IMPROVE PARTICULATE MONITORING NETWORK

PROCEDURES FOR SITE SELECTION

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OVERVIEW

The IMPROVE visibility program (Interagency Monitoring of Protected Visual Environments) is a cooperative measurement effort designed to:

(1) to establish current background aerosol concentrations in mandatory Class I areas;

(2) to identify chemical species and emission sources responsible for existing man-made visibility impairment;

(3) to document long-term trends; and

(4) to provide regional haze monitoring when obtainable at mandatory Class I areas.

The IMPROVE Steering Committee consists of representatives from the Environmental Protection Agency, the four Federal Land Managers (FLMs, National Park Service, Forest Service, Fish and Wildlife Service, Bureau of Land Management), and four inter-state agencies (State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials, Western States Air Resources Council, Northeast States for Coordinated Air Use Management, Mid-Atlantic Regional Air Management Association). Crocker Nuclear Laboratory at the University of California, Davis (UC Davis) has been the contractor for aerosol monitoring since the program was started in 1987.

At present, samples are collected on filters twice per week at 30 IMPROVE sites and 40 IMPROVE Protocol sites. (Protocol sites are administered by FLMs and state agencies rather than directly by the IMPROVE Steering Committee.) During 1999, a modified sampler permitting data logging will replace the existing samplers at all of these sites. By December 1999, there will be 108 IMPROVE sites and at least 10 IMPROVE Protocol sites. Of the 108 sites, approximately 50 will be new or relocated sites. On December 2, 1999, the sampling frequency will shift to the national 1-day-in-3 protocol. Sample changes will continue to be made once a week by an on-site operator and the filters sent back to our laboratory to be analyzed for the major aerosol components and trace metals. The validated concentrations will be available to all parties and to the public via electronic transmission and printed data reports.

The 156 mandatory Class I areas have been combined into 108 clusters on the basis of elevation and spatial separation; one IMPROVE site will be located within each cluster. The next step will be to select suitable specific sampling locations, following criteria of distance from the area(s), elevation, absence of local emission sources, power, and year-round accessibility. The 30 current IMPROVE sites are expected to remain at their specific locations, although the Steering Committee is willing to reconsider past decisions on a case-by-case basis. Twenty-nine existing or former Protocol sites are potential candidates, but other sites will be chosen if clearly better. (Maintaining the historical record will be considered in evaluating criteria.) New sites must be found for the remaining 49 clusters. The local FLM, the state and/or local air quality agency, the national or regional FLM, and UC Davis, will identify potential sampling sites for each cluster. Ideally, the final site selection will involve a consensus of these groups.

After the site is selected, the local FLM will normally obtain permits and have power installed at the site. UC Davis will arrange to have a shelter installed at the site and ship the sampler to the site. Once this is completed, UC Davis personnel will travel to the site, install the sampler and train the site operators. The sample changing by the site operator will require about 20 minutes per week plus transportation to the site.

I. DESCRIPTION OF THE IMPROVE SAMPLER

The IMPROVE sampler is designed to obtain a complete signature of the composition of the airborne particles affecting visibility. $PM_{2.5}$ (fine) articles are collected on Teflon, nylon, and quartz filters and PM_{10} particles on a Teflon filter. Each filter is in a separate module, as shown in Figure 1. The inlets are normally 0.6m apart. The separate controller module is not shown. The analytical measurements are shown in Table 1.

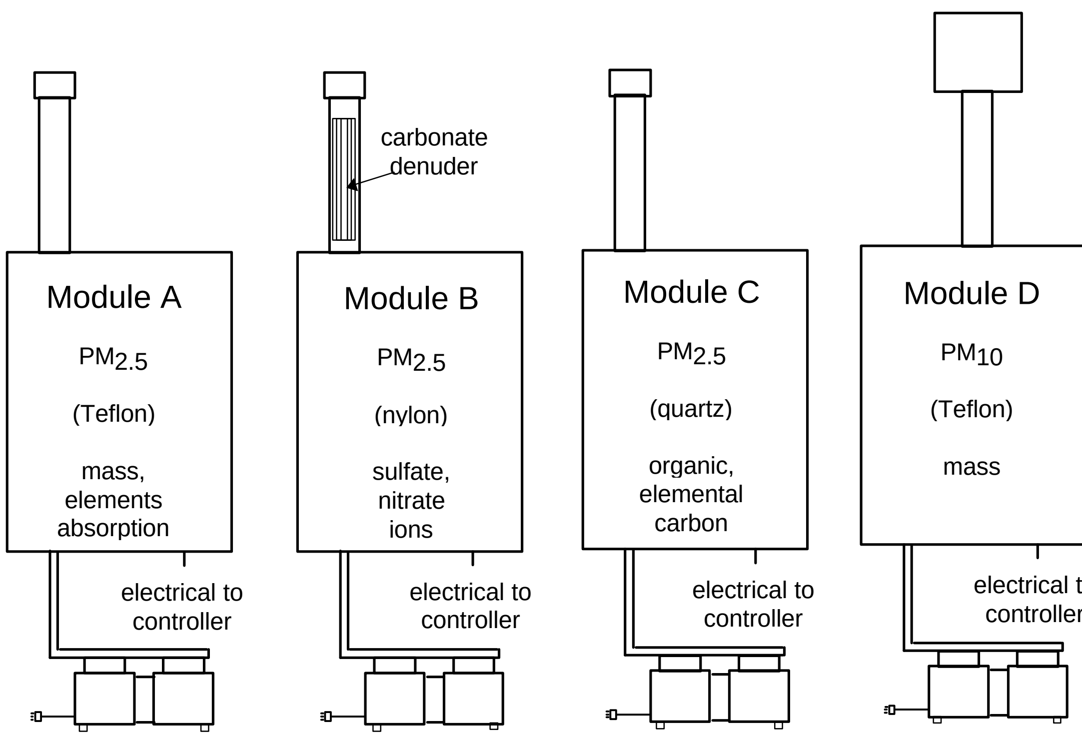


Figure 1. Diagram of the IMPROVE Aerosol Sampler.

Table 1. IMPROVE aerosol measurements.

Module	Size Region	Filter	Analytical Measurement
A	$PM_{2.5}$ particles	Teflon	mass, optical absorption, elemental (H, Na-Pb)
B	$PM_{2.5}$ particles	nylon with denuder	nitrate, sulfate, chloride
C	$PM_{2.5}$ particles	quartz	organic and elemental carbon
D	PM_{10} particles	Teflon	PM_{10} mass

The modified IMPROVE aerosol sampler consists of the following:

- Controller: The controller module contains a microprocessor to start and stop sample collection and continuously record the flow rates for each module. The controller module measures 16” x 12” x 7” and weighs 30 pounds. The controller has a viewing screen, a keypad, a slot for a removable memory card, plus necessary electronic components. All information and the operating program will be stored on the removable memory card. The flow rates and other parameters are displayed on the viewing screen. The controller module is shown in Figure 2.

