

# **Design Specifications for the Development of the Initial Validation Software (Version 3.0) for Processing of NWTC 80-Meter Meteorological Tower Data**

W. Johnson and N. Kelley



**NREL**

**National Renewable Energy Laboratory**

1617 Cole Boulevard  
Golden, Colorado 80401-3393

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Prepared under Task No. WE901310



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## **Glossary of Acronyms, Terms, and Abbreviations**

### **Acronyms and Terms**

21X - refers to the Campbell Scientific 21X data logger; a programmable, microprocessor-based device that interfaces with a range of electrical input signal types.

Channel - a column of fields representing the same parameter. Refers to a specific parameter over a range of records.

IVS - Initial Validation Software; a computer program for initial processing of raw data from NREL/NWTC 80-meter meteorological tower data.

Struct - a C-language reserved word referring to C's ability to have programmer-defined custom data types. Used in this document as if FORTRAN-90 had the same reserved word. FORTRAN-90 has a very similar ability referred to as "derived types" associated with the FORTRAN-90 "type" reserved word. Derived types can work like structs in C when they are encased in the FORTRAN construct called a "module."

Unit - a major subroutine of the IVS.

Validation - the process of examining raw data for correctness.

## Abbreviations

The following abbreviations will be used for file format layouts as well as struct variable names within the program code:

Aspir	- aspirator
Baro	- barometric
Batt	- battery
Coef	- coefficient
Cn	- control
Deg	- degrees (Celsius)
Delt	- delta, symbol for change
Dewpt	- dew point
Dif	- difference
Dir	- direction
Humid	- humidity
Insol	- insolation
Inten	- intensity
Precip	- precipitation
m	- meter(s)
Max	- maximum
Mean	- statistical mean of 10 minutes of data
met	- meteorological, as in "met tower"
Min	- minimum
Press	- pressure
QC	- quality control flag
Sig	- sigma, symbol for standard deviation
Sp	- speed
Temp	- temperature
Turbulenc	- turbulence
Ustar	- friction velocity
Volts	- voltage
Win	- wind

## **1. Change History**

Version 0.1: Rough Draft begun – June 7, 1999

Version 0.2: Next Draft finished – June 8, 1999

Version 1.0: Initial Production of IVS Design Specification Document finished – July 14, 1999

Version 1.1: Minor typos fixed in Sections 8 and 10, Table Numbers added in Section 10 – July 15, 1999

Version 1.2: Beginning of Phase 2 changes, Date – July 20, 1999

Version 1.3: Date/Time verification re-referenced from Unit 4 to Unit 2 in Section 8.5 – July 26, 1999

Version 1.4: Added Phase 2 Testing Information to Appendix C and Section 10 – July 29, 1999

Version 2.0: Secondary Production of IVS Design Specification Document, Phase 2 done – August 3, 1999

Version 3.0: Third Production of IVS Design Specification Document, Phase 3 done – August 20, 1999

## **2. Introduction**

This document describes the design, implementation, and testing of the Initial Validation Software (or IVS) for meteorological tower data at the National Renewable Energy Laboratory/National Wind Technology Center. The document entitled, "Design Requirements for Processing of NREL/NWTC 80-meter Meteorological Tower Data," will be referenced and referred to here as the "Requirements Document" and can be found in Appendix D of this document. The IVS refers to the first stage pictured in Figure 1 of the Requirements Document. The second stage, entitled "Statistical Summaries & Historical Database Development," will be discussed in a future document.

This document will outline all design issues relating to the IVS, including the design process, an outline of the software and testing procedures, and an evaluation of design results after further iterations of the design process. This should provide information about decisions made and the reasoning behind them for the development team, management, and for those who may be called upon to maintain the software.

The IVS provides the capability to read raw data, validate this data, and assemble and store validated data into an output disk file used as intermediate storage. The inputs for this process are a tower's data file composed of 10-minute records and user on-line processing information input (e.g. such as choosing the data file, or flagging bad channels). Another input would be bad channel information from a disk file compiled from historical data contained in tower log books.

There will be three outputs. The first will be a validation summary file containing a header that displays on-line input values, followed by a summary log of all validation decisions made by the program along with comments on why certain decisions were made. The second output will be a display of the summary log to the screen. The third output will be all validated data put into a disk file used as intermediate storage.

### 3. Process Overview

#### 3.1 Process Model

The process used to develop this software may involve many iterative passes as the project evolves to meet changing requirements. There may also be a need to validate the tower data, which will not be apparent until the IVS is completed and run on the data. Hence the requirements for the software will evolve.

The model that most closely illustrates this development process is Boehm's Spiral Model, which resembles the common waterfall model, but in effect cycles over the basics of requirements definition, software design, implementation, and testing over many iterations. Each iteration can be pictured as another loop on a spiral that starts from the center and opens in an ever-wider clockwise spiral. Each loop in the spiral is split into four sectors: objective setting, risk assessment and reduction, development and testing, and planning for the next loop. For the purposes of this diagram, the terms "Validation" and "Verification" answer the questions: "Are we building the right product?" and "Are we building the product right?" respectively.

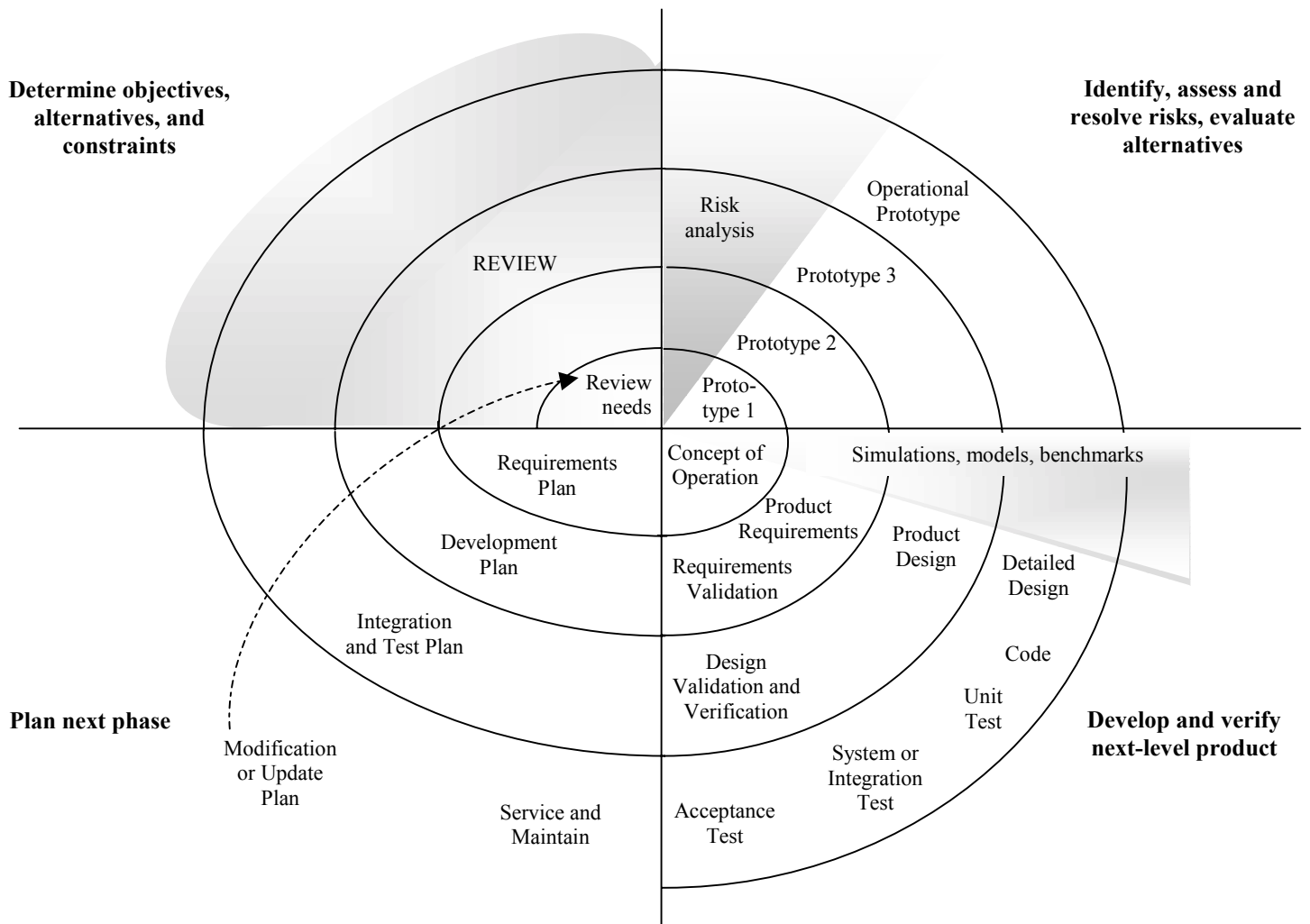


Figure 3.1. Modified Boehm's Spiral Model



### 3.2 Implementation Schedule

The evolution of the IVS will follow three or possibly four phases:

Phase 1 will be to get a fully tested working version of all units with the exception of the input of tower history log data to flag bad channels. The user runtime input and the validation summary data file and printout will be considered working rough drafts at this stage. The software, at this development stage development, will have a prerelease version number of 0.1.

Phase 2 will involve gathering data from the tower history logs and preparing it for entry into files that will be used by the IVS to flag bad channels. A better version of the user runtime input to allow for real-time input of channel flags (similar to the tower history log data file) will be added as well. The validation summary data-file will also be refined. Archive copies of the software will be labeled with a 0.2 prerelease version number.

Phase 3 will involve beta testing the software by processing real data with it. File translators for older data will need to be created and new validation issues might be discovered. After this phase, the version number attached to the software will be 1.00, any minor fixes will be indicated in the last digit (i.e., 1.01). Any major upgrades, such as yearly changes to met tower data file formats, will be indicated in the next to last digit (i.e., 1.10).

Phase 4 will include any further changes that might be discovered when validated and summarized meteorological tower data are processed with early versions of the Statistical Summary and Historical Database program (the second software package created for processing 80-meter meteorological tower data., see the second stage pictured in Figure 1 of the Requirements Document).

The following is an example of Boehm's standard form (see Appendix B) used to document each round of the spiral:

#### **Project Status, Start of Phase 1: June 8, 1999**

Objectives	<ul style="list-style-type: none"><li>- Produce system to validate tower data for technicians and scientists.</li><li>- System must be easy to maintain and change.</li></ul>
Constraints	<ul style="list-style-type: none"><li>- Must be operational before the end of summer 1999.</li><li>- Will need to be changed before January 1, 2000, to reflect scheduled meteorological tower data format changes.</li></ul>
Alternatives	<ul style="list-style-type: none"><li>- Will involve varying degrees of effectiveness of the validation ability of the system.</li></ul>
Risks	<ul style="list-style-type: none"><li>- May be unforeseen validation issues in the tower data.</li><li>- May not have time to resolve all these issues.</li></ul>
Risk Resolution	<ul style="list-style-type: none"><li>- Begin development as soon as possible.</li><li>- Document entire process so tower data validation issues may be reviewed and studied for comprehensiveness.</li></ul>
Results	<ul style="list-style-type: none"><li>- Unknown at this time, as development has barely started.</li></ul>
Plans	<ul style="list-style-type: none"><li>- Might need a catalog of validation issues for tower data.</li><li>- Add addendum to Requirements Document as requirements change.</li></ul>
Commitment	<ul style="list-style-type: none"><li>- Begin development of Phase 1 now.</li></ul>

## 4. Architectural Design

### 4.1 System Structuring

The structure of the IVS will be a call-return model, a main program that will loop through records in a data file and call several other subroutines within the loop to process each record. Each program pass through a record will only look at parameters from that record. The data from prior records (or records ahead) are not needed.

### 4.2 Modular Decomposition

The main program will be responsible for:

1. Setting up two internal data structures: the input record examined and the output record where validation data are assembled for eventual output to a disk file.
2. Calling a subroutine that allows user on-line input of processing options such as input and output file names and bad channel information.
3. Verifying that the input file name contains a correct tower identification (ID) (i.e., m2, M2, m3, or M3). The program will end if an invalid file name is detected. Otherwise, for a valid file name, the correct tower name will be stored in the output record data structure, to be referred to later when any tower-specific decision needs to be made.
4. Calling a subroutine to check record length, i.e. to insure that the each input record of the input file has the proper number of fields for the given tower. Program will end if an invalid record length is detected.
5. Loop through each record of the input file, translating it according to the given tower ID and putting it into an input record data structure. Validate each item in the input record, output a summary of the validations performed, and store the validated results in an output record data structure. Write this output record to a disk file after all validations have been performed.

Inside the main program's read loop, the program flow will be broken up into the following seven basic units:

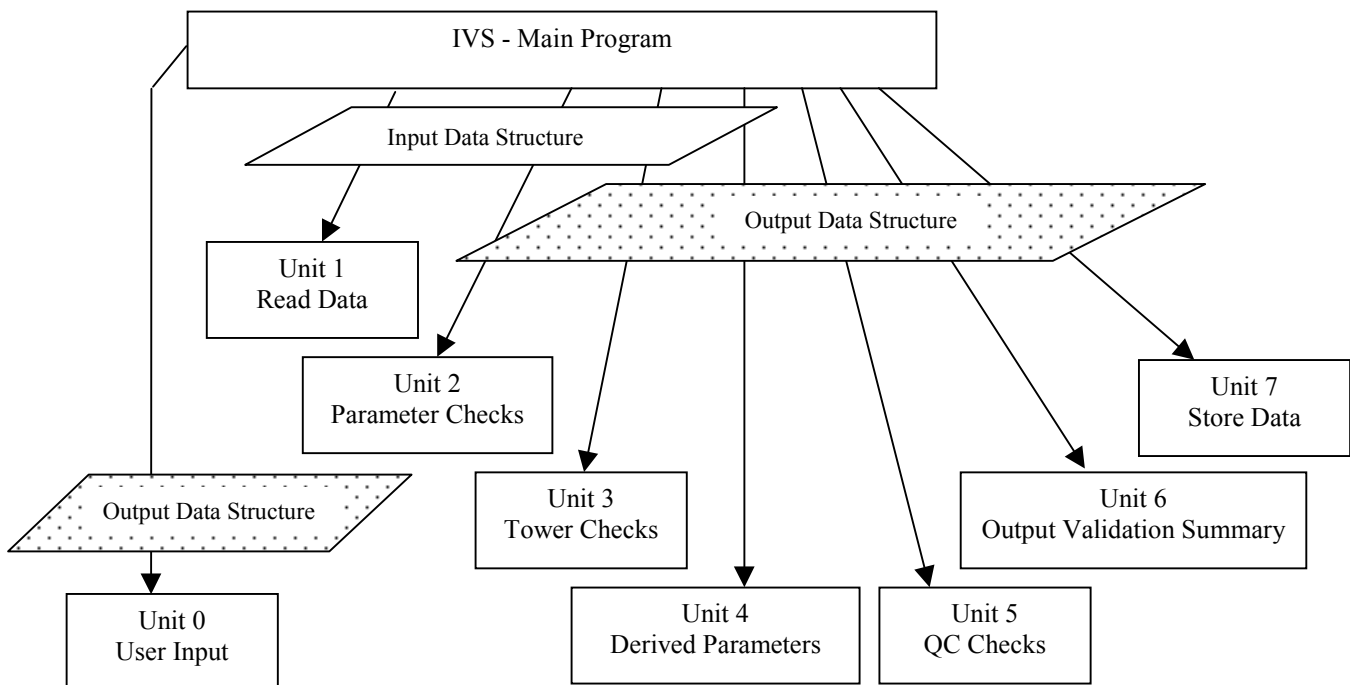
1. Read Data Record—translate raw data and insert into the input data structure.
2. Missing or Faulty Parameter Checks - Basic Record Checks of entire 10 min record such as:
  - (a) Flag bad channels according to selections made by user
  - (b) 21X battery status check
  - (c) Calibrate mode check
  - (d) UPS power failed, UPS power on, or generator power on
3. Tower-Specific Checks—check that 21X word is consistent with the given tower name
4. Derived Parameter Computation—Turbulence Intensity, THERMODYNAMICS, BLPARMS, RICH\_NO
5. Quality Control (QC)Checks—for each channel, starting with aspirator operational status voltage checks
6. Output Validation Summary Data—to a disk file and to a summary screen display
7. Assemble and store validated data to the output disk file.

