

CHAPTER 2

FIELD MONITORING PROGRAM

The field monitoring program was designed to meet the objectives of PREVENT and the needs of the data analysis protocols discussed previously.

2.1 AEROSOL MONITORING SITES

2.1.1 Locations

The PREVENT study focused on Mount Rainier and North Cascades National Parks. Two primary sites were located in and near Mount Rainier at low and high elevation sites. One low elevation primary site was located at North Cascades. At these three primary sites, a complete characterization of the ambient atmospheric extinction coefficient, aerosol and gaseous concentrations, meteorology, and visual air quality conditions was done. In addition to the primary sites, fine particle measurements were made at 31 secondary sites throughout western Washington. Visual air quality was also monitored photographically at several locations throughout western Washington.

Figure 2-1 shows the locations of the three primary and 31 secondary sites. Table 2-1 lists these sites.

2.1.2 Instrumentation

2.1.2.1 IMPROVE Sampler

Each site had a version of the IMPROVE sampler. This modular sampler was designed for the IMPROVE/NPS networks to collect fine (0-2.5 μm) and PM_{10} particles (0-10 μm) on various filters. Each filter module in the PREVENT study had solenoids and elapsed timers for four identical filters. The sequence of filters was determined by a controller clock either inside the filter module or in a separate module. The volume of air for a given sample was determined from the duration and average flow rate. The duration for each filter was measured by an elapsed timer. The flow rate was monitored in two ways by two gauges. The primary flow rate measurement was provided by a magnehelic gauge that read the pressure drop of the air as it passed through the cyclone. The second flow rate measurement was based on the pressure drop across the filter; this pressure drop was determined by the small gauge. The operator recorded both gauge readings for each clean filter and both gauge readings and duration for each exposed



Figure 2-1. PREVENT particulate monitoring sites.

filter. The actual calculation of flow rates and volumes was done at the University of California at Davis (UCD).

Table 2-2 lists the modules used during PREVENT. Module 2 differed from module 3 in having an acidic vapor denuder inside the inlet. Module 6 had pairs of quartz filters arranged in tandem; the second filter was used to determine the gas adsorption artifact. Tahoma Woods had an additional module similar to Module 1, but collecting 24-hour samples of fine particles on Teflon filters.

The primary sites at Tahoma Woods and Marblemount had versions with six filter modules.

The primary site at Paradise had a version without module 3. All primary sites had a duration of 12 hours. All secondary sites, Hozomeen, used module 1 on a twenty-four hour sampling schedule. Samples were collected for every day of the monitoring period.

Table 2-1. Locations and elevations of aerosol sampling sites (latitude and longitude are in degrees and minutes).

	Elevation (meters)	Latitude (deg min)	Longitude (deg min)
PRIMARY			
Tahoma Woods, Mount Rainier NP	440	46 46	122 07
Marblemount, North Cascades NP	120	48 32	121 27
Paradise, Mount Rainier NP	1600	46 47	121 45
SECONDARY			
Arlington	60	48 17	121 59
Carbon River	520	47 00	121 59
Carnation	40	47 40	121 57
Carson	400	45 49	121 59
Cowlitz	130	46 31	122 37
Crystal Mountain	1380	46 56	121 29
Glenoma	350	46 31	122 08
Humtulpis	60	47 14	124 00
Hurricane Ridge, Olympic NP	1600	47 58	123 30
Kendall	110	48 53	122 08
Kent	90	47 23	122 12
La Grande	350	46 50	122 19
Mount Baker	1430	48 50	121 41
Mud Mountain	400	47 09	121 56
Newhalem, North Cascades NP	450	48 40	121 17
Nisqually	0	47 02	122 43
North Bend	140	47 30	121 47
Ohanapacosh, Mount Rainier NP	610	46 44	121 34
Packwood	320	46 36	121 41
Puyallup	30	47 11	122 19
Rochester	50	46 48	123 03
Sauvie Island	15	45 56	122 46
Sedro Woolley	150	48 28	122 11
Skookumchuck	110	46 47	122 43
Sobieski Mountain	1000	47 40	121 20
South Mountain	980	47 26	123 22
Stampede Pass	1200	47 17	121 22
Sultan	110	47 52	121 43
Toutle	170	47 17	122 44
Trout Lake	570	46 00	121 32
Willapa	30	46 33	123 35
BATTERY OPERATED DRUM			

Hozomeen, North Cascades NP	150	48 59	121 04
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Table 2-2. IMPROVE modules at the primary sites (Mount Rainier and North Cascades).

Module	Size	Duration	Filter	Measured Parameters
1	fine	12 hr	Teflon (1.1 cm ² area)	mass, elements Na-Pb, b_{abs}
2	fine	12 hr	Nylon with denuder	particulate nitrate
3	fine	12 hr	Nylon w/o denuder	particulate & gaseous nitrate
4a	fine	12 hr	Teflon (3.8 cm ² area)	XRF and quality assurance
4b	gas	12 hr	Impregnated quartz	SO ₂ (as SO ₄ ⁻)
5	PM ₁₀	12 hr	Teflon (3.8 cm ² area)	mass
6	fine	12 hr	Tandem quartz	organic and elemental carbon

2.1.2.2 Drum Sampler

The Davis Rotating Unit for Monitoring (DRUM) sampler collected size-resolved samples at Tahoma Woods and Marblemount. The DRUM strips were analyzable for elements Na to Pb, with a major interest in sulfur. This data permitted the calculation of the scattering efficiency. At Tahoma Woods there was an 8-stage version with 12-hour time resolution and a 4-stage version with 4-hour resolution. At Marblemount there was a 4-stage version with 4-hour resolution. To date only samples collected at Tahoma Woods between July 14 and August 24 have been analyzed.

A battery-powered version of the DRUM sampler with a single rotating stage was used at the Hozomeen site in North Cascades National Park.

2.1.2.3 Other Analyses

Samples of organic aerosols were collected at Tahoma Woods, Paradise and Kent during August. These were analyzed for volatile organic compounds using gas chromatography and mass spectrometry.

2.2 OPTICAL MONITORING SITES

The primary electro-optical parameter of the atmosphere that was estimated was the extinction coefficient (b_{ext}). Visibility through the atmosphere is restricted by scattering and absorption of light by both gases and particles. The atmospheric extinction coefficient is the sum of these effects and is a measure of the total fraction of light that is attenuated per unit distance as a light

beam transverses the atmosphere. b_{ext} is the sum of four components:

b_{sp} = light scattering by particles. This term is usually dominated by fine (less than 2.5 μm) particles.

b_{ap} = light absorption by particles. This term is dominated by elemental carbon (soot) particles.

b_{sg} = light scattering by air molecules (Rayleigh)

b_{ag} = light absorption by gases. Nitrogen dioxide is the major common species that significantly absorbs visible light.

By combining individual measurements of each of these components, a point estimate of the atmospheric extinction coefficient can be determined. Light scattering by air molecules was calculated from the local ambient pressure and temperature of the atmosphere. Particle scattering was measured using an integrating nephelometer. Particle absorption was estimated from transmission measurements through aerosol filters.

2.2.1 Locations

The seven optical monitoring locations used in the PREVENT study were chosen for various reasons:

1. The four Washington Department of Ecology (WA-DOE) nephelometer stations, Dog Mountain, South Mountain, Paradise, and Newhalem, had been in operation for a number of years. Some stations had operated every summer since 1982.
2. The National Park Service (NPS) stations at Tahoma Woods (Mount Rainier) and Marblemount (North Cascades) were collocated with primary particle sampler installations.
3. The NPS station at Carbon River was selected to better characterize the airshed around Mount Rainier National Park.
4. Only three NPS nephelometers were available for use.

