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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**OPTICAL MONITORING DATA REPORTING**
TYPE	**STANDARD OPERATING PROCEDURE**
NUMBER	**4500**
DATE	**OCTOBER 1993**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
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PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Revised nephelometer reporting units.	February 1996	

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedures (SOP) is a guide to the written reporting of optical visibility monitoring data from sites operating according to IMPROVE Protocol. Optical monitoring sites include those equipped with an Optec LPV transmissometer and/or Optec NGN nephelometer.

IMPROVE Program goals include timely reporting of collected data in presentation formats that further the understanding of the visual resource and support effective management decisions. The program encompasses:

- Establishing baseline conditions and long-term trends of visual air quality in Class I wilderness areas, and monitoring progress toward the national visibility goals.

- Obtaining high quality visibility data that can be used in planning, permit review, and policy decision processes by using instrumentation capable of measuring quantities that can be directly related to those perceived by the human eye.

- Establishing a database that will assist in the scientific investigation of visibility and validation of computer models designed to predict visibility impairment.

- Determining the existing sources of visibility impairment, detecting new problems and developments early, and determining the sensitivity of individual vistas and Class I areas to varying concentrations of pollutants.

The program has partitioned visibility-related characteristics and measurements into three groups: optical, scene, and aerosol. This SOP pertains to the optical group and encompasses the following:

- Reporting the measurement of basic electro-optical properties of the atmosphere, independent of specific vista characteristics.

- Reporting data in various comprehensive graphics forms.

- Reporting optical extinction measurements made with transmissometers (represented in a variety of units including haziness in dv, extinction in km^{-1}, and standard visual range in km).

- Reporting optical scattering measurements made with nephelometers (represented as scattering in km^{-1}).

Data reports are prepared in a format that generally conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). The following technical instructions (TIs) provide detailed information regarding reporting data collected by optical instruments:

- TI 4500-5000 Nephelometer Data Reporting (IMPROVE Protocol)

- TI 4500-5100 Transmissometer Data Reporting (IMPROVE Protocol)

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Determine the COTR's (Contracting Officer's Technical Representative) project-specific reporting and distribution requirements).
- Review draft and final data reports for completeness and accuracy.
- Verify that completed reports are properly distributed.

2.2 DATA ANALYST

The data analyst shall:

- Prepare all final data plots for inclusion in the reports.
- Compile data statistics and compose text for draft reports.
- Coordinate with the secretary for report preparation.
- Review final reports for completeness and accuracy before distribution.

2.3 FIELD SPECIALIST

The field specialist shall provide current and accurate site specifications to the data analyst.

2.4 SECRETARY

The secretary shall:

- Word process draft and final reports.
- Coordinate with the data analyst for complete report information, format, and statistics.
- Prepare final, approved reports for photocopying and distribution.
- Distribute final reports in accordance with project-specific distribution requirements.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reports are prepared on IBM-PC compatible systems. A word processing package capable of creating large documents with figures and tables is used (such as WordPerfect), with a letter-quality laserjet printer. Other materials include photocopy and binding machines (with required materials) or a photocopy and binding service.

4.0 METHODS

Data for each optical monitoring instrument type (nephelometer or transmissometer) are released in separate data reports. Data reports are prepared in a format that conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). Reporting consists of various text discussions and graphics presentations concerning the instrumentation and collected data. Specific contents of the seasonal and/or annual report are defined by the contracting agency COTR. This section includes four (4) subsections:

4.1 Seasonal Data Reporting
4.2 Annual Data Reporting
4.3 Other Reporting
4.4 Distribution

4.1 SEASONAL DATA REPORTING

Seasonal reporting is completed within three months after the end of a monitoring season. Standard meteorological monitoring seasons are defined as:

Winter	(December, January, and February)
Spring	(March, April, and May)
Summer	(June, July, and August)
Fall	(September, October, and November)

Optical data are presented in the following formats for each reporting season:

- Overview of monitoring program goals and objectives, and a description of the monitoring networks.
- Comprehensive discussion of data collection, reduction, and processing procedures.
- Brief overview of site configuration(s) and description of instrumentation.
- Map of all site locations and site abbreviations.
- Table of monitoring instrumentation history at each site.
- Table of site specifications and operating period for each site during the reporting season.
- Seasonal data summary plot for each site. The plots contain five data presentations: 1) a graph of the four-hour average variation in visual air quality, 2) a relative humidity graph, 3) a frequency of occurrence graph and table based on hourly data, 4) a visibility metric table, and 5) data recovery statistics.
- Detailed explanation of data presentations included in the summary plots.
- Discussion of events and circumstances influencing data recovery, specific for each site.

- Data recovery and cumulative frequency distribution table, including data recovery statistics and 10%, 50%, and 90% cumulative frequency values for each site. The table includes dv, b_{ext}, and SVR values for transmissometers and b_{scat} (filtered data and unfiltered data) values for nephelometers.

Refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)* and TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)* for detailed discussions on each type of data presentation.

4.2 ANNUAL DATA REPORTING

Annual reporting is completed within three months after the end of the last season to be reported. Optical data are presented in the following formats for each annual reporting period:

- Overview of monitoring program goals and objectives, and a history of the program.

- Comprehensive discussion of data collection, reduction, and processing procedures.

- Brief overview of site configuration(s) and description of instrumentation.

- Map of all site locations and site abbreviations.

- Table of site specifications and operating period for each site and season during the annual reporting period.

- Seasonal data summary plots for each season and site. The plots contain five data presentations: 1) a graph of the four-hour average variation in visual air quality, 2) a relative humidity graph, 3) a frequency of occurrence graph and table based on hourly data, 4) a visibility metric table, and 5) data recovery statistics.

- Annual data summary plots for each site. The plots contain three data presentations: 1) a bar graph depicting the monthly median air quality values, 2) a monthly cumulative frequency summary table including data recovery statistics. The table displays dv and b_{ext} for transmissometers and b_{scat} (for filtered data and all data) values for nephelometers, and 3) an annual frequency of occurrence graph based on hourly data.

- Detailed explanation of data presentations included in the seasonal and annual data summary plots.

- Data recovery and cumulative frequency distribution tables for each season of the reporting period. The tables include data recovery statistics and 10%, 50%, and 90% cumulative frequency values for each site. The tables include dv, b_{ext}, and SVR values for transmissometers and b_{scat} (unfiltered data and filtered data) values for nephelometers.

Refer to TI 4500-5000, *Nephelometer Data Reporting (IMPROVE Protocol)* and TI 4500-5100, *Transmissometer Data Reporting (IMPROVE Protocol)* for detailed discussions on each type of data presentation.

4.3 OTHER REPORTING

Contracting agencies will periodically request additional data reports. Cases or events of special scientific, legal, or political importance to the NPS or other cooperating agencies may occur during the term of the project. New techniques, hardware, software, or other technical advances may also occur that will be applicable to the visibility monitoring program. Additional data reporting or analyses may be required to address these special circumstances and will be executed according to project-specific direction.

4.4 DISTRIBUTION

Reports are reviewed and approved by the project manager prior to preparation for distribution. When ready, ARS contacts the local project-specific COTR office for distribution requirements and provides the deliverable products as directed. The amount or type of deliverable product may vary with each report.

5.0 REFERENCES

AH Technical Services, 1987, Guidelines for Preparing Reports for the NPS Air Quality Division, September.

