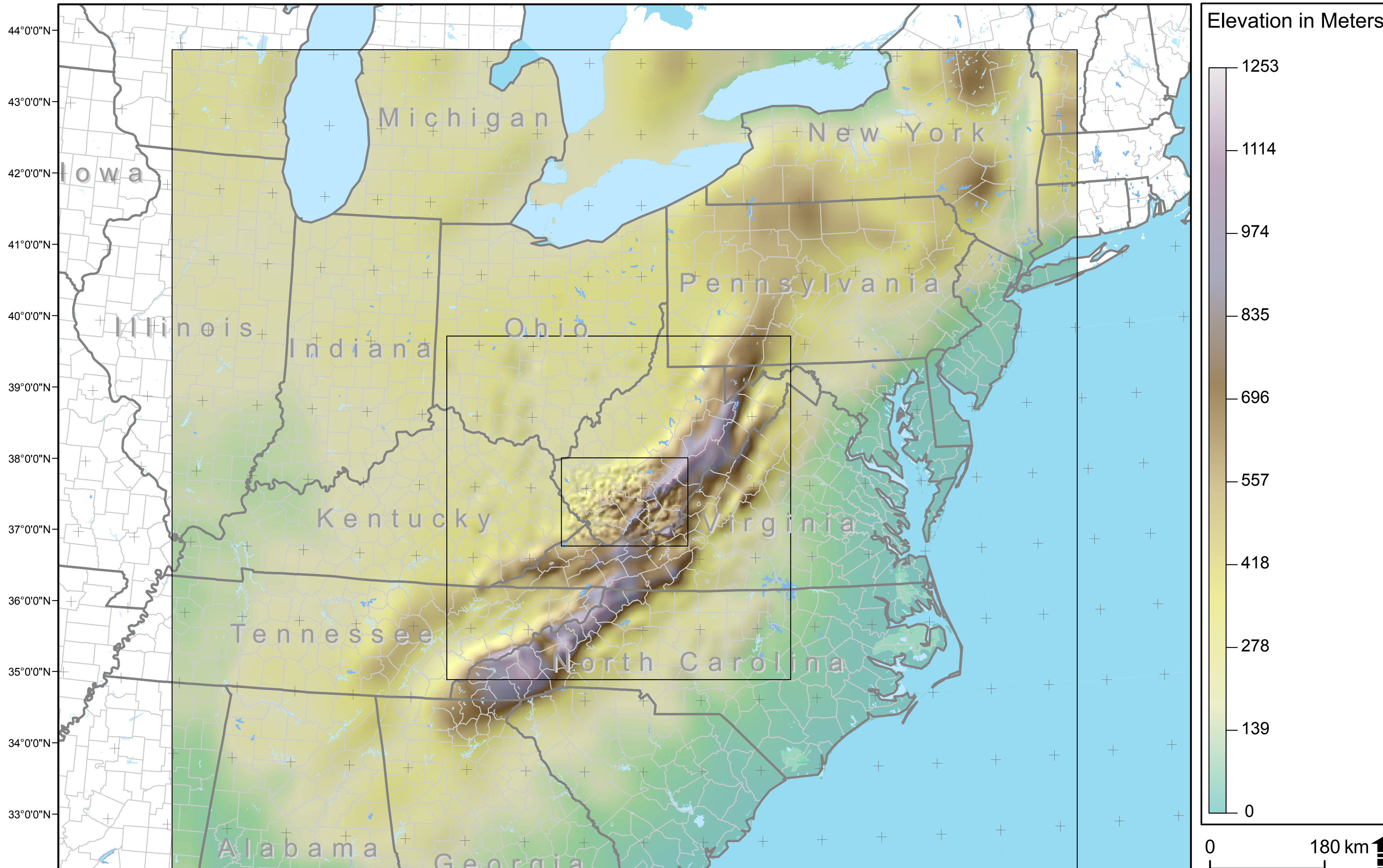


APPENDIX B

MODELING GRID MAPS

BKA Group, LLC - West Virginia Coalfields

Mesoscale Model - Outer, Intermediate and Inner Grids

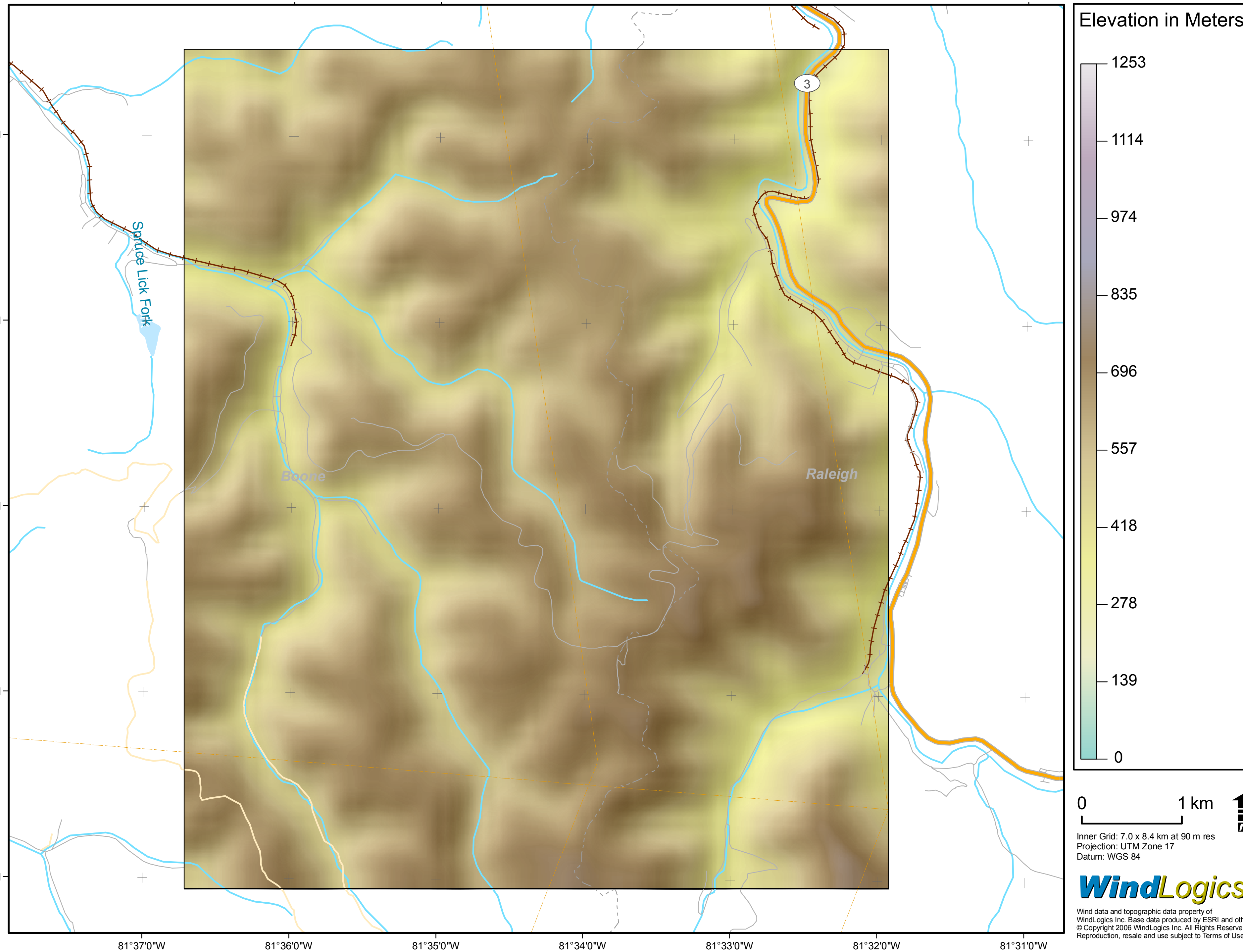


Outer Grid: 1422 x 1422 km at 18 km res
Intermediate Grid: 540 x 540 km at 6 km res
Inner Grid: 198 x 138 km at 2 km res
Projection: Lambert Conformal Conic
Datum: Spherical

