BEFORE THE ADMINISTRATOR
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

In the Matter of:	)	
	)	
FINAL RULE,	)	
AIR QUALITY DESIGNATIONS	)	**EPA-HQ-OAR-2008-0476;**
FOR THE 2008 OZONE NATIONAL	)	**FRL-9668-2, RIN 2060-AP37**
AMBIENT AIR QUALITY STANDARDS,	)	
77 FED. REG. 30,088 (MAY 21, 2012)	)	
	)	
	)	
ANDERSON COUNTY, TENNESSEE,	)	
BLOUNT COUNTY, TENNESSEE, and	)	
KNOX COUNTY, TENNESSEE	)	
	)	
Petitioners.	)	

SUPPLEMENTAL PETITION FOR RECONSIDERATION

On July 20, 2012, pursuant to Section 307 of the Clean Air Act ("CAA"), 42 U.S.C. § 7607, Anderson County, Tennessee ("Anderson County"), Blount County, Tennessee ("Blount County"), and Knox County, Tennessee ("Knox County") (collectively, "Counties") filed a Petition for Reconsideration of the Final Rule entitled "Air Quality Designations for the 2008 Ozone National Ambient Air Quality Standards," 77 Fed. Reg. 30,088 (May 21, 2012) (the "Final Rule"). The Counties, through the undersigned counsel, now file this Supplemental Petition for Reconsideration (the "Supplemental Petition"), which provides further technical analysis in support of the legal and technical arguments set forth in the Counties' Petition for Reconsideration.

INTRODUCTION

EPA based its nonattainment designation for the Knoxville Combined Statistical Area ("Knoxville CSA" or "CSA") on the violating Look Rock monitor in Blount County. EPA

Technical Support Document, *Knoxville, Tennessee Area Designations for the 2008 Ozone National Ambient Air Quality Standards* 16 ("TSD"). Look Rock is one of the most highly instrumented and studied ozone monitoring stations in the southeastern United States. Numerous researchers have studied Look Rock data measured as a part of the CASTNET and NCore monitoring programs, as well as other specialized measurements made from time to time. In addition to ozone, the CASTNET monitoring program measures an array of meteorological parameters,[1] and the NCore monitoring program measures several gaseous and particulate air components.[2] These researchers have reported extensively on their studies. In spite of this wealth of information, EPA took a simplistic approach to determining which counties in the Knoxville CSA to designate nonattainment and ignored much of what is known about the air quality of this very complex site. Consequently, the rationale undergirding EPA's designations is seriously flawed.

EPA performed a number of analyses based on Look Rock CASTNET data, including analyses that it concluded demonstrated that Look Rock ozone levels are influenced by both valley and regional precursor emissions – conditions totally anomalous and not representative of the vast majority of the Knoxville CSA. *See* TSD at 13 (noting that, unlike two other Knox County sites and a high elevation site in North Carolina, Look Rock shows a "combination of . . . two signals": "a typical urban pattern of ozone events in the afternoon" and "a typical high elevation site pattern ozone overnight."). However, despite EPA's conclusion that ozone levels at Look Rock are the result of these totally anomalous conditions, it used the 2009-2011 Look Rock design value exceedance of the NAAQS to designate the entirety of two counties and a portion of a third as nonattainment.

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[1] *See* http://epa.gov/castnet/javaweb/index.html for a description of the CASTNET program.
[2] *See* http://www.epa.gov/ttnamti1/ncore/index.html for a description of the NCore program.

Because EPA was unaware of, or disregarded, the wealth of information that exists regarding air quality and meteorological conditions at Look Rock, it attributed the influences it identified as "valley" impacts to Knoxville. This misconception led EPA to conclude erroneously that Knox County and northern Blount County contribute meaningfully to the exceedance of the NAAQS at Look Rock.

In addition, EPA made the nonattainment designation despite its belief that (1) without designating any of the twelve counties in the Knoxville CSA nonattainment and burdening them with specific additional local emission reductions, NO_X and VOC emissions in the Knoxville CSA are projected to decrease significantly due to national and regional emission-reducing rules already in place; and (2) these national and regional emission reductions will result in all monitors in the Knoxville CSA being well below the ozone NAAQS by 2015. While the aforementioned reductions will result from regional and national emission-reducing rules already in place, they will come at a significant cost to the citizens, businesses, and local governments in the CSA. Designating the entireties of Knox and Blount Counties and a portion of Anderson County as nonattainment will stigmatize the Counties and make it much harder for the area to overcome current economic conditions.

TECHNICAL ANALYSIS

I. ADDITIONAL COMMENTS ON EPA's TECHNICAL ANALYSIS OF THE KNOXVILLE CSA.

In its TSD, EPA provided a list of counties in the Knoxville CSA with ozone monitors (Sevier, Blount, and Knox Counties have multiple monitors) along with the 2009-2011 design values for each of those counties. TSD at 6, Table 3. EPA noted that only one county in the CSA has a design value exceeding the ozone NAAQS: Blount County. Without acknowledging the fact that Blount County has two monitors -- one attaining the NAAQS (Cades

Cove with a 2009-2011 design value of 68 ppb) and one exceeding the NAAQS (Look Rock with a 2009-2011 design value of 77) -- EPA concluded that "Blount County shows a violation of the 2008 ozone NAAQS, therefore this county is included in the nonattainment area." *Id*. at 6.

In the *Meteorology* section of the TSD, EPA provided an analysis of back trajectories using the National Oceanic and Atmospheric Administration's Hybrid Single Particle Lagrangian Integrated Trajectory Model ("HYSPLIT") to evaluate the potential contribution from nearby areas. The HYSPLIT analysis was done for days that exceeded the NAAQS at the Look Rock monitor during the 2009-2011 timeframe. *Id*. at 10-11, Figure 3. In addition, EPA discussed (but did not present) an analysis of the predominant wind directions in the area based on an analysis of thirty years' of ozone season (March through October) National Weather Service ("NWS") data from the Knoxville Airport located just 12.5 miles north-northeast of Look Rock. As EPA points out, the predominant wind direction during this period is from the southwest and west-southwest with a north-northeast component. *Id*. at 10.

The Counties provided EPA with an analysis of the NWS data for this time period, as well as the wind rose summary of that data. Letter from Michael K. Stagg to Gwendolyn Keyes-Fleming (April 5, 2012). Based on the Counties' analysis, disregarding the calms (27.25% of the time), the wind is from the northwest, north, northeast, and east less than a quarter of the time, while it is from the southeast, south, southwest, and west over three quarters of the time. None of the areas EPA chose to designate as nonattainment are in the direction from Look Rock from which the winds dominate; therefore, they do not meaningfully contribute to the Look Rock monitor exceedance.

In the *Geography/Topography* section of the of the TSD, EPA presented an analysis of wind direction data from the CASTNET monitoring site at Look Rock for the days and times

when the hourly average ozone exceeded 75 ppb. TSD at 13, Figure 6. From this analysis, EPA erroneously drew the conclusion that there are "two distinct groups of high ozone events: afternoon ozone from the north to northwest (Knoxville) and overnight ozone from the south to southeast (regional transport)." *Id*. at 13. In its analysis, EPA did not mention that the local measurements of wind direction at the Look Rock CASTNET monitor have been shown by numerous researchers to be influenced by the very localized complex topography surrounding the monitoring site and to not be representative of the area-wide wind patterns. EPA also failed to mention that the local wind data it used in its analysis does not coincide with the wind direction data either from the NWS meteorological station at the Knoxville Airport or the HYSPLIT back trajectories it discusses in the *Meteorology* section of the TSD. Clearly, EPA ignored information it had readily available to reach a conclusion that wind directions measured at Look Rock indicated that sources in Knox County, northern Blount County, and Anderson County were making a "meaningful" contribution to high-ozone events at Look Rock.

Also in the *Geography/Topography* section of the TSD, EPA provided a detailed analysis of ozone concentrations at a high elevation monitor in North Carolina, the two monitors in Knox County, and the Look Rock monitor. *Id.* at 13, Figure 5. Based on that analysis, EPA concluded, "The Look Rock site . . . is impacted by both downwind afternoon ozone formation from Knoxville and high elevation ozone transport. In some cases, these two processes could be affecting the Look Rock monitor simultaneously." *Id*. at 13. Again, EPA ignored readily available information, reached an erroneous conclusion, and used what it considers a totally anomalous situation to designate the entireties of Knox and Blount Counties and a portion of Anderson County as nonattainment.

II. AN ANALYSIS OF HIGH-OZONE EVENTS AT LOOK ROCK BASED ON WHAT IS KNOWN FROM EXTENSIVE MONITORING AND RESEARCH.

As mentioned above, air quality at Look Rock has been studied extensively by various researchers through the years. These studies have demonstrated that localized wind direction measurements at Look Rock do not coincide with area-wide wind patterns. To explain this inconsistency, many researchers rely on the localized wind phenomenon identified by Roger Tanner and others. Roger L. Tanner, Solomon T. Bairai, Kenneth J. Olszyna, Myra L. Valente, and Ralph J. Valente, *Diurnal Patterns in PM2.5 Mass and Composition at a Background, Complex Terrain Site,* 39 Atmospheric Environment 3872 (2005) (hereinafter, "Tanner"); *see also* Kenneth J. Olszyna, Elizabeth M. Bailey, Romualdas Simonaitis, and James F. Meagher, *O_3 and NO_y Relationships at a Rural Site*, 99 J. of Geophysical Research 14,557 (1994) (hereinafter, "Olszyna"); Roger L. Tanner, Patricia Brewer, Ivar Tombach, Scott Reynolds, Eric Edgerton, Ben Hartsell, and Jim Renfro, *Development and Analysis of an Hourly, Chemically Speciated Database for $PM_{2.5}$ Aerosols in the Southeastern US,* Journal of Air and Waste Management Association (submitted June 18, 2008). Tanner explains that

> as expected, the temperature maxima trail solar radiation by about 2 hours. Nocturnal boundary breakup begins in the 0500–0600 (EST) timeframe, and boundary layer growth reaches the altitude of the site (about 825m MSL) in the 0800–1000 (EST) timeframe. In the absence of frontal boundaries, extensive cloudiness and/or precipitation, this is nearly always accompanied by a shift in wind direction from southerly (down-slope) to the west and north direction (up-slope, up-Valley), along with a modest increase in wind velocity. On average, the wind direction drifts toward the south and west during the afternoon hours and collapses to southerly or southeasterly again around sunset.

Tanner at 3872.

This change in wind direction apparently is due to the orientation of the Look Rock ridge and the prevailing valley airflow. As elevation increases above the valley floor toward the tops of the ridges that define the sides of the valley, wind direction rotates to align with winds aloft. Winds aloft are more likely to have a westerly component which causes the wind direction at Look Rock to rotate toward an up-slope configuration. Late in the day, especially in summer, the sun angle is such that the west-facing slope of the Look Rock ridge is heated more than the opposite side which by that time is in shadow. This differential heating warms the slope and the air above it accelerating the up-slope airflow. When the solar heating stops, the western side of the slope cools quickly and the atmosphere begins to stabilize. The stable layer cuts off Look Rock from the westerly airflow aloft, and the cooling allows for the formation of a down-slope wind component.

In other words, the local wind direction measurements made at Look Rock are not an indication of the direction from which air masses arrive at the Look Rock monitor, but are the result of air flow "up-slope, up-Valley" during the daytime and "down-slope" during the nighttime. It, therefore, is erroneous for EPA to conclude that "afternoon ozone" is from Knoxville when the local CASTNET monitor shows wind direction measurements from the north. Rather, these "north" measurements result from a daily localized "up-slope" wind direction.

To cast additional light on this localized wind direction phenomenon described by Tanner, the Counties examined data from the CASTNET monitor as well as from the NCore monitor, both located at Look Rock. While the CASTNET monitor measures ozone and numerous meteorological conditions (wind speed, wind direction, solar radiation, etc.),

the NCore monitoring system measures the concentration of a number of gaseous and particulate air components, including NO, NO_2, total oxides of nitrogen (NO_Y), CO, $PM_{2.5}$, and black carbon.

Of the twenty-three events during the 2009-2011 ozone seasons when the maximum 8-hour average ozone concentration at Look Rock exceeded 75 ppb, practically complete sets of both CASTNET and NCore data exist for nine of the events.[3] These nine events should well represent the twenty-three total events because they occur in the early, middle, and late parts of the ozone season; in each of the three years used to calculate the design value; and on days when the HYSPLIT back trajectories were from practically every compass direction. Tables 1 and 2 in Appendix 1 provide a tabulation of the pertinent data used in the Counties' analysis, while Appendix 2 contains the back trajectories used.

A close inspection of the wind direction data from the Look Rock CASTNET monitor and the HYSPLIT back trajectory data reveals that during the daytime hours, the wind direction measured at the Look Rock CASTNET monitor rarely coincided with the direction from which the parcels of air were computed by HYSPLIT to be arriving at Look Rock. For instance, on April 15, 2010, the Look Rock CASTNET monitor measured wind directions from the north and northwest from 1000 through 1900 EST (a condition consistent with the explanation provided by Tanner as well as other researchers), while the back trajectories indicated no air flow to the Look Rock area from that direction. Rather, back trajectories all day were from the south and southeast. Based on EPA's analysis (*see* TSD at 13-15), which relied primarily on the wind direction measurements at Look Rock, EPA would have concluded that the high ozone concentrations during the daytime hours of April 15, 2010, resulted from emissions in

[3] An "event" often spans two calendar days.

the Knoxville, north Blount, and Anderson County areas. However, as noted above, the afternoon wind direction data at Look Rock actually measures the change in local winds from up-slope to down-slope as the day progresses, not the actual direction from which the winds arrived. Thus, EPA's conclusion that emissions came from areas north of Look Rock in this case is erroneous.

Likewise, on June 25, 2009 (again, consistent with the Tanner description of the meteorology of Look Rock), according to the wind direction measurements made at Look Rock at 1900 (as solar radiation approached zero), the wind began shifting to the east and southeast after having been from the north and northwest since 1000 EST. However, an examination of the back trajectories for this day indicates little change in the wind direction all day, which was from the north to northeast. This inconsistency again shows that Look Rock's wind direction monitor actually measures the daily cycle of up-slope and down-slope airflows, not actual area-wide wind direction. Consequently, the wind direction data at Look Rock cannot be relied upon to reach conclusions about the sources of precursor emissions that create high ozone events at Look Rock.

To further substantiate the view that Tanner and other researchers have of diurnal meteorology at Look Rock, the Counties performed an analysis of all the wind direction data from the Look Rock CASTNET monitor for the 2009-2011 timeframe. For this analysis, wind direction data for each compass quadrant (i.e., east -- 45^{o} to 135^{o}, south – 135^{o} to 225^{o}, west 225^{o} to 315^{o}, and north 315^{o} to 45^{o}) was correlated with solar radiation. Solar radiation was chosen because Tanner and others have observed that wind direction seems to change in the early morning as the sun rises and in the late afternoon when the sun sets. Tanner at 3872. Table 3 in Appendix 1 summarizes the results of this analysis.

This analysis demonstrates that wind directions from the north and west tend to dominate during the daylight hours (higher average solar radiation), while wind directions from the east and south tend to dominate during nighttime hours (lower average solar radiation). The pattern is similar for both the periods of time when the ozone level exceeds 75 ppb and when it does not. However, the predominance of north and west in the daytime and east and south in the nighttime is much more pronounced when the ozone concentration exceeds 75 ppb. This too is consistent with the observation made by Tanner that "in the absence of frontal boundaries, extensive cloudiness and/ or precipitation," which are the ideal conditions for ozone production, "the wind shifts direction from southerly (down-slope) to the west and north direction (up-slope, up-Valley) as the sun rises and drifts toward the south and west during the afternoon hours and changes to southerly or southeasterly around sunset." Tanner at 3872. EPA's reliance primarily on the CASTNET wind direction data from Look Rock to infer that northern Blount County, Knox County, and Tennessee Valley Authority's ("TVA") Bull Run Power Plant are meaningful sources of Look Rock ozone precursors is seriously flawed.[4]

The Counties conducted an in-depth analysis of the HYSPLIT back trajectories during each of the twenty-three events when the maximum 24-hour ozone concentration exceeded 75 ppb. These back trajectories are shown in Appendix 2, and the in-depth analysis is summarized in Table 4 in Appendix 1. As can be seen by this analysis, during only about a third of the episodes (eight out of twenty-three) did the back trajectory pass across the densely populated portions of Knox County where emissions of NO_X and VOCs from Knox County could have made any contribution to ozone concentrations at Look Rock. *See* TSD at 10, Figure 2 (showing the "densely populated portions of Knox County").

[4] As described below, TVA has operated its Bull Run Power Plant with selective catalytic reduction ("SCR") NOx removal technology (with a 90-95% control efficiency) since 2004.

In addition to the aforementioned analysis conducted by the Counties, TVA performed a detailed statistical analysis of the same twenty-three high ozone events and concluded that 65% of the Look Rock high ozone events are not associated with or significantly impacted by Knoxville-area emissions. *See* Stephen F. Mueller, *Cluster Analysis of Look Rock High Ozone Events and Related Air Parcel Trajectories for 2009-2011* (hereinafter, "Mueller") (attached as Appendix 3).[5] The conclusions of TVA and the Counties are consistent and strongly demonstrate that Knox County did not contribute in a meaningful way to high ozone events at Look Rock during the 2009-2011 time period.

III. THE COUNTIES' ANALYSIS OF EACH HIGH-OZONE EVENT.

As noted above, the nine events for which there is complete data from both CASTNET and NCore should well represent the twenty-three events in the 2009-2011 timeframe when the maximum 8-hour ozone concentration at Look Rock exceeded 75 ppb. Consequently, the Counties have conducted an in-depth analysis of these nine events, comparing CASTNET and NCore data with several HYSPLIT back trajectories for the period during the event when the hourly ozone concentration exceeded 75 ppb. Table 4 in Appendix 1 summarizes this detailed analysis.

For the Counties' analysis, the photochemical age of the air mass was used to determine the distance from which the NO_X (NO and NO_2) emissions that contributed to the ozone exceedances must have come. Photochemical age has been used extensively by researchers to describe the average age of NO_X in studies of ozone formation from both point and nonpoint sources. Menachem Luria, Ralph J. Valente, Solomon Bairai, William J. Parkhurst, and Roger L. Tanner,

[5] *Available at* http://www.tva.com/environment/pdf/Cluster_Analysis.pdf.

Nighttime Chemistry in the Houston Urban Plume, 42 Atmospheric Environment 7544 (2008); Menchem Luria, Ralph J. Valente, Solomon Bairai, William J. Parkhurst, and Roger L. Tanner, *Airborne Study of Ozone Formation over Dallas, Texas*, 42 Atmospheric Environment 6951 (2008) (hereinafter, "Luria"); J. Dommen, A.S.H. Prevot, A.M. Hering, T. Stafflebach, G.L. Kok, and R.D. Schillawski, *Photochemical Production and Aging of an Urban Air Mass*, 104 Journal of Geophysical Research pages 5493 (1999). Photochemical age is computed by dividing the concentration of non-NO_X (NO + NO_2), or more highly oxidized forms of nitrogen in an air mass, by the total concentration of all odd-nitrogen oxidized forms. It is normally identified as NO_Z/NO_Y. NO_Z/NO_Y varies from 0.0 to 1.0 with the older photochemical ages being nearer 1.0. A photochemical age near 0 would indicate that all, or almost all, of the oxidized nitrogen in the air mass is present as NO_X, while a photochemical age of 1.0, would indicate that none of the oxidized nitrogen in the air mass is present as NO_X. Olszyna has found that there is little additional ozone formation in an air mass with a photochemical age of 0.7 or greater. Olszyna at 14,561. Further, a lower photochemical age generally implies that nearby sources are more influential, while a higher photochemical age generally implies that sources farther away have had more impact. *See* Mueller at 5-6.

Therefore, for this analysis, air masses arriving at Look Rock with average photochemical ages below 0.5 were considered young, still capable of producing quite a lot of ozone, and the sources of NO_X in the air mass being nearby; air masses with photochemical ages of 0.5 to 0.7 were considered moderately aged, still capable of producing some ozone, and the sources of NO_X being some distance away; and air masses with photochemical ages above 0.7 were considered well-aged, no longer producing much ozone, and the sources of NO_X being a long distance away.

In addition to photochemical age, the concentrations of CO from the NCore data set were used as indicators of the source of ozone precursor emissions. Emissions from mobile sources are relatively high in CO, while emissions from most industrial point sources, certainly electric generating units ("EGUs"), are relatively low in CO. Luria at 6598. Therefore, an air mass arriving at Look Rock with a relatively high concentration of CO would indicate that the sources of the ozone precursors were heavily influenced by mobile sources, while air masses with relatively low CO concentrations would be more indicative of ozone precursor source regions with a low density of mobile sources. Air masses predominated by mobile source emissions have been shown to have CO concentrations in excess of 140 ppb. Luria at 6953. An analysis of all the CO data available for 2009-2011 at Look Rock (not just the data for the nine events, but the entire data set for the three-year period) indicates the average CO concentration to be 180 ppb with a standard deviation of 50 ppb. Therefore, a CO concentration at Look Rock of 0-130 ppb was considered low and indicative of a small influence by mobile sources, a CO concentration of 131-230 was considered high and indicative of substantial influence from mobile sources, and a CO concentration greater than 230 was considered extremely high and strongly influenced by mobile sources.

A. June 25-26, 2009.

During the high-ozone event on June 25-26, 2009, the photochemical ages of the air masses arriving at Look Rock were generally in the old range (ages ranged from 0.69 to 0.92 with an average of 0.78), and the CO concentrations were moderately high (CO ranged from 134 to 207 ppb with an average of 161 ppb). The back trajectories were generally from the northeast to north during the period. Based on this analysis, it appears likely that the sources of the NO_X emissions that created the high ozone event were from a combination of mobile and

point sources in the valley northeast of Look Rock, potentially from as far away as the Tri-Cities area, as well as areas in Hamblen and Jefferson Counties along the Interstate 81 corridor, in Cocke County along the Interstate 40 corridor, and in western Sevier County and eastern Knox County. With a photochemical age averaging 0.78, it is not likely that substantial ozone was produced from nearby NO_X emissions in Blount County.

B. April 2-3, 2010.

During the high-ozone event on April 2-3, 2010, the photochemical ages of the air masses arriving at Look Rock were generally in the old range (ages ranged from 0.47 to 0.93 with an average of 0.81), and the CO concentrations were extremely high (CO ranged from 256 to 327 ppb with an average of 278 ppb). The back trajectories generally were from the south during the period. Based on this analysis, it appears likely that the sources of the NO_X emissions that created the high ozone event were primarily the result of mobile sources. Examining the back trajectories strongly suggests these mobile source emissions emanated from north Georgia, possibly as far away as the Atlanta area. Because the air masses arriving at Look Rock during this event should not have received fresh NO_X emissions during the last twelve hours prior to arriving at Look Rock (because they basically passed over the remote, forested areas of north Georgia, southeast Tennessee, and southwestern North Carolina), and because the photochemical ages of the air masses generally were in the old range, one can conclude that ozone may be transported to a site like Look Rock from vast distances.

C. April 13-14, 2010.

During the high-ozone event on April 13 and the morning of April 14, 2010, the photochemical ages of the air masses arriving at Look Rock averaged in the moderate range (ages ranged from 0.08 to 0.91 with an average of 0.60), and the CO concentrations were high

(CO ranged from 189 to 240 ppb with an average of 221 ppb). With regard to the photochemical age, the air masses arriving at Look Rock were generally old, except for the period 1900 – 2100 when NO_X levels increased dramatically. This dramatic increase in NO_X levels coincided with sundown and a slight increase in CO levels. These changes suggest impacts from nearby mobile sources. The back trajectories were generally from the south and west during the period. Specifically, the air mass arriving at Look Rock during the hour when the NO_X levels were the highest and the photochemical age the lowest spent the preceding three hours over extreme southeastern Loudon County and extreme southwestern Blount County. Based on this analysis, it appears likely that the sources of the NO_X emissions that created the high ozone event were primarily the result of mobile sources southwest and west of Look Rock, particularly in Monroe County and along the I-75 corridor in McMinn County.

D. April 14, 2010.

During the high-ozone event on the afternoon and evening of April 14, 2010, the photochemical ages of the air masses arriving at Look Rock were generally in the old range (ages ranged from 0.50 to 0.88 with an average of 0.80), and the CO concentrations were extremely high (CO ranged from 224 to 242 ppb with an average of 233 ppb). The air masses arriving at Look Rock during the 1700 – 2000 timeframe had slightly higher NO_X levels and younger photochemical ages. Again, this increase in NO_X levels coincided with sundown and, in this case, a dramatic shift in local wind direction. Since there was no change in the direction of the back trajectories, it is apparent that this shift in wind direction was due to the localized phenomenon identified by Tanner and is related to a shift in winds from up-slope to down-slope as the boundary layer settled below the Look Rock monitor. The back trajectories were generally from the south to the southwest during the entire period. Based on this analysis,

it appears likely that the sources of the NO_X emissions that created the high-ozone event were primarily the result of mobile sources south and southwest of Look Rock, particularly in Hamilton, McMinn, and Monroe Counties.

E. April 15, 2010.

During the high-ozone event on April 15, 2010, the photochemical ages of the air masses arriving at Look Rock were generally in the moderate range (ages ranged from 0.32 to 0.85 with an average of 0.66), and the CO concentrations were in the high range (CO ranged from 199 to 248 ppb with an average of 217 ppb). As during some of the aforementioned events, the air masses arriving at Look Rock during 1900 – 2300 timeframe had slightly higher NO_X levels and younger photochemical ages. Again, this increase in NO_X levels coincided with sundown and a dramatic shift in local wind direction. As with the April 14 event, there was no change in the direction of the back trajectories during this period; therefore, it is apparent that this localized shift in wind direction was due to a shift in winds from up-slope to down-slope as the boundary layer settled below the Look Rock monitor. The back trajectories were generally from the southwest during the entire period. Based on this analysis, it appears likely that the sources of the NO_X emissions that created the high-ozone event were primarily the result of mobile sources southwest of Look Rock, particularly along the I-75 corridor in Hamilton, Bradley, McMinn, and Monroe Counties.

F. May 5-6, 2010.

During the high-ozone event on May 5 and the morning of May 6, 2010, the photochemical ages of the air masses arriving at Look Rock were generally in the moderate range (ages ranged from 0.59 to 0.72 with an average of 0.63), and the CO concentrations were in the high range (CO ranged from 190 to 213 ppb with an average of 199 ppb).

The back trajectories were generally from the south and southwest during the entire period and did not cross heavily populated areas or major transportation corridors after crossing over the I-75 corridor in north Georgia eighteen to twenty-four hours before the high-ozone event. Based on this analysis, it appears likely that the sources of the NO_X emissions that created the high-ozone event were primarily the result of mobile sources southwest of Look Rock, possibly in the north Georgia area.

G. May 6-7, 2010.

During the high-ozone event on the afternoon of May 6 and May 7, 2010, the photochemical ages of the air masses arriving at Look Rock were generally in the moderate range (ages ranged from 0.13 to 0.90 with an average of 0.60), and the CO concentrations were in the high range (CO ranged from 202 to 228 ppb with an average of 213 ppb). As with some of the aforementioned events, the NO_X levels increased and the photochemical age declined at sundown as the local winds shifted from up-slope to down-slope. The back trajectories during the event began primarily from the south and shifted during the event toward the west and northwest. Based on this analysis, it appears likely that the sources of the NO_X emissions that created the high-ozone event were primarily the result of mobile sources from the I-75 corridor southwest of Look Rock and from Monroe, Loudon, southern Knox, and northwestern Blount Counties.

H. October 11-12, 2010.

During the high-ozone event on October 11-12, 2010, the photochemical ages of the air masses arriving at Look Rock were generally old (ages ranged from 0.78 to 0.88 with an average of 0.82), and the CO concentrations were in the high range (CO ranged from 158 to 169 ppb with an average of 164 ppb). The back trajectories during the event were generally from

the southwest during the entire event. Based on this analysis, it appears likely that the sources of the NO_X emissions that created the high-ozone event were primarily the result of mobile sources from Bradley, McMinn, and Monroe Counties along the I-75 corridor and potentially from the Chattanooga and North Georgia areas.

I. August 3, 2011.

During the high-ozone event on August 3, 2011, the photochemical ages of the air masses arriving at Look Rock were generally old (ages ranged from 0.71 to 0.90 with an average of 0.83), and the CO concentrations were extremely high – some of the highest measured in the 2009-2011 timeframe (CO ranged from 454 to 567 ppb with an average of 332 ppb). The back trajectories during the event were generally from the southwest during the entire event. Based on this analysis it appears likely that the sources of the NO_X emissions that created the high ozone event were primarily the result of mobile sources from Bradley, McMinn, and Monroe Counties along the I-75 corridor and potentially from the Chattanooga area or farther south.

In summary, the back trajectory information for these nine events is consistent with the data from the NWS meteorological monitoring station at the Knoxville Airport in that the predominant direction from which air masses arrive at Look Rock is the south and southwest. Generally, the photochemical age of the air masses arriving at Look Rock is in the old range, although during several of the nine events as the sun set and localized wind directions (measured at Look Rock) shifted from up-slope to down-slope, NO_X levels increased and photochemical age decreased. During those periods, however, wind directions based on back trajectories were normally not from Knox, northern Blount, or Anderson Counties. Also, CO levels were generally

high, which indicates that the sources of ozone precursors during these nine high ozone events were likely primarily mobile sources as opposed to industrial point sources.