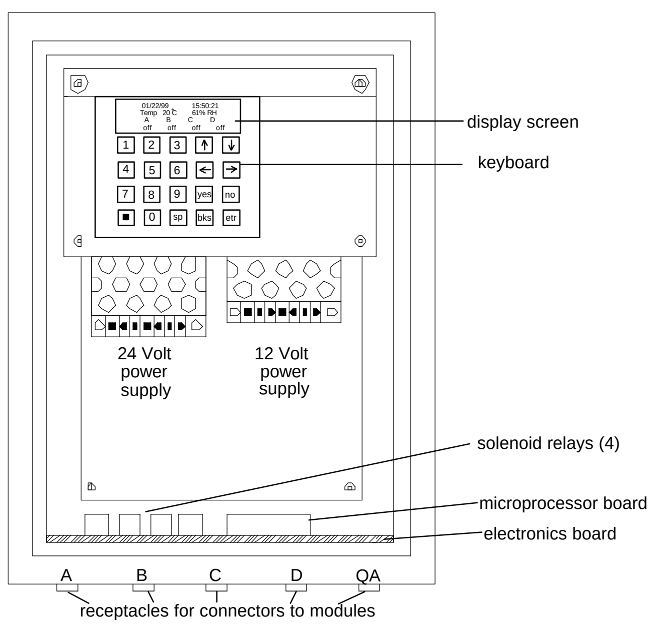
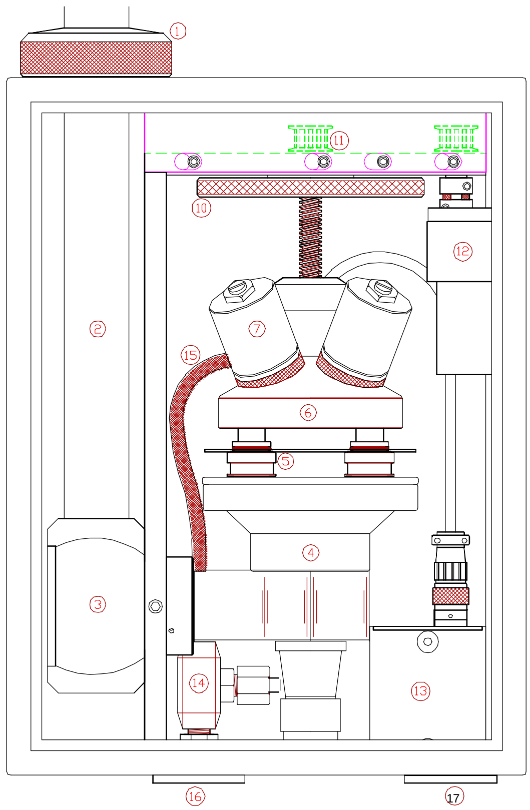


Figure 2. Schematic of the IMPROVE controller module used after 1999.

- Three $PM_{2.5}$ Modules (A, B, C): Each $PM_{2.5}$ module contains a cyclone (to separate out particles larger than 2.5 µm), 4 solenoids, a critical orifice flow controller, 2 flow gauges, an inlet stack, and associated electronics. The nylon module (B) contains a denuder to remove nitric acid vapor. The readable gauges and elapsed timers on the old version of sampler have been eliminated. Each module measures 16” x 12” x 7” and weighs 40 pounds. Figure 3 shows a PM2.5 module of the new design. The air stream at the filters goes vertically up. All the filters will be pre-loaded into cassettes and the cassettes into cartridges in the central sample handling laboratory. Each module will have a separate color-coded cartridge. The solenoid manifold is raised and lowered either by a motor drive or manually by a hand wheel.



$PM_{2.5}$ Filter Module

1. compression sleeve to support inlet stack
2. inlet stack (rain/insect protector at top)
3. inlet tee
4. cyclone / cassette manifold
5. cartridge with 4 filter cassettes
6. solenoid / cassette manifold
7. solenoid valve (4)

10. hand wheel (to raise #6)
11. timing pulleys for motor
12. motor drive (to raise #6)
13. electronics enclosure
14. critical orifice valve
15. hose to critical orifice/pump
16. connector for hose to pump
17. connector for line to controller

Figure 3. Schematic of the new IMPROVE PM2.5.

- One PM_{10} Module (D): This module is the same as a $PM_{2.5}$ module, except the inlet and cyclone are replaced by a commercial PM_{10} inlet. The air stream at the PM10 filters goes vertically down.
- Selected sites will have an additional $PM_{2.5}$ module for quality assurance.
- A simple shelter to protect the sample during weekly sample changing in adverse weather. The shelter is discussed further below. The cost of the basic shelter will be paid for by the UC Davis contract. Normally, the shelter will be built of wood by a local contractor.
- Four vacuum pumps to provide air flow through the filters. Each pump measures 12” x 7” x 9”, weighs 25 pounds, and draws about 3.2 amperes of power at 120 volts. The pumps will generally be on the floor of the shelter. The complete sampler requires 120 Volt, 60 Hertz AC power on a 20-ampere circuit.

<u>Shelter</u>: The primary purpose of the shelter is to protect the sample from precipitation and wind, and the operator from severe cold, during the weekly sample changes. We currently have an excellent recovery rate of 94%, despite the fact that most IMPROVE sites have extreme weather at some time of the year. The shelters will allow us to maintain or improve this record. At sites with high summer temperatures and less severe winters, the shelters will be more open, allowing maximum ventilation. The plans for shelters are currently under review. The parameters for the shelter are as follows:

- The inside dimensions will be at least 6 ft x 8 ft.
- The shelter shall meet any requirements by the local FLM for visual appearance.

- The shelter will be well ventilated, but not heated or air-conditioned.
- The shelter will be able to support heavy snow loads. In some sites with deep snow pack, the shelter may have to be installed on a platform. The siting criteria allow for this possibility.

The samples for all sites in the IMPROVE network will be changed every Tuesday by a local site operator. The change day will remain on Tuesday even after the sampling frequency changes from twice a week to one-day-in-three during the first week of December 1999. The site operator will receive a box with all the necessary filters, a microprocessor memory card, and a field log sheet. The steps for the change are as follows.

1. The operator presses the appropriate buttons on the microprocessor keyboard to read and display the flow rates for the exposed filters in the sampler. The operator records the displayed values on the log sheet.
2. The operator removes the cartridges of exposed filters from each module, seals them in the provided bag, and places the bag in the shipping box for these samples. The operator removes the memory card in the controller and places it in the same shipping box.
3. The operator inserts the cartridges of clean filters in each module and a new memory card in the controller.
4. The operator presses the appropriate buttons on the microprocessor keyboard to read and display the flow rates for the clean filters. The operator records the displayed values on the log sheet.
5. The operator verifies that the readings are reasonable. The microprocessor will also make checks and flash a warning if there are problems.
6. The operator will then return the shipping box with exposed filters, the completed log sheet, and the old memory card to UC Davis.