Each of these procedures represents both a separate unit within the program, and one-seventh of a pass through one data record. They will be within a loop that will be preceded by another major unit numbered as "Unit 0", which will handle user on-line input of processing options. Each unit may be composed of several subroutines.

### 4.3 Control Modeling

The main program will control the sequencing of the unit calls and will also pass some control data to and from certain units. Otherwise, control within each unit will be local to that unit. Most control information will be contained in the input and output data structures because they will be accessed by the subprogram units. For example, the main program will send tower ID information contained in the output data structure to Unit 5, the Quality Control Checks (QC) the unit so certain QC decisions can be made involving tower specific-data. Another example is the bad channel flags. They will be put in the output data structure from user input in Unit 0 and passed to Unit 2 for channel flag decisions.

The only exception process involves certain parts of Unit 6, which are called from some of the other units. This involves the sending of text strings to Unit 6 to be output as validation summary data. These control relationships are not pictured in the diagram below.



**Figure 4.1. Call-Return Model for IVS**  
(showing data structures passed to/from subprogram units)

## 5.0 System Model

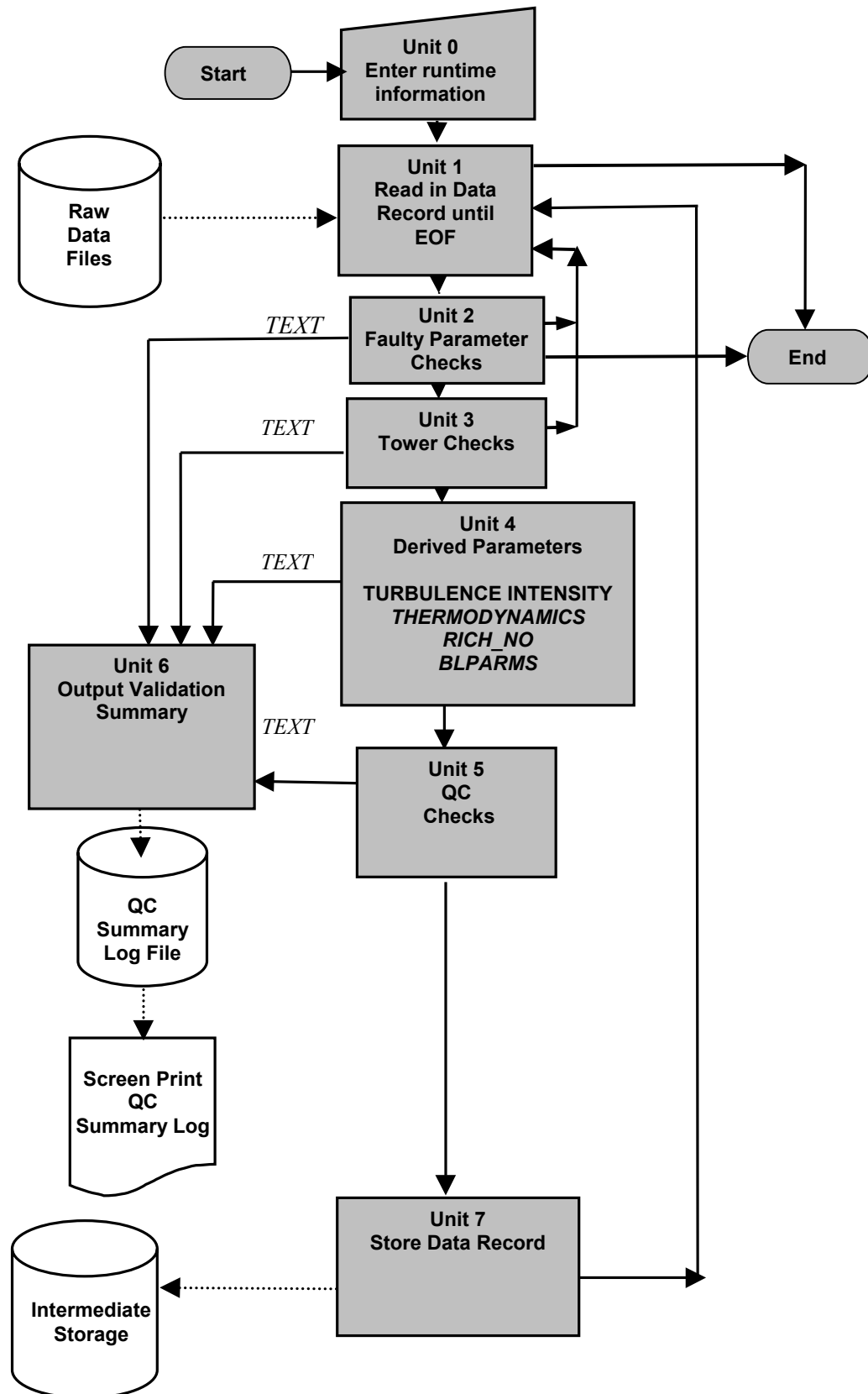


Figure 5. System Model

## 6. Unit Interfaces, Attributes, and Procedures

Various C language-like constructs included in FORTRAN-90 will be used as necessary. However, because of the simple nature of the problem, no C++ or object-oriented constructs are used. What follows, however, does resemble an object-oriented model if you consider the main program as the object with its variables as class attributes and its subroutines as class methods.

The following tables show the major components of the main program code including information on all Units 0 through 7. Components included are the most significant local variables and all major subroutines called. Subroutine and variable names used in the code are shown in bold type.

**Table 6.1. Unit Descriptions and Functions**

<b>Main Program</b>		
<b>Significant Local Variables</b>	<b>Type</b>	<b>Notes</b>
<b>fileFormats</b>	Data module with two derived types	Contains both <b>Input</b> and <b>Output</b> Data Structures.
<b>recordCount</b>	Integer	Count of records read in
<b>outputCounter</b>	Integer	Count of validated records to output
<b>amountOfItems</b>	Integer	Tower-specific record length amount
<b>Subroutines called (interface)</b>	<b>Return Values</b>	<b>Procedure Notes</b>
<b>Unit 0. OnLineInput</b> ( <b>readPathName</b> , <b>readFileName</b> , <b>writePathName</b> , <b>writeFileName</b> )	- Indicates bad channels in <b>Output Data Structure</b> . - File names sent to main program.	- Can use UNIX command line arguments to define input and output file paths and names, with third argument for file calendar year
<b>RecordLength</b> ( <b>readPathName</b> , <b>readFileName</b> , <b>amountOfItems</b> )	- None	- Ends main program in case of record length error
<b>Unit 1. Read99M2DataRecord</b> (*100)	- Updates <b>Input Data Structure</b> - 100 is program end statement #	- Unit 1 is made up of several read routines, <b>Read99M2...</b> is only one.
<b>Unit 2. FaultyParameterChecks</b> ( <b>recordCount</b> , <b>outputCounter</b> , *20, *100)	- outputs validation errors - 100 is program end statement # - 20 is read loop end statement #	- Uses <b>recordCount</b> and <b>outputCounter</b> for output of validation errors - Ends read loop of main program in case of faulty parameter error
<b>Unit 3. TowerSpecificChecks</b> ( <b>recordCount</b> , <b>outputCounter</b> , *20)	- Outputs validation errors - 20 is read loop end statement #	- Uses <b>recordCount</b> and <b>outputCounter</b> for output of validation errors - Ends read loop in case of error
<b>Unit 4. DerivedParameterComputation</b> ( <b>outputCounter</b> )	- Updates <b>Output Data Structure</b> - Outputs validation errors	- Uses <b>outputCounter</b> for scaffolding code used for testing
<b>Unit 5. QualityControlChecks</b> ( <b>recordCount</b> , <b>outputCounter</b> , *20)	- Updates <b>Output Data Structure</b> - Outputs validation errors - 20 is read loop end statement #	- Uses Date and Time in <b>Output Data Structure</b> for output of QC validation errors. Uses <b>recordCount</b> and <b>outputCounter</b> for output of date & time validation errors
<b>Unit 7. StoreValidatedData</b>	- Outputs <b>Output Data Structure</b> record to disk file	
<b>Unit 6. OutputValidationSummary</b>	- Outputs final validation data	- Call is outside of read loop; parts of Unit 6 are called by the other units

## 7. Requirements Satisfaction Table

Programmers will find the following tables useful as it maps requirements to sections or units within the program. Managers might find them useful for tracking requirements satisfaction or assessing requirements evolution.

**Table 7.1a. Program Requirements Tracking**

Unit	Program Objective # (from Requirements Document)								
	1	2	3	4	5	6	7	8	9
0. Runtime Input		X							
1. Read Data Record	X								
2. Missing/Faulty Parameter Checks		X							
3. Tower Specific Checks			X						
4. Derived Parameter Computation					X				
5. QC Checks				X					
6. Output Validation Summary Data									
7. Store Validated Data							X		

**Notes:** Program Objective numbers 7 - 9 will be satisfied by future software for Statistical Summaries & Historical Database Development. Also note that there is no Program Objective for Unit 6 to satisfy. Unit 6 was taken from Figures 1 and 2 in the Requirements Document.

**Table 7.1b. Program Requirements Tracking**

Unit	Required Processing Operation # (from Requirements Document)											
	1	2	3	4	5	6	7	8	9	10	11	12
Main Program												X
0. Runtime Input				X								
1. Read Data Record	X											
2. Missing/Faulty Parameter Checks		X	X		X	X		X				
3. Tower Specific Checks												
4. Derived Parameter Computation									X	X		
5. QC Checks							X					
6. Output Validation Summary Data				X								
7. Store Validated Data											X	

**Notes:** Unit 3, Tower Specific Checks is not marked on this chart. Required Processing Operation 8, "Apply any data corrections as required," is included under Unit 2, but in reality it would be a new program feature and might involve a whole new unit of it's own; such a unit would likely be placed after Unit 2.

## **8. Design Rationale**

As specified in the Coding Language Requirements section on page 5 of the Requirements Document, the programming language used will be FORTRAN-90, and the program will be tested on the UNIX and if possible, the Windows NT environment.

Because one of the main objectives for the IVS is to allow for easy maintenance of the system, it should be easy to change and; tracing reinitialized global variables or rearranging pointers or array indexes should be avoided. Therefore, the two major data structures of the program will not use arrays but will use "structs" instead. This means that each tower data parameter will be accessed within the program by a variable name and not by an array address. See the Glossary for a list of abbreviations used in naming these variables (Section 13.2) , and for a definition of how the C language "struct" relates to similar devices in FORTRAN-90 (Section 13.1).

### **8.1 Rationale for Reading Data into the Input Struct**

When reading a disk file, various file translator subroutines can be chosen by the Read Unit based on the user-selected file type. Each file translator will put the input parameters read in into a standard input struct format, so the rest of the program will be unaffected by input disk file parameter order.

Should a new parameter be added to the tower data, then both the structs for Input Standard Format and the Output Standard Format would have to be changed, along with creation of a QC check on the new parameter. However, no re-indexing will have to be done; the new variable can be inserted wherever desired within the format of the struct. Re-sequencing might have to be done for any old file translator still in use. Nevertheless, once a retrofitted file translator has been fully tested to reliably put data into the Standard Input Format, the rest of the program should run as before.

In a sense, the variables within the input and output structs will work kind of like global variables, although their definition is centralized. Only the struct name (and not all variable names) need be passed to and from subroutines; however, the struct variable values can be globally modified within each subroutine. This is a case where the functional need for a centralized database overrides the need for data hiding within subprograms.

### **8.2 Rationale for Handling Bad Channel Flags**

User-defined date/time range of bad channels must be compared with a given record's date and time. This means that before bad channels can be determined, a record's Julian date and time must be validated first. Later in the program, during the QC checks in Unit 5, the date and time must be validated again to determine if the user has flagged a date or time as a bad channel.

Julian dates and times as they relate to 10-min record number (1-144) have the following validation rules. When a record has a time of 0 (meaning midnight or 24:00), the record was sampled for the last 10 minutes of that day. The 21X, however, will attach the next date to such a record because common convention attributes midnight as belonging to the next calendar date. Unit 2 will move the date and year for such a record back to the prior date, allowing for January 1 going to Julian date 365 or 366 for leap years.

Upon running the Input Unit (Unit 0), the user will be prompted with a list of channels to select from and by typing in a number, the corresponding channel is chosen. After selecting a channel, the user will be prompted to enter the time range when the bad channel occurred. The program will store this information internally and while executing Unit 2 (the Faulty Parameter Checks Unit), the program will set these

parameters to -99.9 for the given time duration. To avoid the use of an additional struct for just the bad channel data alone, this data will be included in the output struct.

The output struct will contain an array which will contain successive bad parameter numbers and time ranges, each indicating the duration of the bad channel. This array will be indexed to the number of bad channels the user selected. Because of this, there will be a limit to the number of bad channels (100) which the user can select during one program run. The bad parameter numbers are based on M2 tower data record parameters and may need to be re-indexed if certain program modifications are made. See Table 2 on page 14 of the Requirements Document for a list of these M2 tower data record parameter numbers.

There is a large switch (FORTRAN case select) statement in Unit 2 that matches bad channel numbers to their corresponding struct names. This switch statement might need to be modified if parameter numbers are changed in the tower data record.

### **8.3 Rationale for the Tower-Specific Checks**

The tower specific checks unit (Unit 3), as it now exists in the design, hardly merits a separate unit. It contains only a few checks to see if the 21X word is consistent with the tower ID given in the input file name. The only reason it is in a separate unit is because it has to perform its tests for several tower IDs and several 21X words.

### **8.4 Rationale for Derived Parameter Computation**

Derived parameter computation utilizes already existing subroutines, so all that is required is to put arguments in the proper order for the existing subroutine interfaces. For clarity, values from input or output structs are passed directly in as arguments whenever possible.