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QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION SERIES	
TITLE	**TRANSMISSOMETER DATA REPORTING (IMPROVE PROTOCOL)**
TYPE	**TECHNICAL INSTRUCTION**
NUMBER	**4500-5100**
DATE	**JANUARY 1994**

AUTHORIZATIONS		
TITLE	NAME	SIGNATURE
ORIGINATOR	Gloria S. Mercer	
PROJECT MANAGER	James H. Wagner	
PROGRAM MANAGER	David L. Dietrich	
QA MANAGER	Gloria S. Mercer	
OTHER		

REVISION HISTORY			
REVISION NO.	CHANGE DESCRIPTION	DATE	AUTHORIZATIONS
0.1	Define elevation angle in site configuration.	March 1995	
1.0	Changes to reporting presentations.	February 1996	

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1.0 PURPOSE AND APPLICABILITY

This technical instruction (TI) describes the procedures and methods for preparing written reports of Optec LPV transmissometer data collected according to IMPROVE Protocol. This TI is referenced from SOP 4500, *Optical Monitoring Data Reporting*, and specifically describes:

- Reporting frequency and contents of seasonal transmissometer reports.
- Reporting contents of annual transmissometer reports.
- Report distribution requirements.

2.0 RESPONSIBILITIES

2.1 PROJECT MANAGER

The project manager shall:

- Determine the COTR's (Contracting Officer's Technical Representative) project-specific reporting and distribution requirements.
- Review draft and final data reports for completeness and accuracy.
- Verify that completed reports are properly distributed.

2.2 DATA ANALYST

The data analyst shall:

- Prepare all final data plots for inclusion in the reports.
- Compile data statistics and compose text for draft reports.
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2.3 FIELD SPECIALIST

The field specialist shall provide current and accurate site specifications to the data analyst.

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The secretary shall:

- Word process draft and final reports.
- Coordinate with the data analyst for complete report information, format, and statistics.

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- Distribute final reports in accordance with project-specific distribution requirements.

3.0 REQUIRED EQUIPMENT AND MATERIALS

All data reports are prepared on IBM-PC compatible systems. A word processing package capable of creating large documents with figures and tables is used (such as WordPerfect), with a letter-quality laserjet printer. Other materials include photocopy and binding machines (with required materials) or a photocopy and binding service.

4.0 METHODS

Data reports are prepared in a format that generally conforms to the *Guidelines for Preparing Reports for the NPS Air Quality Division* (AH Technical Services, 1987). A separate data report is prepared for each instrument type; transmissometer data reports contain only transmissometer data. Reporting consists of various text discussions and graphics presentations concerning the instrumentation and collected data. Specific contents of the reports are defined by the contracting agency COTR. This section includes the following three (3) main subsections:

4.1 Seasonal Data Reporting
4.2 Annual Data Reporting
4.3 Report Distribution

4.1 SEASONAL DATA REPORTING

Seasonal transmissometer reporting is completed within three months after the end of a monitoring season. Standard meteorological monitoring seasons are defined as:

Winter	(December, January, and February)
Spring	(March, April, and May)
Summer	(June, July, and August)
Fall	(September, October, and November)

Seasonal reports contain the five (5) major sections listed below:

1.0 Introduction
2.0 Data Collection and Reduction
3.0 Transmissometer Data Summaries
4.0 References
A.0 Appendix A - Transmissometer Data Collection and Processing Procedures

The information and data presentation formats included in each section of the seasonal report are summarized in the following subsections.

4.1.1 <u>Introduction</u>

The introduction contains a conceptual overview of the purpose of the monitoring program and a description of the monitoring networks.

4.1.2 Data Collection and Reduction

Data collection and reduction is presented in two subsections, Site Configuration and Data Reduction.

4.1.2.1 Site Configuration

Transmissometer system components and basic system operation are briefly discussed in each seasonal report. Measurement principles and data collection specifications are also described. Detailed descriptions of system components and operation are presented in TI 4070-3010, *Installation and Site Documentation for Optec LPV-2 Transmissometer Systems.*

Figures and tables in this section include:

- Map of the United States depicting the location of all IMPROVE and IMPROVE Protocol monitoring network sites. An example map is presented as Figure 4-1.

- Monitoring History Summary Table - The table lists for each monitoring site the name, type of instrumentation, and period of operation for each instrument type (see Table 4-1).

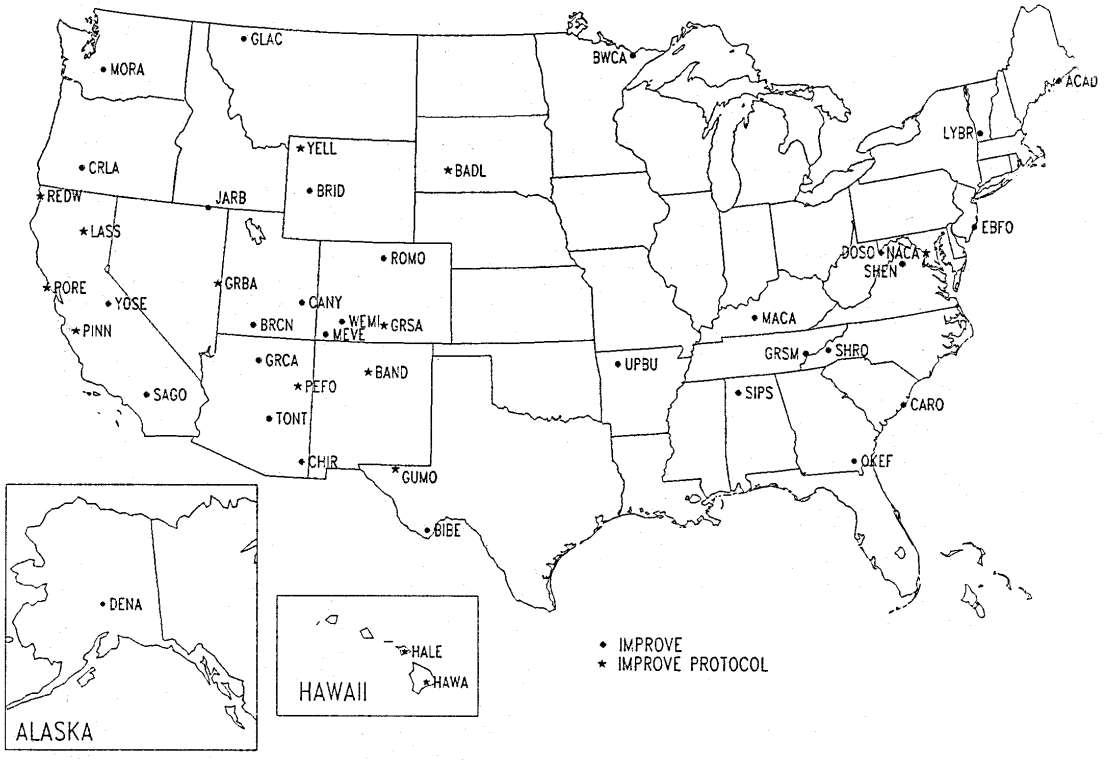
- Site Specifications Summary Table - The table lists for each monitoring site complete site specifications. Site specifications include site name and abbreviation, latitude and longitude of both the receiver and transmitter, elevation of both the receiver and transmitter, the sight path distance between the two components, azimuth, and elevation angle (receiver to transmitter) of the sight path. the table also includes the number of readings taken each day, and the operating period during the season (see Table 4-2).

