

Final Report  
Contract 99-4PM  
For the period 1 June 2002 to 30 June 2002

**A Study of Mesoscale Transport and Boundary Layer Processes in the  
Central Valley of California**

**Amendment A: An Integrated Upper-Air Data Ingest, Web-Display,  
Management, and Validation Program for the CRPAQS and Related  
Studies**

**Amendment B: Upgrading of Upper-Air Systems and Contingency  
Response for the CRPAQS Study**

**Amendment 2: Support of the CRPAQS Fall and Winter Studies**

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## *Abstract*

In support of the California Regional PM<sub>2.5</sub>/PM<sub>10</sub> Air Quality Study (CRPAQS), the Regional Weather and Climate Applications Division of NOAA's Environmental Technology Laboratory deployed an array of wind profilers, sodars, and surface meteorological stations in the south Central Valley of California together with a well-instrumented boundary-layer tower and remote sensing site centered within the array. In particular, from December 1, 1999 to January 31, 2001, six 915-MHz radar wind profilers with RASS and supporting surface meteorological stations were deployed together with a Doppler sodar and surface meteorology site. In February 2000 the Doppler sodar site was supplemented with a radar wind profiler/RASS system. In addition, four instrumented meteorological towers were deployed within major air transport corridors ringing the south Central Valley. The Angiola 100-m tower was instrumented with 5 levels of mean temperature, relative humidity, and wind instruments and 3 levels of sonic anemometers with fast response temperature measurements. Remote sensors at the site included a wind profiler with RASS, a high resolution Doppler sodar, a laser ceilometer, and our S-band cloud and precipitation radar. The surface energy and moisture budget was obtained with four-stream radiation measurements, subsurface heat and moisture measurements, and turbulent flux calculations. In late June 2000, the Angiola site was augmented with a 20-m scaffold tower instrumented with 7 levels of mean temperature, relative humidity, and wind instruments and 4 levels of sonic anemometers with fast response temperature and pressure measurements. Between 1 October 2000 and 31 January 2001, ETL continued to operate, maintain and archive data from two 915-MHz and one 449-MHz wind profilers with RASS in the Central Valley. Meteorological tower data were also collected from these three sites. Also during this period, ETL continued operation of four Doppler sodars that were deployed in support of CCOS. In December 2000, four Doppler sodars were installed at existing profiler sites for the winter study. In addition to the meteorological measurements, NOAA/ETL ingested and displayed data on the ETL web-site in near real-time from seven non-ETL sites using upgraded ETL communications systems as well as providing Level 2 edited data from the entire network. ETL obtained and provided spare parts for all the profiler systems for the 14-month field program and upgraded existing systems to meet the needs of the Study.

## **1. Introduction**

The California Regional PM<sub>2.5</sub>/PM<sub>10</sub> Air Quality Study (CRPAQS) sought to improve scientific understanding of high fine-particulate concentration episodes in central California through a coordinated air quality/meteorology field program extending from 1 December 1999 through 31 January 2001. This project required that the Environmental Technology Laboratory (ETL) deploy 6 wind profilers, a Doppler sodar, 4 stand-alone instrumented 10-m towers, and to instrument the 100-m tower site at Angiola. The Angiola tower effort also included a considerable in-kind contribution of ETL, collecting detailed in situ data from a 20-m surface layer tower to help improve parameterizations in numerical models. Amendment A provided for ETL to ingest and display data on the ETL web-site in near real-time from seven non-ETL sites using upgraded ETL communications systems or alternatives if necessary as well as providing Level 2 edited data from the entire network. Amendment B provided for ETL to obtain and provide spare parts for all the profiler systems for the 14-month field program as well as upgrading existing systems to meet the needs of the Study. Amendment 2 provided for ETL to continue to operate, maintain and archive data from two 915-MHz and one 449-MHz wind profilers with RASS in the Central Valley of California. Operation of the meteorological towers at the three sites continued as well. Also, ETL continued operation of four Doppler sodars that were deployed in support of CCOS and collocated four additional Doppler sodars at existing wind profiler sites.

## **2. Near Real-Time Data Services**

The implementation of near-real-time data services have provided a way for scientists and engineers of CARB and NOAA/ETL to closely monitor the operations and performance of the Boundary Layer Radar (BLR) and near-surface in situ instrumentation present at every ETL BLR site. On an hourly basis, these data are graphically visualized and made accessible to end users via the internet ([www7.etl.noaa.gov/data](http://www7.etl.noaa.gov/data)), and are distributed to NOAA/FSL for initialization in the RUC-2 numerical weather forecast model ([maps.fsl.noaa.gov/#RTimages40](http://maps.fsl.noaa.gov/#RTimages40)). These access points provide an efficient and reliable way for the BLR and in situ data to be used in real-time operational applications, such as weather and air pollution forecasting and assessment.

ETL's near-real-time data services consist of four components, namely extraction, distribution, visualization, and internet interfacing. Data extraction establishes communication between the laboratory and the various remote meteorological sites. Currently, ETL has the technological ability to transfer data using modems with phone lines or cellular, the internet, and GOES satellites. The timeliness of the data extraction process is critical for meeting the RUC-2 initialization deadline (a quarter past the top of the hour), and for producing diagnostic visualization products that represent the latest data available from the instruments (e.g., the BLR consensus calculations for winds and temperature are produced at the top of every hour). These time constraints pose the challenging task of having to transfer data from over thirty different sites in a matter of minutes. To meet these requirements, ETL developed and implemented a scaleable, fault

tolerant telecommunication system that simultaneously transfers data from multiple remote sites (currently scaled to eight) at any given time. The current system configuration takes approximately three to five minutes per hour to transfer data from every CARB site in the state. Once the data are extracted, scripting languages (such as C Shell and Perl) are used to distribute the data to NOAA/FSL for model initialization, and to the NOAA/ETL file management system, where HTTP and FTP connectivity to the internet outside of NOAA/ETL are established. Here, the data are stored in their native formats and are organized by simple directory hierarchies based on information such as instrument type, data type, and site name. Next the data are visualized using FORTRAN programs developed by ETL. Currently, the BLR graphical displays include time-height sections of wind barbs overlaid on color contours of SNR, wind barbs color coded by wind speed, and wind barbs overlaid on color contours of RASS virtual temperature. The time-height domain includes data from the latest 24-hr period up to the maximum unambiguous range of the BLR. After the graphics images are produced, they are processed by a series of image filters that compress the image-file size while preserving the spatial and color resolution. This step produces images in the GIF format that can be quickly downloaded from even the slowest of network connections (such as PPB modem connections). Lastly, after all of the images are created for every site, an HTML page is dynamically constructed with a table of hyper-links that provide access to each of the real-time images.