WindLogics®

BKA Group, LLC - West Virginia Coalfields, Area 1A

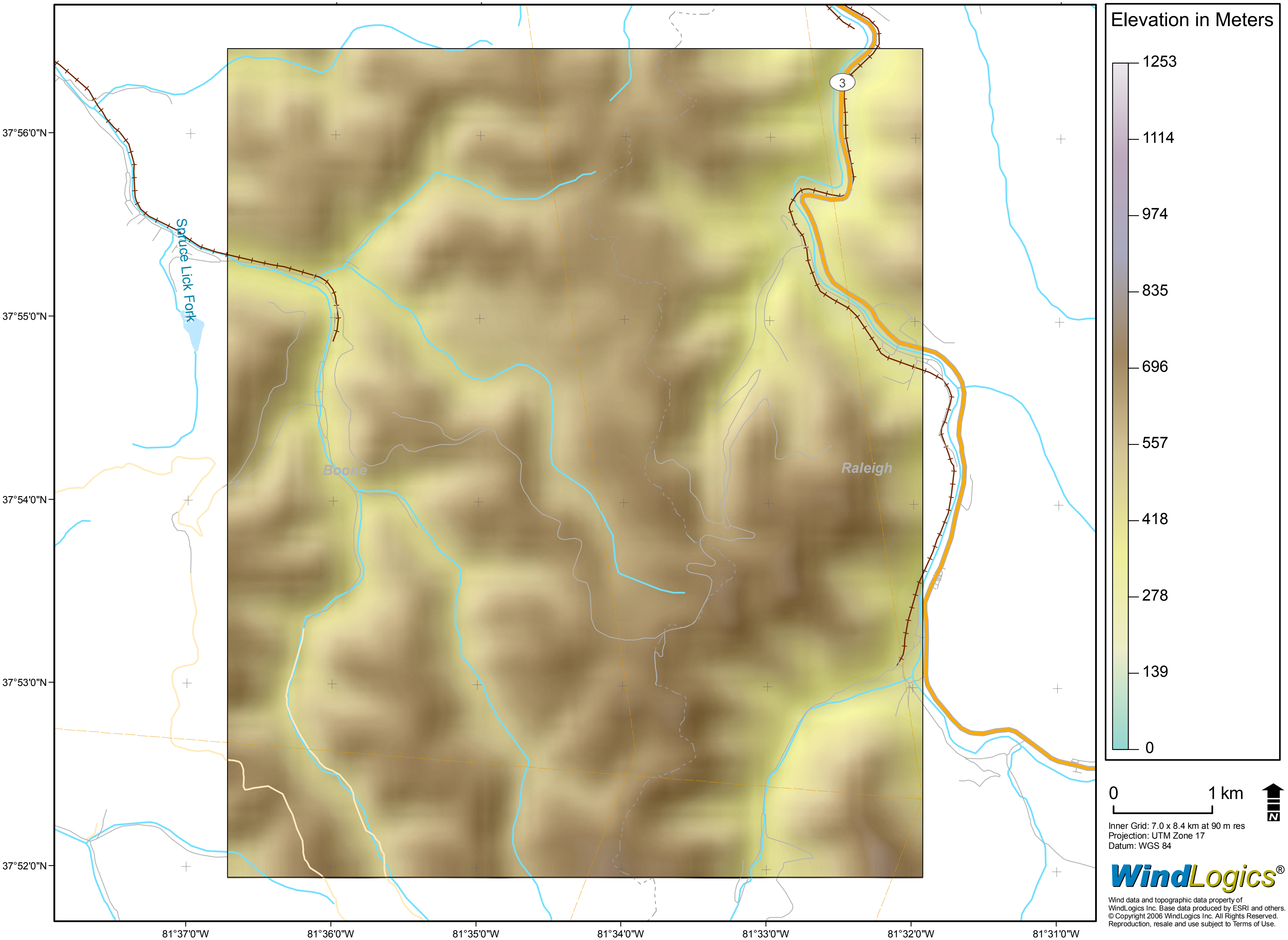
Windfield Model - Inner Grid



Inner Grid: 7.0 x 8.4 km at 90 m res
Projection: UTM Zone 17
Datum: WGS 84

BKA Group, LLC - West Virginia Coalfields, Area 1B

Windfield Model - Inner Grid



Inner Grid: 7.0 x 8.4 km at 90 m res
Projection: UTM Zone 17
Datum: WGS 84

WindLogics®

APPENDIX C

POWER CURVES

WindLogics Inc.
1217 Bandana Blvd. N., St. Paul, MN 55108 Tel: 651.556-4200 Fax: 651.556-4210
www.windlogics.com

GE 1.5SLE

Wind Speed (m/s)	Power (kW)
3.5	20
4.0	43
4.5	83
5.0	131
5.5	185
6.0	250
6.5	326
7.0	416
7.5	521
8.0	640
8.5	785
9.0	924
9.5	1062
10.0	1181
10.5	1283
11.0	1359
11.5	1402
12.0	1436
12.5	1481
13.0	1488
13.5	1500
14.0	1500
14.5	1500
15.0	1500
15.5	1500
16.0	1500
16.5	1500
17.0	1500
17.5	1500
18.0	1500
18.5	1500
19.0	1500
19.5	1500
20.0	1500
20.5	1500
21.0	1500
21.5	1500
22.0	1500
22.5	1500
23.0	1500
23.5	1500
24.0	1500
24.5	1500
25.0	1500