Figure 2-2 displays the PREVENT site locations used to collect optical data. Table 2-3 lists station installation and removal dates.

2.2.2 Instrumentation

2.2.2.1 Integrating Nephelometers

The integrating nephelometer measures the light scattered by ambient atmospheric aerosols and gases. The geometry of the system is such that the signal is proportional to the scattering portion of the atmospheric extinction. The instrument draws air into a closed chamber and

integrates the light scattered from a light source that illuminates the sampling volume. The closed chamber and instrument operating characteristics result in several considerations concerning the use of the instrument for determining atmospheric extinction:

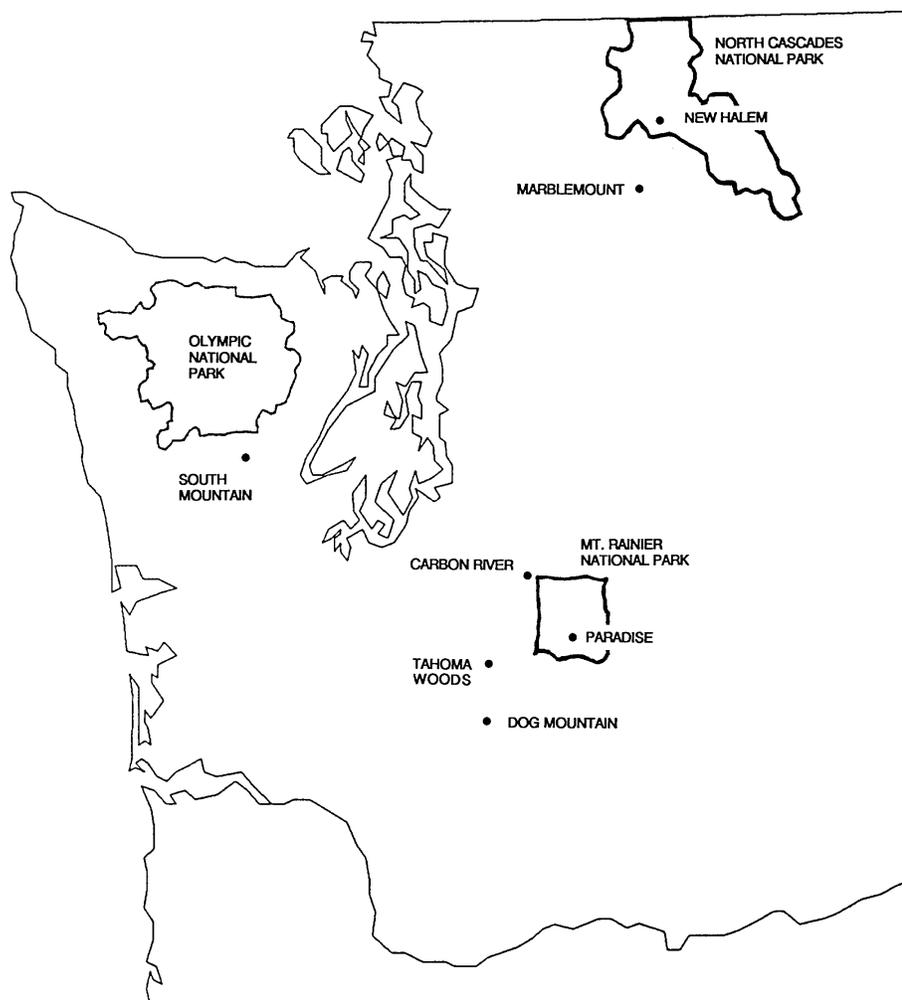


Figure 2-2. PREVENT optical monitoring sites.

- The measurements are totally independent of meteorological conditions and illumination. The scattering component of extinction is measured directly and is free of extraneous atmospheric effects.
- The sample must be drawn through ducts into a chamber, which in practice is a different environment from the ambient conditions. This results in a modification of the aerosol due to impaction on surfaces and change of relative humidity environment due to heating in the instrument. This occurs

even in instruments specifically designed to be unheated.

- The atmospheric sample is representative of the measurement point, rather than of a larger area. Care must be taken to assure that such samples are representative of the monitoring area of concern.
- The instrument is unable to measure light scattering in the extreme forward and backward directions, typically within 8 to 10 degrees of the optical axis. For particles larger than a few μm , the large forward scattered cone of light is missed by the detector optics. This means that the instrument underestimates the scattering from larger particles.
- The nephelometer measures only scattering, not the portion of extinction due to absorption. In any environment containing high levels of carbonaceous material, the nephelometer will seriously underestimate the total ambient atmospheric extinction.

Table 2-3. Monitoring station installation and removal dates.

Nephelometer Stations				
Site Location	Start Date	Start Time	End Date	End Time
South Mountain	6/19/90	14:00	9/3/90	23:59
Dog Mountain	6/19/90	14:00	9/3/90	23:59
Tahoma Woods	6/12/90	14:00	9/3/90	23:59
Paradise	6/13/90	19:00	9/3/90	23:59
Carbon River	6/17/90	13:00	9/3/90	23:59
Marblemount	7/15/90	17:00	9/3/90	23:59
Newhalem	7/12/90	13:00	9/3/90	23:59
See Figure 2-2 for a site location map.				

The errors caused by the various factors noted above vary from location to location. Heating of the sample by the instrument, by even a few degrees Celsius, can cause errors approaching 100% at high relative humidities (as occur during low temperature periods in the winter) when the particles deliquesce. Forward angle truncation typically results in underestimates of about 10% (even after allowing for calibration of the instrument with a Rayleigh scattering gas that compensates for some of the truncation error). The inability to measure absorption accounts for another 10% in atmospheres that contain little absorbing aerosols, but can approach 100% in urban atmospheres.^{1,2} Thus the nephelometer systematically underestimates atmospheric extinction by roughly 20% in a "typical" warm, dry, aerosol atmosphere and over 100% in a cold, humid, absorbing aerosol atmosphere.

To help alleviate problems due to heating during the study, the nephelometer systems were mounted in their own shelters. The shelter, a wooden building approximately 4' x 4' x 8', was continuously ventilated with ambient air to keep the nephelometer optical chamber as close to ambient temperature as possible. Temperatures at the inlet, in the optical chamber and at the exit of the sampling system were monitored and recorded. Nephelometers have been operated successfully in this fashion in a number of field studies.¹ Temperature differences in the sampling train were held to approximately 1.0° to 2.0°C with ambient temperatures ranging from -20° to 30°C.

Clean air zero reference measurements were done automatically every six hours. Full span Freon calibrations were performed at the beginning of the field program and every two weeks during the ten-week intensive monitoring period. The instrument outputs continuous values of particle scattering coefficient when zeroed for clean air. By keeping the sampling system as close to ambient temperature as possible and using short inlet plumbing, the aerosols in the optical chamber experienced the least modifications due to relative humidity and size distribution changes. Data were logged continuously to yield ten-minute average measurements of scattering coefficient. Data was collected on Campbell Scientific 21X micrologger systems with backup strip-chart recorders. Data were also logged on the meteorological station Data Collection Platform (DCP) collocated with the nephelometer. The Campbell data logger handled all internal timing for zero air checks.

The standard inlet system drew air through a sampling cane protected by a bug screen. All particle sizes that were drawn into the cane by the sample flow capable of passing through the bug screen entered the nephelometer (particle diameters of approximately 15 μm or less). This system configuration was used at all sites.