IV. CSAPR and 2008 STANDARD MODELING.

In her September 22, 2011 memorandum to EPA Regional Air Division Directors, Assistant Administrator Gina McCarthy states that "EPA's modeling indicates that approximately half of the 52 areas [not attaining the 2008 standard] would attain the 0.075 ppm standard by 2015 (the expected deadline for Marginal areas) as a result of the emission-reducing rules already in place." Memorandum from Gina McCarthy to Air Division Directors (Sept. 22, 2011) 2 ("McCarthy Memo."). Later in that same memorandum, Ms. McCarthy lists some of the "emission-reducing rules" to which her earlier statement refers, such as the Cross-State Air Pollution Rule ("CSAPR"),[6] the Portland Cement Rule, the Light and Heavy Duty Vehicle standards, the Boiler Maximum Achievable Control Technology, the Mercury and Air Toxics Standards for power plants, the New Source Performance Standards for Commercial Incinerators/Solid Waste Incinerators and the Oil/Gas sector, and the Tier 3 vehicle and fuel standards. *Id*. She notes, "These federal actions will ensure steady forward progress to clean up the nation's air and protect the health of American families, while minimizing and in many cases eliminating the need for states to use their scarce resources on local actions." *Id*.

In support of these statements, Ms. McCarthy refers to modeling described in the *Spreadsheet projecting the hypothetical 8-hour ozone nonattainment areas for the 75 ppb NAAQS to 2015 to estimate the number of marginal nonattainment areas that are expected to*

[6] In light of several petitions for review of CSAPR, the U.S. Appeals Court for the D.C. Circuit stayed CSAPR on December 30, 2011, and ordered that the Clean Air Interstate Rule ("CAIR") remain in effect pending resolution of the petitions for review. On August 21, 2012, the D.C. Circuit vacated CSAPR and reinstated CAIR. *See* Order, *EME Homer City Generation, L.P. v. EPA*, No. 11-1302 (D.C. Cir. Aug. 21, 2012).

attain the NAAQS by their attainment date of 2015, (EPA-HQ-OAR-2010-0885-0064). In that document, EPA describes how it used CSAPR modeling to make projections for the ozone monitors across the country for 2015. Basically, the approach projects the 2008-2010 ozone design values to 2015 using the modeled average percent per year change in ozone from the 2014 CSAPR final rule modeling (i.e., the CSAPR remedy case). The CSAPR modeling used a base year of 2005 and a future year of 2014 – a nine-year projection. EPA pro-rated the percent average annual ozone changes over the nine-year period to estimate the expected change in ozone between the 2008-2010 period and 2015, the year Marginal nonattainment counties must attain the 2008 standard. Because there are five years between 2010 and 2015, EPA used 5/9ths of the modeled percent change (between 2005 and 2014) and applied this pro-rated factor to the 2008-2010 design value for each monitor.

The CSAPR modeling is described in detail in *Air Quality Modeling Final Rule Technical Support Document*, US EPA, OAQPS, Air Quality Assessment Division, Research Triangle Park, NC (June 2011). EPA used 2005 as the base year for the CSAPR modeling because it was the most current year for which EPA had a complete National Emissions Inventory ("NEI") available. *Id*. at 2. In addition to the 2005 base case, three future scenarios were modeled – 2012 base case, 2014 base case, and 2014 remedy. *Id*. The 2014 remedy case contained the emission reductions resulting from CSAPR plus all the other "emission-reducing rules" expected to come into effect between 2012 and 2014. *Id*. at 50 n.55. In contrast, the other future scenarios were based on just the other "emission-reducing rules" coming into effect between 2012 and 2014. *Id*.

The details of the emission inventories used in creating the emissions inputs for the modeling are described in *Emissions Inventory Final Rule Technical Support Document*, US

EPA, OAQPS, Air Quality Assessment Division, Research Triangle Park, NC (June 28, 2011). According to this document, emission inputs for the 2012 and 2014 scenarios generally take into account "Federal and State measures already promulgated before emissions processing on the Transport Rule [CSAPR] began in December, 2010." *Id*. at 68. With respect to electric generating unit ("EGU") emissions, the document states that "the emissions reflect state rules and federal consent decrees through December 1, 2010." *Id*. For mobile sources, "all national measures for which data were available at the time of the modeling" were included. *Id.* However, for non-EGU point sources and nonpoint sources, local control programs that might have been necessary for areas to attain the 1997 $PM_{2.5}$ annual NAAQS, the 2006 $PM_{2.5}$ 24-hour NAAQS, and the 1997 ozone NAAQS were generally *not* included in the future scenarios. *Id.*

The Emissions Inventory Final Rule Technical Support Document's "Emissions Summaries"[7] spreadsheet provides the specific emission levels used in the CSAPR modeling by type of emission source and by state. The Counties used the values in this spreadsheet to perform the technical analysis described below. Table 5 in Appendix 1 summarizes the NO_X and VOC emission levels used in the modeling along with the percentage of emission reductions by emission source type for Tennessee. As can be seen, emissions of ozone precursors are projected to drastically decrease across Tennessee between 2005 and 2014 due to nation-wide "emission-reducing rules" included in the CSAPR modeling. NO_X emissions are projected to decrease by about 43% in that timeframe while VOC emissions are projected to decrease by about 23%.

[7] *Available at* http://www.epa.gov/airtransport/techinfo.html.

Using an approach similar to that taken by EPA for comparison with the 2008 ozone NAAQS, the Counties extrapolated the CSAPR modeling for 2014 to 2015[8] by taking the average annual 2005 to 2014 emission reduction percentages for Tennessee listed in Table 5 in Appendix 1 and applying them to the corresponding 2008 emissions for the twelve counties in the Knoxville CSA. In other words, the Counties divided the 2005 to 2014 emission reduction percentages in Table 5 in Appendix 1 by nine (for the nine-year period between 2005 and 2014) and multiplied the resulting average annual emission reduction percentage by seven (for the seven years between 2008 and 2015). The county-level emissions used in the analysis are from the 2008 NEI, v2.[9] These 2008 emission levels vary somewhat from the emission levels referenced by EPA in its attachment to Gwendolyn Keyes Fleming's December 8, 2011 letter to Governor Bill Haslam (concerning EPA's intentions to designate certain counties in Tennessee as nonattainment) due to EPA's use of an earlier version (v1.5) of the 2008 NEI. Version 1.5 is no longer available. Tables 6 and 7 in Appendix 1 summarize the results of the Counties' analysis of the projected NO_x and VOC reductions in the CSA from 2008-2015.

As can be seen in Tables 6 and 7 in Appendix 1, based on this analysis, emissions of NO_X and VOCs are projected by EPA to drastically decrease in the twelve counties making up the Knoxville CSA. Of note is that NO_X emissions are projected to decrease by about 32% in the three counties EPA has designated as nonattainment (Knox, Blount, and Anderson), while VOC emissions are projected to decrease by about 16%. These are significant reductions and will come at a cost to the citizens and businesses in the Knoxville area.

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[8] *See* pages 20-21 *supra*, describing the approach used in *Spreadsheet projecting the hypothetical 8-hour ozone nonattainment areas for the 75 ppb NAAQS to 2015 to estimate the number of marginal nonattainment areas that are expected to attain the NAAQS by their attainment date of 2015*, (EPA-HQ-OAR-2010-0885-0064)).

[9] *Available at* http://www.epa.gov/ttn/chief/net/2008inventory.html.

With regard to EGU emissions in the Knoxville CSA, TVA has already significantly reduced NO_X emissions at both its Bull Run Power Plant in Anderson County and its Kingston Power Plant in Roane County. NO_X emissions have been reduced at Bull Run by about 89% on an annual basis, while annual emissions have been reduced by about 91% at Kingston. In both cases these reductions exceed the 55.7% reduction the Counties assumed in their analysis. These reductions have been achieved by adding SCR to all units at both plants. Table 8 in Appendix 1 summarizes the NO_X emissions levels and rates for Bull Run Power Plant for the last seven years, and Table 9 in Appendix 1 summarizes the emission levels and rates for Kingston. Note that the annual NO_x emission *rates* have decreased at Bull Run and Kingston by about 80% and 74%, respectively. Neither NO_x emissions nor the NO_x emission rate from the Bull Run or Kingston Power Plants is expected to increase through the foreseeable future due to (1) the continued effect of CAIR;[10] (2) the requirements of a federally enforceable consent decree (*See* Consent Decree, *Alabama v. TVA*, No. 3:11-cv-00170 (E. D. Tenn. June 6, 2011) (requiring TVA to, *inter alia*, cap system-wide NO_x emissions through 2018 and each year thereafter); and (3) TVA's own commitments to reduce its load growth and install emission reduction equipment and new technology to control emissions from over 80% of fossil generation in the next ten years. (*See* "2010 Review of TVA's 2008 Environmental Policy" 8, attached hereto as Appendix 4).

Table 10 in Appendix 1 summarizes the results of the modeling done for CSAPR and the extrapolations made by EPA for the 2008 ozone NAAQS for the Knoxville CSA from *Spreadsheet projecting the hypothetical 8-hour ozone nonattainment areas for the 75 ppb NAAQS to 2015 to estimate the number of marginal nonattainment areas that are expected to*

[10] On August 21, 2012, the D.C. Circuit vacated CSAPR and reinstated CAIR. *See* Order, *EME Homer City Generation, L.P. v. EPA*, No. 11-1302 (D.C. Cir. Aug. 21, 2012).

attain the NAAQS by their attainment date of 2015, (EPA-HQ-OAR-2010-0885-0064). These ozone levels represent the improvements to air quality projected to result from the emission reductions EPA projects will be made in the Knoxville area, as well as across the region. As can be seen, all nine of the monitors in the area are projected to be well below the 2008 ozone NAAQS by 2014 and 2015, including Look Rock, based on EPA's modeling. As described above and mentioned in the McCarthy Memo, these monitors are projected to be 7-16% below the NAAQS by 2015 due to "emission-reducing rules already in place" and without "the need for states to use their scarce resources on local actions."

CONCLUSION

Only one monitor out of nine in the Knoxville CSA had a 2009-2011 design value that exceeded the NAAQS. That monitor is located at Look Rock in Blount County. Blount County has a second monitor located just nine miles from Look Rock -- the Cades Cove monitor -- with a design value well below the NAAQS.

As noted above, Look Rock is one of the most instrumented and studied ozone monitoring stations in the southeastern United States. However, instead of relying on readily available (and extensive) Look Rock research, EPA took a simplistic approach to determining which counties in the Knoxville CSA to designate nonattainment and ignored much of what is known about the air quality and meteorology of this very complex Look Rock site.

EPA itself concluded in the TSD that high-ozone events at Look Rock were due to totally anomalous conditions, not representative of the vast majority of the Knoxville CSA. Nonetheless, it used the 2009-2011 Look Rock design value exceedance of the NAAQS to designate the entirety of two counties and a portion of a third as nonattainment.

Because EPA was unaware of or disregarded the wealth of information that exists regarding air quality and meteorological conditions at Look Rock, it attributed the influences it identified as "valley" impacts to Knoxville. EPA's erroneous conclusion concerning the source areas of ozone precursors during high ozone events led it to designate the entirety of Knox and Blount Counties and a portion of Anderson County nonattainment. However, the back trajectory analyses conducted by both the Counties and TVA clearly demonstrate that air masses arriving at Look Rock during the high-ozone periods come from a variety of directions, most often from the south to southwest. Thus, EPA's determination that ozone exceedances will decrease as a result of reducing Knoxville-area emissions (through the nonattainment designation) is arbitrary and capricious.

In addition, EPA's modeling for CSAPR projects significant NO_X and VOC emission reductions in the twelve-county Knoxville CSA between 2005 and 2014. EPA's modeling for implementation of the 2008 standard extrapolated the CSAPR modeling to 2015 and found that approximately half of all currently nonattaining areas nationwide would meet the 2008 standard in 2015, due to national and regional "emission-reducing rules already in place" and without "the need for states to use their scarce resources on local actions." McCarthy Memo. at 2. The Counties calculated the county-by-county emissions projected for the Knoxville CSA by 2015 and found that NO_X emissions in the CSA are projected to decrease by over 25,000 tons per year or about 33% between 2008 and 2015 and that VOC emissions are projected to decrease by over 10,000 tons per year or about 19% over the same time period. *See* Tables 6 and 7 in Appendix 1. Based on the CSAPR modeling and EPA's 2008 ozone standard modeling, all monitors in the Knoxville CSA are projected to be well below the 2008 ozone NAAQS by 2014 and 2015.

The Counties' analysis of nine high-ozone events at Look Rock indicated that the ozone precursor NO_X emissions that contributed to the high ozone levels were primarily from mobile sources. The Counties' analysis of emission reductions that result from national and regional emission-reducing rules indicates that between 2008 and 2015, mobile source NO_X emissions across the twelve-county Knoxville CSA are projected to decrease by 15,695 tons per year or about 33%, while mobile source VOC emissions are projected to decrease by 8,880 tons per year or about 33%.

Further, TVA already has reduced NO_X emissions at both its Bull Run Power Plant and its Kingston Power Plant to levels well below what is reflected in the CSAPR modeling by adding SCRs to all units at both plants (emissions in 2009, 2010, and 2011 were already at this level).

EPA promised to "minimize the regulatory burdens on the States" in making its ozone designations. McCarthy Memo. at 1. Nonetheless, EPA has designated Blount County, Knox County, and a portion of Anderson County nonattainment when (1) EPA's analysis indicates that high-ozone events at the lone (high-altitude) nonattainment monitor are due to anomalous conditions; and (2) EPA's modeling shows that the entire Knoxville CSA will be in attainment with the 2008 standard in 2015. EPA has acted arbitrarily, capriciously, in abuse of its discretion, and otherwise not in accordance with law in making its Knoxville CSA nonattainment designations, and the Counties ask for reconsideration of the Final Rule.

Respectfully submitted and signed on this 16th day of October, 2012.

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Appendix 1

Data Tables.

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20090625	13:00	70	0.79	0.05	0.5	0.55	2.09	2.64
20090625	14:00	79	0.82	0.05	0.58	0.63	2.81	3.44
20090625	15:00	88	0.77	0.05	0.9	0.95	3.19	4.14
20090625	16:00	92	0.81	0.05	0.87	0.92	3.82	4.74
20090625	17:00	93	0.75	0.32	1.01	1.33	3.91	5.24
20090625	18:00	89	0.79	0.22	0.84	1.06	3.88	4.94
20090625	19:00	81	0.76	0.12	0.6	0.72	2.22	2.94
20090625	20:00	81	0.72	0.22	0.55	0.77	1.97	2.74
20090625	21:00	76	0.78	0.05	0.47	0.52	1.82	2.34
20090625	22:00	76	0.69	0.32	0.49	0.81	1.83	2.64
20090625	23:00	76	0.75	0.05	0.47	0.52	1.52	2.04
20090626	0:00	75	0.92	0.05	0.13	0.18	2.02	2.2
Ave.		**81.3**	**0.78**	**0.13**	**0.62**	**0.75**	**2.59**	**3.34**
Max.		**93**	**0.92**	**0.32**	**1.01**	**1.33**	**3.91**	**5.24**
Min.		**70**	**0.69**	**0.05**	**0.13**	**0.18**	**1.52**	**2.04**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20100402	13:00		0.85	0.12	0.91	1.03	5.81	6.84
20100402	14:00		0.90	0.12	0.41	0.53	4.61	5.14
20100402	15:00	79	0.88	0.22	0.37	0.59	4.15	4.74
20100402	16:00	81	0.86	0.22	0.48	0.70	4.34	5.04
20100402	17:00	79	0.84	0.12	0.64	0.76	3.88	4.64
20100402	18:00	80	0.77	0.32	0.84	1.16	3.78	4.94
20100402	19:00	89	0.47	2.92	1.2	4.12	3.62	7.74
20100402	20:00	87	0.69	1.02	0.65	1.67	3.77	5.44
20100402	21:00	81	0.89	0.05	0.41	0.46	3.58	4.04
20100402	22:00	81	0.90	0.05	0.34	0.39	3.65	4.04
20100402	23:00	84	0.93	0.05	0.25	0.30	3.94	4.24
20100403	0:00	83	0.84	0.35	0.37	0.72	3.72	4.44
20100403	1:00	79	0.78	0.55	0.33	0.88	3.06	3.94
20100403	2:00	77	0.80	0.15	0.72	0.87	3.47	4.34
20100403	3:00	76	0.80	0.15	0.66	0.81	3.33	4.14
20100403	4:00	74	0.80	0.05	0.76	0.81	3.33	4.14
Ave		**80.7**	**0.81**	**0.40**	**0.58**	**0.99**	**3.88**	**4.87**
Max		**89**	**0.93**	**2.92**	**1.20**	**4.12**	**4.34**	**7.74**
Min		**74**	**0.47**	**0.05**	**0.25**	**0.30**	**3.06**	**3.94**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20100413	15:00	74	0.84	0.42	0.23	0.65	3.34	3.99
20100413	16:00	76	0.85	0.32	0.26	0.58	3.41	3.99
20100413	17:00	79	0.91	0.05	0.34	0.39	3.80	4.19
20100413	18:00	81	0.67	1.52	0.36	1.88	3.81	5.69
20100413	19:00	81	0.08	17.42	0.79	18.21	1.48	19.69
20100413	20:00	81	0.10	8.52	0.33	8.85	0.94	9.79
20100413	21:00	81	0.43	4.02	0.44	4.46	3.33	7.79
20100413	22:00	82	0.68	1.22	0.3	1.52	3.17	4.69
20100413	23:00	79	0.66	1.32	0.29	1.61	3.08	4.69
20100414	0:00	79	0.70	1.01	0.4	1.41	3.27	4.68
20100414	1:00	78	0.74	0.71	0.74	1.45	4.13	5.58
20100414	2:00	76	0.80	0.21	0.91	1.12	4.36	5.48
20100414	3:00	73	0.78	0.05	1.27	1.32	4.76	6.08
Ave		**78.5**	**0.63**	**2.83**	**0.51**	**3.34**	**3.30**	**6.64**
Max		**82**	**0.91**	**17.42**	**1.27**	**18.21**	**4.76**	**19.69**
Min		**73**	**0.08**	**0.05**	**0.23**	**0.39**	**0.94**	**3.99**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20100414	11:00	74	0.83	0.21	0.6	0.81	4.07	4.88
20100414	12:00	79	0.86	0.11	0.67	0.78	4.60	5.38
20100414	13:00	83	0.88	0.11	0.51	0.62	4.76	5.38
20100414	14:00	84	0.88	0.21	0.51	0.72	5.16	5.88
20100414	15:00	86	0.88	0.11	0.59	0.70	5.38	6.08
20100414	16:00	84	0.85	0.31	0.57	0.88	4.80	5.68
20100414	17:00	85	0.80	0.61	0.65	1.26	5.02	6.28
20100414	18:00	85	0.73	1.11	0.86	1.97	5.31	7.28
20100414	19:00	82	0.50	2.71	1.08	3.79	3.79	7.58
20100414	20:00	78	0.72	0.51	0.79	1.30	3.38	4.68
20100414	21:00	71	0.82	0.11	0.53	0.64	2.84	3.48
Ave		**81.0**	**0.80**	**0.56**	**0.67**	**1.22**	**4.46**	**5.69**
Max		**86**	**0.88**	**2.71**	**1.08**	**3.79**	**5.38**	**7.58**
Min		**71**	**0.50**	**0.11**	**0.51**	**0.62**	**2.84**	**3.48**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20100415	14:00	75	0.84	0.14	0.58	0.72	3.92	4.64
20100415	15:00	78	0.85	0.14	0.57	0.71	4.13	4.84
20100415	16:00	79	0.81	0.44	0.59	1.03	4.31	5.34
20100415	17:00	80	0.83	0.05	0.77	0.82	3.92	4.74
20100415	18:00	80	0.80	0.05	0.81	0.86	3.48	4.34
20100415	19:00	75	0.67	0.44	1.31	1.75	3.49	5.24
20100415	20:00	75	0.32	3.24	0.89	4.13	1.91	6.04
20100415	21:00	74	0.55	1.64	0.97	2.61	3.13	5.74
20100415	22:00	76	0.42	2.34	0.76	3.10	2.24	5.34
20100415	23:00	73	0.52	1.84	0.55	2.39	2.55	4.94
Ave		**76.5**	**0.66**	**1.03**	**0.78**	**1.81**	**3.31**	**5.12**
Max		**80**	**0.85**	**3.24**	**1.31**	**4.13**	**4.31**	**6.04**
Min		**73**	**0.32**	**0.05**	**0.55**	**0.71**	**1.91**	**4.34**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20100505	18:00	74	0.62	0.58	0.6	1.18	1.92	3.10
20100505	19:00	77	0.61	1.08	0.4	1.48	2.32	3.80
20100505	20:00	76	0.63	0.88	0.45	1.33	2.27	3.60
20100505	21:00	76	0.60	1.08	0.49	1.57	2.33	3.90
20100505	22:00	80	0.63	1.08	0.5	1.58	2.72	4.30
20100505	23:00	86	0.59	1.48	0.57	2.05	2.95	5.00
20100506	0:00	84	0.72	1.01	0.4	1.41	3.69	5.10
20100506	1:00	73	0.65	1.01	0.43	1.44	2.66	4.10
Ave		**78.3**	**0.63**	**1.03**	**0.48**	**1.51**	**2.61**	**4.11**
Max		**86**	**0.72**	**1.48**	**0.60**	**2.05**	**3.69**	**5.10**
Min		**73**	**0.59**	**0.58**	**0.40**	**1.18**	**1.92**	**3.10**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20100506	11:00	68	0.84	0.41	0.07	0.48	2.52	3
20100506	12:00	80	0.87	0.31	0.16	0.47	3.23	3.7
20100506	13:00	81	0.88	0.31	0.1	0.41	2.99	3.4
20100506	14:00	82	0.90	0.21	0.14	0.35	3.25	3.6
20100506	15:00	79	0.89	0.21	0.13	0.34	2.86	3.2
20100506	16:00	78	0.85	0.31	0.2	0.51	2.89	3.4
20100506	17:00	77	0.83	0.41	0.18	0.59	2.81	3.4
20100506	18:00	76	0.61	1.21	0.26	1.47	2.33	3.8
20100506	19:00	80	0.13	5.11	0.34	5.45	0.85	6.3
20100506	20:00	79	0.47	2.71	0.46	3.17	2.83	6
20100506	21:00	80	0.32	3.01	0.48	3.49	1.61	5.1
20100506	22:00	79	0.24	5.31	0.35	5.66	1.74	7.4
20100506	23:00	76		5.11	0.67	5.78		
20100507	0:00	77		3.28	0.68	3.96		
20100507	1:00	76	0.49	2.08	0.39	2.47	2.36	4.83
20100507	2:00	76	0.40	1.98	0.57	2.55	1.68	4.23
20100507	3:00	75	0.37	2.08	0.58	2.66	1.57	4.23
Ave		**77.6**	**0.61**	**2.00**	**0.34**	**2.34**	**2.37**	**4.37**
Max		**82**	**0.90**	**5.31**	**0.68**	**5.78**	**3.25**	**7.40**
Min		**68**	**0.13**	**0.21**	**0.07**	**0.34**	**0.85**	**3.00**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20101011	17:00	75	0.82	0.05	0.2	0.25	1.13	1.38
20101011	18:00	79	0.80	0.05	0.26	0.31	1.27	1.58
20101011	19:00	77	0.78	0.05	0.26	0.31	1.07	1.38
20101011	20:00	75	0.78	0.05	0.23	0.28	1.00	1.28
20101011	21:00	76	0.82	0.05	0.2	0.25	1.13	1.38
20101011	22:00	78	0.85	0.05	0.18	0.23	1.35	1.58
20101011	23:00	78	0.83	0.05	0.23	0.28	1.40	1.68
20101012	0:00	77	0.84	0.05	0.18	0.23	1.24	1.47
20101012	1:00	78	0.88	0.05	0.14	0.19	1.38	1.57
20101012	2:00	75	0.83	0.05	0.17	0.22	1.05	1.27
Ave		**76.8**	**0.82**	**0.05**	**0.21**	**0.26**	**1.20**	**1.46**
Max		**79**	**0.88**	**0.05**	**0.26**	**0.31**	**1.40**	**1.68**
Min		**75**	**0.78**	**0.05**	**0.14**	**0.19**	**1.00**	**1.27**

Table 1: Pertinent Nitrogen Data Used in the Counties' Analysis.								
Date	**Time**	**Ozone ($\mu g/m^3$)**	**NO_Z/NO_Y**	**NO ($\mu g/m^3$)**	**NO_2 ($\mu g/m^3$)**	**NO_X ($\mu g/m^3$)**	**NO_Z ($\mu g/m^3$)**	**NO_Y ($\mu g/m^3$)**
20110803	12:00	73	0.89	0.06	0.05	0.11	0.93	1.04
20110803	13:00	80	0.84	0.05	0.16	0.21	1.13	1.34
20110803	14:00	78	0.90	0.05	0.11	0.16	1.48	1.64
20110803	15:00	77	0.88	0.05	0.16	0.21	1.53	1.74
20110803	16:00	76	0.90	0.06	0.1	0.16	1.38	1.54
20110803	17:00	82	0.82	0.05	0.21	0.26	1.18	1.44
20110803	18:00	78	0.84	0.05	0.13	0.18	0.96	1.14
20110803	19:00	77	0.81	0.05	0.09	0.14	0.60	0.74
20110803	20:00	78	0.72	0.05	0.1	0.15	0.39	0.54
20110803	21:00	72	0.71	0.05	0.05	0.10	0.24	0.34
Ave		**77.1**	**0.83**	**0.05**	**0.12**	**0.17**	**0.98**	**1.15**
Max		**82**	**0.90**	**0.06**	**0.21**	**0.26**	**1.53**	**1.74**
Min		**72**	**0.71**	**0.05**	**0.05**	**0.1**	**0.24**	**0.34**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20090625	13:00	70	338	17	3.1	891	190.9	31.4	609
20090625	14:00	79	335	19	2.7	871	196.9	15.5	669
20090625	15:00	88	330	16	2.3	752	207.4	18.5	735
20090625	16:00	92	337	19	1.8	586	172.9	24.0	668
20090625	17:00	93	7	21	0.9	417	166.2	23.4	
20090625	18:00	89	360	16	0.8	213	142.8	14.4	472
20090625	19:00	81	37	20	1.7	46	133.9	17.9	437
20090625	20:00	81	52	28	1	0	141.5	13.6	468
20090625	21:00	76	48	22	1.9	0	138.7	12.6	440
20090625	22:00	76	79	30	0.7	0	144.0	13.1	426
20090625	23:00	76	151	8	1.2	0	150.8	18.6	466
20090626	0:00	75	151	10	0.8	0	143.4	21.2	434
Ave.		**81.3**		**19**	**1.6**		**160.8**	**18.7**	**529**
Max.		**93**		**30**	**3.1**		**207.4**	**31.4**	**735**
Min.		**70**		**8**	**0.7**		**133.9**	**12.6**	**426**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20100402	13:00		28	90	0.8	109	295.4	NA	976
20100402	14:00		334	25	2.2	532	266.5	NA	346
20100402	15:00	79	311	22	3	584	262.2	NA	1056
20100402	16:00	81	311	24	2.6	372	268.8	NA	1080
20100402	17:00	79	309	17	2.2	193	268.4	NA	537
20100402	18:00	80	299	17	2.3	31	274.7	NA	1180
20100402	19:00	89	248	31	0.8	0	288.4	NA	779
20100402	20:00	87	148	11	3	0	284.4	NA	1447
20100402	21:00	81	160	10	4.6	0	269.0	NA	1249
20100402	22:00	81	161	13	4.5	0	274.7	NA	960
20100402	23:00	84	160	11	5.1	0	318.3	NA	1097
20100403	0:00	83	160	18	3.7	0	326.7	NA	1777
20100403	1:00	79	172	34	3	0	279.4	NA	743
20100403	2:00	77	168	21	4.5	0	256.3	NA	1096
20100403	3:00	76	166	16	5	0	258.6	NA	1052
20100403	4:00	74	162	13	6.5	0	259.7	NA	678
Ave		**80.7**		**23**	**3.4**		**278.2**	**NA**	**1003**
Max		**89**		**34**	**6.5**		**326.7**	**NA**	**1777**
Min		**74**		**10**	**0.8**		**256.3**	**NA**	**537**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20100413	15:00	74	324	41	1.9	671	189.0	16.4	358
20100413	16:00	76	308	31	2	478	196.7	18.3	355
20100413	17:00	79	329	24	2.2	264	209.2	17.7	
20100413	18:00	81	315	32	1.2	75	220.6	14.5	492
20100413	19:00	81	240	30	0.2	1	234.1	15.4	461
20100413	20:00	81	289	5	1	0	237.7	16.4	447
20100413	21:00	81	280	18	0.9	0	229.0	18.1	448
20100413	22:00	82	298	8	1.5	0	220.3	16.3	457
20100413	23:00	79	248	30	1	0	216.3	15.5	437
20100414	0:00	79	323	24	0.8	0	216.9	18.5	435
20100414	1:00	78	11	15	2.6	0	227.7	18.4	
20100414	2:00	76	359	10	2.1	0	230.8	19.6	563
20100414	3:00	73	346	6	2.4	0	240.1	18.9	592
Ave		**78.5**		**21**	**1.5**		**220.6**	**17.2**	**459**
Max		**82**		**41**	**2.6**		**240.1**	**19.6**	**592**
Min		**73**		**5**	**0.2**		**189.0**	**14.5**	**355**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20100414	11:00	74	331	22	3.4	859	234.1	23.8	600
20100414	12:00	79	330	19	3.8	903	242.9	21.5	609
20100414	13:00	83	333	22	3.8	881	233.0	21.4	546
20100414	14:00	84	342	26	3.9	799	235.5	22.9	
20100414	15:00	86	341	26	3.9	658	228.7	18.2	623
20100414	16:00	84	350	30	3.2	475	224.2	19.6	527
20100414	17:00	85	354	29	2.5	264	230.3	19.8	528
20100414	18:00	85	22	22	2	80	236.2	17.9	517
20100414	19:00	82	110	29	1.4	1	229.8	17.8	482
20100414	20:00	78	144	11	2.9	0	234.9	17.4	506
20100414	21:00	71	146	6	3.2	0	235.2	18.8	
Ave		**81.0**		**22**	**3.1**		**233.2**	**19.9**	**549**
Max		**86**		**30**	**3.9**		**242.9**	**23.8**	**623**
Min		**71**		**6**	**1.4**		**224.2**	**17.4**	**482**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20100415	14:00	75	315	20	3.3	812	247.9	19.6	
20100415	15:00	78	333	22	3.1	677	242.2	20.1	632
20100415	16:00	79	337	26	2.6	492	222.6	19.4	565
20100415	17:00	80	320	18	2.8	283	217.6	18.0	586
20100415	18:00	80	314	11	3.1	84	210.9	14.3	517
20100415	19:00	75	343	18	2.7	1	208.5	13.8	458
20100415	20:00	75	76	23	0.4	0	199.0	15.2	413
20100415	21:00	74	171	16	1.4	0	200.5	18.8	435
20100415	22:00	76	191	42	1.1	0	213.1	16.1	
20100415	23:00	73	228	62	0.8	0	209.2	16.1	482
Ave		**76.5**		**26**	**2.1**		**217.2**	**17.1**	**511**
Max		**80**		**62**	**3.3**		**247.9**	**20.1**	**632**
Min		**73**		**11**	**0.4**		**199.0**	**13.8**	**413**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20100505	18:00	74	281	42	1.1	134	191.2	10.6	369
20100505	19:00	77	251	32	1.5	8	195.2	11.3	387
20100505	20:00	76	256	35	1.5	0	195.9	10.8	378
20100505	21:00	76	205	59	0.6	0	195.6	11.4	
20100505	22:00	80	170	56	0.9	0	190.3	13.2	388
20100505	23:00	86	181	63	0.7	0	207.4	14.0	509
20100506	0:00	84	207	65	0.7	0	212.5	14.3	552
20100506	1:00	73	235	56	1	0	204.6	14.8	484
Ave		**78.3**		**51**	**1.0**		**199.1**	**12.6**	**438**
Max		**86**		**65**	**1.5**		**212.5**	**14.8**	**552**
Min		**73**		**32**	**0.6**		**190.3**	**10.6**	**369**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20100506	11:00	68	300	26	1.7	909	208.9	17.1	398
20100506	12:00	80	309	25	2	945	209.5	17.1	435
20100506	13:00	81	308	29	2	927	208.1	18.7	436
20100506	14:00	82	310	28	2.3	845	207.7	14.8	456
20100506	15:00	79	314	24	2.4	708	207.7	16.7	425
20100506	16:00	78	315	26	1.6	525	202.4	17.2	427
20100506	17:00	77	307	25	1.3	321	206.1	17.9	431
20100506	18:00	76	302	49	0.7	123	210.1	14.3	421
20100506	19:00	80	240	29	0.7	8	227.7	16.7	415
20100506	20:00	79	193	13	0.9	0	212.6	16.4	413
20100506	21:00	80	179	9	1	0	210.0	15.6	367
20100506	22:00	79	160	53	0.2	0	221.5	16.1	
20100506	23:00	76	138	14	1.1	0	217.2	16.4	408
20100507	0:00	77	156	14	1.4	0	215.7	16.0	410
20100507	1:00	76	163	33	1.1	0	215.1	16.0	412
20100507	2:00	76	165	34	1.1	0	216.0	16.7	416
20100507	3:00	75	151	17	1.7	0	219.2	17.4	421
Ave		**77.6**		**26**	**1.4**		**212.7**	**16.5**	**418**
Max		**82**		**53**	**2.4**		**227.7**	**18.7**	**456**
Min		**68**		**9**	**0.2**		**202.4**	**14.3**	**367**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20101011	17:00	75	255	39	0.9	34	157.7	18.8	
20101011	18:00	79	176	33	1	0	162.7	18.0	381
20101011	19:00	77	157	21	1.6	0	161.9	17.4	382
20101011	20:00	75	172	52	0.8	0	165.7	17.3	380
20101011	21:00	76	168	45	1	0	168.7	19.3	395
20101011	22:00	78	166	42	1	0	163.4	23.0	424
20101011	23:00	78	166	36	1.2	0	164.4	18.5	415
20101012	0:00	77	163	30	1.6	0	162.1	17.7	412
20101012	1:00	78	169	42	1.3	0	165.9	18.0	415
20101012	2:00	75	181	61	0.8	0	165.1	18.2	
Ave		**76.8**		**40**	**1.1**		**163.8**	**18.6**	**401**
Max		**79**		**61**	**1.6**		**168.7**	**23.0**	**424**
Min		**75**		**21**	**0.8**		**157.7**	**17.3**	**380**