With the shift to one-day-in-three protocol, there will be an extra step every third week, when the sampling day is Tuesday. The procedure will interrupt the collection for the few minutes of the change. The operator will move the specially marked cassette from each old cartridge and place it in a hole in the corresponding new cartridge. The operator will transfer cassettes but not touch the filters. When the change is complete, the sampling will automatically resume.

II. CURRENT STATUS OF SITE SELECTION

In order to monitor the aerosol at all 156 mandatory Class I areas with 108 sites, the areas were combined into clusters so that one site could represent multiple areas. The 108 clusters are given in Appendix 1.[1] Distance and elevation criteria were used: all areas in a cluster should be within 100 km of a current or potential site, whose elevation lies between the highest and lowest elevations of all areas in the cluster, with a permitted variance of 100 ft or 10%. In a few cases, a cluster was split if other factors suggested that two sites would be appropriate. The states and FLMs participated in the selection of the clusters. Figure 4 shows a map of the general locations of the planned sites.

[1] In December 1998, the IMPROVE Steering Committee approved 93 of the 108 clusters. One cluster has not yet been allocated. The 14 remaining clusters, tentatively allocated to California, will be finalized by a consensus of the state of California and representatives of the IMPROVE steering committee.

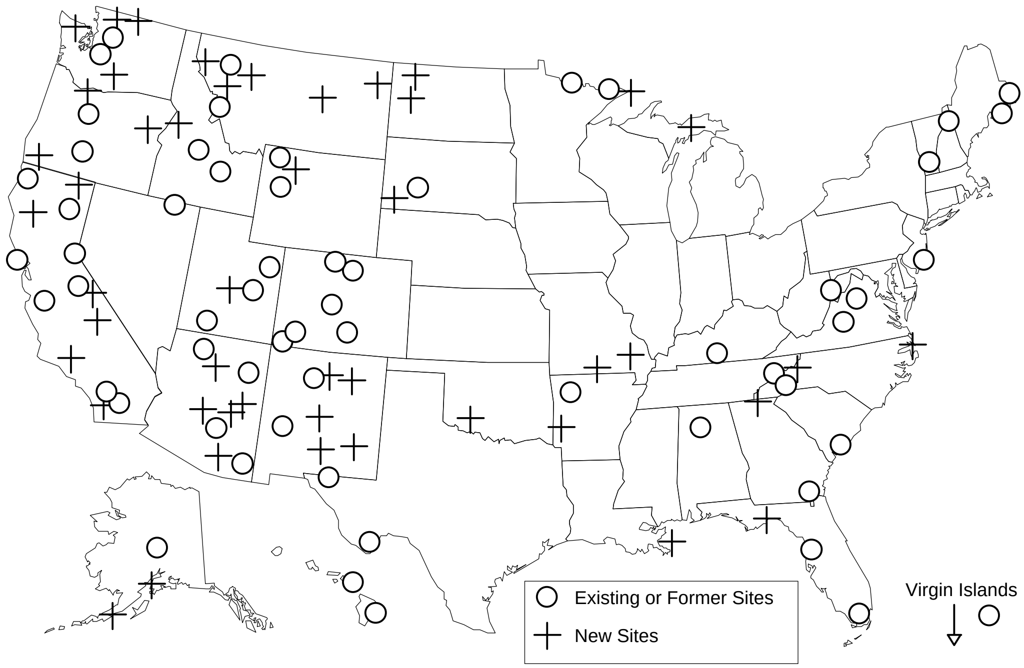


Figure 4. General location of sites.

Fifty-nine of the clusters have either current or past sites that meet the siting criteria. Maintaining the historical record will be a strong consideration in selecting specific locations. The 30 IMPROVE sites (type IMP in Appendix I) will be retained, unless additional information by the state and/or local air quality agency or FLM indicates the site is inadequate. The 29 current or former Protocol sites meeting the siting criteria will be strong candidates for their clusters, although alternate sites may be considered. Two clusters have Protocol sites that fail the elevation criterion and are listed in Appendix I as needing new sites (Saguaro and Sequoia).

III. PROCEDURES FOR SELECTING A SAMPLING SITE LOCATION

A. CRITERIA FOR PROSPECTIVE SITES

The proposed procedure would be to identify several prospective sites in each cluster, and then select the best site. The final determination of the site will involve a consensus of the local FLM, the state and/or local air quality agency, the national or regional FLM, and UC Davis. The lead role in the selection of prospective sites will normally be assumed by the local FLM manager and the state and/or local air quality agency. However, the national or regional FLM may want to participate at this early level. In clusters with multiple Class I areas, the role may be shared by more than one local FLM manager. For all situations, the UC Davis field manager, Peter Beveridge, will provide advice. Under previous National Park Service contracts, he has helped locate all the existing sites in the IMPROVE network.

The site criteria fall into three categories: (1) the site must represent all the Class I areas in the cluster, (2) the site should be regionally representative, avoiding local pollution sources or areas with unusual meteorology, and (3) the site must avoid nearby obstacles that could affect sample collection. In most cases, the criteria are based on EPA guidelines. The criteria are not absolutes. A site that falls slightly outside a criterion may be the best choice. Significant variances from any criterion should be well documented and will be reviewed by the IMPROVE steering committee before the site is installed. The following criteria should be used as guidelines in selecting the specific location of a sampling site.

1. The site must represent all the Class I areas in the cluster.
   a. The distance between the site and the closest portion of all Class I areas should not be greater than 100 km. A smaller distance would be desirable. Note that the closest site may not be the best site.
   b. The elevation of the site should lie between the highest and lowest elevations of all Class I areas in the cluster. Exceedances of 100 feet or 10% are considered meeting the criterion. Larger exceedances are permitted if agreed to by the states and FLMs. Appendix 1 gives the range of site elevations for the cluster.

2. The site must avoid small valleys with non-representative meteorology. Valleys with towns or other emission sources are definitely to be avoided. Valleys without emission sources, but with significant inversions, should also be avoided.

3. The site must avoid all local sources of pollution.
   a. Automotive Sources: vehicle usage, distance between road and sampler
      - <10,000 vehicles per day   >25m between road and sampler.
      - 10,000-20,000 vehicles per day   >50m between road and sampler.
      - 20,000-40,000 vehicles per day   >75m between road and sampler.
      - >40,000 vehicles per day   >100m between road and sampler.

   b. Combustion Sources
      Avoid any areas influenced by diesel generator emissions, wood smoke, or incinerators.
   c. Dust Sources
      At least 400m from a large potential source of dust, such as a landfill, agricultural operations, or an unpaved road with more than 400 cars per day.

