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November 9, 2012

To: Reed Sato, Chief Counsel
Department of Toxic Substance Control

From: Thomas A. Cahill, Professor of Physics and Atmospheric Sciences and Head
DELTA Group Thomas A. Cahill

Re: Yorke Engineering analyses

The letter by Robert P. Hoffman along with the comments presented by Yorke Engineering in response to the UC Davis DELTA Group Report entitled "Deposition of Coarse Toxic Particles in Wilmington, CA" (Report) regarding the Terminal Island shredder, are without scientific substance.

Based upon the Report, changes were made to SA Recycling's air pollution control equipment. When the emissions were studied for the second time in spring, 2009, using the same sampling protocols, primary sampling site, and a secondary sampling site located deeper into the community, it was found that lead, zinc, and the very fine iron tracer were sharply reduced. The reduction in these measurements not only shows the effectiveness of the new air pollution control equipment, but also confirms that SA Recycling was the source of the high summer, 2008 measurements collected by the UC Davis DRUM Sampler.

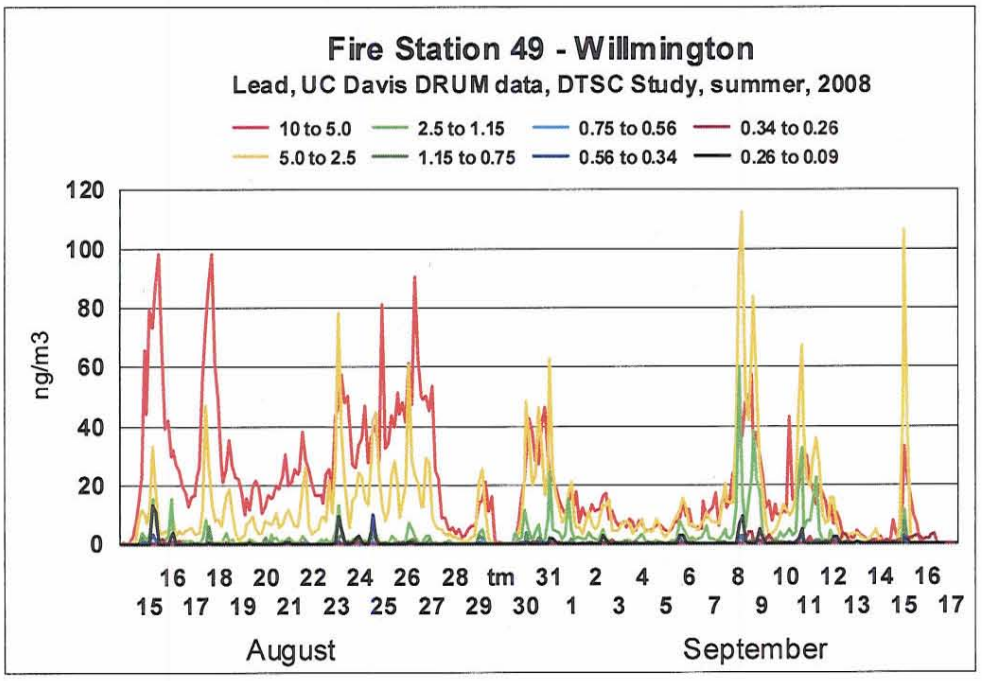
I would like to address some comments made by Hoffman in his letter dated May 18, 2009 to the Department. In his letter, Hoffman stated that the"....needless alarm and angst it (the Report) will cause to anyone in the community who reads it" is untrue when in fact, it was community complaints regarding the dust that initiated the investigation. It should be made clear that any "angst" might only be associated from the knowledge that the dust was contaminated with lead. Additionally, there was continual confusion regarding ambient air standards. Our data was not directed at ambient air standards, only to the deposition of toxic waste onto the ground and other surfaces. We never implied hazardous waste levels in the air - that is the task of the South Coast Air Quality Management District (AQMD), the California Air Resources Board (CA ARB), and the United States Environmental Protection Agency (US EPA).

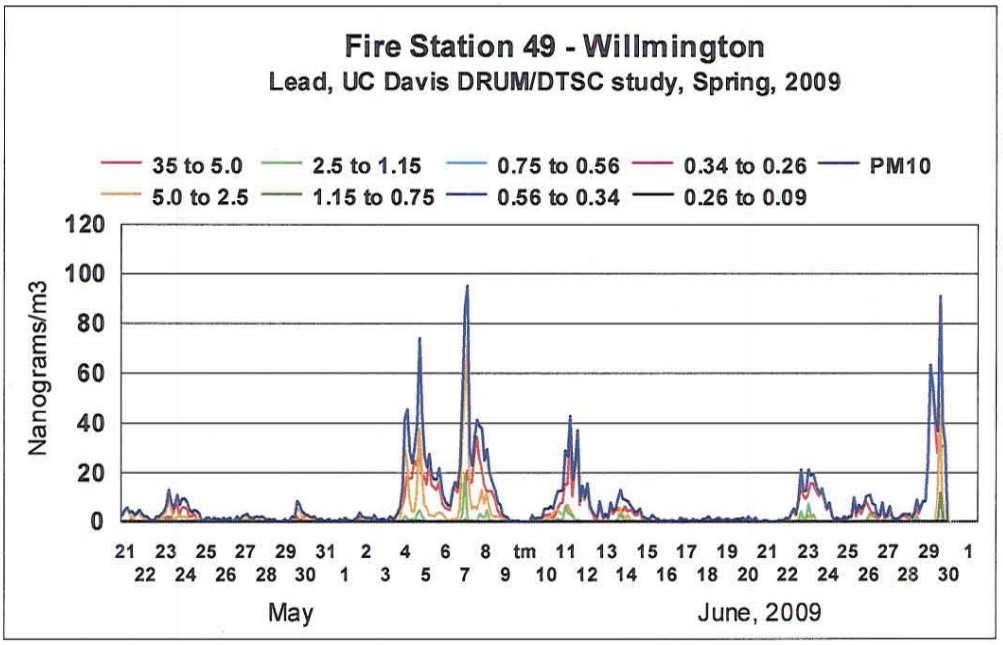
I would also like to note that as a part of the settlement with the Los Angeles County District Attorney's Office, SA Recycling reimbursed the UC Davis DELTA Group financially for its

work. If there had been substantive problems with the Report, the time to address them should have been in the formal legal settlement.

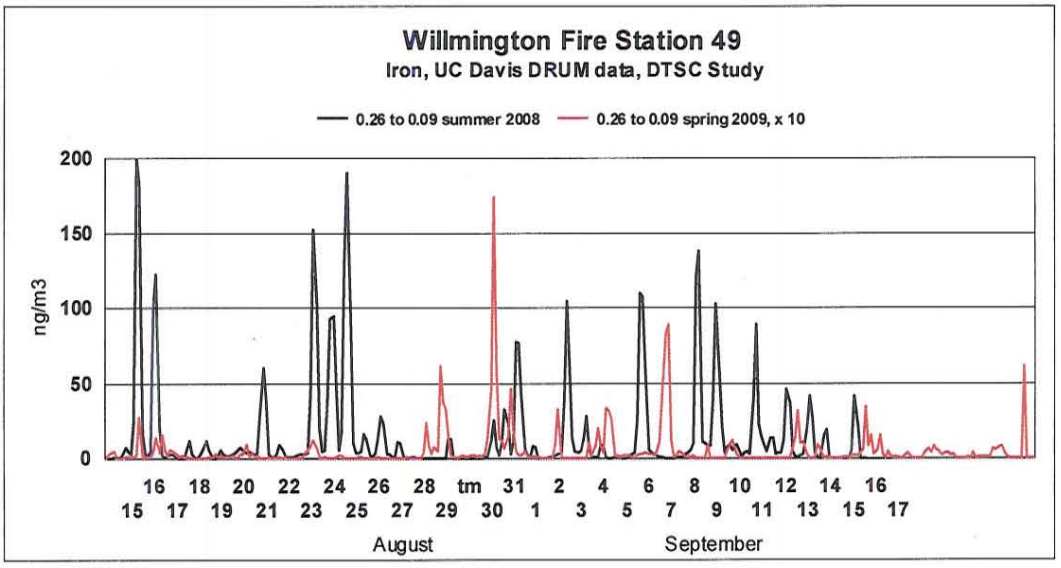
The Yorke Engineering criticisms of the Report reflect reliance on out dated diagnostic methods and are unsupportable scientifically. I would like to summarize the lack of knowledge by Yorke Engineering of current aerosol research, which forms the basis of the disagreements. The heart of the matter is that UC Davis capabilities, honed and developed in the past decades (including current US EPA and National Science Foundation funding), allows a direct scientific connection between atmospheric particles and deposited toxic materials. In their analyses, Yorke Engineering relies on ineffective and antiquated concepts of aerosol source receptor relationships, that do not appreciate the enormous power of size/time/compositionally resolved aerosol sampling which, working with detailed meteorology, can unambiguously trace a source to a receptor. These techniques have been approved in formal US EPA QAPP/QC documents, supported by peer reviewed publications, and are widely used by the US EPA in research studies across the nation. This type of connection is impossible by using the standard ARB and US EPA Federal reference method for sampling and analysis, which Yorke Engineering relies on for their comments and understanding.

First, the very success of SA Recycling's efforts to reduce the pollutants before our secondary measurements in spring, 2009 confirms our original conclusions. Measurements of lead, zinc and fine iron made in spring, 2009, after SA Recycling added and improved air pollution control equipment, showed dramatic reductions, for some parameters as much as 97%, showing that SA Recycling was indeed the source of these pollutants in summer, 2008. Below we show the lead levels for summer, 2008, and spring, 2009. There is a dramatic reduction, 71% reduction in lead finer than 1 μm, 84% reduction in lead coarser than 1 μm, and a 97% reduction in the very fine iron tracer of SA Recycling operations. This is important because recent peer reviewed publications have supported medical investigations on the toxicity of very fine iron and its impact on the lung.