Table 2: Pertinent Meteorological, Carbon, and Particulate Data Used in the Counties' Analysis.									
Date	**Time**	**Ozone ($\mu g/m^3$)**	**Wind Direction (degrees)**	**Sigma Theta (degrees)**	**Wind Speed (m/s)**	**Solar Radiation (Wh/m^2)**	**CO ($\mu g/m^3$)**	**$PM_{2.5}$ ($\mu g/m^3$)**	**Black Carbon (ng/m^3)**
20110803	12:00	73	314	31	2.4	815	331.5	20.0	411
20110803	13:00	80	321	41	1.3	927	365.8	20.1	436
20110803	14:00	78	231	74	0.3	871	444.1	20.2	
20110803	15:00	77	187	58	0.7	635	527.8	17.9	424
20110803	16:00	76	246	67	0.6	479	567.3	20.9	403
20110803	17:00	82	259	64	0.7	325	551.8	17.8	465
20110803	18:00	78	253	45	1.1	128	513.1	17.9	408
20110803	19:00	77	260	49	1	12	465.8	15.5	403
20110803	20:00	78	243	63	0.8	0	408.2	16.8	384
20110803	21:00	72	193	70	0.7	0	367.8		361
Ave		**77.1**		**56**	**1.0**		**454.3**	**18.6**	**411**
Max		**82**		**74**	**2.4**		**567.3**	**20.9**	**465**
Min		**72**		**31**	**0.3**		**331.5**	**15.5**	**361**

Table 3: Analysis of Wind Direction Data for Look Rock Based on CASTNET Measurements for 2009-2011.			
Average Hourly Ozone Above 75 ppb			
Wind Direction	**Number of Hours Wind From (hrs)**	**Percent of Time Wind From (%)**	**Average Solar Radiation ($Whrs/m^2$)**
N	135	47.4	385
E	37	13.0	18
S	71	24.9	21
W	42	14.7	251
Average Hourly Ozone 75 ppb or Below			
Wind Direction	**Number of Hours Wind From (hrs)**	**Percent of Time Wind From (%)**	**Average Solar Radiation ($Whrs/m^2$)**
N	7181	30.6	221
E	1015	4.3	54
S	7842	33.3	97
W	747	31.8	196

Table 4: Detailed Look Rock Back Trajectory Analysis.				
Episode Date(s)	**Times 1-Hr Ozone 75 ppb (24-hr Clock)**	**General Direction of Back Trajectory**	**Did Back Trajectory Cross Any Portion of Knox County?**	**Back Trajectory Reference (Appendix 2)**
6/25/2009	1400-2300	Northeast	Yes, sparsely populated eastern portion	Figure 1
4/2-3/2010	1500-0400	South	No	Figure 2
4/13-14/10	1600-0300	South to southwest	No	Figure 3
4/14/2010	1200-2000	South to southwest	No	Figure 4
4/15/2010	1500-2200	South to southwest	No	Figure 5
5/5-6/10	1900-0000	South to southwest	No	Figure 6
5/6-7/10	1200-0200	South to southwest	No	Figure 7
7/7/2010	1500-1900	North	Yes, densely populated central portion	Figure 8
7/8/2010	1100-1900	North to northeast	Yes, densely populated central portion	Figure 9
9/2/2010	1200-1900	North	Yes, densely populated central and west portions	Figure 10
9/21-22/10	2000-0100	South to southeast	No	Figure 11
10/11-12-10	1800-0100	South to southwest	No	Figure 12
6/2-3/11	1500-0600	North to northeast	Yes, densely populated central and west portions	Figure 13
6/3-4/11	1200-0600	East to northeast	Yes, only 500 m over sparsely populated eastern portion	Figure 14
6/4/2011	1300-2100	North to northeast	Yes, densely populated central and west portions	Figure 15
6/6/2011	1600-2200	North to northeast	Yes, sparsely populated eastern portion	Figure 16
6/30/2011	1500-2300	Northeast	Yes, sparsely populated eastern portion	Figure 17
7/2/2011	0000-0600	East	No	Figure 18
7/2/2011	1200-2200	North to northeast	Yes, densely populated central portion	Figure 19
7/13/2011	1300-1700	North	Yes, densely populated central portion	Figure 20
8/3/2011	1300-2000	Southwest	No	Figure 21
8/12/2011	1400-2300	North to northeast	Yes, densely populated central portion	Figure 22
9/2/2011	1400-2100	South to southwest	Yes, sparsely populated southwest portion	Figure 23

Table 5: NO_X and VOC Emission Levels and Emission Reduction Percentages Used in CSAPR Modeling by Source Type for Tennessee.		
Source Type	**2005 Emissions (TPY)**	
	NO_X	**VOC**
2005 EGU	102,934	798
2005 Non-EGU Point	54,255	79,846
2005 Nonpoint	18,676	143,122
2005 Non-road	82,331	58,612
2005 On-road	267,818	100,951
Fires	1,012	10,803
2005 Total	**527,026**	**394,132**
Source Type	**2012 Emissions (TPY)/Reductions (%)**	
2012 EGU	37,694/63.4	863/-8.1[1]
2012 Non-EGU Point	51,355/5.3	66,682/16.5
2012 Nonpoint	18,483/1.0	136,736/4.5
2012 Non-road	65,209/20.8	42,527/27.4
2012 On-road	164,294/38.7	62,182/38.4
2012 Fires	1,012/0.0	10,803/0.0
2012 Total	**338,047/35.9**	**319,793/18.9**
Source Type	**2014 Emissions (TPY)/Reductions (%)**	
2014 EGU	29,276/71.6	773/3.1
2014 Non-EGU Point	49,126/9.5	66,476/16.7
2014 Nonpoint	18,184/2.6	133,244/6.9
2014 Non-road	60,111/27.0	37,647/35.8
2014 On-road	144,394/46.1	56,570/44.0
2014 Fires	1,012/0.0	10,803/0.0
2014 Total	**302,103/42.7**	**305,513/22.5**

Table 6: Projected 2008-2015 NO_X Emission Reductions by County and Source Type for the Knoxville CSA Based on CSPAR Modeling and the 2008 NEI.				
State/County/Emission Source Type	**2008 NO_X Emissions[1] (TPY)**	**2008-2015 Percent NO_X Emission Reduction[2] (%)**	**Projected 2015 NO_X Emissions[3] (TPY)**	**Projected 2008-2015 NO_X Emission Reduction[4] (TPY)**
Anderson				
EGU	8725.87	55.7	3,869.35	4,856.52
Non-EGU Point	1134.78	7.4	1,051.33	83.45
Nonpoint	60.55	2.0	59.30	1.24
Nonroad	831.99	21.0	657.34	174.64
Onroad	2,353.52	35.8	1,509.92	843.59
Fires	57.54	0.0	57.54	0.00
Total	**13,164.25**		**7,204.48**	**5,959.44**
Blount				
EGU	7.87	55.7	3.49	4.38
Non-EGU Point	881.60	7.4	816.77	64.83
Nonpoint	75.42	2.0	73.88	1.55
Nonroad	888.62	21.0	702.90	186.53
Onroad	2,340.07	35.9	1,501.30	838.78
Fires	36.67	0.0	36.67	0.00
Total	**4,230.25**		**3,135.01**	**1,096.07**
Campbell				
EGU	0.00	55.7	0.00	0.00
Non-EGU Point	164.55	7.4	152.45	12.10
Nonpoint	32.64	2.0	31.97	0.67
Nonroad	593.12	21.0	468.62	124.50
Onroad	3,182.45	35.9	2,041.73	1,140.72
Fires	53.82	0.0	53.82	0.00
Total	**4,026.58**		**2,748.59**	**1,277.99**
Cocke				
EGU	0.00	55.7	0.00	0.00
Non-EGU Point	145.04	7.4	134.37	10.67
Nonpoint	18.31	2.0	17.93	0.38
Nonroad	263.01	21.0	207.80	55.21
Onroad	1,898.44	35.8	1,217.97	680.48
Fires	75.64	0.0	75.64	0.00
Total	**2,400.44**		**1,653.71**	**746.74**

Table 6: Projected 2008-2015 NO_X Emission Reductions by County and Source Type for the Knoxville CSA Based on CSPAR Modeling and the 2008 NEI.				
State/County/Emission Source Type	**2008 NO_X Emissions[1] (TPY)**	**2008-2015 Percent NO_X Emission Reduction[2] (%)**	**Projected 2015 NO_X Emissions[3] (TPY)**	**Projected 2008-2015 NO_X Emission Reduction[4] (TPY)**
Grainger				
EGU	0.00	55.7	0.00	0.00
Non-EGU Point	82.47	7.4	76.40	6.06
Nonpoint	6.64	2.0	6.50	0.14
Nonroad	155.33	21.0	122.73	32.61
Onroad	645.61	35.9	414.20	231.41
Fires	39.49	0.0	39.49	0.00
Total	**929.54**		**659.32**	**270.22**
Hamblen				
EGU	0.00	55.7	0.00	0.00
Non-EGU Point	4,470.59	7.4	4,141.83	328.75
Nonpoint	24.68	2.0	24.17	0.51
Nonroad	673.54	21.0	532.16	141.38
Onroad	2,128.19	35.9	1,365.36	762.83
Fires	2.54	0.0	2.54	0.00
Total	**7,299.54**		**6,066.06**	**1,233.47**
Jefferson				
EGU	0.00	55.7	0.00	0.00
Non-EGU Point	252.20	7.4	233.65	18.55
Nonpoint	21.75	2.0	21.30	0.45
Nonroad	539.67	21.0	426.38	113.28
Onroad	3,255.31	35.9	2,088.48	1,166.83
Fires	24.65	0.0	24.65	0.00
Total	**4,093.58**		**2,794.46**	**1,299.11**
Knox				
EGU	0.00	55.7	0.00	0.00
Non-EGU Point	1,745.91	7.4	1,617.52	128.39
Nonpoint	254.48	2.0	249.36	5.22
Nonroad	3,271.83	21.0	2,585.04	686.79
Onroad	13,976.54	35.9	8,966.79	5,009.75
Fires	27.36	0.0	27.36	0.00
Total	**19,276.12**		**13,446.07**	**5,830.15**

Table 6: Projected 2008-2015 NO_X Emission Reductions by County and Source Type for the Knoxville CSA Based on CSPAR Modeling and the 2008 NEI.				
State/County/Emission Source Type	**2008 NO_X Emissions[1] (TPY)**	**2008-2015 Percent NO_X Emission Reduction[2] (%)**	**Projected 2015 NO_X Emissions[3] (TPY)**	**Projected 2008-2015 NO_X Emission Reduction[4] (TPY)**
Loudon				
EGU	3.64	55.7	1.61	2.03
Non-EGU Point	1,070.50	7.4	991.78	78.72
Nonpoint	40.41	2.0	39.58	0.83
Nonroad	503.65	21.0	397.93	105.72
Onroad	2,979.14	35.8	1,911.30	1,067.84
Fires	6.94	0.0	6.94	0.00
Total	**4,604.28**		**3,349.14**	**1,255.14**
Roane				
EGU	7,927.21	55.7	3,515.20	4,412.01
Non-EGU Point	176.60	7.4	163.61	12.99
Nonpoint	40.41	2.0	39.58	0.83
Nonroad	693.65	21.0	548.05	145.61
Onroad	2,866.05	35.8	1,838.74	1,027.31
Fires	16.42	0.0	16.42	0.00
Total	**11,720.34**		**6,121.6**	**5,598.75**
Sevier				
EGU	0.00	55.7	0.00	0.0
Non-EGU Point	212.16	7.4	195.56	15.60
Nonpoint	31.38	2.0	30.74	0.64
Nonroad	357.87	21.0	282.75	75.12
Onroad	2,653.30	35.8	1,702.25	951.05
Fires	38.76	0.0	38.76	0.00
Total	**3,293.47**		**2,250.06**	**1,042.41**
Union				
EGU	0.00	55.7	0.00	0.00
Non-EGU Point	57.89	7.4	53.63	4.26
Nonpoint	5.74	2.0	5.62	0.12
Nonroad	150.92	21.0	119.24	31.68
Onroad	283.08	35.8	181.62	101.47
Fires	22.02	0.0	22.02	0.00
Total	**519.65**		**382.13**	**137.53**

1. 2008 emissions are from the 2008 NEI, v2 found at http://www.epa.gov/ttn/chief/net/2008inventory.html.
2. Based on the emission reductions for 2005-2014 from the CSAPR modeling. 2005-2014 percent reductions were divided by nine and multiplied by seven.
3. Based on 2008 emissions minus the percent reduction from column 3 times the 2008 emissions.
4. The difference between 2008 emissions and the projected 2015 emissions.

Table 7: Projected 2008-2015 VOC Emission Reductions by County and Source Type for the Knoxville CSA Based on CSPAR Modeling and the 2008 NEI.				
State/County/Emission Source Type	**2008 VOC Emissions[1] (TPY)**	**2008-2015 Percent VOC Emission Reduction[2] (%)**	**Projected 2015 VOC Emissions[3] (TPY)**	**Projected 2008-2015 VOC Emission Reduction[4] (TPY)**
Anderson				
EGU	47.18	2.5	46.02	1.16
Non-EGU Point	607.66	13.0	528.52	79.14
Nonpoint	884.27	5.4	836.80	47.47
Nonroad	745.04	27.8	537.76	207.28
Onroad	886.75	34.2	583.53	303.21
Fires	903.15	0.0	903.15	0.00
Total	**4,074.05**		**3,435.78**	**638.26**
Blount				
EGU	0.57	2.5	0.55	0.02
Non-EGU Point	2,422.09	13.0	2,106.65	315.45
Nonpoint	1,306.76	5.4	1,236.61	70.15
Nonroad	1,106.39	27.8	798.58	307.81
Onroad	1,255.48	34.2	826.19	429.30
Fires	369.56	0.0	369.56	0.00
Total	**6,460.85**		**5,338.14**	**1,122.73**
Campbell				
EGU	0.00	--	0.00	0.00
Non-EGU Point	175.92	13.0	153.00	22.91
Nonpoint	394.91	5.4	373.71	21.20
Nonroad	459.64	27.8	331.76	127.88
Onroad	649.82	34.2	427.62	222.20
Fires	915.97	0.0	915.97	0.00
Total	**2,596.26**		**2,202.06**	**394.19**
Cocke				
EGU	0.00	--	0.00	0.00
Non-EGU Point	235.72	13.0	205.02	30.70
Nonpoint	475.34	5.4	449.83	25.52
Nonroad	891.16	27.8	643.23	247.93
Onroad	594.11	34.2	390.96	203.15
Fires	1,078.79	0.0	1,078.79	0.00
Total	**3,275.12**		**2,767.83**	507.30

Table 7: Projected 2008-2015 VOC Emission Reductions by County and Source Type for the Knoxville CSA Based on CSPAR Modeling and the 2008 NEI.				
State/County/Emission Source Type	**2008 VOC Emissions[1] (TPY)**	**2008-2015 Percent VOC Emission Reduction[2] (%)**	**Projected 2015 VOC Emissions[3] (TPY)**	**Projected 2008-2015 VOC Emission Reduction[4] (TPY)**
Grainger				
EGU	0.00	--	0.00	0.00
Non-EGU Point	55.03	13.0	47.86	7.17
Nonpoint	231.28	5.4	218.87	12.42
Nonroad	580.22	27.8	418.80	161.42
Onroad	303.22	34.2	199.54	103.68
Fires	830.06	0.0	830.06	0.00
Total	**1,999.81**		**1,715.13**	**284.69**
Hamblen				
EGU	0.00	--	0.00	0.00
Non-EGU Point	1,187.29	13.0	1,032.66	154.63
Nonpoint	1,679.47	5.4	1,589.31	90.15
Nonroad	642.49	27.8	463.74	178.75
Onroad	974.10	34.2	641.02	333.08
Fires	24.14	0.0	24.14	0.00
Total	**4,507.49**		**3,750.87**	**756.61**
Jefferson				
EGU	0.00	--	0.00	0.00
Non-EGU Point	336.16	13.0	292.38	43.78
Nonpoint	799.60	5.4	756.68	42.92
Nonroad	1,131.49	27.8	816.70	314.79
Onroad	823.62	34.2	541.99	281.63
Fires	332.90	0.0	332.90	0.00
Total	**3,423.77**		**2,740.65**	**638.12**
Knox				
EGU	0.00	--	0.00	0.00
Non-EGU Point	751.13	13.0	653.30	97.83
Nonpoint	4,273.79	5.4	4,044.37	229.42
Nonroad	2,507.66	27.8	1,810.00	697.66
Onroad	5,922.24	34.2	3,897.20	2,025.04
Fires	470.01	0.0	470.01	0.00
Total	**13,924.83**		**10,874.88**	**3,049.95**

Table 7: Projected 2008-2015 VOC Emission Reductions by County and Source Type for the Knoxville CSA Based on CSPAR Modeling and the 2008 NEI.				
State/County/Emission Source Type	**2008 VOC Emissions[1] (TPY)**	**2008-2015 Percent VOC Emission Reduction[2] (%)**	**Projected 2015 VOC Emissions[3] (TPY)**	**Projected 2008-2015 VOC Emission Reduction[4] (TPY)**
Loudon				
EGU	2.90	2.5	2.83	0.07
Non-EGU Point	1,020.28	13.0	887.40	132.88
Nonpoint	528.01	5.4	499.66	28.34
Nonroad	758.42	27.8	547.42	211.00
Onroad	783.95	34.2	515.89	268.06
Fires	96.96	0.0	96.96	0.00
Total	**3,190.52**		**2,550.16**	**640.35**
Roane				
EGU	152.07	2.5	148.34	3.74
Non-EGU Point	226.76	13.0	197.23	29.53
Nonpoint	532.44	5.4	503.86	28.58
Nonroad	907.01	27.8	654.67	252.34
Onroad	1,013.70	34.2	667.07	346.62
Fires	189.31	0.0	189.31	0.00
Total	**3,021.29**		**2,360.48**	**660.81**
Sevier				
EGU	0.00	--	0.00	0.00
Non-EGU Point	192.24	13.0	167.21	25.04
Nonpoint	954.67	5.4	903.42	51.25
Nonroad	2,388.01	27.8	1,723.64	664.37
Onroad	1,267.42	34.2	834.04	433.38
Fires	556.71	0.0	556.71	0.00
Total	**5,359.05**		**4,185.02**	**1,174.04**
Union				
EGU	0.00	--	0.00	0.00
Non-EGU Point	64.18	13.0	55.82	8.36
Nonpoint	214.44	5.4	202.93	11.51
Nonroad	480.14	27.8	346.56	133.58
Onroad	133.86	34.2	88.09	45.77
Fires	398.96	0.0	398.96	0.00
Total	**1,291.58**		**1,092.36**	**199.22**

1. 2008 emissions are from the 2008 NEI, v2 found at http://www.epa.gov/ttn/chief/net/2008inventory.html .
2. Based on the emission reductions for 2005-2014 from the CSAPR modeling. 2005-2014 percent reductions were divided by 9 and multiplied by 7.
3. Based on 2008 emissions minus the percent reduction from column 3 times the 2008 emissions.
4. The difference between 2008 emissions and the projected 2015 emissions.

Table 8: 2008-2011 NO_X Emissions and Emission Rates for TVA's Bull Run Power Plant.[1]		
Year	**Annual Emissions (TPY)**	**Annual Emission Rate (lbs/mmBTU)**
2005	11,487.6	0.358
2006	8,352.0	0.370
2007	11,929.8	0.362
2008	8,622.3	0.387
2009	1,270.7	0.086
2010	1,221.0	0.068
2011	911.9	0.069

1. Source: EPA Air Markets Program Data.

Table 9: 2008-2011 NO_X Emissions and Emission Rates for TVA's Kingston Power Plant.[1]		
Year	**Annual Emissions (TPY)**	**Annual Emission Rate (lbs/mmBTU)**
2005	14,318.4	0.284
2006	13,953.2	0.260
2007	12,541.5	0.235
2008	7,927.8	0.148
2009	549.3	0.053
2010	1,602.8	0.091
2011	1,532.5	0.058

1. Source: EPA Air Markets Program Data.

Table 10: Summary of the CSAPR Modeling and EPA's Extrapolations for the 2008 Ozone NAAQS for the Knoxville CSA.					
County	**Monitor Location**	**2003-2007 DV (ppb)**	**CSAPR Projected 2014 DV (ppb)**	**2008-2010 DV (ppb)**	**2015 Extrapolated DV (ppb)**
Anderson	Freels Bend	77.3	63.4	70	63.0
Blount	Cades Cove	68.5	57.5	69	62.9
Blount	Look Rock	85.3	71.3	77	70.0
Jefferson	Lost Creek	82.3	68.3	74	67.1
Knox	Mildred Drive	85.0	71.5	76	69.3
Knox	Rutledge Pike	78.7	66.1	71	64.7
Loudon	Roberts Road	85.0	68.9	73	65.3
Sevier	Clingmans Dome	80.7	67.6	76	69.2
Sevier	Cove Mountain	79.0	65.6	76	68.9

1. From *Spreadsheet projecting the hypothetical 8-hour ozone nonattainment areas for the 75 ppb NAAQS to 2015 to estimate the number of marginal nonattainment areas that are expected to attain the NAAQS by their attainment date of 2015*, (EPA-HQ-OAR-2010-0885-0064).

Appendix 2

EnSafe's Back Trajectories.

