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Witness: Peterka

PREPARED DIRECT TESTIMONY OF

JON A. PETERKA

ON BEHALF OF

SAN DIEGO GAS & ELECTRIC COMPANY

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA**

SEPTEMBER 25, 2015

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PREPARED DIRECT TESTIMONY OF JON A. PETERKA

<u>ON BEHALF OF SAN DIEGO GAS & ELECTRIC COMPANY</u>

I. INTRODUCTION

Q. Please state your name and business address.

A. My name is Jon A. Peterka. My business address is Jon Peterka Engineering LLC, 733 Duke Square, Fort Collins, CO 80525.

Q. By whom are you employed and in what capacity?

A. I am currently the Principal at Jon Peterka Engineering LLC.

Q. Please describe your educational and professional background.

A. I earned my Bachelor of Science and Master of Science in Civil Engineering, Colorado State University, in 1964 and 1965, as well as a Ph.D. in Fluid Mechanics and Thermodynamics from Brown University in 1968.

I co-founded CPP Wind Engineering Consultants – a firm that performs wind tunnel testing, computer simulations, and technical analyses to help building owners, architects, and engineers – and retired from that firm in 2014. I am a Professor Emeritus in the Fluid Mechanics and Wind Engineering Program of the Department of Civil Engineering at Colorado State University in Fort Collins, Colorado. I am also a licensed professional engineer and a member of a number of professional engineering organizations. A complete list of my memberships, publications, professional history, experience in legal cases and other information related to my qualifications can be found in Appendix 1.

I have more than 45 years' experience in wind-engineering applications and research. During that time, I have evaluated over 1,000 buildings and structures for wind loads (local cladding pressures and/or frame forces and moments) primarily through wind tunnel testing;

evaluated pedestrian wind climate for many of these buildings; measured forces on numerous other structures including towers, stacks, bridges and solar collectors; defined snow loads for many structures; investigated pollutant dispersion from buildings and stacks; determined heat transfer rates from structure surfaces in the wind; helped define siting criteria for wind energy projects as well as wind tunnel and field testing to assist in the development of wind turbine technology; and developed meteorological analysis procedures for power line rating. My research in wind engineering includes statistical characteristics of fluctuating pressures, adjacent building effects, wind flow around and downwind of buildings, natural ventilation, transport of snow and sand, and siting criteria for anemometers. I spent three years developing liquid rocket propulsion systems for the U.S. Army Missile Command. I have also participated on the national committee which writes the national wind load standard ASCE 7, served on the Board of Directors of the Wind Engineering Research Council, and am currently the chairman of an American Society of Civil Engineers Standards committee on wind tunnel testing of structures.

Q. Have you previously submitted testimony before the California Public Utilities Commission?

A. Yes. I submitted testimony on behalf of San Diego Gas & Electric Company ("SDG&E") in connection with the Commission's investigations into the Witch/Rice Fires (I.08-11-006) and the Guejito Fire (I.08-11-007).

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your direct testimony?

A. I have been asked by SDG&E to analyze the wind conditions at the time and location of each of the three wildfires that are part of this proceeding – the Witch Fire,[1] the Guejito Fire,[2] and the Rice Fire.[3] More specifically, I have been asked to determine the mean and gust wind speeds, as well as the wind direction, at the time and location of the initiation of each of the three wildfires in October 2007.

Q. Please summarize the conclusions of your wind analysis.

A. The wind speeds and directions for each of the three fires at time of fire initiation are

Fire	**Mean Wind** Speed, mph	**Peak 3-Second Gust** Speed, mph	**Wind Direction** degrees clockwise from North	**Height** above ground for cited speed, feet
Witch	56	78-87	83	66 ft (line height)
Guejito	34	59-68	72	24 ft (line height)
Rice	37	70-75	68	82 ft (tree branch level)

Q. How is the remainder of your testimony organized?

A. In Section III, I present the methodology that I employed to analyze the wind conditions associated with the initiation of each of the three wildfires in October 2007 and set forth my conclusions about wind speeds and gusts at the time and location of initiation of each wildfire. In Section IV, I describe the steps I took to corroborate my analysis. In Section V, I review and

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1 It is my understanding, based on my review of a California Department of Forestry and Fire Protection ("Cal Fire") Investigation Report, that Cal Fire concluded that the Witch Fire began on October 21, 2007 near Highway 78, west of Santa Ysabel, CA. More specifically, Cal Fire determined that the Witch Fire began between Pole # 416675 and Pole # 416676 on Tie Line # 637.

2 It is my understanding, based on my review of the Cal Fire Investigation Report, that Cal Fire concluded that the Guejito Fire began on October 22, 2007 in the river bottom of the Guejito Creek in the San Pasqual Valley.

3 It is my understanding, based on my review of the Cal Fire Investigation Report, that Cal Fire concluded that the Rice Fire began on October 22, 2007 off Rice Canyon Road near Fallbrook, CA. More specifically, Cal Fire determined that the Rice Fire began under a 12kV distribution line between Pole # 112340 and Pole # 213072.

assess certain recorded data about wind conditions at several locations in San Diego County in October 2007.

III. METHODOLOGY FOR ASSESSMENT OF WIND CONDITIONS

Q. How did you develop your own conclusions about the wind speeds and wind gusts at the location of initiation of each of the three wildfires?

A. To obtain wind conditions at each fire initiation location, I used a two-pronged approach. First, mesoscale model simulations were run to examine the winds near the surface from a regional perspective. Second, the local terrain was modeled and location-specific winds were measured in an atmospheric boundary layer wind tunnel to determine the impact that the terrain had on the wind flow. The results were then combined to generate a reasonable estimate of the winds at the fire initiation location and height of the power lines at each location.

Q. What is mesoscale modeling?

A. The Weather Research and Forecasting ("WRF") model is a widely-used numerical model developed under a collaborative partnership between the National Center for Atmospheric Research ("NCAR"), the National Oceanic and Atmospheric Administration ("NOAA"), the National Centers for Environmental Prediction ("NCEP"), and other institutions and organizations. It is a complex computer program that simulates the physical processes of the atmosphere. It is initiated using gridded atmospheric data appropriate for the time period to be simulated. Two such datasets that are often used include the National Centers for Environmental Prediction ("NCEP") Rapid Update Cycle ("RUC") analysis and the NCEP North American Regional Reanalysis. Both datasets are publicly available.

Q. What does the term "mesoscale" mean?

A. Mesoscale refers to the physical size of the weather processes simulated in the WRF model. These weather systems are on the order of a few kilometers to several hundreds of kilometers in size, and fall between synoptic scale weather systems (approaching half the size of the US) and microscale (or turbulence scale) systems.

Q. How was mesoscale modeling performed in your investigation?

A. Four different simulations were run for the Santa Ana[4] wind event over the timeframe of 00:00 GMT October 19 (16:00 PST October 18) to 00:00 GMT October 25 (16:00 PST October 24) 2007 for each of the three wildfires. Each run used different parameterization schemes as outlined in Appendix 18, and nested grids with grid size as small as 1 kilometer. This was done to assess the impact of these schemes on the variability of predicted wind flow, and to select a consistent basis for evaluation of wind speeds.

Q. You also indicated that you performed wind tunnel testing. Why was that necessary?

A. The fire initiation location for each of the three fires is characterized by complex terrain. The effects of larger scale terrain features are fully represented in the simulation. Therefore, to determine the impacts the local terrain has on the wind at the fire initiation location, a wind tunnel simulation was conducted.

Q. How were the wind tunnel tests performed?

A. The tests were conducted in Boundary Layer Wind Tunnel 1 in the CPP, Inc. laboratory located in Fort Collins, CO. This wind tunnel was specifically designed to model atmospheric winds including winds over terrain. A detailed discussion of the simulation methodology can be found in Appendix 2**,** References 8-12.

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[4] Santa Ana winds are wide area wind storms in Southern California that originate from a high pressure system in the Great Basin of Nevada, Utah and Idaho and a low pressure system off the west coast of Southern California or Mexico. These high speed winds flowing "downslope" from mountains occurs in the lee of mountains around the world, each typically with a local name (for example, the "Chinook" in Colorado, "Foehn" in Europe).

The terrain surrounding the initiation point for each fire was modeled at a scale of 1:5000, within the range suggested in Appendix 2, References 11-12, on a test section (or turntable) 9.3 feet (2.8 meters) in diameter. This represents a region 8.8 miles (14.1 kilometers) in diameter at full scale. A round turntable is used to permit the approach wind direction to be varied by rotating the turntable. Terrain was also modeled upwind of the test turntable to ensure the boundary layer was fully developed and representative of flow over this terrain. Specifications of the wind tunnel and experimental setup are provided in Appendix 19. The scaled terrain and test turntable are shown in Appendix 3. For the Witch Fire location, wind profiles were measured for three different approach flow directions (45°, 67.5°, 90° east of north) and eight heights, as detailed in Appendix 19. For the Guejito Fire location, wind profiles were measured for three different approach flow directions (22.5°, 45°, and 67.5° east of north) and eight heights, as detailed in Appendix 19. For the Rice Fire location, wind profiles were measured for four different approach flow directions (0°, 22.5°, 45°, and 85° east of north) and eight heights, as detailed in Appendix 19.

Q. How were the tunnel velocity measurements made?

A. The AeroProbe velocity measurement probe is shown in Appendix 3g. The probe measures fluctuating pressure at each of 5 holes on the probe tip. This permits simultaneous measurement of the magnitude and direction of velocity at each instant in time. A time series of these velocity magnitudes were measured at 250 samples per second model scale (equivalent to approximately 4.4 seconds between samples at full scale) to provide a time series of velocities.

Q. How was the WRF simulation integrated with the wind tunnel data?

A. For each fire ignition location, four WRF runs were evaluated for integration with the wind tunnel data as shown in Appendix 4. For the Witch and the Guejito simulations, Run 2 was selected for integration; for the Rice simulation, Run 1 was selected. These selections were within the band of runs closely grouped in speed at the time of fire initiation. Runs which were non-representative in comparison with bands of closely grouped runs were not used. Excluding two non-representative runs, all other runs were within about 5 percent of their average.

Winds at 820 feet (250 meters) above ground were selected to match the wind tunnel and mesoscale model data to adjust the WRF surface layer wind speeds to account for terrain effects. I selected 250 meters for the match height between mesoscale model and wind tunnel because it is above the immediate influence of local terrain and below the height where features not represented in the wind tunnel become important such as turning of wind direction with increasing altitude.

The wind tunnel data was normalized to its 250 meter speed, and then multiplied by the 250 meter wind speed observed in the selected WRF simulations at time of fire ignition or at time of peak wind speed. The resulting wind speed profiles were fit to a power law profile:

$$U_z = U_{ref}\left(\frac{z}{z_{ref}}\right)^n$$

From this relationship the associated surface roughness (Z_0) was determined, and was further used to calculate the wind speed at the appropriate line height for each site.

For the Witch Fire, a line height of 66 feet (20 meters) was assumed.[5]

For the Guejito Fire, a line height of 24 feet (7.3 meters) was assumed.[6]

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[5] I selected 66 feet line height because we had an available survey that showed the elevations of the transmission line and ground between poles Z416675 and Z416676 near the ignition point. I selected 3250 feet as the line height and 3184 feet as ground elevation. The difference is 66 feet (3250-3184).

[6] I selected 24 feet line height because we had an available survey that showed elevations of the distribution line and telecommunications line above ground near the fire initiation point. The ground level in the middle of the wash under the fire initiation point has an elevation of 413 feet. In the survey

For the Rice Fire, the height of the broken tree branch at 49 feet (15 meters) above displacement height (82 feet above ground level) was assumed.[7]

This process was performed for the WRF wind speeds at the time of fire initiation[8] and at the time of the peak 250 meter wind speed[9] with respect to each of the three wildfires. Appendix 5 shows the WRF profile compared to the wind tunnel profile adjusted to the WRF 250 m speed for the initiation time. Likewise, Appendix 6 compares the profiles at the time of the peak 250 m wind speed. The difference between the profile shapes of the wind tunnel and WRF simulations demonstrates the reason that the wind tunnel data is needed to define the near-ground detailed profile shape.

The resulting power law coefficient (n) and surface roughness (Z_0) values were found to be as follows with n having no units and Z_0 having units of meters:

Witch Fire: n = 0.12 and Z_0 = 0.02; these are consistent with terrain at the site.

Guejito Fire: n = 0.23 and Z_0 = 0.8; these are consistent with terrain at the site.

Rice Fire: n = 0.24 and Z_0 = 0.8; these are consistent with terrain at the site.

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detail drawing showing the height of the lowest distribution line, the height is about 439 feet. The line is thus 24 feet (439-415).

[7] I selected 49 feet above the effective ground level (defined as the displacement height within the tree canopy where the wind profile above the canopy would approach zero when speed is extrapolated from above the canopy down into the canopy). Based on photographs of the site, it was apparent that the line ran below the tree canopy height. Therefore, I used 15 meters (49 feet) above displacement height, or roughly 82 feet above ground (at about the height of the tree canopy) to assess wind speeds, without needing to make assumptions for shielding at line height due to the trees. This reasonably approximates the wind affecting the upper part of the sycamore tree FF 1090 whose broken branch contacted the line.

[8] For the Witch Fire, I used 11:29 am PST on October 21, 2007 (12:29 pm PDT) as the time of fire initiation. For the Guejito Fire, I used 00:00 am PST on October 22, 2007 (1:00 am PDT) as the time of fire initiation. For the Rice Fire, I used 3:16 am PST on October 22, 2007 (4:16 am PDT) as the time of fire initiation.

[9] For the Witch Fire, I used 5:40 am PST on October 22, 2007 (6:40 am PDT) as the time of peak 250 meter wind speed. For the Guejito Fire, I used 6:25 am PST on October 22, 2007 (7:25 am PDT) as the time of peak 250 meter wind speed. For the Rice Fire, I used 6:00 am PST on October 22, 2007 (7:00 am PDT) as the time of peak 250 meter wind speed.

Q. How was wind direction accounted for between WRF and wind tunnel data?

A. The WRF wind direction data was used to adjust the wind tunnel data to account for terrain effects for each fire site at times of ignition and maximum 250 meter speed.

For the Witch Fire ignition location, the WRF data resulted in a 250 m wind direction of 82.7°. Therefore, wind directions measured in the wind tunnel at the closest measurement direction (90°) were decreased by 7.3 degrees. Appendix 7 shows the wind direction profiles at times of ignition and maximum speed. It was found that the wind direction was influenced by terrain at the surface on the order of 1-2° in comparison to the direction at 250 meters.

For the Guejito Fire ignition location, the WRF data resulted in a 250 m wind direction of 72.4°. Therefore, wind directions measured in the wind tunnel at the closest measurement direction (67.5°) were increased by 4.9 degrees. Appendix 8 shows the wind direction profiles at times of ignition and maximum speed. It was found that the wind direction was influenced by terrain at the surface on the order of 5-10 degrees in comparison to the direction at 250 meters.

For the Rice Fire ignition location, the WRF data resulted in a 250 m wind direction of 68.2°. Therefore, wind directions measured in the wind tunnel at the closest measurement direction (85°) were decreased by 16.8 degrees. Appendix 9 shows the wind direction profiles at times of ignition and maximum speed. It was found that the wind direction was influenced by terrain at the surface on the order of 2-3° in comparison to the direction at 250 meters.

Q. How did you analyze wind gusts?

A. For analysis of wind speeds, it is useful to estimate the magnitude of expected maximum gust relative to the mean speed. This value is known as the Gust Factor = Vgust / Vaverage. For this purpose, we used a methodology as defined in Appendix 2, References 6-7. This analysis procedure can account for changes in effective ground roughness length, Z_0, upwind of a site.

This procedure is also useful for estimating a peak gust speed based on output from a mesoscale model simulation.

