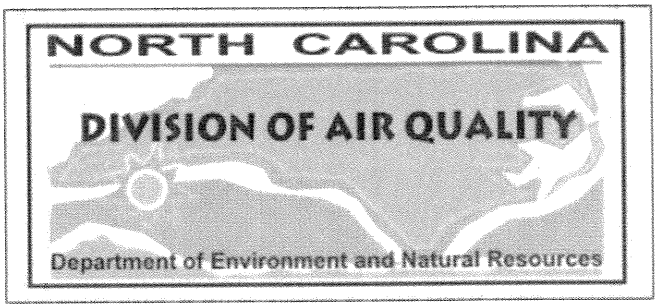
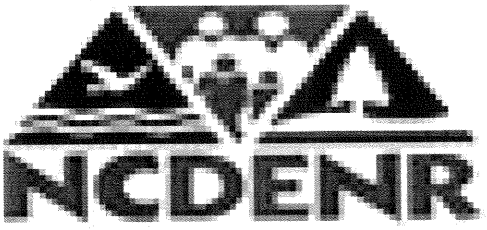


JUNE 19, 2007
EXCEPTIONAL EVENT
DEMONSTRATION PACKAGE

FOR THE

MILLBROOK
(RALEIGH, NORTH CAROLINA)
FINE PARTICLE
FEDERAL REFERENCE METHOD MONITOR
(371830014-88101-1)

December 14, 2007



A Division of the North Carolina Department
of Environment and Natural Resources
Mail Service Center 1641
Raleigh, North Carolina 27699-1641

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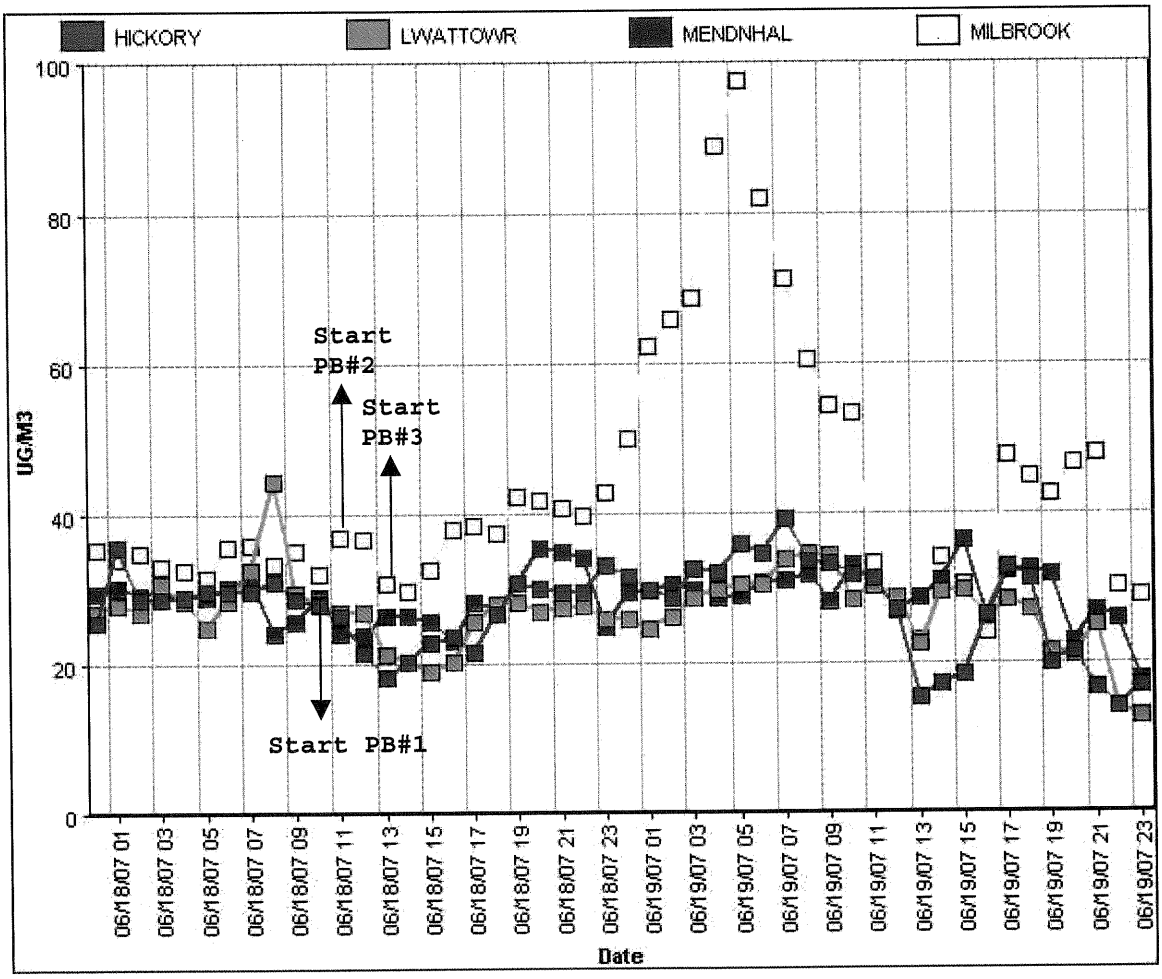
Atypical Analysis

"But For" Test

Millbrook FRM-$PM_{2.5}$
Wake County, NC
Site ID: 371830014 - 88101 - 1
6/19/07
FRM $PM_{2.5}$ Concentration = 43.17 ug/m^3
Recommended Flag Code - Q: Prescribed Fire

DISCUSSION:

Three prescribed fires at the Fort Bragg impacted the Milbrook monitor for several hours on 6/19/07 causing the monitor to exceed the fine particle daily standard of 35 micrograms per meter cubed ($\mu g/m^3$). A memorandum from the North Carolina Division of Forestry provides more information about the prescribed fires, which were needed to protect an endangered species of woodpecker. The Milbrook TEOM-$PM_{2.5}$ trace spiked between 6/18/07 11 pm to 6/19/07 11am (twelve hours). The prescribed burns (PB 1, 2,3) started at 10 AM (400 acres), 11AM (1000 acres), and 1 PM (400 acres) on 6/18/07, and were completed by 2PM, 5PM, and 7PM, respectively. The three prescribed burns were approximately 60 miles southeast of Raleigh. Winds at the Pope Air Force Base meteorological station were predominantly out of the West/Southwest heading towards Raleigh with speeds of 6 to 8 miles per hour. HYSPLIT backward and forward trajectories are provided for graphical evidence of transport. Historical fluctuations of FRM PM2.5 data at the Milbrook monitoring station and a statistically based "but for" analysis is included.



The pre-event and post-event PM 2.5 FRM measurements at Millbrook and two everyday sites that were not impacted by the prescribed burn are included in Table 1. The exceedance value is approximately two to three times higher than the measured maximum values before and following the event and about 50 % larger than the values measured on June 19 at sites to the west of Raleigh (Mendenhall and Hickory).

Table 1. Comparative Data (micrograms per cubic meter)

			Sites not impacted by the prescribed burn	
		Millbrook FRM [a]	**Mendenhall**	**Hickory**
Pre-event 6/13-6/17	5 day average	13.1	17.4 [b]	17.9
	Maximum 24-hour average	22.5	25.8 [b]	25.1
	Minimum 24-hour average	7.1	11.1 [b]	13.3
6/18/07	24-hour average	32.6	28.2	27.2
6/19/07 (Exceedance)	**24-hour average**	**44.1**	**27.7**	**26.2**
Post event 6/20-6/24	5 day average	17.8	15.4	18.6
	Maximum 24-hour average	20.0	19.7	25.0
	Minimum 24-hour average	14.9	11.7	11.5

[a] Average of primary and precision sampler when both values are present on a given day (every day except 6/13, 6/14, and 6/18).
[b] Data for June 15 at Mendenhall are missing.

Table 2. Fine Particle Concentrations in June in the Mooresville Region of North Carolina

Site_ID1	370710016	370350004	370350004	371590021
Site_ID2	305	307	Five	313
Region	MRO	MRO	Day	MRO
Site	GM	HC	Average	UR
06/01/2007		27.70		
06/02/2007	9.62	11.75		7.04
06/03/2007		5.29		
06/04/2007		11.21		
06/05/2007		8.25		9.04
06/06/2007		9.96		
06/07/2007				
06/08/2007	12.97	12.67		15.21
06/09/2007		9.71		
06/10/2007		17.92		
06/11/2007	17.66	25.08		17.92
06/12/2007		22.17		
06/13/2007		13.33	17.90	
06/14/2007	12.97	14.38	Pre-event	14.92
06/15/2007		14.81		
06/16/2007		21.83		
06/17/2007	23.64	25.12		25.83
06/18/2007		27.17		
06/19/2007		26.21		
06/20/2007	11.13	11.46	18.62	13.38
06/21/2007		15.21	Post-event	
06/22/2007		21.46		
06/23/2007	18.12	20.00		17.00
06/24/2007		24.96		
06/25/2007		24.92		
06/26/2007	18.24	17.33		24.13
06/27/2007		26.92		
06/28/2007		20.63		
06/29/2007	13.72	17.58		15.29
06/30/2007		11.83		
Average	15.34	17.82		15.98

Table 3. Fine Particle Concentrations in June in the Winston-Salem Region of North Carolina								
Site_ID1	371890003	370010002	370570002	370810013		370330001	370810013 Average of MH Primary and Precison	370810013 Five Day Average
Site_ID2	411	401	409	413	414	403		
Region	WSRO	WSRO	WSRO	WSRO	WSRO	WSRO		
Site	BN	HD	LX	MH	MH	UC		
06/01/2007				15.87				
06/02/2007	15.90	8.09	7.42	8.12		7.67		
06/03/2007				3.21				
06/04/2007				10.04				
06/05/2007	9.33		9.21	8.92	9.05	8.67		
06/06/2007				9.08				
06/07/2007				21.54				
06/08/2007	9.46	16.85	15.33	17.08		17.29		
06/09/2007				16.17				
06/10/2007				13.25				
06/11/2007	25.33	11.78	16.96	15.46	15.68	13.75		
06/12/2007				15.37				
06/13/2007				13.88			13.88	
06/14/2007	7.71	8.38		11.08		8.79	11.08	
06/15/2007								
06/16/2007				18.83			18.83	Pre-event
06/17/2007	19.41	22.03		25.42	26.09	22.54	25.75	17.39
06/18/2007					28.22		28.22	
06/19/2007				27.71			27.71	
06/20/2007	8.04	13.53	11.21	11.67		12.96	11.67	
06/21/2007			17.21	13.08			13.08	
06/22/2007				18.38			18.38	
06/23/2007	17.11	9.88	14.50	14.12	14.57	10.71	14.35	Post-event
06/24/2007			22.37	19.71			19.71	15.44
06/25/2007				18.25				
06/26/2007	17.24	20.79	24.54	19.88		20.33		
06/27/2007				22.79				
06/28/2007				19.25				
06/29/2007	12.97	19.00	18.29	15.50	16.50	13.58		
06/30/2007				14.21				
Average	14.25	14.48	15.70	15.64	18.35	13.63		