In addition to the near-real-time access, the real-time data and images are archived and made accessible through a link titled "DATA AND IMAGE ARCHIVE" (located below the real-time data access table at [www7.etl.noaa.gov/data](http://www7.etl.noaa.gov/data)). This link provides a HTML request form, which allows the user to manually specify the date and choose the image/data type from a scrolled list of available types. This information is then passed to a Common Gateway Interface (CGI) program which queries the NOAA/ETL file management system for the requested data and displays the data back to the internet browser.

### **3. Overview of field program**

Table 1 shows the instrumentation, location, and installation and removal dates for the NOAA/ETL CRPAQS measurement sites. The table includes CCOS sites that were utilized for CRPAQS measurements during the Fall and Winter studies. The six wind profiler sites (Angiola, Bakersfield, Lost Hills, Mojave, Stevinson, Trimmer), and four stand-alone meteorological tower sites (Altamont Pass, Kings River, Pacheco Pass, Tejon Pass) were all installed by late November 1999. The Stevinson BLR was moved to Chowchilla in late September 2000. The Angiola site meteorological towers experienced delays because of problems with the 100-m tower construction and in obtaining appropriate county permission, particularly for the 20-m tower. Data acquisition for the 100-m tower instrumentation began in late February 2000 and in late June 2000 for the 20-m tower instrumentation. The site at Richmond, which included a wind profiler with RASS, a Doppler sodar, and a 10-m meteorological tower, was installed and operational by early February 2000. In support of the CRPAQS Fall and Winter studies, ETL continued operation of three CCOS profiler sites (Chico, Fresno, Waterford) between 1 October 2000 and 31 January 2001 and installed Doppler sodars at four existing sites

(Bakersfield, Chico, Lost Hills, Chowchilla). In addition, ETL continued operation of four Doppler sodars installed in support of CCOS. These sites included: Angiola, Fresno, New Melones Lake, Waterford.

During the measurement campaign, site visits occurred at approximate one-month-intervals. Radar antenna levels and orientations were verified as well as RASS source levels. Meteorological tower checks included comparisons with calibrated standards. All meteorological instrumentation met manufacturer recommended standards prior to deployment. Instrumentation requiring recalibration during the field phase of the experiment were removed and replaced by newly calibrated instrumentation. Instrumentation not meeting accepted standards were removed as soon as possible and replaced.

Table 1. NOAA Environmental Technology Laboratory CRPAQS measurement sites.

Site Name	Instrument	Latitude	Longitude	Elevation (m)	Date installed	Date of removal
Altamont Pass	10-m met	37° 43' 4"	121° 39' 37"	351	12/10/99	3/7/01
Angiola	Profiler	35° 56' 50"	119° 32' 13"	60	11/13/99	12/11/01
	Mini-sodar				5/22/00	12/4/00
	Sodar				12/13/00	12/11/01
	S-band				5/22/00	1/9/01
	20-m met				6/23/00	12/11/01
	100-m met				2/22/00	6/5/01
Bakersfield	Profiler	35° 20' 58"	118° 57' 26"	118	11/29/99	11/9/01
	10-m met				11/29/99	11/9/01
	Sodar				12/4/00	1/25/01
Chico	Profiler	39° 41' 55"	121° 54' 42"	41	6/2/00	Operating
	10-m met				6/2/00	Operating
	Sodar				12/20/00	Operating
Chowchilla	Profiler	37° 6' 40"	120° 14' 30"	76	9/26/00	12/13/01
	10-m met				9/26/00	12/13/01
	Sodar				12/2/00	10/3/01
Fresno	Profiler	36° 46' 5"	119° 42' 41"	100	6/2/00	3/12/01
	10-m met				5/23/00	3/12/01
	Mini-Sodar				12/15/00	3/12/01
King's River	10-m met	36° 53' 17"	119° 9' 30"	290	11/17/99	3/11/01
Lost Hills	Profiler	35° 37' 20"	119° 41' 15"	87	11/13/99	Operating
	10-m met				12/19/99	Operating
	Mini-sodar				12/4/00	12/14/00
	Sodar				12/19/00	2/10/01
Mojave	Profiler	35° 3' 12"	118° 9' 8"	837	11/10/99	3/10/01
	10-m met				11/10/99	3/10/01

New Melones	Sodar	38° 0' 24"	120° 29' 41"	320	5/10/00	4/5/01
	10-m met				5/10/00	4/5/01
Pacheco Pass	10-m met	37° 4' 24"	121° 13' 13"	454	11/13/99	3/7/01
Richmond	Profiler	37° 56' 41"	122° 24' 14"	111	2/10/00	1/10/02
	10-m met				2/10/00	1/10/02
	Sodar				1/6/00	2/8/01
Stevinson	Profiler	37° 19' 24"	120° 48' 53"	29	11/18/99	9/24/00
	10-m met				11/18/99	9/24/00
Tejon Pass	10-m met	34° 53' 4"	118° 54' 17"	931	11/11/99	3/10/01
Trimmer	Profiler	36° 54' 7"	119° 18' 23"	507	11/17/99	4/4/01
	10-m met				11/17/99	4/4/01
Waterford	Profiler	37° 39' 12"	120° 40' 24"	60	6/22/00	12/19/02
	10-m met				5/10/00	12/19/02
	Sodar				12/15/00	2/13/01

## 3.1 Description of Instrumentation

### 3.1.1 915-MHz wind profiler with RASS

During the CRPAQS measurement period (12/1/99-1/31/01), NOAA/ETL operated seven 915-MHz wind profilers with RASS providing continuous high-resolution wind and virtual temperature profiles in the lowest 2-4 km of the atmosphere during most of the study period. The wind profilers were located at Angiola, Bakersfield, Chowchilla Lost Hills, Mojave, Richmond, Stevinson (moved to Chowchilla on 9/25/00), and Trimmer. All of the wind profilers consisted of two oblique antennas tilted  $15^\circ$  off zenith and one vertical antenna while one profiler consisted of a single phased-array antenna. Four RASS sources surrounded the profiler antennas (Figure 3.1). The profilers obtained wind data using two modes, one with 60-m resolution and the other with 100-m resolution. The height coverage for the 60-m mode ranged from 0.1 to 2.2 km AGL while for the 100-m mode ranged from 0.15 to 3.8 km AGL. Actual height coverage depended on the atmospheric conditions. Hourly virtual temperature profilers were obtained with a 60-m range resolution between 0.1 and 1.5 km AGL. As with the winds from the wind profiler, height coverage is dependent on the existing atmospheric conditions.