Exercising this analysis at each fire initiation site yielded the information in Appendix 10. Input information used to generate Appendix 10 includes wind-tunnel profile measurements to define the effective roughness length Z_0 and mesoscale model output to determine effective mean wind speed and direction. Z_0 is a standard length parameter in meteorology used to describe the effect of surface features such as trees or buildings on the wind speeds. By effective mean wind speed, I mean an average over 10 minutes to one hour. A range of mean velocity averaging times is shown on the abscissa of Appendix 10 while the averaging times for various peak gusts are shown in curves in the graphs. The Gust Factor is read from the ordinate. For mean velocity averaging times of 10 minutes to one hour, the gust factor for a 3- second gust ranges from (1) 1.4 to 1.5 (Witch); (2) 1.9 to 2.1 (Guejito); and (3) 1.8 to 2.0 (Rice). In other words, we expect the peak 3-second gust to be about: (1) 1.5 times the effective mean speed (Witch); (2) 2 times the effective mean speed (Guejito); and (3) 2 times the effective mean speed (Rice), respectively.

Q. What conclusions did you reach in your analysis regarding the wind speeds at the time and location of the initiation of each fire?

A. <u>Witch Fire</u>: Based on my analysis, I found that – at line height of 20 meters (66 feet) above the ground, the mean wind speed at the time of fire initiation was 25 meters per second (56 mph). Winds were gusting between 35 meters per second (78 mph) and 39 meters per second (87 mph).

<u>Guejito Fire</u>: Based on my analysis, I found that – at line height of 7.3 meters above ground (24 feet), the mean wind speed at the time of fire initiation was 15.1 meters per second

(34 mph). Winds were gusting between 30 meters per second (68 mph) and 27 meters per second (59 mph).

Rice Fire: Based on my analysis, I found that – at tree branch height of 25 meters above ground (82 feet), the mean wind speed at the time of fire initiation was 16.5 meters per second (37 mph). Winds were gusting between 31 meters per second (70 mph) and 34 meters per second (75 mph).

IV. CORROBORATION ANALYSIS

Q. Have you undertaken any analysis to corroborate the results of your methodology?

A. Yes I have.

Q. Please describe that analysis.

A. I demonstrated that the same methodology used to determine wind speeds at the time of ignition at the Witch, Guejito, and Rice fire sites can predict recorded wind speeds at Ramona Airport during the storm. Four WRF runs were performed for the Ramona Airport ASOS[10] station using the same run parameters as for the three fire sites. A wind tunnel study was performed that measured the vertical wind speed profile at the modeled site. The results for wind speed and direction (clockwise from true north) for the four runs are shown in Appendix 11. Note that the Ramona ASOS was out of service during a portion of the storm. Some of the run-to-run variability is due to large scale gust structures that are included in the WRF simulation.

Both the city of Ramona and hangars at the airport were directly upwind for the wind direction during the high wind speed portion of the storm, Appendix 12; both of these elements will decrease wind speeds at the ASOS station. Since the roughness of the city and hangars

[10] ASOS stands for Automated Surface Observation System, a National Weather Service first order (their most accurate) meteorological station. It records wind speeds at 10 m (33 feet) above ground.

cannot be fully represented in WRF, corrections to the WRF wind speeds were made for both elements. Adjustments to the WRF wind speed included decreases of 1.0 percent due to the difference between WRF and wind tunnel profile, 7.3 percent for the city and 17.7 percent for the hangars. The city correction was made using Appendix 2, References 6 and 7. Correction for the hangars was made using Appendix 2, References 4 and 13.

References 6 and 7 represent a calculation method for the impact of roughness such as houses and trees on wind speeds in the atmospheric boundary layer. They are used extensively in wind engineering; an example is the American Society of Civil Engineers for the national wind load standard ASCE 7. Reference 4, and explanatory Reference 13, is used by the Federal Aviation Administration for siting anemometers (wind speed measurement instruments) for wind shear detection for U.S. airports. It is increasingly being used internationally for wind shear detection as well.

The largest 3-second gust measured at Ramona Airport during the storm was 55 mph. Based on the ESDU procedure used to estimate the 3-second gust from the WRF simulations, the gusts are predicted to be between 60 and 76 mph, or 9 to 38 percent higher than the actual measurements. The validation exercise is dependent on the overall match between ASOS and WRF wind speeds and directions as shown in the graphs of Appendix 11, as well as the comparison of peak gusts. This validation exercise supports my methodology.

In addition, a research report authored by Dr. Robert Fovell (Appendix 2, Reference 17) discusses WRF runs for the same October 21-22, 2007 storm and contains predictions of wind speeds at the Witch Fire site, including a validation exercise at Ramona for that storm. His validation at Ramona was favorable, and his predicted maximum gust wind speed at the Witch site was 96 mph. If my wind tunnel methodology is not used to adjust Fovell’s speed, the percentage difference between his predicted speed at the Witch fire site and mine is 10 to 18 percent; this is a reasonable comparison. If my wind tunnel adjustment methodology is included, the adjusted Fovell speed is 75 mph, within 4 to 14 percent; this is also a reasonable comparison.

My validation for Ramona Airport wind speeds and favorable comparison to an independent assessment of the Witch site wind speeds by Dr. Fovell provides confidence for the predicted wind speeds at the three fire sites Witch, Guejito, and Rice as presented earlier.

V. RELIABILITY OF WIND DATA FROM SITES IN THE REGION

Q. Is there existing, contemporaneous data of the actual wind conditions from the time and location of initiation of each of the three wildfires?

A. No, there is not existing, contemporaneous data that specifies the actual wind conditions at the time and location of initiation for the three wildfires. There is existing, contemporaneous data regarding wind conditions at other locations in San Diego County, specifically RAWS and ASOS sites.

Q. What is a RAWS site?

A. A Remote Automatic Weather Station ("RAWS") site is a weather station used by forest fire fighters to alert for fire prone weather conditions, and to provide guidance to fire managers for predicting active fire behavior. RAWS are also used for monitoring air quality and for research. RAWS stations measure wind speed (using anemometers), direction, and other environmental variables.

Installation and operation of RAWS stations are guided by Appendix 2, Reference 5. Guidelines include wind speed and direction measurement at 20 feet above ground, placement within typical local terrain (for example within a forest if present), and placement at least one obstacle height away from the nearest upwind wind-blocking obstacle. While measurement frequency varies among stations, many RAWS stations measure a 10-minute mean once per hour plus the largest peak gust occurring during that hour. The peak gust may not be associated with the mean, since it might be measured outside the 10-minute mean measurement period.

Q. What is an anemometer?

A. An anemometer is an instrument that measures wind speed at a specified height above ground. It is often combined with an instrument to measure wind direction.

Q. How do RAWS anemometer installations compare to other standard anemometer installations?

A. RAWS follows siting and data requirements as discussed above. For standard anemometer installations, Appendix, References 1-3 define the requirements for anemometers based on internationally recognized standards set by the World Meteorological Organization ("WMO"). WMO standard anemometer locations are at 10 meters (33 feet) above ground and are placed in an environment that is as open and as free as possible from individual obstacle (examples include trees and buildings) interference, and to permit the measured data to be used to represent the surrounding area. Appendix 2, References 4 (Appendix 3) and 13 were developed by me and another investigator for the FAA to provide guidance on placement of anemometers when open fields without obstacles are not available (examples include forests and suburban areas). WMO requires recording a 10-minute mean speed once per hour plus the accompanying peak gust. Many stations report continuous back-to-back 10-minute segments.

Q. Does the RAWS requirement for an anemometer height of 20 feet and obstacle distance of one height cause difficulties in applying that data to locations away from the RAWS site?

A. Yes. Appendix 2, References 1, 2, 4 (Appendix 3) and 13 show that an anemometer must be placed 10-20 obstruction heights away to avoid serious interference. The RAWS requirement to place the anemometer only one obstacle height away from buildings or trees will normally cause a significant wind blockage, a decrease in mean wind speed, and an increase in gustiness (turbulence) that make the measurement applicable only to the immediate area around the anemometer. RAWS measurements cannot reliably be used to represent wind conditions at other sites.

This information suggests that many RAWS stations are poorly sited for wind data collection, according to the WMO standards (Appendix 2, References 1-3), FAA standards (Appendix 2, References 4 and 13) and Appendix 2, Reference 17 (that examined the RAWS sites near the Witch and Guejito fires). My professional experience also indicates this to be true. When siting an anemometer in areas where the WMO and FAA requirements cannot be met, which includes many RAWS locations, my approach to measure unobstructed wind flow is to increase the height of the anemometer to 1.5 to 2.0 times the shielding obstacle height. When it is necessary to evaluate speeds below obstacle height, a second anemometer is used on the meteorological tower at the desired height. Use of only one anemometer located below the shielding obstacle height prevents evaluation of shielding magnitude and prevents use of the data to represent geographical areas away from the anemometer site.

In addition to these issues, there are influences such as mountains, valleys, gorges, and other large terrain features that cause wind speeds to vary and which must be accounted for in using data from one site to represent wind conditions at another site. Accounting for these terrain influences is frequently difficult because simple evaluation methods are not available.

Q. Have you reviewed wind data from the RAWS and ASOS sites?

A. Yes. I have examined the wind blockage environment and data from the Julian, Pine Hills, Goose Valley, and Valley Center RAWS sites, as well as the Ramona Airport ASOS.

Q. What did you conclude based on that review?

A. For reasons outlined above, I concluded that the wind data produced at those locations was unrepresentative of actual wind conditions at the actual time and locations of initiation of each of the three wildfires. Thus, that wind data could not reasonably serve as a basis for a conclusion as to the wind speeds at the time and location of the initiation of each of the three fires. I explain the basis for that conclusion in greater detail below. As reflected in the discussion below, the primary problems with the RAWS wind data is that terrain factors and other obstructions (*e.g.*, trees) in the proximity of the RAWS sites influence the data that is collected by the anemometers, causing that data to show significantly lower wind speeds and gusts than what would have occurred in an open environment or at the fire sites.

A. Julian RAWS Site

Q. Please describe characteristic features of the Julian RAWS site.

A. For Julian – the nearest RAWS site to the location of initiation of the Witch Fire – there are trees and structures visible upwind that shield the anemometer. A Google Earth image annotated with the wind direction range at this station at the time of the Witch Fire initiation is shown in Appendices 13a and 13b. Photographs of the anemometer are shown in Appendices 13c to 13g. As shown in Appendices 13b, 13f, and 13g, the nearby trees are obstacles to the anemometer for fire initiation wind directions. The side-hill location of the anemometer as shown in Appendices 13e and 13f indicates an acceleration of winds coming from the northeast which would tend to counter the decrease in speeds from shielding, but how the accelerated and retarded speeds might balance is not known and cannot be easily determined. Appendix 13h shows the peak factor (peak gust divided by hourly mean) during the storm was about 2.0 compared to an expected peak factor of about 1.5 for flat open country, strongly indicating a decrease in wind speeds due to shielding, and invalidates the comparison to any of the fire sites. The Julian data is not suitable for direct comparison to any of the three fire sites.

B. Pine Hills RAWS Site

Q. Please describe characteristic features of the Pine Hills RAWS site.

A. The Pine Hills RAWS site location is shown in Appendices 14a and 14b, and photographs of the anemometer are shown in Appendices 14c to 14e. As shown in those appendices, there are three large trees upwind in the sector for winds blowing from the direction ENE (65°) to ESE (115°) during the storm event that partially shield the anemometer. This site exhibited gust factors (Appendix 14f) averaging about 3.0 to as high as 11 from October 19-24, 2007. Shielding from the large trees to the east is certainly the main contributor to those values. These high gust factors are compared to an expected peak factor of about 1.5 for flat open country, strongly indicating a decrease in wind speeds due to shielding, and invalidates the comparison to any of the fire sites. Wind speeds were likely significantly larger for an unshielded observer located even a few tens of feet to the north. The Pine Hills data is not suitable for direct comparison to any of the three fire sites.

C. Goose Valley RAWS Site

Q. Please describe characteristic features of the Goose Valley RAWS site.

A. The Goose Valley RAWS site location annotated with the wind direction range at this site at the time of the Witch Fire initiation is shown in Appendices 15a and 15b, and photographs of the anemometer are shown in Appendices 15c and 15d. The Goose Valley site location is slightly different from the location recorded in the official RAWS web site (as of May 2009), Appendices 15a and 15b. Trees are visible in the upwind direction (ENE) during the storm as shown in Appendix 15d, which will shield the anemometer. Gust factors were on average around 2.4 and as high as 8 from October 19-24, 2007, strongly indicating a decrease in wind speeds due to shielding, and invalidates the comparison to any of the fire sites. The Goose Valley data is not suitable for direct comparison to any of the three fire sites.

D. Valley Center RAWS Site

Q. Please describe characteristic features of the Valley Center RAWS site.

A. The Valley Center RAWS site location annotated with the wind direction range at this site at the time of the Witch Fire initiation is shown in Appendices 16a and 16b, and photographs of the anemometer are shown in Appendices 16c and 16d. The Valley Center site location is somewhat different from the location recorded in the official RAWS web site (as of May 2009), Appendices 16a and 16b. Trees are visible in the upwind direction, NE (45°) to ESE (115°), during the storm as shown in Appendices 16b and 16d, which will partially shield the anemometer for fire initiation wind directions. Gust factors were on average around 2.4 and as high as 7 from October 19-24, 2007, strongly indicating a decrease in wind speeds due to shielding, and invalidates the comparison to any of the fire sites. The Goose Valley data is not suitable for direct comparison to any of the three fire sites.

E. Ramona Airport ASOS Site

Q. Please describe characteristic features of the Ramona Airport ASOS site.

A. The Ramona Airport ASOS site location annotated with the wind direction range at this site at the time of the Witch Fire initiation is shown in Appendices 17a and 17b, and photographs of the anemometer (at 33 feet above ground) are shown in Appendices 17c and 17d. Also refer to Appendix 12 that shows the ASOS site annotated with the most common wind direction during the storm. The wind directions during the storm ranged from NE (50°) to ESE (110°), with a most common wind direction of 75 degrees (used in the validation exercise). The site is in a relatively open field, with airport hangars, and suburban area upwind. The gust factors averaged roughly 1.5, peaking at 2.4 from October 19-24, indicating an anemometer exposure close to open country but with disturbances indicating a somewhat reduced wind speed. Testimony for the validation exercise above showed reductions in mean wind speed from both the upwind city of Ramona and from upwind airport hangars. The validation exercise showed that the Ramona ASOS site had specific wind reduction effects different from the Witch, Guejito, and Rice fire sites and thus could not be used to directly determine wind speeds at any of the three fire sites.

VI. CONCLUSION

Q. Does this conclude your prepared direct testimony?

A. Yes it does.

APPENDIX 1

STATEMENT OF QUALIFICATIONS OF JON PETERKA

Principal, Jon Peterka Engineering LLC
Co-founder and President Emeritus, CPP, Inc., Wind Engineering Consultants, Fort Collins, Colorado.
Professor Emeritus, Fluid Mechanics and Wind Engineering Program, Department of Civil Engineering, Colorado State University, Fort Collins, Colorado.

EDUCATION

Ph.D.	Fluid Mechanics and Thermodynamics, Brown University, 1968
M.S., B.S.	Civil Engineering, Colorado State University, 1964, 1965

EXPERIENCE

More than 45 years' experience in wind-engineering applications and research. Evaluated over 1000 buildings and structures for wind loads (local cladding pressures and/or frame forces and moments) primarily through wind tunnel testing; evaluated pedestrian wind climate for many of these buildings; measured forces on numerous other structures including towers, stacks, bridges and solar collectors; defined snow loads for many structures; investigated pollutant dispersion from buildings and stacks; determined heat transfer rates from structure surfaces in the wind; helped define siting criteria for wind energy projects as well as wind tunnel and field testing for development of wind turbine technology; developed meteorological analysis procedures for power line rating; developed wind uplift model for asphalt shingles. He has performed forensic investigations of meteorological conditions and wind effects.