4.1.2.2 Data Reduction

Each seasonal report contains a brief discussion of data collection, reduction, and processing procedures. The discussion includes daily data review, file format, and monthly and seasonal analytical processing and reduction procedures and assumptions (including discussion of levels of validation, calculation of uncertainties, and identification of meteorological and optical interferences). Reduced data are presented in various units of measurement, including haziness (dv), extinction (b_{ext}), and standard visual range (SVR). More detailed discussions of collection and reduction procedures are presented in an appendix to each report (see Section 4.1.5). Refer to SOP 4300, *Collection of Optical Data (IMPROVE Protocol)*, and TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*, for a complete discussion of procedures.

4.1.3 Transmissometer Data Summaries

Data are presented in various forms in seasonal reports. Each mode of presentation is accompanied by an explanation of the presentation; the following two (2) subsections are included in each seasonal report and detail each data presentation.



IMPROVE SITES

SITE ABRV.	SITE NAME
1. ACAC	ACADIA NP
2. BIBE	BIG BEND NP
3. BWCA	BOUNDARY WATERS CANOE AREA W
4. BRCN	BRYCE CANYON NP
5. BRID	BRIDGER W
6. CANY	CANYONLANDS NP
7. CARO	CAPE ROMAIN NWR
8. CHIR	CHIRICAHUA NM
9. CRLA	CRATER LAKE NP
10. DENA	DENALI NP
11. DOSO	DOLLY SODS W
12. EBFR	EDWIN B FORSYTHE NWR
13. GLAG	GLACIER NP
14. GRCT	GRAND CANYON NP
15. GRSM	GREAT SMOKY MOUNTAINS NP
16. JARB	JARBIDGE W
17. LYBW	LYE BROOK W
18. MACA	MAMMOTH CAVE NP
19. MEVE	MESA VERDE NP
20. MORA	MOUNT RAINIER NP
21. OKEF	OKEFENOKEE NWR
22. ROMM	ROCKY MOUNTAIN NP
23. SAGO	SAN GORGONIO W
24. SHES	SHENANDOAH NP
25. SHRO	SHINING ROCK W
26. SIPS	SIPSEY W
27. TONT	TONTO NM
28. UPBU	UPPER BUFFALO W
29. WEMI	WEMINUCHE W
30. YOSW	YOSEMITE NP

NON-IMPROVE SITES TO BE OPERATED ACCORDING TO IMPROVE PROTOCOL

SITE ABRV.	SITE NAME
1. BADL	BADLANDS NP
2. BAND	BANDELIER NM
3. GRBA	GREAT BASIN NP
4. GRSA	GREAT SAND DUNES NM
5. GUMO	GUADALUPE MOUNTAINS NP
6. HALE	HALEAKALA NP
7. HAWA	HAWAII VOLCANOES NP
8. LASS	LASSEN VOLCANIC NP
9. NACA	NATIONAL CAPITAL-CENTRAL
10. PEFO	PETRIFIED FOREST NP
11. PINN	PINNACLES NM
12. PORE	POINT REYES NS
13. REDW	REDWOOD NP
14. YELL	YELLOWSTONE NP

SITE NAME KEY

NP	National Park	NWR	National Wildlife Refuge
NM	National Monument	W	Wilderness
NS	National Seashore		

Figure 4-1. Example Visibility Network Location Map.

Table 4-1

Example Monitoring History Summary Table

NETWORK	SITE NAME	TELERADIOMETER				CAMERA				TRANSMISSOMETER		NEPHELOMETER	
		MANUAL		AUTO		MANUAL		AUTO					
		Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
IMPROVE	Acadia NP			10/79	02/86	01/80	10/84	04/85		11/87	06/93	06/93	
IMP Pro.	Badlands NP							08/87		01/88			
IMP Pro.	Bandelier NM	07/78	09/84			06/79	02/85	07/87		10/88			
IMPROVE	Big Bend NP	08/78	02/86			09/81	06/86	06/86		12/88			
IMPROVE	Boundary Waters Canoe Area W							10/85				05/93	
IMPROVE	Bridger W							09/86		07/88			
IMPROVE	Bryce Canyon NP	06/78	11/83	12/83	02/86	01/79	11/83	04/84					
IMPROVE	Canyonlands NP	09/78	02/86			07/82	01/87	01/87		12/86			
IMPROVE	Cape Romain NWR												
IMPROVE	Chiricahua NM	06/81	02/86			06/81	06/86	06/86		02/89			
IMPROVE	Crater Lake NP	07/82	09/82			08/82	09/82	06/85		09/88	09/91		
IMPROVE	Denali NP							06/88					
IMPROVE	Dolly Sods W							09/85				05/93	
IMPROVE	Edwin B. Forsythe NWR							05/92				04/93	04/94
IMPROVE	Glacier NP	06/83	05/85	06/85	11/85	07/82	06/85	06/85		02/88			
IMPROVE	Grand Canyon NP (South Rim)	07/78	10/83	12/83	02/86	10/79	11/83	11/83		12/86			
IMPROVE	Grand Canyon NP (In-Canyon)									12/89			
IMP Pro.	Great Basin NP	06/82	02/86			06/82	06/86	06/86		08/92			
IMP Pro.	Great Sand Dunes NM							07/87					
IMPROVE	Great Smoky Mountains NP			12/83	02/85			01/84				03/90	
IMP Pro.	Guadalupe Mountains NP			02/82	02/86	06/83	05/84	06/84		11/88			
IMP Pro.	Haleakala NM							07/87					
IMP Pro.	Hawaii Volcanoes NP							10/86					
IMPROVE	Jarbidge W							09/86				04/93	
IMP Pro.	Lassen Volcanic NP	07/82	11/83			08/82	10/83	06/87					
IMPROVE	Lye Brook W							05/87				08/93	04/94
IMPROVE	Mammoth Cave NP							03/92				03/93	
IMPROVE	Mesa Verde NP	07/78	02/86			09/79	06/86	06/86		09/88	06/93		
IMPROVE	Mount Rainier NP							06/85				06/90	
IMP Pro.	National Capital-Central							12/88					
IMPROVE	Okefenokee NWR							04/92	11/92			02/93	
IMP Pro.	Petrified Forest NP							07/86		04/87			
IMP Pro.	Pinnacles NM							08/86		03/88	06/93		
IMP Pro.	Point Reyes NS							06/87					
IMP Pro.	Redwood NP							06/87					
IMPROVE	Rocky Mountain NP	06/80	05/85			07/85	09/85	07/85		11/87			
IMPROVE	San Gorgonio W							08/86		04/88			
IMPROVE	Shenandoah NP	05/80	10/85			05/80	10/86	10/86		12/88			
IMPROVE	Shining Rock W												
IMPROVE	Sipsey W							11/88					
IMPROVE	Tonto NM							04/89		04/89	09/91		
IMPROVE	Upper Buffalo W							11/88				02/93	
IMPROVE	Weminuche W							08/86	08/93				
IMP Pro.	Yellowstone NP	06/81	06/82			09/81	06/82	09/86		07/89	06/93		
IMPROVE	Yosemite NP	09/82	07/83	01/84	10/85	09/82	09/83	09/84		08/88			

NETWORK KEY

IMPROVE - IMPROVE site
IMP Pro. - Non-IMPROVE site to be operated according to IMPROVE Protocol

SITE NAME KEY

NP - National Park
NM - National Monument
NS - National Seashore
NWR - National Wildlife Refuge
W - Wilderness