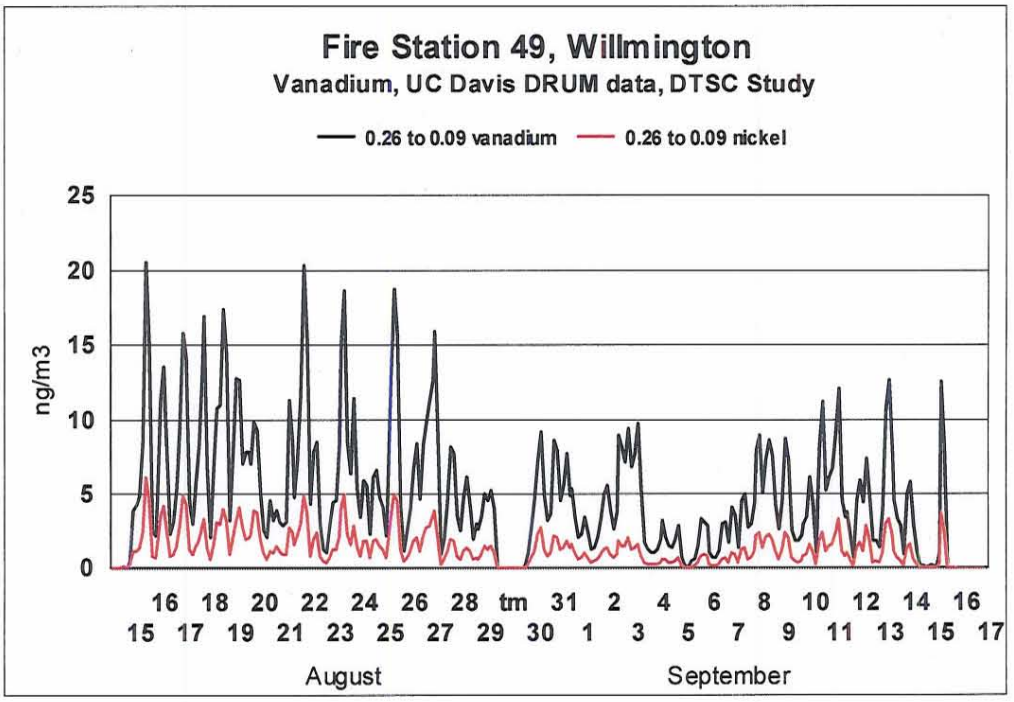




In addition, because of the capabilities of the UC DELTA Group to see very fine (0.26 to 0.09 μm) particles as a function of time, a unique signature of SA Recycling was discovered in very fine iron, which could only be caused by intense temperature and pressure in the shredding process itself. This "fingerprint" was able to clearly identify when the plant was operating, removing further doubt of source identification. The continuing presence of smaller amounts of very fine iron show that plant operations in spring, 2009 were roughly the same as summer, 2008 in frequency, although we have no data on output. Below we have placed the spring, 2009 data on the summer, 2008 for very fine iron.



Finally, the economic slow down of spring, 2009 was seen in the reduced frequency of the presence of ocean going ships burning bunker oil, shown by the unique set of tracers, vanadium and nickel in the figure below.



I have also attached a letter dated May 30, 2012, sent to Enrique Baeza, where I addressed specific comments made by Yorke Engineering regarding the scientific validity of our Report. In Appendix A, of that letter, a summary of UC Davis DELTA Group sampling and analytical capabilities can be found along with an extensive list of peer-reviewed papers.

If you have any questions or would like to discuss any of these issues further please let me know.

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May 30, 2012

To: Enrique Baeza, Supervising Criminal Investigator
Department of Toxic Substance Control

From: Thomas A. Cahill, Professor of Physics and Atmospheric Sciences and Head
DELTA Group

Re: Yorke Engineering analyses

The comments presented by Yorke Engineering in response to the UC Davis DELTA Group Report – Deposition of Coarse Toxic Particles in Wilmington, CA regarding the Terminal Island shredder, are without scientific substance.

This has been proven definitively by the fact that in response to DTSC's investigations of dust deposited from the SA Recycling Terminal Island shredder, improvements were made in their air pollution control system. Upon re-sampling 6 months later, the sampling results showed a sharp reduction in the amount of lead seen in the deposits in the downwind area of Wilmington. It is clear that SA Recycling was the source and that under DTSC pressure, this source, which appears to have been the largest lead emitter in the Southern Los Angeles basin, releasing perhaps ten thousand times more lead than their self-reported value, has been mitigated.

I would like to summarize the lack of knowledge by Yorke Engineering of current aerosol research, which forms the basis of the disagreements. The heart of the matter is that UC Davis capabilities, honed and developed in the past decades (including current US EPA and National Science Foundation funding), allows a direct scientific connection between atmospheric particles and deposited toxic materials. This type of connection is impossible by using the standard ARB and US EPA Federal reference method for sampling and analysis, which Yorke Engineering relies on for their comments and understanding. In Appendix A, I summarize these capabilities and provides an extensive list of peer-reviewed papers derived from them in the past 15 years. These capabilities were also used by the CA ARB and the CA Department of Justice in the successful litigation against Sierra Pacific Industries for deposited dust from the Lincoln, CA co-gen facility.

Below I will address specific Yorke Engineering comments regarding the UC Davis DELTA Group Report – Deposition of Coarse Toxic Particles in Wilmington, CA. The Yorke comments listed below do not relate to the scientific validity of our work and therefore I will not address them.

Comment # 1: The lead concentrations collected for the DELTA Group study are well below levels that the US EPA has established as protective of human health and the environment.

Comment # 2: Hazardous waste standards do not apply to air emissions and the DELTA Group does not use approved methodologies.

Comment # 5: The estimate of 28.3 tons of uncontrolled emissions over 120 days is unsubstantiated and inconsistent with actual data.

The following comments do relate to the scientific validity of our work and I will address them below.

Comment # 3: There are other well known and documented stationary sources of particulate, iron and lead in close proximity.

Comment # 4: There are particulates, lead and other trace metals emitted by the ships, locomotives, and trucks in operation daily throughout the port area from residual (bunker fuel) and diesel fuel combustion.

Comment # 6: Particle size and content do not "prove" source of emissions.

Comment # 7: The sample data does not correlate with shredder operations.

To address comments number 3 and 4, I would like to make it clear that all possible local lead sources were carefully examined by matching wind directions every 1 ½ to 3 hours to aerosols present at Fire Station 49, which is located appoximately 700 meters away in a downwind direction for almost all daytime hours. I would also like to mention that the fire station personnel were the source of many of the early complaints about the shredder along with residents living in the nearby marina.

Below is a map that details the locations of all the CA Air Resources Board (ARB) and the South Coast Air Quality Mangement Distrct (SCAQMD) reported lead emitters in the nearby area, along with a table that identifies the amount (lbs/yr) of lead emitted and reported by each of the facilites in 2008 and 2009, when the sampling actually took place. Note that minimal lead emissions are listed for SA Recycling.

Facility Name	Street Address	City	Zip	2008 Lead Emissions (lbs/year)	2009 Lead Emissions (lbs/year)
Long Beach City, Serrf Project	100 - 120 Henry Ford Ave	Long Beach	90802	38.9	12.8
Al Larson Boat Shop	1046 S Seaside	Terminal Island	90731	0.06	0.062
SA Recycling	901 New Dock Street	Terminal Island	90731	0.01	0.007
Bp West Coast Products Llc,bp Wilmington	1175 Carrack Ave	Wilmington	90748	87.1	87.7
Conocophillips Company	1660 W Anaheim St	Wilmington	90744	27.7	25.3
La City, Harbor Dept	500 Pier A St Berth 161	Wilmington	90744	0.1	0.1
Tesoro Refining And Marketing Co	2101 E Pacific Coast Hwy	Wilmington	90744	27	28.2
Ultramar Inc (nsr Use Only)	2402 E Anaheim S	Wilmington	90744	5.3	9.3
Valero Wilmington Asphalt Plant	1651 Alameda St	Wilmington	90744	0.4	0.1

The only nearby source, the Serrf incinerator, is at a wind direction almost 30° away from the wind trajectory from SA Recycling to the DELTA samplers located at Fire Station 49, and thus could not reach the samplers along the same wind vector. Also, the height of the incenerator stack would prevent the incinerator aerosols from reaching the low elevation DRUM sampler at Fire Station 49, except in extraordinarily unstable air such as a rain storm. Further, the lead emissions from the incinerator, average only 26 lbs/year, which are modest during the time of the study.

It is important to point out that there is negligible lead emitted from any California mobile source since California regulations have prevented lead in fuel since around 1990. The ocean was the only source upwind of the shredder and in the same wind trajectory as our DRUM sampler located at Fire Station 49 for most of the daytime hours. There was was no other lead sources within the same wind trajectory. The emission signature (sulfur, vanadium, and nickel) of the ocean going ships was routinely seen, proving that the air passing SA Recycling and then arriving at Fire Station 49 were from the ocean, in full accord with local port meterology. For detailed meterology of a 2 day period, see Appendix B, which also shows that on almost all hours when the plume did not reach the DRUM sampler at Fire Station 49, it did impact other areas in Wilmington, Long Beach, and other near-by residential areas.

The question of resuspended "legacy lead" must be addressed however. These occur in two modes:

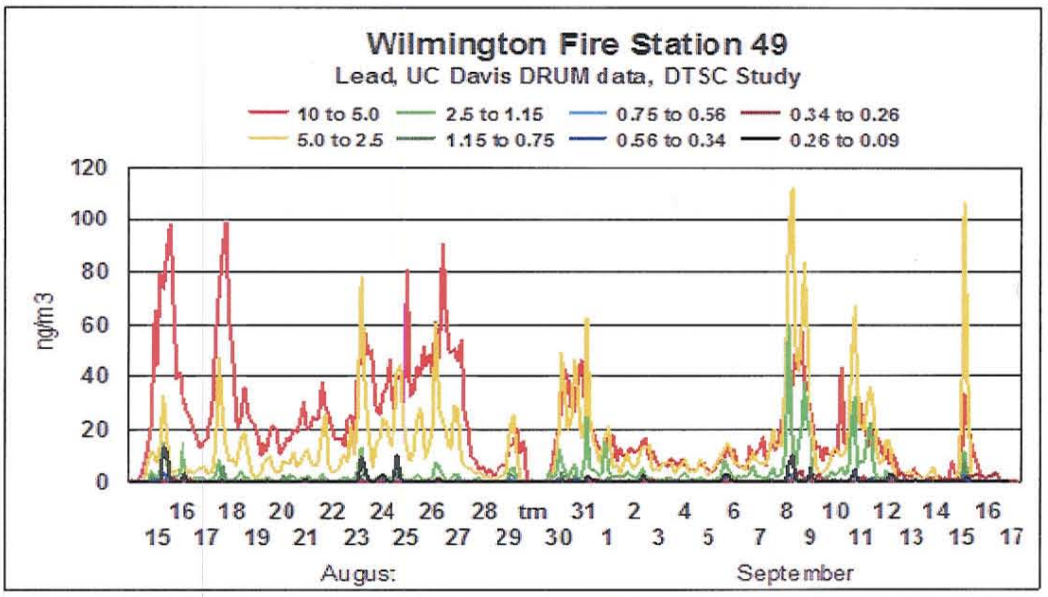
1. Direct re-suspension by strong winds, with particles in the very coarsest modes, and
2. Traffic resuspended contaminated soils, with somewhat finer particles around 2.5 to 0.75 μm.

Since the wind vector is almost always directly across the SA Recycling site during the strongest winds, we must consider that some of the lead may be fugitive from piles on their site and /or traffic on lead contaminated soils on site. These can and should be mitigated, and may be the source of some of the lead seen after the installation of the new air pollution control equipment in 2009.

Other sites mentioned by Yorke Engineering include piles of dredged dirt. These sites are often off trajectory, as much as 90°, and almost never upwind of the sampling site at Fire Station 49. Resuspended dirt is a well-understood problem and would only be seen in the coarsest particles, while the lead seen from the direction of SA Recycling included very fine particles that can only be caused by industrial activities involving high temperatures and pressures.