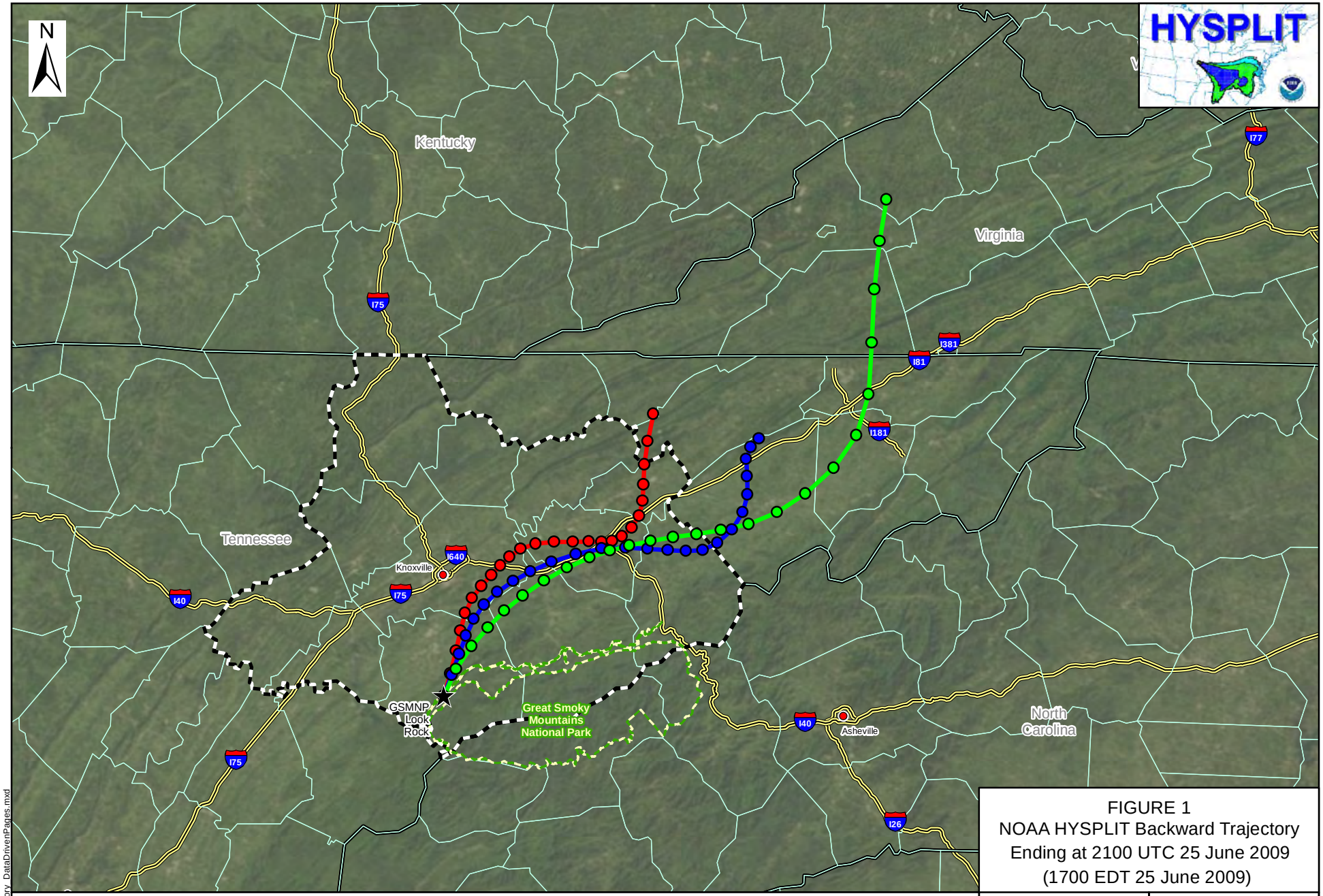

FIGURE 1
NOAA HYSPLIT Backward Trajectory
Ending at 2100 UTC 25 June 2009
(1700 EDT 25 June 2009)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

ENSAFE
1-800-588-7962
WWW.ENSAFE.COM

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP

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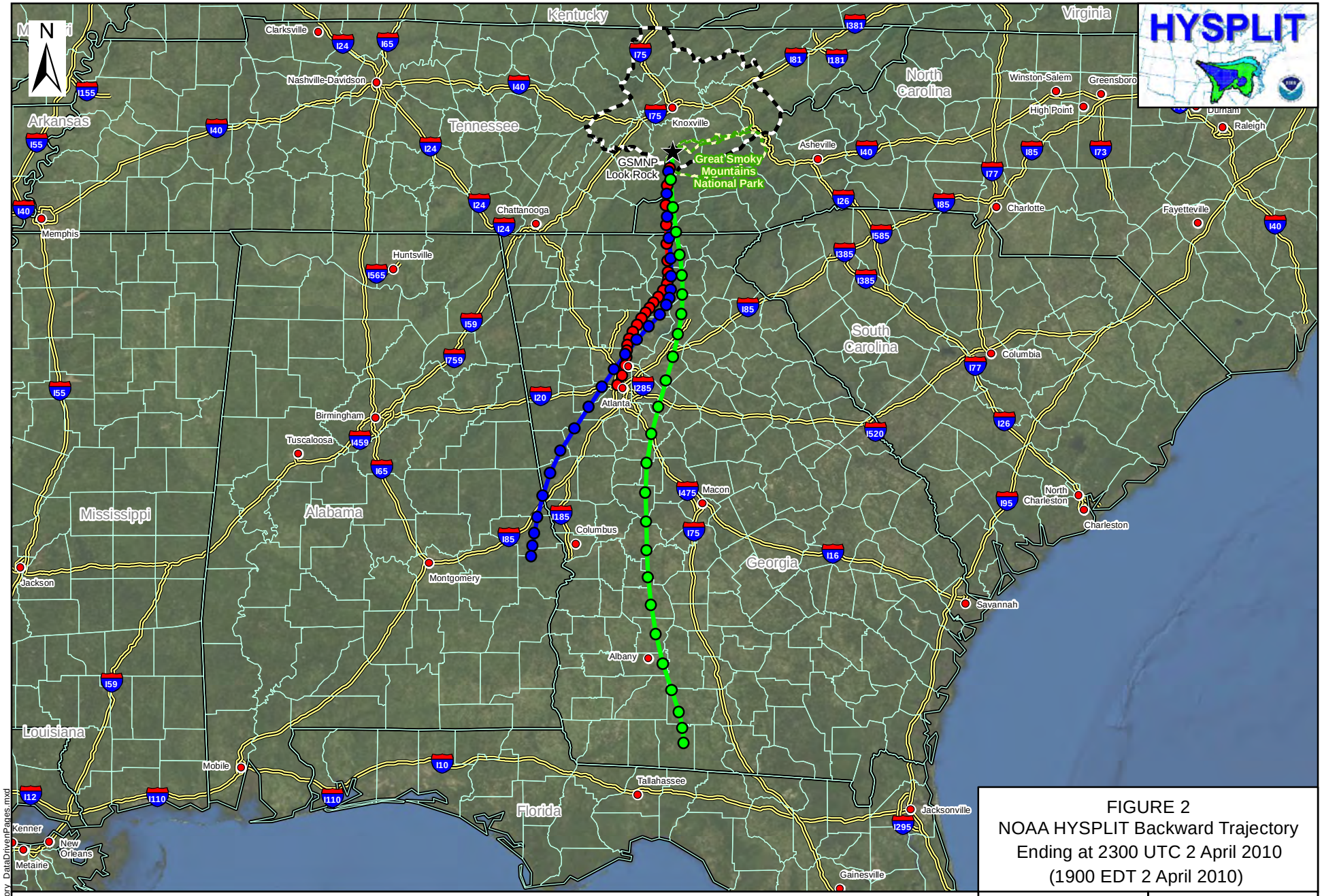

FIGURE 2
NOAA HYSPLIT Backward Trajectory
Ending at 2300 UTC 2 April 2010
(1900 EDT 2 April 2010)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

ENSAFE
1-800-588-7962
WWW.ENSAFE.COM

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP

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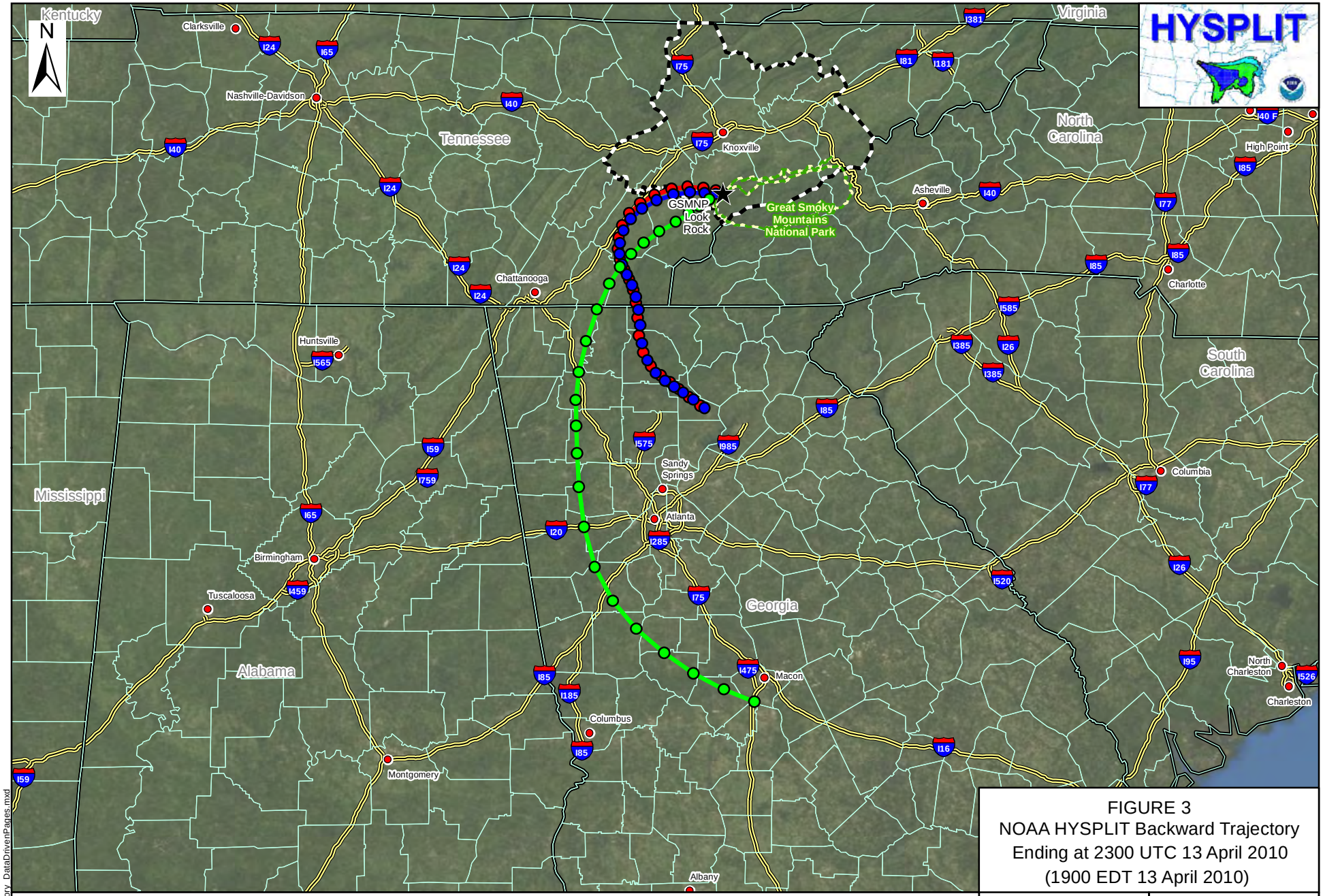

FIGURE 3
NOAA HYSPLIT Backward Trajectory
Ending at 2300 UTC 13 April 2010
(1900 EDT 13 April 2010)

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 25 50 100 Miles
0 30 60 120 Kilometers

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

ENSAFE
1-800-588-7962
WWW.ENSAFE.COM

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP

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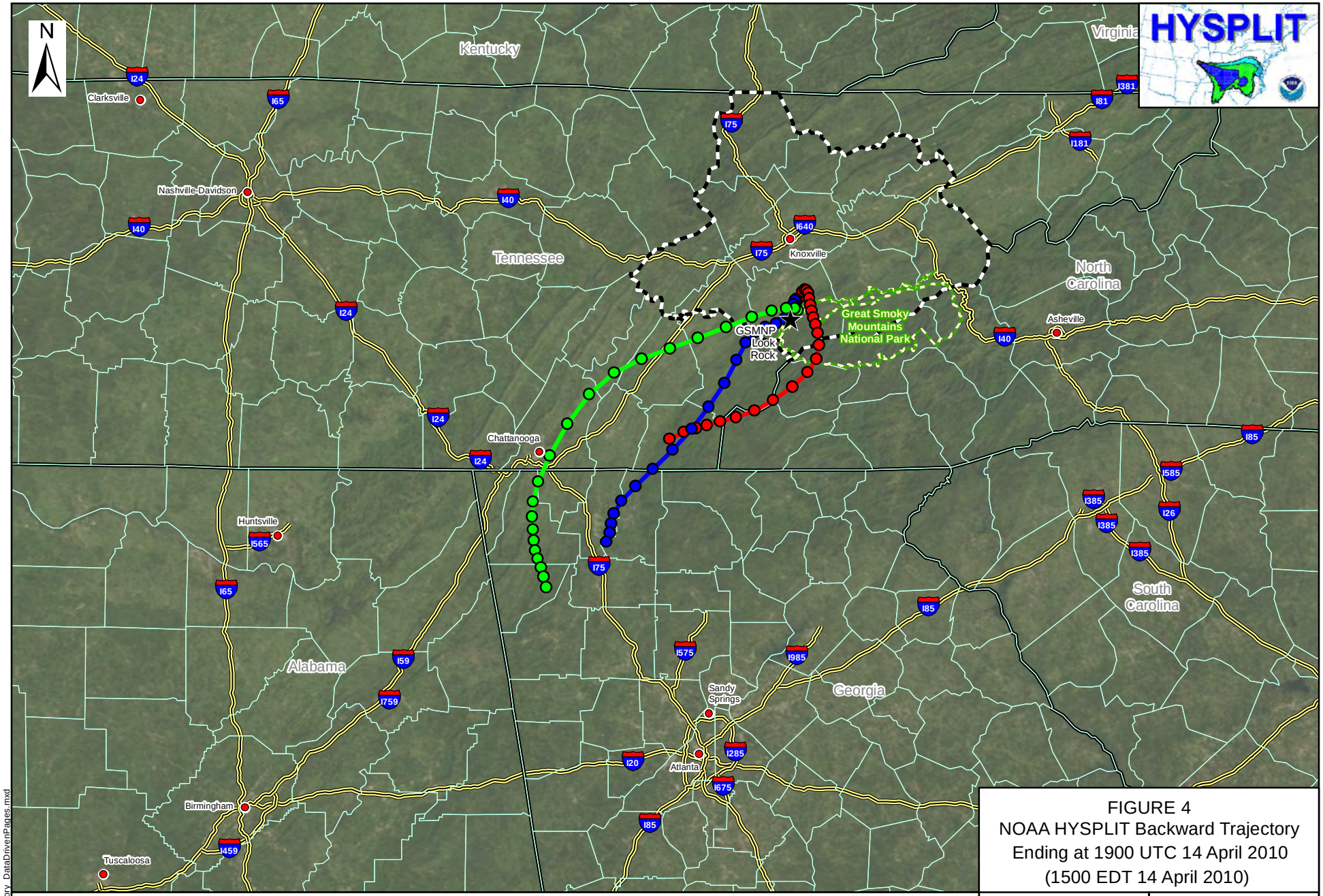

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 20 40 80 Miles
0 20 40 80 Kilometers

FIGURE 4
NOAA HYSPLIT Backward Trajectory
Ending at 1900 UTC 14 April 2010
(1500 EDT 14 April 2010)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

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1-800-588-7962
WWW.ENSAFE.COM

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP

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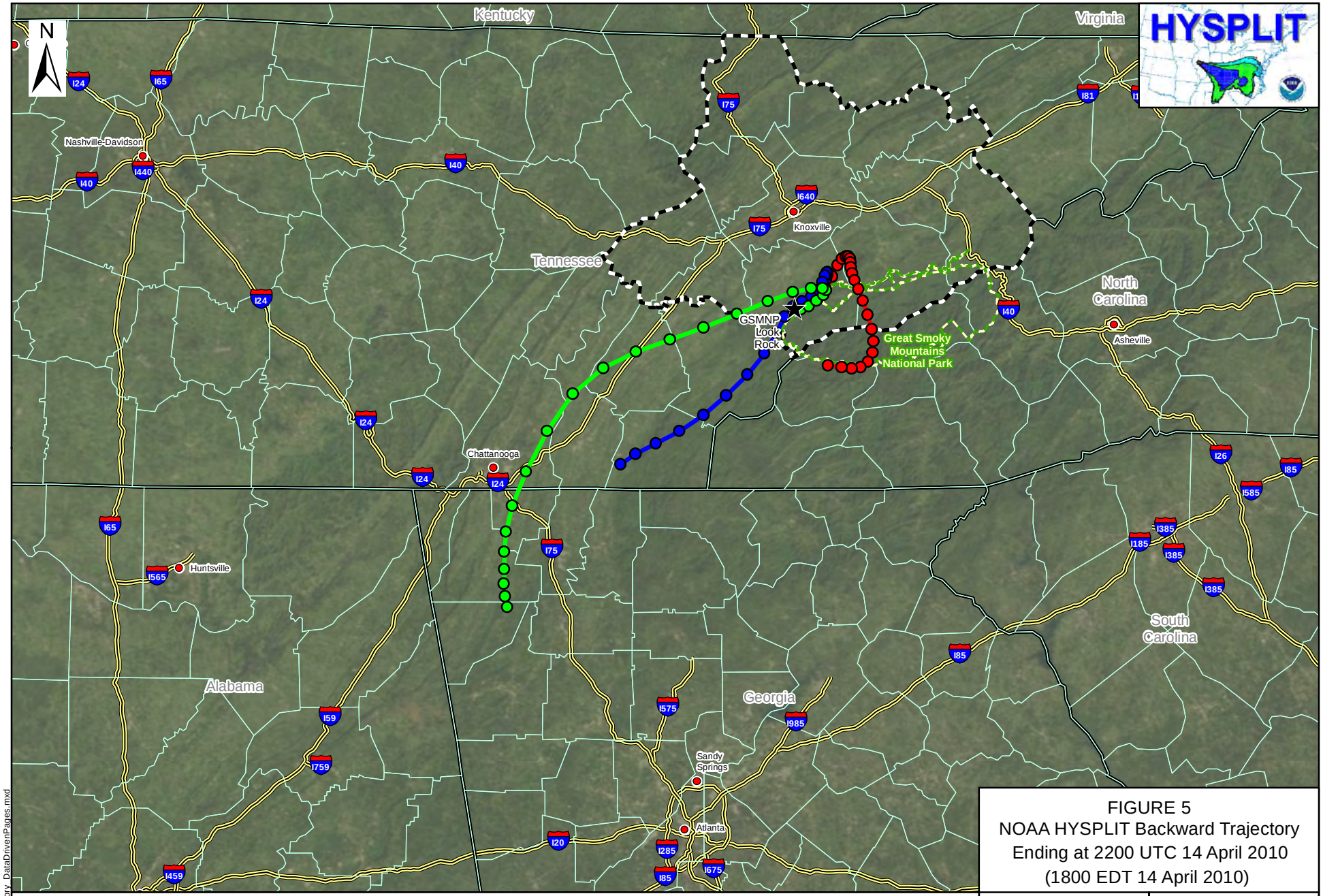

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 15 30 60 Miles
0 20 40 80 Kilometers

FIGURE 5
NOAA HYSPLIT Backward Trajectory
Ending at 2200 UTC 14 April 2010
(1800 EDT 14 April 2010)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

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1-800-588-7962
WWW.ENSAFE.COM

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP

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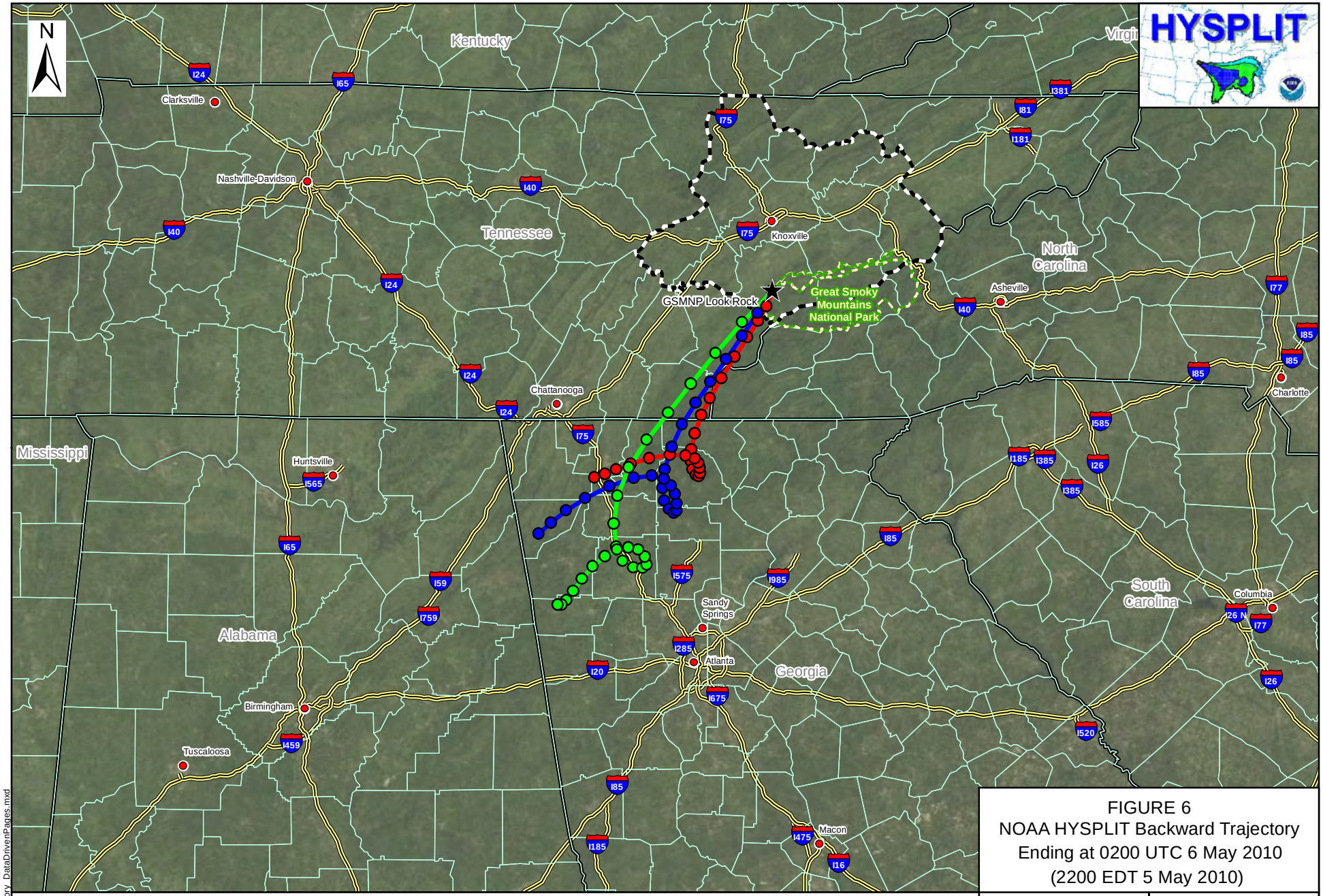

FIGURE 6
NOAA HYSPLIT Backward Trajectory
Ending at 0200 UTC 6 May 2010
(2200 EDT 5 May 2010)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

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1-800-588-7962
WWW.ENSAFE.COM

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP

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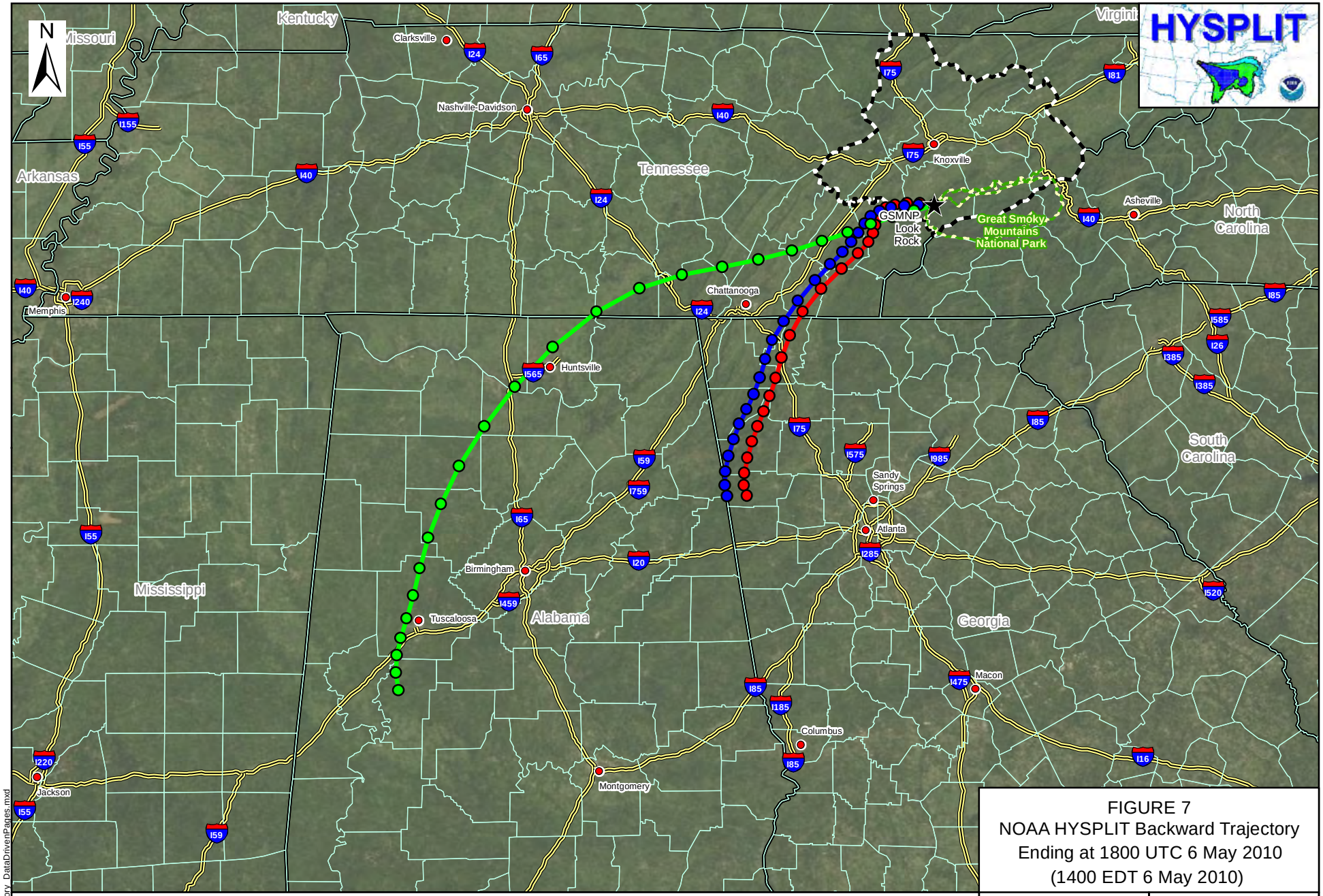
US EPA ARCHIVE DOCUMENT



10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 25 50 100 Miles
0 30 60 120 Kilometers

FIGURE 7
NOAA HYSPLIT Backward Trajectory
Ending at 1800 UTC 6 May 2010
(1400 EDT 6 May 2010)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

ENSAFE
1-800-588-7962
WWW.ENSAFE.COM

Basemap Source: ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGP

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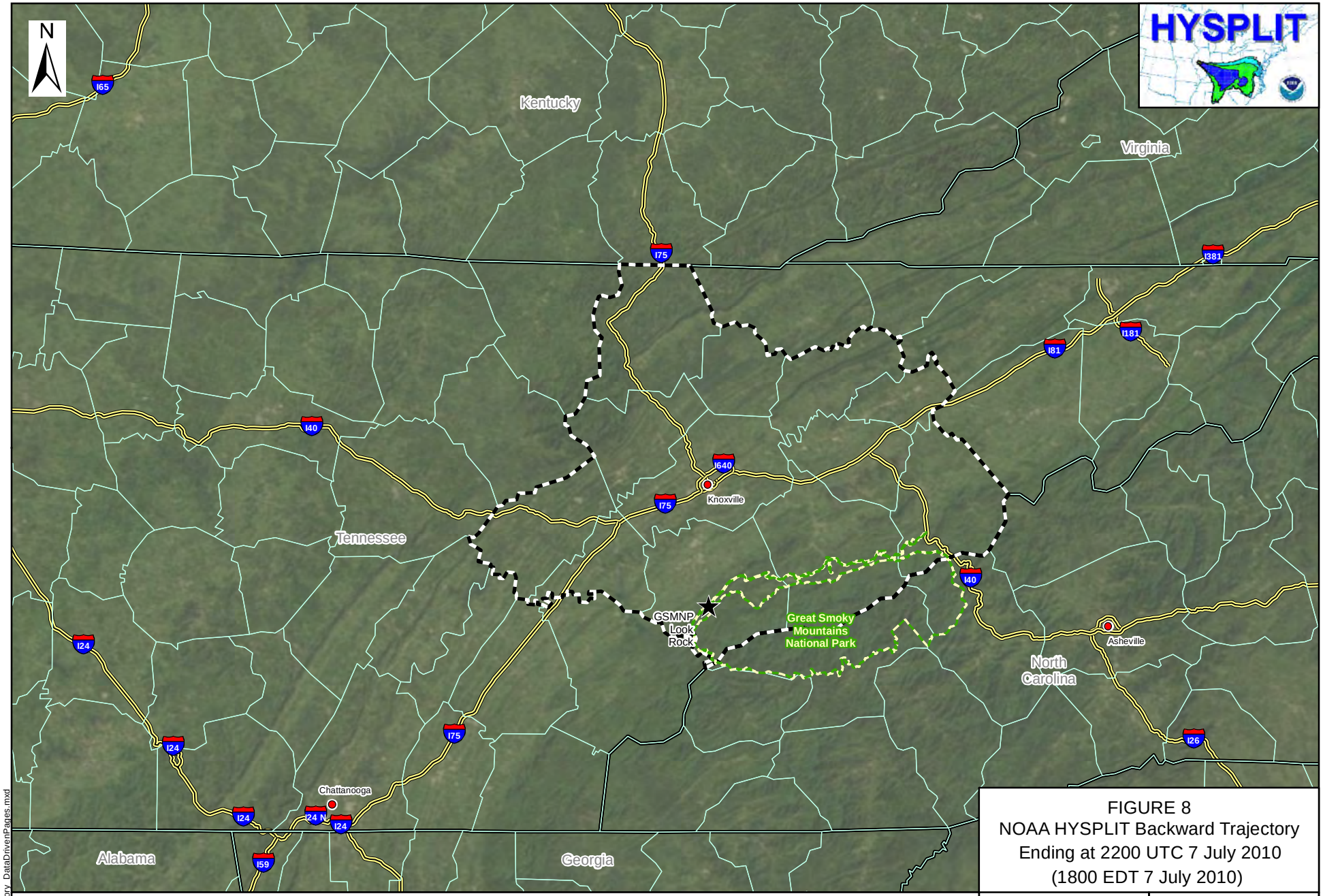

FIGURE 8
NOAA HYSPLIT Backward Trajectory
Ending at 2200 UTC 7 July 2010
(1800 EDT 7 July 2010)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

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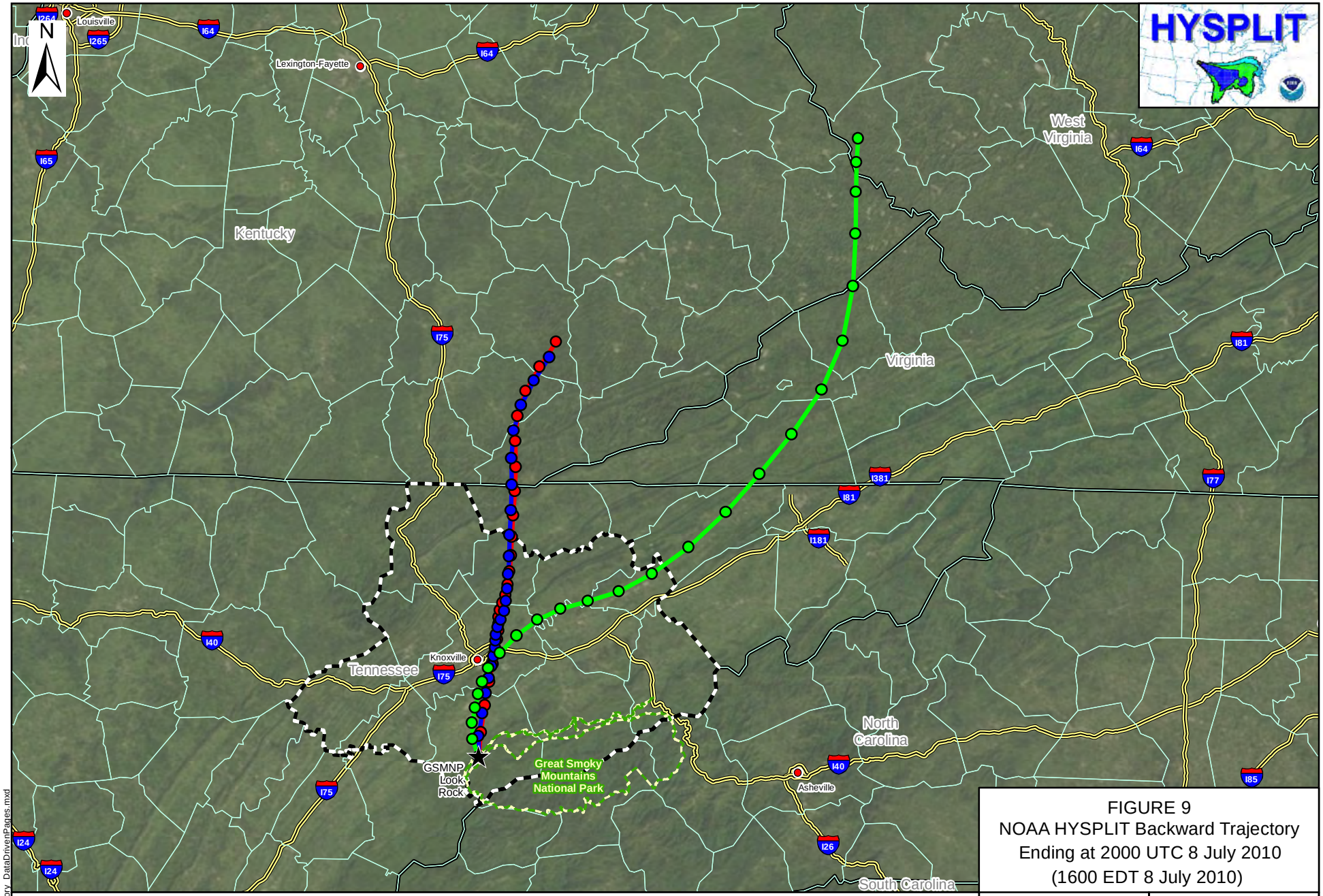