4. The site should avoid large obstructions, such as trees or buildings. In the standard setup, the inlet will be approximately 3.5m (11 feet) above the bottom of the shelter. The sampler could be placed on a platform to clear obstructions, as well as to be above any snow pack. Raising the height of the inlet by increasing the length of the stack beyond the standard 2m is not recommended, although theoretical calculations show no significant loss of particles on the wall of a stack much longer than 2m. (For a 1% loss of particles larger than 0.3 µm, the stack length would have to be over 250m.)
   a. There should be unrestricted airflow for an arc of at least 270°. The predominant wind direction must be in the unrestricted 270°. In practice, having unrestricted flow in all directions is preferable.
   b. <u>Within 10m</u> of the sampler, any solid barriers or trees should be at least 1m below the inlet, as shown on the left side of Figure 5. In general, a pole or meteorological tower will not be a solid barrier. We will set as a guideline that a solid barrier is any object that subtends more than 10°. (Example: Hold a ruler at arm's length (24 inches)—if the object subtends more than four inches, it is a solid barrier.)

c. Beyond 10m of the sampler, the solid barriers or trees should not be higher than 30° above the horizontal with respect to the inlet, as shown on the right side of Figure 5. (Example: Hold a ruler at arm's length (24 inches)—30° is a height of 14 inches.)

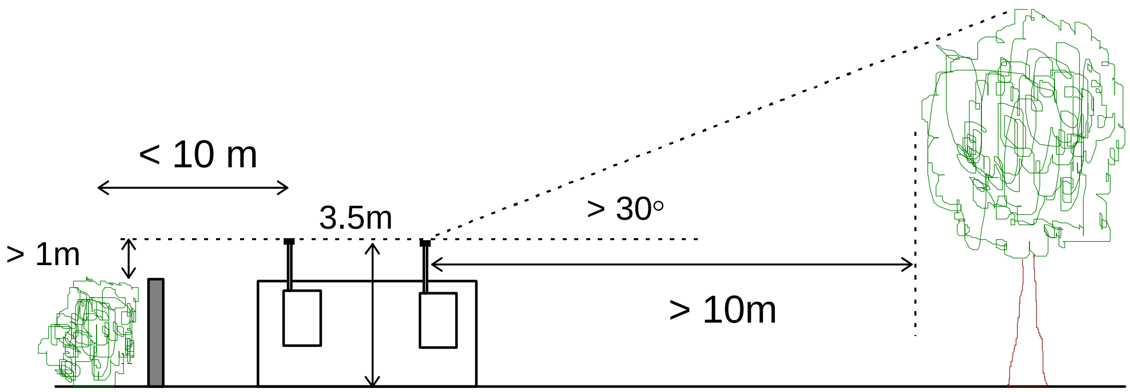


Figure 5. Schematic of location with respect to trees and solid barriers.

5. The site must have electrical power (120 Volt, 60 Hertz, 20 Amperes). If new power must be installed it is anticipated that the local FLM will be able to obtain the necessary financial resources. The Steering Committee will consider exceptions.

6. The site must be accessible for a weekly sample change in all but the most severe weather conditions.

B. PHOTOGRAPHIC AND WRITTEN EVALUATION OF POTENTIAL SITES

Once potential sites have been found to meet the above siting criteria, the local FLM manager, or other persons leading the initial search, will send photos, sketches, and siting information for each potential site to UC Davis. A summary will be distributed to all parties involved in the selection.

1. PHOTO: The local FLM manager will complete and send the requested documentary photographs along with the attached photographic log. (See Appendix 2. Photo Log.) The following photos will facilitate site selection:

   a. Photos taken from North, South, East, and West with the prospective site in each view.
   b. A photo of the 120 Volt power source in relation to the proposed site.
   c. Close up photos of the location proposed as a sampler site.
   d. Photos of the 4 walls inside an existing building (not necessary if installing a new shelter).
   e. Photos of any air quality or meteorological monitoring equipment located nearby.
   f. Any additional photos you feel would be beneficial in preparing for the sampler installation.

2. WRITTEN: The local FLM manager will complete and send an evaluation form for each potential site. (See Appendix 3. Site Evaluation Form for Potential Sites with Sketch on Reverse Side.) Use a separate copy of the blank form for each potential site.

   a. Fill out the information at the top of the form. Include as much information as possible.

b. Provide a sketch of the proposed sites on the reverse side. List approximate dimensions (including height). Also include distances between buildings, fenced compounds, obstructions, etc.
c. Provide a map or sketch of how to get to each potential site from a main road.
d. If possible, include a copy of a topographic map with all potential sites indicated.

C. FINAL SELECTION OF SITE LOCATION

At this point, a joint decision must be made by all concerned parties as to where to locate the sampling site. The concerned parties will be the local FLM, the national and/or regional FLM, the state and/or local air quality agency in which the site is located, and UC Davis. If significant disagreements exist between the concerned parties, UC Davis will prepare a summary for the IMPROVE steering committee discussing each siting alternative and the tradeoff between them. The IMPROVE steering committee will work with the parties to reach a decision.

1. The UC Davis field manager, Peter Beveridge, will prepare a packet on the site with the documentation for each of the potential sites.
2. UC Davis will provide this packet and recommendations to all concerned parties.
3. The UC Davis field manager will coordinate the final selection of the site location. This will generally be done with individual telephone calls or a conference call. If this is unsatisfactory, the UC Davis field manager will coordinate an on-site visit with all concerned parties.

D. AUTHORIZATIONS FOR SITE USE

The local FLM manager will complete the necessary paperwork required to use the site, install power, and build structures:

1. Obtain any needed permission to use the property.
2. Prepare and submit any Environmental Impact Reports.
3. Obtain any needed authorization to install and use electrical power . The FLM will normally be expected to pay for the electrical power used. (An annual usage of approximately 5000 KWhr is expected.)

E. SITE PREPARATION

Once the specific location of an individual site has been agreed upon, the site must be prepared for installation of the sampling equipment. This primarily involves providing a structure and adequate electrical power. The local FLM manager will do the following:

1. Supervise the installation of the shelter, or another agreed upon alternative. The cost of the shelter will paid for by the UC Davis contract.
2. Supervise the installation of the required electrical power (120 Volt, 60 Hertz, 20 amps) at the site. The electrical line should be terminated with a duplex outlet.
3. Notify UC Davis field manager of approximate date when the site will be ready for sampler installation.
4. Fill out and return the site information summary sheet. (See Appendix 4. Site Evaluation Form.) This is only for the final specific location.
5. Receive and record UPS shipment of the sampler.
6. Arrange for transportation of equipment to the site before UC Davis personnel arrive.

F. SELECT A SITE OPERATOR

The operator(s) should have some technical expertise, but does not need to have had previous experience in aerosol monitoring. The important qualification is that the operators be motivated and responsible. It is essential that the operators have adequate time to pay particular attention to the sample changing duties every week. Sometimes this may involve using local personnel in unrelated work areas or contracting the work duties to an outside contractor. This type of arrangement offers the best recovery rate in situations where air quality personnel are far away from the site, required to travel often, or already perform too many duties.