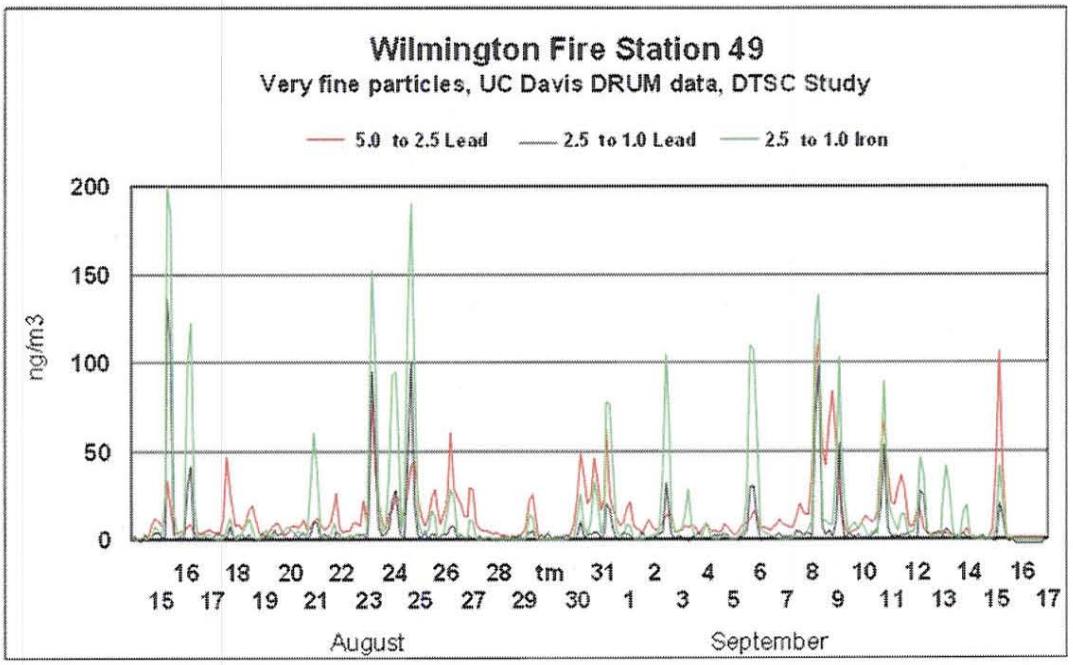
In response to comments number 6 and 7, I would like to point out that the process used in reducing an entire car to shreds in a short period of time requires intense heat and pressure, leading to the use of water to cool the process. Such high temperatures and pressures are needed to generate very fine (< 0.25 μm) and ultra-fine particles. Such very fine particles are never seen in normal soil, which rarely shows any mass much below 1 μm in diameter (Cahill et al AS&T 2011).

Total lead emissions for the sampling interval are shown in the next figure. When looking at this data in detail, we can see that we have a series of peaks that largely occur in daytime, and valleys that occur at night. By looking at the data plotted in the figure we can see that the diurnal pattern is clear in the smaller size modes. For the coarsest size modes, the time resolution of these stages averages over some of this effect.



Lead aerosols seen at Fire Station 49, summer, 2008.

The high levels of coarse lead seen on August 26 and 27 (above) also occur with the unambiguous very fine lead and iron tracer (see below) showing that it came in on the same wind trajectory. Thus this is entirely in accord with the very regular meteorology of daytime transport. The dips in the data (see for example in the 5.0 to 2.5 μm mode) occur at night, when the wind blows away from the Fire Station 49 sampler. It sets an upper limit on non-SA Recycling "legacy" lead in local soils. In the 2.5 to 1.0 μm mode (below) the nighttime minima are extremely low. The fact that these are seen together with both coarse and very fine lead on the same wind direction is consistent with a common source.



Finer aerosols of lead and iron, summer 2008

In our report we stated, "that all the lead seen in any wind direction is caused by shredder operations current and past." Our more recent analysis shows that this statement was too strong and we retract it. A more accurate statement would be "This indicates that some of the lead seen in any wind direction has contributions from shredder operations, current and past."

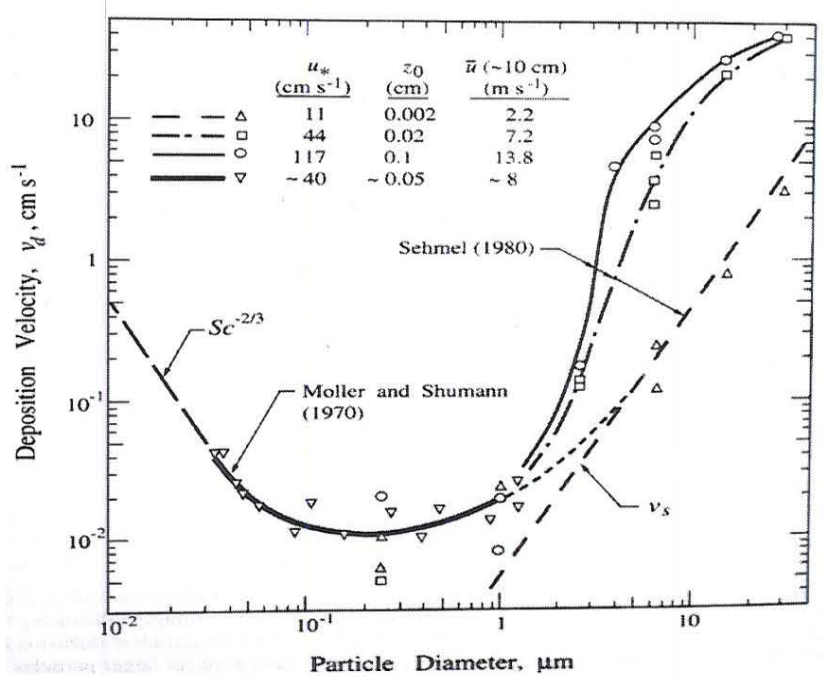
The measurements made downwind of the SA Terminal Island shredder are in the units ng/m^3. To arrive at a deposition rate, one has to factor in the concentration, the size mode it occurs in, and the removal rate from the atmosphere by particle settling.

The calculation proceeds by calculating the mass of the species in each size mode. As an example, assume we have a lead level of 100 ng/m^3 present at a site for an 8 hour period. Also assume this concentration in the size mode from 5 to 15 μm diameter, and a specific concentration of 10,000 ppm lead.

Using a mean size of 10 μm, a low wind velocity of 11 cm/sec, and a low surface roughness z_o = 0.002 cm (typical of a lawn) we can find the deposition velocity v_d from Seinfeld and Pandis (1997) to be 0.3 cm/sec (see plot below). Any increase in wind velocity and surface roughness raises this value by 2 orders of magnitude, making this a lower limit.

Thus in 8 hours, all of the particles will have moved to the ground in a column 86.4 meters high, (0.3 cm/s x 60s/min x 60 min/hr x 8 hr/100 cm/m) containing 8.64 $\mu g/m^2$ of deposit (86.4 m x 0.1 $\mu g/m^3$ = 8.64 $\mu g/m^2$ = 0.00864 mg/m^2), all with a concentration of 10,000 ppm lead.

Since this is a surface layer, it will be easy for it to collect on people's hands leading to a high potential for ingestion.



Deposition of particles

In order to evaluate the amount of lead emitted by SA Recycling, we can use the HYSPLIT dispersion model (Appendix B), local mean meterology, and meassured lead values during daytime peaks, to make a rough estimate. For August, 2008, the assumption was 2 shifts/day, 5 days a week. The distance from the Fire Station 49 station was approximately 700 meters from SA Recycling. Using these values, we would estimate an annual emission rate of roughly 150 lbs lead/year, far more than the 0.007 lbs/year self reported by the facility.

If you have any questions or would like to discuss any of these issues further please let me know.

Appendix A

1. Sample collection
    a. The UC Davis DELTA Group collects aerosol samples in a suite of 8 or 9 size modes from 35 μm to 0.09 μm, with extension to 0.0 μm for special projects. Current regulatory requirements are collection in one size mode, < 2.5 μm ($PM_{2.5}$) or < 10 μm (PM_{10}). For the TI shredder, most of the lead was in coarse modes, however lead in the ultra-fine (< 0.26 μm) was also seen. The combination of both size modes together tagged the shredder as a current source; it is only at elevated temperatures and or pressures that the very fine lead is produced.
    b. The UC Davis DELTA Group collects aerosols as a function of time, usually 3 hour increments but as short as 1 ½ hour increments, which was done as a part of the TI shredder study. This allowed us to closely match wind directions, with defined source to sampler conditions occurring during most daytime hours.

2. Sample analysis
    a. The UC Davis DELTA Group analyzes samples using three major analytical methods – soft beta mass (approved by ARB), elements by synchrotron-induced x-ray fluorescence (S-XRF), and soot by absorption.
        i. First, these analytical methods are all non-destructive, allowing for quality assurance validations and comparisons to other laboratories.
        ii. Second, all have been approved by the U.S. EPA in Joint QA/QC protocols, most recently in 2010 as a part of the Detroit NEXUS study.
        iii. Finally, the analytical techniques are inherently multi-elemental, so that all other elements in the sample are always seen using the state of the art S-XRF at Lawrence Berkeley National Laboratory and the Stanford Synchrotron Research Laboratory (SSRL) at the Stanford Linear Accelerator.
            1. The first example of the power of the S-XRF is the ability to identify the "legacy lead" bound into soils, signaled by standard soil elements in the coarse size mode (Al, Si, K, Ca, Ti, Mn, Fe, Rb, Sr, Zr).
            2. The second was the ability to see the unexpected presence of very fine iron simultaneously with the very fine lead, a tracer (or signature) of current industrial activity at TI.

Each of these advances has been heavily vetted in the refereed literature. A summary of publications using exactly the same DRUM and analytical configurations is given below.

In summary, many of the critiques presented by Yorke Engineering of our Terminal Island shredder report are based on a lack of understanding of the current aerosol capabilities employed by the UC Davis DELTA Group.

Summary of DRUM publications

History: The Air Quality Group (AQG, 1971 – 1997) and the Detection and Evaluation in Long-range Transport of Aerosols (DELTA Group, 1997 – present) have always relied on fundamental and scientific grounds to perform experiments with continuous sampling of size and compositionally resolved aerosols. The samplers used by DELTA have varied in time (typical time resolutions have and can be varied at will) and can be seen in the list below:

1. Lundgren sampler 1972-1974 , revived in 2005 to perform organic analyses versus size 5 stages, slots, 4 hr resolution 160 L/min
2. Multiday sampler 1973 – 1981 3 stages, slots, 24 hr resolution 35 L/min
3. DRUM samplers
    a. Jetted 8 DRUM 1985 – 1995 8 stages, jets, 3 hr resolution 1.0 L/min
    b. DELTA 8 DRUM 1996 – 8 stages, slots, 3 hr resolution 10.0 L/min
    c. DELTA 8 DRUM, 2001 – 8 stages, slots, 3 hr resolution 16.7 L/min
    d. DELTA 3 DRUM, 2001 – 3 stages, slots, 3 hr resolution 22.5 L/min
    e. 8 DRUM upgrade, 2005 – 8 stages, slots, 3 hr resolution 16.7 L/min

The publications below are roughly separated by instrument in inverse chronological order. The numbers are the identifiers in the Master AQG/DELTA master publication list

Publications from DRUM samplers (slotted, 3 and 8 stage, types b through e)

In press

11-4 Richard A. VanCuren, Thomas Cahill, John Burkhart, David Barnes, Yongjing Zhao, Kevin Perry, Steven Cliff, Joe McConnell, **Aerosols and their Sources at Summit Greenland – First Results of Continuous Size- and Time-Resolved Sampling,** in press, Atm. Environment (2011)