Table 4. Fine Particle Concentrations in June in the Raleigh Region of North Carolina								
Site_ID1	370630001	371350007	371830014	371830014	370650004	370370004	371830014 Average of ML Primary and Precison Monitors	Five Day Average
Site_ID2	503	507	509	510	513	501		
Region	RRO	RRO	RRO	RRO	RRO	RRO		
Site	DH	HR	ML	ML	SR	UP		
06/01/2007	10.25							
06/02/2007	6.75	6.42	3.25		8.33	8.13		
06/03/2007	3.08		5.83					
06/04/2007	9.79		7.82					
06/05/2007	11.50	11.83	13.79	14.04	14.33	10.58		
06/06/2007	10.08		12.17					
06/07/2007	21.79		21.04					
06/08/2007	15.36	13.53	14.87		14.83	14.21		
06/09/2007	16.00		15.67					
06/10/2007	15.92		19.58					
06/11/2007	14.83	15.88	13.71	13.17	8.96	13.21		
06/12/2007	18.17		20.54					
06/13/2007				13.29			13.292	
06/14/2007	9.04	9.33		7.37	6.62	8.92	7.375	
06/15/2007	5.00		7.71	6.58			7.1458	
06/16/2007	18.54		19.04	11.46			15.25	
06/17/2007	23.83	22.75	23.25	21.67	26.96	20.42	22.458	13.104
06/18/2007	30.67		32.58				32.583	
06/19/2007	30.00		43.17	45.04			44.104	
06/20/2007	15.63	12.08	16.83	16.37	19.04	14.17	16.604	
06/21/2007	16.82		18.67	18.13			18.396	
06/22/2007	18.25		20.29	19.79			20.042	
06/23/2007	14.08	14.79	14.67	15.12	13.92	15.17	14.896	
06/24/2007	19.17		20.29	17.33			18.812	17.75
06/25/2007	17.79		19.71	16.44				
06/26/2007	20.96	19.71	23.13	21.33	17.33	17.62		
06/27/2007	17.92		19.38	18.75				
06/28/2007	16.79		15.54					
06/29/2007	16.38	18.04	14.29		11.79	12.71		
06/30/2007	15.96		16.58	16.37				
Average	15.87	14.44	17.53	17.19	14.21	13.51		

NCDFR – Fire Environment

Fire Environment Work Group

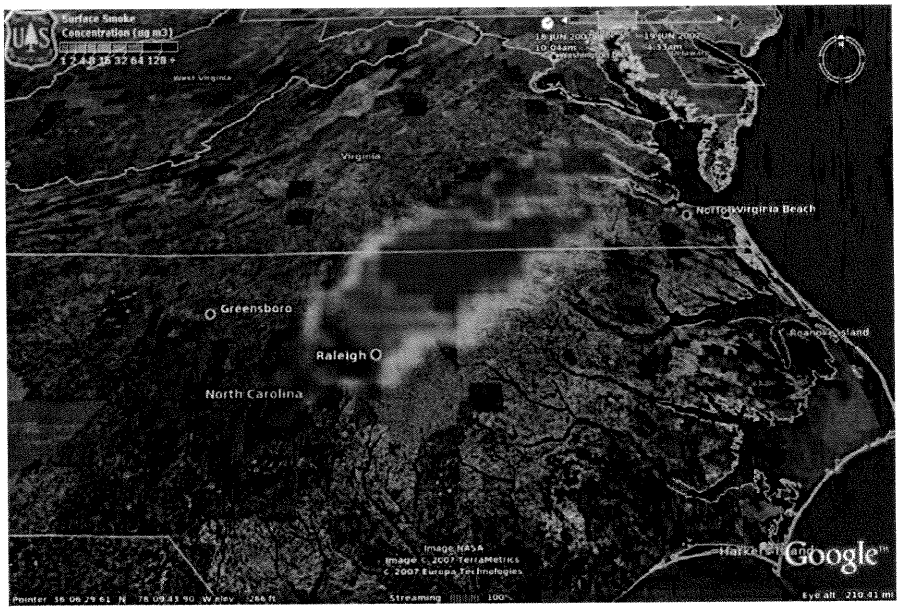
October 18th, 2007

To: J.P. Chauhan

From: Gary M. Curcio, Fire Environment

Subject: Smoke Intrusion at the Wake County Millbrook Monitor

At the request initiated by the NCDFR – Fire Environment Branch, the NCDFR and the US Forest Service High Resolution Modeling Consortium modeled prescribed burns conducted on the Ft Bragg Military Reservation. Several prescribed burns were conducted. The ones of interest were on June 18th, 2007. A multiple agency post burn review was initiated. Key information was ascertained from the DOD Ft Bragg's Natural Resources in order to run the Blue Sky dispersion model. This model was used to determine if the smoke produced by the prescribed burns conceivably caused the Millbrook monitor to reached concentration levels that exceeded the national air ambient standard for PM 2.5. The graphical results of the modeled run are presented below along with the assumptions that were used. Also, I have provided additional information that was requested.



Day modeled – June 18th 2007

Three Prescribed Burns:

- 400 acres starting @ 1000 Hrs / active burning until 1400 Hrs
- 1000 acres starting at 1100 Hrs / active burning until 1900 Hrs
- 400 acres starting @ 1300Hrs / active burning until 1700 Hrs

Fuel loading was a combination of southern rough & pine litter. The consumable fuels averaged 2 tons / acre.

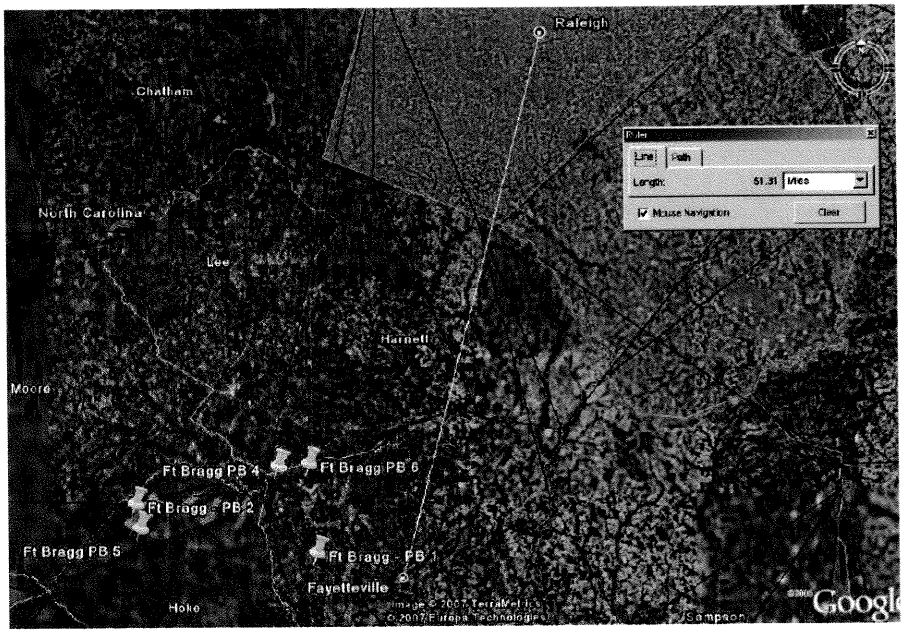
Blue Sky modeled surface PM 2.5 concentrations for the time period starting 1000 hrs on 6/18 and ending 0500 hrs on 6/19. The meteorology for this time placed the smoke dispersion from these prescribed fires passing through the Raleigh area. Peak concentrations were generated by Blue Sky run. These reached around 64 microgram per cubic meter at the Millbrook monitoring site.

Additional Information Requested for the Exceptional Event Rule Documentation

A) Start & Stop Times

Smoke MGMT Unit	132 & 144	128	129
Prescribe Burn #	1	2	3
Acres	412	376	1102
Start Time	1130	930	1245
Complete Time	1930	1945	2030

B) Location & Map of Prescribed Fires



PB 1 burned 6/18/07
Lat 35 04 11.36 N
Long -79 01 24.83W
51.31 miles from Raleigh center & 59.64 from Millbrook

PB 2 burned 6/18/07
Lat 35 08 17.05 N
Long -79 19 13.41W
64.95 miles from Millbrook

PB 3 burned 6/18/07
Lat 35 06 41.13 N
Long -79 19 30.98W
66.41 miles from

C) Prescribed Burns were conducted under the NC SMP

Ft. Bragg is a NCDFR strategic partner who participates in the current NC Smoke Management Program. Ft. Bragg informed the NCDFR of the intent to conduct prescribed burns on June 16th, 18th, and 19th. In the doing so, weather conditions, distance to smoke sensitive areas and the tons of fuel to be emitted were evaluated. A test fire was ignited to determine if Fire Behavior was acceptable. Proving to be acceptable each burn proceeded as planned.

D) Prescribed Fire is used as a management tool for NC's Forests

Use of prescribed fire on Ft. Bragg reduces wildfire hazards, controls plant diseases, improves forage and wildlife habitats, and maintains and restores the longleaf pine natural ecosystem. The surrounding urban communities and wild lands (known as the wild land/urban interface) are especially vulnerable to the effects of catastrophic wildfires and are in most need of protection. Prescribed fire minimizes the potential for catastrophic wildfires and loss. NC wildfires in 2007 have already destroyed homes and structures in NC's forests. This is a continued and growing concern as population density increases.

Prescribed burning is the best tool to reduce hazardous fuels while improving these fire dependent ecosystems. Prescribed burning on FT. Bragg perpetuates the health of the Longleaf Pine Ecosystem. It also assists the endangered species, Red Cockaded Woodpecker. Natural fire is an innate part of the life for many NC plant, reptile, and mammalian species.

E) <u>Effective smoke management actions</u>

When using prescribed fire Ft. Bragg applies appropriate planning steps in order to effectively manage smoke dispersion. These steps include:

1) Informing the NCDFR and nearby areas of the intent to burn;
2) Preparing a prescribed fire plan (PFP) or a smoke management plan for each planned ignition. This identifies "acceptable weather parameters to conduct the burn and to disperse smoke". Fuel, weather, and air quality conditions are reviewed and evaluated before proceeding;
3) Some of the items included in the PFP are:
   > Burner's name and contact information
   > Location and size of the burn
   > Burn method and fuel type
   > Acceptable ignition conditions
   > Expected air emissions & firing techniques to be used to minimize smoke
   > Nearby population centers
   > Consideration and projection of smoke travel
   > Burning Window
   > Duration of the burn
   > Contingency planning for escapes and mop-up actions implemented to minimize the potential for escapes and minimize smoke production
   > Public notification procedures / use of smoke signs / PA systems on vehicles
4) An After Action Review (AAR) is planned with the NCDFR and DOD NR. This event will be reviewed in order to discuss and explore ways to improve smoke management.