2.2.2.2 Nephelometer Stations - National Park Service

The three NPS nephelometer stations, Tahoma Woods, Carbon River and Marblemount, constructed specifically for this study, were identically configured. Nephelometers were housed in shelters of wood frame construction with dimensions of 4'l x 4'w x 8'h. Both shelters and nephelometers were configured with integral ventilation fans to keep the nephelometer sampling chamber temperature as close to the ambient temperature as possible. A discussion of nephelometer operating temperature is provided.

Campbell Scientific 21X data loggers were used both as system controllers and as backup data loggers. The 21X loggers collected and stored sensor readings at selected times, then transferred the values to Synergetics 3400 telemetry DCPs for transmission via the GOES (Geostationary Operational Environmental Satellite) west satellite to the Air Resource Specialists, Inc. facilities in Fort Collins, Colorado. Strip chart recorders were also used as backup data loggers and provided a convenient method for site operators to evaluate system performance.

The NPS stations were equipped to monitor:

- nephelometer raw readings
- nephelometer clean air zero values
- nephelometer inlet temperature
- nephelometer chamber temperature
- ambient temperature
- ambient relative humidity
- barometric pressure

A functional diagram of the NPS stations is shown in Figure 2-3. The sensor and sampling specifications for the NPS Synergetics and Campbell 21X data loggers are given in Tables 2-4 and 2-5.

2.2.2.3 Nephelometer Stations - State of Washington, DOE

Each of the four WA-DOE stations, South Mountain, Dog Mountain, Paradise and Newhalem, were equipped with the same compliment of sensors, and data logger configurations and were identical to those used at the NPS stations. The following aspects of the WA-DOE monitoring configurations differed from station to station, however, as dictated by the available instrument sheltering:

- length of the nephelometer inlet cane, height of the inlet cane above ground level, nephelometer operating temperature, and shelter temperature all lead to heating;
- WA-DOE stations were not equipped with barometric pressure sensors;
- clean air blowers were controlled by external timers, not Campbell 21X data loggers; and
- strip chart recorders from a different manufacturer were used.

2.3 PHOTOGRAPHIC MONITORING SITES

Automatic camera systems used in PREVENT were housed in environmentally-sealed, lockable enclosures and contained the following equipment:

- A 35 mm camera with either a 50 mm or 135 mm lens, UV filter, camera data back (capable of placing date and time on 35 mm slides), and mounting hardware;
- An 8 mm time-lapse camera with mounting hardware;
- A programmable timing system capable of triggering the cameras to take photographs at specific times of the day; and

- Batteries to operate all components.

At monitoring sites specifically installed or retrofitted for PREVENT, 35 mm cameras with 50 mm lens took exposures five to eight times a day depending on site accessibility and the operators' schedules for film changes. Time-lapse cameras (8 mm) also operated at a number of sites and took photographs from 08:00 to 20:00 at one-minute intervals. At the sites operated by other agencies, 35 mm cameras with 135 mm lenses took exposures three times a day (at 09:00, 12:00 and 15:00). Several of these sites were manually operated. Kodachrome 64 color slide film was used in all 35 mm camera systems, with the exception of the Washington State and Oregon State sites. These sites used Kodachrome 25 color slide film. Kodacolor Super-8 movie film was used in all time-lapse systems.

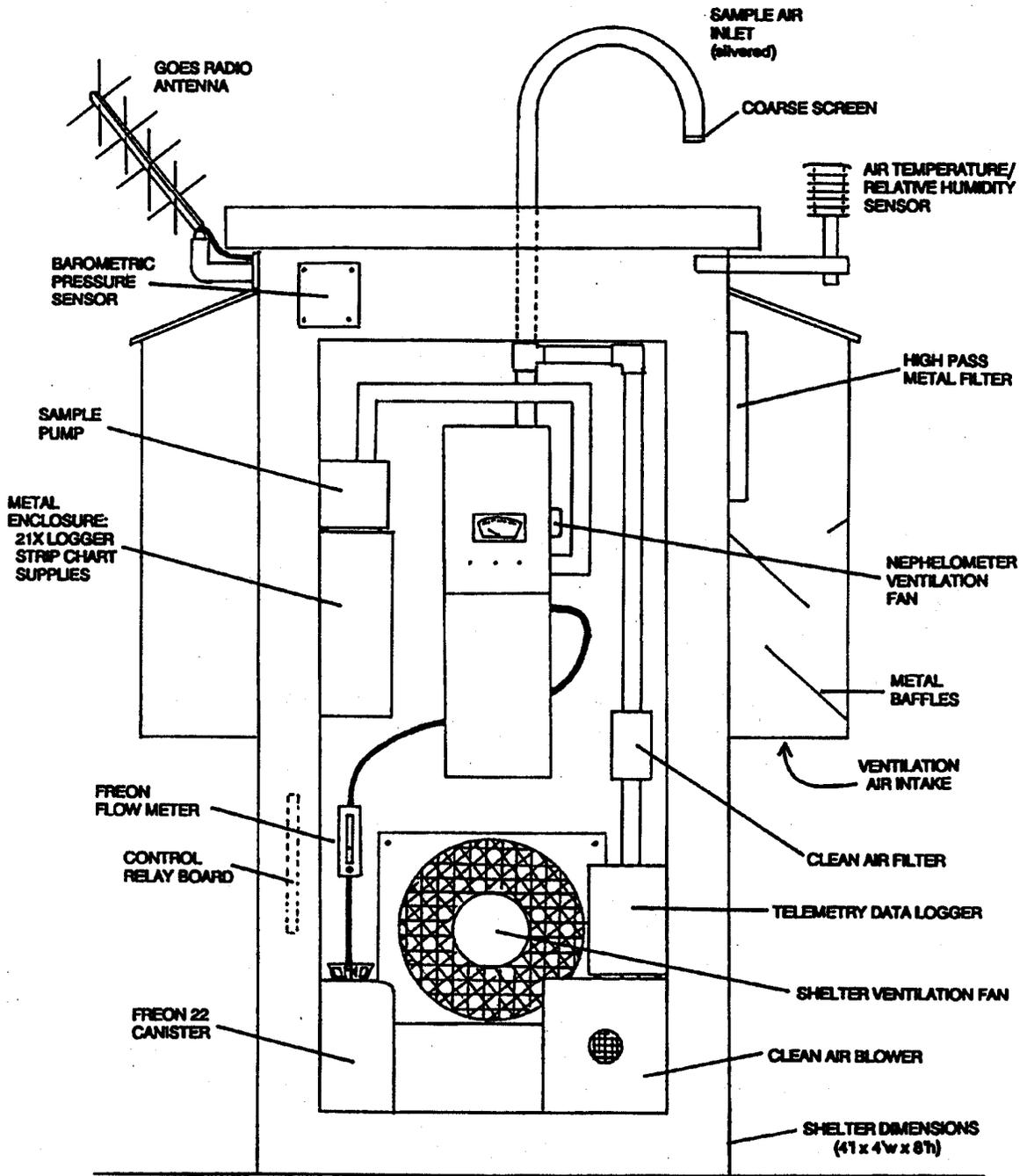


Figure 2.3 National Park Service nephelometer station component and functional diagram.

Table 2-4. National Park Service nephelometer station sensor and sampling specifications primary data collection (Synergetics DCP).