Table 4-2

Example Transmissometer Site Specifications Summary Table

SITE NAME	SITE ABRV	RECEIVER LOCATION			SIGHT PATH					OBS. PER DAY	OPERATING PERIOD DURING SUMMER 1993
		LAT (°N)	LONG (°W)	ELEV (M)	TRANSMITTER LOCATION	ELEV (M)	DIST (KM)	AZIM (°)	ELEV ANGLE (°)		
ACADIA NP	ACAD	44°22'29"	68°15'35"	134	44°21'05" 68°13'40"	466	3.67	134	5.19	24	03/01/93 - 05/31/93
BADLANDS NP	BADL	43°47'15"	101°54'12"	806	43°46'05" 101°56'50"	805	4.15	239	-0.01	24	03/01/93 - 05/31/93
BANDELIER NM	BAND	35°47'05"	106°15'39"	2011	35°48'47" 106°17'51"	2143	4.58	315	1.65	24	03/01/93 - 05/31/93
BIG BEND NP	BIBE	29°20'38"	103°12'24"	1082	29°23'12" 103°12'45"	1033	4.74	353	-0.59	24	05/11/93 - 05/31/93
BRIDGER W	BRID	42°55'41"	109°47'15"	2390	42°58'21" 109°46'13"	2568	5.08	11	2.01	24	03/01/93 - 05/31/93
CANYONLANDS NP	CANY	38°27'50"	109°49'18"	1806	38°28'35" 109°44'58"	1774	6.43	73	-0.29	24	03/01/93 - 05/31/93
CHIRICAHUA NM	CHIR	32°00'35"	109°23°18"	1567	32°00'52" 109°19'27"	2235	6.12	84	6.20	24	03/01/93 - 05/31/93
GLACIER NP	GLAC	48°33'29"	113°56'15"	968	48°31'45" 113°59'37"	975	5.27	232	0.08	24	------
GRAND CANYON NP (SOUTH RIM)	GRCA	35°59'47"	111°59'30"	2256	36°00'30" 111°55'55"	2170	5.79	81	-0.85	24	03/01/93 - 05/31/93
GRAND CANYON NP (IN-CANYON)	GRCW	36°03'59"	112°07'00"	2145	36°06'23" 112°05'35"	755	5.11	25	-15.78	24	03/01/93 - 05/31/93
GREAT BASIN NP	GRBA	38°59'30"	114°12'40"	2130	39°01'13" 114°14'30"	2365	3.91	315	3.44	24	05/22/93 - 05/31/93
GUADALUPE MOUNTAINS NP	GUMO	31°49'56"	104°48'34"	1616	31°49'04" 104°51'23"	1317	4.86	249	-3.53	24	05/14/93 - 05/31/93
MESA VERDE NP	MEVE	37°13'07"	108°29'36"	2245	37°15'27" 108°29'49"	2450	4.29	355	2.74	24	03/01/93 - 05/31/93
PETRIFIED FOREST NP	PEFO	34°53'54"	109°47'45"	1690	34°56'01" 109°44'55"	1710	5.94	47	0.19	24	03/01/93 - 05/31/93
PINNACLES NM	PINN	36°28'22"	121°08'47"	448	36°30'14" 121°10'59"	428	4.80	317	-0.24	24	03/01/93 - 05/31/93
ROCKY MOUNTAIN NP	ROMO	40°21'38"	105°34'50"	2536	40°23'12" 105°37'50"	2932	5.27	305	4.31	24	03/01/93 - 05/31/93
SAN GORGONIO W	SAGO	34°11'36"	116°54'48"	1710	34°09'45" 116°56'07"	1731	4.10	211	0.29	24	03/01/93 - 05/31/93
SHENANDOAH NP	SHEN	38°30'49"	78°25'55"	1079	38°31'03" 78°26'13"	1077	1.64	317	-0.16	24	03/01/93 - 05/31/93
TONTO NM	TONT	33°37'15"	111°02'10"	738	33°38'56" 111°06'26"	786	7.20	115	0.38	24	03/01/93 - 05/31/93
YELLOWSTONE NP	YELL	44°58'08"	110°41'29"	1836	44°56'45" 110°38'48"	1951	4.28	125	1.54	24	03/01/93 - 05/31/93
YOSEMITE NP	YOSE	37°42'47"	119°42'14"	1608	37°42'06" 119°43'47"	1370	2.71	242	-5.04	24	03/01/93 - 05/31/93

SITE NAME KEY

NP National Park
NM National Monument
W Wilderness

4.1.3.1 Data Summary Description

A Seasonal Transmissometer Data Summary plot is prepared for each site that operated during the reporting season. An example Seasonal Transmissometer Data Summary is presented as Figure 4-2. The following is a detailed explanation of the contents of the data summaries and accompanies the summaries in each report. Transmissometer Data Summaries include the following five data presentations:

- **4-Hour Average Variation in Visual Air Quality (Excluding Weather-Affected Data)** - Plot of four-hour averaged b_{ext}, SVR, and dv geometric mean values (without weather-influenced observations) for each day of the reporting season. A mean value is calculated for each four-hour period from the valid transmissions for that day. Gaps in the plot indicate that data were missing, weather-influenced, or failed edit procedures. For example, values are not calculated if the transmissometer was mis-aligned. The left axis of the graph is labeled as haziness (dv) and the right axis as b_{ext} and SVR. Note that SVR and b_{ext} are inversely related. For example, as the visual air quality improves, SVR values increase and b_{ext} values decrease. A Rayleigh atmosphere is defined by an SVR of 391 km and a b_{ext} of approximately 0.01 km^{-1}. A dirty atmosphere is represented by low SVR values and high b_{ext} values. The haziness scale is linear to changes in perceived air quality. A one dv change is about a 10% change in b_{ext}, and increases as the air becomes dirtier.

- **Relative Humidity** - Timeline of four-hour averaged relative humidity measurements. This allows rapid determination of the effect of increasing relative humidity on measured b_{ext} and SVR. Long periods of relative humidity near 100% usually result in corresponding periods of high b_{ext} (low SVR), and are likely associated with precipitation events. This assumption can only be verified by reviewing simultaneous photographic data.

- **Frequency of Occurrence: Hourly Data** - This plot is a frequency distribution of hourly average b_{ext}, SVR, and haziness values, both with and without weather-influenced data. The 10% to 90% values are plotted in 10% increments. The 10%, 50%, and 90% cumulative frequency values for b_{ext} are listed to the right of the plot and haziness to the left of the plot. SVR values are listed in the corresponding cumulative frequency summary table. Note that SVR and b_{ext} are inversely related; for example, as the air becomes cleaner, b_{ext} values decrease and SVR values increase.