I hope this information meets the required documentation for the Exceptional Event Rule. If there are any further questions or additional information needed, please feel free to contact me. The best way to reach me is by cell phone. My number is 919-810-5623.

Station details

Station: KPOB - Pope AFB **Date of first observation:** March 20, 2001
Station type: AWOS - III
City, State: Pope AFB, NC **County:** Cumberland County
Latitude: 35.1708333° **Longitude:** -79.0145°
Elevation: 217 feet above sea level
Climate division: NC06 - Southern Coastal Plain
River basin: Cape Fear
Supported by: FAA / Local Aviation

This page is created dynamically and should not be bookmarked. Instead, bookmark the page preceeding this.

Retrieving hourly data from Pope AFB for 2007-06-18 *thru* 2007-06-19 (2 days)

47 observations for this period of record (97.9% data available; 1 missing records)

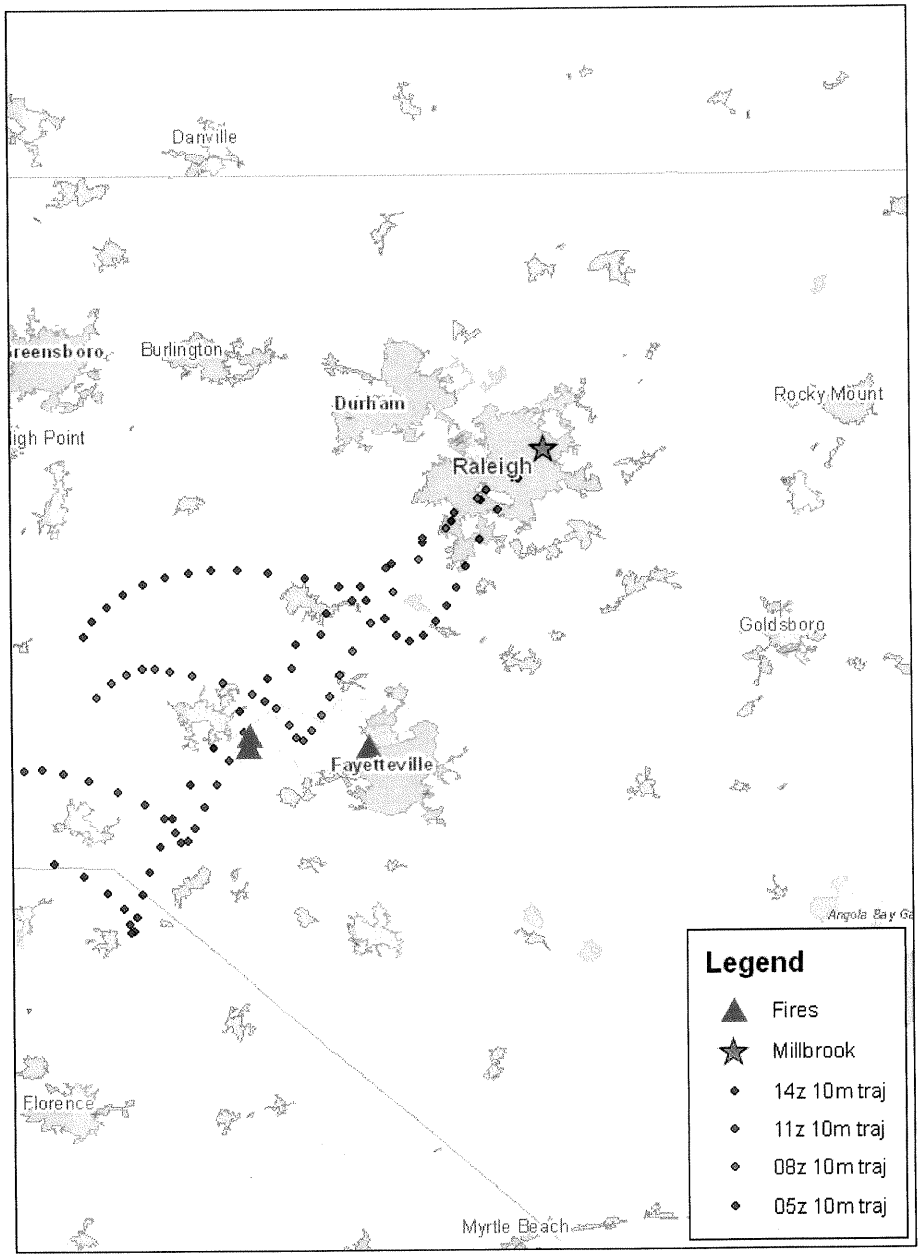
Date/Time of ob (Eastern Standard Time)	Wind Speed at 10m (mph)	Wind Direction at 10m	Wind Gusts at 10m (mph)
06/18/2007 00:55 H	0	Calm or Variable	*
06/18/2007 01:55 H	0	Calm or Variable	*
06/18/2007 02:55 H	0	Calm or Variable	*
06/18/2007 03:55 H	0	Calm or Variable	*
06/18/2007 04:55 H	0	Calm or Variable	*
06/18/2007 05:55 H	2.3	West (260°)	*
06/18/2007 06:55 H	0	Calm or Variable	*
06/18/2007 07:55 H	4.6	West Southwest (250°)	*
06/18/2007 08:55 H	4.6	West (280°)	*
06/18/2007 09:55 H	6.9	West Northwest (290°)	*
06/18/2007 10:55 H	5.8	Northwest (320°)	*
06/18/2007 11:55 H	3.5	Calm or Variable*	*
06/18/2007 12:55 H	0	Calm or Variable	*
06/18/2007 13:55 H	6.9	West Northwest (300°)	*
06/18/2007 14:55 H	6.9	South (190°)	*
06/18/2007 15:55 H	3.5	East Southeast (120°)	*
06/18/2007 16:55 H	5.8	South Southwest (210°)	*
06/18/2007 17:55 H	5.8	South Southwest (200°)	*
06/18/2007 18:55 H	8.1	South Southwest (200°)	*
06/18/2007 19:55 H	6.9	Southwest (220°)	*
06/18/2007 20:55 H	5.8	South Southwest (210°)	*
06/18/2007 21:55 H	8.1	Southwest (230°)	*
06/18/2007 22:55 H	6.9	Southwest (220°)	*

06/18/2007 23:55 H	8.1	Southwest (220°)	*
06/19/2007 00:55 H	6.9	West Southwest (240°)	*
06/19/2007 01:55 H	5.8	West Southwest (250°)	*
06/19/2007 02:55 H	5.8	West Southwest (250°)	*
06/19/2007 03:55 H	5.8	West Southwest (240°)	*
06/19/2007 04:55 H	4.6	West Southwest (250°)	*
06/19/2007 05:55 H	5.8	West Southwest (240°)	*
06/19/2007 06:55 H	8.1	West Southwest (240°)	*
06/19/2007 07:55 H	6.9	West Southwest (250°)	*
06/19/2007 08:55 H	3.5	West Southwest (240°)	*
06/19/2007 09:55 H	0	Calm or Variable	*
06/19/2007 10:55 H	6.9	South Southwest (210°)	*
06/19/2007 11:55 H	3.5	Calm or Variable	*
06/19/2007 12:55 H	8.1	Southwest (230°)	*
06/19/2007 13:55 H	8.1	South (170°)	*
06/19/2007 14:55 H	6.9	West (280°)	*
06/19/2007 15:55 H	3.5	West (280°)	*
06/19/2007 16:55 H	12.7	South Southwest (210°)	*
06/19/2007 17:55 H	11.5	South Southwest (210°)	*
06/19/2007 18:55 H	9.2	South Southwest (210°)	*
06/19/2007 19:55 H	10.4	South Southwest (210°)	18.4
06/19/2007 20:55 missing			
06/19/2007 21:55 H	0	Calm or Variable	*
06/19/2007 22:55 H	6.9	Southwest (220°)	*
06/19/2007 23:55 H	4.6	West (280°)	*
Sum	246		18.4
Average $1/n \sum a_i$	6.5		18.4
Mean *(max+min)/2*	7.5		18.4
High	12.7		18.4
Low	2.3		18.4

Quality Control flags that may appear above

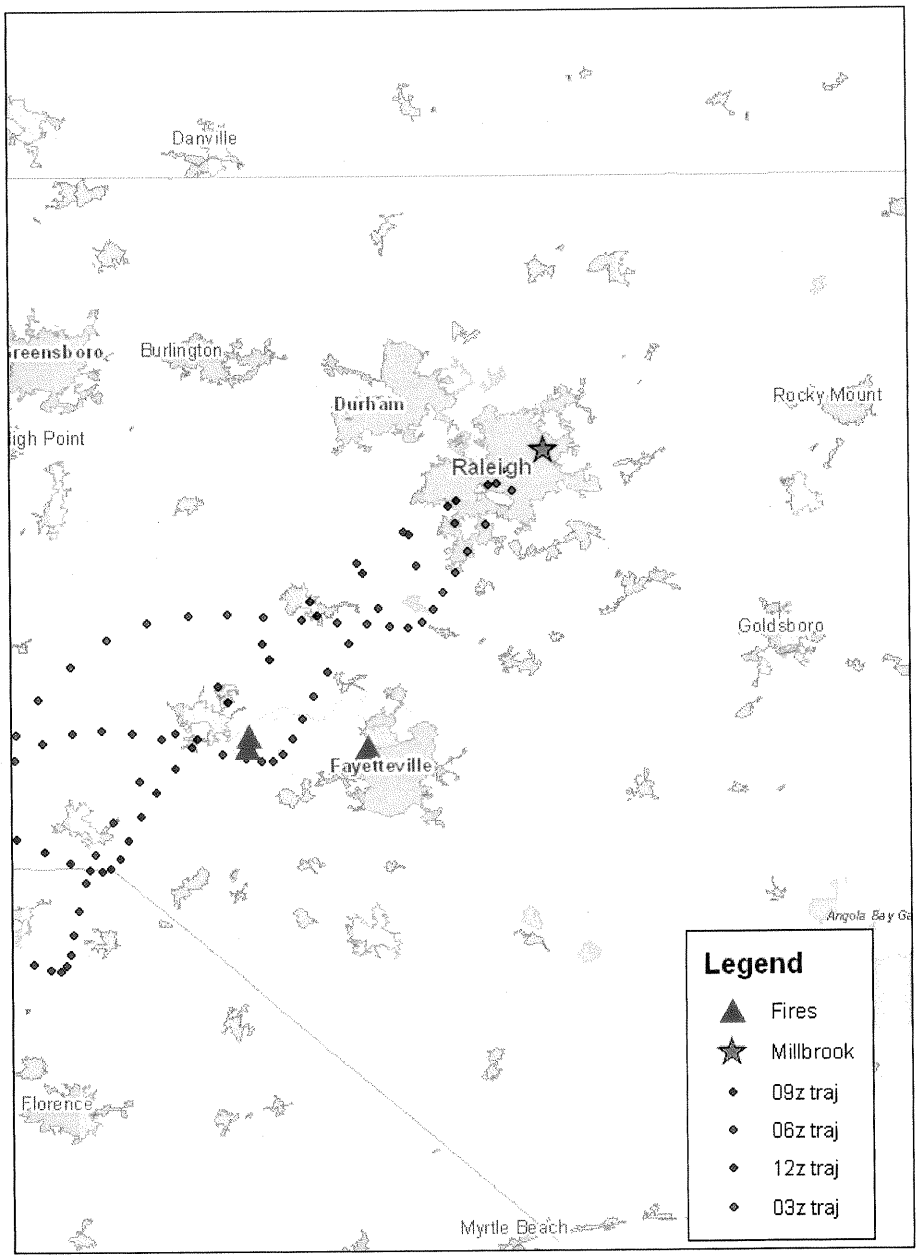
*	47	Not yet quality checked
U	0	Updated manually by a human
T	0	Updated by algorithm
R	0	Possible range failure
B	0	Possible buddy check failure
N	0	Data point differs from NCDC data set
E	0	Extracted/Augmented from NCDC Surface Airways Data
A	0	Augmented from old AgNet files