IMPROVE site operator duties include the following:

1. Review the IMPROVE sampler manual and attend a one hour training session at the site on the day of sampler installation.
2. Once per year, meet with UC Davis personnel during the annual site maintenance trip. The site maintenance visit will generally occur in the spring or summer. Site operators will be contacted two to three weeks before a visit by UC Davis personnel.
3. Receive and inventory the blue transport boxes (containing the filter cassettes) which are mailed to and from the sampling site and the filter handling laboratory at UC Davis. The boxes are labeled by site and sample week date with prepaid mailing labels.
4. Mail the used filter cassettes back to Davis in their blue transport box after they are exposed in the sampler.
5. Perform weekly sample changes. This requires 15-30 minutes at the site every Tuesday. The changing can be done at any time during the 24-hour day. This time includes troubleshooting and documentation duties, but does not include travel time to site. Telephone assistance will be provided by the UC Davis laboratory whenever there are problems.
6. Once a year, perform a four point flow rate audit of each filter module. This takes approximately 30-60 minutes. Instructions and equipment will be provided by mail.

G. INSTALLATION AND OPERATION OF SAMPLERS

1. The local FLM manager and the UC Davis field manager will arrange a 2 day time period when UC Davis personnel can install the IMPROVE sampler at the site.
2. The local FLM will direct the UC Davis technician to the location of the shelter and of the previously shipped sampling equipment.
3. After the site set-up is completed, the site operator(s) will attend a one hour training session at the site on sampler operation and sample changing procedures.
4. The operation of the site will normally begin immediately.

UC DAVIS CONTACT

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Appendix 1. IMPROVE Clusters

Those outside of California were approved by IMPROVE Steering Committee in December 1998
California clusters are tentative and arranged to maintain the distance and elevation criteria.
The California clusters will be finalized in March 1999

CN = cluster number—there will be one site in each cluster *a min/a max* is elevation range for Class I area (feet)
sampling site *type*: IMP = IMPROVE, PRO = current PROTOCOL, FP = former PROTOCOL
s min/s max is acceptable elevation range for site, based on extremes of all areas in cluster, plus 100ft or 10% (feet)
current is elevation of existing or former site (feet) *km* is distance from existing or former site

← Class I Areas →								← Sampling Site					
CN	*Class I Areas*	*ST*	*FLM*	*long.*	*lat.*	*a min*	*a max*	*type*	*s min*	*s max*	*current*	*km*	*comments*
1	Acadia	ME	NPS	68.26	44.37	0	1,530	IMP	0	1,683	420		current IMPROVE site fits criteria
2	Moosehorn	ME	FWS	67.26	45.12	0	480	PRO	0	300	210		current Protocol site fits criteria
	Roosevelt Campobello	NB		66.95	44.88	0	200					37	
3	Lye Brook	VT	FS	73.12	43.15	800	2,900	IMP	700	3,190	3,315		current IMPROVE site 125 ft too high, but acceptable to state
4	Great Gulf	NH	FS	71.22	44.31	1,680	5,807	PRO	1,512	5,954	1,440		current Protocol site is 72 ft below criterion
	Pres. Range-Dry River	NH	FS	71.35	44.21	880	5,413						
5	Brigantine	NJ	FWS	74.45	39.46	0	15	IMP	0	115	16		current IMPROVE site fits criteria
6	Shenandoah	VA	NPS	78.44	38.52	530	4,050	IMP	430	4,455	3,520		current IMPROVE site fits criteria
7	James River Face	VA	FS	79.48	37.62	650	3,073	PRO	550	3,380	720		current Protocol site fits criteria
8	Dolly Sods	WV	FS	79.43	39.11	2,620	4,122	IMP	2,358	4,303	3,800		current IMPROVE site fits criteria
	Otter Creek	WV	FS	79.65	39.00	1,830	3,912					23	
9	Mammoth Cave	KY	NPS	86.07	37.22	414	919	IMP	314	1,019	730		current IMPROVE site fits criteria
10	Great Smoky Mtns	TN	NPS	83.94	35.63	850	6,643	IMP	990	5,875	2,700		current IMPROVE site fits criteria
	Joyce Kilmer-Slickrock	NC	FS	84.00	35.43	1,100	5,341					23	

CN	Class I Areas	ST	FLM	long.	lat.	a min	a max	type	s min	s max	current	km	comments
11	Shining Rock	NC	FS	82.78	35.39	3,180	6,030	IMP	2,862	6,633	5,290		current IMPROVE site fits criteria
12	Cohutta	GA	FS	84.58	34.92	980	4,149	new	880	4,564			
13	Linville Gorge	NC	FS	81.89	35.89	1,650	4,120	new	1,485	4,532			
14	Swanquarter	NC	FWS	76.28	35.31	0	2	new	0	102			
15	Cape Romain	SC	FWS	79.66	32.94	0	25	IMP	0	125	8		current IMPROVE site fits criteria
16	Okefenokee	GA	FWS	82.13	30.74	105	125	IMP	5	106	150		current IMPROVE site almost fits criteria—the elevation
	Wolf Island	GA	FWS	81.30	31.31	0	6					100	variance of 44 feet is probably acceptable
17	St Marks	FL	FWS	84.08	30.12	0	42	new	0	142			
18	Chassahowitzka	FL	FWS	82.55	28.75	0	5	PRO	0	105	8		current Protocol site fits criteria
19	Everglades	FL	NPS	80.68	25.39	0	6	PRO	0	106	5		current Protocol site fits criteria
20	Breton Is	LA	FWS	88.88	29.73	0	2	new	0	102			
21	Sipsey	AL	FS	87.34	34.34	540	1,070	IMP	440	1,177	1020		current IMPROVE site fits criteria
22	Seney	MI	FWS	86.03	46.26	703	801	new	603	901			
23	Boundary Waters	MN	FS	91.50	47.95	1,260	2,301	IMP	1,134	2,531	1,700		current IMPROVE site fits criteria
24	Voyageurs	MN	NPS	93.17	48.59	1,100	1,400	FP	990	1,540	1,135		former Protocol site fits criteria
25	Isle Royale	MI	NPS	89.15	47.92	601	1,394	new	501	1,533	700		Isle Royale (MI) not accessible all year - area is 35 km from
													Grand Portage National Monument (MN)
26	Mingo	MO	FWS	90.20	36.98	332	590	new	232	690			