Fig. 3.1. NOAA/ETL 915-MHz wind profiler with RASS in Concord, New Hampshire.

### 3.1.2 449-MHz wind profiler with RASS

The NOAA/ETL 449-MHz wind profiler operated at the Fresno Air Terminal (FAT) in Fresno during the CCOS measurement period and between 10/1/00 and 1/31/01 for CRPAQS. The 449-MHz wind profiler consists of a single, fixed antenna array measuring 6 m x 6 m (Fig. 3.2). The antenna subsystem is formed from two coaxial collinear arrays arranged orthogonal to each other to form two orthogonal beams and one vertical beam. A steel mesh ground plane is positioned a quarter wavelength below the arrays. Beam steering is achieved electronically by altering the phase of the signals fed to and from different parts of the array. A gate spacing of 203 m resulted in wind data from 0.5 to 10.5 km AGL. RASS was operated using 209-m gates with a height range from 0.5 to 4.5 km AGL. As with the 915-MHz wind profiler, wind and virtual temperature height coverage was highly dependent on the atmospheric conditions.



Fig. 3.2. NOAA/ETL 449-MHz wind profiler with RASS at the Fresno Air Terminal (FAT) in Fresno, CA.

### 3.1.3 ETL Doppler Sodar

NOAA/ETL deployed four two-beam Doppler sodars during CRPAQS in addition to continuing operation of four sodars that were deployed in support of CCOS. The sodar consists of two orthogonal-tilted antennas operating in a monostatic mode in which the transmitter and receiver are collocated (Fig. 3.3). The acoustic pulse emitted by the transmitter is scattered by temperature inhomogeneities in the atmosphere and is received as a frequency shift from the transmitted frequency. The frequency shift is then converted to a radial wind speed along the transmitted beam. Because the sodar is a two-beam system, averaged vertical velocities are assumed to be zero as there is no vertical correction applied. The radial velocities are then converted to horizontal wind speeds and direction. Data were obtained over 15-m range gates with the lowest gate at 15 m and the highest gate at 765 m. Measurement locations included Bakersfield, Chowchilla, Lost Hills, and Richmond, in addition to the CCOS sodars at Chico, Fresno, New Melones Lake, and Waterford.



Fig. 3.3. NOAA/ETL Doppler sodar antennas at the Fresno Air Terminal (FAT) in Fresno, California.

### 3.1.4 Aerovironment Doppler Sodar

NOAA deployed an Aerovironment 3-beam Doppler sodar at the Richmond site during CRPAQS (Fig. 3.4). The system works on the same principals as the ETL Doppler sodar although the system utilizes a vertical antenna allowing for the vertical correction of the horizontal winds. The first range gate was at 60 m with data available in 20-m range gates up to 400 m.



Fig. 3.4. Aerovironment three-beam Doppler sodar at Richmond, California CRPAQS site.

### 3.1.5 Aerovironment mini Doppler sodar

The mini sodar operates at a higher frequency (4500 Hz) than the previously discussed sodar systems, thus achieving greater height resolution (5 m) but less height coverage (200 m). The system utilizes a 32-element phased array antenna to form the three orthogonal beams necessary to calculate the three dimensional wind field. The higher frequency allows the system to perform well at sites with moderate ambient noise. This system operated at the Angiola site between 5/22/00 and 12/4/00, Lost Hills between 12/4/00 and 12/14/00, and Fresno between 12/15/00 and 3/12/01. (Fig. 3.5).



Fig. 3.5. Aerovironment mini Doppler sodar at Angiola site during CRPAQS.

### 3.1.6 ETL 10-m Meteorological Tower

Seven 10-m meteorological towers (Fig. 3.6) operated during the CRPAQS measurement period and were located at wind profiler and Doppler sodar sites. In addition, , four towers were deployed within major air transport corridors ringing the south Central Valley. Each tower sampled the standard meteorological parameters including pressure, temperature, relative humidity, wind speed, wind direction, solar radiation, net radiation, and precipitation. All parameters were sampled every 5 s and averaged over 5 min. Temperature and relative humidity sensors housed in aspirated shields at 2 and 10 m allowed for the determination of stability near the surface at the Bakersfield, Chowchilla, Lost Hills, Mojave, and Stevinson sites. The sites at Altamont Pass, King’s River, Richmond, Tejon Pass, and Trimmer obtained temperature and relative humidity data only at 2 m. All meteorological instrumentation met manufacturer recommended standards prior to deployment. Instrumentation requiring recalibration during the field phase of the experiment were removed and replaced by newly calibrated instrumentation. Instrumentation not meeting accepted standards were removed as soon as possible and replaced.



Fig. 3.6 Standard ETL 10-m meteorological tower.

### **3.1.7 Angiola 100-m and 20-m Towers**

ETL installed six levels of standard meteorological instrumentation on the 100-m Angiola tower. Pressure and aspirated temperature and relative humidity operated at the 2-m level while aspirated temperature and relative humidity and wind speed and direction were obtained at the 10, 23, 43, 72 and 98-m levels. In addition to these instruments, fast response sonic anemometer and pressure sensors were installed at the 25, 50 and 98-m levels. The 20-m tower was instrumented with seven levels of standard meteorological sensors (temperature, relative humidity, wind speed and direction) and four levels of fast response sonic anemometer and pressure sensors.

The following is a summary of Angiola tower installation and operations:

**February 22, 2000:**

Fiber optic cabling was installed on the 100-m tower for transmission of meteorological data to the main computer data acquisition system.

Six levels of slow met were installed on the tower and data collection of the slow met instruments began.

26-m level fast response sonic anemometer and pressure was installed and data collection began.

**April 29, 2000:**

The 50- and 98-m levels of fast response sonic on the 100-m tower were installed and collection of this data began.

**June 23, 2000:**

Fixed a communications problem with one of the slow met levels on the 100-m tower.

**July 26, 2000:**

Installed the remaining two levels of fast response pressure at the 50- and 98-m levels and data collection began.

**October 2-4, 2000:**

Took special rawinsonde observations to use for verification of boundary layer depth against radar and sodar measurements.

**December 8, 2000:**

Temperature and relative humidity calibrations checked on 100-m mean meteorological instrumentation.

**March 11, 2001:**

Last data collected on 100-m tower.

**June 5, 2001:**

100-m tower meteorological sensors removed.

**Angiola 20-m tower meteorological instrumentation**

**April 29, 2000:**

The 20-m tower foundation was poured. Due to difficulties in getting Kings County to approve a building permit for the 20-m tower, the tower installation was delayed by several months from the original plan. Eventually an engineering analysis had to be performed on the tower and structural modifications made to meet Kings County requirements.