HYSPLIT Back Trajectories at Milbrook at various times at 10m on 06/19/07
Legend indicates time(zulu) / trajectory level. HYSPLIT trajectories use Zulu Time or Coordinated Universal Time (UTC) as their time reference. The trajectory images that appear below are stamped in Zulu time. [To make the conversion to Eastern Daylight time(EDT)(Mar to Nov 2007) use this formula: Zulu – 4, e.g. 10am (EDT) = 14z – 4]

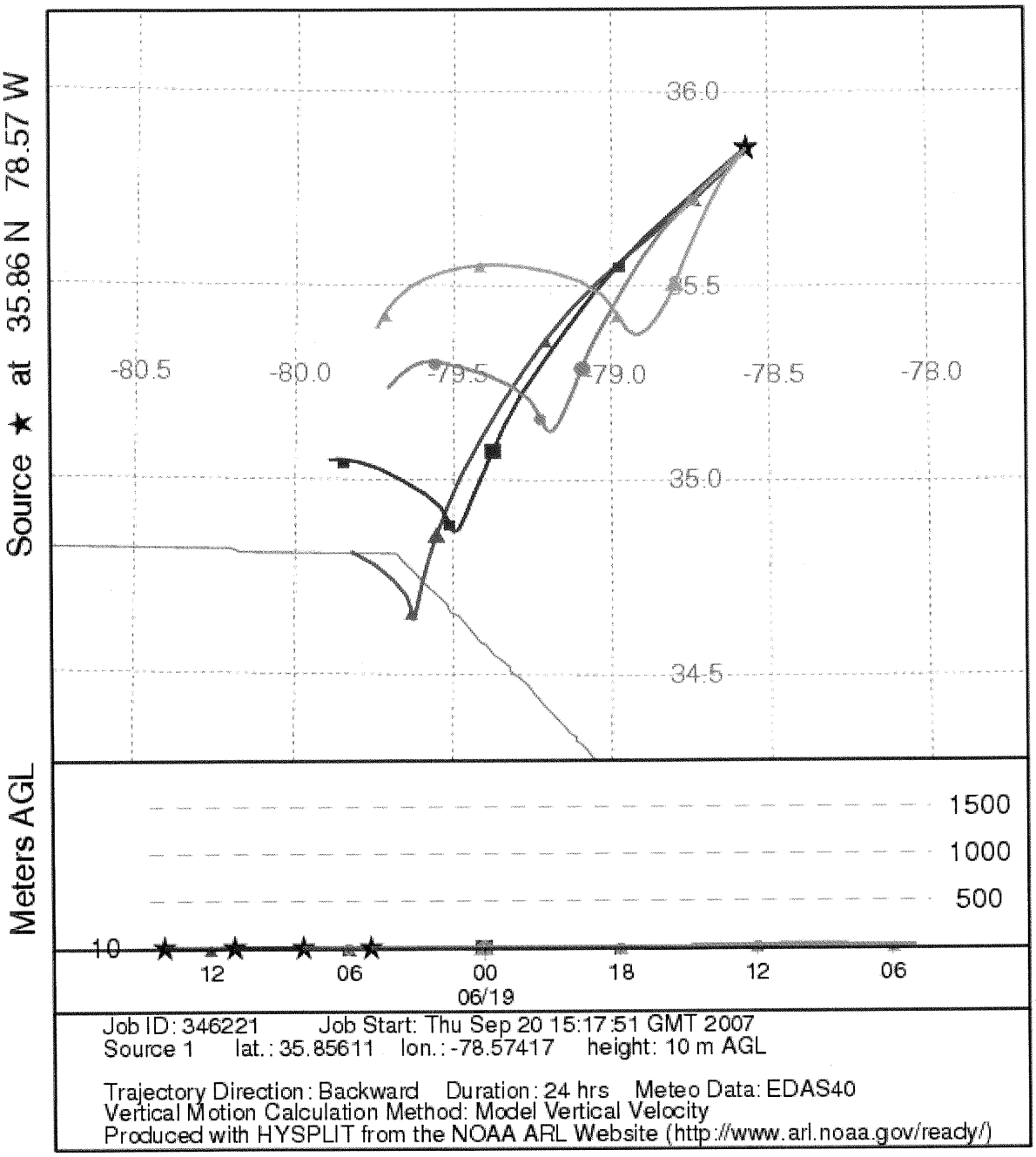


HYSPLIT Back Trajectories at Milbrook at various times at 50m on 06/19/07

Legend indicates time(zulu). HYSPLIT trajectories use Zulu Time or Coordinated Universal Time (UTC) as their time reference. The trajectory images that appear below are stamped in Zulu time. [To make the conversion to Eastern Daylight time(EDT)(Mar to Nov 2007) use this formula: Zulu – 4, e.g. 8am (EDT) = 12z – 4]



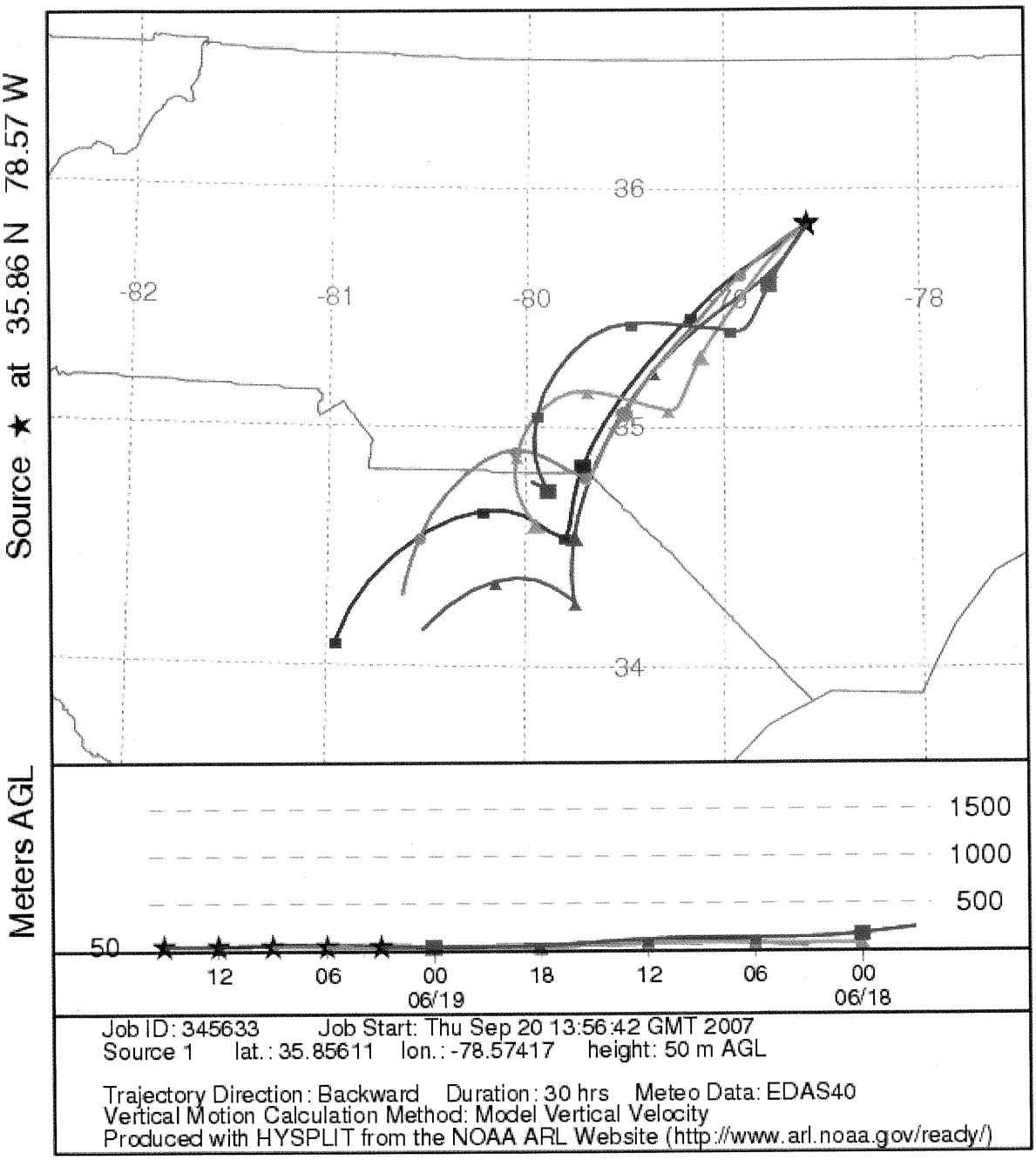
NOAA HYSPLIT MODEL
Backward trajectories ending at 14 UTC 19 Jun 07
EDAS Meteorological Data



Job ID: 346221 Job Start: Thu Sep 20 15:17:51 GMT 2007
Source 1 lat.: 35.85611 lon.: -78.57417 height: 10 m AGL

Trajectory Direction: Backward Duration: 24 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Backward trajectories ending at 15 UTC 19 Jun 07
EDAS Meteorological Data