CN	Class I Areas	ST	FLM	long.	lat.	a min	a max	type	s min	s max	current	km	comments
27	Upper Buffalo	AR	FS	93.21	35.83	1,240	2,340	IMP	1,116	2,574	2,300		current IMPROVE site fits criteria
28	Hercules-Glades	MO	FS	92.90	36.69	760	1,360	new	660	1,496			
29	Caney Creek	AR	FS	94.08	34.41	1,065	2,330	new	959	2,563			
30	Wichita Mountain	OK	FWS	98.59	34.74	1,465	2,260	new	1,319	2,486			
31	Big Bend	TX	NPS	103.19	29.31	1,720	7,825	IMP	1,548	8,608	3,500		current IMPROVE site fits criteria
32	Guadalupe Mountains	TX	NPS	104.80	31.83	3,630	8,749	PRO	3,492	9,624	5,400		current Protocol site fits criteria
	Carlsbad Caverns	NM	NPS	104.48	32.14	3,880	8,960					46	
33	Bandelier	NM	NPS	106.27	35.78	6,066	8,182	PRO	5,459	9,000	6,500		current Protocol site fits criteria
34	San Pedro Parks	NM	FS	106.81	36.11	9,400	10,523	new	8,460	11,575			
35	Wheeler Peak	NM	FS	105.42	36.57	7,840	13,161	new	7,200	14,413			
	Pecos	NM	FS	105.64	35.93	8,000	13,103						
36	Salt Creek	NM	FWS	104.37	33.61	3,525	3,650	new	3,173	4,015			
37	White Mountain	NM	FS	105.83	33.49	6,000	11,580	new	5,400	12,738			
38	Bosque del Apache	NM	FWS	106.83	33.79	4,597	5,930	new	4,137	6,523			
39	Chircahua NM	AZ	NPS	109.39	32.01	5,100	7,800	IMP	4,590	8,580	5,140		current IMPROVE site fits criteria
	Chircahua W	AZ	FS	109.27	31.84	4,680	9,759					22	
40	Saguaro - East	AZ	NPS	110.73	32.25	2,720	8,666	new	3,995	7,663			protocol site in SAGU east (3080 ft) is 900 ft too low for
	Galiuro	AZ	FS	110.32	32.56	3,995	7,663						Galiuro; the state of AZ site at Tucson Mtn is even lower
41	Petrified Forest	AZ	NPS	109.77	35.08	5,310	6,234	PRO	4,779	6,857	5,800		current Protocol site fits criteria

42	Gila	NM	FS	108.25	33.22	5,700	10,770	PRO	5,130	11,847	5,820		current Protocol site fits criteria
43	Mount Baldy	AZ	FS	109.57	34.12	9,219	11,407	new	8,297	12,548			
CN	*Class I Areas*	*ST*	*FLM*	*long.*	*lat.*	*a min*	*a max*	*type*	*s min*	*s max*	*current*	*km*	*comments*
44	Superstition	AZ	FS	111.10	33.63	1,610	6,266	IMP	1,449	6,893	2,600		current IMPROVE site at Tonto Nat Mon fits criteria
45	Sierra Ancha	AZ	FS	110.88	33.82	5,200	8,000	new	4,680	8,800			
46	Pine Mountain	AZ	FS	111.80	34.31	4,600	6,814	new	4,140	7,495			current state of Arizona site at Mt Ord is at 7,100 ft-it fits
	Mazatzal	AZ	FS	111.43	33.92	1,600	7,904						criteria, except it has had some access problems in winter
47	Sycamore Canyon	AZ	FS	116.18	34.03	3,580	7,000	new	3,580	7,000			check on state of AZ nephelometer site
48	Grand Canyon	AZ	NPS	111.98	35.97	1,200	9,125	IMP	1,080	10,038	7,480		current IMPROVE site fits criteria
													Will second site at Indian Gardens remain Protocol?
49	Bryce Canyon	UT	NPS	112.17	37.62	6,600	9,115	IMP	5,940	9,599	8,100		current IMPROVE site fits criteria
	Zion NP	UT	NPS	113.01	37.25	3,700	8,726					84	
50	Canyonlands	UT	NPS	109.82	38.46	3,697	7,211	IMP	3,327	7,932	5,950		current IMPROVE site fits criteria
51	Arches	UT	NPS	109.58	38.64	3,981	5,653	FP	3,583	6,218	5,200		former Protocol site fits criteria
52	Capitol Reef	UT	NPS	111.05	38.36	3,800	8,200	new	3,420	9,020			
53	Great Sand Dunes	CO	NPS	105.52	37.73	8,200	8,900	PRO	7,380	9,790	8,200		current Protocol site fits criteria
54	Mesa Verde	CO	NPS	108.49	37.20	6,300	8,400	IMP	5,670	9,240	7,210		current IMPROVE site fits criteria
55	Weminuche	CO	FS	107.80	37.65	8,000	14,083	IMP	8,100	9,944	9,050	25	current IMPROVE site fits criteria
	La Garita	CO	FS	106.81	37.96	9,000	14,014					90	
	Black Cyn of Gunnison	CO	NPS	107.70	38.58	5,440	9,040					99	WEMI is only acceptable site, even if at edge of criteria
56	Maroon Bells	CO	FS	106.82	39.15	7,500	14,265	PRO	7,065	13,589	11,212	6	current Protocol site at Aspen Mtn ski area fits criteria
	West Elk	CO	FS	107.19	38.69	7,500	13,035					50	
	Eagles Nest	CO	FS	106.25	39.69	7,850	13,534					74	

	Flat Tops	CO	FS	107.25	39.97	7,600	12,354					90	slightly closer to Mt Zirkel (69 km) than to Aspen Mtn (90 km)
57	Rocky Mountain	CO	NPS	105.55	40.28	7,620	14,255	IMP	7,560	14,246	8,960		current IMPROVE site fits criteria
	Rawah	CO	FS	105.94	40.70	8,400	12,951					58	
CN	*Class I Areas*	*ST*	*FLM*	*long.*	*lat.*	*a min*	*a max*	*type*	*s min*	*s max*	*current*	*km*	*comments*
58	Mount Zirkel	CO	FS	106.70	40.55	7,400	12,180	PRO	6,660	13,398	10,557		current Protocol site fits criteria
59	Badlands	SD	NPS	101.94	43.74	2,440	3,140	PRO	2,196	3,454	2,393		current Protocol site fits criteria
60	Wind Cave	SD	NPS	103.48	43.55	3,580	5,013	new	3,222	5,514			site operated here before 1988
61	Theodore Roosevelt	ND	NPS	104.00	47.30	1900	2,700	new	1,710	2,970			two units 75 miles apart / sites at both units before 1988
62	Lostwood	ND	FWS	102.48	48.60	231	2,442	new	131	2,686			
63	Medicine Lake	MT	FWS	104.29	48.50	1,935	2,045	new	1,742	2,250			site operated here before 1988
64	UL Bend	MT	FWS	107.87	47.55	2,250	2,675	new	2,025	2,943			
65	Bridger	WY	FS	109.76	42.98	7,500	13,804	IMP	6,750	15,184	8,000		current IMPROVE site fits criteria
	Fitzpatrick	WY	FS	109.57	43.27	6,000	13,804					36	
66	Yellowstone	WY	NPS	110.40	44.55	5,282	11,358	PRO	5,940	10,560	7,750		current Protocol site fits criteria (west of divide)
	Grand Teton	WY	NPS	110.73	43.68	6,350	13,770					40	
	Red Rock Lakes	MT	FWS	111.70	44.67	6,600	9,600					100	
67	North Absoraka	WY	FS	109.78	44.77	6,250	12,188	new	6,480	13,372			find site east of divide
	Washakie	WY	FS	109.59	43.95	6,460	13,100						
	Teton W	WY	FS	110.18	44.09	7,200	12,156						
68	Jarbidge	NV	FS	115.43	41.89	6,500	10,800	IMP	5,850	11,880	6,200		current IMPROVE site fits criteria
69	Craters of the Moon	ID	NPS	113.55	43.47	5,340	7,729	PRO	4,806	8,502	5,900		current Protocol site funded by Dept of Energy - fits criteria
70	Sawtooth	ID	FS	114.93	44.18	5,150	10,750	PRO	4,635	11,825	6,490		current Protocol site fits criteria