Dr. Peterka's work in wind engineering includes membership on the national committee which writes the wind load provisions of the national wind load standard ASCE 7, development of the non-hurricane wind hazard map for the national wind load standard, consulting for the FAA on aircraft wind shear, participation in a National Research Council report to the U.S. Congress on wind damage, and Board of Directors of the Wind Engineering Research Council. Chairman of ASCE 49, an ASCE Standard committee on wind tunnel testing of structures. Research in wind engineering includes statistical characteristics of fluctuating pressures, adjacent building effects, wind flow around and downwind of buildings, natural ventilation, transport of snow and sand, siting criteria for anemometers, wind loads on asphalt shingles. Other experience includes three years' experience in development of liquid rocket propulsion systems for the U.S. Army Missile Command.

PROFESSIONAL ACTIVITIES/AWARDS

Licensed Professional Engineer in Colorado, Florida, Texas, Oklahoma, and Mississippi. Organizational memberships include the American Society of Civil Engineers, American Association of Wind Engineers, American Society of Mechanical Engineers, American Institute of Aeronautics and Astronautics, and National Society of Professional Engineers. Professional committee activities within the American Society of Civil Engineers includes: ASCE-7 Wind Load Subcommittee, member (1985-present); Aerodynamics Committee, member (1978-2008), chairman (1984-1988); Task Committee on Microclimate of Buildings, member (1980-1983); Task Committee on Wind-Tunnel Testing of Structures, member (1981-1986, 1991-1994); Task Committee on Wind Forces on Solar Collectors, member (1982-1988); Task Committee on Mitigation of Severe Wind Damage, member (1985-1988); Task Committee on Modeling of

Blowing Snow and Sand, member (1985-1989); Committee on Wind Effects, member (1982-1985, 1987-1993); Executive Committee, Aerospace Division, member (1987-1992), chairman (1991); ASCE 49 Standards Committee on Wind Tunnel Testing (1993-present), chairman (1993-present). Other professional activity includes Secretary/Treasurer of the Wind Engineering Research Council (predecessor of the American Society of Wind Engineers) (1979-1985), and board of directors (1979-1989); National Research Council Panel on Wind Engineering (1987-1990). Honorary societies include Sigma Xi, Phi Kappa Phi, Sigma Tau and Chi Epsilon. Awards include two awards for excellence in teaching at Colorado State University; ASCE 1989 Aerospace Science and Technology Award; Wind Engineering Research Council 1990 Outstanding Wind Engineering Research Award; the ASCE 1999 Raymond C. Reese Research Prize; Engineering News Record Top 25 Newsmakers of 2006 award; American Society of Civil Engineers 2010 Cermak Medal; 2013 elected Fellow, American Society of Civil Engineers Structural Engineering Institute; 2014 elected Fellow, American Society of Civil Engineers.

An incomplete list of some specific activities related to Wind Hazard Assessment and Mitigation –

Developed an anemometer siting guide for the Federal Aviation Administration

Developed the 3-second gust wind map that permitted ASCE 7 national wind load standard to move from a fastest mile map to a gust map – awarded the 1999 ASCE Raymond C. Reese Research Prize

Developed a 3-second gust design wind map of the down-slope windstorm region of northeast Colorado for use in local building codes

Assessment of wind damage at the Limon Tornado site

Assessment of wind damage at the Pingree Park tornado site

Assessment of wind damage after Hurricane Andrew

Participated in a National Research Council report to Congress on Natural Hazards

Lead investigator to develop a Monte Carlo simulation for design level hurricane winds in Hawaii and Guam under NASA sponsorship

Developed risk analyses for clients for design against hurricanes and tornadoes

Participated in development of terrain-induced impacts for design against hurricane winds in Hawaii

Member of the ASCE 7 Wind Load Sub-committee that writes the national wind load standard ASCE 7, and that forms the basis for the wind load provisions for the IBC building code

Chairman of the ASCE 49 standards committee standard of practice for wind tunnel testing of buildings for design wind loads

Lead investigator in development of a wind uplift model for asphalt shingles, permitting the development of high-wind resistant shingles

Lead investigator to develop a wind uplift test for asphalt shingles for Underwriters Lab and ASTM

Advisory Committee for research project on asphalt shingles at University of Florida

Reviewer of submitted papers for Journal of Wind Engineering and Industrial Aerodynamics, Journal of Structural Engineering, and Wind and Structures

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Heaney, James P., Jon Peterka, and Leonard T. Wright, *Research Needs for Engineering Aspects of Natural Disasters*, Journal of Infrastructure Systems, Vol. 6, No. 1, (March 2000), pp. 4-14.

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PROFESSIONAL HISTORY – J.A. PETERKA

1959 – 1964	B.S. Civil Engineering, Colorado State University, Fort Collins, CO
1964 – 1965	M.S. Civil Engineering (Engineering Mechanics), Colorado State University, Fort Collins, CO
1965 – 1968	Ph.D. Engineering (Fluid Mechanics and Thermodynamics), Brown University, Providence, RI
1968 – 1970	1st Lt. And Capt. U.S. Army, Missile Development, Army Missile Command, Huntsville, AL
1970 – 1971	Research Engineer, Rocket Propulsion Laboratory, Army Missile Command, Huntsville, AL
1971 – 1976	Assistant Professor of Civil Engineering, Colorado State University, Fort Collins, CO
1976 – 1983	Associate Professor of Civil Engineering, Colorado State University, Fort Collins, CO
1983 – 1993	Professor of Civil Engineering, Colorado State University, Fort Collins, CO (½ time 1985 – 1993) Retired 1993. Emeritus status 1993-present.
1981 – 2008	Vice President, Cermak Peterka Petersen, Inc., Fort Collins, CO (called Cermak/Peterka & Associates, Inc. 1981 - March 1987)
2008 – 2014 February	President, Cermak Peterka Petersen, Inc., Fort Collins, CO Wind Engineering Consultants
2014 March – Current	Principal, Jon Peterka Engineering LLC; Wind Engineering Consultant

Wind Engineering – Years of Experience
1963 - 1965 (2 Years) M.S. level research in physical modeling of atmospheric winds and dispersion of pollutants.
1971 - 2015 (44 years) Research and applied studies in physical modeling of atmospheric winds; wind loads on buildings, bridges, stadia, arenas and towers; dispersion of pollutants; pedestrian wind environment; snow loads; wind structure downwind of obstacles; wind-tunnel instrumentation. Wind loads defined for over 1000 buildings; pedestrian wind evaluation for over 500 buildings; wind loads on numerous bridges, towers and stacks; dispersion measured for several power plant stacks and numerous laboratory or industrial buildings; analysis of meteorological data; forensic analysis of structures subject to extreme wind events.

Legal Cases with Deposition or Trial - Jon Peterka - 2005 - 2015

No.	Case	Year	Court	Case #	Lawyer	Activity
1	Chapoton v. State Farm Re- Hurricane Damage	2007	District Court for Southern District of Mississippi, Southern Division	1:06cv471	Dion Shanley -- Hickman, Goza & Spragins	Report Deposition
2	Willis v. State Farm Re- Hurricane Damage	2007	District Court for Southern District of Mississippi, Southern Division	1:06cv902	Dion Shanley -- Hickman, Goza & Spragins	Report Deposition
3	Gagne v. State Farm Re- Hurricane Damage	2007-2009	District Court for Southern District of Mississippi, Southern Division	1:06cv711	Doug Foster -- Webb, Sanders & Williams	Report Deposition
4	Luffey v. State Farm Re- Hurricane Damage	2007	District Court for Southern District of Mississippi, Southern Division	1:06cv901	Doug Foster -- Webb, Sanders & Williams	Report Deposition
5	Coca Cola Enterprises v. Carl E. Woodward, LLC Re- Hurricane Damage	2007-2009	24th Judicial District Court for the Parish of Jefferson State of Louisiana	635-290	Richard S. Vale Blue Williams, LLP New Orleans	Report Deposition
6	Public Utilities Commission of CA v. San Diego Gas & Electric Re- Witch & Rice Fires	2008-2009	California Public Utilities Commission	I.08-11-006	Jeffrey Boozell Quinn Emanuel Urquhart Oliver & Hedges, LLP Los Angeles	Written Testimony
7	Public Utilities Commission of CA v. San Diego Gas & Electric Re- Guejito Fire	2008-2009	California Public Utilities Commission	I.08-11-007	Jeffrey Boozell Quinn Emanuel Urquhart Oliver & Hedges, LLP Los Angeles	Written Testimony
8	James A. Clark, et al v. State Farm Re- Ames, IA Tornado	2008-2009	US District Court, Southern District of Iowa, Davenport Division	3:08-cv-18	Michael Weston Lederer, Weston, Craig, PLC Cedar Rapids	Report Deposition Trial
9	Texas Dept. Insurance v. Texas Windstorm Insurance Assoc. Re- Roofing Shingles	2010	State Office of Administrative Hearings, Austin, TX	SOAH 454-09-6187.C	Adam Schramek Fulbright & Jaworski LLP Austin, TX	Report Deposition Hearing
10	Public Utilities Comm. of CA v. Southern Calif. Ed. et al. Re- Malibu Canyon Fire	2009-2010	California Public Utilities Commission	I.09.01.018	Brian Cardoza Southern Calif. Edison	Report Written Testimony
11	Larimer County v. Neenan et al. Re: Snow Loads	2010-1011	District Court Larimer County State of Colorado	Civil Action 2008CV1258 Division 5A	Brett Godfrey Godfrey & Lapuyade Englewood, CO	Report Deposition
12	United States v. Sierra Pacific Industries, et al. Re: Moonlight Fire	2011-2012	Eastern District of California	Case No. 2:09-cv-02445 -KJM-EFB	Bill Warne Downey Brand Sacramento, CA	Report Deposition
13	CalFire v. Sierra Pacific Industries, et al. Re: Moonlight Fire	2012-2013	Superior Court of California County of Plumas	Case No. CV09-00205	Bill Warne Downey Brand Sacramento, CA	Report Deposition

Legal Cases with Deposition or Trial - Jon Peterka - 2005 - 2015

14	Yanez v. State Farm Re: Hurricane Ike Damage	2013	11th Judicial District Court, Harris County, TX	Cause No. 2009-71356	Brian M. Chandler Ramey, Chandler, Quinn & Zito, Houston, TX	Report Trial
15	Fuentes v. State Farm Re: Hurricane Ike Damage	2013	11th Judicial District Court, Harris County, TX	Cause No. 2010-61039	David V. Jones Jones, Andrews & Ortiz San Antonio, TX	Report Deposition Trial
16	Beasley v. State Farm Re: Hurricane Ike Damage	2013	11th Judicial District Court, Harris County, TX	Cause No. 2010-69039	David V. Jones Jones, Andrews & Ortiz San Antonio, TX	Report Deposition
17	Lover v. State Farm Re: Hurricane Ike Damage	2013	11th Judicial District Court, Harris County, TX	Cause No. 2010-15815	Grady Cayce Martin, Disiere, Jefferson & Wisdom Houston, TX	Report Deposition
					Updated 2015-03	

APPENDIX 2

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[2] World Meteorological Organization, 2008: *Guide to Meteorological Instruments and Methods of Observation*, *Part I Chapter 5: Measurement of Surface Wind.* WMO-No. 8, Geneva.

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[5] National Wildfire Coordinating Group, 2008: *NWCG Fire Weather Station Standards.*

[6] ESDU (1993a) Strong winds in the atmospheric boundary layer, Part 1: mean hourly wind speeds, ESDU Report 82026, ESDU International.

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[14] CALFIRE Witch Fire Report (2008), California Department of Forestry and Fire Protection, Investigation report, Incident 07-CA-MVU-10432, Section 6, page 8.

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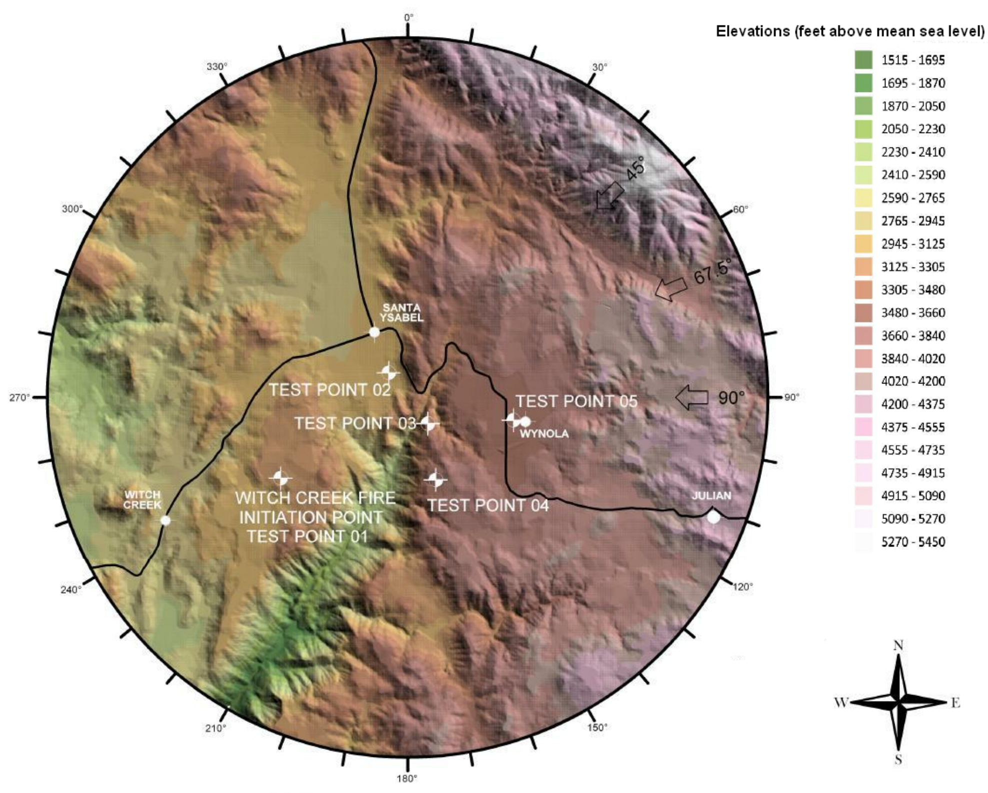
[16] CALFIRE Rice Fire Report (2008), California Department of Forestry and Fire Protection, Investigation report, Incident 07-CA-MVU-010502, Section 6, page 8.

[17] Fovell, R.G. (2012), Downslope Windstorms of San Diego County: Sensitivity to Resolution and Model Physics, 13th WRF Users Workshop, June 2012.

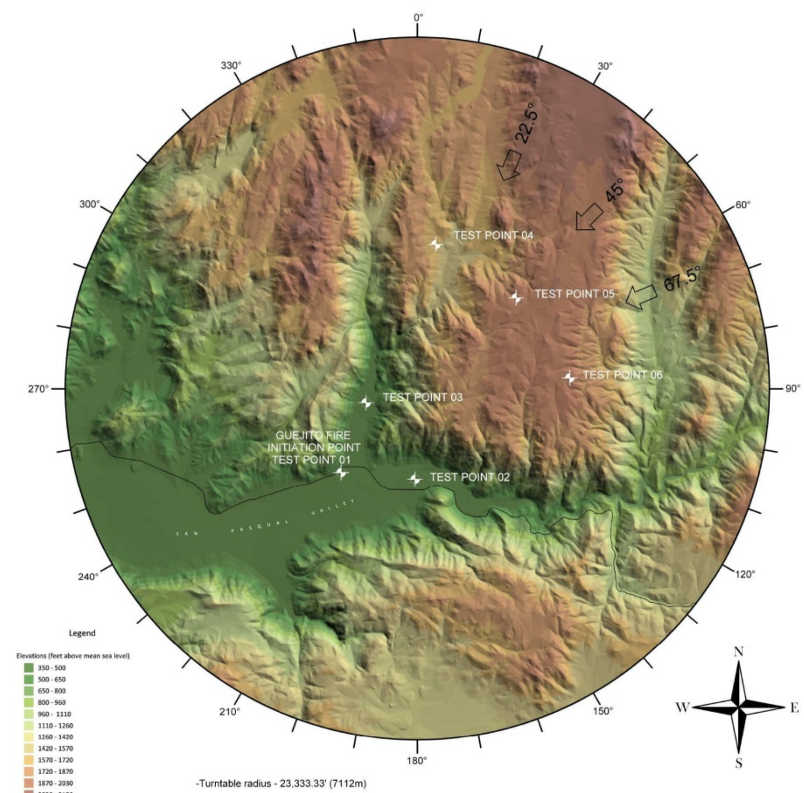
APPENDIX 3

Appendix 3a. Witch Creek wind tunnel model test turntable with upwind terrain.