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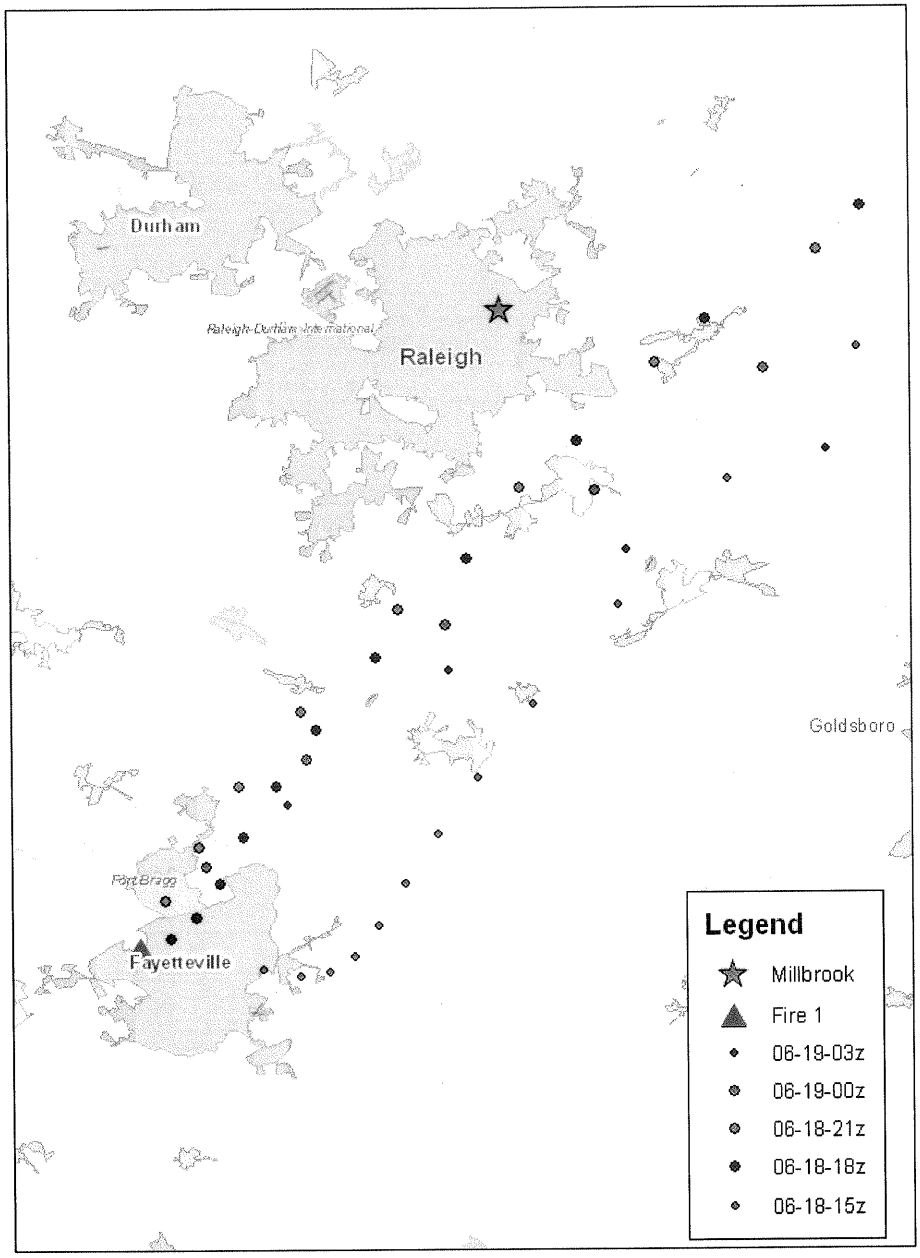
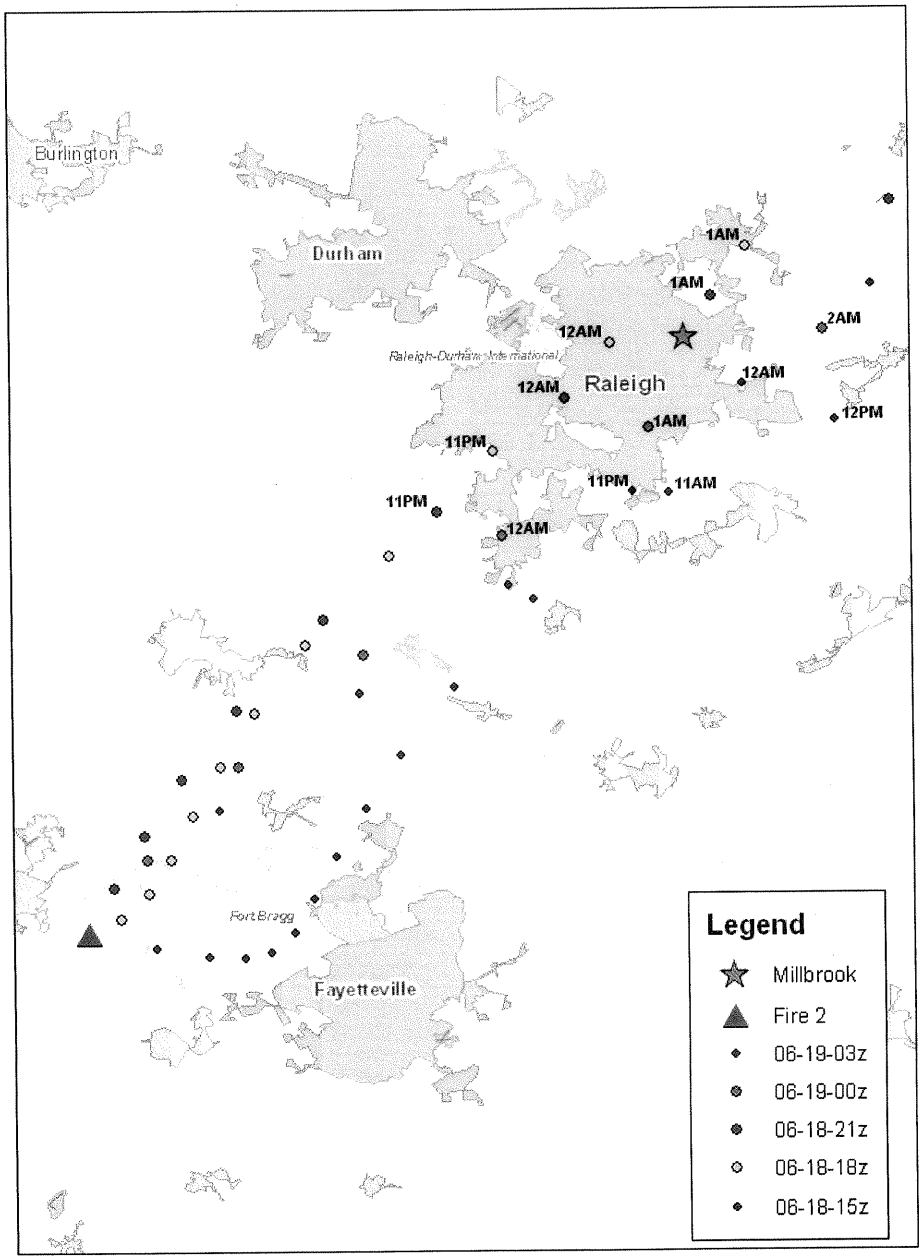
Trajectory Direction: Backward Duration: 30 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

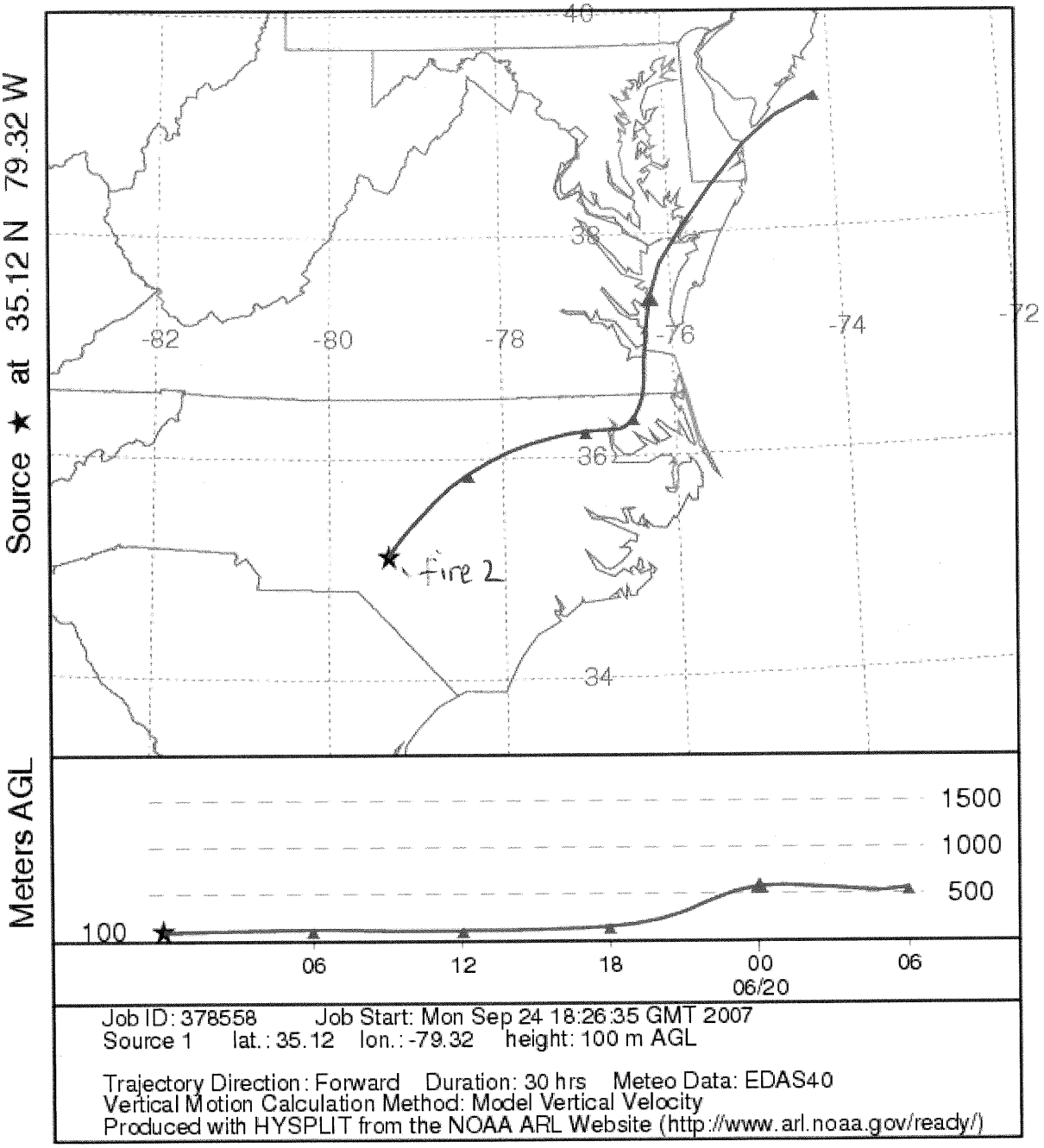
HYSPLIT forward trajectories at Milbrook at various times at 100m on 06/19/07
Legend indicates Fire 1 and time(zulu). HYSPLIT trajectories use Zulu Time or Coordinated Universal Time (UTC) as their time reference. The trajectory images that appear below are stamped in Zulu time. [To make the conversion to Eastern Daylight time(EDT)(Mar to Nov 2007) use this formula: Zulu – 4, e.g. 8am (EDT) = 12z – 4]