Published

11-1 Thomas A. Cahill, David E. Barnes, Earl Withycombe, and Mitchell Watnik, **Very Fine and Ultra-Fine Metals and Ischemic Heart Disease in the California Central Valley 2: 1974 – 1991**, Aerosol Science and Technology 45, 1135-1142 (2011)

11-2 Thomas A. Cahill, David E. Barnes, Nicholas J. Spada, Jonathan A. Lawton, and Thomas M. Cahill , **Very Fine and Ultra-Fine Metals and Ischemic Heart Disease in the California Central Valley 1: 2003 – 2007**, Aerosol Science and Technology 45, 1125-1134 (2011)

11-3 Thomas A. Cahill, Thomas M. Cahill, David E. Barnes, Nicholas J. Spada and Roger Miller , **Inorganic and organic aerosols downwind of California's Roseville Railyard**, Aerosol Science and Technology 45, 1049-1059 (2011)

10-1 Cahill, TM, **Organic aerosols in the California Central Valley**, Environmental Science and Technology 44 2315 - 2312 (2010)

10-2 Cahill, Catherine F., Peter G. Rinkleff, Jonathan Dehn, Peter V. Webley, Thomas A. Cahill, and David E. Barnes, **Aerosol measurements from a recent Alaskan volcanic eruption: implications for ash transport predictions**, J. Volcanology and Geothermal Research 198, 76 - 80 (2010)

08-1 Cahill, Catherine F, Thomas A. Cahill, and Kevin D. Perry. **The size- and time-resolved composition of aerosols from a sub-Arctic boreal fire prescribed burn**. *Atmospheric Environment* 42 7553-7559 (2008)

07-1 Emma Pere-Trepat, Eugene Kim, Pentti Taatero, and Philp k. Hopke, **Source Apportionment of time and size resolved ambient particulate matter measured with a rotating DRUM impactor,** *Atmospheric Environ.* 41: 5921–5933 (2007).

06-1 Alan W. Gertler, Andrzej Bytnerowicsz, Thomas A. Cahill, Michael Arbaugh, Steven Cliff, Jülide Kahyaoğlu-Koračin, Leland Tarney, Rocio Alonso, Witold Fraczek. **Local Air Pollutants Threaten Lake Tahoes Clarity**. *California Agriculture, Vol. 60 Num. 2, 49-58, 2006.*

05-1 Perry, Kevin; Cliff, Steven S.; Jimenez-Cruz, Michael P.; **Evidence for hygroscopic mineral dust particles from the Intercontinental Transport and Chemical Transformation Experiment**. *Journal of Geophysical Research, Vol. 109, 2004.*

04-1 Thomas A. Cahill, Steven S. Cliff, Michael Jimenez-Cruz, James F. Shackelford[1], Michael Dunlap[1], Michael Meier[1],Peter B. Kelly[2], Sarah Riddle[2], Jodye Selco[3,*], Graham Bench[4], Patrick Grant[4], Dawn Ueda[4], Kevin D. Perry[5], and Robert Leifer[6], **Analysis of Aerosols from the World Trade center Collapse Site, New York, October 2 to October 30, 2001**. *Aerosol Science and Technology* 38; 165–183 (2004)

04-2 Han, J.S, K.J. Moon, J.Y. Ahn, Y.D. Hong, Y.J Kim, S. Y. Rhu, Steven S. Cliff, and Thomas A. Cahill, **Characteristics of Ion Components and Trace Elements of Fine Particles at Gosan, Korea in Spring Time from 2002 to 2002,** *Environmental Monitoring and Assessment* 00: 1-21, 2003

04-3 Seinfeld, J.H., Carmichael, G.R., Arimoto, R, Conant, W. C., Brechtel, F. J., Bates, T. S., Cahill, T. A., Clarke, A.D., Flatau, B.J., Huebert, B.J., Kim, J., Markowicx, K.M., Masonis, S.J., Quinn, P.K., Russell, L.M., Russell, P.B., Shimizu, A., Shinozuka, Y., Song, C.H., Tang, Y., Uno, I., Vogelmann, A.M., Weber, R.J., Woo, J-H., Zhang, Y. **ACE-Asia: Regional Climatic and Atmospheric Chemical Effects of Asian Dust and Pollution,** *Bulletin American Meteorological Society* 85 (3): 367+ MARCH 2004

04-5 Cahill, T. A., Cliff, S. S., Shackelford, J. F., Meier, M., Perry, K. D., Bench, G., and Leifer, R. **Very Fine Aerosols from the World Trade Center Collapse Piles: Anaerobic Incineration?** Advances in Chemistry (2004)

Cahill, T. A., Cliff, S. S., Jimenez-Cruz, M., Shackelford, J. F., and Perry, K. **Quality Assurance and Evolution of DRUM data for the Fresno FACES study: Comparison of DRUM, Dichot, RAAS, and FRM-SASS data, March-December 2001.** (Report, 2004)

04-6 R. Z. Leifer[1], G. Bench[2], and T. A. Cahill[3], **Characterization of the Plumes Passing Over Lower Manhattan After the WTC** Advances in Chemistry (2004)

03-1 Cahill, C.F. **Asian Aerosol Transport to Alaska during ACE-Asia**. J. Geophys. Res. J. Geophys. Res., 108 (D23), 8664 (2003)

03-4 Reuter, John E., Cahill, Thomas A., Cliff, Steven S., Goldman, Charles R., Heyvaert, Alan C., Jassby, Alan D., Lindstrom, Susan, and Rizzo, Davis M., **An Integrated Watershed Approach to Studying Ecosystem health at Lake Tahoe, CA-NV**, in *Managing for Healthy Ecosystems* Rapport et al, ed., CRC Press, New York, 1283-1298 (2003)

01-1 V. Shutthanandan, S. Thevuthasan, R. Disselkamp, A. Stroud, A. Cavanaugh, E.M. Adams, D.R. Baer, L. Barrie, S.S. Cliff, T.A. Cahill. **Development of PIXE, PESA and transmission ion microscopy capability to measure aerosols by size and time**. 2001 *Nuclear Instruments and Methods in Physics Research B: Beam Interactions with Materials and Atoms*.

01-4 Graham Bench, P.G. Grant, D. Ueda, S.S. Cliff, K.D. Perry, and T. A. Cahill. **The use of STIM and PESA to respectively measure profiles of aerosol mass and hydrogen content across Mylar rotating drum impactor samples.** 2001 *Aerosol Science and Technology* 36:642-651.

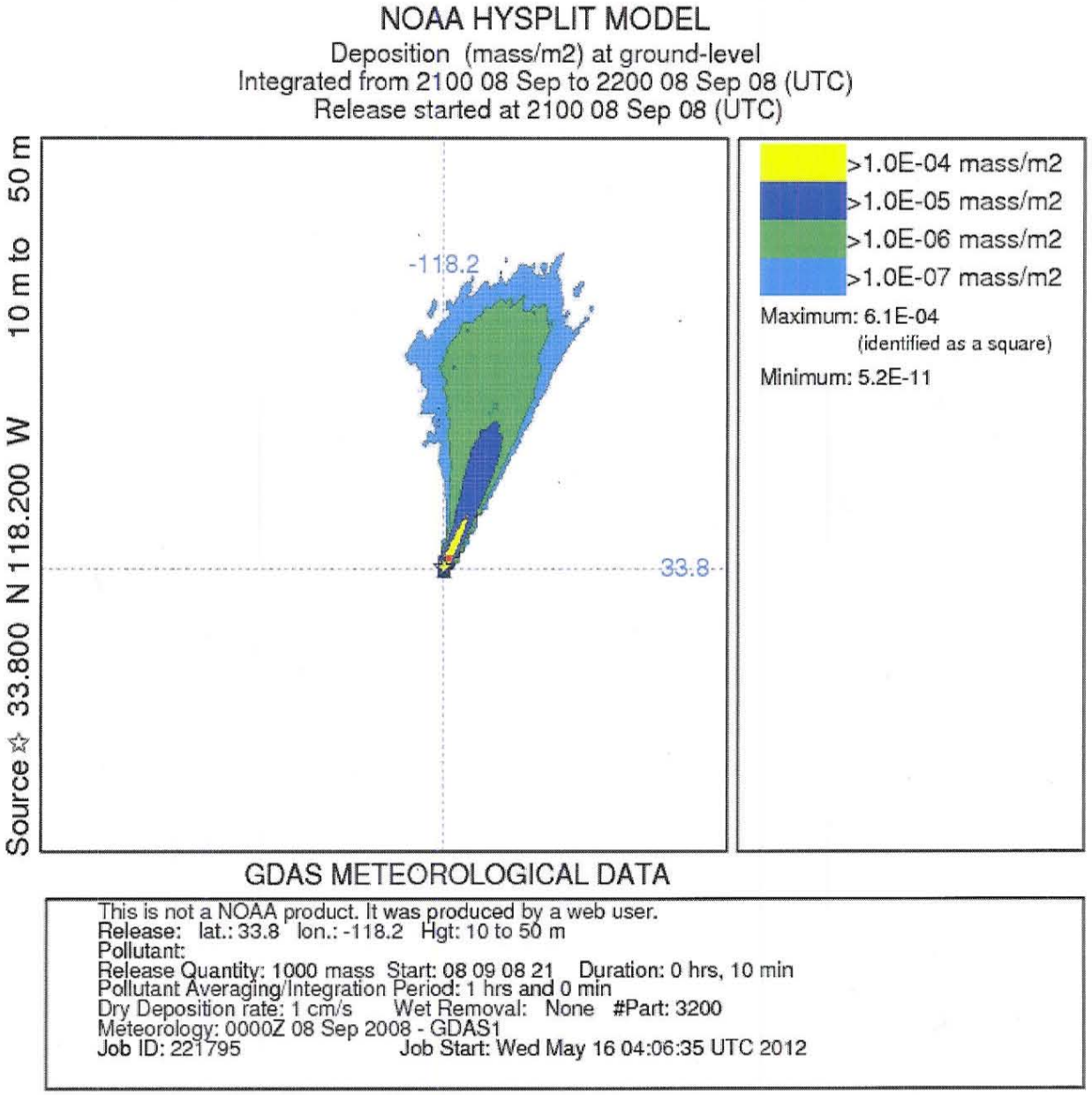
00-1 Miller, Alan E. and Thomas A. Cahill. **Size and compositional analyses of biologically active aerosols from a CO_2 and diode laser plume.** 2000 *International Journal of PIXE*. Vol. 9, Nos. 3 & 4.

99-3 Perry, Kevin D., Thomas A. Cahill, Russell C. Schnell, and Joyce M. Harris. **Long-range transport of anthropogenic aerosols to the NOAA Baseline Station at Mauna Loa Observatory, Hawaii.** 1999 *Journal of Geophysical Research Atmospheres*. Vol. 104, No. D15, Pages 18,521-18,533.