FIGURE 9
NOAA HYSPLIT Backward Trajectory
Ending at 2000 UTC 8 July 2010
(1600 EDT 8 July 2010)

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DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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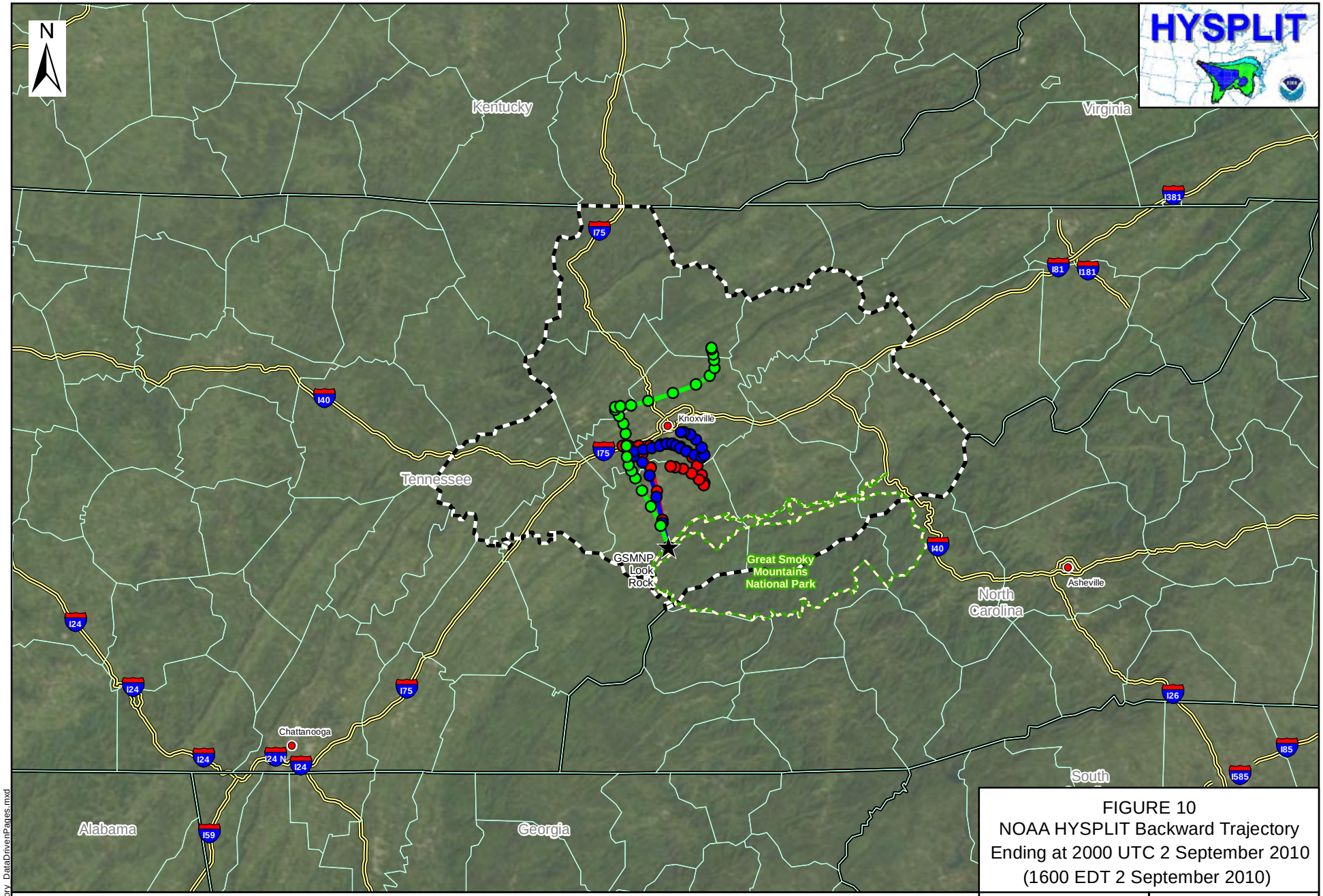

FIGURE 10
NOAA HYSPLIT Backward Trajectory
Ending at 2000 UTC 2 September 2010
(1600 EDT 2 September 2010)

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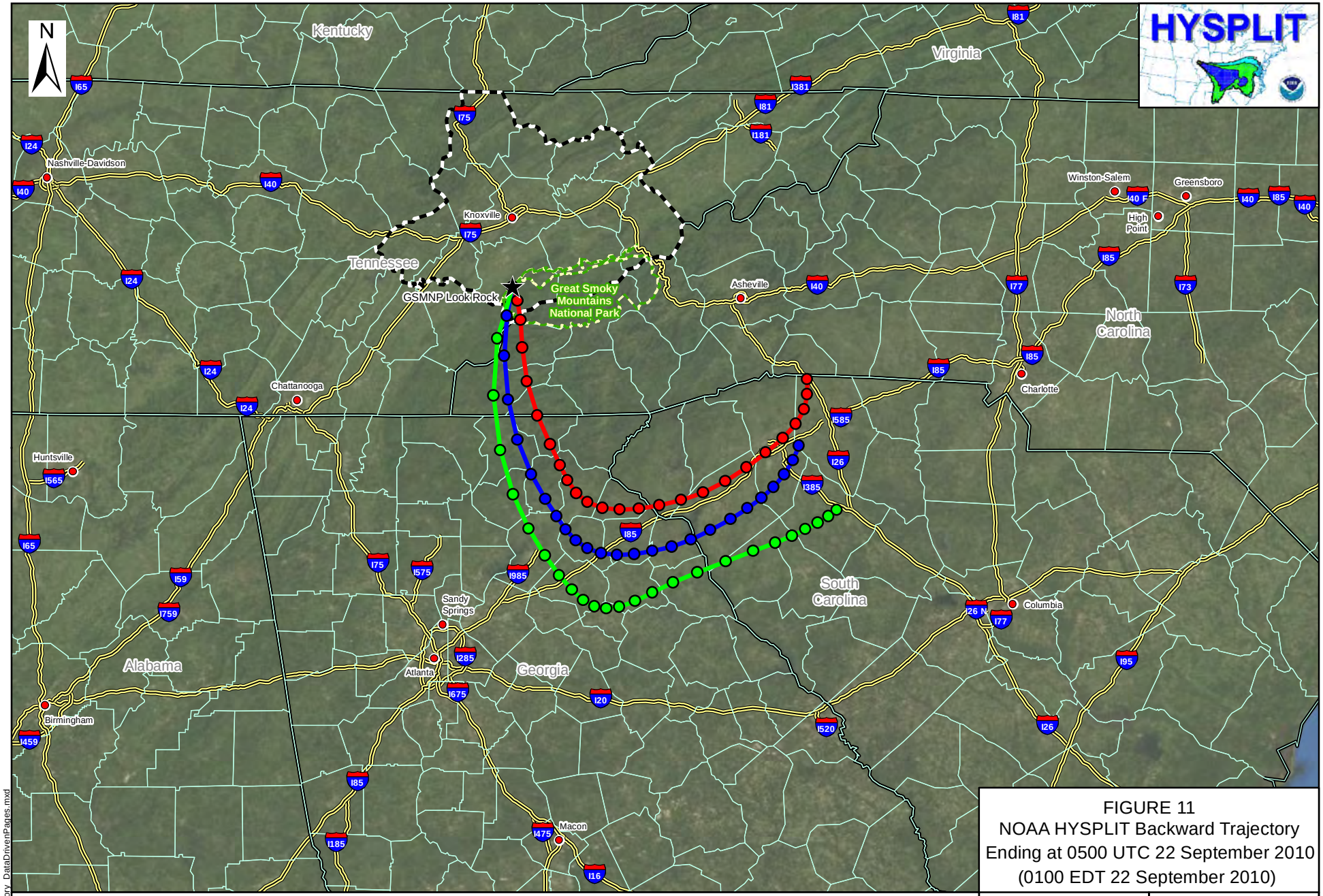

FIGURE 11
NOAA HYSPLIT Backward Trajectory
Ending at 0500 UTC 22 September 2010
(0100 EDT 22 September 2010)

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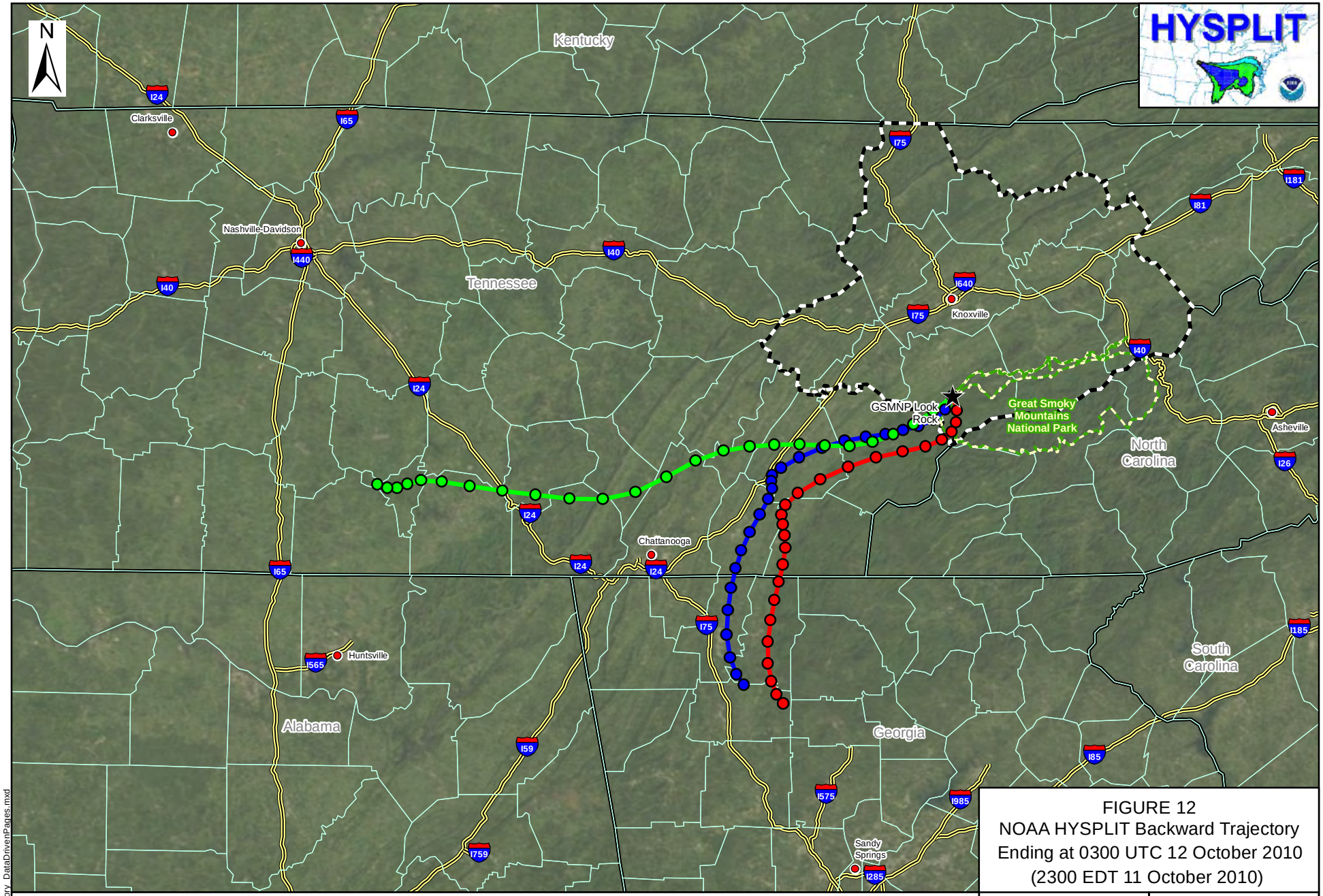

FIGURE 12
NOAA HYSPLIT Backward Trajectory
Ending at 0300 UTC 12 October 2010
(2300 EDT 11 October 2010)

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 15 30 60 Miles
0 20 40 80 Kilometers

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DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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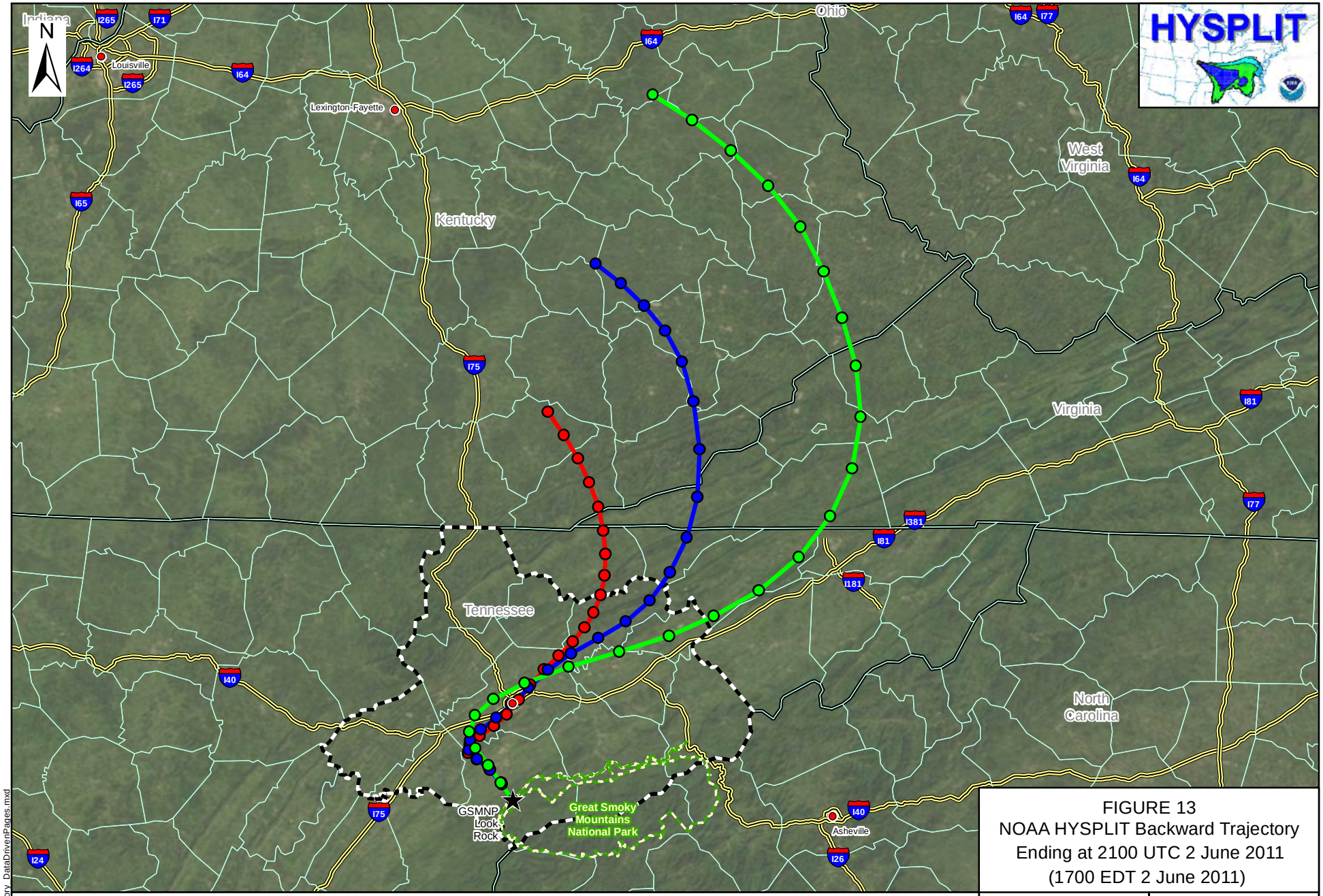

FIGURE 13
NOAA HYSPLIT Backward Trajectory
Ending at 2100 UTC 2 June 2011
(1700 EDT 2 June 2011)

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 15 30 60 Miles
0 20 40 80 Kilometers

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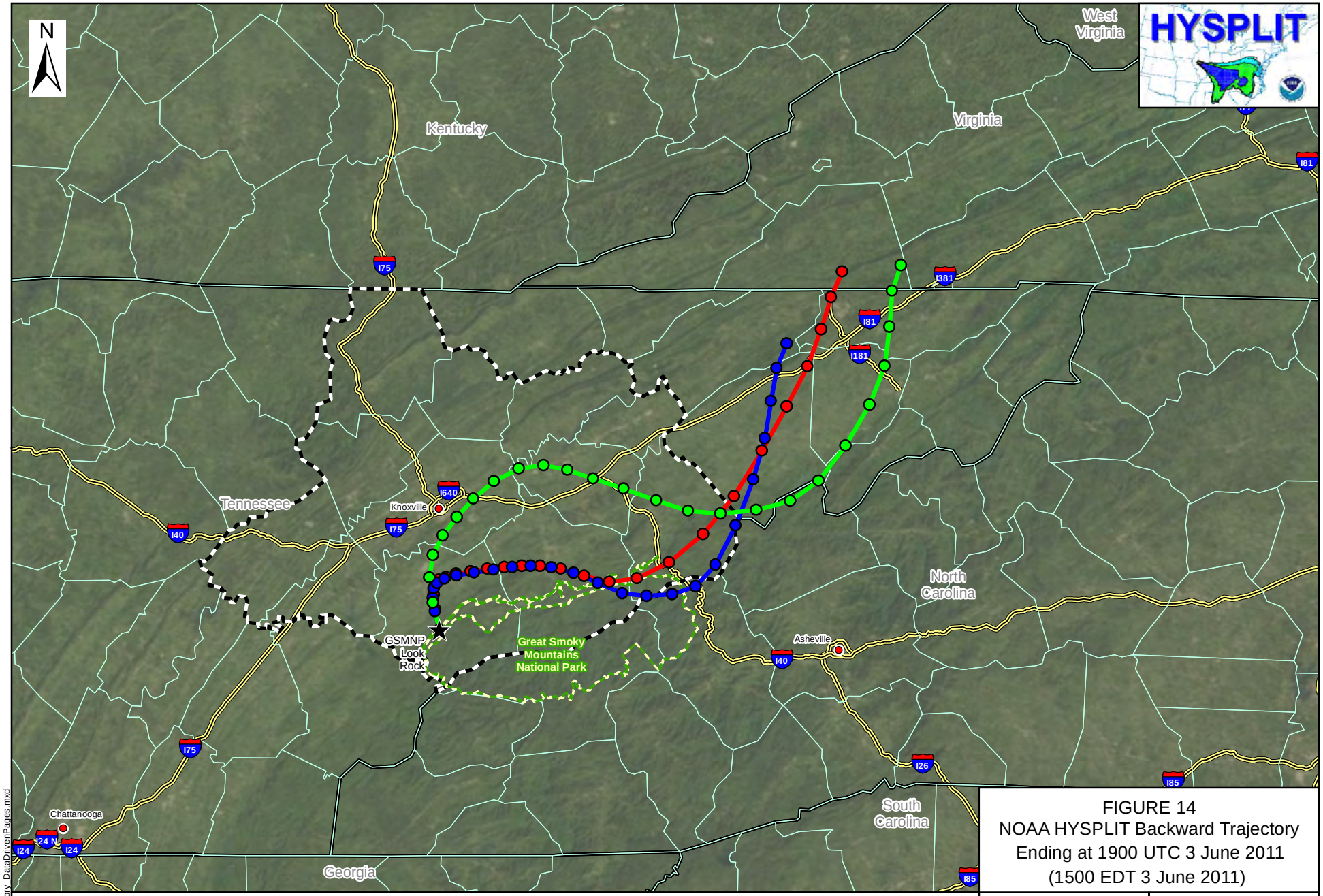

FIGURE 14
NOAA HYSPLIT Backward Trajectory
Ending at 1900 UTC 3 June 2011
(1500 EDT 3 June 2011)

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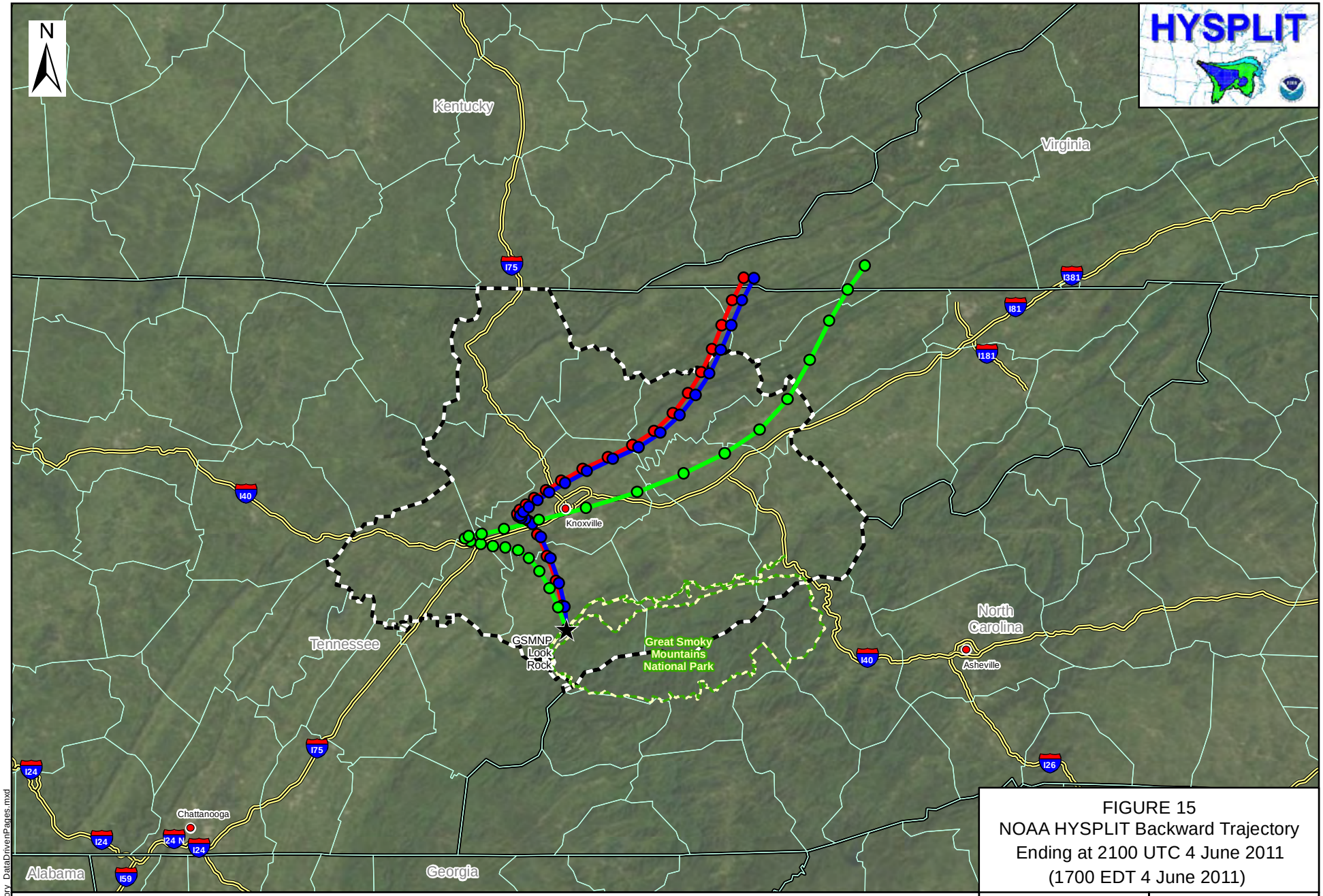

FIGURE 15
NOAA HYSPLIT Backward Trajectory
Ending at 2100 UTC 4 June 2011
(1700 EDT 4 June 2011)

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 12.5 25 50 Miles
0 15 30 60 Kilometers

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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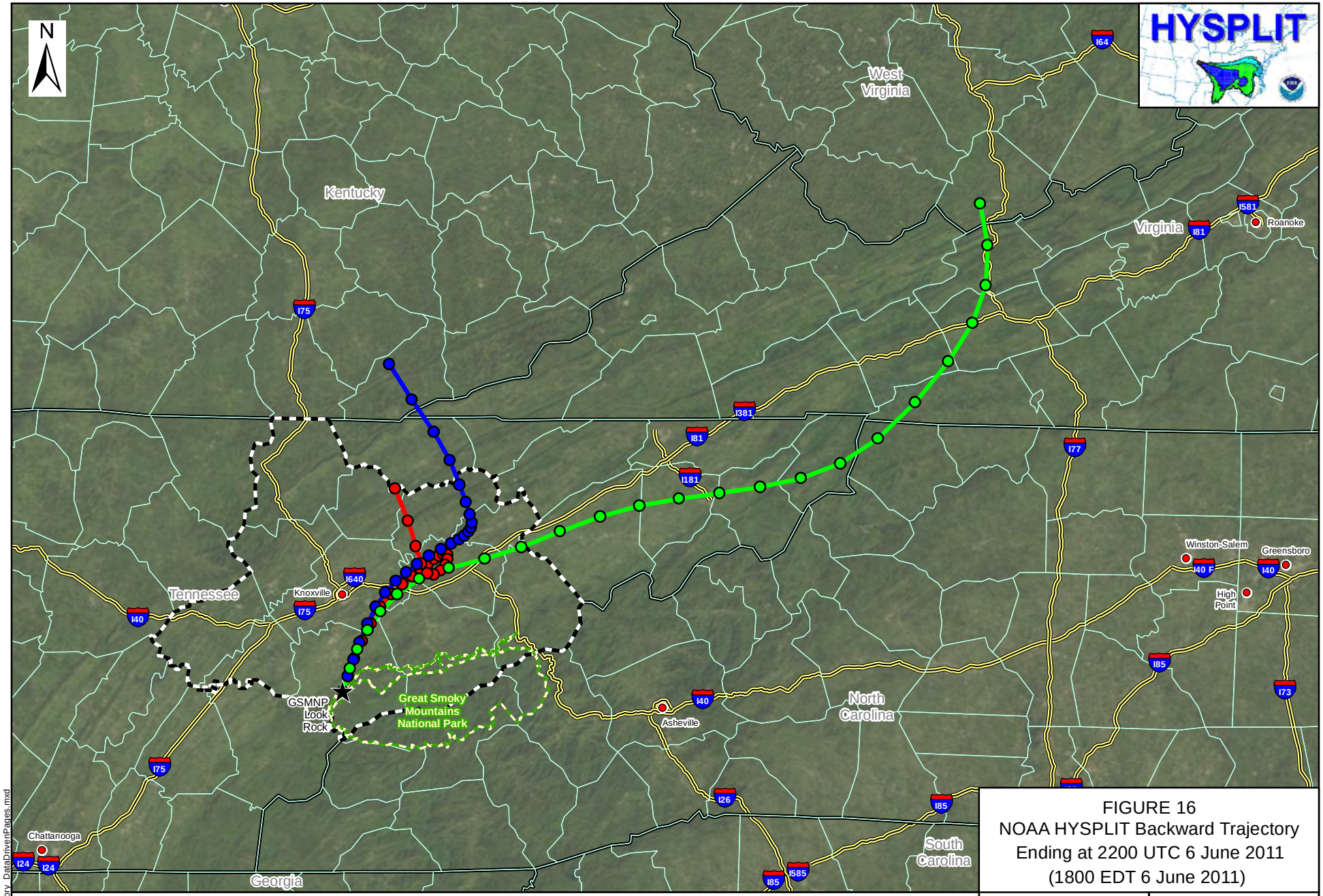

FIGURE 16
NOAA HYSPLIT Backward Trajectory
Ending at 2200 UTC 6 June 2011
(1800 EDT 6 June 2011)