**May 9, 2000:**

20-m tower erected.

**June 23, 2000:**

Installed 7 levels of mean speed, direction, T, and RH and data collection began. Installed 4 levels of fast response sonic anemometers and pressure and data collection began.

**December 8, 2000:**

Temperature and relative humidity calibrations checked on 20-m tower mean meteorological instrumentation.

**March 9, 2001:**

End of winter 2000-2001 20-m tower data collection.

**October 11, 2001:**

Replaced all mean speed, direction, T and RH instrumentation with newly calibrated instruments. 20-m tower data collection restarted.

**December 11, 2001:**

End of 20-m tower data collection.

**December 12, 2001:**

20-m tower removed from Gilkey property.

### 3.1.8 Radiation and Flux Instrumentation

At the Angiola site, ETL installed instrumentation for the measurement of energy balance and radiation budgets. Instrumentation included sonic anemometers, hygrometers, pyranometers, pyrgeometers, net radiometers, soil heat flux sensors, soil moisture sensors, and sub-surface temperature sensors. Figure 3.7 shows the instrument setup at the Pleasant Grove CCOS site. At the Angiola site, the upward looking pyranometer and the pyrgeometers were mounted on a 2-m radiation stand while the downward looking pyranometer was mounted at the top of the 100-m tower. As discussed in the previous section, sonic anemometers were mounted at three levels on the 100-m tower and at four levels on the 20-m tower.



Fig. 3.7 ETL 10-m meteorological tower with fast response sonic anemometer and hygrometer and 2-m radiation stand at the CCOS Pleasant Grove, California site.

## 4. Measurement Sites

ETL deployed a total of twelve meteorological monitoring sites for CRPAQS from Stevinson in the northern San Joaquin Valley to Bakersfield in the southern San Joaquin Valley to Trimmer in the Sierra Nevada foothills to Richmond in the San Francisco Bay Area. The Mojave site was located in the western Mojave Desert.

### 4.1 Altamont Pass

The meteorological tower site at Altamont Pass (Fig. 4.1) was located at an elevation of 351 m ASL just south of I-580 at Flynn Road. The site was installed on 12/10/99 and operated continuously until removal on 3/7/01.



Fig. 4.1. ETL 10-m meteorological tower at the CRPAQS Altamont Pass site.

## 4.2 Angiola

The ETL site at Angiola represented the most extensive deployment of instrumentation of any of the ETL CRPAQS sites. Instrumentation included a 915-MHz wind profiler with RASS (Fig. 4.2), S-band radar, ceilometer, instrumented 100-m and 20-m towers, radiation and flux instruments, and a Doppler sodar. The wind profiler/RASS system was installed on 11/13/99 and operated nearly continuously until site removal on 12/11/01.



Fig. 4.2. Equipment trailer and wind profiler/RASS antennas at CRPAQS Angiola site.

### 4.3 Bakersfield

The monitoring site was at the Kern Sanitation Authority Waste Treatment Facility just south of Hwy. 58 and approximately 6 km southeast of downtown Bakersfield. Instrumentation included a 915-MHz wind profiler with RASS (Fig. 4.3) and a 10-m meteorological tower (Fig. 4.4). A Doppler sodar was installed on 12/4/00. The site was installed and operational on 11/29/99 and removed on 11/9/01.



Fig. 4.3. Wind profiler antennas and RASS enclosures at Bakersfield monitoring site.



Fig. 4.4. Meteorological tower at Bakersfield monitoring site.

## 4.4 Chowchilla

The monitoring site was at the Chowchilla Municipal Airport, located 2 km southeast of Chowchilla. Site instrumentation included a 915-MHz wind profiler with RASS (Fig. 4.5), a Doppler sodar, and a 10-m meteorological tower (Fig. 4.6). The wind profiler and meteorological tower were installed and operational on 9/26/00 and were removed on 12/13/01. The Doppler sodar operated between 12/2/00 and 10/3/01.

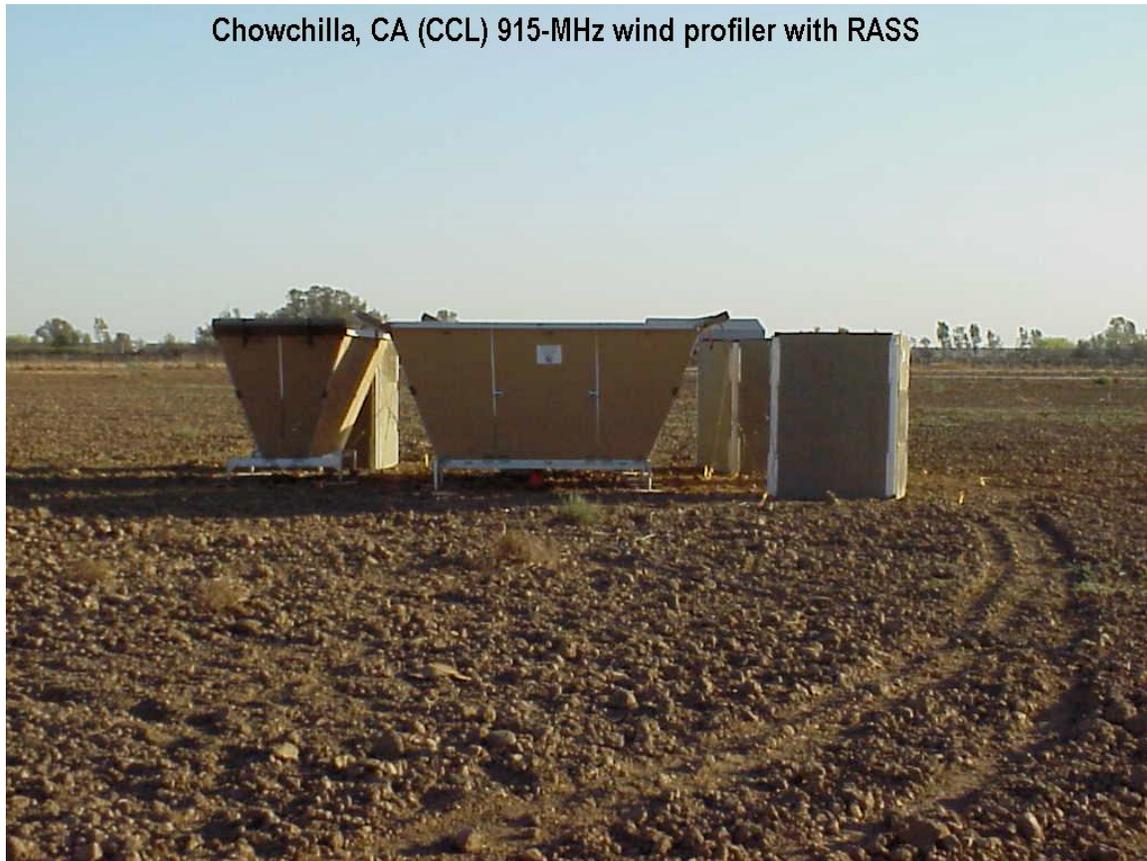


Fig. 4.5. ETL meteorological monitoring site at the Chowchilla, California CRPAQS site.