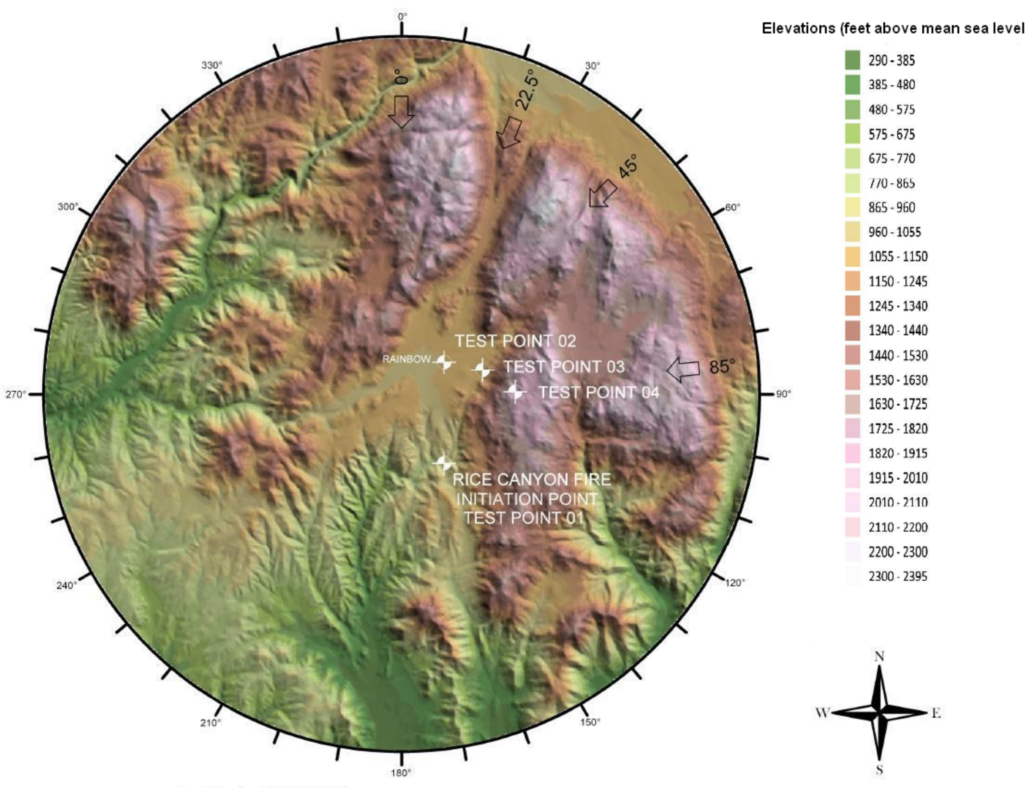
Appendix 3b. Witch Creek wind tunnel model test turntable.

Appendix 3c. Guejito wind tunnel model test turntable with upwind terrain.



Appendix 3d. Guejito wind tunnel model test turntable.

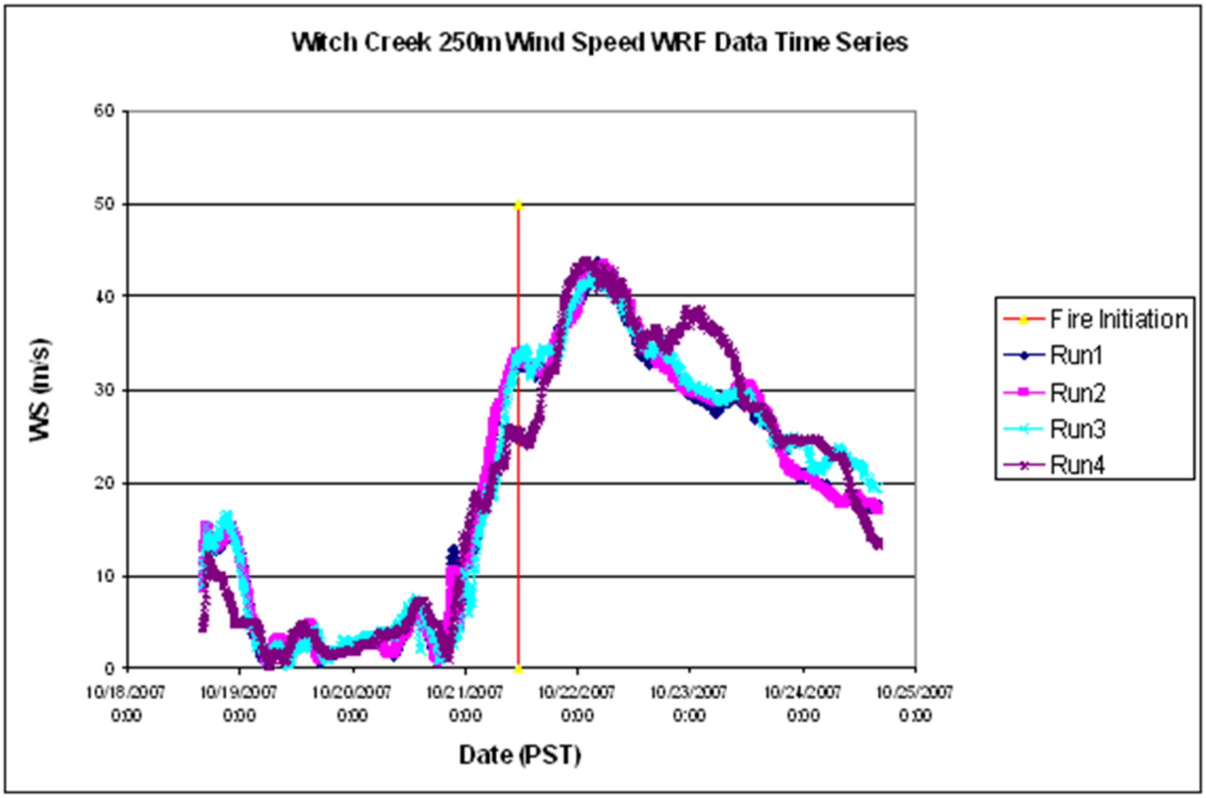
Appendix 3e. Rice Canyon wind tunnel model test turntable with upwind terrain.



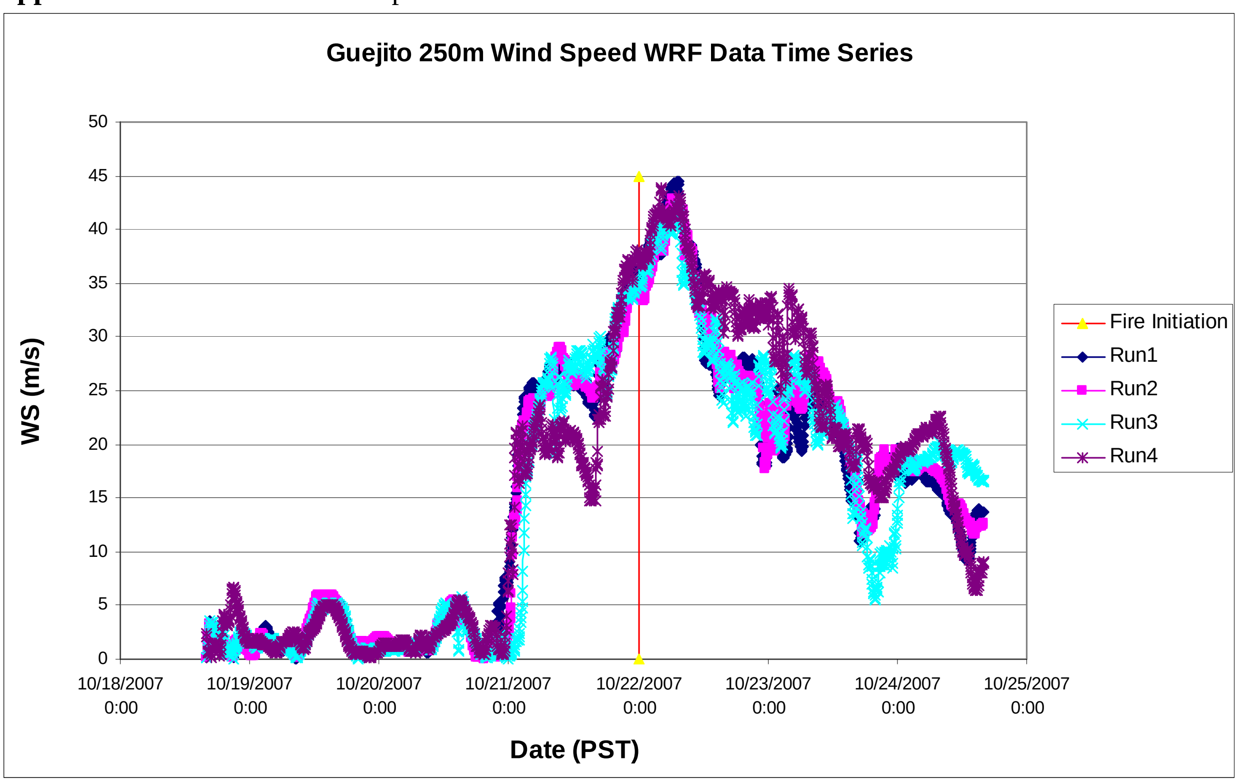
Appendix 3f. Rice Canyon wind tunnel model test turntable.

Appendix 3g. Measurement probe to sample 3 components of velocity on all three models.

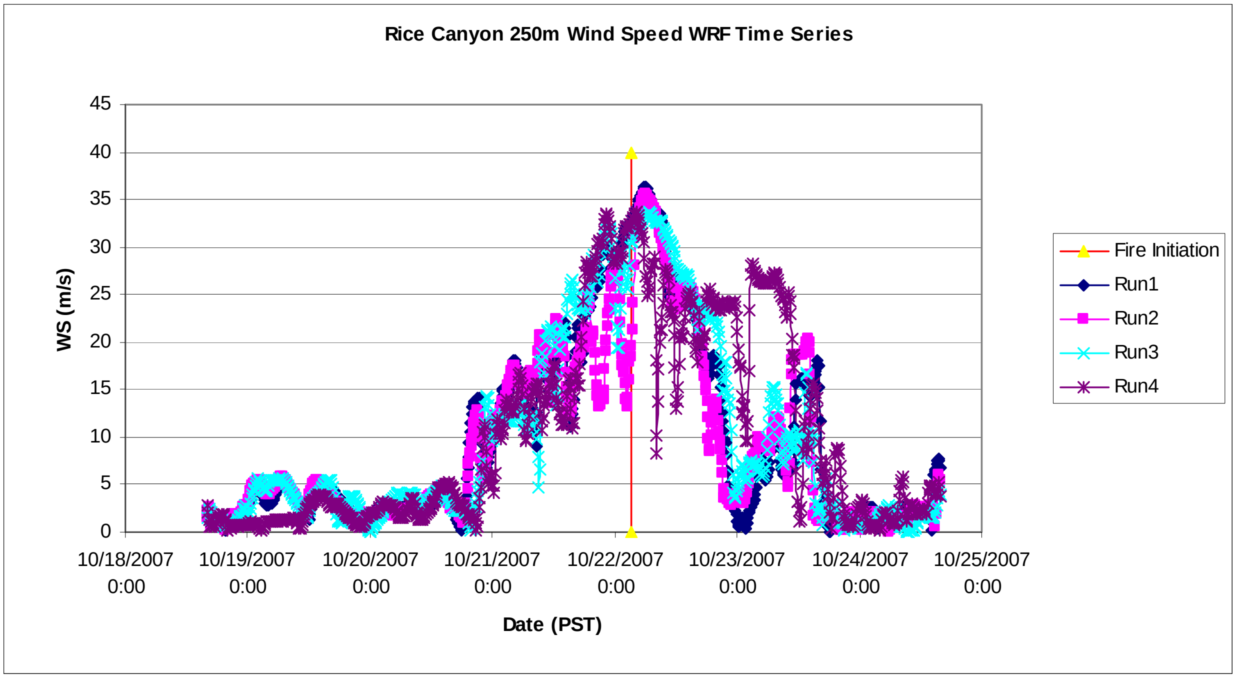
APPENDIX 4



Appendix 4a. WRF 250m wind speed time histories for all four runs at the Witch fire site.

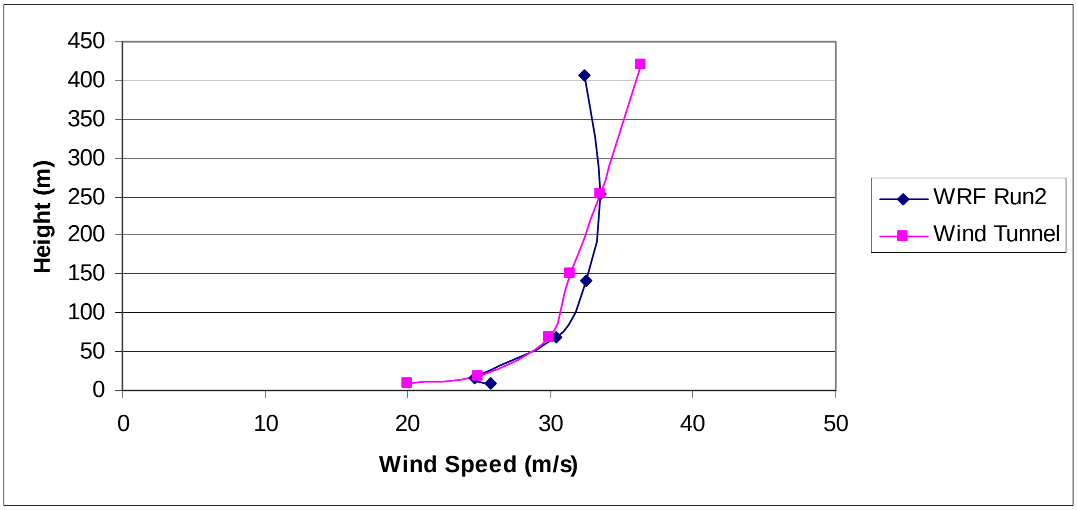


Appendix 4b. WRF 250m wind speed time histories for all four runs at the Guejito fire site.

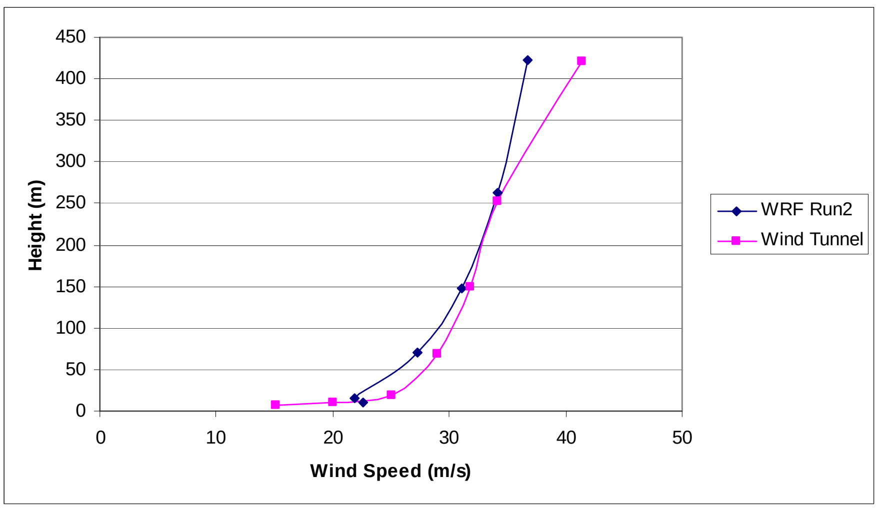


Appendix 4c. WRF 250m wind speed time histories for all four runs at the Rice fire site.