### **8.5 Rationale for Quality Control Checks**

The order of QC checks in the code basically follows the chart entitled “M2 Tower QC Criteria” on page 26 of the Requirements Document, which also follows the sequence of output parameters in Table 5 on page 20 of the same document. The only exception is that the QC checks for aspirator status (output parameters 133-135) are performed before most of the QC checks in Unit 5. The date and time parameters are checked at the beginning of Unit 5 as well as in Unit 2 (Faulty Parameter Checks).

When possible, dependence on other QC checks is ignored and a redundant QC test code is included at each parameter to retest prerequisite parameter values. This makes it easier to test each parameter without having to follow logic in other places in the program. Unless absolute dependence was required, each QC column is not dependent on another, as per the specifications of the Requirements Document (Appendix F).

The following are examples of where independent QCs were created:

- Maximum and minimum barometric pressure
- Maximum and minimum dewpoint temperature
- 2 m maximum & minimum air temperature

The following are examples of where dependent QCs remain:

- All wind parameters dependent on the wind through tower test.
- All derived parameters are dependent on other 21X parameters.



Not all QC flags generate output of validation summary data. We decided not to include a summary log entry for any of the parameters associated with the wind-through tower test because the log entries would be far too extensive. Also, none of the QC tests on derived parameters triggers a summary validation log entry. Only base parameters from the 21X data logger generate a QC summary output.

### **8.6 Rationale for Output Validation Summary Data**

There are two possible approaches for output validation: one is to have a centralized code for all summary messages in one subroutine with an internal decoder to determine which summary message to output. However, printing summary data on the spot means no flag decoding, which might become difficult when modifying or tracking down where the summary message was printed.

The validation summary information display / summary file appends will be scattered though out the program. However each print-to-screen or file append message will have a unit number identified with the message, thus allowing the source code of the message to be found and modified if necessary. Each validation summary output will consist of a subroutine call that takes a text string as input. Modification of individual scattered summary output appends will therefore usually only involve editing the text string that functions as a description field for the summary output message.

### **8.7 Rationale for Storing Validated Data to Disk File**

Some prototype experimentation was required to establish a FORTRAN-90 write-statement that would make the code a simple list of output struct variable names, thus allowing any future IVS modifications to be as straight forward here as in the rest of the program. There is a FORTRAN-90 constraint to the number of continued lines making up one FORTRAN statement, which might affect the theoretical amount of struct variable names allowed in the write-statement list. In order to fit all the struct names in the limited list length, the grouping of two struct names per each continued line was required . The write-statement is followed by a FORTRAN format statement that defines the numerical precision of the numbers written to the disk file.

## **9. Implementation and Unit Testing Plan**

The implementation of the software is relatively straightforward. The steps involved are: First, creating file input/output units and then successively adding validation units. Next, the on-line user input unit will be added along with the validation summary output unit. Finally, the tower history log input file will be added and the validation summary and on-line input units updated to reflect this addition.

As soon as each unit is put in place, it will be tested by the programmer for 100% statement coverage. Unit testing for the IVS is more of an inspection test by the programmer than a true unit test because of the interdependence of the units and the sequence in which they must be run.

## **10. System Testing Plan**

Although the unit testing will involve "white-box" testing to establish that units run, the system testing will be a series of "black-box tests". Various input file scenarios will be created along with a listing of expected program responses. Scaffolding code and test data files for this test will remain in place with code commented out in the final program so these tests can be reactivated should the program be modified. For all program branches, edge tests will be created that will allow testing of 100% branch and 100% statement coverage. However, in some cases, 100% branch coverage may not be feasible. Such cases will be noted in

the test results. Final test reports and output examples will be found in Appendix C of this document. Unless otherwise indicated, all expected responses below include an error message logged to the validation summary output. See Appendix C for documents referred to by the right-most column below. The "else" used in Table 10.1 refers to the logical ELSE decision statement used in the FORTRAN language.

For the aspirator tests, because the 21X stores the data in millivolts even though the M2 tower has an offset of 0.671 mV, it is ignored. The following truth table simplifies the 12 different states found in the Requirements Document to eight possible failure voltage values (including zero), each one switching up to three different aspirator levels. The test data includes a zero value (0.671 mV) followed by the base test data values shown in the rightmost column in **Table 10.2** below. The test data have 14 more outside edge values following the 8 base values, which are the edge tests for the base value  $\pm 20$  mV. The former values are each 1 mV outside the edge values.

**Table 10.1. System Testing Plan**

Unit	Test	Data Set	Expected Response	Output Parameter	Location of Result (Appendix C)
Main Program	Input File name does not start with "m2" or "m3"	- File name with or without M2, m2, M3, or m3	- Program ends if start of file name does not indicate a valid tower - <b>else</b> put Tower ID into output struct	N/A	
Main Program	Invalid Record Length	- First part of M2 file is: 121, 1999, 740, ... - or: 121,740, ...	- Extra item will end program - Missing item will end program	N/A	
2 Faulty Para's	Bad Parameter Checks	- User data entry in Unit 0.1	- Put -99.9 in affected column.	various...	
2	21X Battery Voltage (V) V <= 10.5	- Last column of input data is: 3.296	- Remove record from output	N/A	<b>Validation Summary Printout Example, page 28</b>
2	Calibrate Mode	- AC Power Status is: 59 (Hz)	- When AC power status is <= 60 remove record from output - <b>else</b> set parameter 136 to T	136	<b>Validation Summary Printout Example, page 28</b>
3 Tower Checks	21X word is not a valid tower ID	- First part of M2 file is: 122,1999, 144, ...	- Remove record from output	N/A	<b>Validation Summary Printout Example, page 28</b>
4 Derived Params	Julian Date out of range	- Julian date is: 944, 0, or 945	- Remove record from output	4	<b>Validation Summary Printout Example, page 28</b>
4	Time out of range	- Time is: 9:99, 99:50, or 23:99	- Remove record from output.	7	<b>Validation Summary Printout Example, page 28</b>

**Table 10.2. Aspirator Status Voltages**

Aspirator Levels			Output Voltage in mV
(0 = Ok, 1 = Failure)			
2 m	50 m	80 m	
0	0	0	0
0	0	1	313
0	1	0	625
0	1	1	938
1	0	0	1250
1	0	1	1563
1	1	0	1875
1	1	1	2188

**Table 10.3 Aspirator Signal Acceptance Ranges (mV)**

Base Data	Edge ± 20	Outside Edge
313	333	334
	293	292
625	645	646
	605	604
938	958	959
	918	917
1250	1270	1271
	1230	1229
1563	1583	1584
	1543	1542
1875	1895	1896
	1855	1854
2188	2208	2209
	2168	2167

**Table 10.4. QC Check Criteria**

Unit	Test	Data Set	Expected Response	Output Parameter	Location of Result (Appendix C)
5  QC Checks	- Aspirator Base Data test - Edge Data test - Outside Edge test	(shown above) with three sets of data:  - base data representing inside the edges - data for the edges - data for outside the edges.	- Base Values should count in 3- bit binary with F = 1, T = 0 from 0 to 7, mirror image of above truth table. - Edge Values should count, look like base value truth table, but each successive binary number should be two rows wide. - Outside Edges resulting values should all be "T."	133, 134, and 135	<b>Test Results</b> Rows 18–53 (Julian Day 146) Columns 133–135 (aspir 80, 50, 2)

**Table 10.4. QC Check Criteria (continued)**

Unit	Test	Data Set	Expected Response	Output Parameter	Location of Result
5 QC Checks	Acceptable Mean Wind Speed, based on Mean Wind Direction values for all 6 tower heights	- For M2 tower: Wind Direction edge values of 92°, 132° - inside the edges 92.1°, 131° - outside the edges 91°, 132.1°	- Edges, QC should be blank - Inside edges, QC should be asterisk - Outside edges, QC should be blank *NOTE: Output to Validation Summary Log is suppressed for these QCs.	10 16 22 28 34 40	<b>Test Results</b> Rows 1–6, Columns 9–40
5	For all 6 tower heights: - Mean Wind Direction - Mean Wind Direction Sigma - Mean Wind Speed Sigma.	- based on Mean Wind Speed QCs	- QCs for all 6 rows of test data should follow results for Acceptable Wind Speed tests above. *NOTE: Output to Validation Summary Log is suppressed for these QCs.	12, 18, 24, 30, 36, 42, 14, 20, 26, 32, 38, 44, 46, 48, 50, 52, 54, 56	<b>Test Results</b> Rows 1–6, Columns 11–56
5	2 m Barometric Pressure	Edge Tests: - Edges: 741, 999 - Inside edges: 741.1, 998 - Outside edges: 740, 999.1	- Edges, QC should be star - Inside Edges, QC is blank - Outside Edges, QC is asterisk	58	<b>Test Results</b> Rows 16–, Columns 57–58
5	2 m Dewpoint Temperature	Edge Tests: - Edges: -48, 48 - Inside Edges: -47.9, 47.9 - Outside Edges: -48.1, 48.1	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 2 m Aspirator is F	60  135	<b>Test Results</b> Rows 1–6, Columns 59–60  (Aspirator Tests)
5	50 m Air Temperature	Edge Tests: - Edges: -48, 48 - Inside Edges: -47.9, 47.9 - Outside Edges: -48.1, 48.1	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 50m Aspirator is F	62  134	<b>Test Results</b> Rows 1–6, Columns 61–62  (Aspirator Tests)
5	2 m Air Temperature	Edge Tests: - Edges: -48, 48 - Inside Edges: -47.9, 47.9 - Outside Edges: -48.1, 48.1	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 2 m Aspirator is F	64  135	<b>Test Results</b> Rows 1–6, Columns 63–64  (Aspirator Tests)
5	80-50 m Delta Temperature	Edge Tests: - Edges: -4.5, 14.5 - Inside Edges: -4.4, 14.4 - Outside Edges: -4.6, 14.6	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 80m Aspirator is F - QC is star if 50m Aspirator is F	66  133 134	<b>Test Results</b> Rows 1–6, Columns 65–66  (Aspirator Tests)

**Table 10.4. QC Check Criteria (continued)**

Unit	Test	Data Set	Expected Response	Output Parameter	Location of Result
5 QC Checks	50-2 m Delta Temperature	Edge Tests: - Edges: -4.5, 14.5 - Inside Edges: -4.4, 14.4 - Outside Edges: -4.6, 14.6	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 50m Aspirator is F - QC is star if 2m Aspirator is F	68  134 135	<b>Test Results</b> Rows 1–6, Columns 67–68  (Aspirator Tests)
5	For all 6 tower heights: - Max Wind Speed - Max Wind Gust Direction	- based on Mean Wind Speed QCs	- QC's for all 6 rows of test data should follow results for Acceptable Wind Speed tests above. (Parameters 10...40) *NOTE: Output to Validation Summary Log is suppressed for these QCs.	70, 76, 82, 88, 94, 100, 74, 80, 86, 92, 98, 104	<b>Test Results</b> Rows 1–6, Columns 69–104
5	For all 6 tower heights: - Max Wind Speed Time	- Max Wind Time: 23:00, 0:59, 22:59, 0:58, 24:00, 0:60.	- Asterisk in QC column when hours < 0 or hours > 23 - Asterisk in QC column when minutes < 0 or min > 59	72, 78, 84, 90, 96, 102	<b>Test Results</b> Rows 1–6, Columns 71–102
5	2 m Max Barometric Pressure	Edge Tests: - Edges: 741, 999 - Inside edges: 741.1, 998 - Outside edges: 740, 999.1	- Edges, QC should be star - Inside Edges, QC is blank - Outside Edges, QC is asterisk	106	<b>Test Results</b> Rows 1–6, Columns 105–106
5	2 m Max Barometric Pressure Time	- Max Baro Time: 23:00, 0:59, 22:59, 0:58, 24:00, 0:60.	- Asterisk in QC column when hours < 0 or hours > 23 - Asterisk in QC column when minutes < 0 or min > 59	108	<b>Test Results</b> Rows 1–6, Columns 107–108
5	2 m Max Dewpoint Temperature	Edge Tests: - Edges: -48, 48 - Inside Edges: -47.9, 47.9 - Outside Edges: -48.1, 48.1	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 2 m Aspirator is F	110  135	<b>Test Results</b> Rows 1–6, Columns 109–110  (Aspirator Tests)
5	2 m Max Dewpoint Temperature Time	- Max Dewpt Time: 23:00, 0:59, 22:59, 0:58, 24:00, 0:60.	- Asterisk in QC column when hours < 0 or hours > 23 - Asterisk in QC column when minutes < 0 or min > 59	112	<b>Test Results</b> Rows 1–6, Columns 111–112
5	2 m Max Air Temperature *NOTE: test data replaced by program with -99.9	Edge Tests: - Edges: -48, 48 - Inside Edges: -47.9, 47.9 - Outside Edges: -48.1, 48.1	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 2 m Aspirator is F	114  135	<b>Test Results</b> Rows 1–6, Columns 113–114  (Aspirator Tests)
5 *NOTE	2 m Max Air Temperature Time *Data is -99.9	- 2 m Max Air Time: 23:00, 0:59, 22:59, 0:58, 24:00, 0:60.	- Asterisk in QC column when hours < 0 or hours > 23 - Asterisk in QC column when minutes < 0 or min > 59	116	<b>Test Results</b> Rows 1–6, Columns 115–116

**Table 10.4. QC Check Criteria (continued)**

Unit	Test	Data Set	Expected Response	Output Parameter	Location of Result (Appendix C)
5 QC Checks	2 m Min Barometric Pressure	Edge Tests: - Edges: 741, 999 - Inside edges: 741.1, 998 - Outside edges: 740, 999.1	- Edges, QC should be asterisk - Inside Edges, QC is blank - Outside Edges, QC is asterisk	118	<b>Test Results</b> Rows 1–6, Columns 117–118
5	2 m Min Barometric Pressure Time	- Max Baro Time: 23:00, 0:59, 22:59, 0:58, 24:00, 0:60.	- Asterisk in QC column when hours < 0 or hours > 23 - Asterisk in QC column when minutes < 0 or min > 59	120	<b>Test Results</b> Rows 1–6, Columns 119–120
5	2 m Min Dewpoint Temperature	Edge Tests: - Edges: -48, 48 - Inside Edges: -47.9, 47.9 - Outside Edges: -48.1, 48.1	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star* if 2m Aspirator is F	122  135	<b>Test Results</b> Rows 1–6, Columns 121–122  (Aspirator Tests)
5	2 m Min Dewpoint Temperature Time	- Max Dewpt Time: 23:00, 0:59, 22:59, 0:58, 24:00, 0:60.	- Asterisk in QC column when hours < 0 or hours > 23 - Asterisk in QC column when minutes < 0 or min > 59	124	<b>Test Results</b> Rows 1–6, Columns 123–124
5	2 m Min Air Temperature  *NOTE: test data replaced by program with -99.9	Edge Tests: - Edges: -48, 48 - Inside Edges: -47.9, 47.9 - Outside Edges: -48.1, 48.1	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk  - QC is star if 2 m Aspirator is F	126  135	<b>Test Results</b> Rows 1–6, Columns 125–126  (Aspirator Tests)
5	2 m Min Air Temperature Time  *NOTE: test data replaced by program with -99.9	- 2m Max Air Time: 23:00, 0:59, 22:59, 0:58, 24:00, 0:60.	- Asterisk in QC column when hours < 0 or hours > 23 - Asterisk in QC column when minutes < 0 or min > 59  *NOTE Until actual 2m Max & Min data is available, these tests cannot work on test data.	128	<b>Test Results</b> Rows 1–6, Columns 127–128
5	Total Insolation	Edge Tests: - Edges: 0, 42000 - Inside Edges: 1, 41999 - Outside Edges: -1, 42001	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk	130	<b>Test Results</b> Rows 1–6, Columns 129–130
5	Total Precipitation	Edge Tests: - Edges: 0, 500 - Inside Edges: 1, 499 - Outside Edges: -1, 501	- Edges, QC should be blank - Inside Edges, QC is blank - Outside Edges, QC is asterisk	132	<b>Test Results</b> Rows 1–6, Columns 131–132