98-2 Pryor, S.C., R. J. Barthelmie, L. L. S. Geernaert, T. Ellerman, and K. Perry. **Aerosols in the Western Baltic: Results from ASEPS '97.** *Submitted to the 5th International Aerosol Conference, Edinburgh, 12-18th September, 1998.*

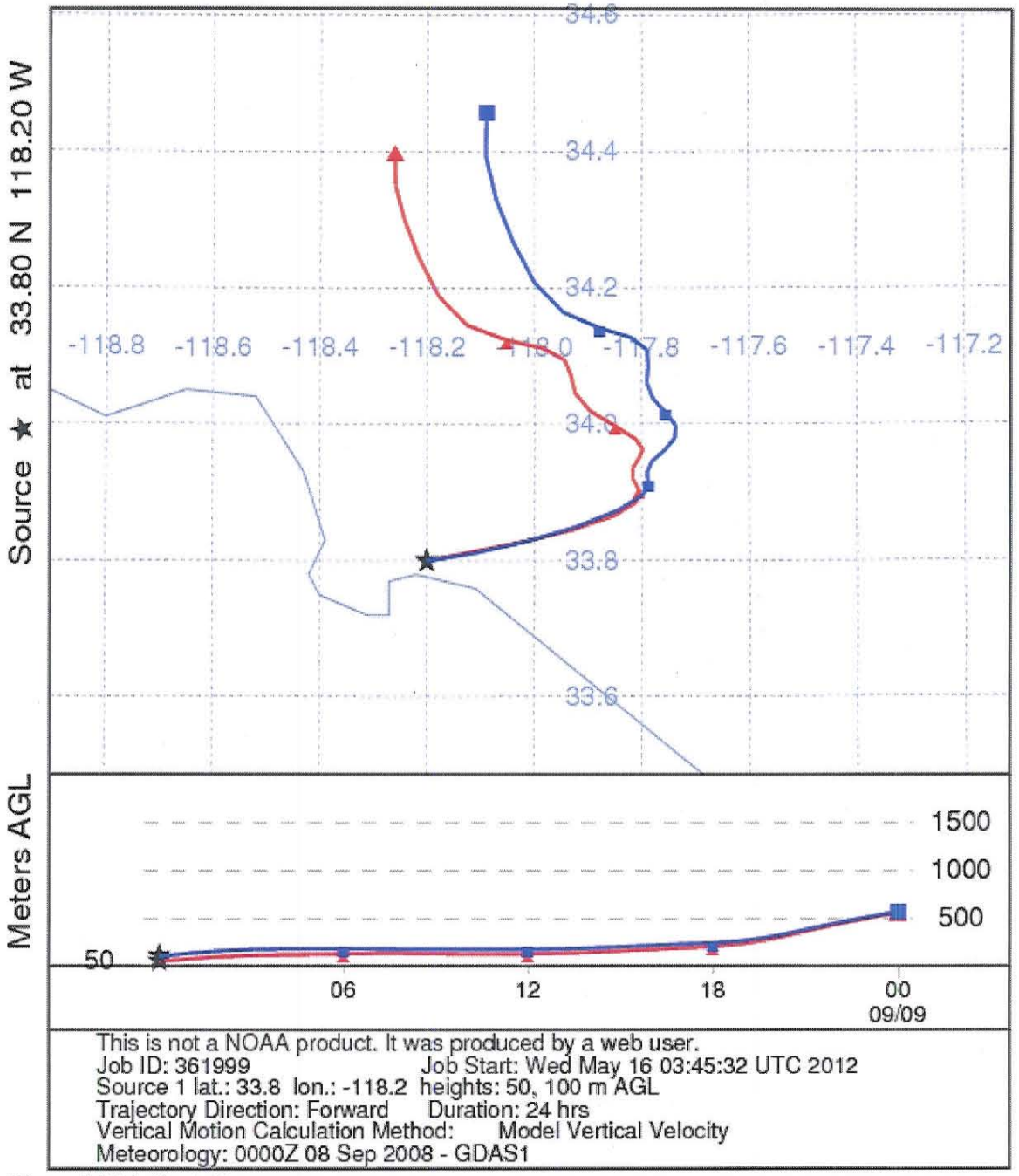
97-1 Cahill, Thomas A., and Kevin D. Perry. **Asian Transport of Aerosols to Mauna Loa Observatory, Spring.** 1994 *Climate Monitoring and Diagnostics Laboratory, No. 23*, Summary Report 1994-1995, U.S. Department of Commerce National Oceanic and Atmospheric Administration Environmental Research Laboratories/CMDL 94-95, pp 114-116.

Appendix B Time: 2 PM, Sept. 8, 2008



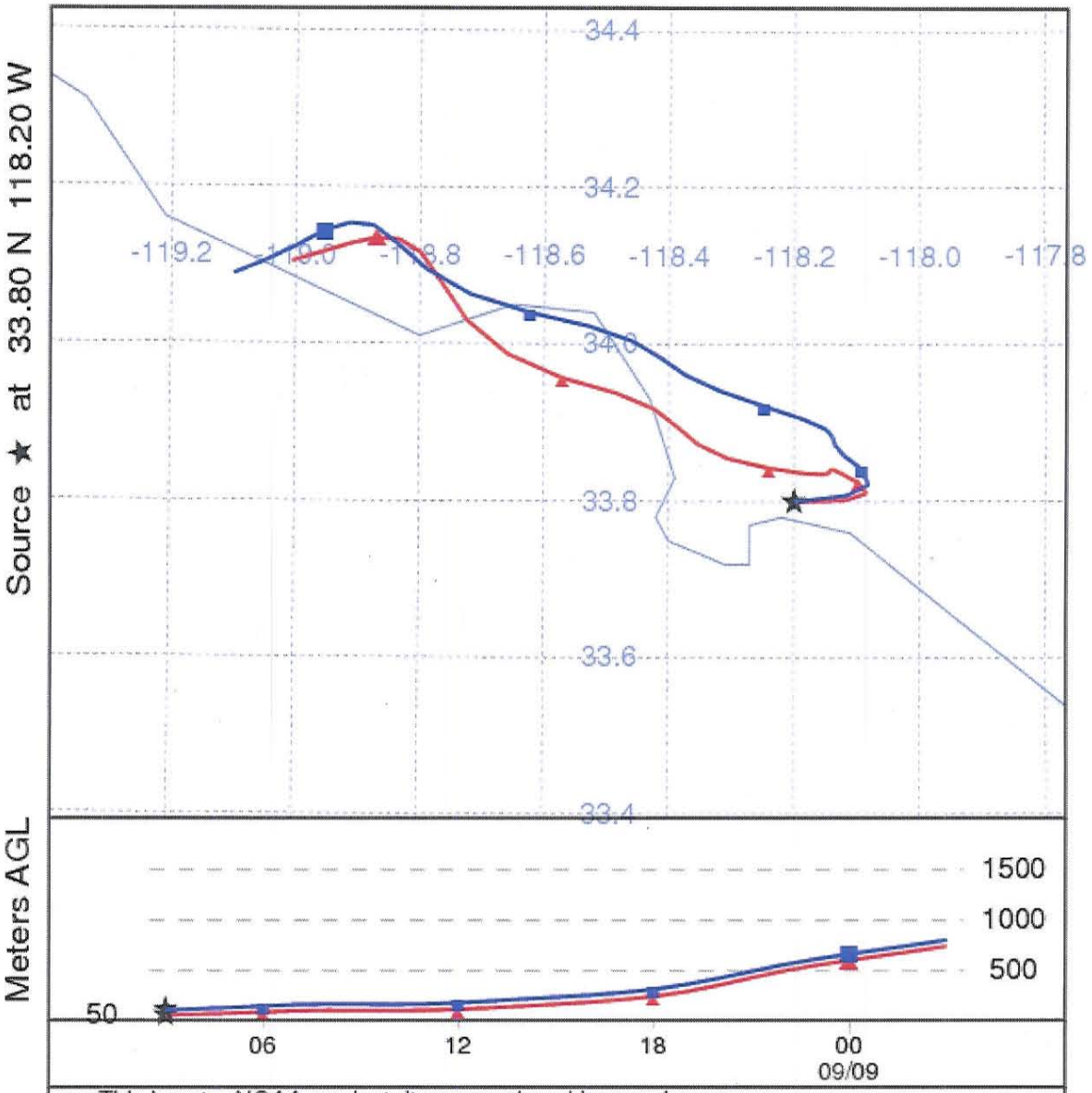
This is not a NOAA product. It was produced by a web user.
Release: lat.: 33.8 lon.: -118.2 Hgt: 10 to 50 m
Pollutant:
Release Quantity: 1000 mass Start: 08 09 08 21 Duration: 0 hrs, 10 min
Pollutant Averaging/Integration Period: 1 hrs and 0 min
Dry Deposition rate: 1 cm/s Wet Removal: None #Part: 3200
Meteorology: 0000Z 08 Sep 2008 - GDAS1
Job ID: 221795 Job Start: Wed May 16 04:06:35 UTC 2012

NOAA HYSPLIT MODEL
Forward trajectories starting at 0000 UTC 08 Sep 08
GDAS Meteorological Data



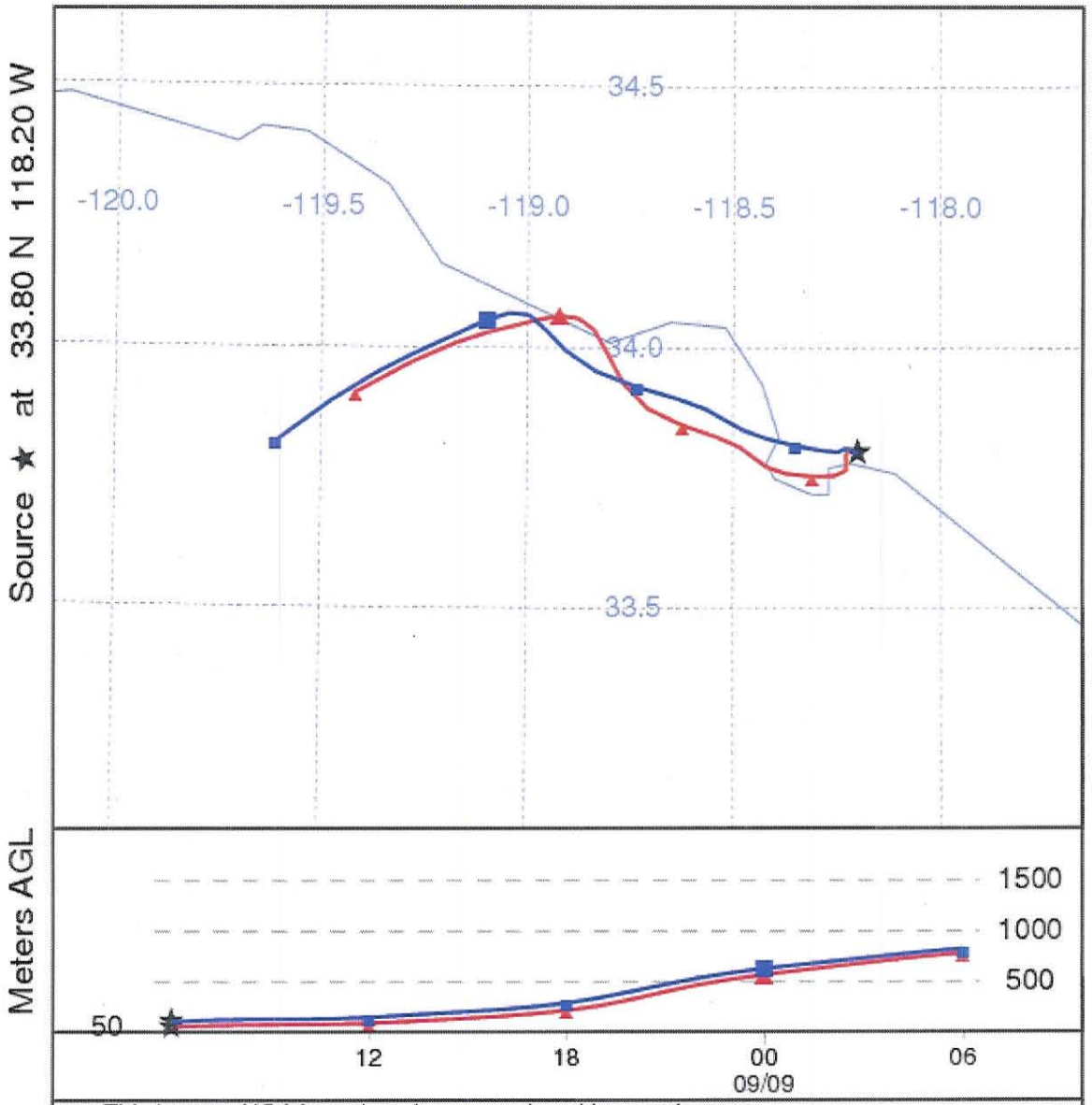
Time: 5 PM, Sept. 7

NOAA HYSPLIT MODEL
Forward trajectories starting at 0300 UTC 08 Sep 08
GDAS Meteorological Data