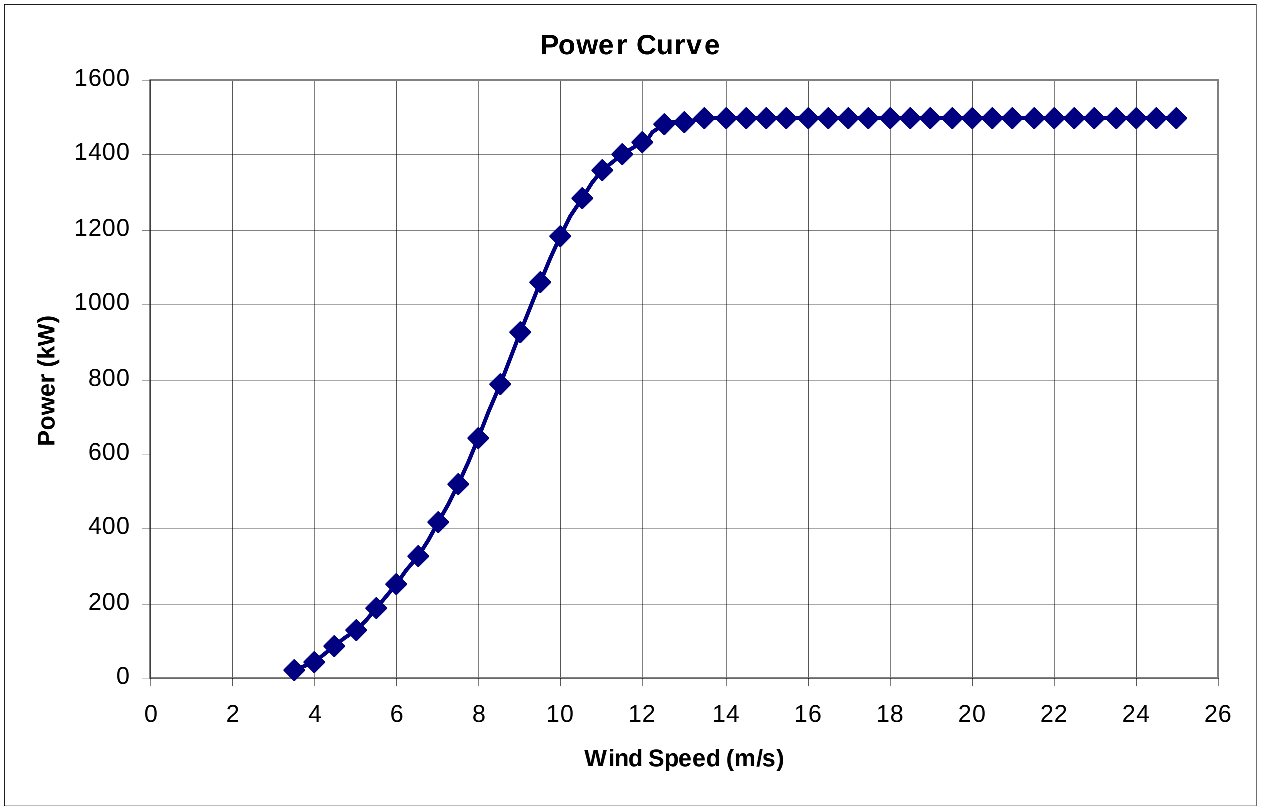
Standard Operational Data	
Cut In Wind Speed	3.5 m/s
Cut Out Wind Speed	25 m/s
Air Density	1.225 kg/m^3
Capacity	1500 kW
Rotor Diameter	77 m

The WindLogics modeling process uses the standard power curve at 1.225 kg/m^3. The modeled air density (for each hour and site/point location) is used to adjust the wind speed that is applied to the power curve for that hour.

The formula that is used to adjust the wind speed is:

Air Density Adjusted Wind Speed = WS * (AD/1.225) $^{(1/3)}$

Where AD is the modeled Air Density and WS is the model estimated Wind Speed at that hour



WindLogics Inc.
1217 Bandana Blvd. N., St. Paul, MN 55108 Tel: 651.556-4200 Fax: 651.556-4210
www.windlogics.com