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DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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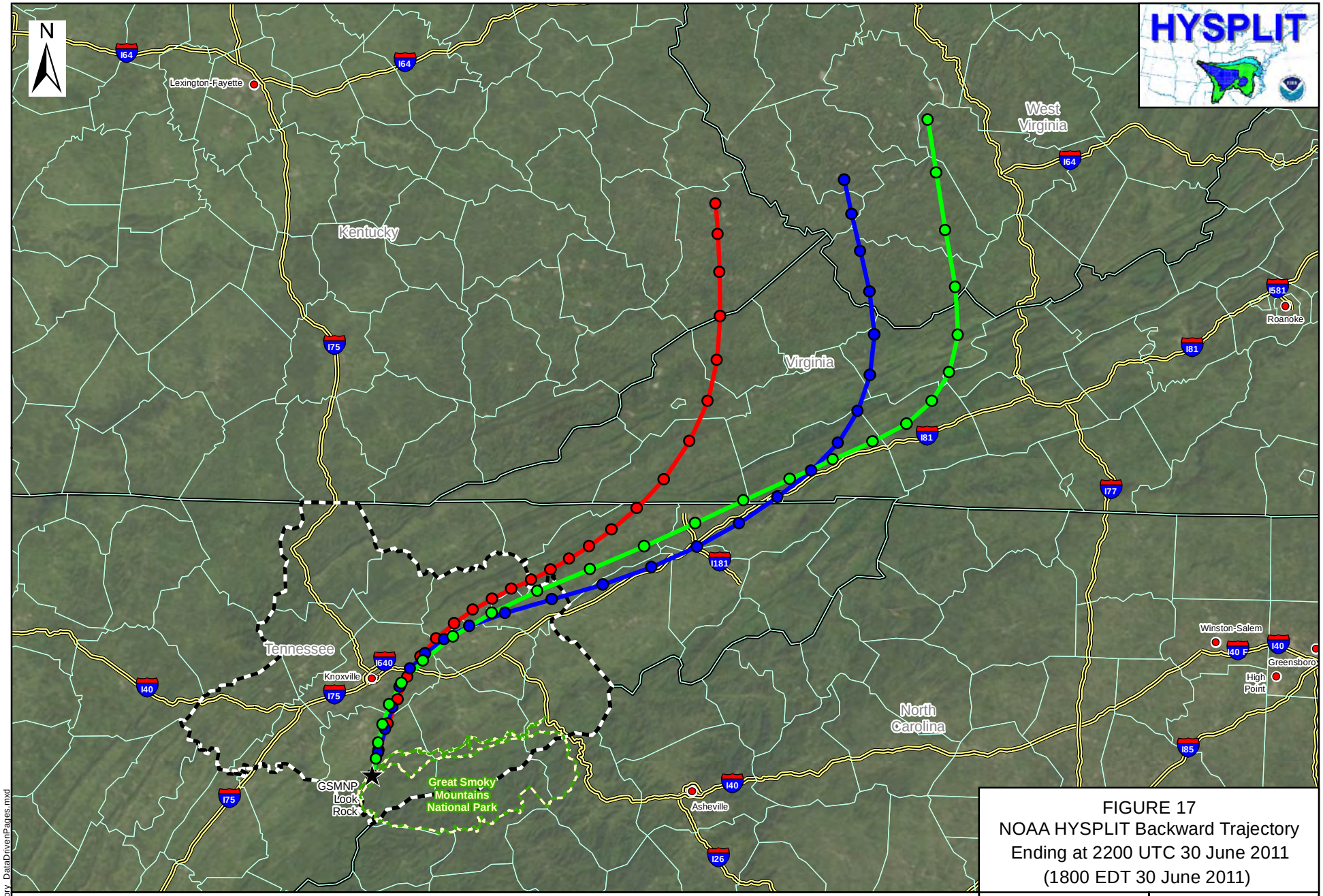

FIGURE 17
NOAA HYSPLIT Backward Trajectory
Ending at 2200 UTC 30 June 2011
(1800 EDT 30 June 2011)

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory
Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 15 30 60 Miles
0 20 40 80 Kilometers

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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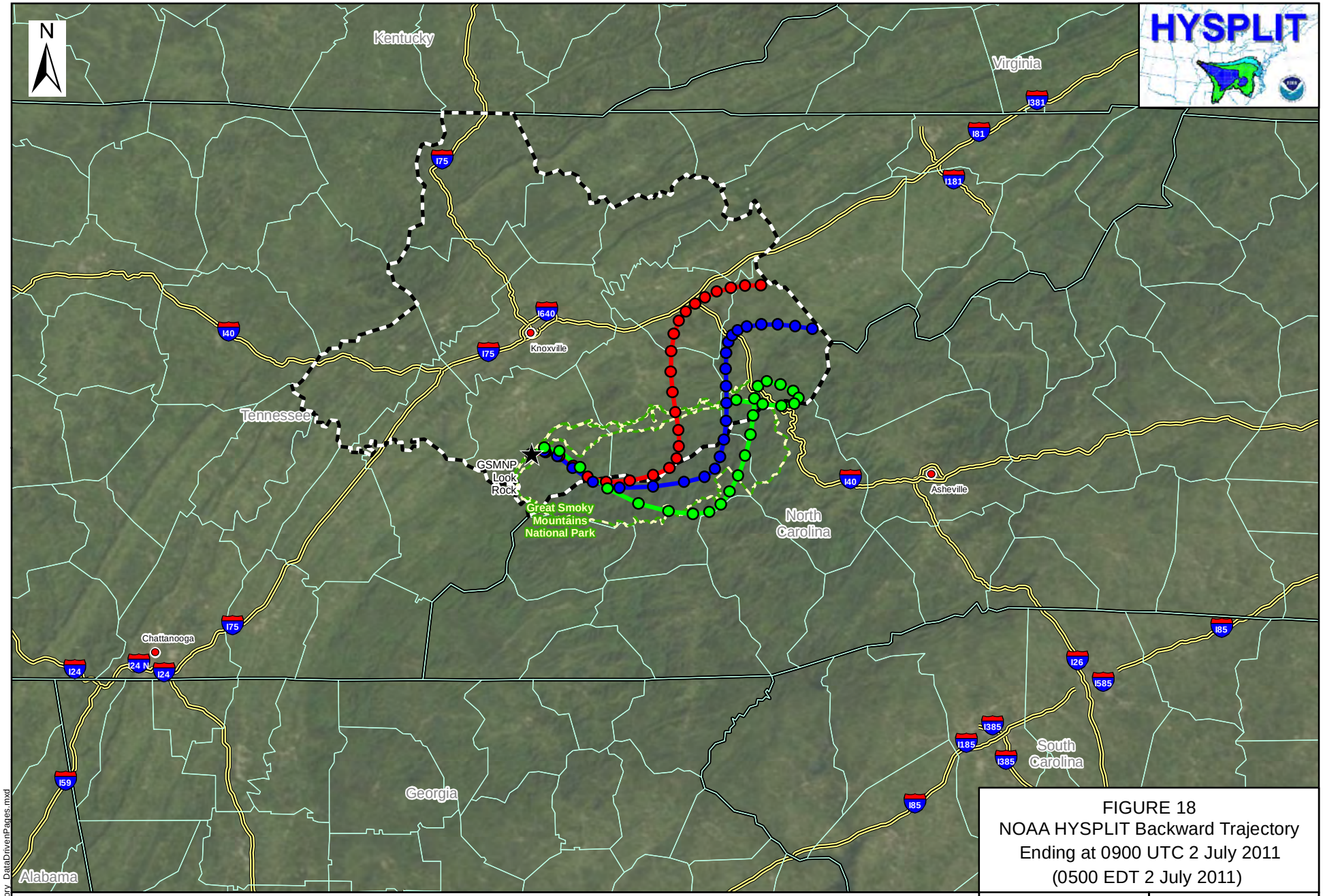

FIGURE 18
NOAA HYSPLIT Backward Trajectory
Ending at 0900 UTC 2 July 2011
(0500 EDT 2 July 2011)

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DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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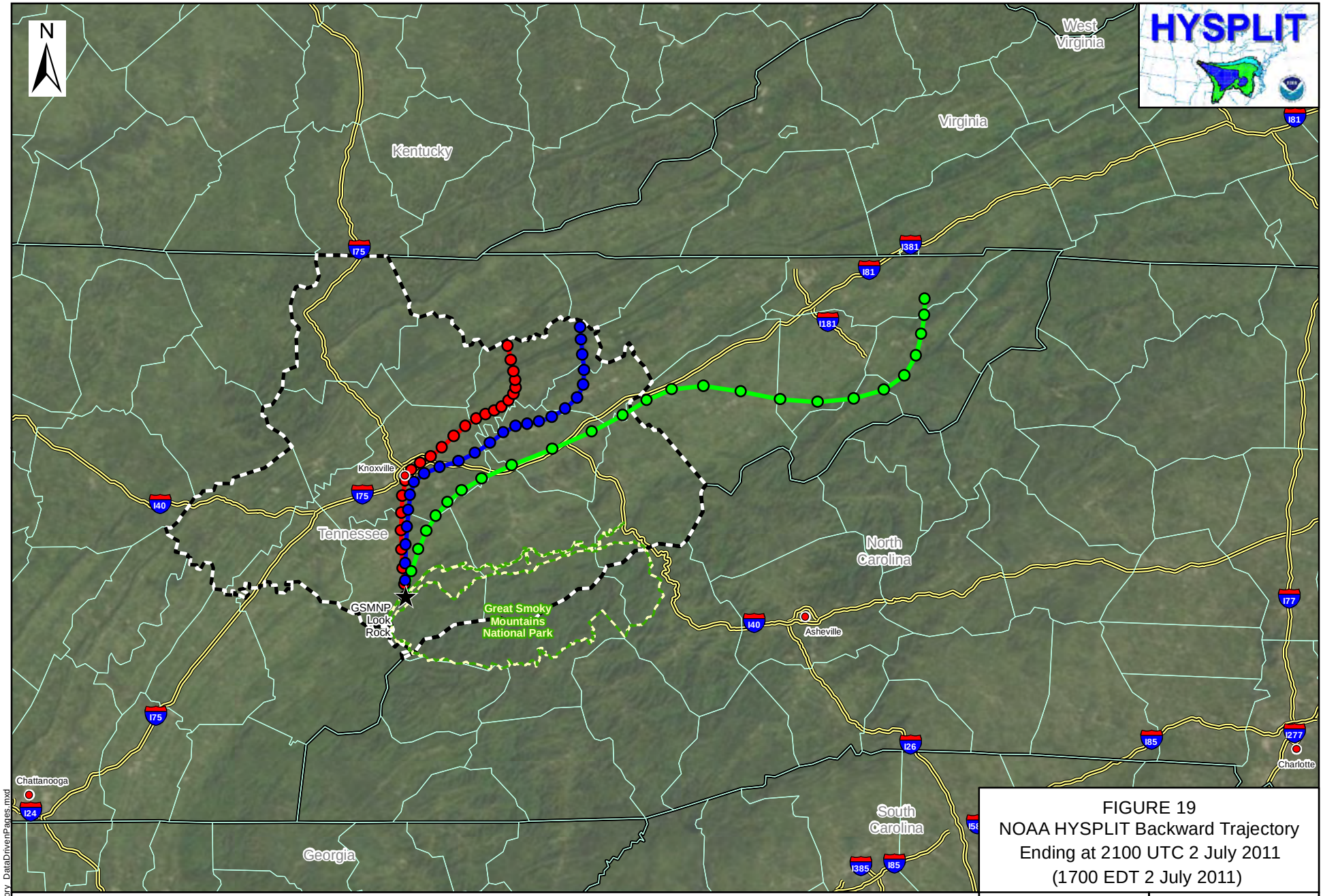

FIGURE 19
NOAA HYSPLIT Backward Trajectory
Ending at 2100 UTC 2 July 2011
(1700 EDT 2 July 2011)

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 12.5 25 50 Miles
0 15 30 60 Kilometers

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
PROJECT NO: 0888812099	

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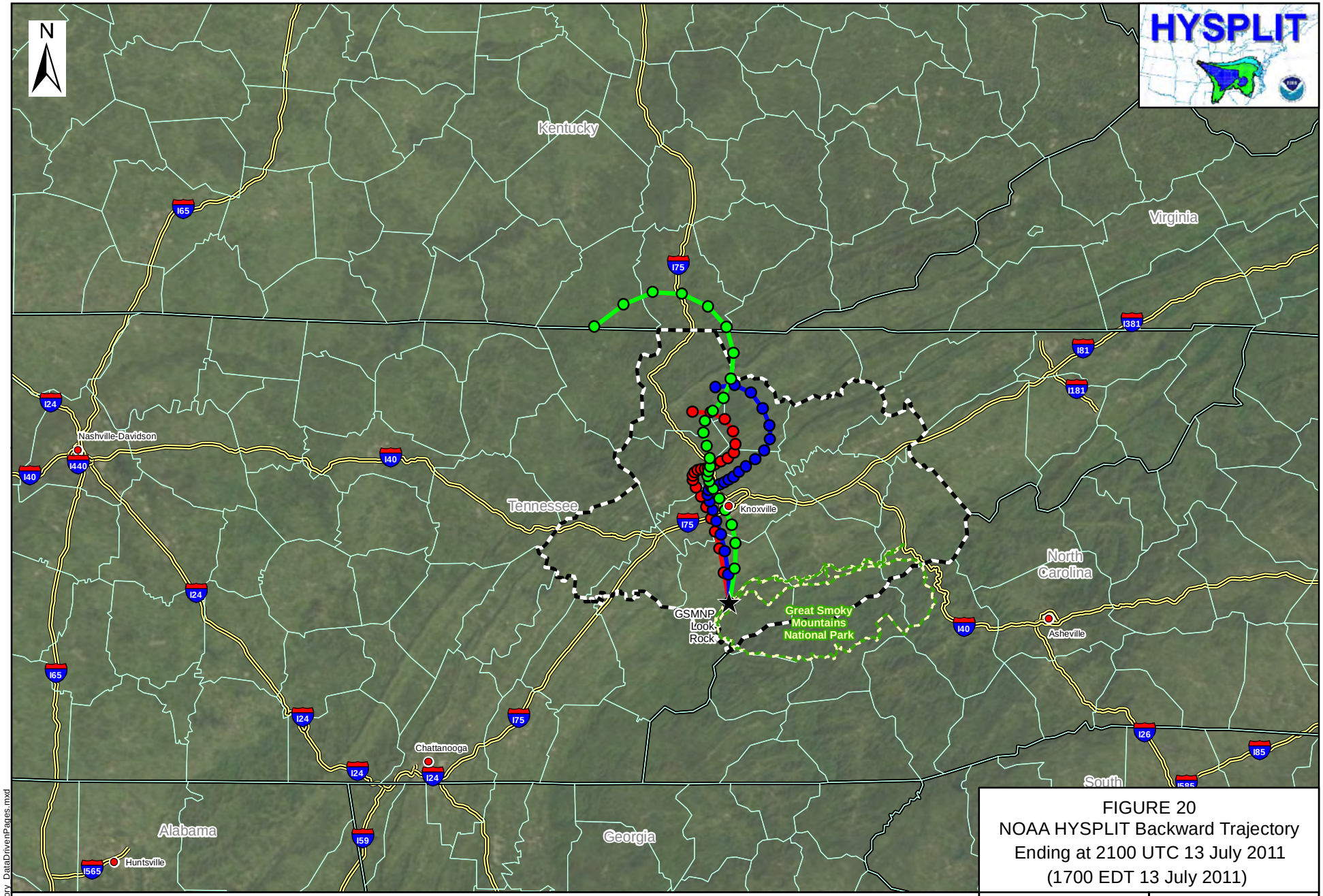

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 15 30 60 Miles
0 20 40 80 Kilometers

FIGURE 20
NOAA HYSPLIT Backward Trajectory
Ending at 2100 UTC 13 July 2011
(1700 EDT 13 July 2011)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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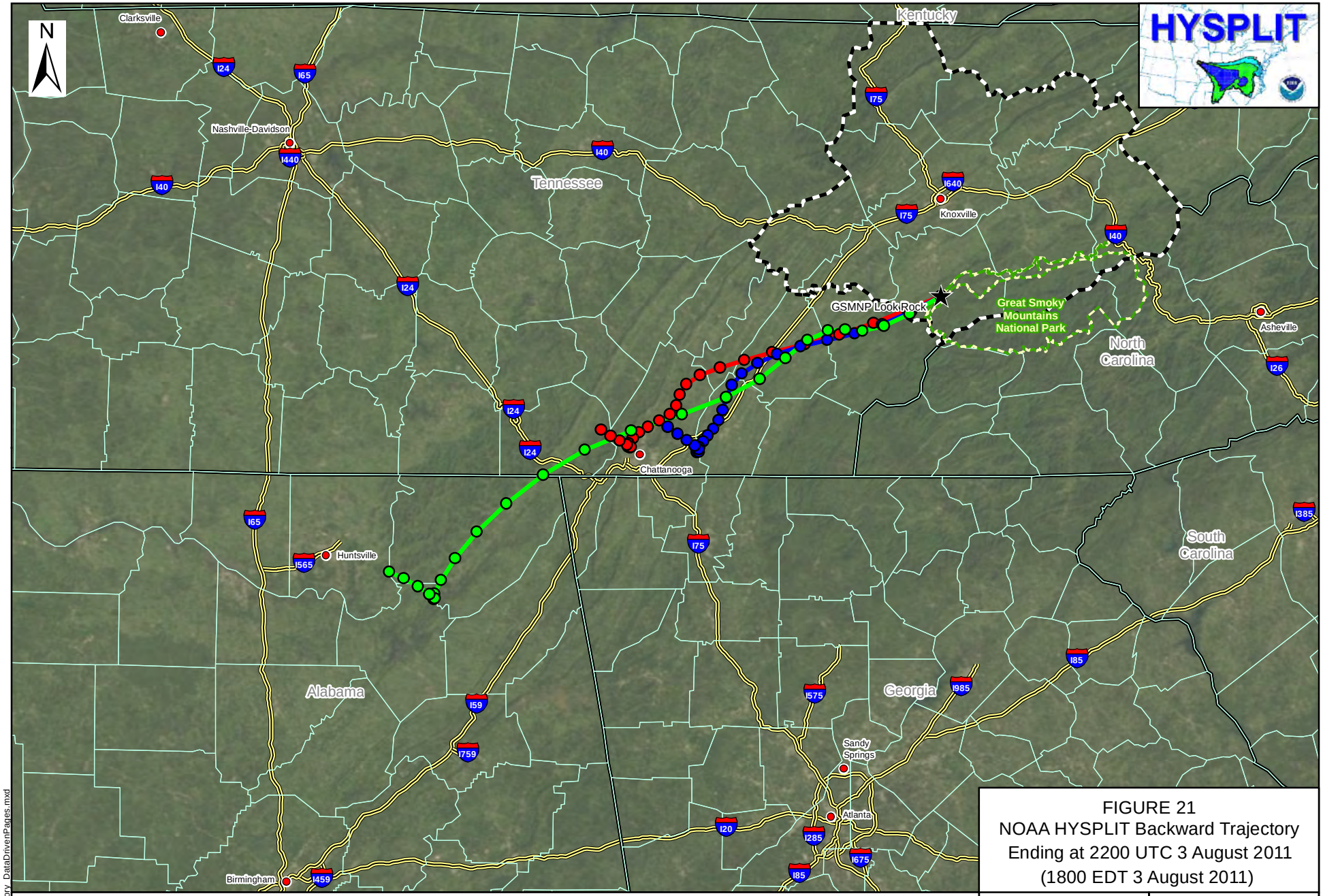

10.0 m AGL Trajectory
100.0 m AGL Trajectory
500.0 m AGL Trajectory

Highways
Great Smoky Mountains National Park Boundary
Statistical Boundary

0 15 30 60 Miles
0 20 40 80 Kilometers

FIGURE 21
NOAA HYSPLIT Backward Trajectory
Ending at 2200 UTC 3 August 2011
(1800 EDT 3 August 2011)

REQUESTED BY: J. Shipp/B. Bolton	
DRAWN BY: N. Rinehart	
DATE: 10/10/2012	
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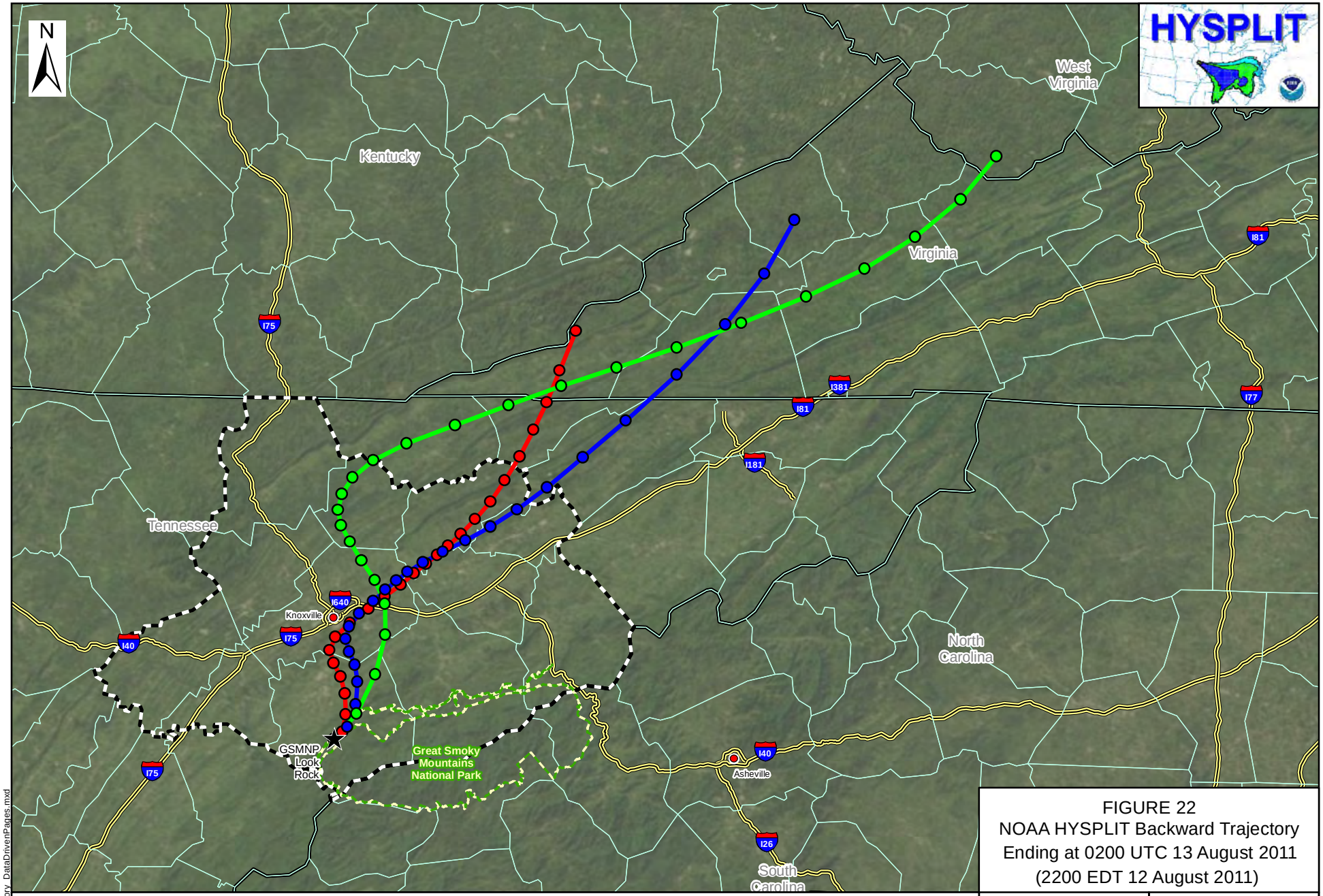

FIGURE 22
NOAA HYSPLIT Backward Trajectory
Ending at 0200 UTC 13 August 2011
(2200 EDT 12 August 2011)

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DRAWN BY: N. Rinehart	
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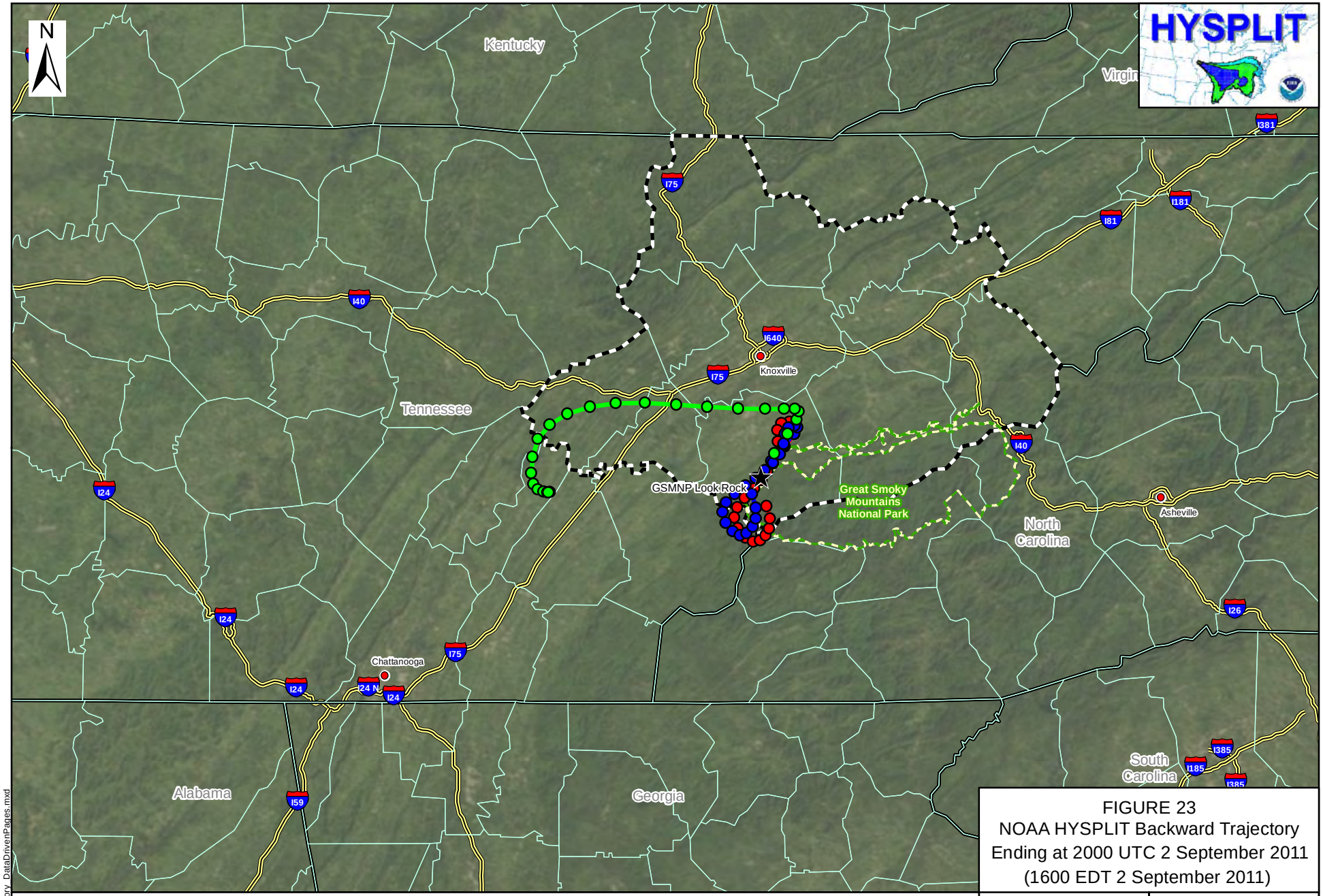

FIGURE 23
NOAA HYSPLIT Backward Trajectory
Ending at 2000 UTC 2 September 2011
(1600 EDT 2 September 2011)

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DRAWN BY: N. Rinehart	
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Appendix 3

TVA's "Cluster Analysis of Look Rock High Ozone Events and Related Air Parcel Trajectories for 2009-2011."

Cluster Analysis of Look Rock High Ozone Events and Related Air Parcel Trajectories for 2009-2011

Prepared by Stephen F. Mueller, CCM
Tennessee Valley Authority
September 2012

Cluster analysis is a statistical procedure designed to explore relationships within groups of data. As such its primary use is to identify commonalities across different sets of variables with no assumed prior knowledge of how such variables might be related (Wilks, 2006). Cluster analysis has been applied in studies of atmospheric and climate data. The SAS® statistical software package provides tools for performing cluster analysis. An analysis of Look Rock ozone and trajectory data during 2009-2011 high ozone events was performed using the SAS ACECLUS and CLUSTER procedures[1] (SAS version 9.2).

The ACECLUS procedure analyzes raw data to convert it into variables better suited for cluster analysis. This analysis converts data that are elliptical in *n*-dimensional space (i.e., exhibit more variation in one direction than the other) into spherical data that are then re-configured into *n* canonical (transformed) variables representing different combinations of the original data. In this way, ACECLUS performs a procedure similar to what is done in computing principal components for principal component analysis. The resulting canonical variables are then made available for analysis using CLUSTER.

CLUSTER performs a hierarchical analysis starting with all data points in their own separate cluster. In a continuous sequence, the data points are combined ("agglomerated") into fewer clusters by associating data pairs having the most similarities based on the relative separation between the cluster-mean values of the canonical variables. The relative degree of reduction in total parametric variance across the remaining clusters provides a measure of how the clustering process reduces variations from more to fewer data clusters. SAS CLUSTER documentation provides guidance, based on several statistical metrics, on how to identify significant numbers of clusters. This guidance was used in developing the clustering results described here.

Data

Simulated air parcel coordinates (latitude and longitude) for trajectories arriving at Look Rock during high ozone episodes form the basis of this cluster analysis along with ozone levels measured at Look Rock. HYSPLIT model trajectories arriving at 10, 100 and 500 m above Look Rock were provided for different hours during 23 high 8-hr ozone periods of 2009-2011. Data for 63 sets of trajectories were combined with the maximum hourly and 8-hr average ozone (centered on the maximum hourly ozone level) mixing ratios measured on a given day. A subset of 9 high ozone events--represented by 40 sets of trajectories--were accompanied by other air

[1] Documentation found at http://support.sas.com/documentation/cdl/en/statug/63033/HTML/default/ viewer.htm#aceclus_toc.htm (ACECLUS) and http://support.sas.com/documentation/cdl/en/statug/63033/HTML/default/viewer.htm#cluster_toc.htm (CLUSTER).

quality data to provide a more detailed picture of the conditions associated with the high ozone events. Thus, 14 events were characterized only by ozone and 23 sets of trajectory data.