HYSPLIT forward trajectories at Milbrook at various times at 100m on 06/19/07
Legend indicates Fire 2 and time(zulu) / trajectory level. HYSPLIT trajectories use Zulu Time or Coordinated Universal Time (UTC) as their time reference. The trajectory images that appear below are stamped in Zulu time. [To make the conversion to Eastern Daylight time(EDT)(Mar to Nov 2007) use this formula: Zulu – 4, e.g. 10am (EDT) = 14z – 4]



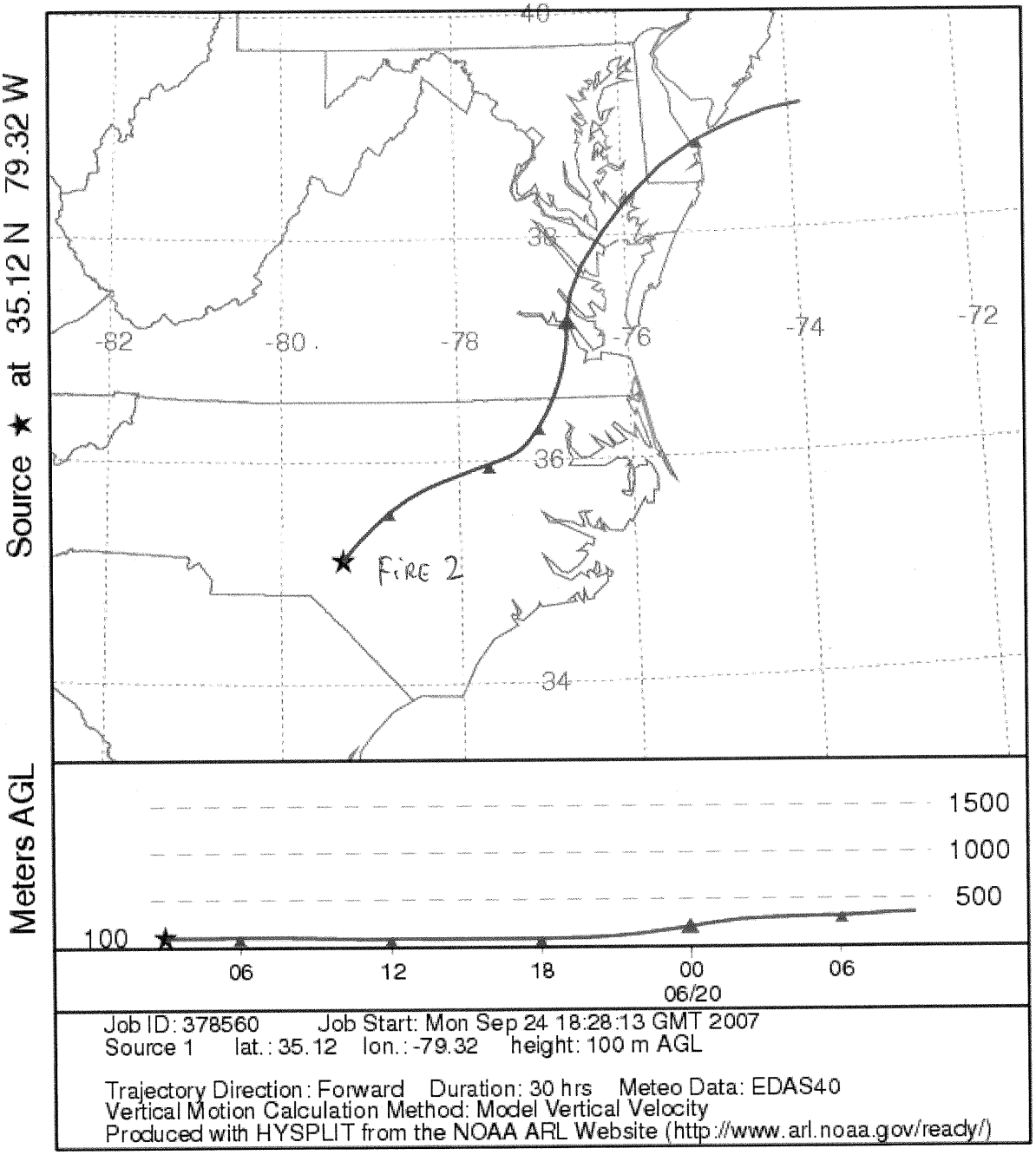
NOAA HYSPLIT MODEL
Forward trajectory starting at 00 UTC 19 Jun 07
EDAS Meteorological Data



Job ID: 378558 Job Start: Mon Sep 24 18:26:35 GMT 2007
Source 1 lat.: 35.12 lon.: -79.32 height: 100 m AGL

Trajectory Direction: Forward Duration: 30 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

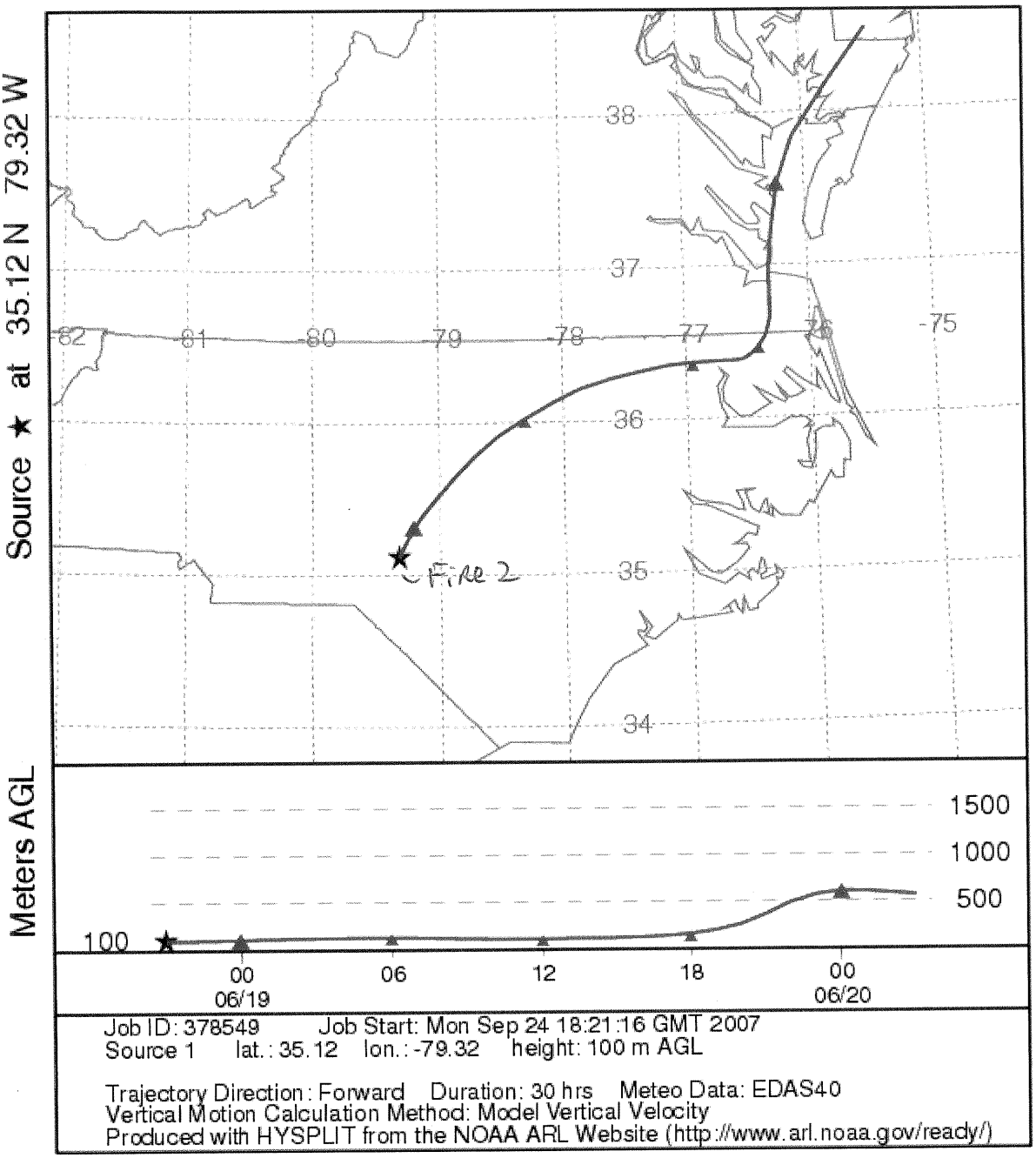
NOAA HYSPLIT MODEL
Forward trajectory starting at 03 UTC 19 Jun 07
EDAS Meteorological Data



Job ID: 378560 Job Start: Mon Sep 24 18:28:13 GMT 2007
Source 1 lat.: 35.12 lon.: -79.32 height: 100 m AGL

Trajectory Direction: Forward Duration: 30 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