PARAMETER	SENSOR	UNITS	SAMPLING FREQUENCY	NOTES
Nephelometer Raw Readings	Belfort 1591 Nephelometer	mV	6 samples/hour taken at 00, 10, 20, 30, 40, and 50 minutes	NPS nephs. 0 - 5v = 0 - 10x10 ⁻⁴ bsp
Inlet Temperature	Copper/Constastan Thermocouple	°C	1 sample/hour taken at 00 minutes	
Chamber Temperature	Copper/Constastan Thermocouple	°C	1 sample/hour taken at 00 minutes	
Ambient Temperature	Campbell MN 207 AT/RH	°C	1 sample/hour taken at 00 minutes	
Ambient Relative Humidity	Campbell MN 207 AT/RH	%RH	1 sample/hour taken at 00 minutes	Sensor readings not accurate above 95%
Barometric Pressure	Campbell MN SBP270	mbars	1 sample/hour	uncorrected for elevation

Table 2-5. National Park Service nephelometer station sensor and sampling specifications backup data collection (Campbell 21X DCP).

PARAMETER	SENSOR	UNITS	SAMPLING FREQUENCY	NOTES
Nephelometer Raw Readings	Belfort 1591 Nephelometer	mV	10-minute averages of 10-second samples (600 samples/avg.)	NPS nephs. 0 - 5v = 0 - 10x10 ⁻⁴ bsp
Inlet Temperature	Copper/Constastan Thermocouple	°C	Hourly averages of 10-second samples (3600 samples/avg.)	
Chamber Temperature	Copper/Constastan Thermocouple	°C	Hourly averages of 10-second samples (3600 samples/avg.)	
Ambient Temperature	Campbell MN 207 AT/RH	°C	Hourly averages of 10-second samples (3600 samples/avg.)	
Ambient Relative Humidity	Campbell MN 207 AT/RH	%RH	Hourly averages of 10-second samples (3600 samples/avg.)	Sensor readings not accurate above 95%
Barometric Pressure	Campbell MN SBP270	mbars	Hourly averages of 10-second samples (3600 samples/avg.)	uncorrected for elevation

2.3.1 Locations

Sites were selected to monitor visibility-related air quality conditions that exist in western Washington and northern Oregon. Figure 2-4 is a map of all photographic monitoring sites that operated in the region. Table 2-6 lists the locations and monitoring configurations for the six sites installed or retrofitted specifically for PREVENT. Table 2-7 lists the locations and monitoring configurations for the eight sites operated by other agencies that could be used to support PREVENT. Note that many of the sites have multiple views. Figures A2-1 through A2-25 in Appendix 2 documents the 35 mm views at each site.

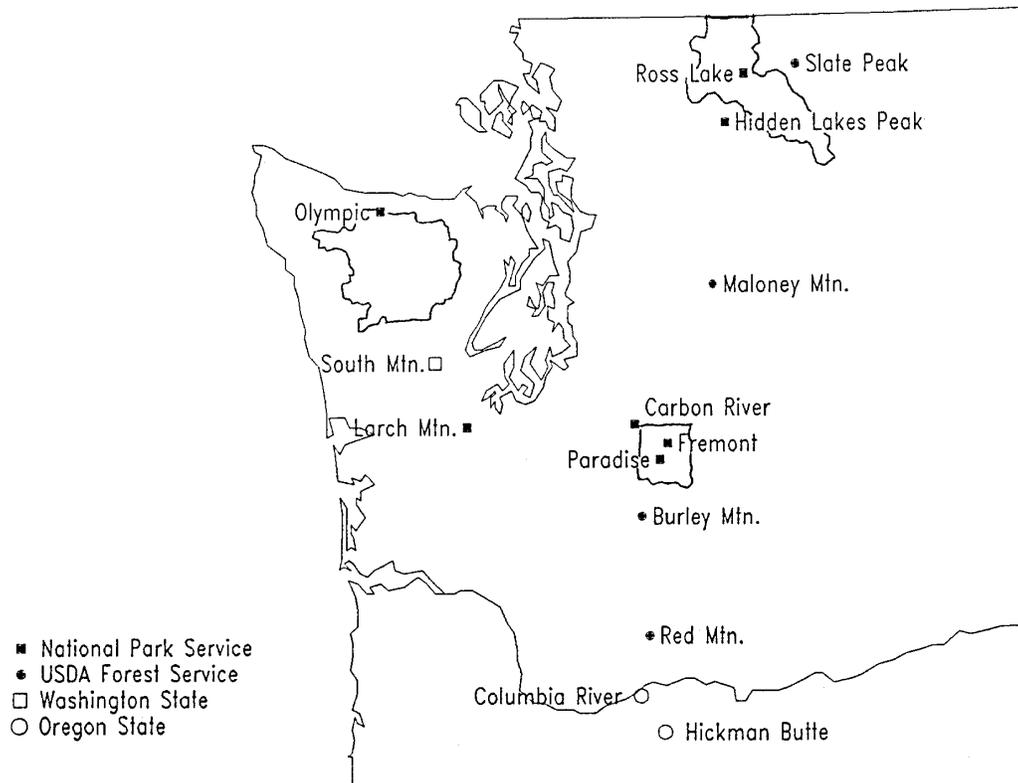


Figure 2-4. PREVENT photographic monitoring sites.

2.4 METEOROLOGICAL MONITORING SITES

Several types of meteorological data were collected daily from operational networks in support of PREVENT. These data were routinely retrieved via modem from WeatherBank (a service that provides data from the National Weather Service (NWS) and the Canadian Weather

Table 2-6. PREVENT camera site specifications.

Agency	Site Name	Site Abbr.	View Name	View Azimuth	Camera Type		Observation Frequency		Latitude	Longitude	View Fig. #
					35mm	8mm	35mm	8mm (on & off times)			
NPS (contract operator)	Carbon River	CARI	Mount Rainier	135°	Auto	Auto	8/day****	08:00-20:00	47.0800	121.9117	A2-1
NPS	Fremont L.O. (Sunrise)	FREA	Northwest North	315°	Auto	Auto	8/day****	08:00-20:00	46.9006	121.6714	A2-2
		FREB		360°	Auto	Auto	8/day****	08:00-20:00			A2-3
NPS	Hidden Lakes Peak	HLMB	Mount Baker	315°	Auto	Auto	6/day**	08:00-20:00	48.4845	121.2098	A2-4
		HLMR	Mount Rainier	195°	Auto	Auto	5/day*	08:00-20:00			A2-5
		HLPR	Pickett Range	360°	Auto	Auto	5/day*	08:00-20:00			A2-6
NPS (contract operator)	Larch Mountain	LARA	Mount Rainier	97°	Auto	Auto	8/day****	08:00-20:00	46.9858	123.1371	A2-7
		LARB	Centralia P.P.	150°	Auto	Auto	8/day****	08:00-20:00			A2-8
NPS	Paradise (orig. MORA mon. site)	MORA	The Rockies	255°	Auto	Auto	7/day***	08:00-20:00	46.8189	121.7292	A2-9
NPS	Ross Lake (orig. NOCA mon. site)	NOCA	Desolation Peak	1°	Auto	Auto	7/day***	08:00-20:00	48.7203	121.0633	A2-10

*08:00, 10:00, 12:00, 14:00, 16:00
 **08:00, 10:00, 12:00, 14:00, 16:00, 18:00
 ***08:00, 10:00, 12:00, 14:00, 16:00, 18:00, 20:00
 ****06:00, 08:00, 10:00, 12:00, 14:00, 16:00, 18:00,

Table 2-7. Non-PREVENT camera site specifications.