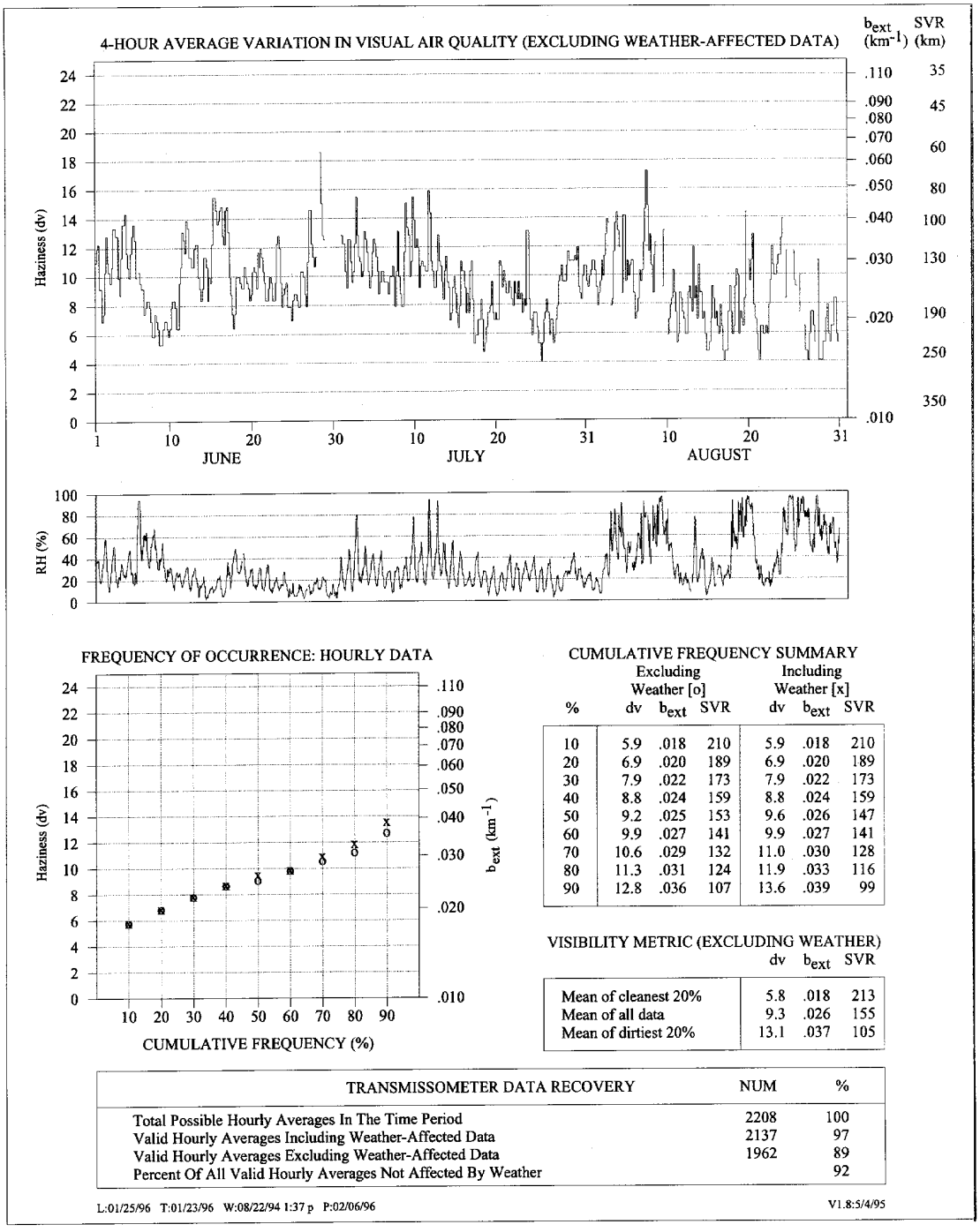
  For b_{ext}, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the b_{ext} was less than or equal to the 10% value;
50%	Median value; 50% of the b_{ext} observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the b_{ext} was less than or equal to the 90% value (10% of the time it was greater than or equal to the 90% value).

GRAND CANYON NATIONAL PARK (SOUTH RIM), ARIZONA

Transmissometer Data Summary

Summer Season: June 1, 1993 - August 31, 1993



CUMULATIVE FREQUENCY SUMMARY

%	Excluding Weather [o] dv	b_{ext}	SVR	Including Weather [x] dv	b_{ext}	SVR
10	5.9	.018	210	5.9	.018	210
20	6.9	.020	189	6.9	.020	189
30	7.9	.022	173	7.9	.022	173
40	8.8	.024	159	8.8	.024	159
50	9.2	.025	153	9.6	.026	147
60	9.9	.027	141	9.9	.027	141
70	10.6	.029	132	11.0	.030	128
80	11.3	.031	124	11.9	.033	116
90	12.8	.036	107	13.6	.039	99

VISIBILITY METRIC (EXCLUDING WEATHER)

	dv	b_{ext}	SVR
Mean of cleanest 20%	5.8	.018	213
Mean of all data	9.3	.026	155
Mean of dirtiest 20%	13.1	.037	105

TRANSMISSOMETER DATA RECOVERY	NUM	%
Total Possible Hourly Averages In The Time Period	2208	100
Valid Hourly Averages Including Weather-Affected Data	2137	97
Valid Hourly Averages Excluding Weather-Affected Data	1962	89
Percent Of All Valid Hourly Averages Not Affected By Weather		92

L:01/25/96 T:01/23/96 W:08/22/94 1:37 p P:02/06/96 V1.8:5/4/95

Figure 4-2. Example Seasonal Transmissometer Data Summary.

For SVR, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the SVR was greater than or equal to the 10% value;
50%	Median value; 50% of the SVR observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the SVR was greater than or equal to the 90% value (10% of the time it was less than or equal to the 90% value).

For deciview, the 10%, 50%, and 90% values are linear with respect to b_{ext} changes. A one dv change is approximately a 10% change in b_{ext}. Clean days are characterized by low haziness values (small dv) and dirty days are characterized by high haziness values (large dv).

- **Visibility Metric (Excluding Weather)** - This table presents mean values excluding weather for dv, b_{ext}, and SVR. The best, worst, and average conditions using the arithmetic means of the 20th percentile least impaired visibility, the 20th percentile most impaired visibility, and for all data for the season are presented.

- **Data Recovery Statistics**

  Total Possible Hourly Averages in the Time Period - The total possible category is calculated by subtracting the number of hourly averages included in periods when the instrument was removed due to conditions unrelated to system performance (construction, site relocation, etc.) from the theoretical maximum number of hourly average periods possible during a season.

  Valid Hourly Averages Including Weather-Affected Data - The number of all valid hourly averages collected during a season. The percentage represents the number of valid hourly averages compared to the total possible hourly averages.

  Valid Hourly Averages Excluding Weather-Affected Data - The number of valid hourly averages (excluding any data affected by weather) collected during a season. The percentage represents the number of valid hourly averages compared to the total possible hourly averages.

  Percent of All Valid Hourly Averages Not Affected by Weather - This percentage collection efficiency represents the number of valid hourly averages (excluding any data affected by weather) compared to the number of all valid hourly averages.

4.1.3.2 Events and Circumstances Influencing Data Recovery

Each seasonal report contains a brief discussion of events and circumstances that influence data recovery. Operational status throughout the reporting period is presented for each site in an operation summary table. The table lists for each site, site name and abbreviation, the actual time period during the season that each site collected data, data collection losses or problem description, and problem resolutions. An example Operation Summary Table is presented as Table 4-3. An analysis summary table is also prepared (for all data and for all data excluding weather events) based on actual monitoring periods. The table lists for each site, site name and abbreviation, the number of seasonal hourly averages possible, the number and percentage of hourly averages usable, and the cumulative frequency distribution (10%, 50%, and 90% dv, b_{ext}, and SVR values). An example Analysis Summary Table is presented as Table 4-4.

4.1.4 References

References are presented in two subsections: 1) Technical References, and 2) Related Reports and Publications. Technical references are those documents that are cited in the seasonal report. Related reports and publications include all prior reports pertaining to the monitoring program, produced by Air Resource Specialists, Inc. (ARS).

4.1.5 Appendix A - Transmissometer Data Collection and Processing Procedures

Each seasonal report contains an appendix that fully details transmissometer data collection and processing procedures. The following subsections, which are presented in the appendix, discuss these procedures.