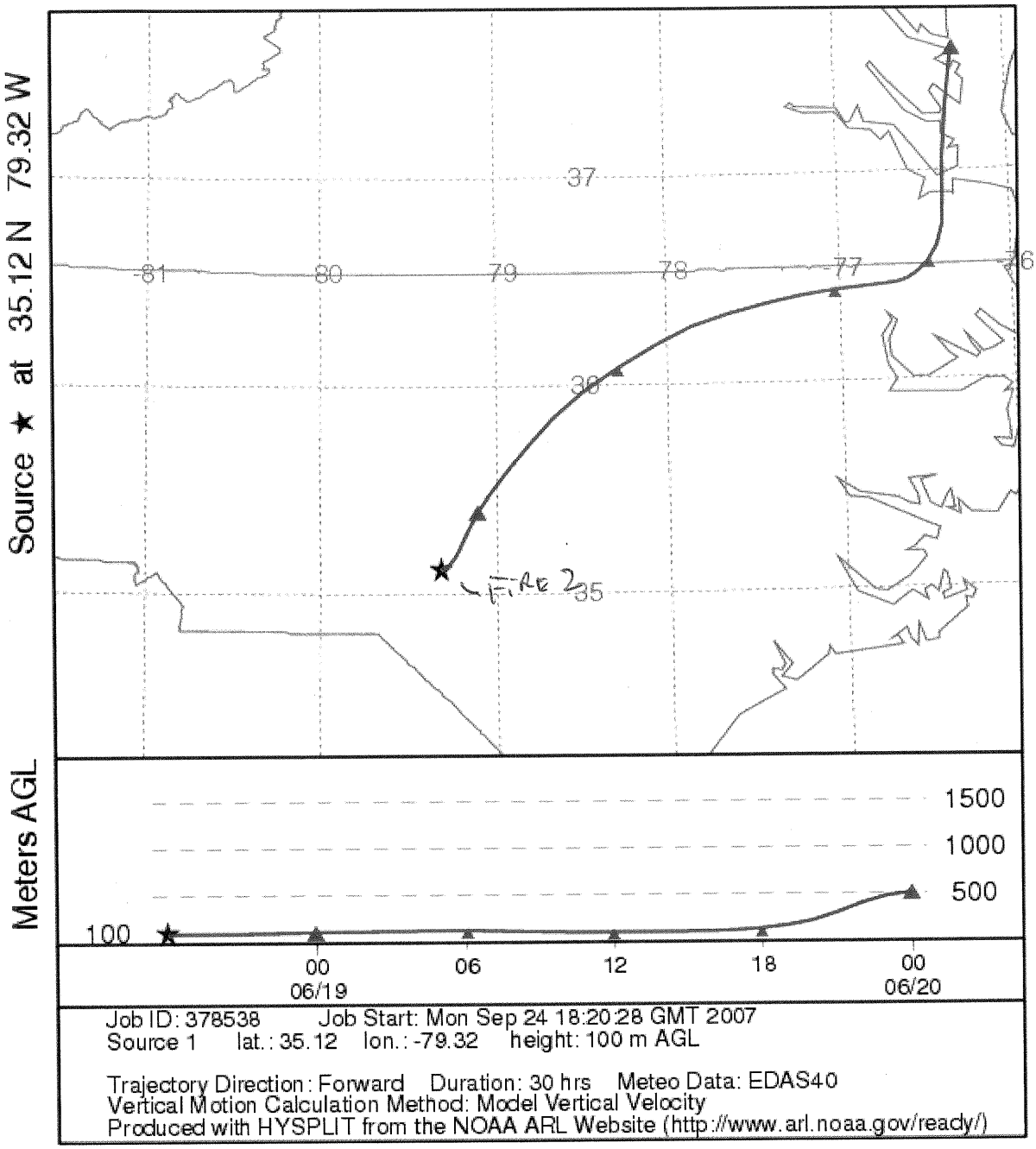
NOAA HYSPLIT MODEL
Forward trajectory starting at 21 UTC 18 Jun 07
EDAS Meteorological Data



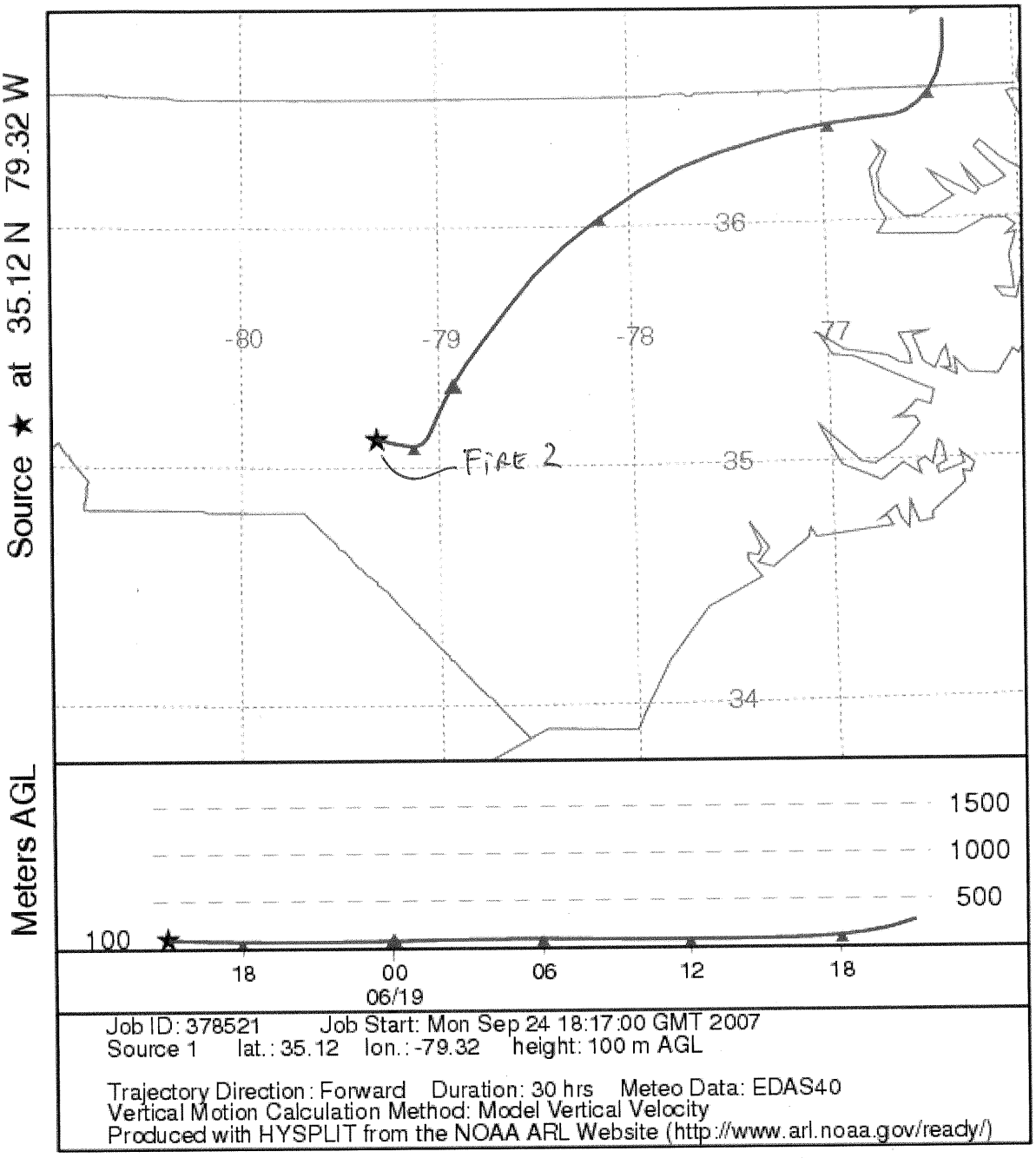
Job ID: 378549 Job Start: Mon Sep 24 18:21:16 GMT 2007
Source 1 lat.: 35.12 lon.: -79.32 height: 100 m AGL

Trajectory Direction: Forward Duration: 30 hrs Meteo Data: EDAS40
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Forward trajectory starting at 18 UTC 18 Jun 07
EDAS Meteorological Data



NOAA HYSPLIT MODEL
Forward trajectory starting at 15 UTC 18 Jun 07
EDAS Meteorological Data



"Atypical" Analysis for Milbrook 19 June 2007 Exceedance

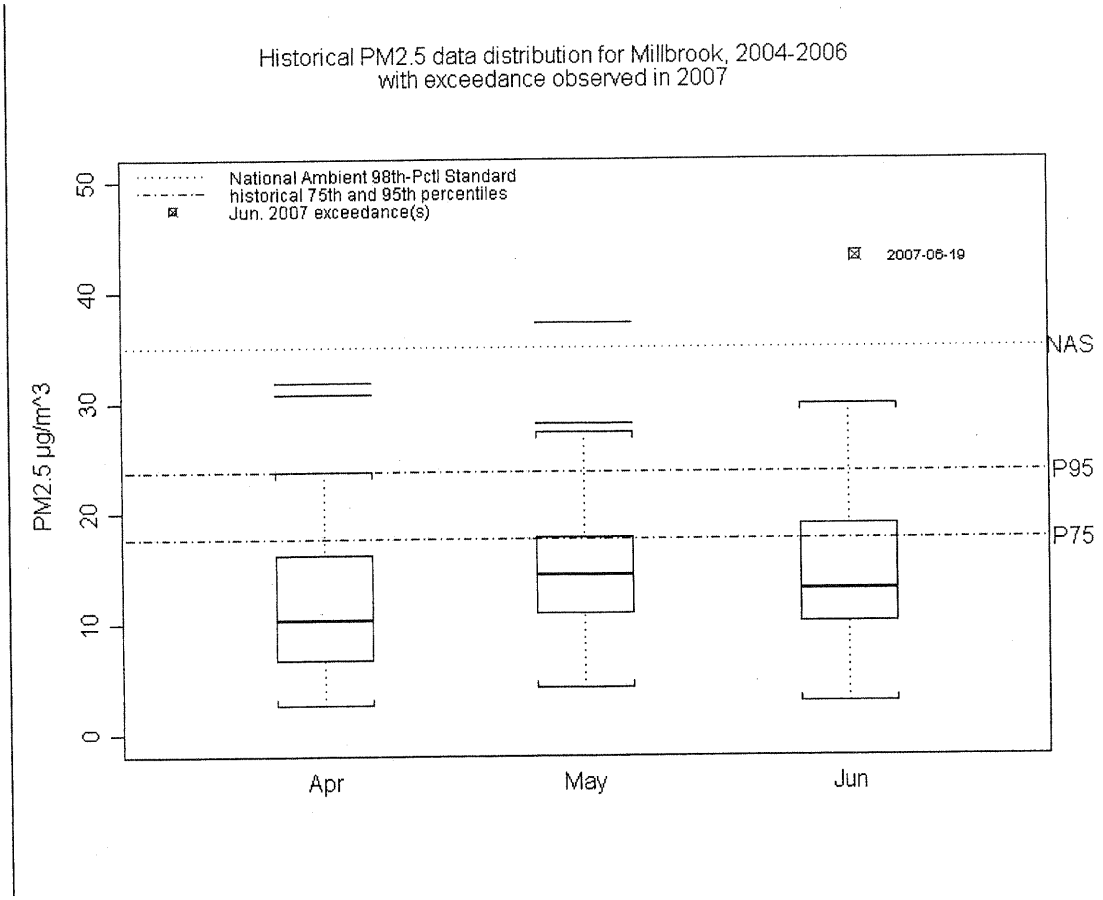


Figure 3.1 - shows "normal historical fluctuations" of PM2.5 data for the Millbrook monitoring station during the third calendar quarter in the form of boxplots for the individual *monthly* distributions with reference lines showing the historical levels of the 75th and 95th percentile levels as well as the level of the National Ambient 98th-percentile Standard (17.6 µg/m^3, 23.76 µg/m^3, and 35.0 µg/m^3, respectively).