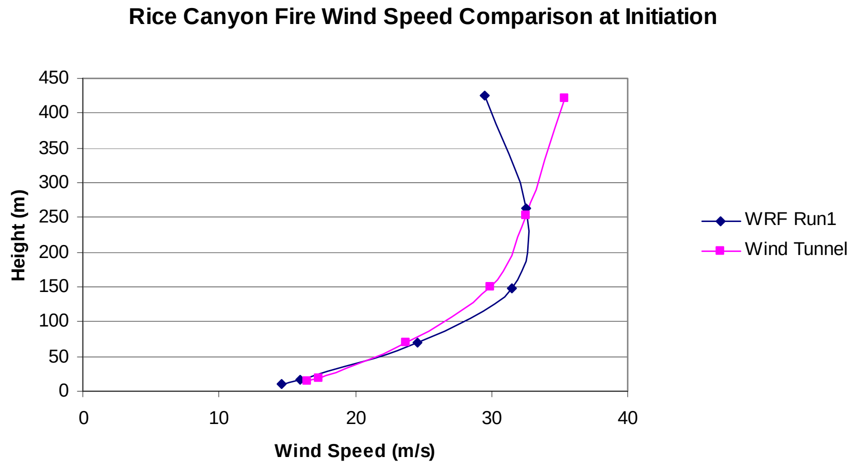
APPENDIX 5



Appendix 5a. WRF wind speed profiles at the Witch site for the fire initiation time.

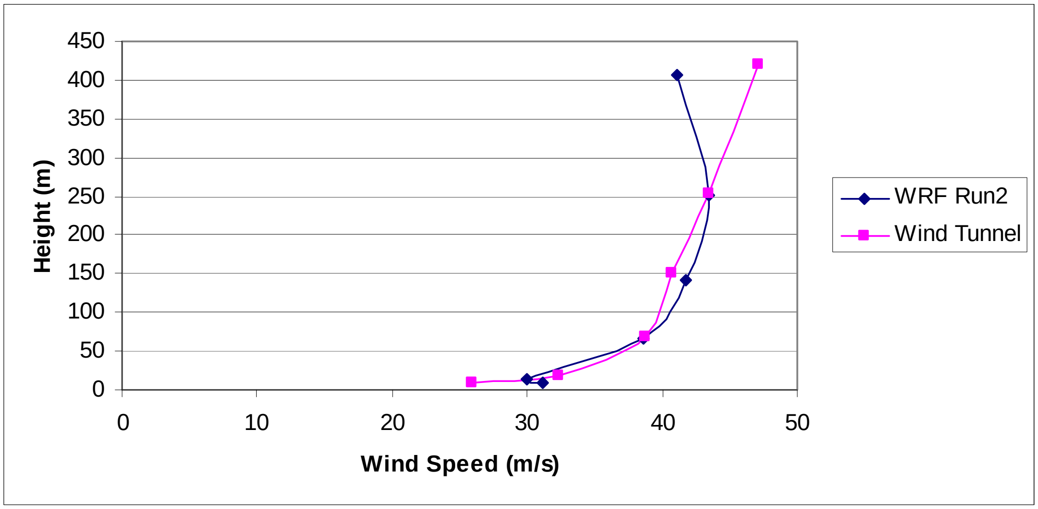


Appendix 5b. WRF wind speed profiles at the Guejito site for the fire initiation time.

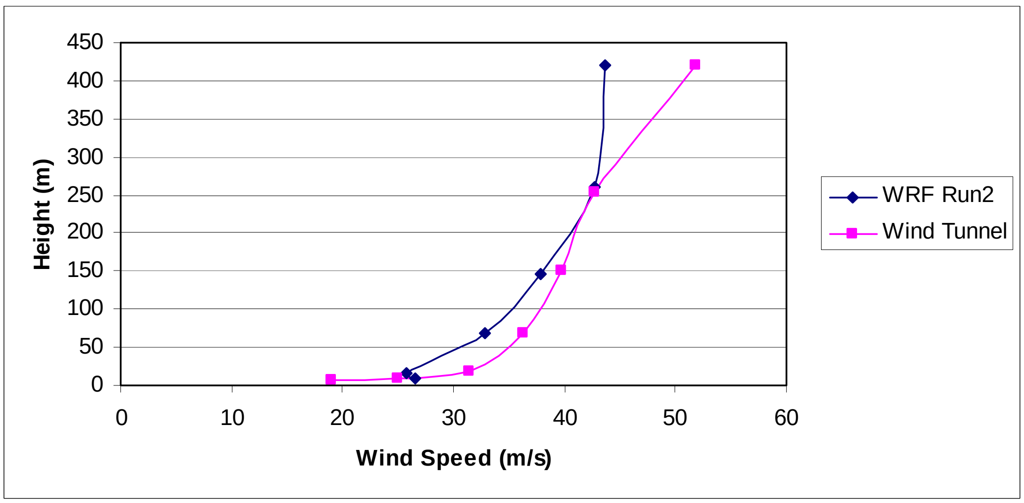


Appendix 5c. WRF wind speed profiles at the Rice site for the fire initiation time.

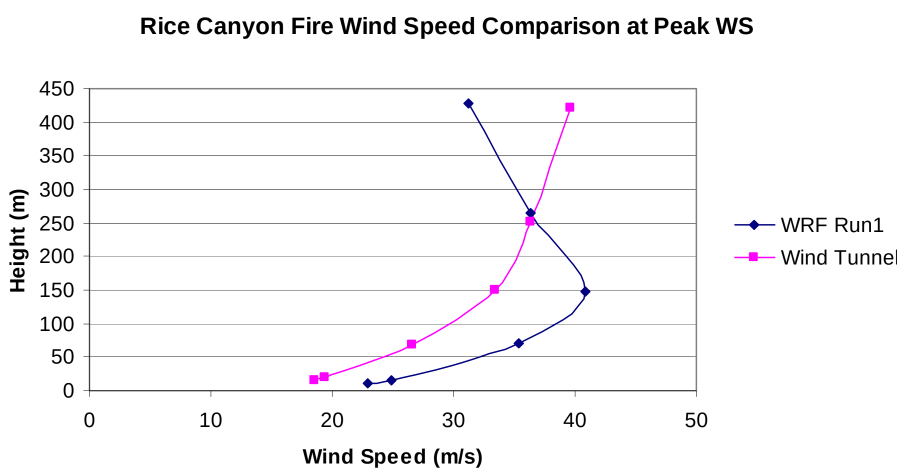
APPENDIX 6



Appendix 6a. WRF wind speed profiles at the Witch site for the time of maximum wind speed.

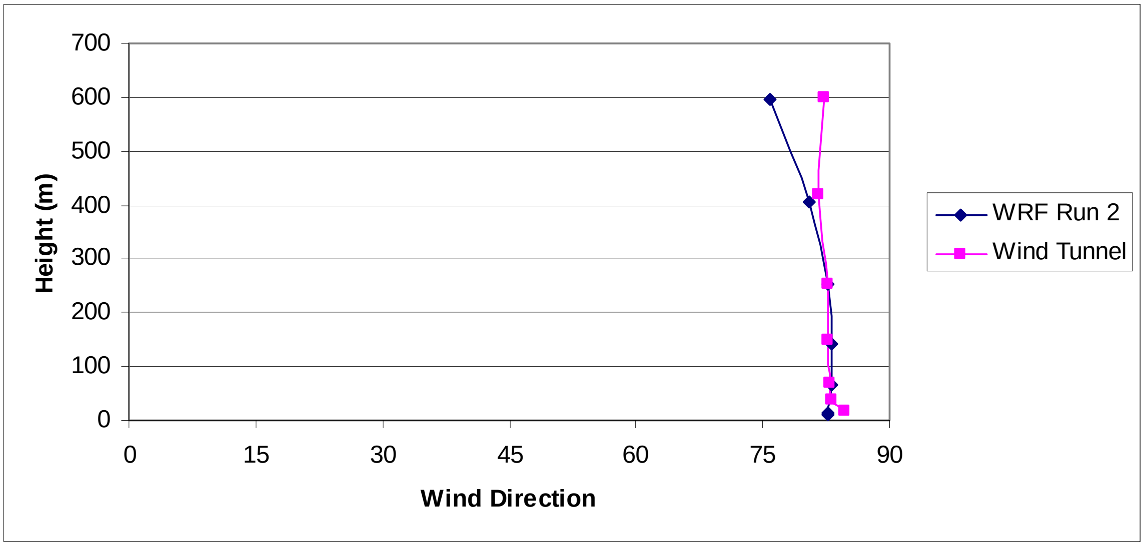


Appendix 6b. WRF wind speed profiles at the Guejito site for the time of maximum wind speed.

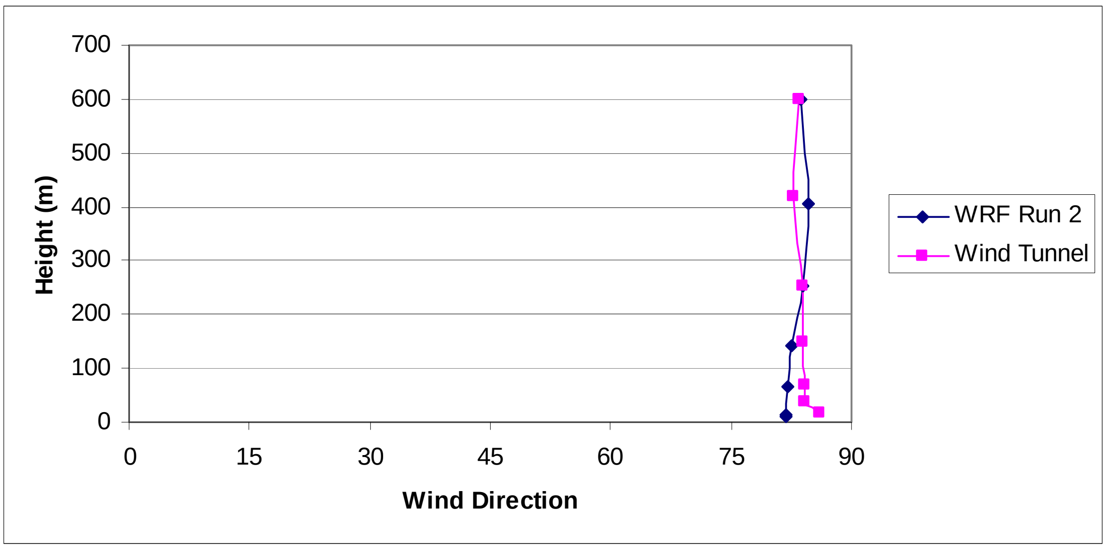


Appendix 6c. WRF wind speed profiles at the Rice site for the time of maximum wind speed.

APPENDIX 7

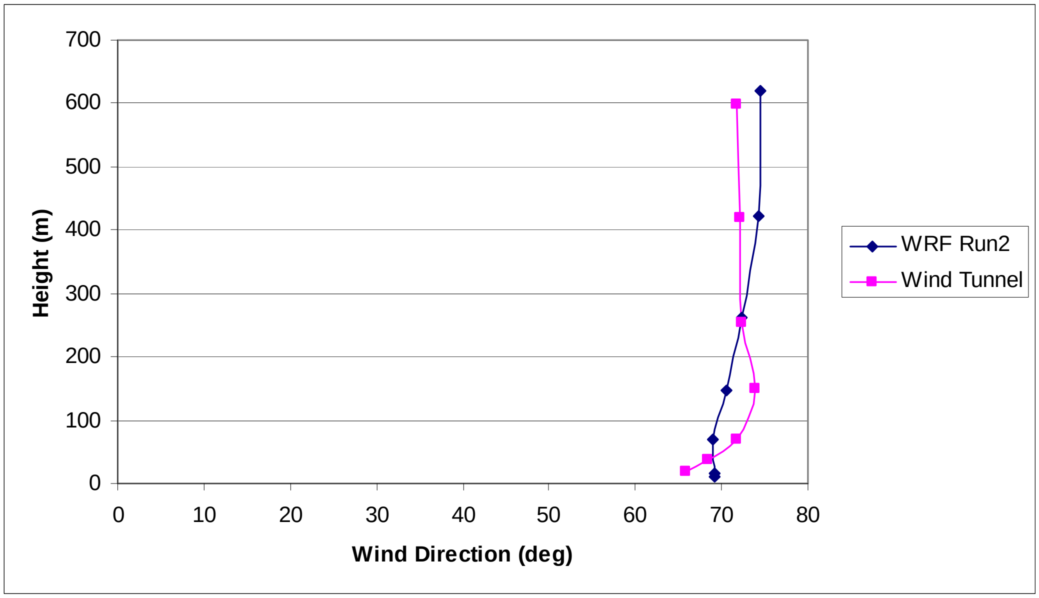


Appendix 7a. WRF wind direction profiles at the Witch site for the time of fire initiation.

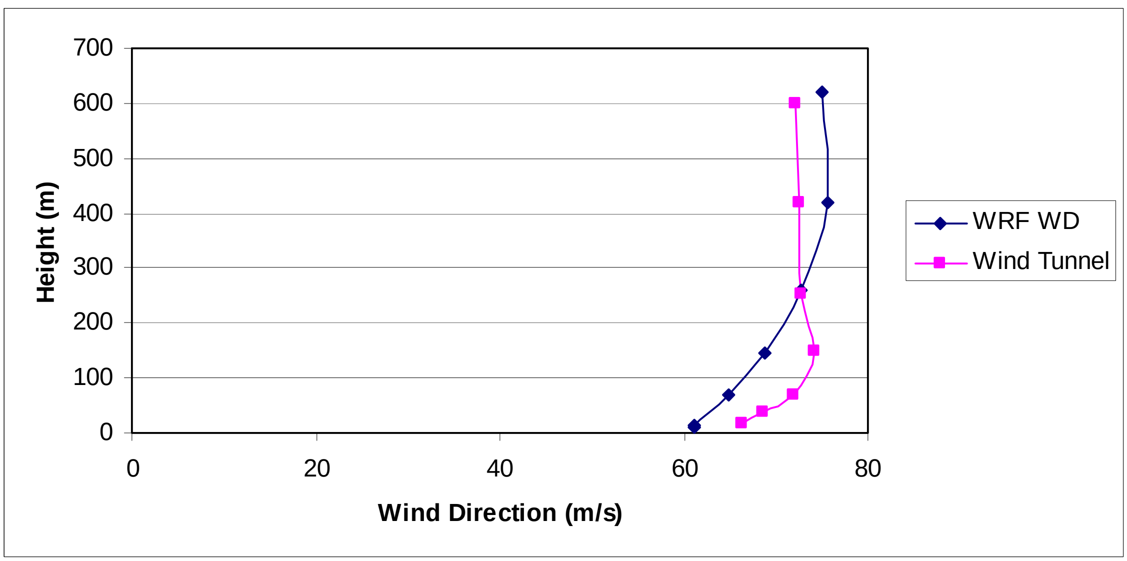


Appendix 7b. WRF wind direction profiles at the Witch site at time of maximum wind speed at 250 m.

APPENDIX 8

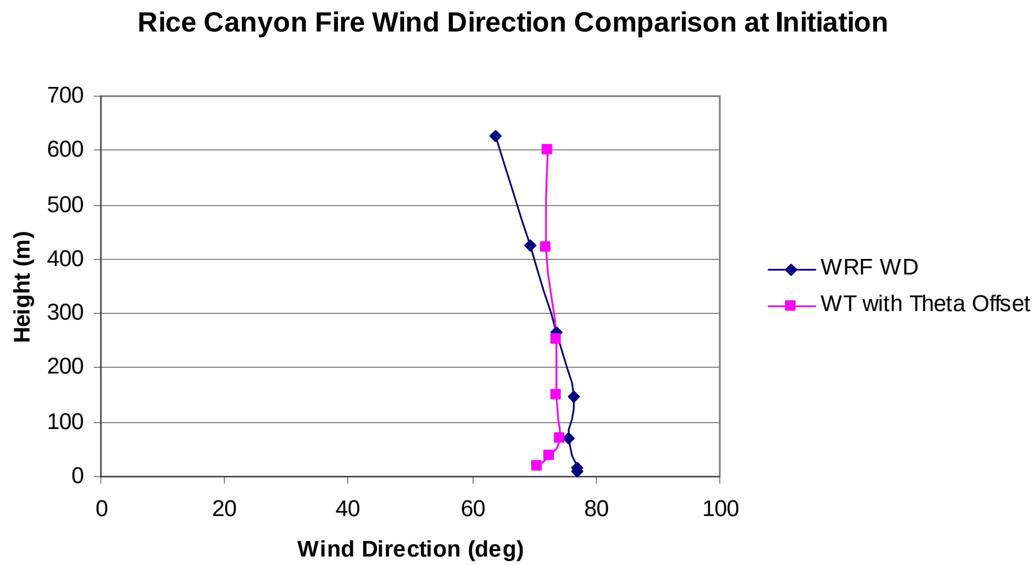


Appendix 8a. WRF wind direction profiles at the Guejito site for the time of fire initiation.