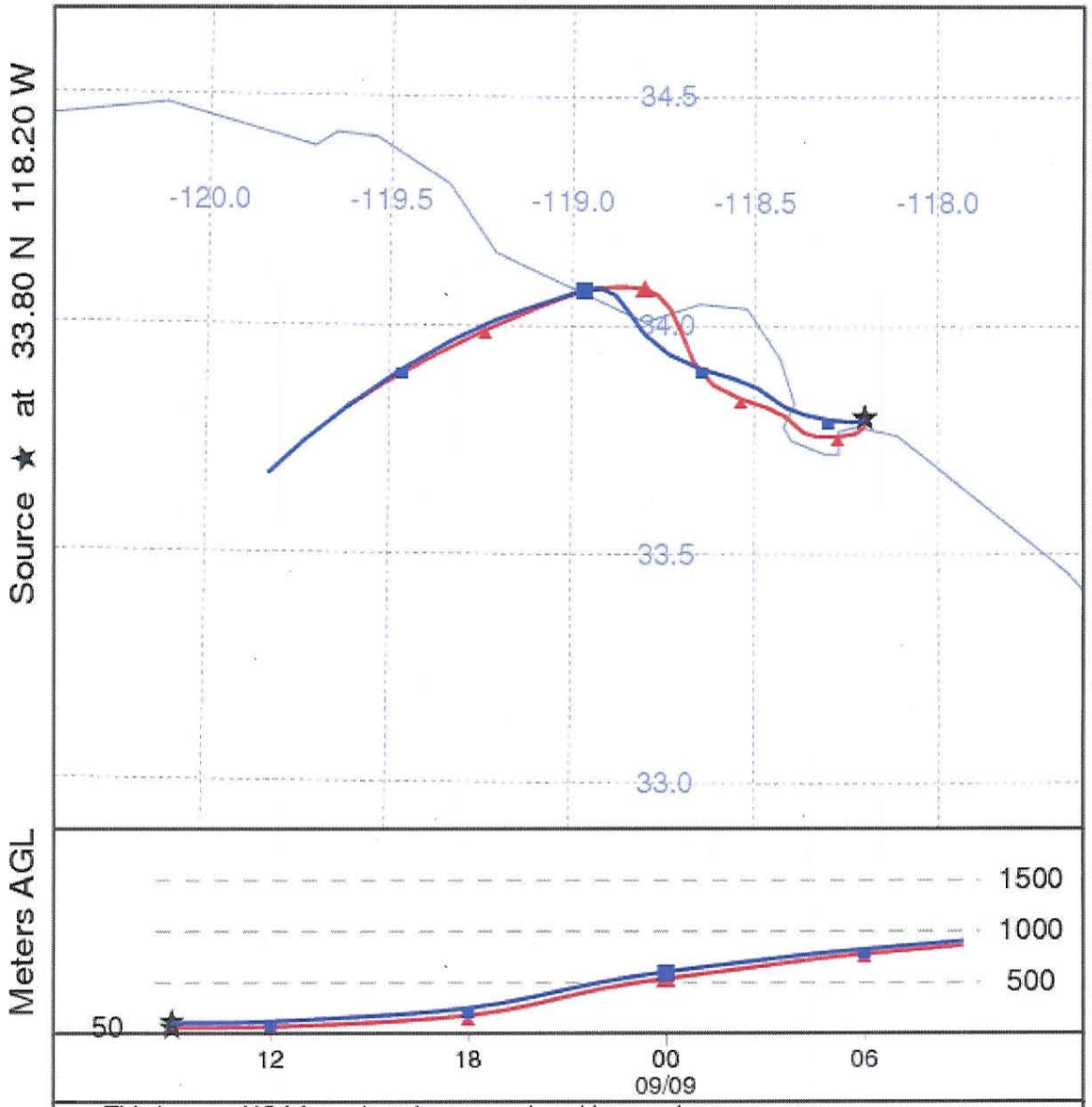
This is not a NOAA product. It was produced by a web user.
Job ID: 342001 Job Start: Wed May 16 03:47:02 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 0600 UTC 08 Sep 08
GDAS Meteorological Data



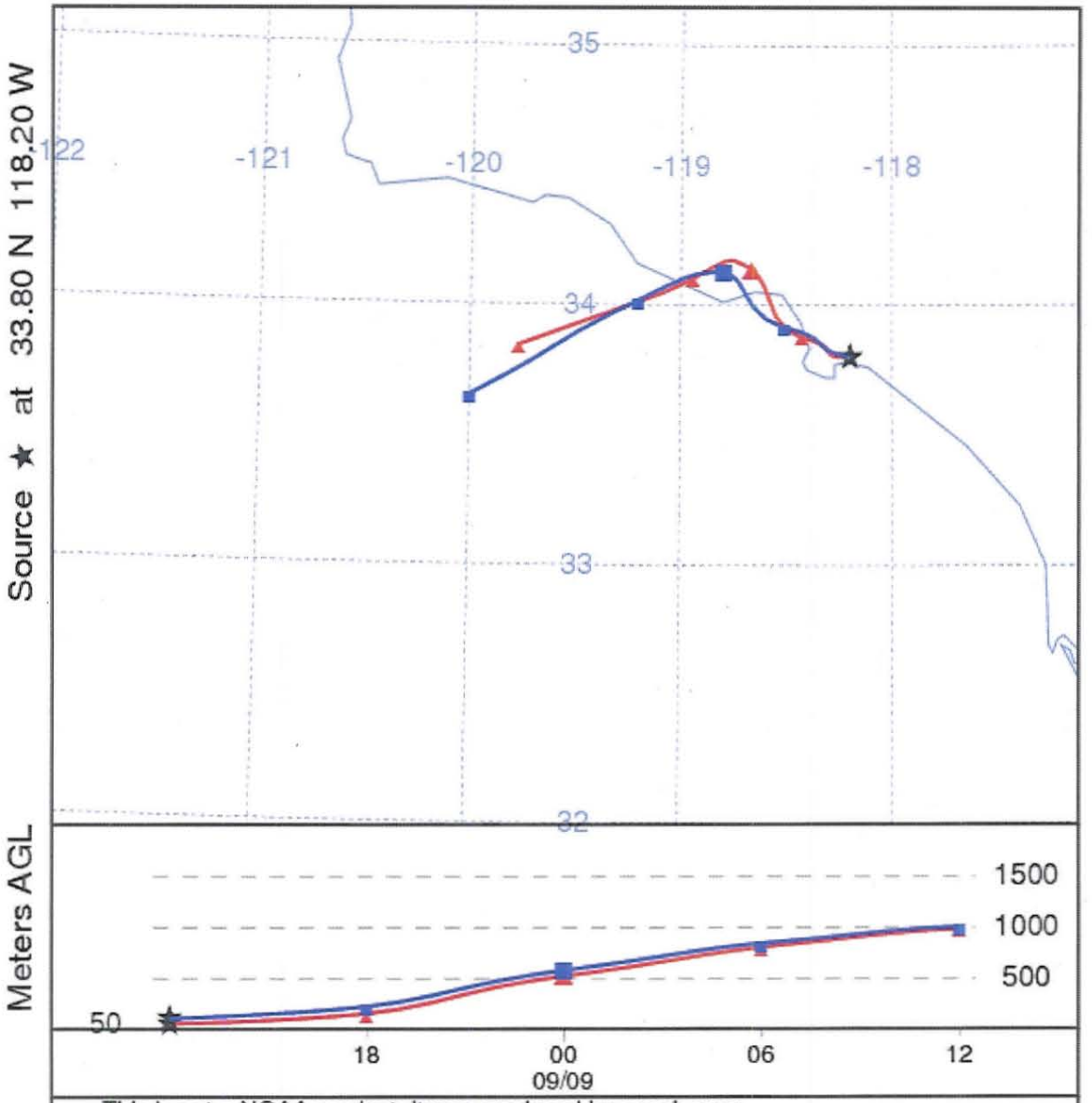
This is not a NOAA product. It was produced by a web user.
Job ID: 382003 Job Start: Wed May 16 03:48:25 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 0900 UTC 08 Sep 08
GDAS Meteorological Data