EPA has discussed the possible use of the historical 75th and 95th percentiles as objective thresholds for favorable concurrence decisions [CFR citation needed here]. The historical 95th percentile level for this event is 23.8 µg/m^3. The 19 June 2007 exceedance exceeds the historical 95th percentile level by 82 percent.

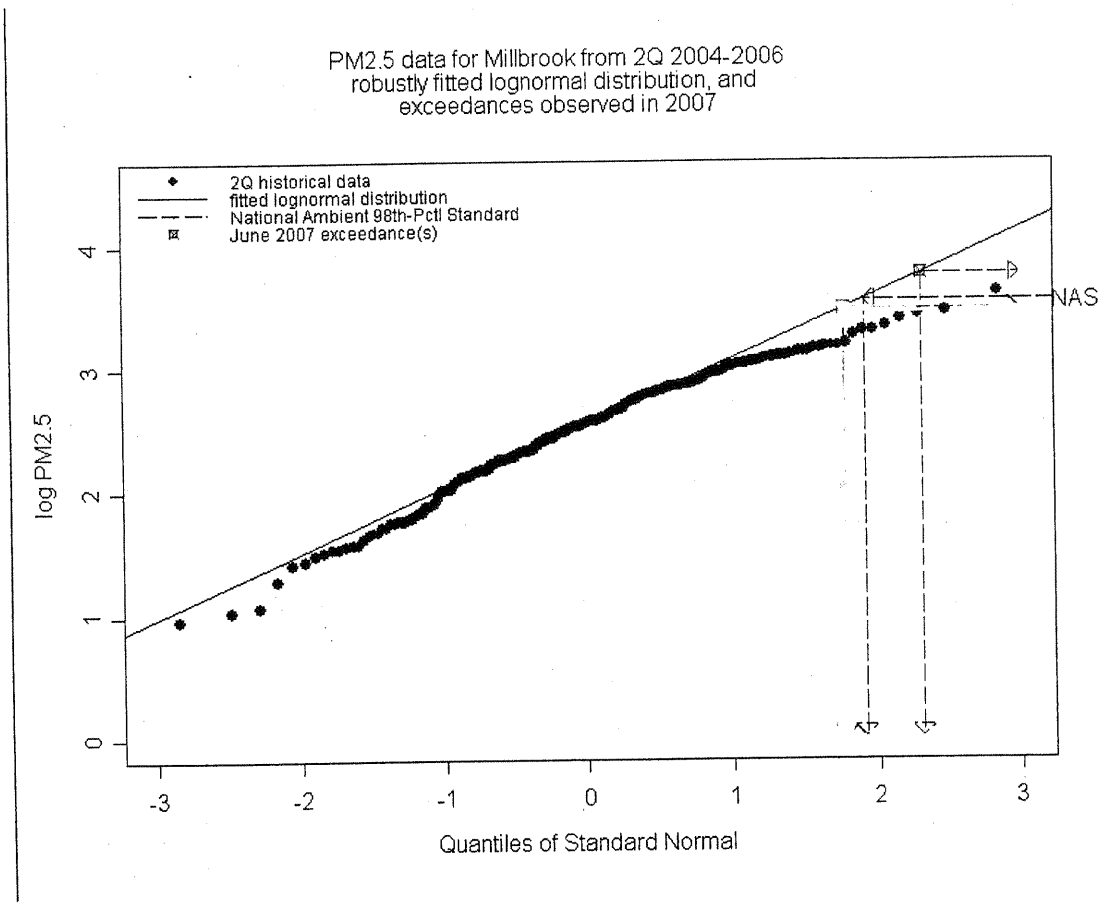


Figure 3.2 - shows "normal historical fluctuations" of PM2.5 data for the Millbrook monitoring station during the third calendar quarter in the form of a lognormal distribution quantile plot.

Particulate pollution data are often well approximated by lognormal distributions. This graph shows the natural logarithms of the historical data (in log-$\mu g/m^3$ units) sorted from smallest concentration to largest concentration, plotted against the corresponding quantiles of a standard normal distribution. An *exact* lognormal distribution closely matching these data is shown as a diagonal straight line in the graph. The level of the National Ambient 98th-percentile Standard (x=3.56), the 19 June 2007 exceedances (x=[3.77]) are shown as a point on the lognormal distribution line, illustrating that expected probability of exceeding the level of the National Ambient 98th-percentile Standard in the absence of exceptional events is about 2.8 percent (1.91 standard deviations greater than the lognormal mean value), and the expected probability of "unexceptional data" exceeding the level observed on 19 June 2007 is 1.0 percent (more than 2.31 standard deviations greater than the lognormal mean value). The estimated parameters of the lognormal approximation are:

- median PM2.5 = 12.89
- mean PM2.5 = 14.78
- 98th pctl PM2.5 = 37.78

"But For" Test: There would have been no exceedance or violation "but for" the event at Milbrook on 6/19/07.

Executive summary

To demonstrate that the prescribed fires at Fort Bragg, NC caused an exceedance of the daily fine particle standard of 35 micrograms per cubic meter at the Milbrook monitor on June 19, 2007, we need to find a way to either estimate (1) what the fine particle concentration value would have been on June 19, 2007, if the prescribed fires had not been present or (2) how many fine particles the prescribed fires contributed to the fine particle concentration measured at the Milbrook monitor on June 19, 2007. Either approach should be sufficient to demonstrate that the prescribed fires caused this exceedance. There are several possible ways to approach either question. For the impact of these prescribed fires at Milbrook on June 19, 2007, we opted to develop a model using meteorological measurements to estimate what the fine particle concentration value would have been on June 19, 2007 at Milbrook if the prescribed fires had not occurred. A more detailed description of the model is provided below.

The model developed explains less than half of the observed variation in the fine particle concentrations in the dataset. As a result there is a large amount of uncertainty in the estimation of the fine particle concentration at Milbrook on June 19, 2007. However, we can use the value calculated by the model and the uncertainty calculated by the model for that value to calculate the maximum value that we would expect to see at Milbrook on June 19, 2007, with a certain probability. If we calculate the maximum expected value using a 99 percent probability and it is less than 35 micrograms per cubic meter, then there is at most a 1 percent probability that a value above the standard would have occurred at Milbrook on June 19, 2007, if there had not been prescribed fires in the area.

Using the developed model and calculating the maximum expected value using a 99 percent probability indicates that there is a 1 percent probability that a value exceeding 28.26 micrograms per cubic meter would have occurred at Milbrook on June 19, 2007. Thus, without the prescribed fires, there is less than 1 percent probability that the National Ambient Air Quality Standard would have been exceeded on that day. As a result, we believe that the value of 43.2 micrograms per cubic meter, which exceeded the daily fine particle standard, would not have occurred at Milbrook if there had not been prescribed fires at Fort Bragg, NC around the day of June 19, 2007.

-Data description-

For each day in the 2nd quarter of 2004, 2005, 2006 and 2007 on which there was a valid PM2.5 concentration I acquired the following met data to model the PM2.5 concentrations:

AT daily mean ambient temperature at the PM2.5 monitoring station
RH daily mean relative humidity at the PM2.5 monitoring station
PR daily total precipitation at the collocated met tower

PR.lag1 previous-day daily total precipitation at the collocated met tower

WS24 daily arith mean wind speed at KRDU, the NWS automated met station at Raleigh-Durham Airport, NC.
VWD24 daily vector average wind direction at KRDU
WG24 daily mean wind gust speeds at KRDU
RN24 daily total precipitation at KRDU
RN24.lag1 previous-day daily total precipitation at KRDU

-Linear Models-

I ended up omitting from the model RN24, RN24.lag1 and WG24 because they had missing values on the exceedance days, which prevents any model that uses them from making a prediction.

-Method of analysis-

-1- Define a covariate for the exceptional event, setting its value at +1 on the the day of the event and 0 on all other dates. PM.e1 is the covariate for 06/19/2007 (actual concentration 43.2).

-2- Define the response variable PM2.5 as follows:

Response Variable "PM2.5"

= actual PM2.5 concentration, if there is not an exceedance
= 0.0 if there is an exceedance

-3- Fit linear model as defined in the model below. The coefficients associated with PM.e1 provide estimates of the expected concentrations that would have occurred if there had not been an exceptional event. (The coefficient value is to be subtracted from the surrogate 0.0 value, so it is actually the *negative* of the estimated concentration.)

-4- Results

Call: aov(formula = PM2.5 ~ AT + RH + PR + PR.lag1 + WS24 + VWD24 + PM.e1, data = MLtest004.df, na.action = na.exclude)

```
Residuals:
    Min      1Q  Median      3Q     Max
 -16.72  -3.051 -0.3912   2.793   16.17

Coefficients:
              Value Std. Error  t value Pr(>|t|)
(Intercept) -73.8914   48.4760  -1.5243   0.1287
         AT   0.5160    0.0570   9.0605   0.0000
         RH   0.1035    0.0641   1.6159   0.1074
         PR   0.0016    0.0498   0.0322   0.9743
```

```
    PR.lag1  -0.0706    0.0496    -1.4240    0.1557
       WS24  -0.4449    0.1009    -4.4111    0.0000
      VWD24   0.0057    0.0033     1.7506    0.0812
      PM.e1 -17.2352    4.7375    -3.6380    0.0003

Residual standard error: 4.703 on 256 degrees of freedom
Multiple R-Squared: 0.392
F-statistic: 20.63 on 8 and 256 degrees of freedom, the p-value is 0
21 observations deleted due to missing values
```

-5- Discussion

The linear model explains less than half of the observed variation in PM2.5 concentrations in the dataset, and there is accordingly a large amount of uncertainty in the estimation of the two concentrations that were affected by exceptional events.

Let's report the estimates in the context of normal approximations. The expected values are as shown in the Coefficients tables, and 2.325× Std. Error defines a 99-percent upper bound under the observed uncertainty.

This means that "but for the exceptional event" we have concentrations as shown in Table 5. The column labeled "expectation" is the model's estimate of what concentration would have most likely been observed were the exceptional event not present. The column labeled "UPLimit.99" takes the standard error into account and shows a threshold that there is less than 1 percent probability of exceeding. On 19 June 2007, the expected concentration was slightly more than 17 $\mu g/m^3$, and the 99-percent upper probability limit was slightly less than 30 $\mu g/m^3$.

Table 5. Millbrook Exceptional Event Concentrations on 19 June 2007.

	actual	expectation	UPLimit.99
PM.e1	43.2	17.24	28.26