Appendix 8b. WRF wind direction profiles at the Guejito site at time of maximum wind speed at 250 m.

APPENDIX 9



Appendix 9a. WRF wind direction profiles at the Rice site for the time of fire initiation.

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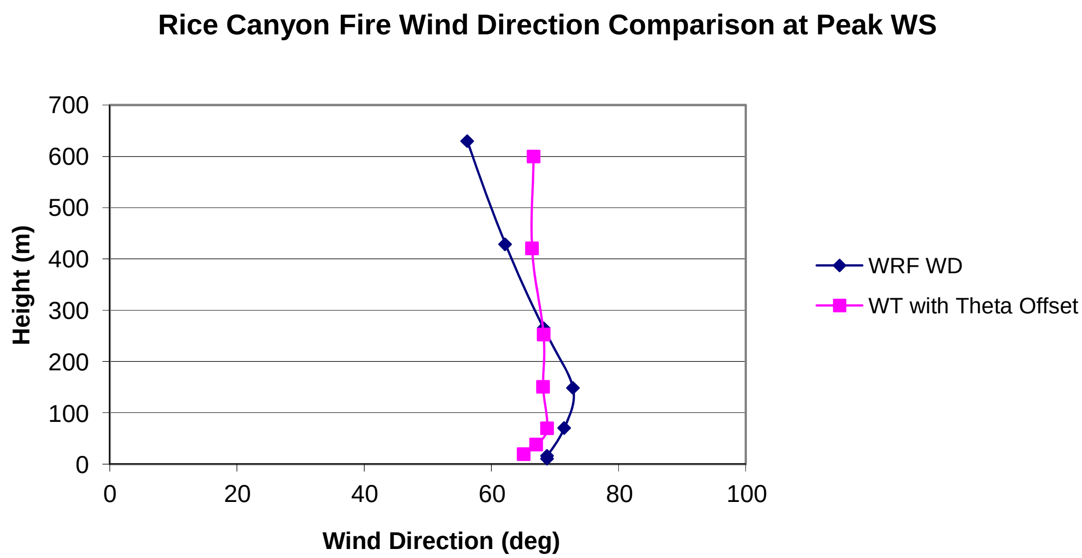
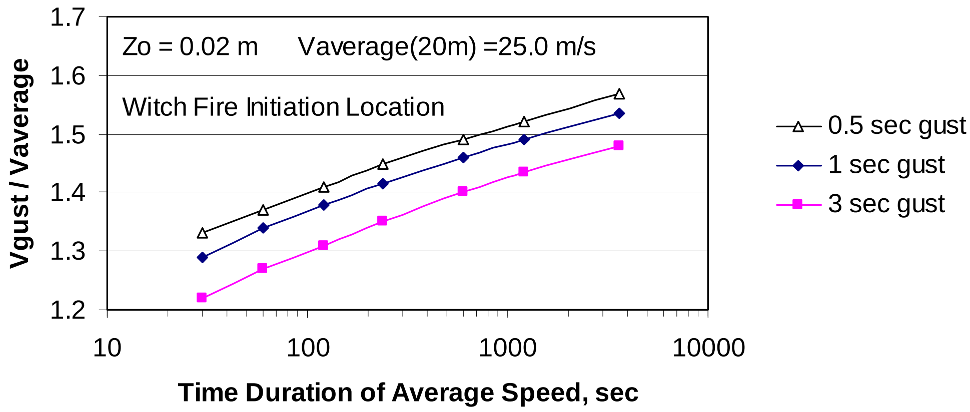
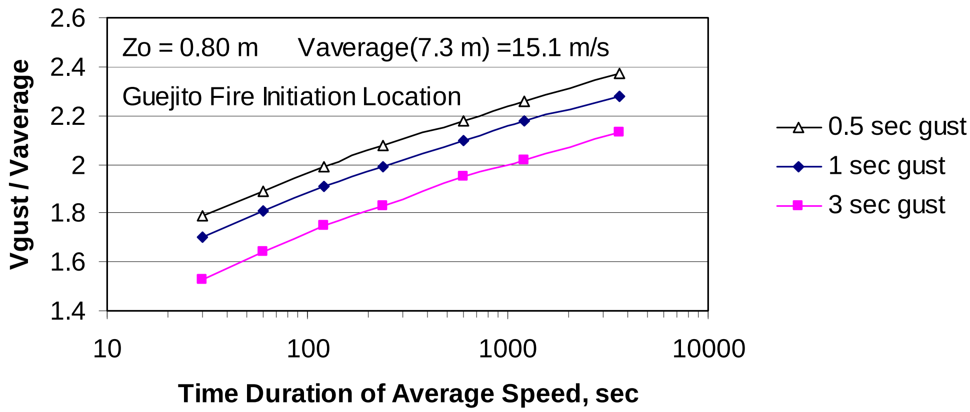


Appendix 9b. WRF wind direction profiles at the Rice site at time of maximum wind speed at 250 m.

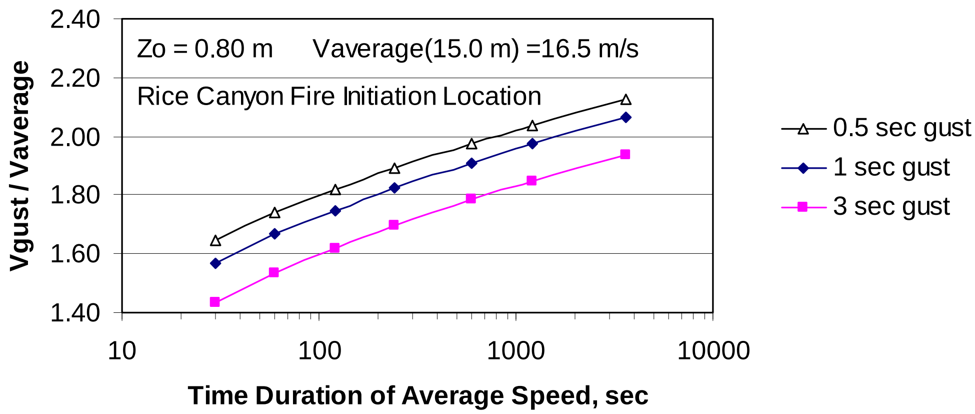
APPENDIX 10



Appendix 10a. Gust factor as a function of averaging times for mean and gust at the Witch site.

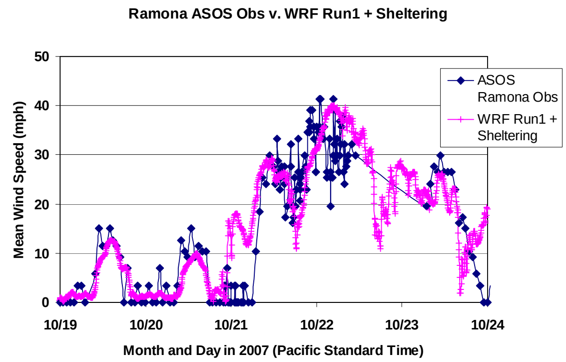


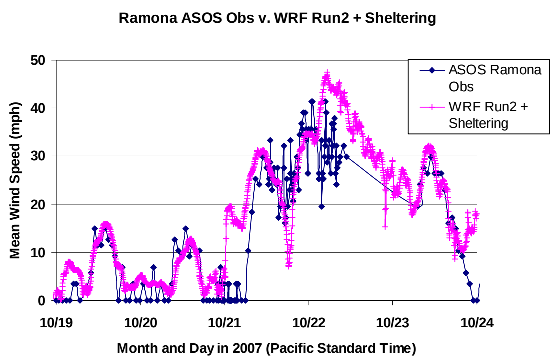
Appendix 10b. Gust factor as a function of averaging times for mean and gust at the Guejito site.

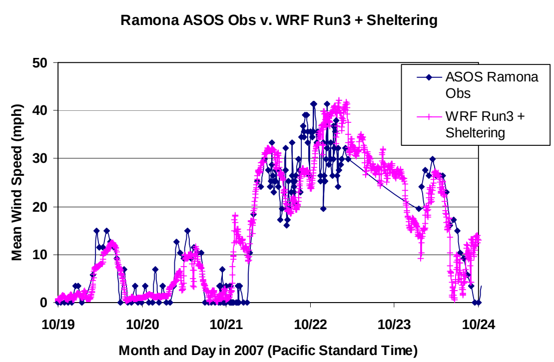


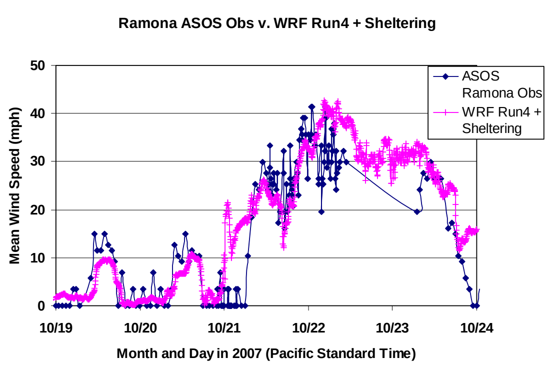
Appendix 10c. Gust factor as a function of averaging times for mean and gust at the Rice site.

APPENDIX 11

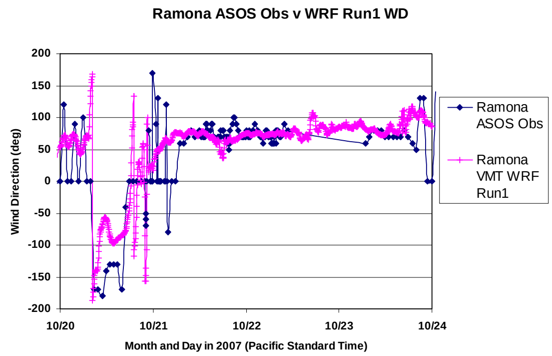


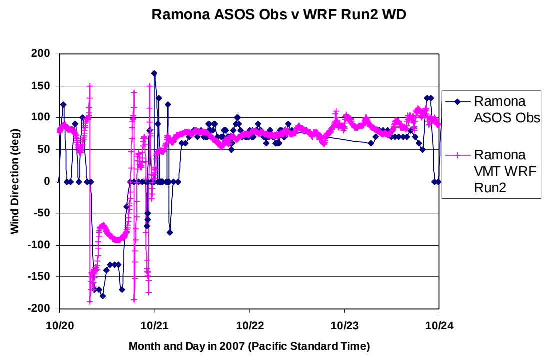


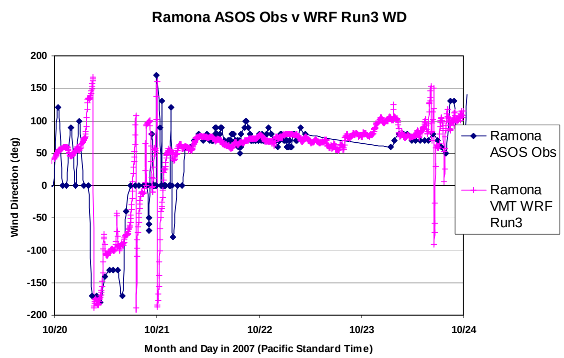


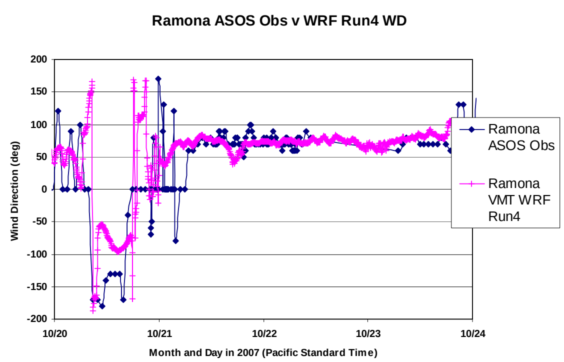


Appendix 11a. Comparison of measured wind speeds at Ramona WRF/Wind Tunnel prediction.



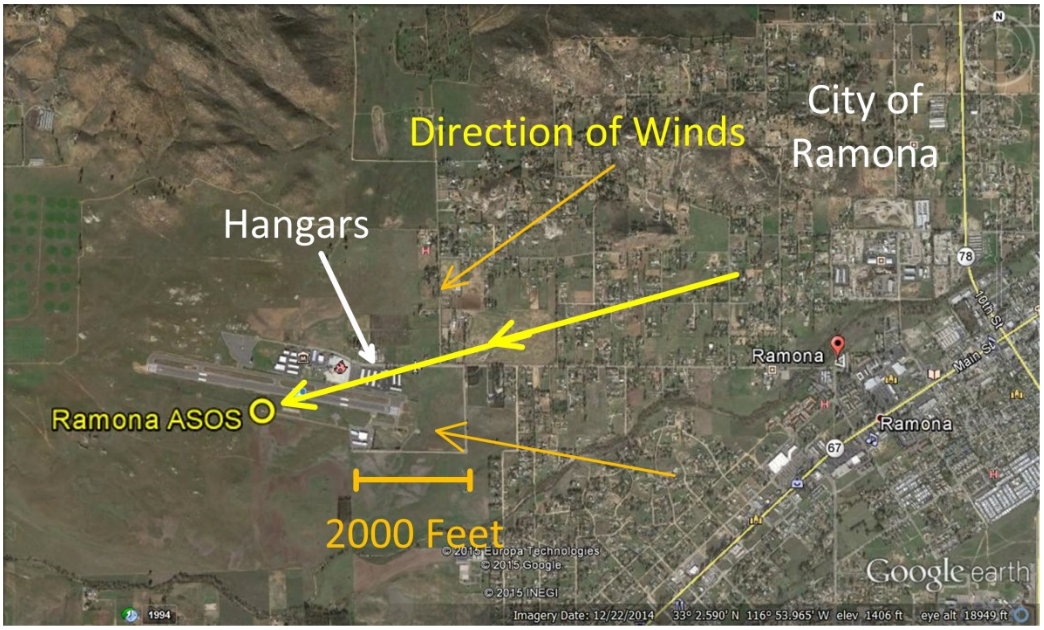






Appendix 11b. Comparison of measured wind directions at Ramona WRF/Wind Tunnel prediction.

APPENDIX 12



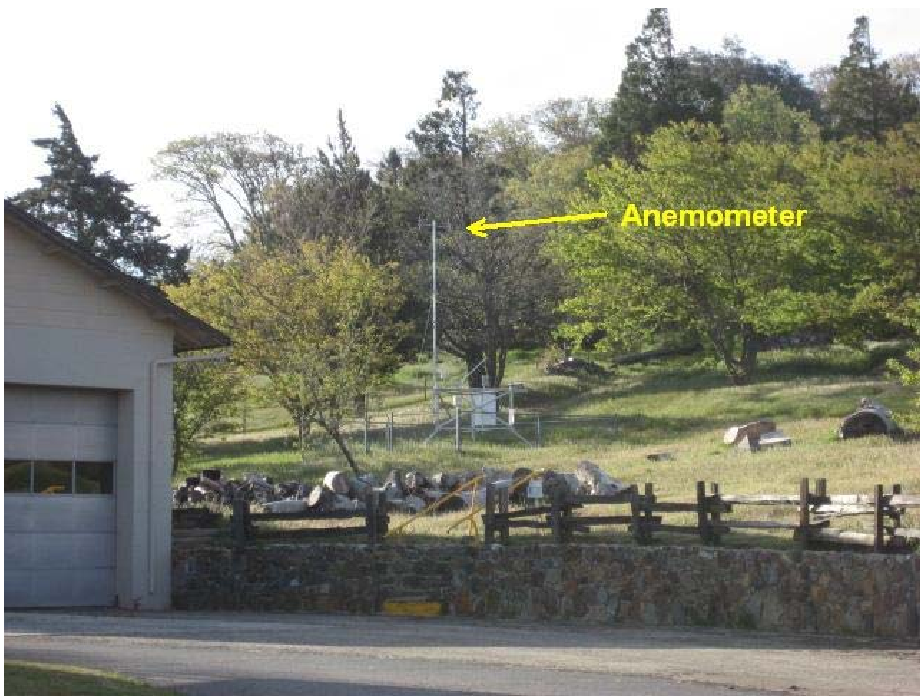
Appendix 12. Relationship of Ramona Airport ASOS meteorological station, most common storm wind direction, location of the city of Ramona, and location of upwind hangars.