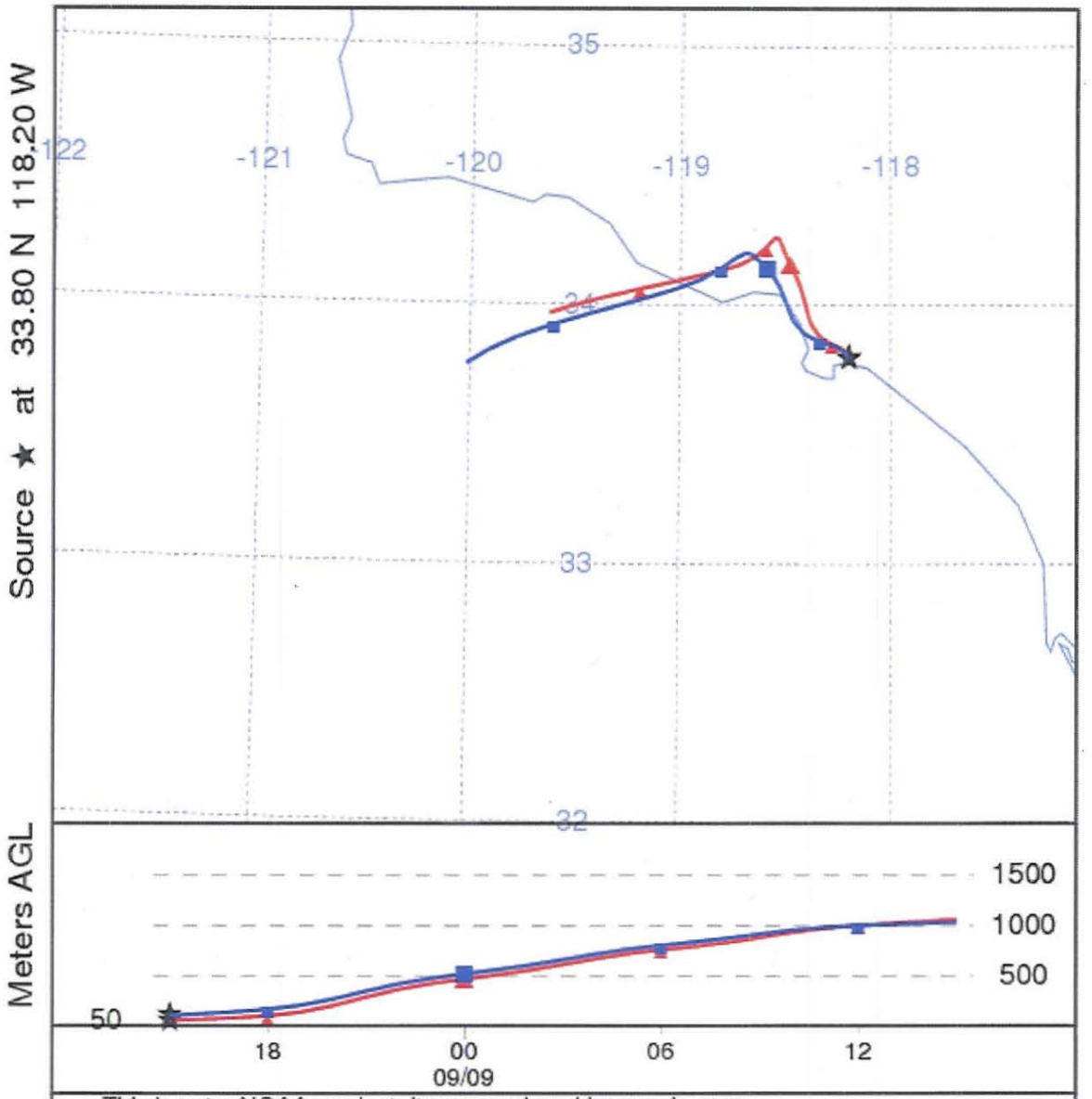
This is not a NOAA product. It was produced by a web user.
Job ID: 382005 Job Start: Wed May 16 03:49:16 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 1200 UTC 08 Sep 08
GDAS Meteorological Data



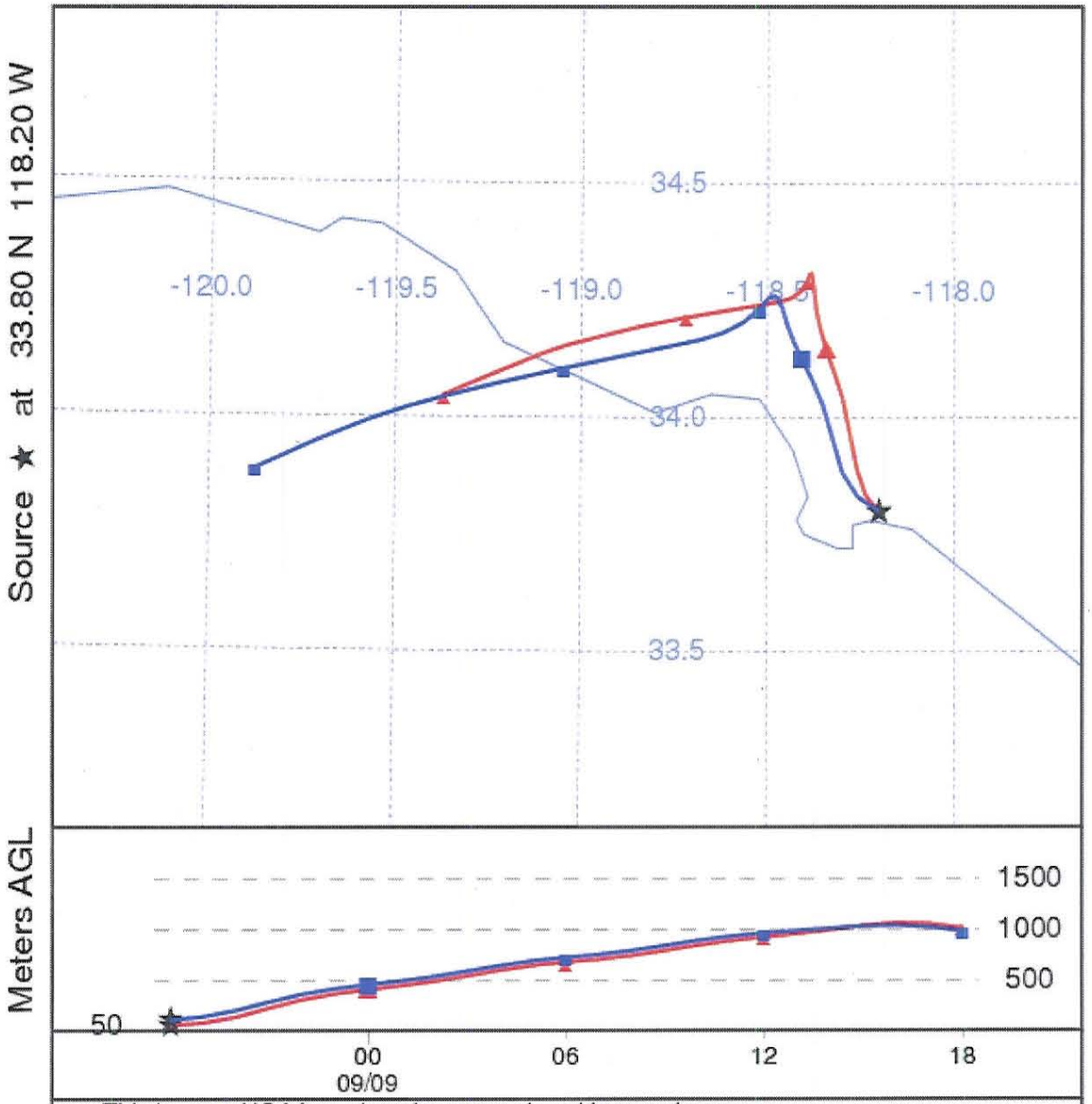
This is not a NOAA product. It was produced by a web user.
Job ID: 362007 Job Start: Wed May 16 03:50:20 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 1500 UTC 08 Sep 08
GDAS Meteorological Data



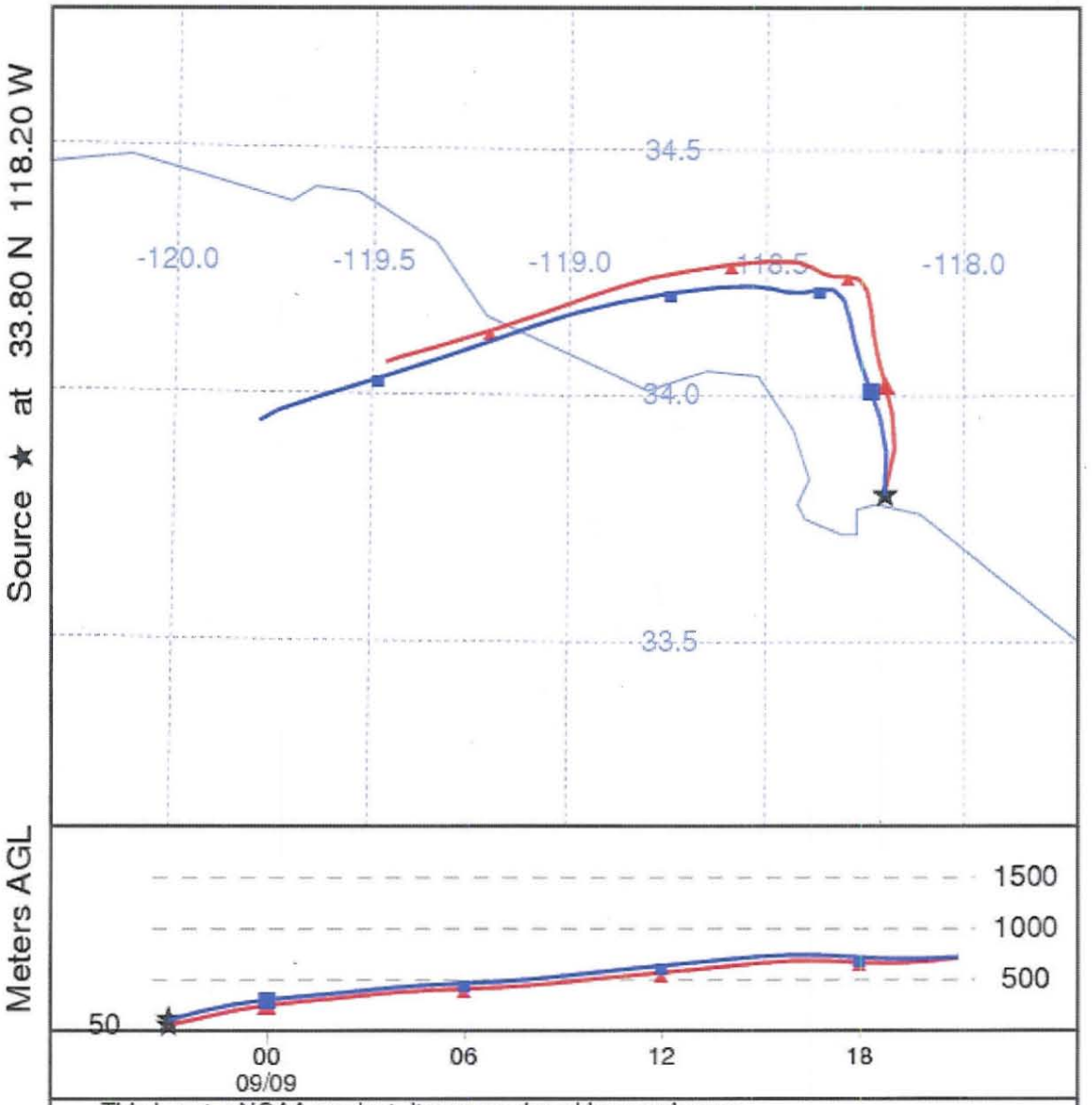
This is not a NOAA product. It was produced by a web user.
Job ID: 302008 Job Start: Wed May 16 03:51:05 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 1800 UTC 08 Sep 08
GDAS Meteorological Data