4.1.5.1 On-Site Data Logging and Transmission

Transmissometer data transmittal from the site to ARS facilities is discussed. The data are transferred through data collection platforms (DCPs) to the GOES satellite, to ARS via telephone modem. A description of data collection procedures is included in SOP 4300, *Collection of Optical Monitoring Data (IMPROVE Protocol)*.

4.1.5.2 Daily Data Collection and Review

Detailed data collection and daily review procedures performed at ARS facilities are described. This discussion includes the steps involved in reviewing data files for extraneous information, searching for problems that require corrective action, verifying the date and time of the transmitted data, and applying preliminary validity codes. Refer to TI 4400-5000, *Transmissometer Data Reduction and Validation (IMPROVE Protocol)*, for a complete discussion of data reduction procedures.

4.1.5.3 Monthly and Seasonal Data Processing Procedures

Detailed discussions of the various processing and validation levels performed during each season are presented. Figure 4-3 presents the transmissometer data processing flow chart. Discussion includes file formats, validity codes applied during the various stages of processing (validation levels), theoretical concepts of uncertainty measurements, and identification of meteorological and optical interferences that affect the calculation of b_{ext} from transmittance measurements.

Table 4-3

Operational Summary Table

SITE NAME	SITE ABBRV	DATA COLLECTION PERIOD	DATA COLLECTION LOSSES/ PROBLEM DESCRIPTION	PROBLEM RESOLUTIONS/COMMENTS
BADLANDS NATIONAL PARK	BADL	06/01/93 - 08/31/93	Timing malfunction at transmitter 8/20-8/24	Power surge; site operator reset timing.
BANDELIER NATIONAL MONUMENT	BAND	06/01/93 - 08/31/93		
BIG BEND NATIONAL PARK	BIBE	06/01/93 - 08/31/93		
BRIDGER WILDERNESS	BRID	06/01/93 - 08/31/93		
CANYONLANDS NATIONAL PARK	CANY	06/01/93 - 08/31/93		
CHIRICAHUA NATIONAL MONUMENT	CHIR	06/01/93 - 08/31/93		
GLACIER NATIONAL PARK	GLAC	06/01/93 - 08/31/93		
GRAND CANYON NATIONAL PARK	GRCA	06/01/93 - 08/31/93		
	GRCW	06/01/93 - 08/31/93	Alignment and power problems at transmitter 8/8-8/22	Site operator corrected alignment, replaced fuse and batteries in transmitter control box, and reset system timing.
GREAT BASIN NATIONAL PARK	GRBA	06/01/93 - 08/31/93	Lamp malfunction 7/19-7/30	Site operator replaced lamp.
GUADALUPE MOUNTAINS NATIONAL PARK	GUMO	06/01/93 - 08/31/93	Transmitter power problem 7/1-7/20	Transmitter turned off to recharge batteries.
PETRIFIED FOREST NATIONAL PARK	PEFO	06/01/93 - 08/31/93	DCP solar panel cable severed; power loss 6/1-6/11	ARS personnel visited site to repair cables and replace DCP.
ROCKY MOUNTAIN NATIONAL PARK	ROMO	06/01/93 - 08/31/93	Transmitter chopper motor malfunction 7/12-7/21	Transmitter removed for repair.
			Receiver timing malfunction 8/19-8/24	Site operator reset receiver computer and timing.
SAN GORGONIO WILDERNESS	SAGO	06/01/93 - 08/31/93		
SHENANDOAH NATIONAL PARK	SHEN	06/01/93 - 08/31/93		
YOSEMITE NATIONAL PARK	YOSE	06/01/93 - 08/31/93	Tree branches obscuring transmitter beam 6/8-6/30	ARS personnel visited site and pruned branches.

Table 4-4

Example Analysis Summary Table
Data Recovery and Cumulative Frequency Distribution

ALL DATA

SITE NAME	SITE ABBRV	DATA RECOVERY		CUMULATIVE FREQUENCY DISTRIBUTION								
		HOURLY AVERAGES POSSIBLE	HOURLY AVERAGES USABLE	Haziness (dv)			b_{ext} (km^{-1})			SVR (km)		
				10%	50%	90%	10%	50%	90%	10%	50%	90%
BADLANDS NATIONAL PARK	BADL	2208	2075 (94%)	6.4	12.2	23.0	.019	.034	.100	213	117	39
BANDELIER NATIONAL MONUMENT	BAND	2208	2173 (98%)	8.3	10.6	15.3	.023	.029	.046	166	133	84
BIG BEND NATIONAL PARK	BIBE	2208	2114 (96%)	9.6	14.8	20.3	.026	.044	.076	153	90	52
BRIDGER WILDERNESS	BRID	2208	1991 (90%)	7.9	10.6	13.9	.022	.029	.040	171	131	96
CANYONLANDS NATIONAL PARK	CANY	2208	2112 (96%)	9.9	12.2	14.6	.027	.034	.043	144	114	90
CHIRICAHUA NATIONAL MONUMENT	CHIR	2208	2191 (99%)	8.3	12.5	21.7	.023	.035	.088	167	111	44
GLACIER NATIONAL PARK	GLAC	2208	2155 (98%)	9.9	14.8	23.8	.027	.044	.108	148	90	36
GRAND CANYON (SOUTH RIM) NATIONAL PARK	GRCA	2208	2137 (97%)	5.9	9.6	13.6	.018	.026	.039	210	147	99
GRAND CANYON (IN-CANYON) NATIONAL PARK	GRCW	2208	2154 (98%)	11.6	13.4	17.7	.032	.038	.059	122	103	66
GREAT BASIN NATIONAL PARK	GRBA	2208	1938 (88%)	8.3	10.3	13.6	.023	.028	.039	165	137	99
GUADALUPE MOUNTAINS NATIONAL PARK	GUMO	2208	1906 (86%)	8.3	11.9	18.1	.023	.033	.061	170	119	64
PETRIFIED FOREST NATIONAL PARK	PEFO	2208	1895 (86%)	8.8	11.6	15.9	.024	.032	.049	162	121	80
ROCKY MOUNTAIN NATIONAL PARK	ROMO	2208	2060 (93%)	7.9	11.0	43.1	.022	.030	.741	169	126	5
SAN GORGONIO WILDERNESS	SAGO	2208	2199 (100%)	11.9	19.6	34.1	.033	.071	.303	118	55	13
SHENANDOAH NATIONAL PARK	SHEN	2208	2201 (100%)	22.0	33.6	55.9	.090	.287	2.68	44	14	1
YOSEMITE NATIONAL PARK	YOSE	2208	1472 (67%)	9.2	13.6	16.9	.025	.039	.054	157	100	72