For the 9 "detailed" events, data provided 8-hr averages and hourly maximum mixing ratios of CO, NO, NO_2, NO_y and photochemical age (τ=NO_z/NO_y), along with 8-hr average solar radiation flux and ridge top wind direction and speed. These 8-hr averages coincided with the 8-hr ozone averages previously mentioned.

Analysis

Trajectory coordinates and ozone mixing ratio (hourly maxima or 8-hr averages) provide excellent variables for cluster analysis because they are linear variables with little covariance between data pairs. The canonical variable equivalents input into CLUSTER were selected for their expected ability to characterize Look Rock high ozone events. Although any and all trajectory coordinates could have been used, it is best to minimize the number of parameters in a cluster analysis for ease of interpretation. To this end, CLUSTER was run with trajectory coordinates for 10 and 100 m trajectories (lat_{10}, lon_{10}, lat_{100} and lon_{100}) at 12 hr upwind of Look Rock in combination with either the 8-hr average (C_{8h}) or maximum hourly (C_{max}) ozone mixing ratio for each event. Both 3 and 5 variable clustering were examined (3 parameter clustering used one ozone metric and one set of trajectory coordinates; 5 parameter clustering used one ozone metric and both sets of trajectory coordinates). Additional parameters add more canonical variance to each analysis (and more potential clusters) and there can be a trade-off between the useful information derived from the clusters and quantity of results to be interpreted.

Although both C_{8h} and C_{max} were tested, neither was clearly superior in providing more definitive clusters. A bit more variance was contained in the fewest significant clusters using C_{max} in combination with both trajectory points. Also, more clusters were needed to identify a major portion of the overall parametric variances when data from both trajectories were used rather than only one of the two trajectories. However, given the complexity of boundary layer airflow and the potential for emissions from different locations to contribute to ozone formation in an environment characterized by complex topography, it was decided that more useful results could be obtained by jointly analyzing the 10- and 100-m trajectory coordinate fields.

After reviewing results based on C_{max}, lat_{10}, lon_{10}, lat_{100} and lon_{100} (a 5-parameter model) it was evident that the 9 event days accompanied by detailed Look Rock data could be grouped into only 5 clusters representing 79 percent of the total parametric variance in the data. However, to achieve a similar degree of parametric variance (80 percent) required 11 clusters for the larger 23 event/63 trajectory data set. Clusters are labeled using C_1, C_2, ...C_n for an *n*-cluster result. The first cluster represents the largest set of agglomerated variance with each subsequent cluster representing decreasing amounts of variance. Comparing trajectories common to both sets of results (i.e., for the 9 event subset and the 23 events) it is possible to identify how well the 9-event subset represents the larger 3-year data base. Table 1 summarizes the commonalities and differences between the two clustering analyses.

There is no perfect one-to-one match between the two sets of clusters. The larger number of clusters needed to characterize the 23-event data set introduces more clusters than could be

identified using the smaller event subset. This causes some trajectories clustered together in the smaller subset analysis to split across multiple clusters in the larger set. However, some clusters remained intact between the two analyses. The most important (largest contribution to total variance) cluster for the 9-event subset, C_1, was contained entirely in the second cluster of the full data set (denoted FC_2). The second subset cluster (C_2) was mostly included in FC_3 although small portions were also found in FC_7 and FC_{10}. All of C_3 mapped to FC_4, all of C_4 mapped to FC_7 and all of C_5 mapped to FC_8. C_6 and FC_{11} also had a large degree of overlap and both included the largest number of individual data points with the smallest relative contributions to total variance within their data sets. Other subset clusters were split across the clusters of the full data set in varying amounts. The complete data set identified 3 clusters--FC_1, FC_5 and FC_6--that had no cross-mapping with the subset. These 3 unmapped clusters represent 37 percent of the total variance in the larger set of data.

Table 1. Relative mapping between clusters derived from the full 3-year 23-event data set and the 9-event subset.

Clusters[a]	
23-Event Set	*9-Event Subset Mapping*[b]
FC_1	
FC_2	C_1 (100%)
FC_3	C_2 (67%)
FC_4	C_3 (100%)
FC_5	
FC_6	
FC_7	C_2 (17%) & C_4 (100%)
FC_8	C_5 (100%) & C_6 (5%)
FC_9	C_6 (14%)
FC_{10}	C_2 (17%) & C_6 (9%)
FC_{11}	C_6 (73%)

[a]The cluster designations in each column refer to the designations used for the individual cluster analyses and are not equivalent across columns.

[b]Values in () denote the fraction of observations in the subset cluster that contributed to the clusters from the larger data set.

To better understand how well the subset represents the full set it is imperative to examine the relative spatial representations of the different clusters regarding air pollutant transport and the comparative ozone values between the two sets of clusters. Plots of 12-hr upwind 10- and 100-m trajectory locations averaged by cluster are illustrated in Figure 1. Except for FC_8, the cluster-average 10- and 100-m trajectory locations at 12 hr upwind from Look Rock fall within 40 km and one direction sector of each other. Therefore, the trajectories at the two levels are mutually consistent and do not indicate airflow from vastly different origins.

Figures 2 and 3 compare average C_{8h} and C_{max} for the data that fall into the clusters of the full data set. Subset clusters that mapped to the larger cluster set do a good job of representing the average cluster C_{8h} (Figure 2) even though this parameter was not included in the clustering procedure. For C_{max}, the match between the two data sets (Figure 3) was excellent as would be expected because C_{max} was used to define the clusters. Other parameters that match well between the two data sets are the upwind distances (relative to Look Rock) of the 10- and 100-m trajectories (Figures 4 and 5).

Interpretation

With 8 of 11 clusters containing detailed data from the 9-event subset it is possible to determine how most subsets differ from the others. Figures 6-8 illustrate cluster averages of 8-hr NO_y, CO

Table 2. Summary of event cluster characteristics.

Cluster	% of Trajec-tories	O_3[a]	NO_y/Age	CO	Transport[b]
1	10	Highest	N/A	N/A	From NNE within 40-45 km (i.e., 10 km ENE of downtown Knoxville)
2	14	High	Moderate/ high	Low	From NNE/NE within 75-80 km
3	6	Moderately high	Moderate/ high	Moderate	From S/SSW within 150-200 km (passing east of Atlanta)
4	3	Moderately high	Moderate/ high	Moderate	From S within 185-200 km
5	3	Moderate	N/A	N/A	From NE within 100-150 km
6	11	Moderately low	N/A	N/A	From NNE/NE within 70-80 km
7	5	Moderately low	Moderately high/ high	Moderate	From SE within 145-160 km
8	8	Moderate	High/low	Moderate	From ESE through SSW sectors within 15-35 km
9	5	Moderately low	Low/high	High	From WSW within 135-140 km (Chattanooga)
10	5	Moderately low	Moderate/ moderate	Moderate	From SW within 80-100 km
11	30	Moderately low	Moderate/ moderate	Moderate	From WSW within 75-80 km

[a]Ratings are relative across the population of all event clusters. All 8-hr average ozone levels exceed 75 ppb except for cluster 6 (74 ppb).
[b]Distances refer to transport during the 12 hours preceding arrival at Look Rock and include information from both the 10- and 100-m trajectories.

and photochemical age (τ). Of those clusters containing data, FC_8 had the highest NO_y levels while FC_9 had the lowest. The airmasses in FC_9 had the highest mean τ while the lowest was found for FC_8. In general, τ was inversely associated with NO_y. FC_9 had the highest average CO levels and FC_2 had the lowest. From these data the clusters can be characterized as summarized in Table 2.

Clusters 1, 2 and 6

The highest ozone was associated with clusters FC_1 and FC_2 and the transport directions were very similar with 12-hr origins being farther upwind for FC_2 (i.e., winds were stronger for FC_2).

Detailed air quality data other than ozone were not available for FC_1, but given the similarities in transport directions and ozone levels (with lower ozone levels associated with higher transport speeds as expected) it is likely that the air quality signatures of these two clusters are similar. FC_2 had moderate NO_y levels, high τ and low CO. Thus, the airmasses associated with FC_2 do not have a strong urban signature despite passing only 10 km or so east of downtown Knoxville. Instead, they appear more strongly associated with transport from more distant sources despite the fact that 12-hr transport distances were not that high. FC_6 transport overlapped completely with that of FC_1 and FC_2 with speeds intermediate between FC_1 and FC_2. FC_6 ozone levels were lower than either FC_1 or FC_2 and, like FC_1, FC_6 did not have detailed air quality data. Thus, all that can be deduced is that conditions (either meteorology or ozone precursors) were not as amenable to ozone formation in cluster 6.

Cluster 5

Cluster 5 is set apart from the other clusters by the strength of its transport and the direction (NE) of its origins. With air originating in northeast Tennessee during the 12 hours preceding arrival at Look Rock, it is most likely that FC_5 ozone levels were influenced by sources near Kingsport, TN. No detailed air quality data were available.

Clusters 3 and 4

Clusters 3 and 4 are unique in that they have the highest transport speeds during the 12 hours preceding arrival at Look Rock and originate from well south of Look Rock over north central Georgia. Ozone levels are relatively high, NO_y and CO levels are moderate, and τ is high. These clusters could be associated with emissions east of Atlanta and are definitely not due to emissions anywhere near Look Rock.

Clusters 7 and 8

Clusters FC_7 and FC_8 share several features--both originate southeast of Look Rock, both have moderately high ozone and CO levels and both have relatively high NO_y levels. The primary differences are in transport speeds/distances and τ. FC_7 is associated with very aged air (high τ) and high transport speeds; 12-hr airmass origins are over extreme northeast Georgia and extreme western South Carolina. However, FC_8 is associated with the lowest transport speeds of any cluster and the largest directional divergence between 10- and 100-m trajectories. Airmass origins are within 30 km of Look Rock, essentially over the Great Smoky Mountains National Park (GSMNP) and nearby national forests and wilderness areas. There are no significant source regions in this area. Despite this, τ was lower for FC_8 than any other cluster and this implies a nearby source of NO. Given the transport directions and low winds it is likely that Look Rock air quality in cluster 8 was influenced by emissions from the small Happy Valley community east of the Look Rock/Foothills Parkway (Chilhowee Mountain) and west of GSMNP and, perhaps to some extent, by the Look Rock campground east of the air monitoring station. Emissions from fireplaces, wood stoves and campfires could contribute the relatively fresh NO emissions and moderate CO levels that were measured.

Clusters 9 and 11

Clusters FC_9 and FC_{11} share a common transport direction (WSW) and moderately low high ozone levels. However, they differ considerably in their transport speeds and other air quality characteristics. FC_9 has low NO_y but high τ and CO. Given the 12-hr transport distances and directions it is likely that FC_9 events were influenced by Chattanooga emissions. The relatively high CO levels may reflect the fact that FC_9 trajectories follow the Chattanooga-Knoxville transportation and industrial corridor for much of the 12-hr period prior to arrival at Look Rock. FC_{11} events follow similar paths but transport speeds are lower and both CO and τ are lower than for FC_9. The lower FC_{11} speeds put the Chattanooga source region further upwind in time than for FC_9. The lower τ for these events implies that more nearby sources are important than for FC_9 events and the lower CO suggests that they are not mobile sources. FC_{11} comprises the largest single cluster with 30 percent of all computed trajectories.

Cluster 10

Trajectories for cluster 10 originate in northwest Georgia 12 hours upwind of Look Rock. This region does not have large urban areas but it does include a variety of industrial facilities and electric generating stations. Air quality data suggest that these moderately low high ozone events are associated with moderate levels of emissions.

Summary

A cluster analysis of high ozone events at Look Rock provides insight into the sources and conditions associated with various categories or clusters of events. The data suggest that, out of 11 distinct clusters, only 4 (FC_1, FC_2, FC_5 and FC_6) are likely to have any contributions from the Knoxville urban area. Of these 4, one (FC_5) has such strong transport from the northeast that airmasses spend very little time over Knoxville-area emissions sources. Of the remaining 3 clusters, FC_1 has the highest ozone levels and the greatest potential for Knoxville-area contributions because of the relatively long time spent by sampled air parcels traveling across the urban source region. Clusters 1, 2 and 6 with the highest potential impacts from the Knoxville area comprise 35 percent of the computed air parcel trajectories associated with Look Rock high ozone events. In other words, 65 percent of the Look Rock high ozone events are not associated with or significantly impacted by Knoxville-area emissions.

Reference

Wilks, D.S. *Statistical Methods in the Atmospheric Sciences*, Academic Press, New York, 2006, 549-559.

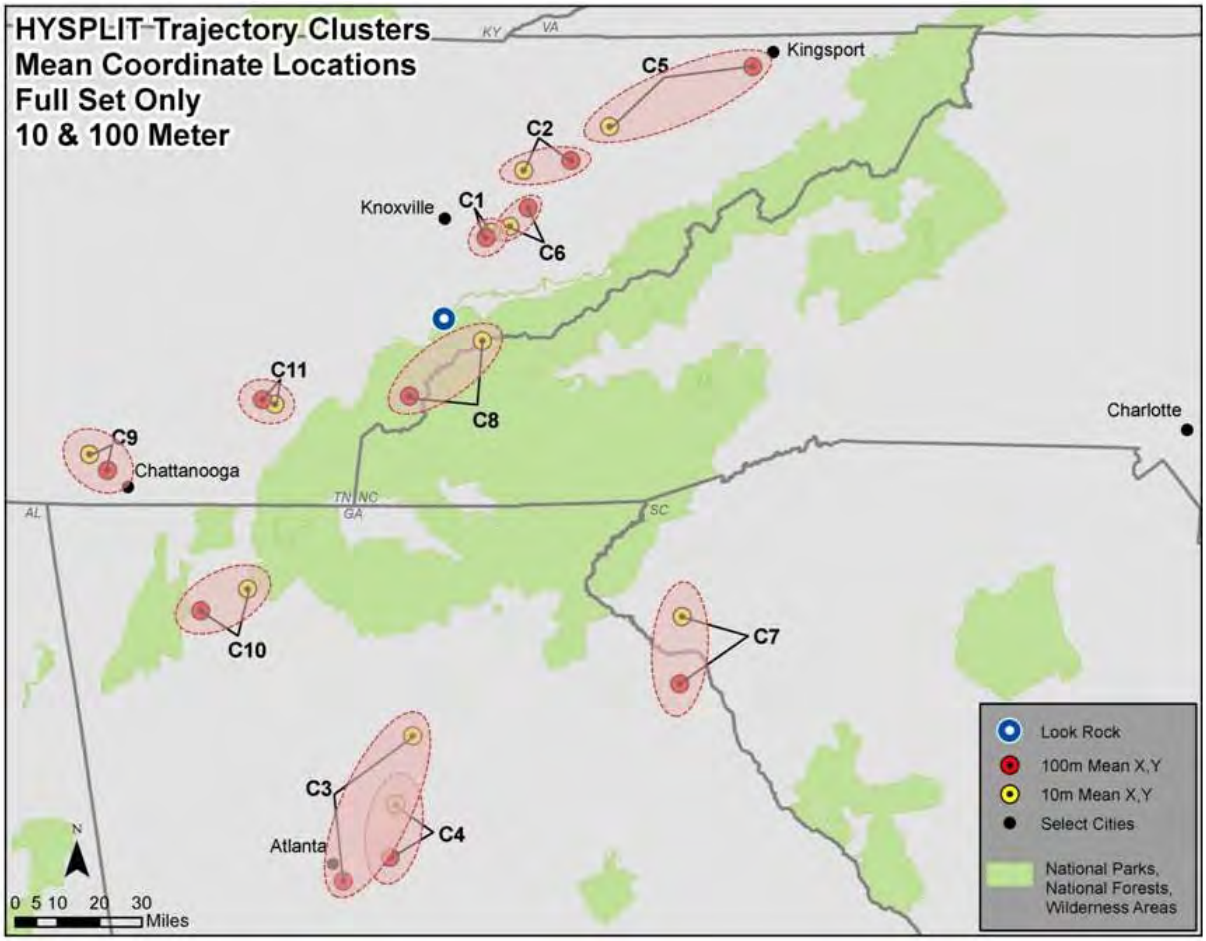


Figure 1. Cluster-averaged 10- and 100-m trajectory locations at 12 hours upwind of Look Rock during high ozone events. Locations are labeled by cluster number. Pink ovals denote ozone precursor source regions at 12 hours prior to arrival at Look Rock.

Figure 2. Comparison of cluster averaged 8-hr ozone mixing ratios for periods centered on the maximum observed one hour ozone value on Look Rock high ozone event days. Note that this is not the same as the daily maximum 8-hr average ozone value.

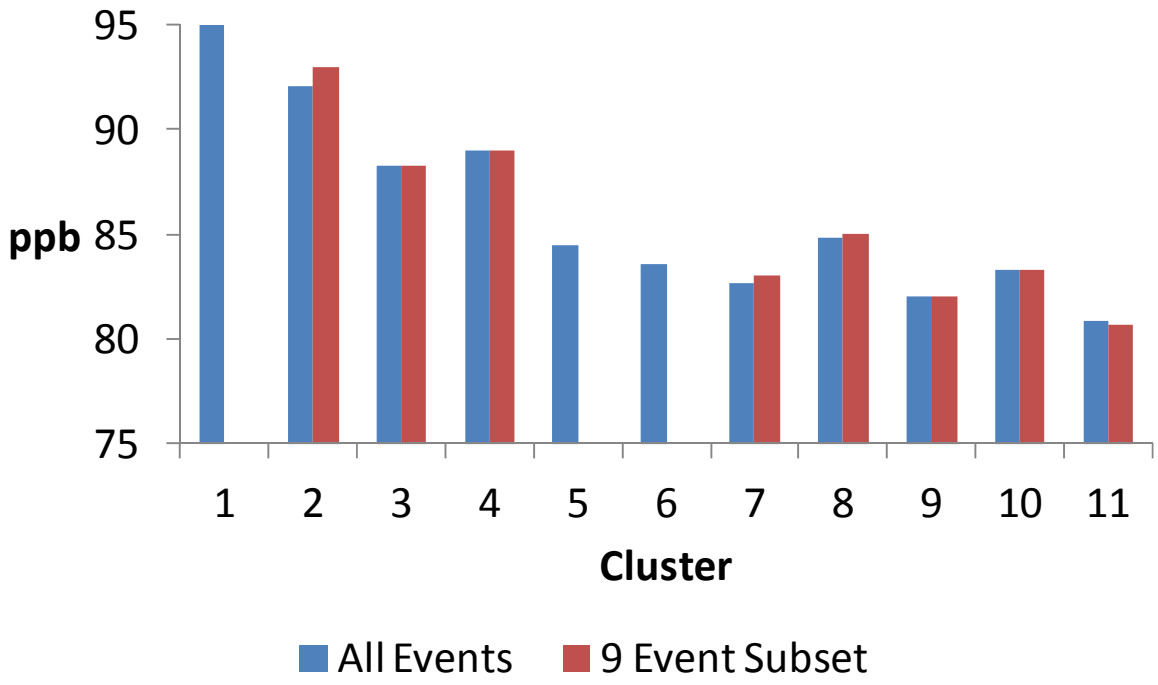


Figure 3. Comparison of cluster averaged maximum hourly ozone mixing ratios observed at Look Rock on high ozone event days.

Figure 4. Cluster average computed trajectory distances upwind of Look Rock at 12 hr preceding arrival at Look Rock during high ozone events for trajectories arriving at a height 10-m above the destination.

Figure 5. Cluster average computed trajectory distances upwind of Look Rock at 12 hr preceding arrival at Look Rock during high ozone events for trajectories arriving at a height 100-m above the destination.

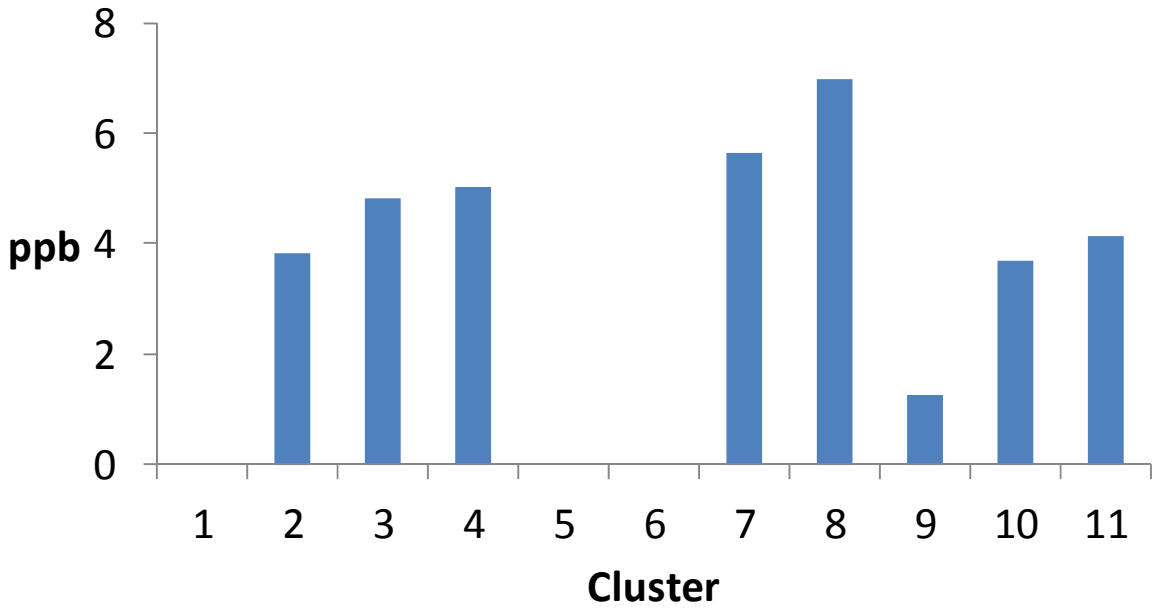


Figure 6. Cluster average NO_y mixing ratios for 8-hr periods centered on the daily maximum hourly ozone mixing ratio measured during high ozone events at Look Rock.

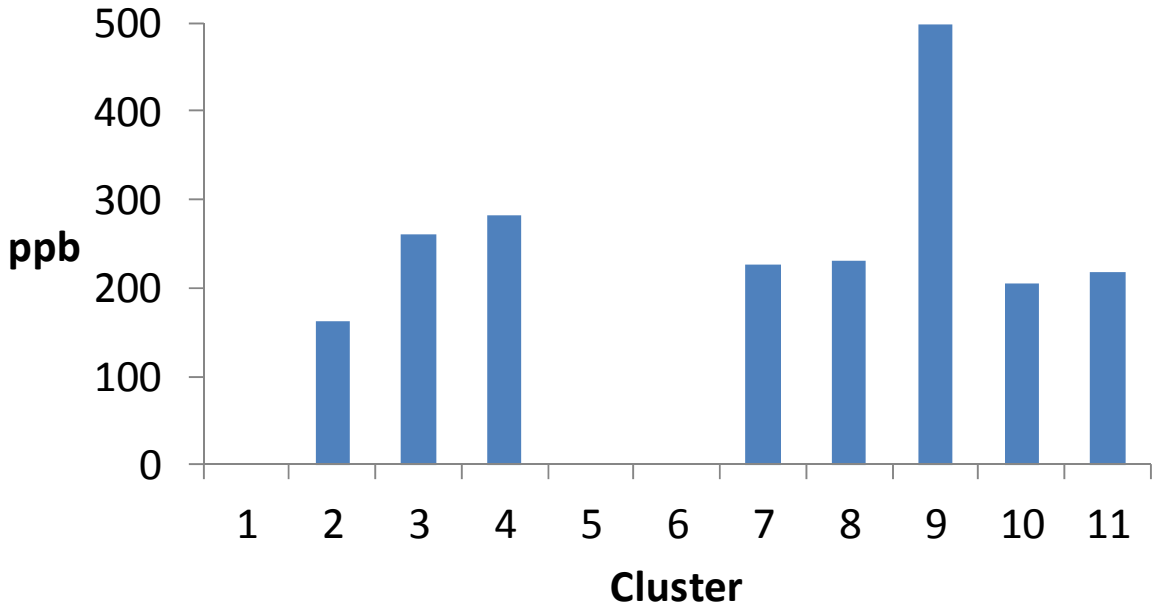


Figure 7. Cluster average CO mixing ratios for 8-hr periods centered on the daily maximum hourly ozone mixing ratio measured during high ozone events at Look Rock.

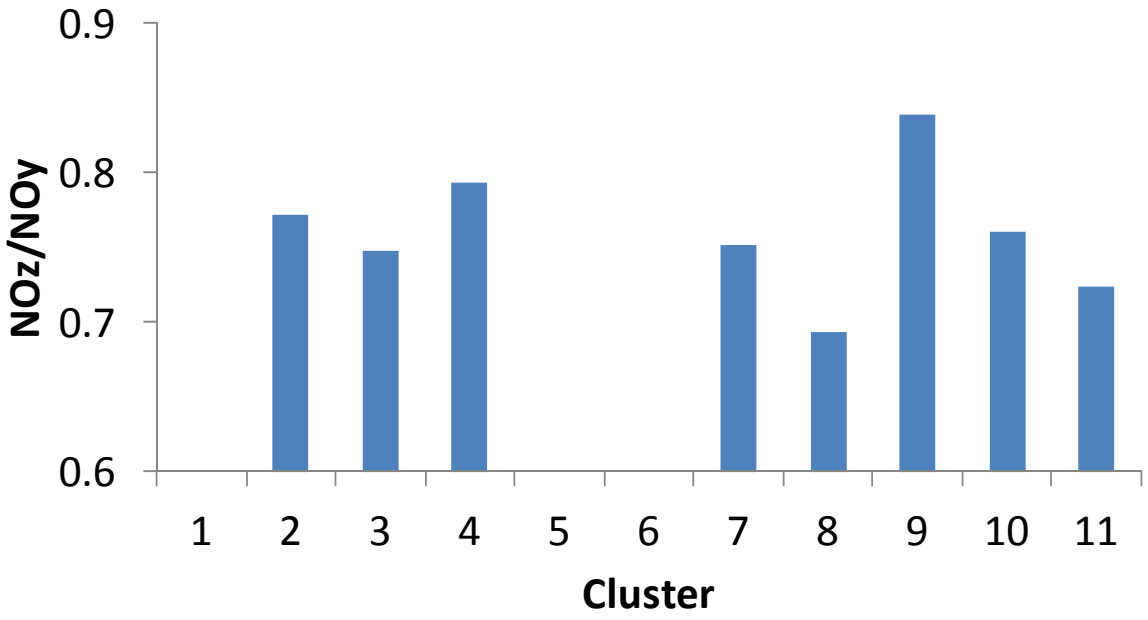


Figure 8. Cluster average photochemical age (τ) for 8-hr periods centered on the daily maximum hourly ozone mixing ratio measured during high ozone events at Look Rock.

Appendix 4

TVA's "2008 Environmental Policy."

TENNESSEE VALLEY AUTHORITY

2008 Environmental Policy

Table of Contents

The TVA Board

CHAIRMAN WILLIAM SANSOM of Knoxville, Tennessee, is chairman and chief executive officer of The H.T. Hackney Co., and has held that position since 1983. Hackney is a diversified company involved in wholesale grocery, gas and oil, and furniture manufacturing.

DENNIS BOTTORFF of Nashville, Tennessee, serves as chairman and partner of Council Ventures, a venture capital firm. He was chairman of AmSouth Bancorporation until his retirement in 2001 and previously was chief executive officer of First American Bank.

DON DEPRIEST of Columbus, Mississippi, is chairman of a venture capital firm headquartered in Alexandria, Virginia, that has founded or invested in such companies as American Telecasting, now merged with Sprint. His Charisma Communications Corp. was a pioneer in the cellular phone business. He previously chaired the Columbus, Mississippi, Utilities Commission.

MIKE DUNCAN of Inez, Kentucky, is chairman, chief executive officer, and director of Community Holding Co.; chairman, CEO, and director of Inez Deposit Bank; and chairman of the Republican National Committee. He is a director of the Regional Center for Rural Development.

THOMAS GILLILAND of Blairsville, Georgia, recently retired as executive vice president, general counsel, and secretary of United Community Banks Inc. He is a former chief of staff to Georgia Lt. Gov. Pierre Howard, and he served as chairman of the Stone Mountain Authority under Georgia governors Roy Barnes and Sonny Perdue.

SKILA HARRIS of Washington, D.C., is a native of Bowling Green, Kentucky, and served as a full-time TVA director from November 1999 through March 2006. She previously held positions in the U.S. Department of Energy, the White House, and energy-management and engineering-consulting firms.

HOWARD THRAILKILL of Huntsville, Alabama, recently retired as president and chief operating officer of Adtran, Inc., in Huntsville, which supplies equipment for telecommunications service providers and corporate end-users. Previously, he was president and chief executive officer of Floating Point Systems.

Message from the CEO

Stewardship of the Tennessee Valley

We are very much aware of the impact that the Tennessee Valley Authority's operations have on the environment, and we are working in partnership with others to further the region's environmental quality. In fulfilling its historic mission, TVA has contributed to the region's economic progress by meeting an ever-increasing demand for electricity while significantly reducing its impact on the environment. Yet, we recognize that greater challenges lie ahead to meet higher environmental standards and ensure the finite water and land resources under our stewardship are available for future generations.

The annual demand for electricity in the TVA service region is forecast to grow more than the national average. To offset the impact of meeting this demand, we are increasing our efforts in energy efficiency to reduce demand growth, investing in lower-carbon generating sources for meeting any additional growth, and lowering emissions from our current generating plants. This approach will help us improve performance and be proactive in our environmental stewardship responsibilities, while meeting the demand for more power at an affordable cost. However, future decisions to take further actions in these areas could put an upward pressure on power rates.

This policy sets out environmental objectives that will help us make decisions about our business and identifies areas that will allow TVA to produce cleaner and still-affordable electricity and provide environmental leadership in partnership with our stakeholders. We are establishing this policy because I, and all the people at TVA, appreciate the opportunity to provide cleaner power to you and your family now and in the generations to come.