Agency	Site Name	Site Abbr.	View Name	View Azimuth	Camera Type		Observation Frequency		Latitude	Longitude	View Fig. #
					35mm	8mm	35mm	8mm (on & off times)			
NPS	Maloney Mtn.	BURA	Mount Rainier	10°	Manual	---	3/day*	---	46.5333	121.8667	A2-11
	Olympic N.P.	OLYA	Mount Mueller	285°	Auto	---	3/day*	---	48.0542	123.7833	A2-12
USFS	Red Mtn.	RERA	Mount Rainier	3°	Manual	---	3/day*	---	45.9344	121.8197	A2-13
	Burley Mtn.	BURL			Manual	---	3/day*	---	46.5333	121.8667	A2-14 A2-15
		2	Goat Rocks	73°							
		3	Mount St. Helens	227°							
	Maloney Mtn.	MAMO	Big Chiwakum	87°	Auto	---	3/day*	---	47.6817	121.3222	A2-16
	Red Mtn.	REMO				Manual	---	3/day*	---	45.9344	121.8197
1		Goat Mountain	304°								
2		Craggy Peak	356°								
3		Ltl. Mount Adams	50°								
4	Mount St. Helens	316°									
Slate Peak	SLPE	Princess Mtn.	338°	Auto	---	3/day*	---	48.7619	120.6792	A2-18	
Washington State	South Mtn.	SOMO	Mount Washington	16°	Auto	---	3/day*	---	47.3011	123.3737	A2-19
			The Brothers	21°							
Oregon State	Vista House	VIHO	Augspurgen Mtn	40°	Manual	---	3/day*	---	45.6316	121.8864	A2-20
	Hickman Butte	HIBU	Frog Lake Butte	138°	Manual	---	3/day*	---	45.4485	121.7160	A2-21

*0900, 1200, 1500

Service) and the U.S. Forest Service (USFS) Administrative Forest Fire Information Retrieval and Management System (AFFIRMS) network.

Also, "hard copy" weather maps issued by the National Weather Service were acquired daily from Mountain States Weather Services.

2.4.1 Locations

2.4.1.1 National Weather Service

National Weather Service data collected from WeatherBank included:

- hourly surface observations from 52 stations in Washington, Oregon, and British Columbia;
- upper air radiosonde observations every 12 hours for eight stations in Washington, Oregon, and British Columbia;
- winds aloft forecasts every 12 hours for Seattle, Yakima, and Portland; and
- several types of verbal forecasts and summaries.

Table 2-8 presents the 52 surface stations, their three letter codes, and their latitudes and longitudes. Figure 2-5 shows the locations of these surface stations. Radiosonde observations were collected for the stations listed in Table 2-9; their locations are shown in Figure 2-6. The verbal information collected included the Washington State Zone Forecasts, the Mount Rainier Recreational Forecasts, the Washington State Weather Summaries, and the Air Stagnation Advisories. These reports were valid for various regions, as described within the text of each particular report, and thus, did not generally apply to a single point on a map.

2.4.1.2 United States Forest Service AFFIRMS

The AFFIRMS data collected from the USFS included:

- hourly surface observations from about 30 automated stations in Washington and Oregon; and
- verbal fire weather outlooks for Wenatchee and Olympic, Washington; and Salem, Pendleton, and Medford, Oregon.

Table 2-8. National Weather Service surface meteorological stations for which hourly data were collected from WeatherBank.

Station	Code	Longitude	Latitude
WASHINGTON			
Bellingham	BLI	122.53	48.80
Boeing Field	BFI*	122.20	47.32
Bremerton	PWT	122.77	47.48
Ellensburg	ELN	120.52	47.00
Everett	PAE	122.28	47.92
Friday Harbor	FHR	123.02	48.52
Hanford	HMS	119.60	46.57
Hoquiam	HQM	123.93	46.97
Lacey	GRF*	122.76	47.03
McChord AFB	TCM*	122.58	47.20
Olympia	OLM	122.80	47.03
Omak	40M	119.53	48.42
Port Angeles	CLM	123.50	48.12
Quillayute	UIL	124.55	47.95
Renton	RNT	122.22	47.50
Sea-Tac AP	SEA	122.30	47.45
Shelton	SHN	123.15	47.23
Stampede Pass	SMP	121.33	47.28
Tacoma	TIW	122.58	47.27
Toledo	TDO	122.85	46.47
Wenatchee	EAT	120.20	47.40
Whidbey Island	NUW*	122.40	48.17
Yakima	YKM	120.53	46.57
OREGON			
Astoria	AST	123.88	46.15
Cascade Locks	CZK	121.88	45.68
Clatsop Spit	CTS	124.02	46.23
Hillsboro	HIO	122.95	45.53
Portland	PDX	122.60	45.60
The Dalles	DLS	121.15	45.62
Troutdale	TTD	122.40	45.55

* Latitude/Longitude locations estimated

Table 2-8. Continued.

Station	Code	Longitude	Latitude
BRITISH COLUMBIA			
Abbotsford	YXX*	122.18	49.02
Campbell River	YBL*	125.30	50.01
Comox	YQQ	125.00	49.70
Estevan Point	WEB	126.50	49.38
Fort Nelson	YYE	122.60	53.98
Hope	YHE*	121.28	49.21
Kamloops	YKA	120.45	50.70
Kelowna	YLW*	119.29	49.50
Nanaimo	YCD	123.87	49.05
Penticton	YYF	119.60	49.47
Port Alberni	WQC	124.83	49.25
Port Alberni	YPB	124.83	49.25
Port Hardy	YZT*	127.30	50.41
Powell River	YPW*	124.34	49.75
Prince George	YXS	121.68	53.88
Squamish	YSE*	123.11	49.41
Tofino	YAZ*	125.51	49.05
Vancouver	YVR*	123.06	49.13
Vernon	WVK*	119.19	50.17
Victoria	WLM*	123.22	48.25
Victoria Intl.	YYJ*	123.22	48.25
Victoria S.	WIR*	123.45	48.37