**Table 10.4. QC Check Criteria (continued)**

Unit	Test	Data Set	Expected Response	Output Parameter	Location of Result (Appendix C)
5 QC Checks	For all 6 tower heights: - Turbulence Intensity	Based on QCs for: - Mean Wind Speed QCs	- QCs for all six rows of test data should follow results for Acceptable Wind Speed tests above. (Parameters 10...40) *NOTE: Output to Validation Summary Log is suppressed for these QCs.	138, 140, 142, 144, 146, 148	<b>Test Results</b> Rows 1–6, Columns 137–148
5	- Relative Humidity	Based on QCs for: - 2 m Barometric Pressure - 2 m Dewpoint - 2 m Air Temperature	- QCs for all six rows of test data should follow combined results for 2 m Barometric Pressure, 2 m Dewpoint, and 2m Air Temperature *NOTE: No Summary Log output.	150	<b>Test Results</b> Rows 1–6, Columns 149–150
5	2-50 m Richardson Number	Based on QCs for: - 2 m Baro. Press. - 2 m Dewpoint - 2 m Air Temp. - 50-2m Delta Temp - Mean Wind Speed QCs	- QCs for all six rows of test data should follow combined results for QCs of numbers this is computed from. *NOTE: No Summary Log output.	152	<b>Test Results</b> Rows 1–6, Columns 151–152
5	50-80 m Richardson Number	Based on QCs for: - 2 m Baro. Press. - 2 m Dewpoint - 50 m Air Temp. - 80-50m Delta Temp - Mean Wind Speed QCs	- QCs for all six rows of test data should follow combined results for QCs this is computed from. *NOTE: No Summary Log output.	154	<b>Test Results</b> Rows 1–6, Columns 153–154
5	2-80 m Richardson Number	Based on QCs for: - 2 m Baro. Press. - 2 m Dewpoint - 2 m Air Temp. - 50 m Air Temp. - 50-2 m Delta Temp - 80-50m Delta Temp - Mean Wind Speed QCs	- QCs for all six rows of test data should follow combined results for QCs of numbers this is computed from. *NOTE: No Summary Log output.	156	<b>Test Results</b> Rows 1–6, Columns 155 –156
5	u* Quality Control $r^2$	Not Determined, would need to figure subroutine input parameters that would produce a value $\leq 0.5$	- Blank in QC column when $u^*$ Quality Control $r^2 > 0.5$ - Asterisk in QC column when $u^*$ Quality Control $r^2 \leq 0.5$ *NOTE: No Summary Log output.	162	<b>Test Results</b> Rows 1–6, Columns 161–162

**Table 10.4. QC Check Criteria (continued)**

Unit	Test	Data Set	Expected Response	Output Parameter	Location of Result (Appendix C)
5	Friction Velocity $u^*$	Based on QCs for: - Mean Wind Speed QCs  - $u^*$ Quality Control $r^2$	- Should follow combined results for QCs of numbers this is computed from.  *NOTE: No Summary Log output.	158	<b>Test Results</b> Rows 1–6, Columns 157–158
5	Surface Roughness	Based on QCs for: - Mean Wind Speed QCs  - $u^*$ Quality Control $r^2$	- Should follow combined results for QCs of numbers this is computed from.  *NOTE: No Summary Log output.	160	<b>Test Results</b> Rows 1–6, Columns 159–160
5	2-80 m Mean Power Law Coefficient	Based on QCs for: - Mean Wind Speed QCs	- Should follow combined results for QCs of numbers this is computed from.  *NOTE: No Summary Log output.	164	<b>Test Results</b> Rows 1–6, Columns 163–164

\*The names "asterisk" or "star" are used interchangeably to signify the QC Flag character.



**Table 10.5. Bad Channel Criteria Identification and Testing**

<b>Unit</b>	<b>Test</b>	<b>Data Set</b>	<b>Expected Response</b>	<b>Output Parameter</b>	<b>Location of Result (Appendix C)</b>
2	Bad channel tests for: 80 m, 50 m, 20 m, 10 m, 5 m, & 2 m mean wind speed	Each test is performed on a 10-minute interval of a day labeled with Julian date of 147.	- Each wind speed column and its dependent columns should have -99.9 value. Dependent channels are <b>SigmaWinSp, MaxWinSp, and MaxGustTime</b> . - QC Star in <b>MaxGustTime</b> . *NOTE: No Summary Log output for all but <b>MaxGustTime</b>	9, 15, 21, 27, 33, 39	<b>Test Results</b> Rows 54–59, Columns 9–39
2	Bad channel tests for: 80 m, 50 m, 20 m, 10 m, 5 m, & 2 m mean wind direction	Each test is performed on a 10-minute record of a day labeled with Julian date of 147.	- Each wind speed column and its dependent columns should have -99.9 value. Dependent channels are <b>SigmaWinSpeed, MaxWinSp, and MaxWinSp Time</b> . - QC Star in Max Gust Time. *NOTE: No Summary Log output for all but <b>MaxGustTime</b>	11, 17, 23, 29, 35, 41	<b>Test Results</b> Rows 60–65, Columns 11–41
2	Bad channel test for: Mean Barometric Pressure	Test data is a 10-minute record within a day labeled with Julian day 147.	- Mean Baro Press column and its dependent columns should have -99.9 values. Dependent channels are Max and Min BaroPress and Max & Min Baro Times. - QC Star on all these channels.	57	<b>Test Results</b> Row 66, Columns 57, 105,107,117, 119
2	Bad channel test for: 2 m Dewpoint Temperature	“	- Dewpoint column and its dependent columns should have -99.9 values. Dependent channels are Max and Min Dewpoints and Max & Min Dewpoint Times. - QC Star on all these channels.	59	<b>Test Results</b> Row 67 Columns 59, 109, 111, 121, 123
2	Bad channel: 50 m Air Temperature	“	- 50 m Air Temperature column has -99.9 value. - QC asterisk on this channel.	61	<b>Test Results</b> Row 68 Column 61
2	Bad channel: 2 m Air Temperature	“	- 2 m Air Temperature col & it's dependent cols have -99.9 values. Dependent cols are Max & Min 2m Air Temp and Max & Min 2 m Air Temp Times. - QC Star on all these channels.	63	<b>Test Results</b> Row 69 Columns 63, 113, 115, 125, 127

**Table 10.5. Bad Channel Identification Criteria and Testing (continued)**

<b>Unit</b>	<b>Test</b>				
2	Bad channel: 80-50 m Delta Temperature Difference	“	- 80-50 m Delta Temp column has -99.9 value. - QC asterisk on this channel.	65	<b>Test Results</b> Row 70 Column 65
2	Bad channel: 50-2 m Delta Temperature Difference	“	- 50-2 m Delta Temp column has -99.9 value. - QC asterisk on this channel.	67	<b>Test Results</b> Row 71 Column 67
2	Bad channel: Total Insolation	“	- Total Insolation column has -99.9 value. - QC asterisk on this channel.	129	<b>Test Results</b> Row 72 Column 129
2	Bad channel: Total Liquid Precip	“	- Total Liquid Precip column has -99.9 value. - QC asterisk on this channel.	131	<b>Test Results</b> Row 73 Column 131
2	Bad channel: Aspirator Status Signal	“	- The three Aspirator Status columns have an ‘F’ value due to the Input value being set to -99.9	133, 134, 135	<b>Test Results</b> Row 74 Columns 133, 134, 135

## 11. Project Milestones

A. Milestone 1	Phase 1 completed	Wednesday, July 14, 1999
B. Milestone 2	Phase 2 completed	Tuesday, August 3, 1999
C. Milestone 3	Phase 3 completed	Friday, August 13, 1999
D. Milestone 4	Final Acceptance of Version 1.01 of the IVS	Friday, August 20, 1999

## 12. References

- Boehm, B.W. (1988). A Spiral Model of Software Development and Enhancement. *IEEE Computer*, 21(5), pp. 61-72.
- Sommerville, Ian (1996). *Software Engineering* 5th edition, New York: Addison-Wesley.

## **APPENDIX A**

### **Data Format for User On-Line Input**

## Appendix A – Data Format for User On-Line Input

```

* * * * *
* Do you wish to set any channels as bad (y/n)? *
*   (Enter a blank to signify no.)           *
* * * * *

```

y

```

-----
                          BAD CHANNEL SELECT MENU
-----

```

```

1  21xID Word                30  2m  mean baro pressure
2  Calendar Year             31  2m  mean dewpoint temp
3  Julian Date               33  50m air temperature
4  Time at Record End        34  2m  air temperature
5  AC Power Status Signal    35  80-50m delta temp dif
6  80m mean wind speed       36  50-2m  delta temp dif
7  80m mean wind direction   71  total insolation
9  50m mean wind speed       72  total liquid precip
10 50m mean wind direction   73  aspirator status signal
12 20m mean wind speed       74  21X battery voltage
13 20m mean wind direction
15 10m mean wind speed
16 10m mean wind direction
18 5m  mean wind speed
19 5m  mean wind direction
21 2m  mean wind speed
22 2m  mean wind direction   99  Exit / Undo

```

```

-----
-----
To flag a channel as bad, type in a number to the left of the
corresponding channel description. (To exit selection routine, enter 99.)

```

7

```

Type in the start date & time for this bad channel. (Julian Date, Time)
(Press enter to select all records in the file.)

```

144, 10

```

Type in the ending date & time for this bad channel. (Julian Date, Time)

```

144, 0

```

-----
You have selected:

```

```

Channel No.   Start Date Time   End Date Time
              7             144  0:10           144  0:00

```

```

-----
Press enter to continue, to undo this selection, enter 99.

```

## **APPENDIX B**

### **Completed Progress Forms for Each Iteration of the Design Process**

## Appendix B – Completed Progress Forms for Each Iteration of the Design Process

### Project Status: Start of Phase 1: June 8, 1999

- Objectives - Produce system to validate tower data for technicians and scientists.  
- System must be easy to maintain and change.
- Constraints - Must be operational before the end of Summer 1999.  
- Will need to be changed before January 1, 2000, to reflect scheduled met tower data format changes.
- Alternatives - At this point, alternatives will involve varying degrees of effectiveness of the validation ability of the system.
- Risks - May be unforeseen validation issues in the tower data.  
- May not have time to resolve all these issues.
- Risk Resolution - Begin development as soon as possible.  
- Document entire process so tower data validation issues may be reviewed and studied for comprehensiveness.
- Results - Unknown at this time, development has barely started.
- Plans - Might need a catalog of validation issues for tower data.  
- Add addendum to Requirements Document as requirements change.
- Commitment - Begin development of Phase 1 now.

### Project Status: End of Phase 1, Start of Phase 2: July 14, 1999

- Objectives - Produce Phase 2 of system design while testing Phase 1 with real data.  
- Have working copy of software always available.
- Constraints - Might want to update software slightly before testing with real data..
- Alternatives - At this point, alternatives will involve varying degrees of effectiveness of the validation ability of the system.
- Risks - May be unforeseen validation issues in the tower data.  
- May not have time to resolve all these issues.
- Risk Resolution - Begin development as soon as possible.  
- Continue to append to documentation of entire process so tower data validation issues may be reviewed and studied for comprehensiveness.
- Results - This document is now being updated as the software evolves.  
- Testing so far looks good, will see how real data looks.
- Plans - Use this document as a catalog of validation issues for tower data.  
- Add addendum to Requirements Document as requirements change.
- Commitment - Begin development of Phase 2 now.

**Project Status: End of Phase 2, Start of Phase 3: August 3, 1999**

- Objectives - Produce Phase 3 of system design by testing Phase 2 with real data.  
- Add file translators and additional validation as needed while processing tower data files from 1995 to 1999.
- Constraints - Software is essentially in beta testing stage, constraints involve time available for final testing for completeness and acceptance.
- Alternatives - At this point, alternatives will involve varying plans of action if final testing is incomplete by August 20, 1999.
- Risks - May be unforeseen validation issues in the tower data.  
- May not have time to resolve all these issues.
- Risk Resolution - Begin development as soon as possible.  
- Continue to document entire process so tower data validation issues may be reviewed and studied for comprehensiveness.
- Results - Testing so far looks good, will see how real data looks.
- Plans - Use this document as a catalog of validation issues for tower data.
- Commitment - Begin development of Phase 3 now.

**Project Status: End of Phase 3: August 20, 1999**

- Objectives - Release of software to users or future maintenance.
- Constraints - Training in software use has been very brief, running of past year data very rushed.
- Alternatives - Study of this document or meeting of minds by all participants except the developer.  
- Reruns of past data can be easily made because bad channel information is contained in .bdc files in the validation directories.
- Risks - May be unforeseen validation issues in the tower data not seen until Statistical Summaries & Historical Database Software is developed and run.
- Risk Resolution - Use this document of entire process to modify Initial Validation Software (IVS) if needed at that time.
- Results - Real data from M2 tower has been run for the years 1996–1999 using version 1.00 of the IVS. Most of 1997 has been run on the M3 tower. A program bug was found early in M3 runs, it was repaired with version 1.01 of the IVS.
- Plans - Finish up past data runs and perform runs on future data coming from towers (see Risks and Risk Resolution above).
- Commitment - Acceptance test of IVS is now complete.



## **APPENDIX C**

### **Validation Summary Printout Example And Test Results**

## Appendix C – Validation Summary Printout Example and Test Results

What follows is a **validation summary printout** and its corresponding **test results** from a single program run. The test data included a combination of quality control (QC) edge tests, various record validation tests, aspirator QC edge tests, and bad parameter tests; hence, the input file was named "...EdgeVarAsprPar...". The **Test Results** output file printout, which follows the **Validation Summary Printout** has the first six rows (Julian date 143) reserved for QC edge tests, rows 7–12 for various other tests, and rows 13–48 (Julian date 146) reserved for aspirator QC tests. The next 21 rows, 49–69 (Julian date 147) are the output results from 21 of the bad parameter tests.