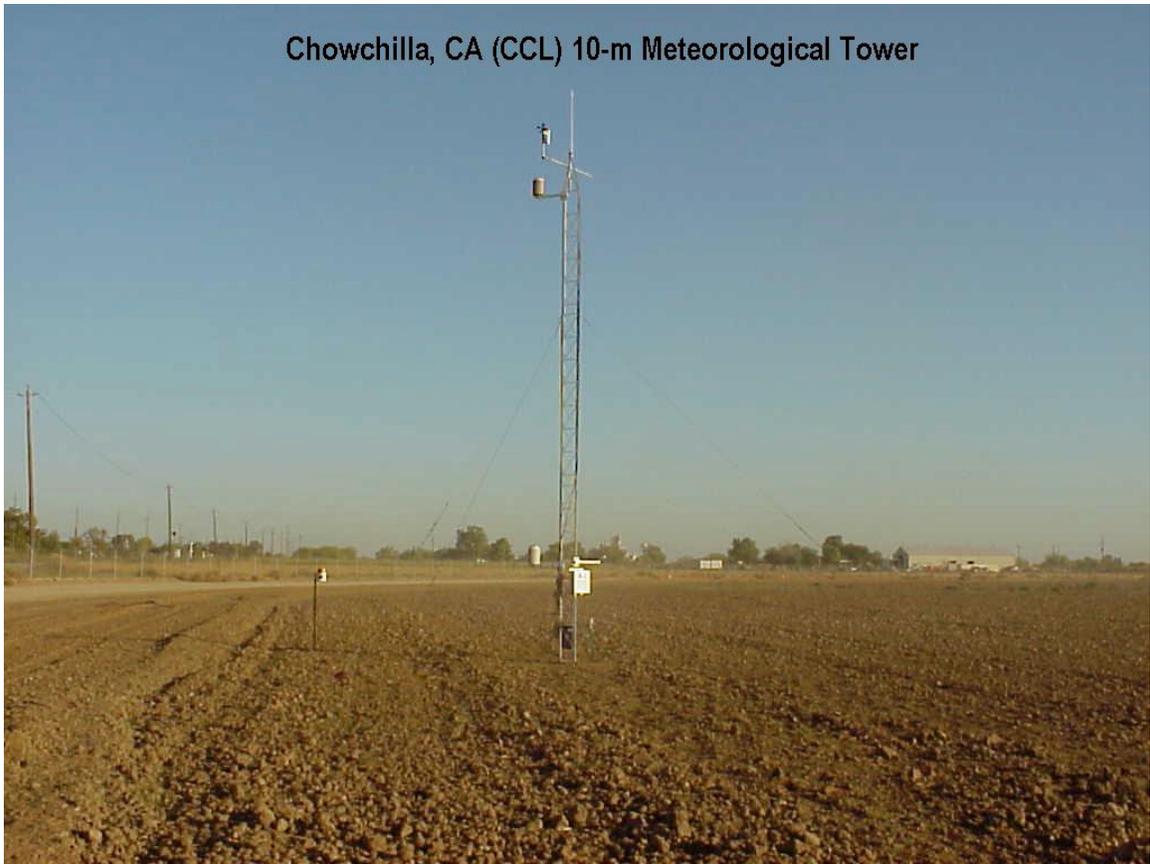


Fig. 4.6. Meteorological tower at Chowchilla CRPAQS monitoring site.

## 4.5 Fresno

The site, at the California Air National Guard Base on the south side of the Fresno Air Terminal (FAT) was located on the eastern edge of the City of Fresno, CA in an urban environment. Because of the site location at an airport, there were few obstructions to the flow although the high levels of ambient noise negatively impacted the Doppler sodar performance. Instrumentation at the site included a 449-MHz wind profiler with RASS and a Doppler sodar (Fig. 4.7), and a 10-m meteorological tower (Fig. 4.8). The site was installed on 5/23/00 and removed on 3/12/01.



Fig. 4.7. Wind profiler, RASS, and Doppler sodar antennas at the Fresno site.

Fresno, CA (FAT) 10-m meteorological tower



Fig. 4.8. Meteorological tower (10 m) at the Fresno site.

## 4.7 Kings River

A 10-m meteorological tower (Fig 4.9) operated at this site between 11/17/99 and 3/11/01. The site was at the Kings River Powerhouse at the point where the Kings River enters the Pine Flat Reservoir. The tower was located along the axis of the valley. Dominant flows were thermally forced circulations along the west to east oriented Kings River valley in which Pine Flat Reservoir is embedded.



Fig. 4.9. Meteorological tower (10 m) at the Kings River CRPAQS monitoring site.

## 4.8 Lost Hills

The Lost Hills site is located at the Lost Hills Airport in Lost Hills, California. The site is flat and free of obstructions. On 11/13/99 ETL installed a 915-MHz wind profiler with RASS and a 10-m meteorological tower (Fig. 4.10). The site is still operational and should remain until the end of September 2003. A Doppler sodar was installed on 12/4/00 and removed on 2/10/01.



Fig. 4.10. Wind profiler, RASS enclosures, and 10-m meteorological tower at Lost Hills CRPAQS monitoring site.

## 4.9 Mojave

This site was at the southwest side of the Mojave Airport in Mojave, California. The site was 15 km east-southeast of Tehachapi Pass in a region that experiences extremely strong westerly winds, particularly during the spring and summer months. On 11/10/99 ETL installed a 915-MHz wind profiler with RASS (Fig. 4.11) and a 10-m meteorological tower (Fig. 4.12). The equipment was removed on 3/10/01.



Fig. 4.11. ETL wind profiler and RASS antennas at CRPAQS monitoring site at Mojave Airport near Mojave, CA.