* Latitude/Longitude locations estimated

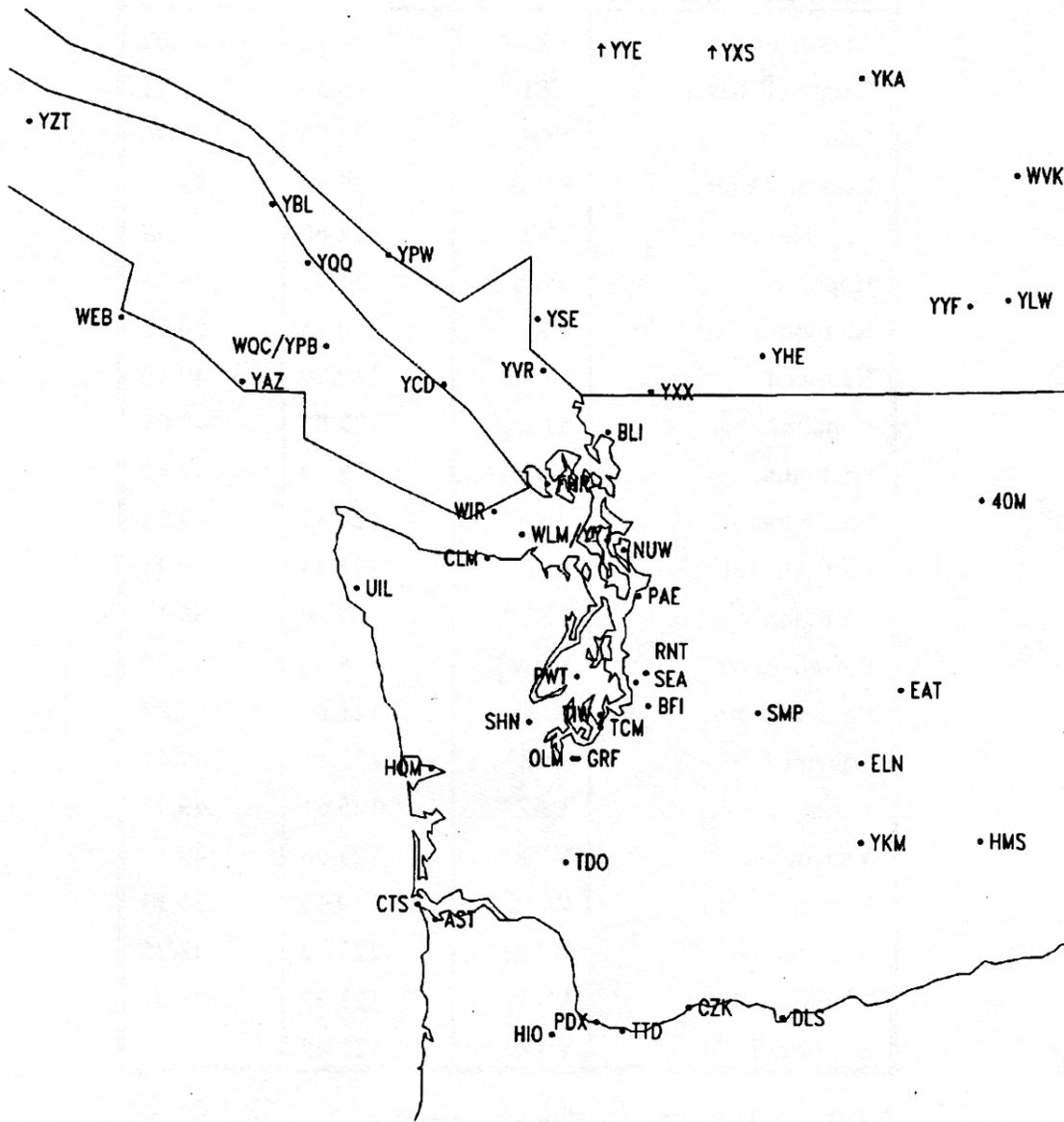


Figure 2-5. National Weather Service surface meteorological stations for which hourly data were collected from WeatherBank. Fort Nelson (YZE) and Prince George (YXS) are located north of the map boundary.

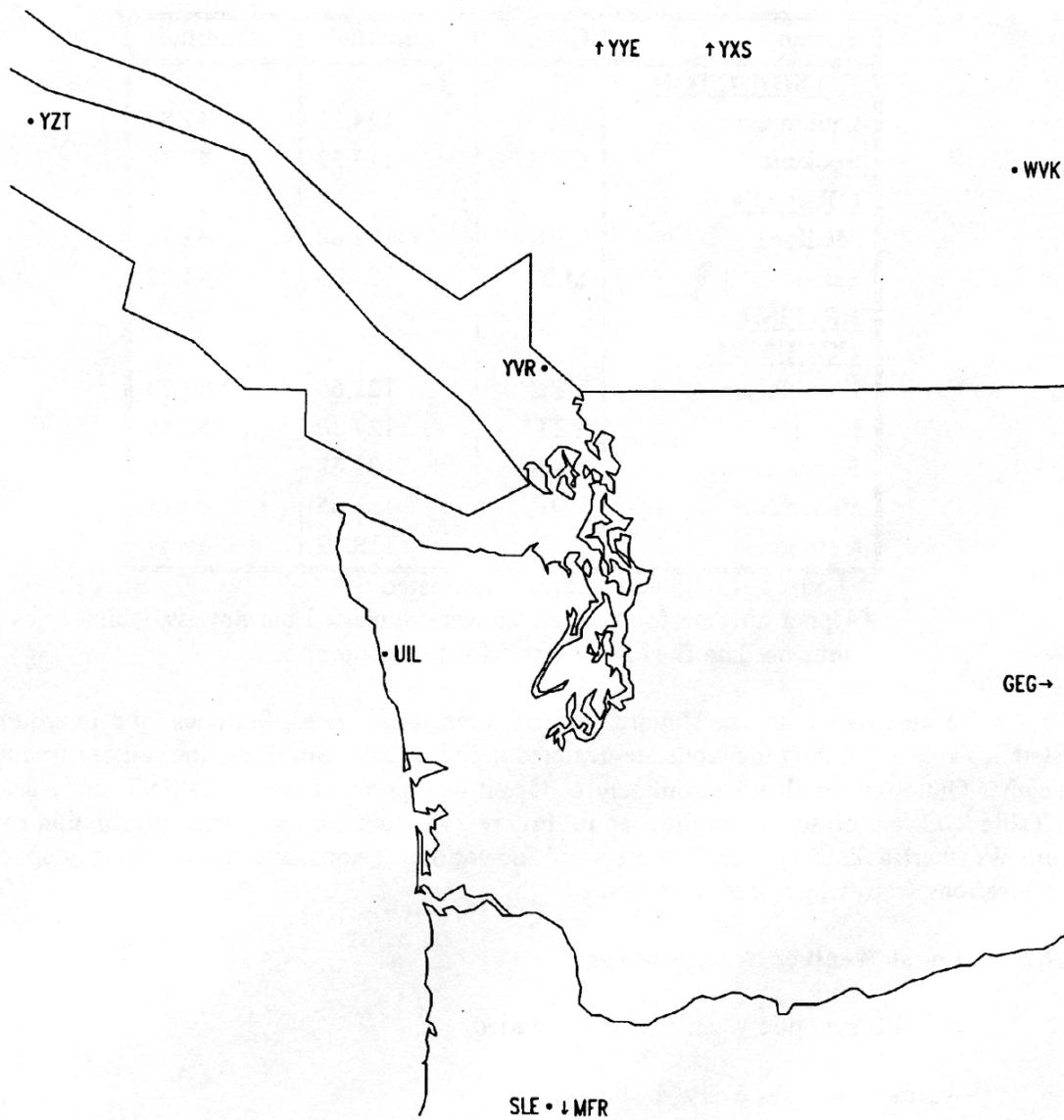


Figure 2-6. National Weather Service upper air radiosonde stations for which twice daily observations were collected from WeatherBank. Fort Nelson (YVE) and Prince George (YXS) are located north of the map boundary. Spokane (GEG) is located east of the map boundary. Medford (MFR) is located south of the map boundary.

Table 2-9. National Weather Service upper air radiosonde stations for which twice daily observations were collected from WeatherBank.

Station	Code	Longitude	Latitude
WASHINGTON			
Quillayute	UIL	124.33	47.57
Spokane	GEG	117.32	47.38
OREGON			
Medford	MFR	122.88	42.38
Salem	SLE	123.00	44.92
BRITISH COLUMBIA			
Fort Nelson	YYE	122.60	53.98
Port Hardy	YZT*	127.30	50.41
Prince George	YXS	121.68	53.88
Vancouver	YVR [†]	123.05	49.13
Vernon	WVK*	119.19	50.17

* Latitude/Longitude locations estimated

[†] Upper air data for Vancouver were requested, but not available; thus, no data files were saved for this station.