### Notes on Testing

Some parameters were not QC edge-tested for 100% branch coverage. These include the Turbulence Intensity-derived parameters, which were just visually observed in the program code. For these, the IF statement was copied and pasted from the 80 m level to the other five levels, so if 80 m level QC branch logic is correct, the rest should be also. The following derived parameters – Richardson Numbers, Friction Velocity  $u_*$ , Surface Roughness,  $u_*$  Quality Control  $r^2$ , and 2-80 m Mean Power Law Coefficient were not tested for branch coverage, just visually observed in the program code. For these, the **Test Results** printout that follows was used to verify that the IF statement could trigger a "\*" flag; however, no testing was performed on each individual logic branch within each IF statement. Testing was performed to see if a blank QC flag would be triggered.

For bad channel on/off testing, 27 additional rows were added behind the rest of the input test data. These are the 27 fundamental channels of the 21X as shown in **Appendix A** of this document. Of these, 21 of them will produce information for the **Test Results** output file printout below. The remaining six parameters including the date, time, and 21X battery voltage, will not produce output data, and these bad channel records are removed from the output data. These were placed behind the others and are printed last on the **Validation Summary Printout Example** below.

None of the 21 bad channels triggered a QC star or a -99.9 on the 2-80 m Mean Power Law Coefficient because its QC is based on the wind-through-the-tower condition. Although bad parameters trigger a QC star for the Friction Velocity  $u_*$ , Surface Roughness, and  $u_*$  Quality Control  $r^2$  derived parameters, they don't become a -99.9 as the Turbulence Intensity, Humidity, and Richardson Numbers do.

### Validation Summary Printout Example

```
-----  
                          NREL / NWTC  
                          Initial Validation Software  
                          for 80 meter Meteorological Tower Data  
                          IVS Version 1.01  
-----
```

```
-----  
                          Validation Summary Report  
-----
```

```
Input File Name:  ./m2EdgeVarAsprPar.test  
Output File Name:  ./out
```

Bad channels are:

Channel No.	Start Date	Time	End Date	Time
6	147	0:10	147	0:10
9	147	0:20	147	0:20
12	147	0:30	147	0:30
15	147	0:40	147	0:40
18	147	0:50	147	0:50
21	147	1:00	147	1:00
7	147	1:10	147	1:10
10	147	1:20	147	1:20
13	147	1:30	147	1:30
16	147	1:40	147	1:40
19	147	1:50	147	1:50
22	147	2:00	147	2:00
30	147	2:10	147	2:10
31	147	2:20	147	2:20
33	147	2:30	147	2:30
34	147	2:40	147	2:40
35	147	2:50	147	2:50
36	147	3:00	147	3:00
71	147	3:10	147	3:10
72	147	3:20	147	3:20
73	147	3:30	147	3:30
1	147	3:40	147	3:40
2	147	3:50	147	3:50
3	147	4:00	147	4:00
4	147	4:10	147	4:10
5	147	4:20	147	4:20
74	147	4:30	147	4:30

```

2m Mean Baro Press out of range ..... date time: 143 10 Unit 5
2m Max Baro Press out of range .... date time: 143 10 Unit 5
2m Min Baro Press out of range .. date time: 143 10 Unit 5

2m Mean Baro Press out of range ..... date time: 143 20 Unit 5
2m Max Baro Press out of range .... date time: 143 20 Unit 5
2m Min Baro Press out of range .. date time: 143 20 Unit 5

2m Mean Baro Press out of range ..... date time: 143 50 Unit 5
> 2m Mean Dewpoint Temp out of range date time: 143 50 Unit 5
> 50m Air Temperature out of range date time: 143 50 Unit 5
> 2m Air Temperature out of range date time: 143 50 Unit 5
> 80-50 Delta Temperature out of range date time: 143 50 Unit 5
> 50-2 Delta Temperature out of range date time: 143 50 Unit 5
    80m Max Gust Time out of range | date time: 143 50 Unit 5
    50m Max Gust Time out of range | date time: 143 50 Unit 5
    20m Max Gust Time out of range | date time: 143 50 Unit 5
    10m Max Gust Time out of range | date time: 143 50 Unit 5
    5m Max Gust Time out of range | date time: 143 50 Unit 5
    2m Max Gust Time out of range | date time: 143 50 Unit 5
2m Max Baro Press out of range .... date time: 143 50 Unit 5
    2m Max Baro Time out of range . date time: 143 50 Unit 5
    > 2m Max Dewpoint Temp out of range date time: 143 50 Unit 5
        2m Max Dewpt Time out of range > date time: 143 50 Unit 5
2m Min Baro Press out of range .. date time: 143 50 Unit 5
    2m Min Baro Time out of range . date time: 143 50 Unit 5

```

> 2m Min Dewpoint Temp out of range	date time: 143	50	Unit 5
2m Min Dewpt Time out of range >	date time: 143	50	Unit 5
Total Insolation out of range	date time: 143	50	Unit 5
Total Liquid Precipitaion out of range	date time: 143	50	Unit 5
2m Mean Baro Press out of range .....	date time: 143	100	Unit 5
> 2m Mean Dewpoint Temp out of range	date time: 143	100	Unit 5
> 50m Air Temperature out of range	date time: 143	100	Unit 5
> 2m Air Temperature out of range	date time: 143	100	Unit 5
> 80-50 Delta Temperature out of range	date time: 143	100	Unit 5
> 50-2 Delta Temperature out of range	date time: 143	100	Unit 5
80m Max Gust Time out of range	date time: 143	100	Unit 5
50m Max Gust Time out of range	date time: 143	100	Unit 5
20m Max Gust Time out of range	date time: 143	100	Unit 5
10m Max Gust Time out of range	date time: 143	100	Unit 5
5m Max Gust Time out of range	date time: 143	100	Unit 5
2m Max Gust Time out of range	date time: 143	100	Unit 5
2m Max Baro Press out of range ....	date time: 143	100	Unit 5
2m Max Baro Time out of range .	date time: 143	100	Unit 5
> 2m Max Dewpoint Temp out of range	date time: 143	100	Unit 5
2m Max Dewpt Time out of range >	date time: 143	100	Unit 5
2m Min Baro Press out of range ..	date time: 143	100	Unit 5
2m Min Baro Time out of range .	date time: 143	100	Unit 5
> 2m Min Dewpoint Temp out of range	date time: 143	100	Unit 5
2m Min Dewpt Time out of range >	date time: 143	100	Unit 5
Total Insolation out of range	date time: 143	100	Unit 5
Total Liquid Precipitaion out of range	date time: 143	100	Unit 5
- Julian Date out of range	prior output record: 6		Unit 2.1
...this record removed from output.	input record: 7		
* Calibrate mode on.	prior output record: 6		Unit 2.0
...this record removed from output.	input record: 8		
* Battery voltage below 10.5 volts.	prior output record: 7		Unit 2.0
...this record removed from output.	input record: 10		
- Julian Date out of range	prior output record: 11		Unit 2.1
...this record removed from output.	input record: 15		
- Record Time out of range	prior output record: 11		Unit 2.1
...this record removed from output.	input record: 16		
*Tower ID does not match 21x IDword.	prior output record: 12		Unit 3
...this record removed from output.	input record: 18		
- Julian Date out of range	prior output record: 12		Unit 2.1
...this record removed from output.	input record: 19		
- Record Time out of range	prior output record: 12		Unit 2.1
...this record removed from output.	input record: 20		
80m Aspirator voltage in Fail range	date time: 146	20	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	20	Unit 5
50m Aspirator voltage in Fail range	date time: 146	30	Unit 5
> 50m Air Temperature questionable	date time: 146	30	Unit 5

> 80-50 Delta Temperature questionable	date time: 146	30	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	30	Unit 5
80m Aspirator voltage in Fail range	date time: 146	40	Unit 5
50m Aspirator voltage in Fail range	date time: 146	40	Unit 5
> 50m Air Temperature questionable	date time: 146	40	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	40	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	40	Unit 5
2m Aspirator voltage in Fail range	date time: 146	50	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	50	Unit 5
> 2m Air Temperature questionable	date time: 146	50	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	50	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	50	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	50	Unit 5
80m Aspirator voltage in Fail range	date time: 146	100	Unit 5
2m Aspirator voltage in Fail range	date time: 146	100	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	100	Unit 5
> 2m Air Temperature questionable	date time: 146	100	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	100	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	100	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	100	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	100	Unit 5
50m Aspirator voltage in Fail range	date time: 146	110	Unit 5
2m Aspirator voltage in Fail range	date time: 146	110	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	110	Unit 5
> 50m Air Temperature questionable	date time: 146	110	Unit 5
> 2m Air Temperature questionable	date time: 146	110	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	110	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	110	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	110	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	110	Unit 5
80m Aspirator voltage in Fail range	date time: 146	120	Unit 5
50m Aspirator voltage in Fail range	date time: 146	120	Unit 5
2m Aspirator voltage in Fail range	date time: 146	120	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	120	Unit 5
> 50m Air Temperature questionable	date time: 146	120	Unit 5
> 2m Air Temperature questionable	date time: 146	120	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	120	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	120	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	120	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	120	Unit 5
80m Aspirator voltage in Fail range	date time: 146	130	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	130	Unit 5
80m Aspirator voltage in Fail range	date time: 146	140	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	140	Unit 5
50m Aspirator voltage in Fail range	date time: 146	150	Unit 5
> 50m Air Temperature questionable	date time: 146	150	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	150	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	150	Unit 5

50m Aspirator voltage in Fail range	date time: 146	200	Unit 5
> 50m Air Temperature questionable	date time: 146	200	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	200	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	200	Unit 5
80m Aspirator voltage in Fail range	date time: 146	210	Unit 5
50m Aspirator voltage in Fail range	date time: 146	210	Unit 5
> 50m Air Temperature questionable	date time: 146	210	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	210	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	210	Unit 5
80m Aspirator voltage in Fail range	date time: 146	220	Unit 5
50m Aspirator voltage in Fail range	date time: 146	220	Unit 5
> 50m Air Temperature questionable	date time: 146	220	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	220	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	220	Unit 5
2m Aspirator voltage in Fail range	date time: 146	230	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	230	Unit 5
> 2m Air Temperature questionable	date time: 146	230	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	230	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	230	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	230	Unit 5
2m Aspirator voltage in Fail range	date time: 146	240	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	240	Unit 5
> 2m Air Temperature questionable	date time: 146	240	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	240	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	240	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	240	Unit 5
80m Aspirator voltage in Fail range	date time: 146	250	Unit 5
2m Aspirator voltage in Fail range	date time: 146	250	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	250	Unit 5
> 2m Air Temperature questionable	date time: 146	250	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	250	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	250	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	250	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	250	Unit 5
80m Aspirator voltage in Fail range	date time: 146	300	Unit 5
2m Aspirator voltage in Fail range	date time: 146	300	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	300	Unit 5
> 2m Air Temperature questionable	date time: 146	300	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	300	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	300	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	300	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	300	Unit 5
50m Aspirator voltage in Fail range	date time: 146	310	Unit 5
2m Aspirator voltage in Fail range	date time: 146	310	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	310	Unit 5
> 50m Air Temperature questionable	date time: 146	310	Unit 5
> 2m Air Temperature questionable	date time: 146	310	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	310	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	310	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	310	Unit 5

> 2m Min Dewpoint Temp questionable	date time: 146	310	Unit 5
50m Aspirator voltage in Fail range	date time: 146	320	Unit 5
2m Aspirator voltage in Fail range	date time: 146	320	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	320	Unit 5
> 50m Air Temperature questionable	date time: 146	320	Unit 5
> 2m Air Temperature questionable	date time: 146	320	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	320	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	320	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	320	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	320	Unit 5
80m Aspirator voltage in Fail range	date time: 146	330	Unit 5
50m Aspirator voltage in Fail range	date time: 146	330	Unit 5
2m Aspirator voltage in Fail range	date time: 146	330	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	330	Unit 5
> 50m Air Temperature questionable	date time: 146	330	Unit 5
> 2m Air Temperature questionable	date time: 146	330	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	330	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	330	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	330	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	330	Unit 5
80m Aspirator voltage in Fail range	date time: 146	340	Unit 5
50m Aspirator voltage in Fail range	date time: 146	340	Unit 5
2m Aspirator voltage in Fail range	date time: 146	340	Unit 5
> 2m Mean Dewpoint Temp questionable	date time: 146	340	Unit 5
> 50m Air Temperature questionable	date time: 146	340	Unit 5
> 2m Air Temperature questionable	date time: 146	340	Unit 5
> 80-50 Delta Temperature questionable	date time: 146	340	Unit 5
> 50-2 Delta Temperature questionable	date time: 146	340	Unit 5
> 2m Max Dewpoint Temp questionable	date time: 146	340	Unit 5
> 2m Min Dewpoint Temp questionable	date time: 146	340	Unit 5
80m Max Gust Time out of range	date time: 147	10	Unit 5
50m Max Gust Time out of range	date time: 147	20	Unit 5
20m Max Gust Time out of range	date time: 147	30	Unit 5
10m Max Gust Time out of range	date time: 147	40	Unit 5
5m Max Gust Time out of range	date time: 147	50	Unit 5
2m Max Gust Time out of range	date time: 147	100	Unit 5
80m Max Gust Time out of range	date time: 147	110	Unit 5
50m Max Gust Time out of range	date time: 147	120	Unit 5
20m Max Gust Time out of range	date time: 147	130	Unit 5
10m Max Gust Time out of range	date time: 147	140	Unit 5
5m Max Gust Time out of range	date time: 147	150	Unit 5
2m Max Gust Time out of range	date time: 147	200	Unit 5

2m Mean Baro Press out of range .....	date time: 147	210	Unit 5
2m Max Baro Press out of range ....	date time: 147	210	Unit 5
2m Max Baro Time out of range .	date time: 147	210	Unit 5
2m Min Baro Press out of range ..	date time: 147	210	Unit 5
2m Min Baro Time out of range .	date time: 147	210	Unit 5
> 2m Mean Dewpoint Temp out of range	date time: 147	220	Unit 5
> 2m Max Dewpoint Temp out of range	date time: 147	220	Unit 5
2m Max Dewpt Time out of range >	date time: 147	220	Unit 5
> 2m Min Dewpoint Temp out of range	date time: 147	220	Unit 5
2m Min Dewpt Time out of range >	date time: 147	220	Unit 5
> 50m Air Temperature out of range	date time: 147	230	Unit 5
> 2m Air Temperature out of range	date time: 147	240	Unit 5
> 80-50 Delta Temperature out of range	date time: 147	250	Unit 5
> 50-2 Delta Temperature out of range	date time: 147	300	Unit 5
Total Insolation out of range	date time: 147	310	Unit 5
Total Liquid Precipitaion out of range	date time: 147	320	Unit 5
*Tower ID does not match 2lx IDword. prior output record: 69			Unit 3
...this record removed from output. input record: 78			
- Calendar Year out of Range prior output record: 69			Unit 2.1
...this record removed from output. input record: 79			
- Julian Date out of range prior output record: 69			Unit 2.1
...this record removed from output. input record: 80			
- Record Time out of range prior output record: 69			Unit 2.1
...this record removed from output. input record: 81			
* Calibrate mode on. prior output record: 69			Unit 2.0
...this record removed from output. input record: 82			
* Battery voltage below 10.5 volts. prior output record: 69			Unit 2.0
...this record removed from output. input record: 83			