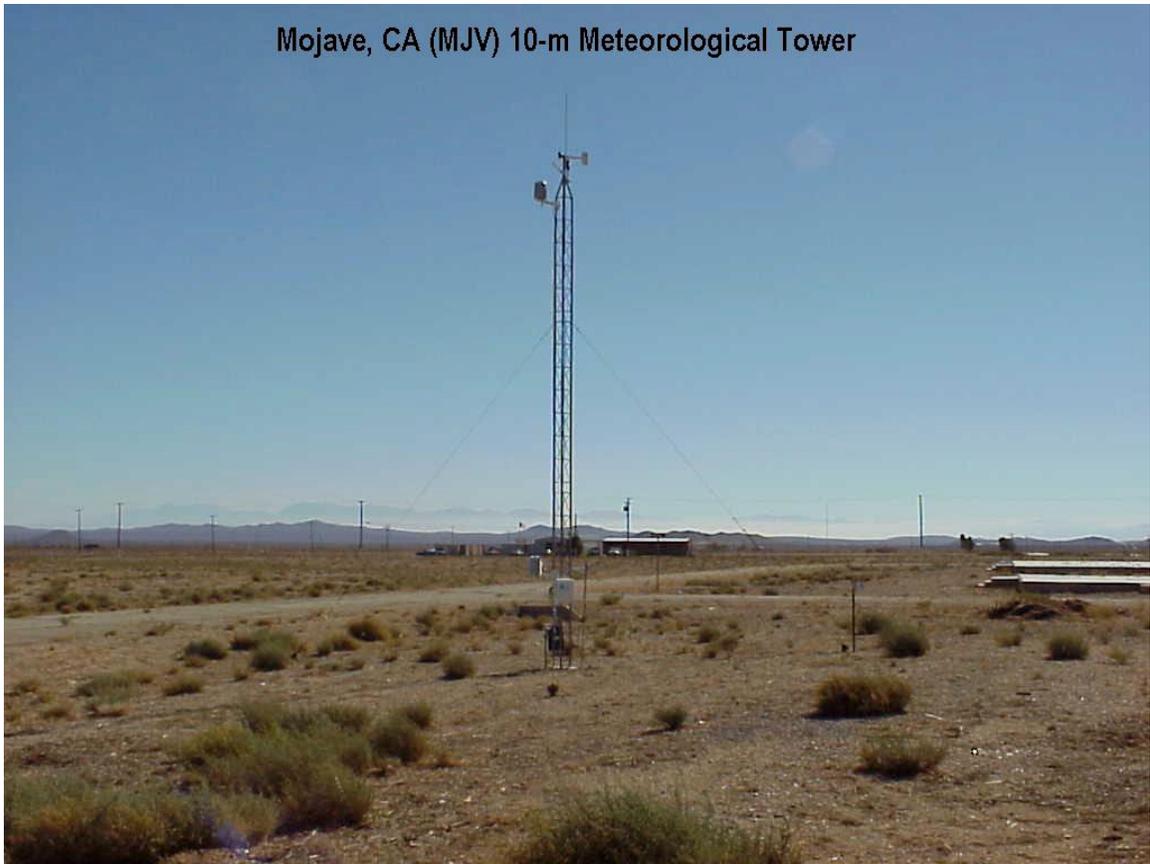


Fig. 4.12. ETL 10-m meteorological tower at CRPAQS monitoring site at Mojave Airport near Mojave, CA.

#### 4.10 Pacheco Pass

The 10-m meteorological tower (Fig. 4.13) was located in the Cottonwood Creek Wildlife Area, just northwest of Pacheco Pass at an elevation of 454 m ASL. The tower was installed on 11/13/99 and removed on 3/7/01.



Fig. 4.13. Meteorological tower site at Pacheco Pass, California.

## 4.11 Richmond

The Richmond site was on property owned by the Chevron Richmond Refinery on the east side of San Pablo Bay just north of the Richmond San Rafael Bridge and 15 km north of downtown San Francisco. ETL installed a 915-MHz wind profiler with RASS, a 10-m meteorological tower (Fig. 4.14), and a Doppler sodar (Fig. 3.4). The instruments were installed on 2/10/00 and removed on 1/10/02. The sites location at an elevation of 111 m on a ridge above San Pablo Bay allowed for good exposure to the ambient flows although the topography may have affected the winds in the lower levels.



Fig. 4.14. Equipment shelter, 10-m meteorological tower and radar and RASS antennas at Richmond CRPAQS monitoring site.

## 4.12 Stevinson

The Stevinson site was at the Stevinson Ranch Golf Course just east of Stevinson, California. At the site ETL installed a 915-MHz wind profiler with RASS (Fig. 4.15) and a 10-m meteorological tower (Fig. 4.16). The site was installed on 11/18/99 and removed on 9/24/00. The site was then reinstalled at Chowchilla.



Fig. 4.15. Wind profiler and RASS antennas at Stevinson CRPAQS monitoring site.



Fig. 4.16. Meteorological tower at Stevinson CRPAQS monitoring site.

### 4.13 Tejon Pass

The meteorological tower (Fig. 4.17) was installed within the Castac Valley just west of I-5 at an elevation of 931 m ASL, approximately 10 km northwest of Tejon Pass. The tower was installed on 11/11/99 and removed on 3/10/01.



Fig. 4.17. Meteorological tower at CRPAQS Tejon Pass site.

## 4.14 Trimmer

The Trimmer site was at the U.S. Forest Service heliport, 1 km northwest of Pine Flat Reservoir, at an elevation of 507 m ASL. The topography in the surrounding area was complex with tree-covered hills, although the site exposure was good except for some potential for flow blocking in the lower levels with westerly winds. Site installation took place on 11/17/99 and site removal occurred on 4/4/01. Figure 4.18, looking to the east, shows the wind profiler and RASS antennas at the site.



Fig. 4.18. Wind profiler and RASS antennas at the Trimmer CRPAQS monitoring site.

## **5. ETL Data Collection, Processing, Storage, and Management**

### **5.1 Data Collection**

Daily radar, RASS and meteorological data (from the 10-m, 20-m, or 100-m instrumented towers) are transferred from the site computer hard drive to either JAZ cartridges or Panasonic optical disks on-site on approximately a monthly basis. One backup copy of the data remains on-site until such time that it is backed up at NOAA/ETL. Data are then transferred from JAZ or optical disk in duplicate to two separate media at NOAA/ETL: One copy of the data is transferred to a RAID protected hard drive, and a second copy to another optical drive. The data are separated into different directories based on their data types for later processing.

### **5.2 Data Processing**

Level 1A processing of the radar and RASS data is accomplished by running the moments data through a modified Weber-Wuertz algorithm to remove obvious spurious data for wind speed, wind direction, and temperature. Three different formats for each daily file are created. One of those formats is used to further process the data to level 1B.