71	Anaconda-Pintler	MT	FS	113.42	45.98	5,100	10,793	PRO	4,590	11,144	6,190	26	current Protocol site at Sula Peak fits criteria
	Selway-Bitterroot	ID	FS	114.00	45.86	1,600	10,131					40	
72	Glacier	MT	NPS	114.00	48.51	3,219	10,448	IMP	2,897	11,493	3,170		current IMPROVE site fits criteria
CN	*Class I Areas*	*ST*	*FLM*	*long.*	*lat.*	*a min*	*a max*	*type*	*s min*	*s max*	*current*	*km*	*comments*
73	Bob Marshall	MT	FS	113.38	47.75	4,000	9,356	new	4,050	10,292			find site west of divide
	Mission Mountains	MT	FS	113.85	47.40	4,500	9,360						
74	Scapegoat	MT	FS	112.73	47.17	5,000	9,411	new	4,500	8,778			find site east of divide
	Gates of the Mountains	MT	FS	111.81	46.87	3,750	7,980						
75	Cabinet Mountains	MT	FS	115.71	48.21	3,000	8,738	new	2,700	9,612			
76	Eagle Cap	OR	FS	117.29	45.10	4,000	9,839	new	3,776	9,790			two areas 130 km apart, need site midway
	Strawberry Mountain	OR	FS	118.73	44.30	4,196	8,900						
77	Hells Canyon	ID	FS	116.57	45.34	1,200	9,300	new	1,080	10,230			
78	Mount Rainier	WA	NPS	122.12	46.76	1,380	14,411	IMP	1,242	15,852	1,380		current IMPROVE site fits criteria
79	Goat Rocks	WA	FS	121.48	46.54	2,240	8,184	new	2,152	8,769			
	Mt Adams	WA	FS	121.50	46.19	2,391	7,972						
80	Alpine Lakes	WA	FS	121.42	47.42	1,700	9,297	PRO	1,530	10,227	3,810		current Protocol site at Snoqualmie Pass fits criteria
81	North Cascades	WA	NPS	121.44	48.54	330	9,206	new	1,039	10,127			former site at Marblemount (400 ft) is not acceptable--
	Glacier Peak	WA	FS	121.04	48.21	1,154	10,587						it is 600 ft too low for Glacier Peak
82	Pasayten	WA	FS	120.52	48.85	2,600	9,066	new	2,340	9,973			
83	Olympic	WA	NPS	123.35	47.32	0	7,969	new	0	8,766			site at Hurricane Ridge (5250) operated during summer 1990
84	Three Sisters	OR	FS	122.04	44.29	1,781	10,298	PRO	2,767	7,954	2,850		current Protocol site fits criteria
	Mount Jefferson	OR	FS	121.83	44.55	2,972	10,358					33	

	Mount Washington	OR	FS	121.87	44.30	3,074	7,231					14	
85	Mount Hood	OR	FS	121.69	45.38	1,800	9,200	new	1,620	10,120			

CN	*Class I Areas*	*ST*	*FLM*	*long.*	*lat.*	*a min*	*a max*	*type*	*s min*	*s max*	*current*	*km*	*comments*
86	Crater Lake	OR	NPS	122.13	42.90	1,932	8,926	IMP	5,386	9,016	6,500		current IMPROVE site fits criteria
	Diamond Peak	OR	FS	122.10	43.53	4,383	8,563					70	
	Mountain Lakes	OR	FS	122.11	42.34	4,820	8,196					62	
	Gearhart Mountain	OR	FS	120.85	42.49	5,984	8,300					108	closer to Lava Beds (90 km), but 600 ft too high
87	Lava Beds	CA	NPS	121.34	41.71	4,000	5,400	new	4,128	5,940	4,800		site operated before 1988; acceptable for South Warner
	South Warner	CA	FS	120.20	41.33	4,587	9,437						95 km from old Lava Beds site
88	Redwood	CA	NPS	124.08	41.56	0	3,117	PRO	0	3,429	760		current Protocol site fits criteria
89	Kalmiopsis	OR	FS	123.93	42.27	217	5,092	new	117	5,601			
90	Lassen Volcanic	CA	NPS	121.57	40.54	5,759	10,457	PRO	5,432	8,446	5,866		current Protocol site fits criteria, except for Yolla Bolly
	Thousand Lakes	CA	FS	121.58	40.70	5,353	8,090					18	
	Caribou	CA	FS	121.18	40.50	6,035	7,678					33	
91	Point Reyes	CA	NPS	122.90	38.12	0	1,409	PRO	0	1,550	125		current Protocol site fits criteria
92	Pinnacles	CA	NPS	121.16	36.49	800	3,304	PRO	700	3,634	1,040		current Protocol site fits criteria
	Ventana	CA	FS	121.59	36.22	540	5,627					45	
93	Marble Mountain	CA	FS	123.21	41.52	741	7,895	new	2,056	8,484			site between Marble Mountain and Yolla Bolly
	Yolla Bolly Middle Eel	CA	FS	122.96	40.11	2,284	7,713						
94	San Rafael	CA	FS	119.83	34.78	1,109	6,311	new	998	6,942			
95	Desolation	CA	FS	120.12	38.98	5,938	9,415	FP	5,344	10,357	6,700		former Protocol site at Bliss State Park fits criteria

96	Yosemite	CA	NPS	119.70	37.71	2,000	13,000	IMP	4,386	10,692	5,300		current IMPROVE site fits criteria
	Mokelumne	CA	FS	120.03	38.58	3,754	9,720					55	20 km closer to BLIS than to YOSE, but both acceptable
	Emigrant	CA	FS	119.75	38.20	4,593	10,964					54	
	Ansel Adams	CA	FS	119.20	37.65	3,200	12,350					56	
	John Muir	CA	FS	118.84	37.39	4,873	13,880					55	could be represented by clusters 96, 97, or 98