-----  
----- End of Report -----  
-----



Table C.1. Test Results

Cols:	1	2	3	4	5	6	7	8	9	11	13	Cols:	15	17
Rows	TR	Year	Date	Rec#	Time	AC	80MeanWSp	80MeanWDir	80WDirSig	Rows	50MeanWSp	50MeanWDir		
1	M2	1999	143	1	10	120	3.45	132	11.58	1	3.51	132		
2	M2	1999	143	2	20	119	3.42	92	8.89	2	3.96	92		
3	M2	1999	143	3	30	120	3.45 *	131 *	11.58 *	3	3.51 *	131 *		
4	M2	1999	143	4	40	119	3.42 *	92.1 *	8.89 *	4	3.96 *	92.1 *		
5	M2	1999	143	5	50	120	3.45	132.1	11.58	5	3.51	132.1		
6	M2	1999	143	6	100	119	3.42	91	8.89	6	3.96	91		
7	M2	1999	144	48	800	119	2.23	359.2	11.99	7	2.22	353.3		
8	M2	1999	144	50	820	119	3.22	21.8	12.86	8	3.32	21.5		
9	M2	1999	144	51	830	119	3.26	18.3	9.47	9	3.28	18.5		
10	M2	1999	144	52	840	119	4.02	22.3	12.05	10	3.96	22.5		
11	M2	1999	144	53	850	119	4.46	24.6	8.4	11	4.54	23.4		
12	M2	1999	144	56	920	119	4.85	17.4	8.7	12	4.76	15.5		
13	M2	1999	146	1	10	119	3.42	321.5	8.89	13	3.96	306		
14	M2	1999	146	2	20	120	3.45	326.5	11.58	14	3.51	306.9		
15	M2	1999	146	3	30	119	3.32	331.1	9.87	15	3.55	311.3		
16	M2	1999	146	4	40	119	2.68	327.5	12.27	16	2.98	304.1		
17	M2	1999	146	5	50	120	1.78	337.8	14.35	17	2.46	311.2		
18	M2	1999	146	6	100	119	1.19	338.5	12.14	18	1.68	314		
19	M2	1999	146	7	110	119	0.88	350.7	22.62	19	1.45	305.6		
20	M2	1999	146	8	120	119	0.35	237.1	47.04	20	1.15	263.1		
21	M2	1999	146	9	130	119	3.03	174.7	11.52	21	3.67	174.5		
22	M2	1999	146	10	140	119	3.94	163.8	4.19	22	4.22	166.8		
23	M2	1999	146	11	150	119	3.85	176.7	4.75	23	4.16	178.4		
24	M2	1999	146	12	200	119	4.21	186.2	1.91	24	4.11	190.1		
25	M2	1999	146	13	210	119	4.37	200.3	6.58	25	4.23	204.8		
26	M2	1999	146	14	220	119	4.94	214.9	4.83	26	4.95	218.6		
27	M2	1999	146	15	230	119	5.32	228.2	4.87	27	5.39	227.5		
28	M2	1999	146	16	240	119	4.75	231.1	3.65	28	3.72	234.4		
29	M2	1999	146	17	250	119	4.09	232.6	3.5	29	4.04	232.3		
30	M2	1999	146	18	300	119	2.67	252.8	12.29	30	2.74	261.4		
31	M2	1999	146	19	310	119	2.35	279.6	6.01	31	2.58	282		
32	M2	1999	146	20	320	119	2.18	287.8	9.51	32	2.24	287.5		
33	M2	1999	146	21	330	119	1.87	301.4	19.85	33	1.89	302.1		
34	M2	1999	146	22	340	119	3.07	331.5	10.12	34	3.12	320.5		
35	M2	1999	146	23	350	119	3.07	345.6	11.43	35	2.61	333.8		
36	M2	1999	146	24	400	119	1.84	331.3	27.39	36	1.55	320		
37	M2	1999	146	25	410	119	2.17	339.1	15.92	37	1.67	337		
38	M2	1999	146	26	420	119	2.43	339.5	14.5	38	2.25	329.8		
39	M2	1999	146	27	430	119	2.02	351.3	14.87	39	1.93	352.5		
40	M2	1999	146	28	440	119	0.61	257.5	44.44	40	0.73	222.2		
41	M2	1999	146	29	450	119	0.44	194.6	29.68	41	0.25	138.2		
42	M2	1999	146	30	500	119	1.24	211.6	12.37	42	0.75	201.8		
43	M2	1999	146	31	510	119	1.97	216.9	5.06	43	1.93	220.9		
44	M2	1999	146	32	520	119	2.21	210.7	9.77	44	2.55	213.6		
45	M2	1999	146	33	530	119	3.41	212.2	6.92	45	2.98	212.1		
46	M2	1999	146	34	540	119	4.24	212.1	4.42	46	3.8	209.4		
47	M2	1999	146	35	550	119	6.11	204	8.34	47	5.29	201.1		
48	M2	1999	146	36	600	119	5.89	189.6	5.82	48	5.49	185.3		
49	M2	1999	147	1	10	119	-99.9	353.9	5.44	49	4.43	338.4		
50	M2	1999	147	2	20	119	4.36	340.6	7.63	50	-99.9	326.4		
51	M2	1999	147	3	30	120	4.5	342.6	5.82	51	4.09	327		
52	M2	1999	147	4	40	120	4.77	328.9	5.44	52	4.46	313.6		
53	M2	1999	147	5	50	120	5.21	328	4.31	53	4.88	314.5		
54	M2	1999	147	6	100	120	6.25	330.2	5.95	54	5.8	316.9		
55	M2	1999	147	7	110	119	6.67	-99.9	-99.9	55	6.1	317.9		
56	M2	1999	147	8	120	119	7.16	340.1	9.92	56	6.56	-99.9		
57	M2	1999	147	9	130	120	7.17	347	4.9	57	6.41	335.9		
58	M2	1999	147	10	140	120	6.96	344	4.14	58	6.17	331.8		
59	M2	1999	147	11	150	119	6.09	342.2	5.73	59	5.46	329.6		
60	M2	1999	147	12	200	119	5.57	340.8	6.9	60	4.96	327.6		
61	M2	1999	147	13	210	119	5.71	350.3	4.04	61	4.82	334.5		
62	M2	1999	147	14	220	119	4.75	351.4	4.91	62	4.07	338		
63	M2	1999	147	15	230	119	5.98	358.5	4.73	63	5.01	345.6		
64	M2	1999	147	16	240	119	6.63	1.8	4.56	64	5.89	349.8		
65	M2	1999	147	17	250	119	3.88	355.2	9.16	65	3.7	346.3		
66	M2	1999	147	18	300	119	4.16	8	4.6	66	4.01	6.7		
67	M2	1999	147	19	310	119	3.85	7.1	4.43	67	3.63	3.3		
68	M2	1999	147	20	320	119	3.35	10.7	6.67	68	3	4.7		
69	M2	1999	147	21	330	119	2.91	0.4	5.47	69	2.41	349		

Cols:	19	21	23	25	27	29	31	33
Rows:	50WDirSig	20MeanWSp	20MeanWDir	20WDirSig	10MeanWSp	10MeanWDir	10WDirSig	5MeanWSp
1	8.27	2.32	132	12.25	2.06	132	11.77	1.85
2	5.62	2.58	92	12.25	2.06	92	14.74	1.76
3	8.27 *	2.32 *	131 *	12.25 *	2.06 *	131 *	11.77 *	1.85 *
4	5.62 *	2.58 *	92.1 *	12.25 *	2.06 *	92.1 *	14.74 *	1.76 *
5	8.27	2.32	132.1	12.25	2.06	132.1	11.77	1.85
6	5.62	2.58	91	12.25	2.06	91	14.74	1.76
7	14.83	2.12	351.4	14.66	2.01	351.6	14.63	1.97
8	14.08	3.2	25.9	15.14	3.08	25.2	16.47	2.92
9	8.08	3.34	20.3	8.72	3.32	20.9	8.56	3.18
10	14.31	3.91	20.2	19.87	3.65	21.8	18.59	3.43
11	9.94	4.42	25.7	10.75	4.28	25.6	10.85	4.06
12	11.31	4.38	12.9	17.1	4.05	15.8	16.89	3.86
13	5.62	2.58	291.6	12.25	2.06	288	14.74	1.76
14	8.27	2.32	292.9	12.25	2.06	288.2	11.77	1.85
15	7.45	2.61	296.8	9.27	2.18	293.5	10.71	1.95
16	9.33	2.48	291.9	8.36	2.12	290.7	10.31	1.85
17	8.43	2.1	289.5	9.74	1.67	279.7	12.73	1.51
18	10.18	1.46	282	10.73	1.1	264.4	14.02	0.96
19	9.83	1.46	271.9	10.5	1.3	257.1	12.01	1.15
20	18.68	1.5	222.8	11.75	1.93	214.4	7.64	1.83
21	11.62	3.68	180.4	5.79	3.4	179.4	6.18	3.05
22	2.89	3.74	177.1	4.31	3.46	175.1	5.84	3.09
23	3.48	3.5	190.2	6.41	3.12	192.1	7.21	2.67
24	3.35	3.98	206.2	4.12	3.51	207.1	4.25	2.89
25	6.3	4.06	219	6.53	3.35	219.8	7.15	2.82
26	2.51	3.91	225.8	5.69	3.11	224.6	7.52	2.71
27	4.5	3.76	230.6	8.27	3.05	229.9	10.13	2.65
28	6.46	2.67	236.9	9.37	2.3	236.3	11.49	2.06
29	4.43	3.11	231.2	7.71	2.62	225.5	7.92	2.38
30	16.26	2.02	261	16.55	1.65	253.7	17.24	1.46
31	6.6	1.78	284.5	12.89	1.55	285.6	15.36	1.47
32	6.25	1.77	291.8	12.1	1.55	290.2	13.53	1.42
33	9.15	1.46	294.9	6.78	1.42	292.3	9.19	1.37
34	9.31	2.55	310.8	12.71	2.2	309.8	15.98	1.92
35	11.91	2.14	329.5	8.34	1.81	332.9	11.92	1.47
36	30.02	1.13	320.3	43.36	0.76	319.8	51	0.68
37	50.12	1.33	356.4	39.72	1.23	1.4	41.44	1.17
38	9.84	2.13	331.5	21.21	2.05	338.1	26.84	1.92
39	13.21	1.93	10.8	9.97	1.85	10.3	28.7	1.75
40	42.53	0.86	214.6	21.5	0.87	202	25.65	0.91
41	37.17	0.34	139.9	18.35	0.28	141.8	19.08	0.24
42	11.55	0.49	198.4	10.76	0.36	200.7	8.36	0.25
43	9.58	1.51	223.5	12.84	1.33	223.4	14.55	1.25
44	6.86	2.53	215.7	6.48	2.2	213.7	7.89	2.02
45	7.21	2.54	211.4	7.94	2.16	207.8	8.93	1.88
46	3.93	3.01	208.9	5.69	2.66	205.7	6.56	2.34
47	7.17	4.26	202.6	6.5	3.81	201	6.47	3.38
48	6.19	4.59	184.6	7.34	4.14	183.2	8.49	3.67
49	5.37	3.38	326.2	6.81	2.64	321.7	7.71	2.11
50	5.41	3.37	318.7	5.03	2.66	316.7	7.37	2.06
51	4.65	-99.9	316.2	4.53	2.64	311.3	7.27	2.12
52	4.32	3.75	305.5	5.5	-99.9	301.3	5.91	2.59
53	2.93	3.74	304.9	5.92	3.08	302.4	6.72	-99.9
54	5.03	4.59	311.1	5.47	3.71	309	7.41	3.12
55	6.75	4.92	311.2	6.88	4.06	310.4	8.43	3.48
56	-99.9	5.45	317.9	7.96	4.71	317.1	9.04	4.01
57	4.45	5.31	-99.9	-99.9	4.46	333.2	6.72	3.89
58	4.89	4.92	325	7.72	4.12	-99.9	-99.9	3.52
59	5.41	4.21	319.7	7.17	3.6	316.4	9.06	3.12
60	7.06	4.13	319.5	6.27	3.48	319.2	7.99	2.96
61	5.2	3.97	327.7	5.03	3.34	329.5	7.37	2.8
62	3.54	3.35	337.1	3.64	2.97	343.6	4.35	2.41
63	3.73	3.71	341.7	4.23	2.99	343.8	6.53	2.34
64	6.64	4.71	349.8	8.14	3.95	354.3	7.59	3.2
65	9.55	2.6	350.5	14.54	1.71	357.2	16.44	1.27
66	5.23	3.19	13.6	5.81	2.35	19.2	9.46	1.77
67	9.2	2.72	7.3	10.01	2.12	11.3	8.47	1.68
68	11.13	2.02	5.5	10.68	1.6	10.7	10.94	1.39
69	10.58	1.44	347.9	12.91	0.93	350	13.67	0.56