The automated surface stations' names, three letter codes, latitudes, and longitudes are listed in Table 2-10; their locations are depicted in Figure 2-7. Similarly, the stations issuing Fire Weather Outlooks which were routinely collected in support of the PREVENT study are listed in Table 2-11 and presented on the map in Figure 2-8. As with the verbal information received from WeatherBank, these reports were valid for various regions, and not necessarily specific to the locations from which they were issued.

2.4.2 National Weather Service Maps

The NWS synoptic weather maps included:

- surface analyses every six hours;
- upper air analyses every 12 hours at 850, 700, 500, and 300 mb;
- twelve-hour upper level wind prognoses;
- twelve-hour nested grid model (NGM) boundary layer winds/relative humidity forecasts; and
- four-panel forecast charts of 850, 700, and 500 mb heights and vorticity and 1000 - 500 mb thicknesses valid for 00 (analysis), 12, 24, 36, and 48 hours.

Table 2-10. Automated surface weather stations for which hourly data were collected from the USFS AFFIRMS network.

Station Name	Code	Station ID#	Longitude	Latitude
WASHINGTON				
Butte	FIR ⁴	452006	120.1060	48.6189
Camp 4	CAM	452132	120.3000	48.0000
Canyon Creek	CAN ¹	451921	122.2167	45.9167
Cedar Flats	CED ¹	451922	122.1167	46.1333
Cougar Mountain	COU	450117	123.2000	47.9167
Denny AHL Seed O	DEN	450903	123.4167	47.6167
Douglas Ingram First	DIR	452035	120.1000	48.1128
Finney Creek	FIN	451509	121.7903	48.4028
Gold Hill	GOL ³	451613	121.5431	48.2444
Hager Creek	HAG ¹	451115	121.6000	46.5500
Humtulpis	HUM	450312	123.7833	47.6167
Jefferson Creek	JEF	450911	123.2833	47.9167
Johnson Ridge	JHN	451611	121.2750	47.7958
Kidney Creek	KID ²	451409	121.9347	49.0000
Leecher	LEE	452020	120.0000	48.2500
Lester	LES	451705	121.5250	47.2083
Lost Lake	LOS	452029	119.0625	48.8686
Monument	JUD ¹	452034	120.6500	48.9939
Sawmill Flats	SAW	452221	121.1000	46.9833
Sitkum River	SIT	450128	124.2625	47.9569
Swauk	SWA	452219	120.6500	47.2667
Tom Creek	TOM	450121	123.9333	48.0500
Trout Creek	TRO ¹	451917	121.6833	46.1167
Washington Pass Lost	WAS	452033	120.6500	48.5250
OREGON				
Blue Ridge	BLR			
Log Creek	LOG	350811	121.7167	45.5167
Pollywog	POL	350604	123.8833	45.5000
Red Box	RED	350912	121.4500	45.4833
Wamic Mill	WAM	350718	121.9167	45.0667
Wanderers Peak	WAN	350913	121.4500	45.2333
		350726	122.2000	45.1000

¹Hourly AFFIRMS data for these stations were requested, but not available. Thus, no data files were saved for these stations.

²Hourly AFFIRMS data for Kidney Creek were not available for JUN, so no file was saved for this station for this month.

³Hourly AFFIRMS data for Gold Hill were not available for JUL, AUG, or SEP, so no files were saved for this station for these months.

⁴Hourly AFFIRMS data for first Butte were not available for AUG, so no file was saved for this station for this month

Figure 2-7. Automated surface weather stations for which hourly data were collected from the USFS/AFFIRMSnetwork.

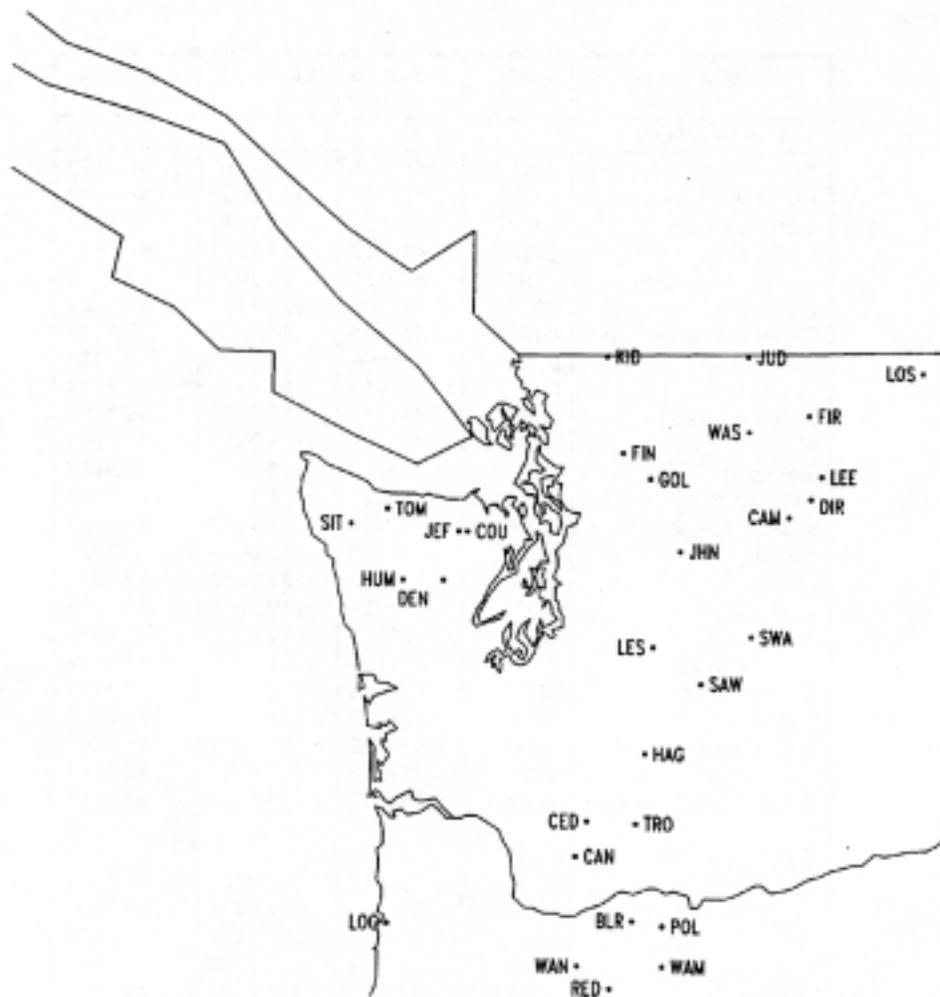


Figure 2-8. Stations issuing fire weather outlooks collected from the USFS AFFIRMS network. Pendleton (PDT) is located east of the map boundary. Medford (MFR) is located south of the map boundary.