APPENDIX 13

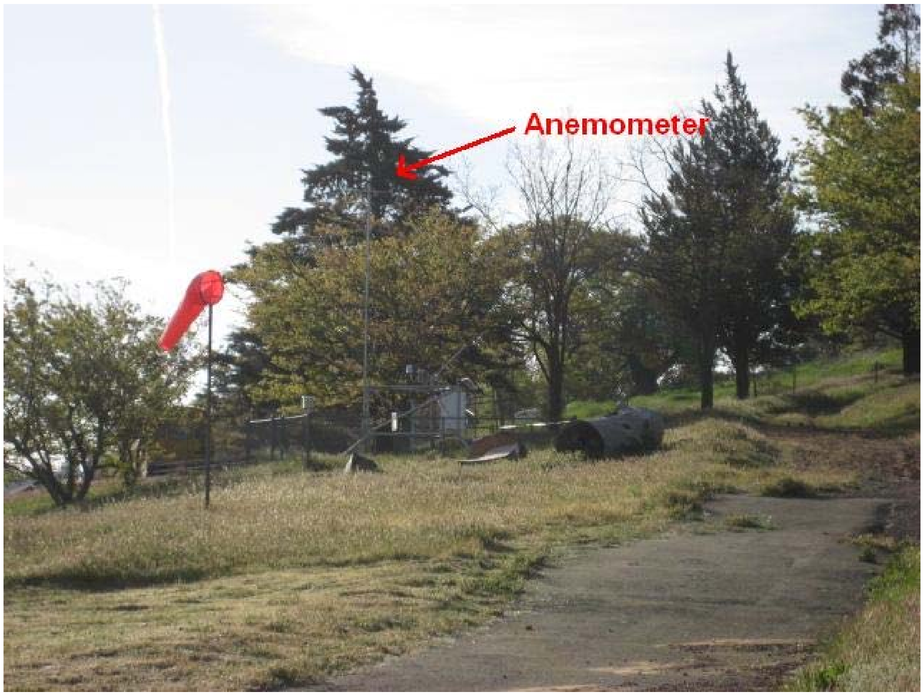
Appendix 13a. Julian anemometer location; note sheltering trees and structures surrounding site on all sides.

Appendix 13b. Julian anemometer location and location of photographs JULC1-1, JULC1-2, JULC1-3, JULC1-4, and JULC1-5 with wind direction range during the Santa Ana event; note sheltering trees and structures upwind of anemometer.

Appendix 13c. Photograph JULC1-1 looking SSW (see Appendix 13b).



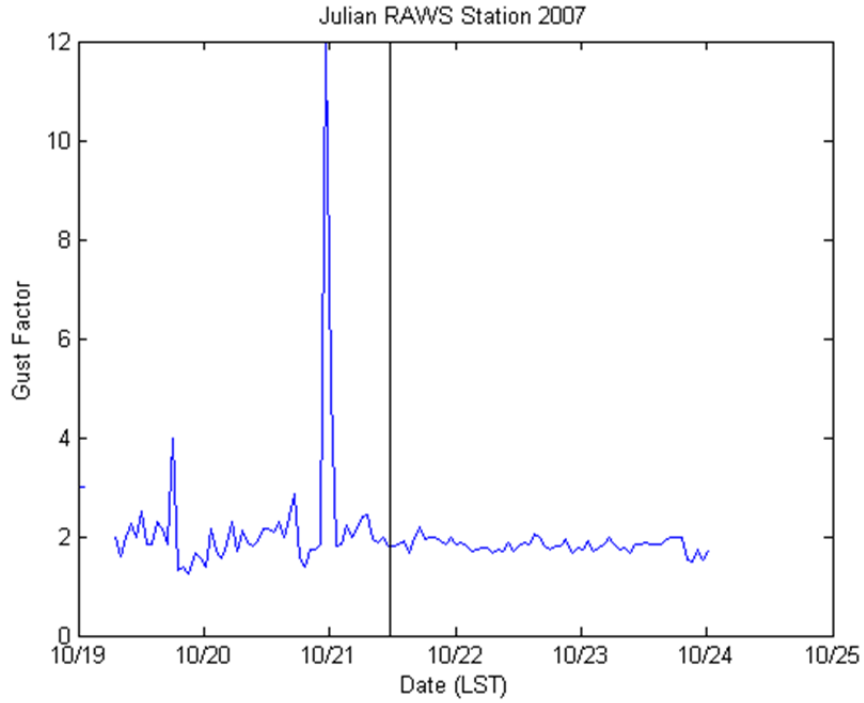
Appendix 13d. Photograph JULC1-2 looking SE (see Appendix 13b).



Appendix 13e. Photograph JULC1-3 looking ESE (see Appendix 13b).

Appendix 13f. Photograph JULC1-4 looking E (see Appendix 13b).

Appendix 13g. Photograph JULC1-5 looking NE (see Appendix 13b).



Appendix 13h. Gust factor time history for Julian during the storm event. The black line indicates the Witch Creek fire initiation time. The data point at Gust Factor = 12 may be a data acquisition error.

APPENDIX 14

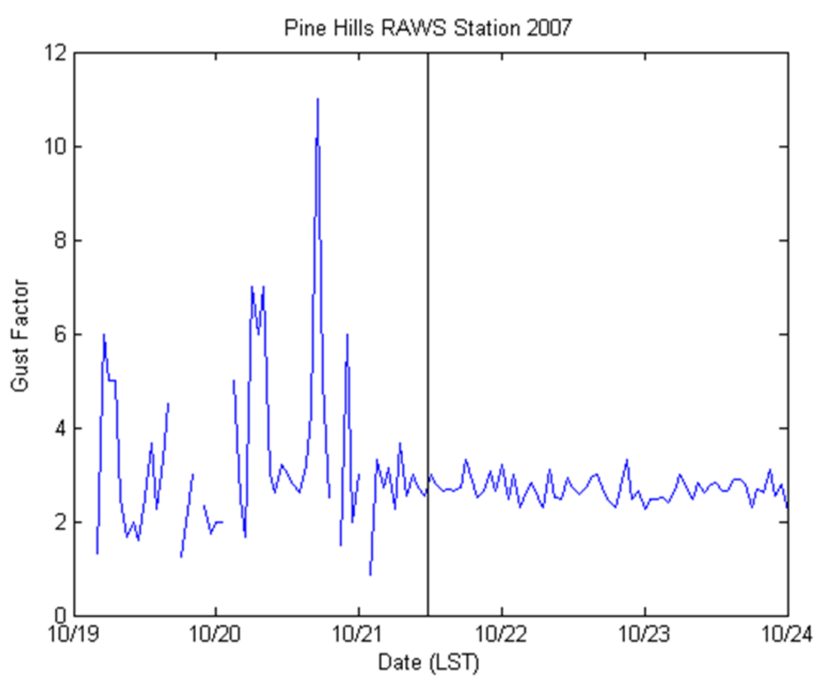
Appendix 14a. Pine Hills actual location; note tree to the northeast and east where storm winds originated.

Appendix 14b. Pine Hills anemometer location and location of photographs PIHC1-4, PIHC1-7, and PIHC1-8 with wind direction range during the Santa Ana event; note the large tree directly upwind of the anemometer.

Appendix 14c. Photograph PIHC1-4 looking SE (see Appendix 14b).

Appendix 14d. Photograph PIHC1-7 looking E (see Appendix 14b).

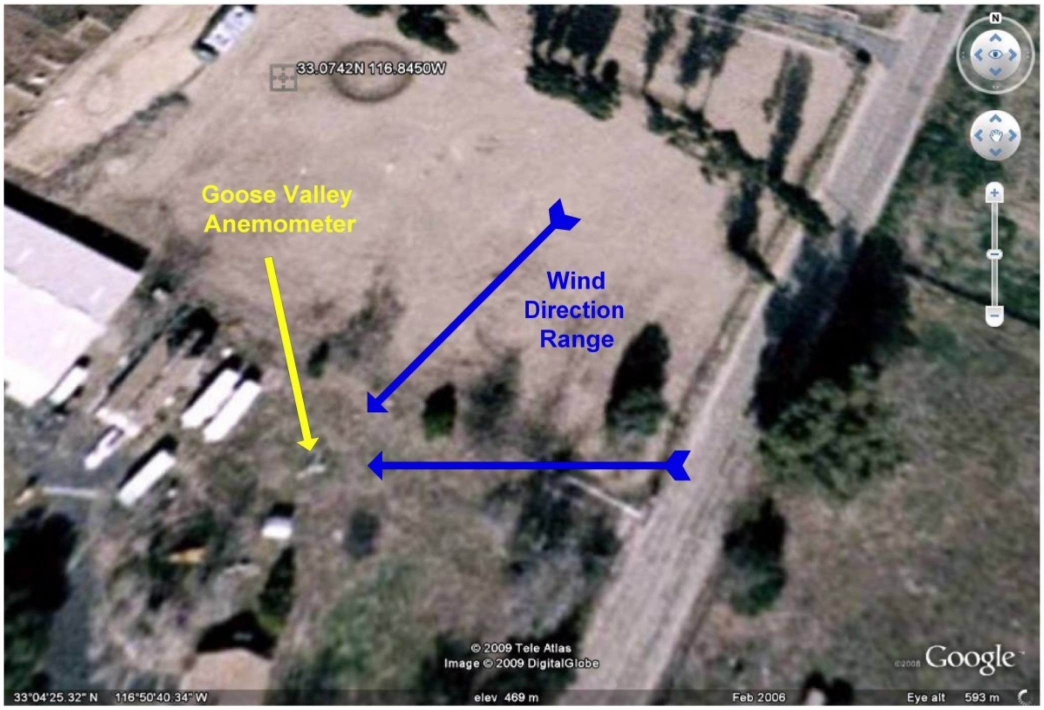
Appendix 14e. Photograph PIHC1-8 looking NE (see Appendix 14b).



Appendix 14f. Gust factor time history for Pine Hills during the storm event. The black line indicates the Witch Creek fire initiation time.

APPENDIX 15

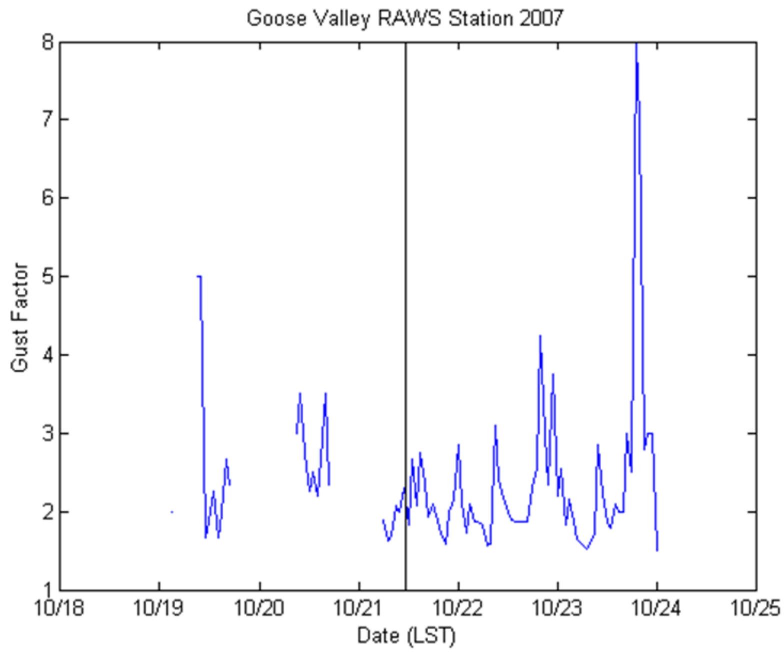
Appendix 15a. Goose Valley anemometer location as recorded and the actual location; note sheltering buildings and trees to the east-northeast.



Appendix 15b. Goose Valley anemometer location with wind direction range during the Santa Ana event; note sheltering trees upwind of anemometer.

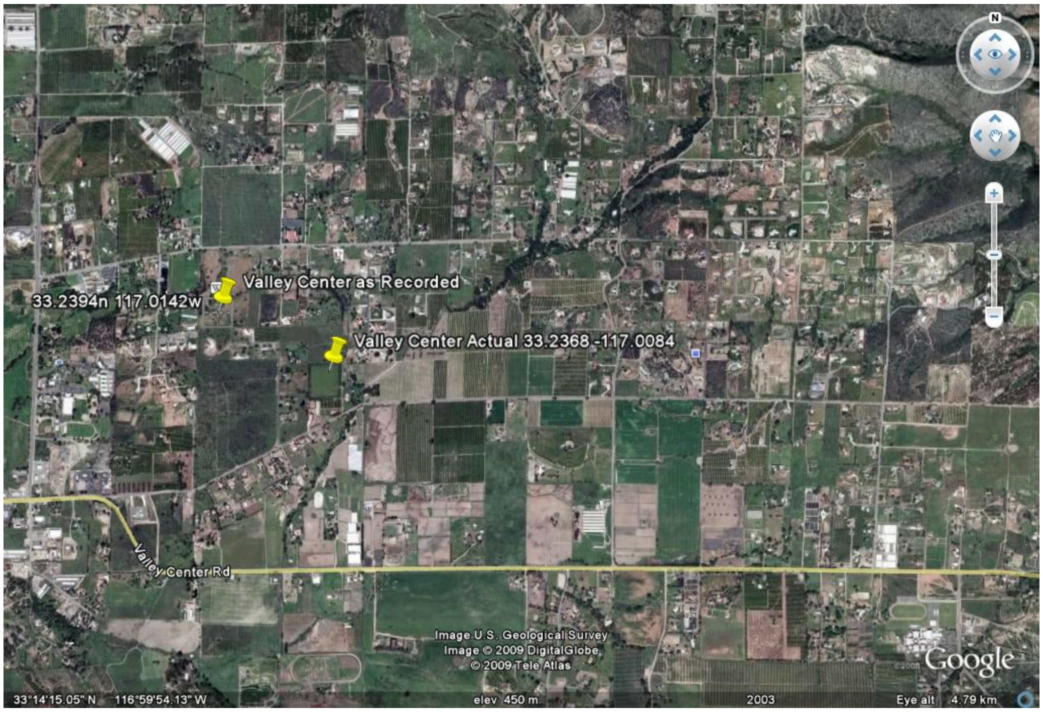
Appendix 15c. Goose Valley anemometer location looking northwest.

Appendix 15d. Goose Valley anemometer location looking northeast - anemometer is below tree height.