Cols:	35	37	39	41	43	45	47	49
Rows	5MeanWDir	5WDirSig	2MeanWSp	2MeanWDir	2WDirSig	80SigWSp	50SigWSp	20SigWSp
1	132	11.86	1.58	132	12.29	0.608	0.569	0.569
2	92	15.71	1.5	92	16.44	0.49	0.277	0.554
3	131 *	11.86 *	1.58 *	131 *	12.29 *	0.608 *	0.569 *	0.569 *
4	92.1 *	15.71 *	1.5 *	92.1 *	16.44 *	0.49 *	0.277 *	0.554 *
5	132.1	11.86	1.58	132.1	12.29	0.608	0.569	0.569
6	91	15.71	1.5	91	16.44	0.49	0.277	0.554
7	352.8	15.62	1.71	350.4	17.37	0.362	0.37	0.483
8	28.3	19.59	2.6	25.7	21.3	0.503	0.516	0.492
9	22.4	9.6	2.87	20.7	11.97	0.569	0.589	0.513
10	24.9	20.14	3.06	23.6	22.19	0.635	0.554	0.539
11	29.3	12.56	3.62	29	13.26	0.586	0.567	0.622
12	19.2	17.84	3.44	18.1	18.5	0.695	0.772	0.754
13	287.8	15.71	1.5	283.9	16.44	0.49	0.277	0.554
14	288.7	11.86	1.58	286.5	12.29	0.608	0.569	0.569
15	293.7	11.18	1.55	291.9	11.94	0.477	0.356	0.394
16	290.2	11.34	1.57	286.1	12.85	0.515	0.365	0.411
17	277.3	13.21	1.24	274.5	14.15	0.348	0.394	0.428
18	257.1	15.54	0.82	252.8	15.4	0.282	0.248	0.286
19	251.1	11.3	0.95	242.7	10.89	0.288	1.619	0.178
20	213.5	7.31	1.42	212.3	7.4	0.129	0.884	0.276
21	183	6.97	2.59	180.5	8.61	1.028	0.895	0.445
22	178.2	6.54	2.65	176.1	8.64	0.421	0.3	0.452
23	196.2	7.31	2.2	195.7	8.1	0.28	0.171	0.173
24	210	5.36	2.41	208.3	6.92	0.111	0.094	0.237
25	222.9	7.98	2.47	222.1	8.71	0.138	0.11	0.297
26	227.2	7.11	2.34	226.5	8.18	0.542	0.424	0.357
27	231.3	9.98	2.37	229.3	11.46	0.29	0.269	0.514
28	237.4	10.75	1.78	235.6	12.56	0.362	0.558	0.55
29	225.4	7.87	2.17	223.1	8.84	0.342	0.559	0.348
30	252.7	19.28	1.22	250.7	21.39	0.368	0.356	0.257
31	287.1	16.71	1.27	285.8	16.28	0.23	0.158	0.247
32	290.9	12.81	1.21	288.8	13.19	0.42	0.293	0.283
33	291.3	10.54	1.2	287.5	10.69	0.336	0.255	0.196
34	311.6	16.61	1.57	309.6	15.03	1.091	0.786	0.885
35	335.6	15.34	1.1	334.7	16.18	0.517	0.646	0.789
36	303.9	66.15	0.64	291.2	64.95	0.729	1.376	0.449
37	10	44.85	1.03	8.9	45.53	0.845	1.436	0.641
38	342	30.73	1.66	341.3	34.41	0.336	0.286	0.257
39	12.5	34.74	1.41	11.4	45.37	0.495	0.568	0.565
40	199	19.74	0.93	195.4	19.27	0.309	1.74	0.576
41	136.1	14.06	0.28	138.6	18.28	0.247	0.012	0.104
42	207.5	8.34	0.38	209.7	8.47	0.332	0.81	0.241
43	226.6	15.97	1.08	224.8	16.27	0.413	0.561	0.426
44	215.8	9.42	1.76	213.5	9.6	0.309	0.255	0.213
45	208.5	9.46	1.54	206.7	10.44	0.505	0.48	0.312
46	206.3	7.69	1.95	204.5	9.59	0.443	0.412	0.35
47	204.3	7.4	3.02	202.7	8.16	0.751	0.797	0.706
48	187.2	10.2	3.23	185.9	11.13	0.621	0.526	0.573
49	321	8.97	1.64	316.6	9.51	-99.9	0.436	0.373
50	317.5	9.55	1.58	315.2	10.59	0.408	-99.9	0.327
51	309.8	7.66	1.67	305.6	9.15	0.365	0.295	-99.9
52	300.5	6.05	2.23	295.3	6.47	0.244	0.247	0.215
53	303.1	7.52	2.12	299.1	8.43	0.442	0.402	0.268
54	309.5	8.72	-99.9	306.4	9.14	0.528	0.515	0.416
55	311.2	9	3.04	308.6	9.93	0.616	0.569	0.642
56	316.8	9.54	3.52	313.6	10.74	0.69	0.674	0.67
57	334.6	7.64	3.37	332.3	9	0.69	0.746	0.882
58	323.8	10.49	2.97	319.8	11.27	0.659	0.918	0.763
59	-99.9	-99.9	2.69	311.7	9.83	0.456	0.545	0.427
60	320.1	8.78	2.46	-99.9	-99.9	0.519	0.515	0.509
61	331.9	7.86	2.32	330	9.75	0.467	0.422	0.407
62	346.9	6.69	1.8	345.7	9.59	0.498	0.291	0.34
63	344.9	6.93	1.78	343	9.16	0.423	0.549	0.476
64	355.4	9.24	2.56	353.1	10.99	0.511	0.508	0.516
65	3.4	17.04	0.74	5.1	17	0.219	0.183	0.372
66	28.6	13.23	1.31	31.9	15.6	0.343	0.345	0.376
67	15	9.83	1.22	15.4	12.05	0.341	0.304	0.283
68	14.9	14.42	0.95	13.7	15.78	0.334	0.385	0.49
69	347.3	15.74	0.36	335.6	22.92	0.261	0.307	0.325

Cols:	51	53	55	57	59	61	63	65	67
Rows	10SigWSp	5SigWSp	2SigWSp	2meanBaro	2meanDew	50AirTemp	2AirTemp	80-50Delta	50-2Delta
1	0.656	0.625	0.688	999 *	48	48	48	14.5	14.5
2	0.486	0.479	0.509	741 *	-48	-48	-48	-4.5	-4.5
3	0.656 *	0.625 *	0.688 *	998	47.9	47.9	47.9	14.4	14.4
4	0.486 *	0.479 *	0.509 *	741.1	-47.9	-47.9	-47.9	-4.4	-4.4
5	0.656	0.625	0.688	999.1 *	48.1 *	48.1 *	48.1 *	14.6 *	14.6 *
6	0.486	0.479	0.509	740 *	-48.1 *	-48.1 *	-48.1 *	-4.6 *	-4.6 *
7	0.592	0.582	0.621	819.3	8.91	14.15	15.15	-0.219	-0.968
8	0.507	0.542	0.621	819.31	9.62	14.52	16.01	-0.216	-1.468
9	0.532	0.548	0.554	819.28	9.12	14.55	15.65	-0.216	-1.083
10	0.637	0.686	0.698	819.23	9.28	14.56	15.81	-0.244	-1.211
11	0.688	0.705	0.7	819.22	9.3	14.52	15.78	-0.249	-1.224
12	0.767	0.814	0.784	819.01	9.67	14.91	16.41	-0.302	-1.483
13	0.486	0.479	0.509	816.07	6.55	12.65	10.69	0.314	2.036
14	0.656	0.625	0.688	815.91	6.4	12.53	10.81	0.439 *	1.774
15	0.296	0.327	0.327	815.85	6.42	12.64 *	10.69	0.173 *	2.039 *
16	0.376	0.374	0.465	815.92	6.33	12.55 *	10.93	0.154 *	1.676 *
17	0.447	0.419	0.451	816.01	6.12 *	12.87	11.22 *	-0.029	1.699 *
18	0.373	0.371	0.257	816.06	6.08 *	12.96	11.38 *	-0.178 *	1.632 *
19	0.24	0.201	0.239	816.01	6.61 *	13.03 *	11.29 *	-0.216 *	1.791 *
20	0.29	0.191	0.165	816.06	7.43 *	12.94 *	10.96 *	-0.199 *	2.028 *
21	0.321	0.365	0.423	816.07	7.86	12.31	10.79	-0.172 *	1.562
22	0.505	0.517	0.494	816.08	7.72	11.94	10.89	-0.142 *	1.064
23	0.197	0.235	0.256	816.04	7.86	12.05 *	10.82	-0.227 *	1.269 *
24	0.222	0.234	0.276	816.07	7.91	12.09 *	10.7	-0.225 *	1.445 *
25	0.371	0.337	0.331	816.07	7.72	12.15 *	10.7	-0.196 *	1.5 *
26	0.351	0.34	0.365	816.04	7.6	12.09 *	10.63	-0.081 *	1.498 *
27	0.475	0.383	0.342	816.01	7.43 *	11.98	10.62 *	-0.237	1.391 *
28	0.444	0.389	0.414	816.03	7.4 *	11.46	10.7 *	0.04	0.794 *
29	0.294	0.303	0.297	816.08	7.59 *	11.47	10.14 *	-0.228 *	1.359 *
30	0.276	0.245	0.236	816.11	7.78 *	11.23	9.87 *	-0.106 *	1.398 *
31	0.266	0.244	0.243	816.07	8.07 *	10.81 *	9.81 *	0.205 *	1.036 *
32	0.239	0.219	0.211	816.08	8.14 *	10.83 *	9.87 *	0.233 *	0.992 *
33	0.171	0.192	0.197	816.15	8.07 *	10.98 *	9.9 *	0.08 *	1.125 *
34	0.883	0.806	0.689	816.2	7.95 *	10.88 *	10.06 *	-0.061 *	0.859 *
35	0.856	0.894	0.821	816.26	7.7	10.62	10.08	-0.296	0.577
36	0.439	0.432	0.424	816.34	7.75	10.18	9.93	-0.366	0.318
37	0.656	0.646	0.585	816.45	8	9.98	9.8	-0.345	0.23
38	0.282	0.311	0.342	816.47	8.28	9.94	9.7	-0.249	0.279
39	0.685	0.712	0.64	816.52	8.3	9.9	9.53	-0.13	0.393
40	0.596	0.686	0.669	816.61	8.36	9.72	9.45	-0.249	0.267
41	0	0	0	816.69	8.46	9.6	9.38	-0.207	0.266
42	0.17	0.096	0.157	816.75	8.67	9.75	9.41	-0.26	0.36
43	0.348	0.27	0.261	816.75	8.58	9.72	9.43	-0.191	0.298
44	0.208	0.222	0.256	816.8	8.68	9.73	9.4	-0.274	0.375
45	0.388	0.346	0.314	816.8	8.48	9.96	9.39	-0.232	0.611
46	0.362	0.368	0.362	816.83	8.44	10.05	9.52	-0.223	0.537
47	0.65	0.576	0.601	816.84	8.21	10.19	9.47	-0.221	0.756
48	0.494	0.438	0.461	816.89	7.67	10.3	9.49	-0.195	0.857
49	0.343	0.294	0.251	819.47	4.46	12.92	11.49	-0.211	1.447
50	0.326	0.28	0.274	819.5	4.42	12.74	11.34	-0.252	1.48
51	0.281	0.264	0.244	819.51	4.51	12.88	11.37	-0.271	1.562
52	-99.9	0.251	0.27	819.43	4.54	12.89	11.27	-0.211	1.669
53	0.272	-99.9	0.296	819.32	4.48	12.88	11.38	-0.129	1.54
54	0.468	0.478	-99.9	819.3	4.49	12.81	11.53	-0.124	1.337
55	0.656	0.559	0.594	819.3	4.67	12.81	11.77	-0.126	1.081
56	0.793	0.801	0.745	819.34	4.84	12.7	11.98	-0.179	0.781
57	0.912	0.753	0.748	819.3	5.04	12.65	11.9	-0.151	0.803
58	0.713	0.659	0.657	819.26	5.16	12.59	11.69	-0.128	0.949
59	0.402	0.414	0.42	819.28	5.22	12.55	11.62	-0.108	0.991
60	0.536	0.465	0.436	819.28	5.44	12.53	11.88	-0.149	0.706
61	0.337	0.35	0.359	-99.9 *	5.5	12.4	11.91	-0.091	0.539
62	0.433	0.401	0.365	819.36	-99.9 *	12.31	11.78	-0.166	0.583
63	0.43	0.416	0.434	819.41	5.87	-99.9 *	11.61	-0.057	0.865
64	0.514	0.454	0.472	819.44	5.84	12.38	-99.9 *	-0.213	0.643
65	0.369	0.331	0.321	819.81	6.14	11.55	10.64	-99.9 *	0.96
66	0.427	0.388	0.367	819.93	6.12	11.54	10.85	-0.316	-99.9 *
67	0.312	0.222	0.209	820.05	6.07	11.42	10.99	-0.304	0.473
68	0.442	0.344	0.326	820.08	6.11	11.25	11.02	-0.257	0.282
69	0.399	0.368	0.155	820.06	6.15	11.13	10.98	-0.238	0.205

Cols:	69	71	73	75	77	79	81	83	85	87
Rows	80MaxWSp	MxTim	80MaxWDir	50MaxWSp	MxTim	50MaxWDir	20MaxWSp	MxTim	20MaxWDir	10MaxWSp
1	5.05	2300	317.9	4.91	2300	310.9	3.7	2300	294.2	4.04
2	4.69	59	315.4	4.6	59	303.8	4.09	59	292.8	3.49
3	5.05 *	2259	317.9 *	4.91 *	2259	310.9 *	3.7 *	2259	294.2 *	4.04 *
4	4.69 *	58	315.4 *	4.6 *	58	303.8 *	4.09 *	58	292.8 *	3.49 *
5	5.05	2400 *	317.9	4.91	2400 *	310.9	3.7	2400 *	294.2	4.04
6	4.69	60 *	315.4	4.6	60 *	303.8	4.09	60 *	292.8	3.49
7	3.29	757	355.8	3.17	758	18.5	3.67	754	343.4	3.14
8	4.39	814	36.3	4.8	816	13.3	4.35	819	21.5	4.63
9	4.55	829	10.8	5.05	829	16.3	4.79	828	23.2	4.71
10	6.05	839	9.8	5.4	835	32.3	5.55	832	14.2	5.06
11	6.11	847	25.1	6.05	847	35.4	6.1	845	23.7	5.95
12	7.04	916	27.7	6.73	913	3	6.47	914	9.7	6.06
13	4.69	2	315.4	4.6	5	303.8	4.09	0	292.8	3.49
14	5.05	14	317.9	4.91	12	310.9	3.7	11	294.2	4.04
15	4.4	28	332.8	4.42	22	304.4	3.73	24	291.7	3.08
16	4.05	35	311.5	3.93	37	306	3.82	37	294.2	3.35
17	2.98	40	333.8	3.34	40	298.2	3.19	40	304.8	2.68
18	1.76	50	334.2	2.43	50	299.9	2.07	54	288.4	1.92
19	1.59	103	349.8	19.04	108	299.9	1.82	103	276.9	1.77
20	0.89	118	209.3	15.54	118	223.6	2.11	118	204.3	2.49
21	4.69	122	179.1	5.02	122	178.7	4.79	128	180.2	4.16
22	4.85	133	170.9	4.92	132	167.8	4.68	133	172.1	4.51
23	4.24	147	176.6	4.55	146	176.1	3.91	142	182.7	3.79
24	4.61	159	189.6	4.36	159	192.3	4.45	158	210.6	4.06
25	4.8	209	209.5	4.54	209	212	4.58	209	221.6	4.03
26	6.33	219	223.9	6.41	219	219.6	4.82	217	221.6	4.11
27	6.06	221	223.1	6.02	220	221.1	5.03	223	236.3	4.5
28	5.78	230	229.3	5.37	230	231.7	4.29	230	232.9	3.52
29	4.95	241	230.6	5.19	241	229.1	4.01	242	222.7	3.46
30	3.65	250	241.5	3.56	250	241.6	2.93	250	234	2.53
31	2.9	307	280.1	3.01	305	285.7	2.29	304	281.9	2.02
32	3.02	310	281.5	2.83	310	285	2.86	310	273.3	2.15
33	2.75	329	323.6	2.8	329	318.6	1.94	323	287.2	1.86
34	5.47	338	325.4	5.42	338	323.1	4.64	339	326.2	4.61
35	4.38	349	334.7	4.19	340	323.4	4.41	340	332	4.16
36	4.14	350	362.8	18.07	358	314	2.14	356	314.2	1.75
37	3.74	407	333.2	13.35	400	277.2	2.43	408	327.6	2.41
38	3.03	410	336.9	3.23	414	326.2	2.78	417	339.6	2.65
39	3.02	423	352.2	2.7	423	3.7	2.57	424	6.3	2.8
40	1.35	436	245.5	19.23	435	251.5	1.98	432	199	1.85
41	1.06	440	220.7	0.51	447	160.3	1.15	442	125.5	0.28
42	1.84	458	225.6	18.2	455	221.6	1.22	459	208.6	1.12
43	2.88	508	211.3	2.97	509	211.4	2.66	509	220.4	2.33
44	2.97	519	216	3.23	516	224.4	3.07	516	217.9	2.72
45	4.9	528	203	4.38	528	206.1	3.29	523	203.2	3.23
46	5.53	539	210.2	4.94	539	209.9	4.39	539	205.7	3.72
47	7.97	549	184.3	7.63	549	183.4	6.13	548	196.6	5.39
48	7.22	554	195.7	6.75	550	185.7	6.08	550	185.3	5.56
49	-99.9	-99 *	4.2	5.4	0	336	4.82	1	322.6	4.03
50	5.63	13	346.8	-99.9	-99 *	330.7	4.51	16	332	4.02
51	5.36	27	347.8	5.06	26	322.9	-99.9	-99 *	319.5	3.41
52	5.34	36	326.6	5.29	36	312.9	4.35	38	302.2	-99.9
53	6.52	48	333.4	6.61	49	315.3	4.8	48	309.9	3.74
54	7.69	52	335	7.75	55	318	5.77	56	305	5.02
55	8.36	-99 *	-99.9	7.96	109	323.6	6.76	109	318.2	6.62
56	9.18	117	354.6	8.49	-99 *	-99.9	7.7	115	308.9	6.7
57	8.73	120	342.8	8.41	125	337.4	7.86	-99 *	-99.9	6.7
58	8.51	130	345.3	8.13	131	338.5	7.17	131	336.9	6.45
59	7.38	142	342.6	6.62	140	328.6	5.89	140	330.8	4.57
60	6.79	154	331.5	6.44	159	322.1	5.66	159	313.8	5.16
61	6.74	204	354.3	6.05	203	334.6	4.89	205	334.1	4.2
62	6.01	219	358.6	4.88	210	339.9	4.17	210	339.2	3.83
63	7.3	230	359.8	6.53	230	345.5	5.36	228	345.8	4.31
64	7.65	231	9.1	7.31	238	0.8	6.29	231	348.1	5.75
65	4.48	337	2.7	4.11	337	-25.5	3.38	337	-0.3	2.63
66	5.35	343	3.9	5.37	345	-2	4.54	346	8.5	3.58
67	4.78	350	6.8	4.48	350	1.4	3.59	351	13.5	3.21
68	4.44	405	7.3	3.79	407	18.6	3.18	400	347.2	2.6
69	3.6	413	3.5	3.06	417	1.4	2.42	417	346.2	2.04