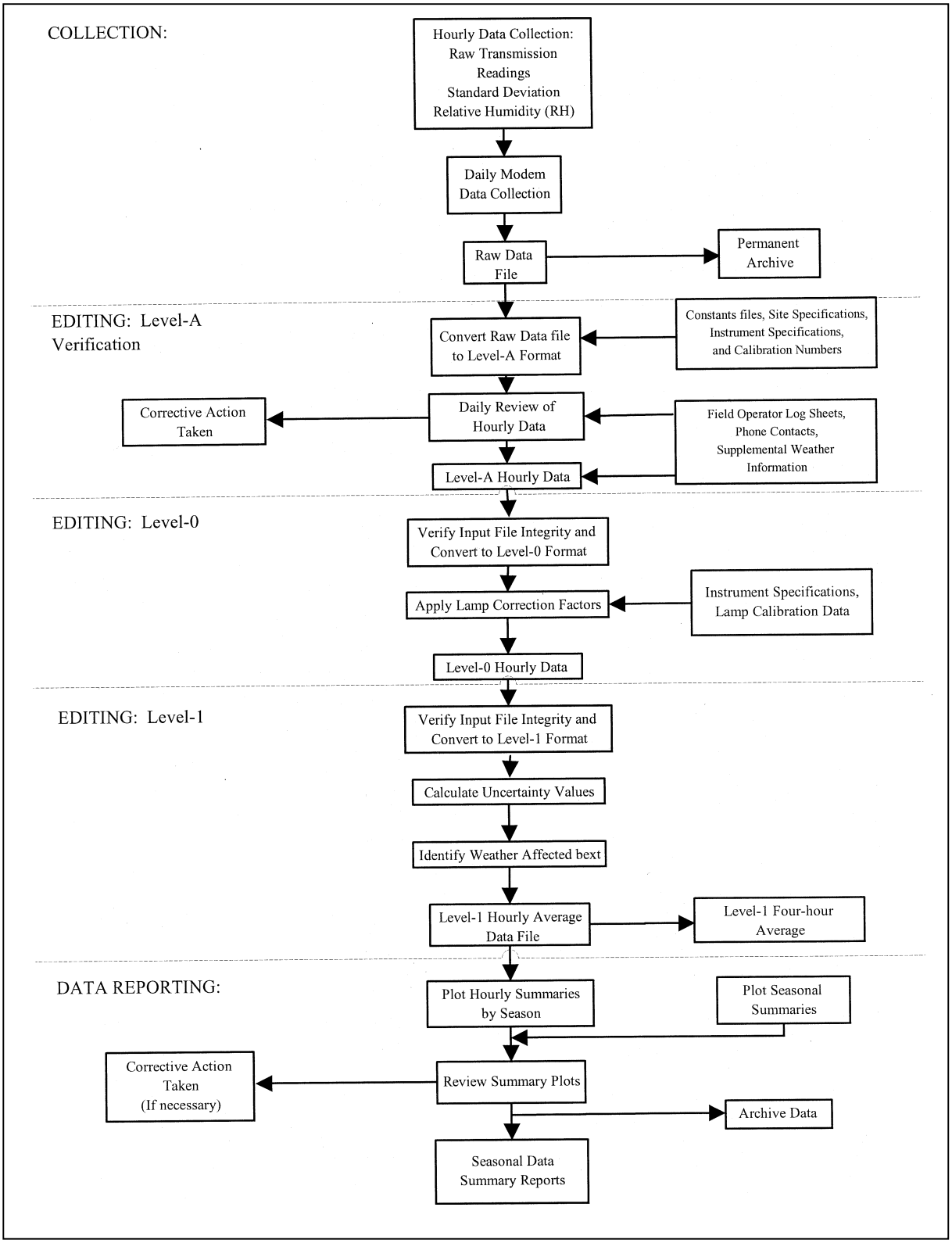


Figure 4-3. Transmissometer Data Processing Flow Chart.

4.1.5.4 Supplemental Visibility Indices

A final discussion regarding transmissometer data processing contains a definition of supplemental visibility indices (standard visual range and deciview).

4.2 ANNUAL DATA REPORTING

Annual reports contain seven (7) major sections:

1.0 Introduction
2.0 Data Collection and Reduction
3.0 Site Configuration
4.0 Data Summary Description
5.0 Transmissometer Data Summaries
6.0 Summary
7.0 References

The information and data presentation formats included in each section are summarized in the following subsections.

4.2.1 Introduction

The introduction section contains a conceptual overview of the purpose of the monitoring program and a description of the monitoring networks. It also includes a map of the United States, depicting locations of all transmissometer monitoring sites (see Figure 4-1).

4.2.2 Data Collection and Reduction Procedures

Each annual report contains detailed transmissometer data collection and processing procedures, identical to the appendix included in seasonal reports (refer to Section 4.1.5). Discussion includes data collection methods, data file review, data validation, application of validity codes, processing through various validation levels, and discussion of file formats, theoretical concepts of uncertainty measurements, and identification of meteorological and optical interferences that affect the calculation of b_{ext} from transmissometer measurements.

4.2.3 Site Configuration

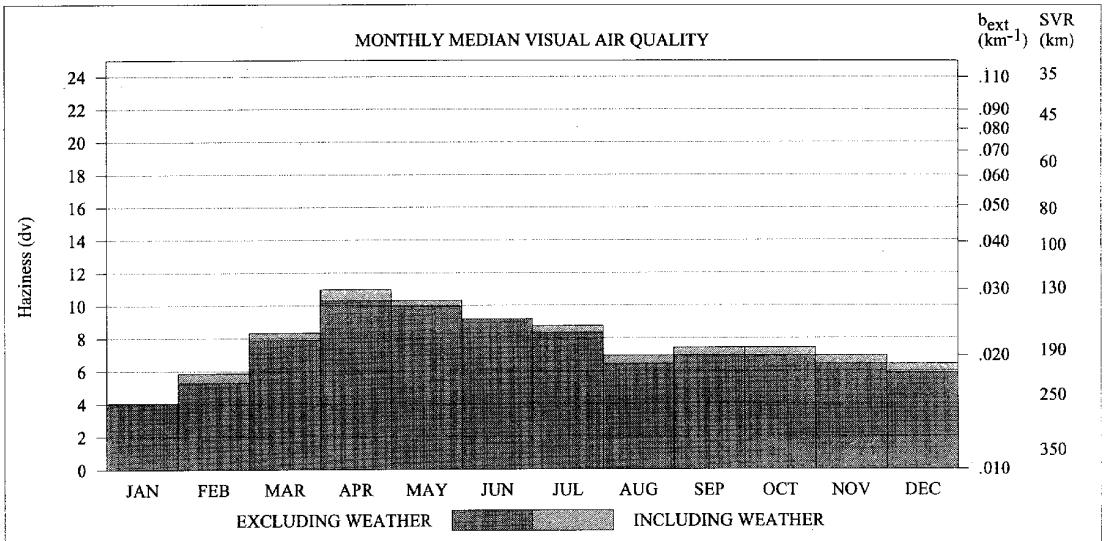
The site configuration section contains a brief discussion of instrumentation at each transmissometer site and basic principles of operation. A site specifications summary table is presented (see Table 4-2).

4.2.4 Data Summary Description

Each annual report contains a data summary description section describing seasonal and annual data summaries. Refer to Section 4.1.3 for a detailed discussion of seasonal summaries. Annual data summaries are prepared for each site that operated during the reporting period, and are based on a calendar year instead of season. An example Annual Transmissometer Data Summary is presented as Figure 4-4. The following is a detailed explanation of the contents of the data summaries and accompanies the summaries in each report. Annual Transmissometer Data Summaries include three data presentations:

GRAND CANYON NATIONAL PARK (SOUTH RIM), ARIZONA
Annual Transmissometer Data Summary
All Data: January 1, 1994 - December 31, 1994