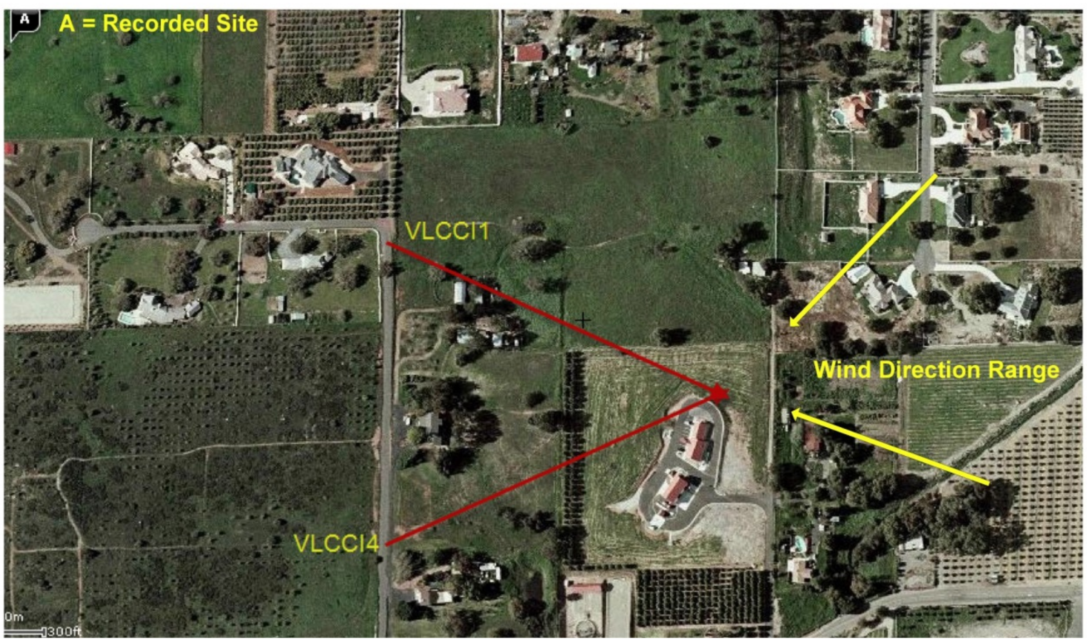


Appendix 15e. Gust factor time history for Goose Valley during the storm event. The black line indicates the Witch fire initiation time.

APPENDIX 16

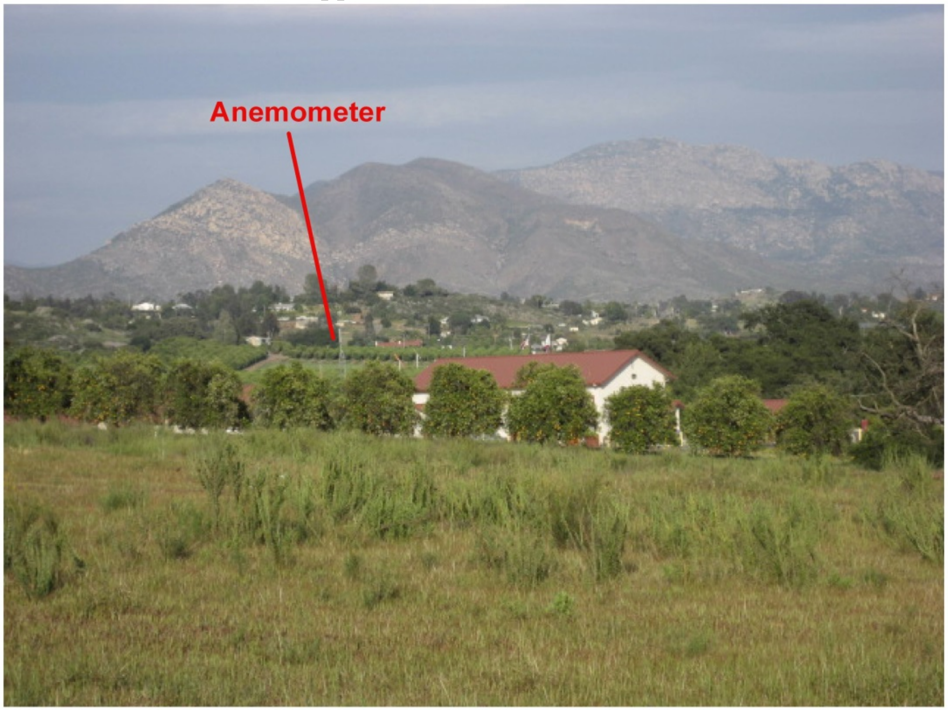


Appendix 16a. Valley Center actual location and recorded location; note suburban or agricultural roughness to northeast and east where storm winds originated.

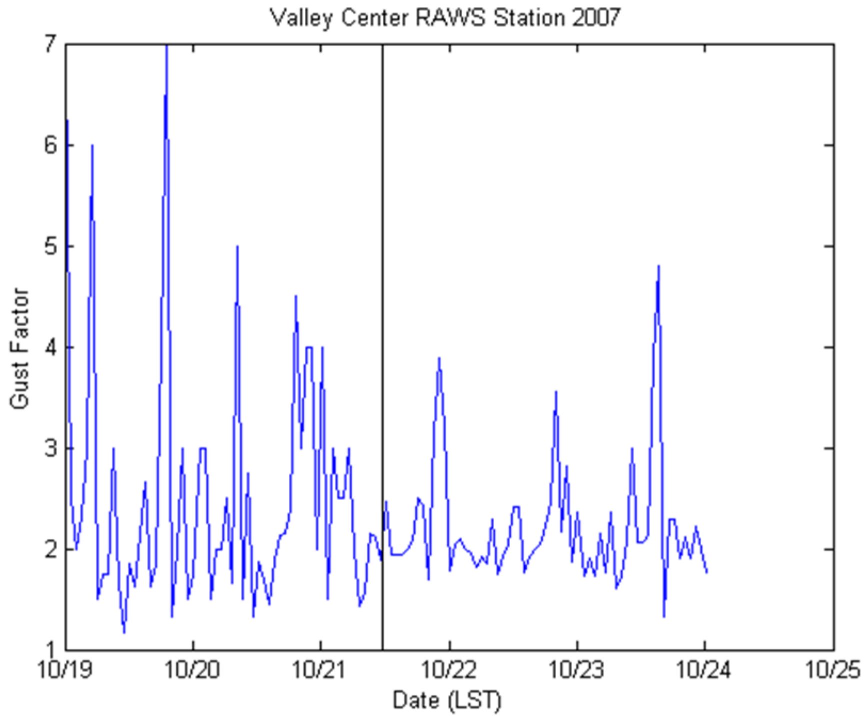


Appendix 16b. Valley Center anemometer location and position of photographs of Appendices 17c and 17d.

Appendix 16c. Valley Center anemometer; photo VLCCI1 looking southeast, see Appendix 16b for location.



Appendix 16d. Valley Center Anemometer; photo VLCCI4 looking northeast, see Appendix 16b for location.

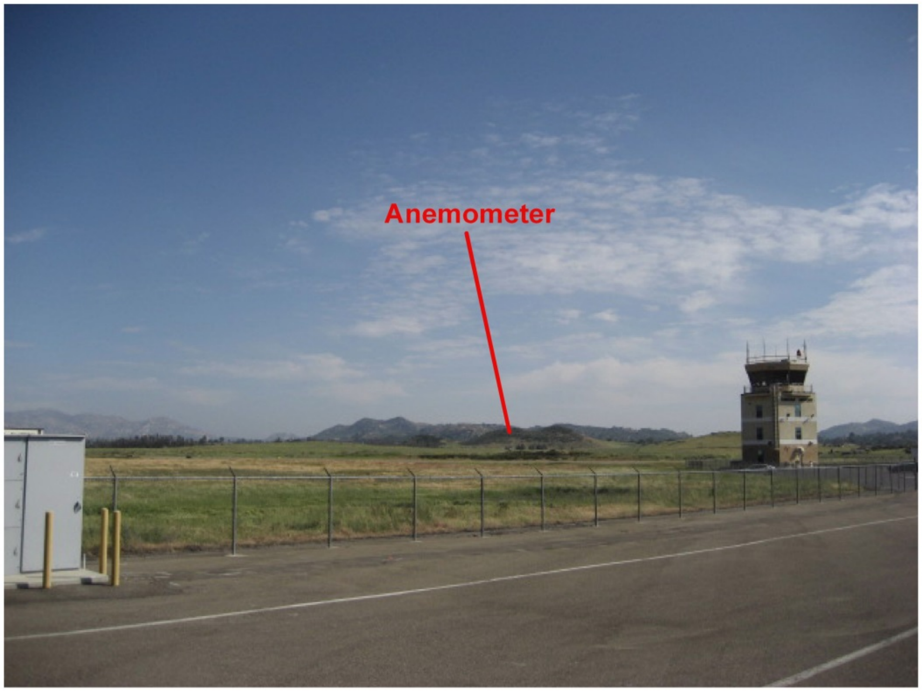


Appendix 16e. Gust factor time history for Valley Center during the storm event. The black line indicates the Witch Creek fire initiation time.

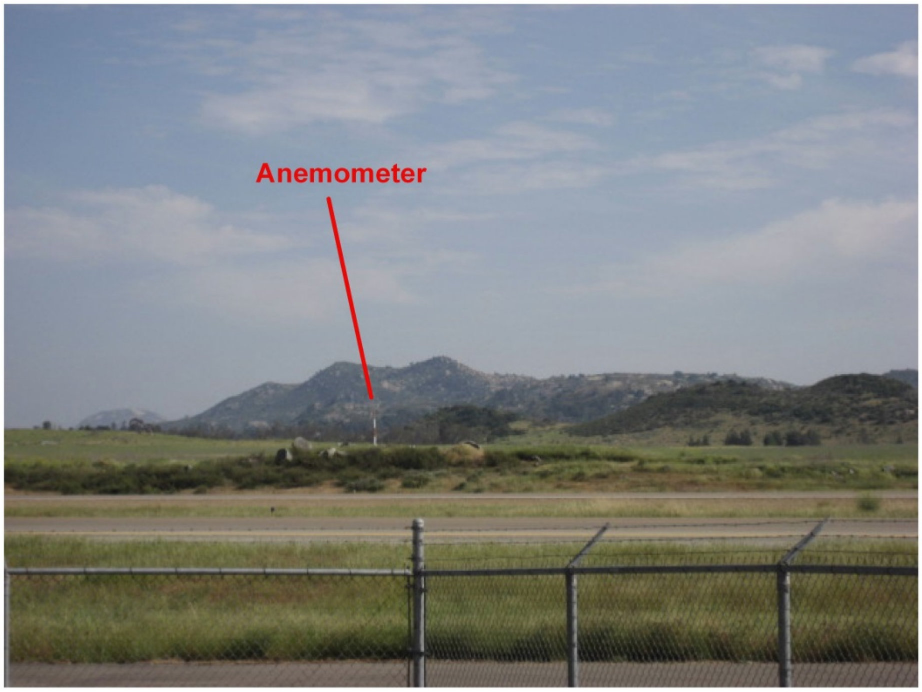
APPENDIX 17

Appendix 17a. Ramona Airport ASOS station location. Note suburban development upwind for the storm event and airport hangar buildings upwind causing some shielding. Refer to Appendix 12 for another view and refer to discussion of Appendix 12.

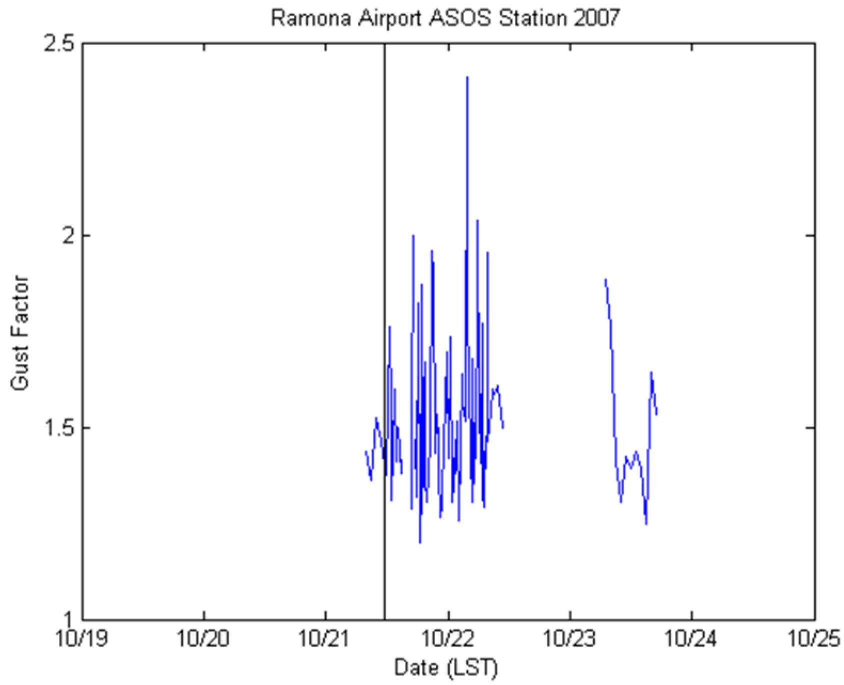
Appendix 17b. Ramona Airport ASOS station and location of photographs KRNM1 and KRNM3; "A" is the anemometer site.



Appendix 17c. Photo of Ramona ASOS from location KRNM1 (see Appendix 17b).



Appendix 17d. Photo of Ramona ASOS from location KRNM3 (see Appendix 17b).



Appendix 17e. Gust factor time history for Ramona Airport during the storm event. The black line indicates the Witch Creek fire initiation time.

APPENDIX 18

Appendix 18 — WRF Specifications

Parameterization Schemes

Schemes	Run 1	Run 2	Run 3	Run 4
FDDA	Yes	yes	no	yes
Initialization	20km RUC	20km RUC	20km RUC	32km NARR
Microphysics	WSM 5-class	WSM 5-class	WSM 5-class	WSM 5-class
Longwave Radiation	RRTM	RRTM	RRTM	RRTM
Shortwave Radiation	Dudhia	Dudhia	Dudhia	Dudhia
Convective	Kain-Fritsch*	Kain-Fritsch*	Kain-Fritsch*	Kain-Fritsch*
PBL	YSU	MYJ	YSU	YSU
Surface	Noah	Noah	Noah	Noah
Nesting	1-way	1-way	1-way	1-way

*Applied for outer grid only.

APPENDIX 19

Appendix 19 — Wind Tunnel Specifications

Wind Tunnel Setup – Witch, Guejito, and Rice Simulations

Scale	1:5000
Upwind Roughness Height (in)	0.5
Trip Height (in)	11
Number of Spires	5
Spire Height (in)	36
Test Directions – Witch	45, 67.5, 90
Test Directions – Guejito	22.5, 45, 67.5
Test Directions – Rice	0, 22.5, 45, 85

Profile Measurement Heights – Witch, Guejito, and Rice Simulations

Model Scale (in)	**Full-Scale (m)**
0.15	18.9
0.30	37.9
0.55	69.4
1.19	150.3
2	252.5
3.33	420.5
4.75	600
24	3030.3

Profile Locations – Witch Simulation

Test Point	**Test Point Name**	**Latitude**	**Longitude**	**Distance from Point 01(km)**
01	Witch Fire Initiation	N33° 04' 59.48"	W116° 41' 37.64"	0
02	3km NE	N33°06'07.20"	W116°40'15.60"	3
03	3km ENE	N33°05'34.82"	W116°39'45.67"	3
04	3km E	N33°04'58.80"	W116°39'39.60"	3
05	4.7km ENE	N33°05'37.18"	W116°38'40.51"	4.7

Profile Locations – Guejito Simulation

Test Point	**Test Point Name**	**Latitude**	**Longitude**	**Distance from Point 1 (km)**	**Elevation (m)**
1	Guejito Fire Initiation	33.093549	-116.962275	0	133.3
2	Canyon point east of Point 1	33.09242	-116.946263	1.5	136.3
3	Canyon point north of Point 1	33.106314	-116.956968	1.5	138.4
4	NNE of Point 1	33.135315	-116.942107	5	489.8
5	NE of Point 1	33.125638	-116.924648	5	585.3
6	ENE of Point 1	33.111075	-116.912923	5	594.0

Profile Locations – Rice Simulation

Test Point	Test Point Name	Latitude	Longitude	Distance from Point 01(km)
01	Rice Canyon Fire Initiation	33.398554°	-117.145548°	0
02	2km N	33.416583	-117.145732	2
03	2km NNE	33.41527	-117.13749	2
04	2km NE	33.411411	-117.13045	2