Tom Kilgore
President and Chief Executive Officer

CHAPTER 1

Environmental Policy

BACKGROUND

As stated in the 2007 TVA Strategic Plan, "TVA will be proactive in addressing environmental concerns, including those related to global climate change." This Environmental Policy provides board-level guiding principles to successfully lead TVA to reduce its environmental impact while continuing to provide reliable and competitively priced power to the Valley. There is a growing recognition of the environmental and economic need for an increased emphasis on actions that support sustainable initiatives to most effectively meet the three dimensions of the TVA mission. In the Strategic Plan, about half of the identified strategic objectives and critical success factors relate directly to TVA's environmental-related activities and policy-making. Following the release of the Strategic Plan, the board asked for the development of an integrated environmental policy to outline objectives and critical success factors across the multiple areas of TVA's activities. The policy also addresses TVA's response to the uncertain future of legislation on greenhouse gases (GHGs), including carbon, and the scarcity of available mitigating technologies in a carbon-constrained future.

ENVIRONMENTAL POLICY

TVA's overarching Environmental Policy objective is to provide cleaner, reliable, and still-affordable energy, support sustainable economic growth in the Tennessee Valley, and engage in proactive environmental stewardship in a balanced and ecologically sound manner.

EXHIBIT 1
Overall Environmental Policy Alignment With TVA's Mission

In this context, the Environmental Policy directly aligns with the threefold TVA mission of Energy, Economic Development, and Environment, and as shown in the center of Exhibit 1, accents and integrates environmental leadership into all aspects of the TVA mission.

The Environmental Policy itself is not intended to serve as TVA's response to future environmental regulations, nor is it intended to outline a specific regulatory forecast for planning purposes. Rather, the policy establishes an overarching framework to guide decision-making and future strategic development. The board of directors will review the Environmental Policy every two years. More frequent reviews may be needed to respond to significant market and regulatory changes and ensure alignment with TVA's strategic priorities.

Cleaner, reliable, and still-affordable energy

TVA has an enduring responsibility to deliver reliable and affordable power to the residents and businesses in the Tennessee Valley. We have made investments to comply with environmental regulations in an efficient and affordable manner. We recognize the challenge ahead to achieve continuous improvements to make our generation portfolio cleaner while still meeting our commitment to a reliable and affordable energy supply.

Sustainable economic development

Growth is an important component of maintaining the economic vitality of the Tennessee Valley, and TVA is committed to continued leadership in economic

development. We recognize unplanned growth can place great demands on all of our resources and lead to outcomes that can erode the quality of life within the Tennessee Valley. We believe the solution lies in achieving sustainable community and economic growth while considering environmental impacts.

Proactive environmental stewardship

Looking forward, we see the magnitude of the environmental challenges growing larger and requiring increasing innovation and leadership to find practical, effective, and affordable answers to our stewardship challenges. To meet the environmental challenges of the 21st century and beyond, we must be proactive in our commitment to provide both affordable energy and environmental stewardship. We must work together to reduce the "footprint" we all impose upon the environment.

GUIDING PRINCIPLES

TVA will continue to integrate responsible environmental practices into its business operations by establishing goals, measuring progress, and reporting performance through a comprehensive environmental management system. Employees are trained on their environmental responsibilities and factor environmental considerations into business decisions. TVA remains committed to complying with environmental laws and regulations, with a goal of continuous improvement.

Climate Change Mitigation

TVA plans to actively reduce its carbon emissions through cleaner energy options and energy efficiency initiatives.

Air Quality Improvement

TVA improves regional air quality by installing emission control equipment on existing generation and planning for cleaner future energy options.

Water Resource Protection and Improvement

TVA manages an integrated river system for multiple uses while striving to provide clean and sufficient water for the Valley's needs.

Waste Minimization

TVA surveys all aspects of its operational and business functions to implement ways to reduce waste and increase recycling.

Sustainable Land Use

TVA manages public lands for multiple benefits, striving to keep them in good environmental health while balancing the need for sustainable development.

Natural Resource Management

TVA protects natural resources while providing recreational opportunities across the Valley.

POLICY DEVELOPMENT

The development of the Environmental Policy followed four phases. The first phase identified the key environmental focus areas and established an overarching framework for the policy. The evaluations performed in the second phase analyzed market forces and established a range of possible regulatory outcomes, highlighting the potential impacts of both on TVA. The third phase defined a series of environmental objectives and identified the critical success factors necessary to meet those objectives. The fourth phase asked for public comments and incorporated those comments into the final document, subject to approval of the policy by the TVA Board of Directors.

STAKEHOLDER INVOLVEMENT

TVA's evaluation of stakeholders' suggestions and feedback revealed four emerging themes they believe TVA should emphasize:

Leadership

TVA must take a leadership position in areas of its core competency such as nuclear power and hydroelectric power.

Partnerships

TVA should expand partnership opportunities with stakeholders, such as local, federal, and state institutions, in specific focus areas.

Coordination

TVA should leverage its credibility and position as a federal agency to foster coordination among multiple parties to achieve common goals.

Commitment

TVA should clearly articulate its environmental commitment, preferred strategies for least-cost solutions, and associated performance metrics.

CHAPTER 2

Environmental Objectives and Critical Success Factors

The Environmental Policy is organized into six environmental areas that encompass the variety of issues faced by TVA. These areas are climate change mitigation, air quality improvement, water resource protection and improvement, waste minimization, sustainable land use, and natural resource management.

CLIMATE CHANGE MITIGATION

Environmental Objective

TVA will stop the growth in volume of emissions and reduce the rate of carbon emissions by 2020 by supporting a full slate of reliable, affordable, lower-carbon-dioxide (CO_2) energy-supply opportunities and energy efficiency.

Critical Success Factors

- Reduce load growth by at least one-fourth over five years, through energy efficiency and demand-side management initiatives.
- Meet the remaining load growth through lower-carbon-emitting energy sources such as affordable renewables, nuclear, and combined heat and power.
- Improve the efficiency of the transmission network, including the use of technologies such as Smart Grid, which helps achieve environmental benefits through improved communication and remote control, making the system more responsive in real time.
- Strive to reduce the rate of carbon and other GHG emissions from the existing generation fleet.
- Use affordable regional resources to comply with renewable and clean-energy standards and mandates, limiting the use of purchased compliance credits.
- Invest in a technology portfolio that supports low- or zero-carbon emitting generation options and electricity grid infrastructure to support a lower-carbon economy.
- Promote public education and outreach to encourage energy efficiency, clean end-user energy generation, premium green-energy offerings, and regional climate change mitigation opportunities.

AIR QUALITY IMPROVEMENT

Environmental Objective

TVA will continue efforts to reduce sulfur-dioxide, nitrogen-oxide, mercury, and particulate emissions and engage regional and national stakeholders to develop better ways to understand, monitor, and improve regional air quality, including all regulated air emissions.

Critical Success Factors

- Reduce emissions across the system by continuing to install emission reduction equipment and new technology to control over 80 percent of fossil generation in the next 10 years.
- Allow for earlier retirement of coal-fired plants if energy efficiency, renewables, and clean-energy gains exceed targets.
- Elevate air quality improvement as a critical component in evaluating future capacity-planning decisions.
- Promote open exchange and collaboration with others to improve the industry's air quality control technology and modeling.

WATER RESOURCE PROTECTION AND IMPROVEMENT

Environmental Objective

TVA will improve reservoir and stream-water quality, reduce the impact of its operations, and leverage alliances with local and regional stakeholders to promote water conservation.

Critical Success Factors

- Mitigate TVA's impact on aquatic systems while balancing thermal cooling needs with consumptive use.
- Demonstrate a sustainable reduction of consumptive use of water at TVA's metered facilities.
- Integrate the impacts of water quality and quantity into the long-range planning and decision-making process.
- Maintain river system infrastructure for safe operation while operating in compliance with the operating policy from TVA's Reservoir Operations Study (ROS).
- Promote the integration of energy efficiency and water conservation into community planning and building construction.
- Collaborate in community outreach and partnerships through voluntary demonstrations of the efficient use of water resources and protection of water quality.

SUSTAINABLE LAND USE

Environmental Objective

TVA will strive to maintain the lands under its management in good environmental health, balancing their multiple uses, and will improve its land transaction processes to support sustainable development.

Critical Success Factors

- Actively manage TVA lands to meet the desired conditions for their purpose as defined in the Reservoir Land Management Plans.
- Develop a policy for managing TVA's mineral rights that considers the potential environmental impacts.
- Improve reservoir shoreline conditions through collaborative partnership initiatives and balance the multiple uses of the reservoirs in accordance with TVA's Land Policy and Shoreline Management Policy.
- Manage TVA lands, mineral rights, and shoreline access to better achieve environmental commitments while meeting the needs for recreation, residential access, and economic development.

WASTE MINIMIZATION

Environmental Objective

TVA will drive increased sustainability in existing compliance programs and waste management practices by focusing on waste avoidance, minimizing waste generation, and increasing recycling to reduce environmental impacts.

Critical Success Factors

- Reduce the waste footprint of all TVA facilities by pursuing operational and business practices to decrease waste generation and improve recycling.
- Increase the percentage of recycled coal-combustion waste.
- Minimize low-level nuclear waste and contribute to efforts by industry groups and agencies to formulate innovative and sustainable solutions for the management of spent nuclear fuel waste.
- Further reduce the risk of polychlorinated biphenyl (PCB) releases to the environment over time by eliminating use of PCBs in large electrical equipment.

NATURAL RESOURCE MANAGEMENT

Environmental Objective

TVA will be a leader in natural resource management through the implementation of sustainable practices in dispersed recreation while balancing the protection of cultural, heritage, and ecological resources.

Critical Success Factors

- Allow for properly managed, eco-friendly dispersed recreation while balancing the protection of biological, cultural, and heritage resources.
- Promote ecological diversity and wildlife habitats on TVA lands through partnerships and voluntary initiatives.
- Increase the level of environmental quality and management consistency among TVA-managed and -leased recreation facilities.

CHAPTER 3

Environmental Areas

CLIMATE CHANGE MITIGATION

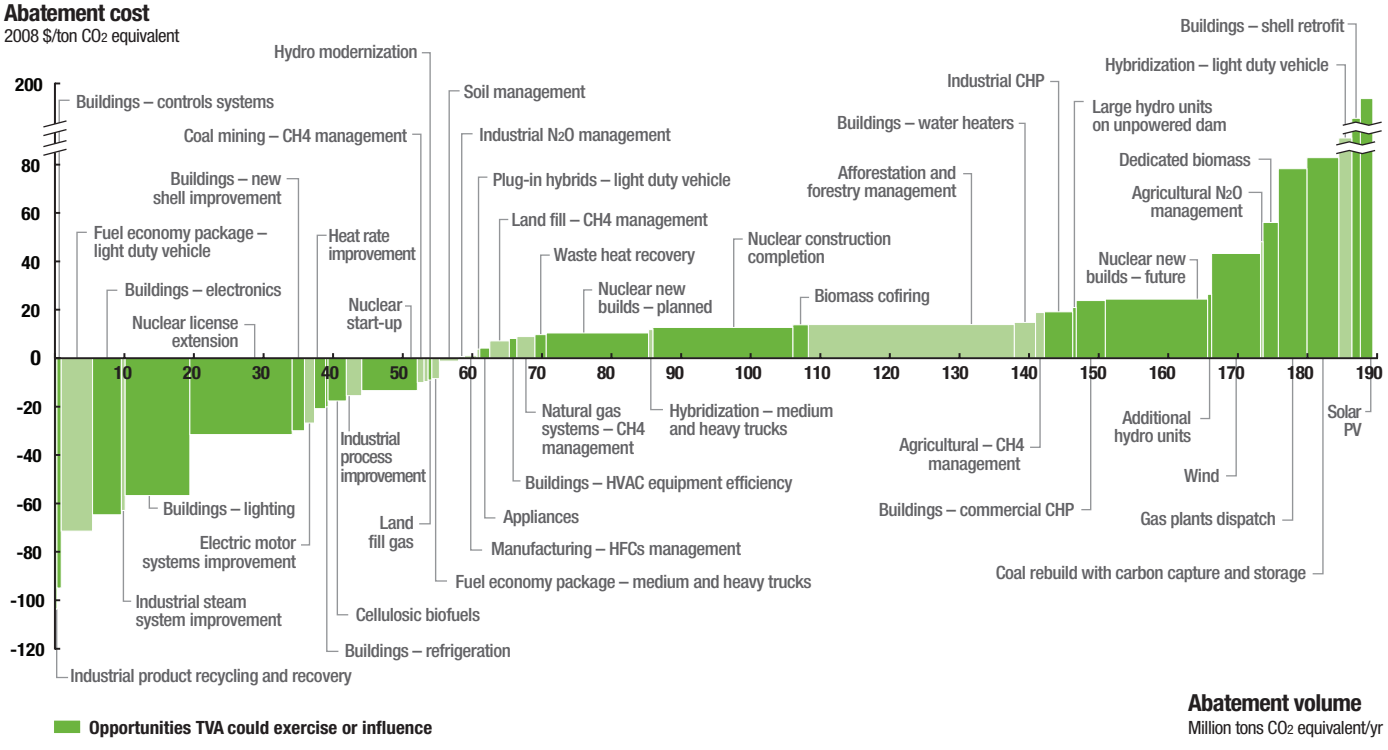
Greenhouse gases are produced by many natural and industrial processes. In order of abundance, the top four gases are water vapor, CO_2, methane, and nitrous oxides. GHGs are important to maintaining the temperature on the earth. Over the past decade, the impact of man-made GHG emissions has been the focus of much scientific, business, and policy debate in the United States and abroad. Man-made CO_2 originates primarily from fossil-fuel combustion for transportation, electricity generation, and industrial processes, accounting for more than 80 percent of the nation's total GHG emissions. Forty percent of the nation's CO_2 emissions can be directly attributed to electricity generation.

TVA is a large emitter in the power sector due to the size of its fossil generation portfolio. However, about 30 percent of TVA's current generation comes from non-carbon-emitting sources — nuclear, hydropower, and renewables – and that figure is forecast to be over 50 percent by 2020. TVA's generating portfolio emissions "intensity" (tons-of-CO_2-per-megawatt-hour) is near the national average and considerably better than that of most utilities in the Southeast.

Legislation has been introduced in the United States Congress requiring reductions of GHG emissions, specifically focusing on CO_2. If enacted, such legislation could result in significant additional costs for TVA. To prepare to respond to this issue, TVA has undertaken a study of the opportunities to reduce GHG emissions in the Valley. In order to understand the cost-effectiveness of TVA's available actions relative to others within the Valley economy, TVA has created a comprehensive catalog of specific opportunities to reduce GHGs and estimated the corresponding volumes and relative costs associated with each. Those opportunities for carbon abatement that are within TVA's control or influence are shown with dark-green bars. Preliminary output from this analysis is depicted in Exhibit 2 on the next page.

EXHIBIT 2

Tennessee Valley's Carbon Abatement Opportunities and TVA Opportunities (TVA shown as dark-green bars)



Source: TVA – Team analysis

The abatement curve visualized in Exhibit 2 illustrates the range of actions the Valley can take to reduce carbon emissions, including non-CO_2 gases. Each bar denotes a single type of opportunity to reduce carbon emissions or increase carbon absorption. The width of the bar represents the total net annual emissions reduction that would result from pursuing the opportunity. The height of the bar highlights the cost of pursuing each option relative to the costs that would be incurred if the current practices were maintained. Sequencing the options from least cost to highest cost helps provide a sense of the relative priority of the abatement measures and can be used to identify the least-cost approach to achieving any targeted level of emissions reduction.

The shape of the curve warrants explanation. The societal costs associated with each measure can be positive or negative in the aggregate. The benefits received are spread over time to one or more beneficiaries who may be different from those making the initial investments. A "negative cost" implies that pursuing the related option will result in a net savings over the life cycle of the opportunity relative to what would be incurred in the business-as-usual case. These savings are frequently the result of reduced energy costs associated with improved energy efficiency. The positive cost options require an incremental expense to abate emissions above and beyond the business-as-usual case.

Five key insights have emerged from this analysis that are of critical relevance to TVA's Environmental Policy:

- **A significant amount of energy-efficiency potential exists within the Valley and requires a corresponding level of investment to realize that potential.**
- **Nuclear power options available to TVA can provide significant abatement potential at a modest incremental cost.**
- **Compared to other regions, the Valley has a limited supply of renewable energy to support carbon and clean-energy objectives.**
- **Coal generation remains an important resource to meet TVA's mission to deliver low-cost power.**
- **Modern transmission and distribution grid technologies can help support the transition to a lower-carbon energy supply by improved real-time information and controls.**

Given the potential for legislation that will require TVA to find ways to reduce GHG emissions – particularly carbon emissions – we must position TVA to address the challenge of operating in a carbon-constrained world. Specifically, TVA will continue to reduce the carbon intensity of its generating system and take advantage of lower-CO_2-emitting energy sources consistent with maintaining a reliable and affordable energy supply. Technology innovations will be needed to address the intermittency of many renewable generation sources. TVA will target reducing load growth by at least one-fourth in five years through energy efficiency and demand response while meeting the remaining load growth through lower-carbon-emitting options.

AIR QUALITY IMPROVEMENT

TVA is a regional leader in the installation and operation of air emission control equipment through an aggressive investment of more than $4.8 billion. This investment has reduced TVA's sulfur-dioxide emissions by about 83 percent since 1977, and lowered nitrogen-oxide emissions during the summer ozone season by 81 percent since 1995. As an additional benefit of these controls, mercury emissions also have been reduced. TVA's efforts have contributed to continued air quality improvement across the region. These improvements are important to the quality of life and economic sustainability in the Valley. The fundamentals of TVA's program focus on complying with air pollution control requirements, considering air-quality impacts on urban and environmentally sensitive areas, and supporting stakeholder interests. TVA's Clean Air Program is based on a strategy of self-compliance that involves the installation of controls on fossil plants to achieve tangible air quality and health benefits for Valley citizens with a limited use of the allowance markets.

Despite these successes, work remains. EPA's Clean Air Interstate Rule, more-restrictive National Ambient Air Quality Standards, and future mercury and regional haze requirements will ensure that regional air quality continues to improve. In the ongoing effort to contribute to that improvement, TVA will continue to reduce its sulfur-dioxide, nitrogen-oxide, mercury, and particulate emissions. We will pursue this objective by continuing to invest in assets that

will measurably reduce emissions from fossil-fired plants and thereby improve air quality. This investment will reduce emissions across the system through the installation of emission reduction equipment and new technology to control over 80 percent of fossil generation in the next 10 years. It's possible that, if energy efficiency efforts yield higher load reductions than forecast, we will have an opportunity to retire higher-emitting fossil plants earlier. In addition, TVA will continue to engage regional and national stakeholders to develop better ways to understand, monitor, and improve regional air quality.

WATER RESOURCE PROTECTION AND IMPROVEMENT

TVA operates the Tennessee River System to provide a wide range of public benefits: year-round navigation, flood-damage reduction, affordable electricity, improved water quality, water supply, land use, and recreation.

In 2004, the TVA Board approved a new operating policy based on the results of the agency's Reservoir Operations Study. The policy maintains TVA's ability to meet its fundamental responsibilities for flood control, commercial navigation, and power production while protecting water quality and accommodating the increased demands created by recreational and residential growth. It shifts the focus of TVA's reservoir operations from achieving specific summer pool elevations on the reservoirs to managing the flow of water throughout the river system in an integrated way to support multiple demands.

TVA pursues its progressive management of water quality and water quantity impacts through the permitting of activities on and around TVA reservoirs; the collection, maintenance, and distribution of water quality information; targeted water quality improvement initiatives; and strategies to manage increased water demand.

The increasing demand for water due to residential, commercial, and industrial growth requires a focus on resource conservation in the Tennessee Valley region. In addition, chronic rainfall deficits can result in low water flows, which could lead to future constraints on power operations. Rapid growth coupled with the challenge of availability further amplifies the importance of balancing resource management activities for multiple, and often competing, uses across the Valley.

Facing these challenges, TVA will lead by example. TVA will demonstrate an efficient use of water in its operations and will collaborate and coordinate with internal and external stakeholders to protect and improve water quality and sufficiency, while maintaining an in-depth knowledge of changing conditions in the river system. TVA's goal is to mitigate its impact on aquatic systems while balancing thermal cooling needs with consumptive use. At the same time, TVA will continue to improve river system operations to balance diverse demands.

WASTE MINIMIZATION

TVA manages an array of different wastes, including municipal solid waste, wastewater, hazardous waste, low- and high-level nuclear waste, other regulated wastes (e.g., asbestos and PCBs), scrap metal, office waste, and coal-combustion waste, which includes fly ash, bottom ash, and gypsum. One of TVA's strengths is its waste management system and the day-to-day implementation of this system at the various facilities by trained environmental personnel. Employees help integrate waste-management expertise at every level of TVA to minimize the impact on Valley resources.

TVA has a strong focus on the use of coal-combustion waste, which comprises its single largest waste stream. Approximately 43 percent of this waste is recycled into by-products. Similarly, TVA recycles the majority of its electronic waste and scrap metal. While focusing on compliance with waste requirements, TVA uses a team approach to seek out and implement further waste-minimization opportunities. In addition, the agency is collaborating with others to identify sustainable solutions for better management of nuclear waste.

TVA will reduce its waste footprint in regulated materials and increase the percentage of recycled coal-combustion waste. In this effort, TVA will augment its existing compliance programs and waste management practices by focusing on waste reduction at the source (in part through improved procurement practices), avoiding waste generation, and increasing recycling efforts (especially of municipal waste).

SUSTAINABLE LAND USE

TVA manages public lands for multiple benefits, including economic development, conservation, and recreation. TVA is the steward of 293,000 acres of public land and 11,000 miles of shoreline in the Valley along the Tennessee River. In addition, TVA maintains 293,000 acres of flowage easement rights, 258,000 acres of transmission rights-of-way, 35,000 acres of facility properties, and 159,000 acres of mineral rights.

When deciding the proper uses of TVA-managed lands and shoreline or acquiring properties for its operations, TVA, while ensuring compliance with appropriate laws and regulations, considers the effects of these activities on the environment.

Section 26a of the TVA Act gives TVA permitting jurisdiction over proposed construction in and along the Tennessee River and its tributaries. Under this jurisdiction, TVA has the responsibility to address obstructions that might affect navigation, flood control, and public lands.

Increasing growth within the region necessitates a balance of resource conservation, sustainable economic development, and eco-friendly recreation. To demonstrate and promote best practices in sustainable land use, TVA intends to lead by example. It will maintain the public lands under its management in good environmental health to support multiple uses in meeting diverse stakeholder expectations. It will also improve its acquisition, development, and disposal of managed lands to support sustainable development in the Valley.

These efforts will align with TVA's Land Policy, approved by the TVA Board in November 2006, and its Shoreline Management Policy, approved by the board in June 1999.

These policies direct TVA to manage and balance the multiple uses of lands under its jurisdiction and use its environmental decision-making process to minimize the environmental liabilities and impacts and ensure compliance.

TVA will continue to actively manage its public lands to meet the desired conditions for their defined purpose, and it will also develop a policy for managing mineral rights that considers the potential environmental impacts.

NATURAL RESOURCE MANAGEMENT

TVA manages natural resources in the Valley while providing for many types of recreational opportunities. The agency has set aside more than 181,000 acres of public land for natural resource management, which includes the enhancement of wildlife habitat and dispersed informal recreation. TVA also oversees and manages an additional 31,000 acres for sensitive resources. The guidelines for use of these sensitive land resources include restrictions on activities that might endanger significant cultural or natural features.

TVA has more archaeological sites per acre under its management than any other federal agency—over 10,000 archaeological sites have been identified on TVA-managed lands. Since 1976, TVA has maintained information on rare plants and animals, caves, and other environmentally sensitive resources in the 80,000-square-mile TVA service area.

In its approach to natural resource management, TVA will demonstrate leadership through the ecologically sound management of natural resources and the protection of cultural and heritage resources. TVA is committed to increasing the proportion of TVA-managed resources that meet the desired environmental conditions of sustainable recreation, ecological diversity, and cultural resource protection. More and more residents and visitors are enjoying the diverse, unique natural resources of the Valley by engaging in dispersed recreation activities such as hiking, bird watching, and fishing. An increase in outdoor activity has been shown to result not only in a healthier lifestyle but also a greater awareness of the importance of natural resource conservation. An increase in conservation practices by the public helps ensure the unique and beautiful Valley resources will be preserved for the continued enjoyment of generations to come.

To support this objective, TVA will pursue collaboration and partnerships to improve the delivery of its natural resource management activities, while also increasing the effectiveness of dispersed public recreation and reducing the impact of human uses on the environment. TVA will allow for properly managed, eco-friendly dispersed recreation on the lands it manages while balancing that goal with the protection of biological, cultural, and heritage resources.

CHAPTER 4

Commitments

COMMITMENTS TO OUR CUSTOMERS

In collaboration with our 159 distributors, TVA is committed to providing low-cost, reliable power to more than 8.8 million residents and businesses and 62 directly served large industrial and federal facilities in the seven states of the Tennessee Valley. TVA's new Environmental Policy, in accordance with the 2007 TVA Strategic Plan, emphasizes three issues that are important from its customers' perspective: maintaining affordable rates, expanding collaboration, outreach, and education, and furthering the Valley's quality of life.

Affordable rates

- TVA will strive to manage potential future rate increases for new generation and transmission construction by collaborating with distributors and customers to pursue lower-cost energy-efficiency and load-management options that may partially offset the need for capacity additions.
- For large commercial and industrial customers, TVA will continue to focus on rates as a principal measure of affordability and competitiveness when promoting cost-effective energy-efficiency and load-management programs.
- For residential and small commercial customers, TVA will emphasize the total bill impact by focusing on the combined effect of rate and consumption.

Collaboration, outreach, and education

- TVA will increase its focus on education and outreach to inform Valley residents on key issues, including energy efficiency and renewables, water conservation, and natural resource protection.
- TVA will collaborate with distributors and directly served customers to implement enabling technologies for clean-energy and energy-efficiency solutions.

Quality of life

- TVA will continue to promote an improved quality of life with an emphasis on the deployment of clean, low-carbon emissions technology in the Valley.
- TVA will consider the environmental footprint of industries recruited into the Valley.
- TVA will improve air quality and continue to promote the sustainable management of land, water, and natural resources.
- TVA will provide for the expansion of ecologically friendly recreation activities within the Valley.

PERFORMANCE INDICATORS

TVA has an established set of metrics to monitor how well its performance fulfills the threefold TVA mission highlighted in the 2007 Strategic Plan, which outlines the policy level direction for TVA. Examples of these metrics are shown in Exhibit 3 on the next page. They include the metrics that are found in TVA's Strategic Plan, such as delivered cost of power, economic development index, and environmental performance, and additional ones associated with the Environmental Policy. This combined set of performance metrics establishes the successful translation of the TVA Environmental Policy into specific and measurable indicators that can be monitored for implementation of the policy. TVA will implement these metrics in an integrated approach to close the gap between the current level and desired improvement in environmental performance.

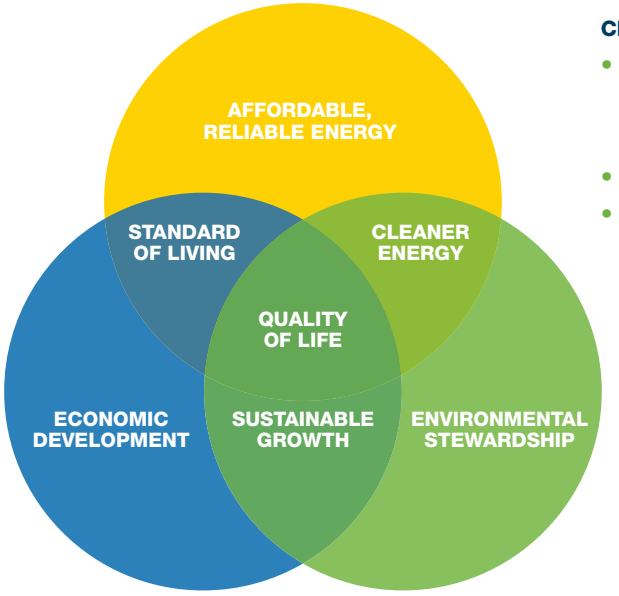
EXHIBIT 3
Aligning TVA's Mission With Environmental Commitments and Performance Measures

The large circles represent the threefold TVA mission, while the intersections of the circles represent a higher quality of life realized through an integrated approach of pursuing cleaner energy, promoting sustainable growth, and providing proactive stewardship.

AFFORDABLE, RELIABLE ENERGY
- Connection Point Interruptions
- Equivalent Availability Generation Assets
- Productivity

STANDARD OF LIVING
- Customer Satisfaction
- TFO/Asset Value
- Quality of Jobs
- Recordable Injury Rate
- Cultural Health Index

CLEANER ENERGY
- Energy Efficiency Targets:
  - Participation in DSM Initiatives
  - MW Reduction
- Renewables Targets
- Emission Rates (CO_2, SO_x, NO_x, Hg)



ECONOMIC DEVELOPMENT
- Economic Development Index
- Jobs Created and Retained
- Environment Footprint of Recruited Industries

ENVIRONMENTAL STEWARDSHIP
- Environmental Performance
- Stream Miles Improvement
- Waste Reduction
- Recreational Use
- Land Meeting Desired Uses

SUSTAINABLE GROWTH
- Average Retail Price of Power

TVA Strategic Plan Metrics

Additional Environmental Metrics

Online Resources

View this policy electronically at **www.tva.com/environment/policy.htm**

View the 2007 TVA strategic plan at **www.tva.gov/stratplan**

View the results of the Reservoir Operations Study at **www.tva.gov/environment/reports/ros_eis/index.htm**

View TVA's Land Management Policy at **www.tva.gov/river/landandshore/land_policy.htm**

View TVA's Shoreline Management Policy at **www.tva.gov/river/landandshore/landuse_shore.htm**

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