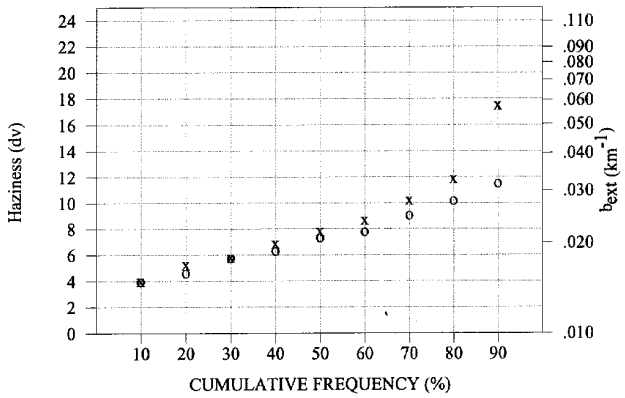
MONTHLY MEDIAN VISUAL AIR QUALITY



MONTHLY CUMULATIVE FREQUENCY SUMMARIES

		EXCLUDING WEATHER						INCLUDING WEATHER						DATA RECOVERY STATISTICS					
		10%		50%		90%		10%		50%		90%		POSS.	COLLECTED		VALID:IN. WX.		VALID:EX. WX.
MONTH	YEAR	bext	dv	bext	dv	bext	dv	bext	dv	bext	dv	bext	dv	NUM	NUM	%	NUM	%	NUM	%
JAN	1994	0.012	1.8	0.015	4.1	0.022	7.9	0.012	1.8	0.015	4.1	0.044	14.8	744	744	100	743	100	637	86
FEB	1994	0.014	3.4	0.017	5.3	0.021	7.4	0.014	3.4	0.018	5.9	0.675	42.1	672	657	98	657	98	446	66
MAR	1994	0.018	5.9	0.022	7.9	0.030	11.0	0.018	5.9	0.023	8.3	0.082	21.0	744	735	99	735	99	603	81
APR	1994	0.018	5.9	0.028	10.3	0.040	13.9	0.018	5.9	0.030	11.0	0.246	32.0	720	717	100	717	100	554	77
MAY	1994	0.022	7.9	0.027	9.9	0.036	12.8	0.022	7.9	0.028	10.3	0.038	13.4	744	744	100	744	100	680	91
JUN	1994	0.018	5.9	0.025	9.2	0.036	12.8	0.018	5.9	0.025	9.2	0.036	12.8	720	714	99	555	77	534	74
JUL	1994	0.014	3.4	0.023	8.3	0.033	11.9	0.014	3.4	0.024	8.8	0.043	14.6	744	742	100	499	67	426	57
AUG	1994	0.015	4.1	0.019	6.4	0.028	10.3	0.015	4.1	0.020	6.9	0.031	11.3	744	744	100	536	72	460	62
SEP	1994	0.015	4.1	0.020	6.9	0.027	9.9	0.015	4.1	0.021	7.4	0.039	13.6	720	709	98	679	94	545	76
OCT	1994	0.016	4.7	0.020	6.9	0.031	11.3	0.016	4.7	0.021	7.4	0.037	13.1	744	727	98	722	97	629	85
NOV	1994	0.014	3.4	0.019	6.4	0.027	9.9	0.015	4.1	0.020	6.9	0.107	23.7	720	714	99	714	99	566	79
DEC	1994	0.015	4.1	0.018	5.9	0.026	9.6	0.015	4.1	0.019	6.4	0.675	42.1	744	744	100	744	100	531	71
ALL DATA		0.015	4.1	0.021	7.4	0.032	11.6	0.015	4.1	0.022	7.9	0.058	17.6	8760	8691	99	8045	92	6611	75

ANNUAL FREQUENCY OF OCCURRENCE: HOURLY DATA



D:10/03/95 2:52 p P:02/20/96

ANNUAL CUMULATIVE FREQUENCY SUMMARY

%	Excluding Weather [o] dv	bext	SVR	Including Weather [x] dv	bext	SVR
10	4.1	.015	250	4.1	.015	250
20	4.7	.016	235	5.3	.017	222
30	5.9	.018	210	5.9	.018	210
40	6.4	.019	199	6.9	.020	189
50	7.4	.021	181	7.9	.022	173
60	7.9	.022	173	8.8	.024	159
70	9.2	.025	153	10.3	.028	137
80	10.3	.028	137	11.9	.033	116
90	11.6	.032	120	17.6	.058	67

FOR A GIVEN % OF THE TIME THE HAZINESS IS LESS THAN OR EQUAL TO THE CORRESPONDING dv VALUE.

V1.03:09/06/94

Figure 4-4. Example Annual Transmissometer Data Summary.

- **Monthly Median Visual Air Quality** - Plot of median monthly b_{ext}, SVR, and dv values both with and without weather-affected data. The left axis of the graph is labeled as haziness (dv) and the right axis as b_{ext} and SVR. Note that SVR and b_{ext} are inversely related. For example, as the visual air quality improves, SVR values increase and b_{ext} values decrease. A Rayleigh atmosphere is defined by an SVR of 391 km and a b_{ext} of approximately 0.01 km^{-1}. A dirty atmosphere is represented by low SVR values and high b_{ext} values. The haziness scale is linear to changes in perceived air quality. A one dv change is about a 10% change in b_{ext}, and increases as the air becomes dirtier.

- **Monthly Cumulative Frequency Summaries, All Data** - Table of cumulative frequency distribution average b_{ext} and dv values both with and without weather-influenced data. The 10% to 90% values are presented in 10% increments. Also included are data recovery statistics (total possible readings, number of collected readings, and number of valid (both with and without weather-affected data).

- **Annual Frequency of Occurrence: Hourly Data** - This plot is a frequency distribution of hourly average b_{ext}, SVR, and haziness values, both with and without weather-influenced data. The 10% to 90% values are plotted in 10% increments. The 10%, 50%, and 90% cumulative frequency values for b_{ext} are listed to the right of the plot and haziness to the left of the plot. SVR values are listed in the corresponding cumulative frequency summary table. Note that SVR and b_{ext} are inversely related; for example, as the air becomes cleaner, b_{ext} values decrease and SVR values increase.

  For b_{ext}, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the b_{ext} was less than or equal to the 10% value;
50%	Median value; 50% of the b_{ext} observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the b_{ext} was less than or equal to the 90% value (10% of the time it was greater than or equal to the 90% value).

  For SVR, the 10%, 50%, and 90% values can be interpreted as:

Value	Interpretation
10%	10% of the time the SVR was greater than or equal to the 10% value;
50%	Median value; 50% of the SVR observations are less than the 50% value and 50% of the observations are greater than the 50% value; and
90%	90% of the time the SVR was greater than or equal to the 90% value (10% of the time it was less than or equal to the 90% value).

For deciview, the 10%, 50%, and 90% values are linear with respect to b_{ext} changes. A one dv change is approximately a 10% change in b_{ext}. Clean days are characterized by low haziness values (small dv) and dirty days are characterized by high haziness values (large dv).

4.2.5 Transmissometer Data Summaries

The data summary section presents first the seasonal summary plots, then the annual summary plots. Data recovery and cumulative frequency distribution tables follow, containing a summary of values for each season (see Table 4-4).

4.2.6 Summary

The summary section provides a synopsis of the transmissometer network, including changes in operational techniques, and a general conclusion of the monitoring year in review.

4.2.7 References

Identical to the seasonal reports, references are presented in two subsections: 1) Technical References, and 2) Related Reports and Publications. Technical references are those documents that are cited in the annual report. Related reports and publications include all prior reports pertaining to the monitoring program, produced by ARS.

4.3 REPORT DISTRIBUTION

Reports are reviewed and approved by the project manager prior to preparation for distribution. When ready, ARS contacts the local project-specific COTR office for distribution requirements and provides the deliverable products as directed. The amount or type of deliverable product may vary with each report; for example, 15 seasonal reports and 5 annual reports are delivered to the NPS.

5.0 REFERENCES

AH Technical Services, 1987, Guidelines for Preparing Reports for the NPS Air Quality Division, September.