Level 1B processing involves visually inspecting daily wind and temperature files for inconsistencies not discovered with the Weber-Wuertz algorithm. Radian Corporation's LapGraph software is used. Approximately 5 days of data are displayed at once. Time and height consistency checks are performed and the suspect data is marked as invalid. Once a site has been processed to level 1B, the data are run through an in-house algorithm in order to send to CARB in their prescribed format. All radar and RASS data have been processed, packed, delivered and accepted by CARB.

Data were edited for bird removal during two time periods for the entire CCOS/CRPAQS experiments. Those periods were March 1 – May 31, 2000 and September 1 – November 30, 2000. They were edited with an algorithm that thresholds on spectral width and signal-to-noise ratio. The algorithm removed some birds but was not too powerful. Data were also visually examined during the LapGraph editing and any obvious birds were examined more closely and removed if deemed to exist.

Radar winds and RASS data for CCOS IOP2 and IOP3 have been re-processed to level 1C by visual inspection on a profile-by-profile basis and removing data deemed unacceptable or meteorologically improbable. Mixing depths were determined for both IOP's. Those data have been presented to CARB.

Level 1A processing of the meteorological data is carried out with an in-house algorithm to remove spurious suspect data and is flagged as such. Level 1B processing involves creating daily climatologies of the meteorological data and examining the data in time to try to identify any inconsistencies. All meteorological data, except for the mean met data from the 100-m Angiola tower, has been processed, packed, delivered and accepted by CARB.

Level 1A processing of the Doppler sodar data involves two different algorithms depending on the instrument manufacturer. Data from the ETL 2-axis Doppler sodars were processed using an algorithm developed in-house. Data obtained from the

Aerovironment Inc. 3-axis Doppler sodar at Richmond and the mini-sodar at Angiola and Fresno were processed using Aerovironment's Profiler Analysis and Display Software (PADS).

The ETL 2-beam Doppler sodar obtains, for each beam, the first moments, expressed as radial velocities along a sodar beam, in real time from the FFT spectra and saves these data. The editing of raw moment values was done by histogram, or consensus, editing. Radial velocity bins were defined, and the raw moments from one beam during the time period were placed into appropriate histogram bins. The acceptable histogram peak width was defined and the percentage of data points within the histogram peak was then computed. If this percentage is greater than the percentage threshold necessary to accept the data as good, then the moments within the histogram peak are considered to represent true wind moments. All moments outside this peak are considered to be noise. If an accepted histogram peak is present and contains at least a minimum number of points, the remaining good values are tested for realistic turbulence characteristics. If it fails this test, the values are considered to be too uniform to be coming from a meteorological source. After the moments for the entire hour and both beams are edited in this manner, the moment times for which the moments from both beams were found to be good are combined to form a wind. A vertical velocity of  $0 \text{ ms}^{-1}$  is assumed. All winds within the hour are then vector averaged, and a mean one-hour wind speed and direction is computed and written to file. The generated winds are then viewed and flagged as necessary (Level 1B).

The Aerovironment system performs, in real time, data quality checks on the incoming data according to preset data quality control limits. In post processing these data quality limits can be refined to obtain the cleanest data possible. Data are invalidated on a height by component by wind table basis according to reliability values, signal intensities, sigmas, component wind speeds, and signal-to-noise ratios. Level 1B processing involves displaying wind barbs in 24 hour time height sections, identifying suspicious data, and flagging those data as necessary

The following table (Table 5.1) lists the wind profiler, RASS, Doppler sodar, and surface meteorology sites for CRPAQS/CCOS, the levels to which the data has been processed as of 6/16/03, and whether the data has been delivered and accepted by ARB.

Table 5.1. Data processing completion chart for ETL CRPAQS/CCOS sites.

**Winds  
Processing  
Completion  
Chart**  
**Winter 1999/2000 thru  
Winter 2000/2001**

<u>Site</u>	<u>Dates</u>	<u>Processing Level</u>	<u>Packed</u>	<u>Delivered</u>	<u>Accepted</u>
Arbuckle	May 12, 2000-Oct 19, 2000	1B	YES	YES	YES
Angiola	Dec 8, 1999-Jan 31, 2001	1B	YES	YES	YES
Bakersfield	Dec 7, 1999-Jan 31, 2001	1B	YES	YES	YES
Chowchilla	Sept 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Chico	June 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Fresno	June 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Goleta	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Grass Valley	May 9, 2000- Jan 31, 2001	1B	YES	YES	YES
Los Banos	Dec 9, 1999-Jan 31, 2001	1B	YES	YES	YES
Lemoore	Dec 1, 1999-Nov 6, 2000	1B	YES	YES	YES
Lost Hills	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Mojave	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Monterey	Dec 5, 1999-Jan 31, 2001	1B	YES	YES	YES
Pleasant Grove	Apr 16, 2000- Oct 16, 2000	1B	YES	YES	YES
Redding	Apr 27, 2000-Oct 19, 2000	1B	YES	YES	YES
Richmond	Feb 11, 2000-Jan 31, 2001	1B	YES	YES	YES
Sacramento	Jan 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Stevinson	Dec 1, 1999-Sept 24, 2000	1B	YES	YES	YES
Trimmer	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Travis (AFB)	Dec 6, 1999-Dec 5, 2000	1B	YES	YES	YES
Visalia	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Waterford	June 22, 2000-Jan 31, 2001	1B	YES	YES	YES

**Temperature  
Processing  
Completion  
Chart**  
**Summer 2000**

<u>Site</u>	<u>Dates</u>	<u>Processing Level</u>	<u>Packed</u>	<u>Delivered</u>	<u>Accepted</u>
Arbuckle	May 12, 2000-Oct 19, 2000	1B	YES	YES	YES
Angiola	Dec 8, 1999-Jan 31, 2001	1B	YES	YES	YES
Bakersfield	Dec 7, 1999-Jan 31, 2001	1B	YES	YES	YES
Chowchilla	Sept 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Chico	June 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Fresno	June 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Goleta	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Grass Valley	May 9, 2000- Jan 31, 2001	1B	YES	YES	YES
Los Banos	Dec 9, 1999-Jan 31, 2001	1B	YES	YES	YES
Lemoore	Dec 1, 1999-Nov 6, 2000	1B	YES	YES	YES