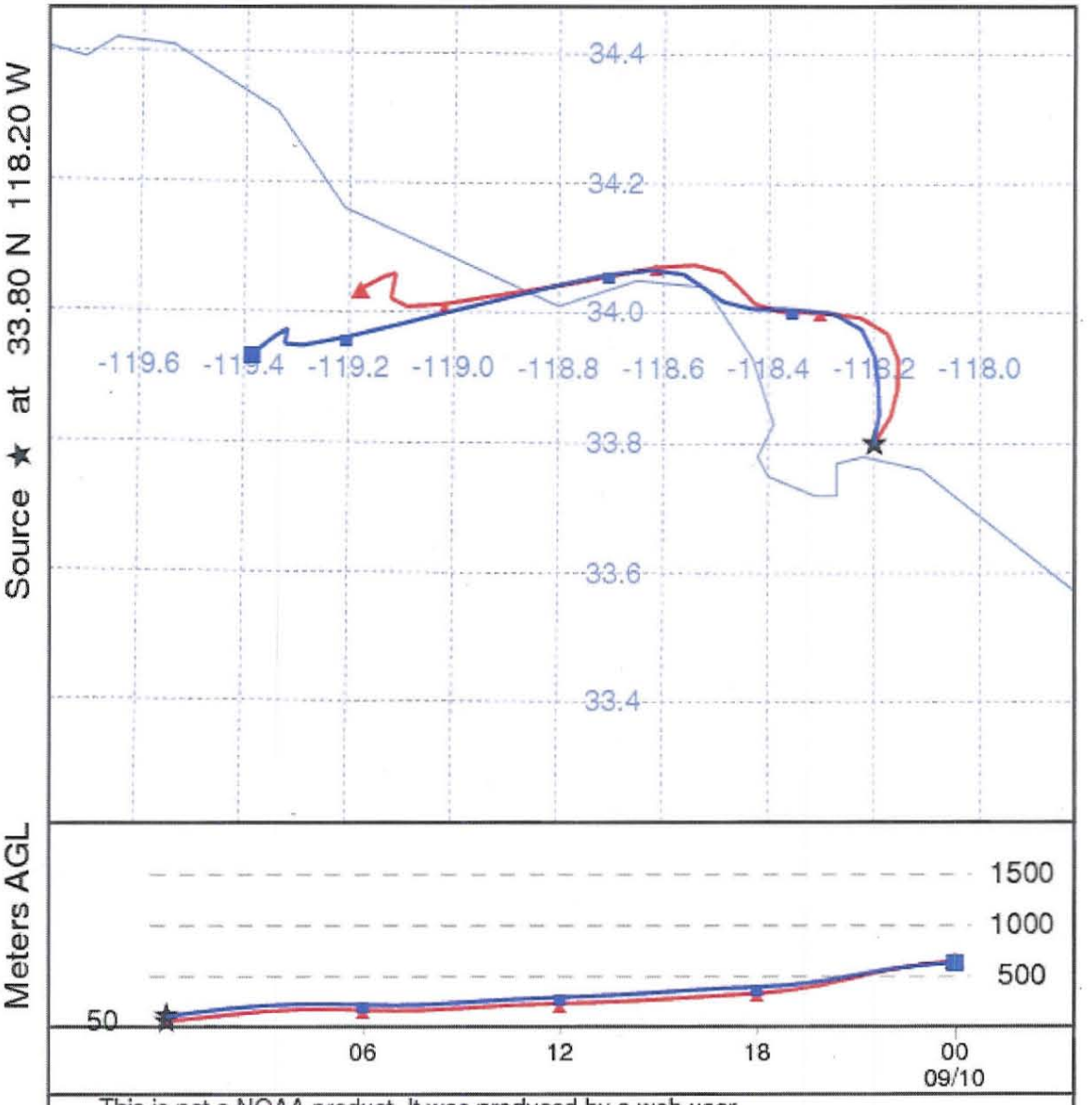
This is not a NOAA product. It was produced by a web user.
Job ID: 312009 Job Start: Wed May 16 03:51:51 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 2100 UTC 08 Sep 08
GDAS Meteorological Data



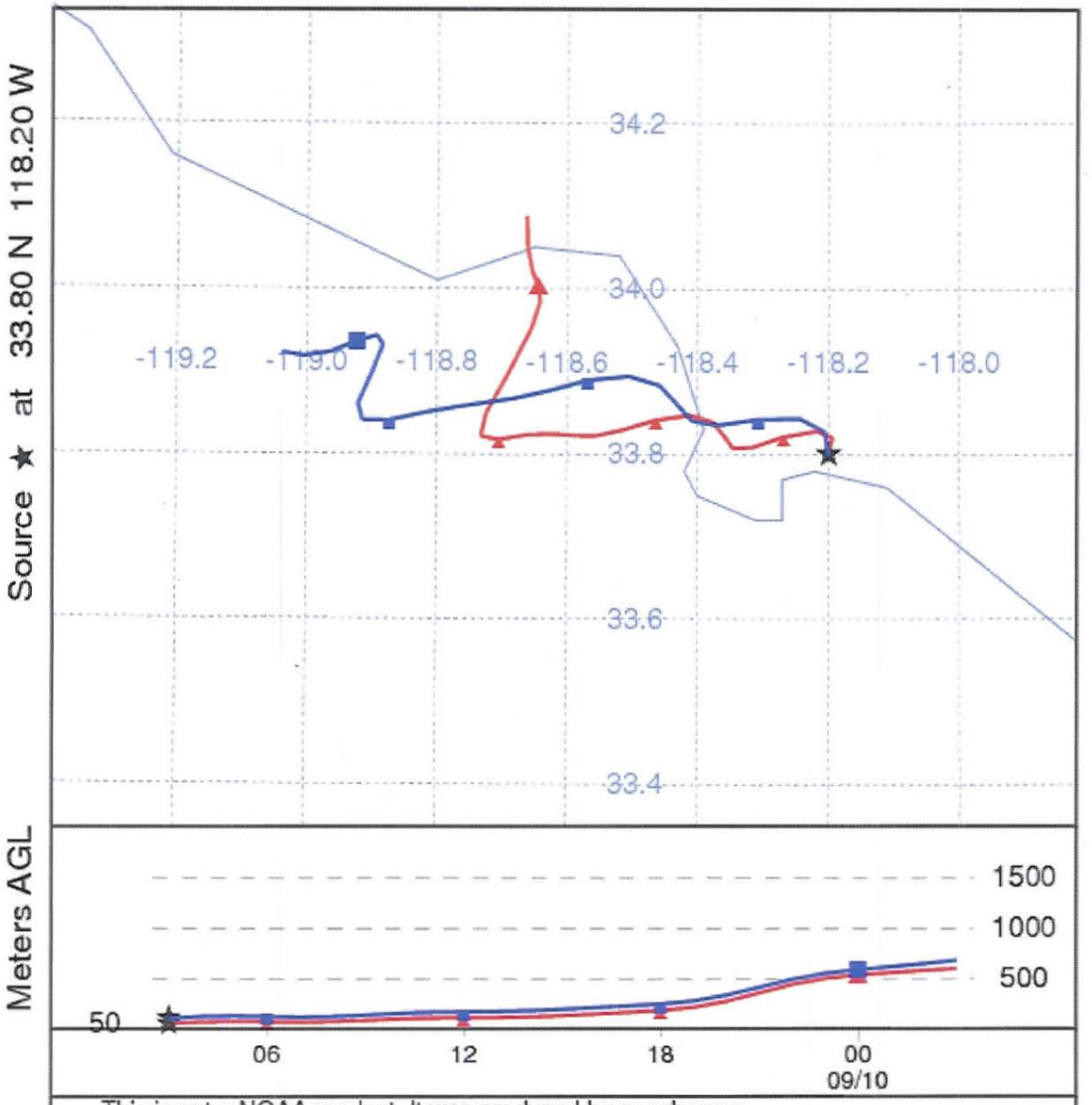
This is not a NOAA product. It was produced by a web user.
Job ID: 342010 Job Start: Wed May 16 03:52:49 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 0000 UTC 09 Sep 08
GDAS Meteorological Data



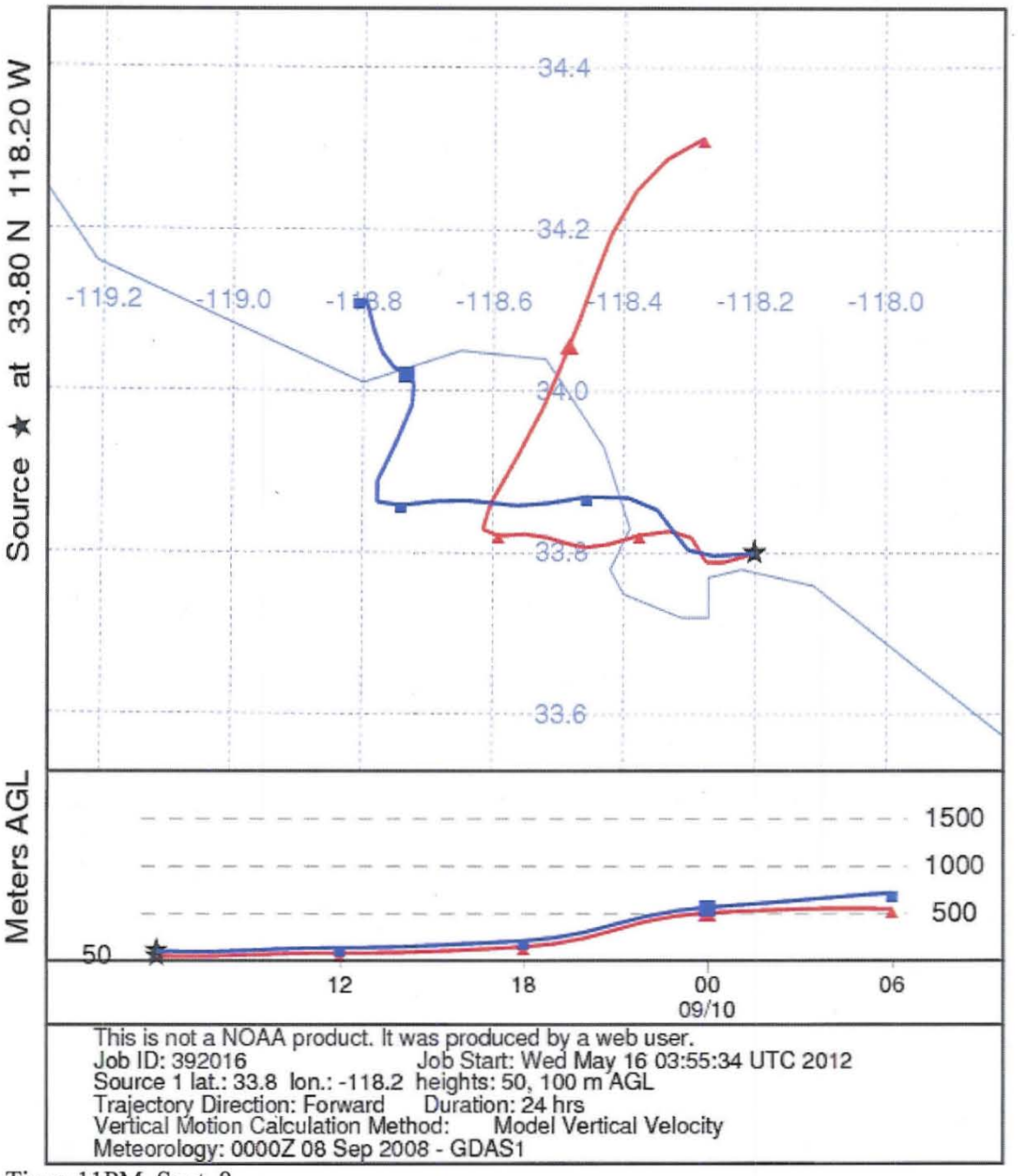
This is not a NOAA product. It was produced by a web user.
Job ID: 332012 Job Start: Wed May 16 03:53:51 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 0300 UTC 09 Sep 08
GDAS Meteorological Data



This is not a NOAA product. It was produced by a web user.
Job ID: 372014 Job Start: Wed May 16 03:54:46 UTC 2012
Source 1 lat.: 33.8 lon.: -118.2 heights: 50, 100 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 08 Sep 2008 - GDAS1

NOAA HYSPLIT MODEL
Forward trajectories starting at 0600 UTC 09 Sep 08
GDAS Meteorological Data



Time: 11PM, Sept. 8