CN	*Class I Areas*	*ST*	*FLM*	*long.*	*lat.*	*a min*	*a max*	*type*	*s min*	*s max*	*current*	*km*	*comments*
97	Hoover	CA	FS	119.45	38.14	7,640	12,446	new	6,876	11,330			need site above 6900 ft
	Kaiser	CA	FS	119.18	37.28	7,000	10,300						a site east of the Sierra divide would be most appropriate
98	Sequoia	CA	NPS	118.82	36.50	1,500	14,494	new	2,403	10,146			current SEQU site (1800 ft) is too low - need site above 2400
	Kings Canyon	CA	NPS	118.76	36.82	1,500	14,494						perhaps at Giant Forest (NADP site) or Wolverton
	Dome Land	CA	FS	118.19	35.70	2,670	9,224						the distance is 80 km from both potential sites above
99	San Gorgonio	CA	FS	116.90	34.18	3,116	10,911	IMP	3,857	8,443	5,618		current IMPROVE site fits criteria
	San Gabriel	CA	FS	117.94	34.27	1,593	7,675					96	
	Cucamonga	CA	FS	117.57	34.25	4,285	8,583					62	
	San Jacinto	CA	FS	116.65	33.75	1,348	8,922					53	
100	Agua Tibia	CA	FS	116.98	33.41	1,615	4,763	new	1,454	5,239			
101	Joshua Tree	CA	NPS	116.18	34.03	1,200	5,814	FP	1,080	6,395	4,100		former Protocol site operated for 1 year (1992)
102	Denali	AK	NPS	148.97	63.72	200	20,320	IMP	100	22,352	2,160		current IMPROVE site fits criteria
103	Tuxedni	AK	FWS	152.60	60.15	0	2,674	new	0	2,941			find site on road to Homer (35 miles), perhaps near Ninichik
104	Bering Sea	AK	FWS	172.79	60.45	0	1,475						impossible to service - there are no sites with required power and accessibility within 350 km. - site will be re-allocated
105	Simeonof	AK	FWS	159.28	54.92	0	1,430	new	0	1,573			find site near Sand Point or Squaw Harbor, 100 km west

106	Virgin Islands	VI	NPS	64.79	18.33	0	1,277	PRO	0	1,405	150		current Protocol site fits criteria
107	Hawaii Volcanoes	HI	NPS	155.27	19.43	0	13,677	PRO	0	15,045	4,100		former Protocol site fits criteria
108	Haleakala	HI	NPS	156.28	20.81	0	10,023	PRO	0	11,025	3,800		current Protocol site fits criteria

APPENDIX 2. PHOTO LOG

POTENTIAL SITE #1 NAME:

Photo #	Date	Time	Description/Comments
			Photo from N. including site
			Photo from E. including site
			Photo from S. including site
			Photo from W. including site
			Photo of power source relative to site
			Close-up of building or location from N.
			Close-up of building or location from E.
			Inside of building facing N.
			Inside of building facing E.
			Inside of building facing S.
			Inside of building facing W
			Photo of nearby air sampling/meteorological equip.
			Photo of nearby air sampling/meteorological equip.

POTENTIAL SITE #2 NAME:

Photo #	Date	Time	Description/Comments
			Photo from N. including site
			Photo from E. including site
			Photo from S. including site
			Photo from W. including site
			Photo of power source relative to site
			Close-up of building or location from N.
			Close-up of building or location from E.
			Inside of building facing N.
			Inside of building facing E.
			Inside of building facing S.
			Inside of building facing W.
			Photo of nearby air sampling/meteorological equip.
			Photo of nearby air sampling/meteorological equip.

APPENDIX 3. SITE EVALUATION FORM FOR POTENTIAL SITES WITH SKETCH ON REVERSE SITE

One form for each potential site
(send completed form to UC Davis)

SITE NAME:____

Site Access Constraints (4-wheel drive road, gates/locks, time of day/week/month/year):______________________

____

Elevation:_____________

Nearest City or Town:________________________Distance:_____________Direction____________________

Potential for Vandalism:____

Site Area Uses Within 200 Yards: ____

Average and Maximum Snow Depth at Proposed Site:____

Is there any nearby air monitoring instrumentation (aerosol, meteorological, nephelometer, gaseous)?___________

If yes, describe type, location, distance and direction from the proposed site._______________________________

____

Is 120 volt AC power available (Distance?):____

Is a telephone available nearby? (Distance?):____

Nearest Telephone Pole #, Box #, or Telephone #:____

Particulate Sources Type / Distance / Direction

Site (within 200 yards.)

Fugitive Dust:____

Combustion:____

Other:____

On the back of this page:

1. Please draw a quick sketch of the proposed site. Indicate North, and include the dimensions of nearby buildings and the distances to prominent objects seen in the photos.
2. Also sketch the route taken to get from a main road to the site.

If possible, please send a topographic map or photocopy of the site area and return it with this form.

APPENDIX 4. SITE INFORMATION FORM

Single form for final site
(send copy of completed form to UC Davis)

Site Name:_____________________________Class I area(s):________________________________

Contacts	Phone	Fax
1:____________________________	______________________	______________________________
2:____________________________	______________________	______________________________
3:____________________________	______________________	______________________________

Comments:____

Mailing Address:____

UPS Shipping Address (cannot be a PO. Box):____

Freight Address:____

Site Access Route (directions):____

____

Site Access Constraints (4-wheel drive road, gates/locks, time of day/week/month/year):______________________

____

Elevation: _______ Latitude: _____deg. _____min. Longitude: _____deg. ______min. (to tenths of minute)

Topographic Map Name (1/25,000 or other appropriate scale):____

____

(Please send or photocopy the topographic map that includes the site and return it with this form)

Nearest City or Town:________________________________Distance:______________Direction______________

Potential for Vandalism:____

Site Area Uses Within 200 Yards: ____

Average and Maximum Snow Depth at Proposed Site:____

Is there any nearby air monitoring instrumentation (aerosol, meteorological, nephelometer, gaseous)?___________

If yes, describe type, location, distance and direction from the proposed site._______________________________

____

(form continued on page 2)

SITE INFORMATION FORM (page 2 of 2)

Is 120 volt AC power available (Distance?):______________________What is meter box number?______________

Reliability of Electrical Power (i.e. history of power outages):____

____

Power Company:____________________________________Contact:____________________________________

Address:____

Telephone No:________________________________ FAX____

Is a Telephone Available Nearby? (Distance?):____

Nearest Telephone Pole #, Box #, or Telephone #:____

Telephone Company:____Contact:_____________________________

Address:____

Telephone No.:______________________________ FAX____

Percent of Ground Cover:

Site (within 200 yards.):

_______ trees _______ shrubs _______ grass _______ crops _______ bare soil
_______ rock _______ pavement _______ building _______ water

Local (200 yards - 10 miles):

_______ trees _______ shrubs _______ grass _______ crops _______ bare soil
_______ rock _______ pavement _______ building _______ water

Regional (10 miles - 100 miles)

_______ trees _______ shrubs _______ grass _______ crops _______ bare soil
_______ rock _______ pavement _______ building _______ water

Particulate Sources Type / Distance / Direction

Site (within 200 yards.)

Fugitive Dust:____

Combustion:____

Other:____

Local (200 yards. - 10 miles)

Fugitive Dust:____

Combustion:____

Other:____

Regional (10 miles - 100 miles)

Fugitive Dust:____

Combustion:____

Other:____

Comments / suggestions:____