Lost Hills	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Mojave	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Monterey	Dec 5, 1999-Jan 31, 2001	1B	YES	YES	YES
Pleasant Grove	Apr 16, 2000- Oct 16, 2000	1B	YES	YES	YES
Redding	Apr 27, 2000-Oct 19, 2000	1B	YES	YES	YES
Richmond	Feb 11, 2000-Jan 31, 2001	1B	YES	YES	YES
Sacramento	Jan 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Stevinson	Dec 1, 1999-Sept 24, 2000	1B	YES	YES	YES
Trimmer	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Travis (AFB)	Dec 6, 1999-Dec 5, 2000	1B	YES	YES	YES
Visalia	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Waterford	June 22, 2000-Jan 31, 2001	1B	YES	YES	YES

## Met Tower Processing Completion Chart

Site	Dates	Processing Level	Packed	Delivered	Accepted
Arbuckle	March 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Altamont Pass	Dec 25, 1999-Jan 31, 2001	1B	YES	YES	YES
Bakersfield	Dec 5, 1999-Jan 31, 2001	1B	YES	YES	YES
Chowchilla	Oct 4, 2000-Jan 21, 2001	1B	YES	YES	YES
Chico	March 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Fresno	June 1, 2000-Jan 31, 2001	1B	YES	YES	YES
Goleta	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Grass Valley	May 26, 2000-Jan 31, 2001	1B	YES	YES	YES
Kings River Powerplant	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Lost Hills	Dec 12, 1999-Jan 31, 2001	1B	YES	YES	YES
Mojave	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
New Melones Lake	May 11, 2000-Jan 31, 2001	1B	YES	YES	YES
Pacheco Pass	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Pleasant Grove	Apr 15, 2000-Jan 31, 2001	1B	YES	YES	YES
Redding	Apr 27, 2000-Jan 31, 2001	1B	YES	YES	YES
Richmond	Feb 11, 2000-Jan 31, 2001	1B	YES	YES	YES
Tejon Pass	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Trimmer	Dec 1, 1999-Jan 31, 2001	1B	YES	YES	YES
Waterford	June 16, 2000-Jan 31, 2001	1B	YES	YES	YES

### **5.3 Data Storage**

Storage of the original moment data and the processed data in three formats are finally migrated to compact disk medium in duplicate. Original data are separated into a “field” copy on one CD that comes from the backup disks. The second copy is migrated to another CD as the “dms7” copy from the RAID protected hard drive copy.

### **5.4 Data Management**

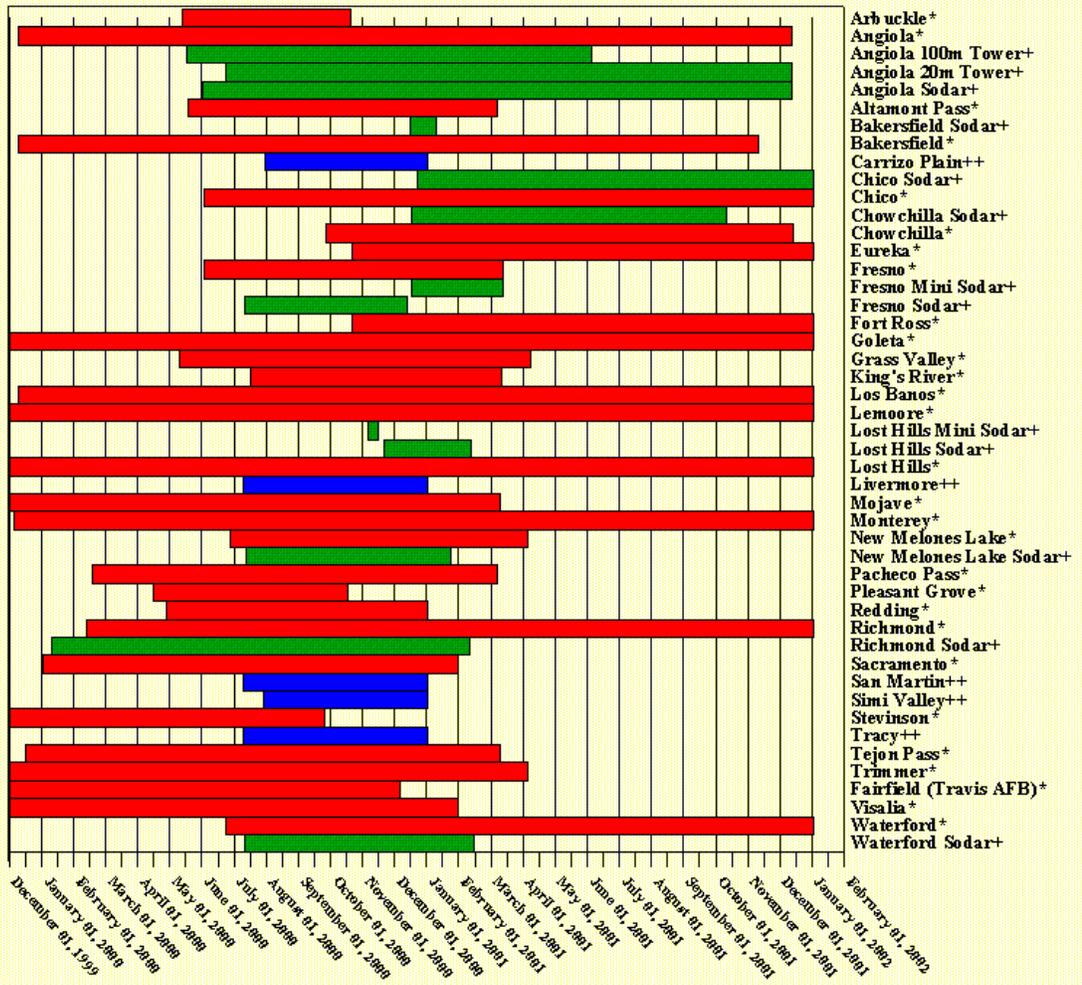
The data is managed with a Microsoft Access database to facilitate easy retrieval. Data can be accessed based on site code, project code, dates of operation of sites, the ETL in-house directory structure, instrument type, or physical parameter measured.

### **5.5 Data Coverage**

The following graph (Fig. 5.1) shows all sites used for post processing for CARB, visualization, and Rapid Update Cycle II (RUC II) numerical forecast model, sites for post processing for CARB only, and sites used for visualization and RUC II only.



**NOAA ETL Data Coverage for California December 1, 1999 to January 1, 2002**



█ \* These sites are for post processing for CARB, visualization, and for ingest into the Rapid Update Cycle II (RUC II) numerical forecast model.  
█ + These sites are for post processing for CARB only.  
█ ++ These sites are for visualization and RUC II only.

Fig. 5.1. ETL data coverage for CCOS/CRPAQS projects.