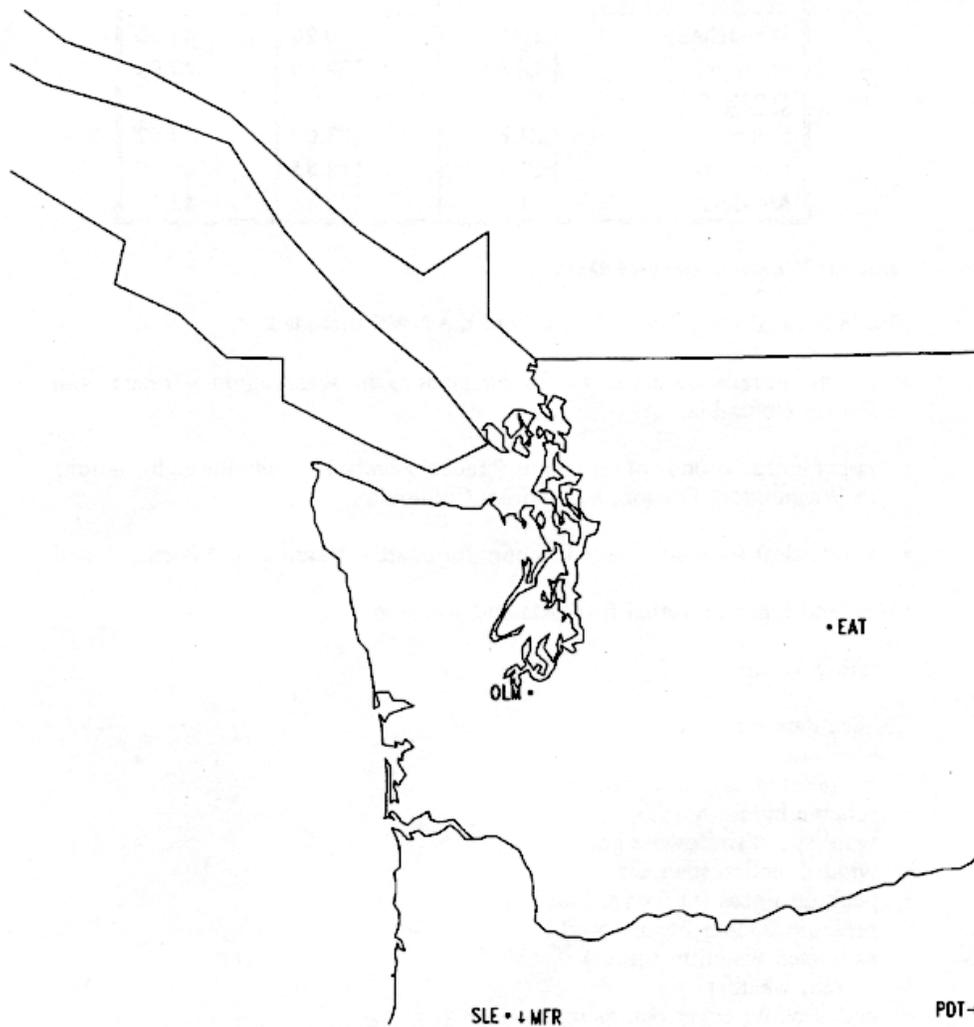


Table 2-11. Stations issuing fire weather outlooks collected from USFS AFFIRMS network.

Station	Code	Longitude	Latitude
<u>WASHINGTON</u>			
Wenatchee	EAT	120.20	47.40
Olympic	OLM	122.80	47.03
<u>OREGON</u>			
Salem	SLE	123.00	44.92
Pendleton	PDT	118.85	45.68
Medford	MFR	122.88	42.38

2.4.3 National Weather Service Data

The individual daily files of data from the NWS included:

- hourly surface observations for 60 stations in Washington, Oregon, and British Columbia;
- upper air radiosonde observations ("raobs") every 12 hours for eight stations in Washington, Oregon, and British Columbia;
- winds aloft forecasts every 12 hours for Seattle, Yakima, and Portland; and
- several types of verbal forecasts and summaries.

2.4.3.1 Surface Data

Surface data included:

- temperature and dewpoint (°F)
- relative humidity (%)
- wind speed (miles per hour)
- wind direction (degrees)
- peak gustiness (miles per hour)
- pressure (inches of mercury)
- estimated visibility (miles)
- current weather
- coded cloud cover comments

2.4.3.2 Upper Air Data

The NWS upper air data acquired from WeatherBank include:

Mandatory Levels (surface, 1000, 850, 700, 500, 400, 300, 250, 200, 100, 50 mb, etc.)

- temperature (°C)
- dewpoint depression (°C)
- wind speed (meters per second)
- wind direction (degrees)

Significant Levels

- temperature (°C)
- dewpoint depression (°C)

Wind Data at Various Altitudes (in meters)

- wind speed (meters per second)
- wind direction (degrees)

2.4.3.3 Assorted Verbal Forecasts, Summaries, and Winds Aloft Forecasts

The various NWS verbal forecasts and summaries included the Washington State Zone Forecasts, the Mount Rainier Recreational Forecasts, the Washington State Weather Summaries, and the Air Stagnation Advisories. The twice-daily, winds-aloft forecasts included wind speed, direction, and temperature at altitudes of 3,000, 6,000, 9,000, 12,000, 18,000, 24,000, 30,000, 34,000, and 39,000 feet for Yakima, Seattle, and Portland. After the daily files were retrieved from the archives, files containing only the verbal and winds aloft forecasts were created. Then another program sorted them into separate files for each data type. Next, these files were manually checked for duplicate, missing or truncated reports, and corrected, if necessary.

2.4.3.4 Hard Copy Weather Maps

Weather maps issued by the NWS were collected daily by Mountain States Weather Services. These hard copy maps include:

- surface Analysis for 00, 06, 12, 18Z (#s N005, N141, N075, and N105, respectively)
- 850 mb analysis at 00Z and 12Z (#D157)
- 700 mb analysis at 00Z and 12Z (#D270)
- 500 mb analysis at 00Z and 12Z (#D155)
- 300 mb analysis at 00Z and 12Z (#D183)
- twelve-hour upper level wind prognosis (6,000, 9,000, 12,000, 18,000, 24,000, 30,000, 36,000, and 39,000 ft.) (#N095)

- twelve-hour NGM boundary layer winds/relative humidity (#D189)
- forecast charts for 00 (analysis), 12, 24, 36, and 48 hours (#D170, D177, D185, D182, and D180, respectively), including:
 - 500 mb heights and vorticity
 - 1000 - 500 mb thickness
 - 700 mb heights and humidity
 - 850 mb heights and temperature

2.4.4 U.S. Forest Service AFFIRMS Data

The individual daily AFFIRMS data acquired from the USFS included hourly surface observations from about 30 automated stations in Washington and Oregon; verbal Fire Weather Outlooks for Wenatchee and Olympic, Washington; and Salem, Pendleton, and Medford, Oregon.

2.4.4.1 Surface Data

The hourly surface data included:

- a rain gage measurement (in inches)
- wind speed (in miles per hour)
- wind direction (in degrees)
- air temperature (°F)
- relative humidity (%)

2.4.4.2 Fire Weather Outlooks

The verbal Fire Weather Outlooks for Wenatchee and Olympic, Washington; and Medford, Salem, and Pendleton, Oregon, were sorted by first extracting the daily data files from the archive, and then concatenating the sections containing alphanumeric fire weather information. Next, individual files containing all the fire weather outlook reports for a single station were created. These files of fire weather information for individual stations were then checked for missing, truncated, or duplicate reports (if the outlook for a given day was not updated, the report for the previous day was re-transmitted, resulting in duplicate reports). If a report was missing, the message "REPORT MISSING OR NOT AVAILABLE" was inserted with the pertinent header information for that station.

REFERENCES

1. Molenaar, J.V., D.S. Cismoski, and R.M. Tree, 1992. Intercomparison of ambient optical monitoring techniques. Presented at the *85th Annual Meeting and Exhibition, Air and Waste Management*. Kansas City, MO, Paper No. 92-60.09, June 21-26.
2. Molenaar, J.V. and W.C. Malm, 1992. Ambient optical monitoring techniques. Presented at the *Conference on Visibility and Fine Particles*. Vienna, Austria, September