Cols:	89	91	93	95	97	99	101	103	105	107
Rows	MxTim	10MaxWDir	5MaxWSp	MxTim	5MaxWDir	2MaxWSp	MxTim	2MaxWDir	2MaxBaro	BTime
1	2300	293.3	3.81	2300	293.7	3.25	2300	284.7	999 *	2300
2	59	286.4	3.42	59	311	3.19	59	308.4	741 *	59
3	2259	293.3 *	3.81 *	2259	293.7 *	3.25 *	2259	284.7 *	998	2259
4	58	286.4 *	3.42 *	58	311 *	3.19 *	58	308.4 *	741.1	58
5	2400 *	293.3	3.81	2400 *	293.7	3.25	2400 *	284.7	999.1 *	2400 *
6	60 *	286.4	3.42	60 *	311	3.19	60 *	308.4	740 *	60 *
7	757	353.4	3.06	757	354.7	2.78	757	353.7	819.44	756
8	820	13.7	4.07	815	43.6	3.92	812	31	819.44	810
9	828	20.1	4.63	828	22.3	4.31	826	27.6	819.44	821
10	837	39.3	5.55	836	24.6	4.94	836	17.3	819.38	831
11	847	28.2	5.69	840	25.6	5.56	840	31.4	819.38	844
12	913	12.3	6.1	915	10.4	5.62	915	15.4	819.13	910
13	0	286.4	3.42	0	311	3.19	0	308.4	816.24	0
14	11	293.3	3.81	11	293.7	3.25	11	284.7	816.1	10
15	21	290.3	3.01	21	284.1	2.57	29	280.5	815.99	28
16	37	280.7	2.86	37	285.3	2.74	37	276.6	816.1	34
17	42	280.6	2.5	40	301.4	2.34	40	295.2	816.21	48
18	52	281.4	1.75	52	281.1	1.44	52	285.5	816.19	55
19	105	265.9	1.56	104	260	1.38	104	251.7	816.16	100
20	119	197.7	2.36	120	194.8	1.71	114	214.7	816.22	111
21	129	178.6	3.97	129	185.1	3.52	129	183	816.21	125
22	133	174.3	4.46	133	177.5	4.12	133	172.6	816.27	135
23	142	182	3.41	142	182.4	3.11	142	190.3	816.22	146
24	158	211	3.59	159	220	3.06	159	221.8	816.19	151
25	201	216.3	3.59	204	223.9	3.38	209	228	816.22	200
26	217	234.6	3.62	217	222.6	3.37	215	215.1	816.19	216
27	229	226.7	3.79	229	245.1	3.3	225	256.8	816.16	222
28	230	234.3	3.26	230	218.8	3.2	230	225	816.21	239
29	242	214.7	3.16	243	223.4	2.93	248	221.5	816.25	247
30	250	245.5	1.97	259	275.3	1.78	258	269	816.25	253
31	304	294.6	1.85	300	297.1	1.78	302	314.7	816.24	309
32	311	278.2	1.93	311	265.4	1.62	317	296.1	816.24	317
33	323	288	1.79	321	282.6	1.62	324	291.5	816.35	329
34	339	339.2	4.2	339	342.5	3.87	339	335.8	816.35	335
35	340	338.2	3.75	340	348.2	3.24	340	344.3	816.49	345
36	354	247.8	1.65	354	258.9	1.69	354	233	816.52	358
37	408	331.8	2.49	408	341	2.2	408	336.3	816.63	405
38	417	340.8	2.86	412	304	2.93	412	307.6	816.63	417
39	421	27.4	2.63	420	18.8	2.3	420	18.1	816.71	421
40	432	197.4	1.94	432	195.9	1.95	432	196.7	816.77	439
41	440	161	0.24	440	162.3	0.28	440	170.4	816.88	447
42	459	214	1.07	459	213.8	0.86	500	208.9	816.88	451
43	509	197.6	2.03	509	216.5	1.9	509	205.9	816.94	503
44	516	224.3	2.52	510	205.1	2.29	510	203.9	816.94	510
45	529	194.8	2.8	529	205.6	2.41	529	210.8	816.94	521
46	539	206	3.69	539	218.4	3.15	539	218.1	816.96	536
47	549	199.9	4.9	549	202.8	4.78	549	207	817.01	545
48	552	196.8	4.98	558	187.5	4.38	553	189.5	817.05	559
49	1	330.1	3.06	1	326.1	2.42	4	318.2	819.63	0
50	19	317.3	3.11	19	305.5	2.31	17	336.2	819.65	15
51	29	313.3	2.97	29	300.2	2.4	23	312.6	819.65	20
52	-99 *	301.4	3.42	38	295.2	3.13	38	305.7	819.65	32
53	44	301.5	-99.9	-99 *	301.4	2.85	48	299.2	819.46	49
54	56	305.2	4.6	57	319.3	-99.9	-99 *	309.4	819.43	50
55	109	317.1	6.22	109	319.7	5.59	109	315.2	819.46	104
56	113	317.6	6.37	117	308.8	6	116	320.6	819.51	119
57	125	335.4	6.11	125	345.4	5.44	125	343.8	819.44	125
58	-99 *	-99.9	6.52	133	333.1	5.72	133	332.7	819.41	132
59	141	328.2	4.31	-99 *	-99.9	3.82	140	315.1	819.44	149
60	156	322	4.22	156	313.5	3.62	-99 *	-99.9	819.44	158
61	205	328.6	3.78	202	320.4	3.36	203	319	-99.9 *	-99 *
62	211	342.5	3.2	211	344.4	2.67	211	344.6	819.52	214
63	229	339	3.55	229	337.2	2.95	229	346.9	819.57	228
64	231	354.8	4.5	233	349	4.11	233	357.8	819.63	235
65	337	1.1	2.41	337	1.3	1.56	336	12.4	820	339
66	347	21.4	3.02	347	21.5	2.25	349	40.1	820.08	345
67	351	5.9	2.39	354	16.5	1.82	352	350.5	820.22	357
68	400	17.3	2.43	402	24.9	1.9	402	21.1	820.22	402
69	418	347	1.55	419	341.7	0.94	419	340.6	820.22	411

Cols:	109	111	113	115	117	119	121	123	125	127
Rows	2MaxDewPt	DTime	2MxAirTemp	ATime	2MinBaro	BTTime	2MinDewPt	DTime	2MinAirTemp	ATime
1	48	2300	-99.9 *	-99 *	999 *	2300	48	2300	-99.9 *	-99 *
2	-48	59	-99.9 *	-99 *	741 *	59	-48	59	-99.9 *	-99 *
3	47.9	2259	-99.9 *	-99 *	998	2259	47.9	2259	-99.9 *	-99 *
4	-47.9	58	-99.9 *	-99 *	741.1	58	-47.9	58	-99.9 *	-99 *
5	48.1 *	2400 *	-99.9 *	-99 *	999.1 *	2400 *	48.1 *	2400 *	-99.9 *	-99 *
6	-48.1 *	60 *	-99.9 *	-99 *	740 *	60 *	-48.1 *	60 *	-99.9 *	-99 *
7	9.35	752	-99.9 *	-99 *	819.1	751	8.41	756	-99.9 *	-99 *
8	10.61	815	-99.9 *	-99 *	819.1	819	8.89	818	-99.9 *	-99 *
9	9.84	820	-99.9 *	-99 *	819.1	827	8.61	827	-99.9 *	-99 *
10	9.57	832	-99.9 *	-99 *	819.02	840	8.97	839	-99.9 *	-99 *
11	9.56	848	-99.9 *	-99 *	819.02	843	9.03	845	-99.9 *	-99 *
12	10.13	912	-99.9 *	-99 *	818.82	919	9.11	910	-99.9 *	-99 *
13	6.8	2	-99.9 *	-99 *	815.82	8	6.15	0	-99.9 *	-99 *
14	6.59	10	-99.9 *	-99 *	815.68	17	6.23	14	-99.9 *	-99 *
15	6.53	23	-99.9 *	-99 *	815.6	24	6.29	29	-99.9 *	-99 *
16	6.53	37	-99.9 *	-99 *	815.68	31	6.23	39	-99.9 *	-99 *
17	6.39 *	45	-99.9 *	-99 *	815.74	42	5.94 *	48	-99.9 *	-99 *
18	6.19 *	50	-99.9 *	-99 *	815.88	54	5.9 *	59	-99.9 *	-99 *
19	7.57 *	104	-99.9 *	-99 *	815.83	104	5.9 *	100	-99.9 *	-99 *
20	7.95 *	119	-99.9 *	-99 *	815.86	116	6.33 *	110	-99.9 *	-99 *
21	8.13	124	-99.9 *	-99 *	815.86	120	7.48	127	-99.9 *	-99 *
22	7.99	134	-99.9 *	-99 *	815.91	139	7.59	130	-99.9 *	-99 *
23	8.08	147	-99.9 *	-99 *	815.88	142	7.61	144	-99.9 *	-99 *
24	8.05	156	-99.9 *	-99 *	815.88	150	7.71	158	-99.9 *	-99 *
25	8	205	-99.9 *	-99 *	815.88	209	7.45	209	-99.9 *	-99 *
26	7.68	213	-99.9 *	-99 *	815.88	212	7.47	210	-99.9 *	-99 *
27	7.57 *	220	-99.9 *	-99 *	815.82	220	7.3 *	228	-99.9 *	-99 *
28	7.56 *	237	-99.9 *	-99 *	815.82	230	7.21 *	239	-99.9 *	-99 *
29	7.71 *	242	-99.9 *	-99 *	815.96	240	7.32 *	240	-99.9 *	-99 *
30	7.94 *	256	-99.9 *	-99 *	815.93	252	7.56 *	250	-99.9 *	-99 *
31	8.18 *	303	-99.9 *	-99 *	815.88	305	7.91 *	300	-99.9 *	-99 *
32	8.29 *	313	-99.9 *	-99 *	815.88	310	8.02 *	318	-99.9 *	-99 *
33	8.19 *	324	-99.9 *	-99 *	815.96	320	7.9 *	329	-99.9 *	-99 *
34	8.2 *	333	-99.9 *	-99 *	816.02	338	7.68 *	338	-99.9 *	-99 *
35	7.81	340	-99.9 *	-99 *	816.08	341	7.53	343	-99.9 *	-99 *
36	7.87	358	-99.9 *	-99 *	816.11	350	7.56	353	-99.9 *	-99 *
37	8.42	405	-99.9 *	-99 *	816.27	408	7.67	400	-99.9 *	-99 *
38	8.47	418	-99.9 *	-99 *	816.27	411	8.07	410	-99.9 *	-99 *
39	8.48	427	-99.9 *	-99 *	816.37	423	8.12	423	-99.9 *	-99 *
40	8.58	432	-99.9 *	-99 *	816.46	430	8.19	435	-99.9 *	-99 *
41	8.6	449	-99.9 *	-99 *	816.44	440	8.39	440	-99.9 *	-99 *
42	8.87	458	-99.9 *	-99 *	816.58	450	8.42	455	-99.9 *	-99 *
43	8.85	509	-99.9 *	-99 *	816.52	501	8.19	501	-99.9 *	-99 *
44	8.87	510	-99.9 *	-99 *	816.66	510	8.46	512	-99.9 *	-99 *
45	8.52	520	-99.9 *	-99 *	816.58	529	8.45	525	-99.9 *	-99 *
46	8.59	539	-99.9 *	-99 *	816.66	530	8.39	532	-99.9 *	-99 *
47	8.59	540	-99.9 *	-99 *	816.63	544	7.88	549	-99.9 *	-99 *
48	7.88	550	-99.9 *	-99 *	816.69	550	7.56	552	-99.9 *	-99 *
49	4.54	1	-99.9 *	-99 *	819.32	0	4.35	7	-99.9 *	-99 *
50	4.51	19	-99.9 *	-99 *	819.35	10	4.29	15	-99.9 *	-99 *
51	4.6	23	-99.9 *	-99 *	819.32	28	4.4	29	-99.9 *	-99 *
52	4.63	34	-99.9 *	-99 *	819.18	36	4.4	30	-99.9 *	-99 *
53	4.51	42	-99.9 *	-99 *	819.15	44	4.44	48	-99.9 *	-99 *
54	4.56	59	-99.9 *	-99 *	819.13	58	4.4	52	-99.9 *	-99 *
55	4.75	102	-99.9 *	-99 *	819.13	106	4.52	100	-99.9 *	-99 *
56	4.97	119	-99.9 *	-99 *	819.15	110	4.73	110	-99.9 *	-99 *
57	5.2	128	-99.9 *	-99 *	819.05	126	4.96	122	-99.9 *	-99 *
58	5.24	136	-99.9 *	-99 *	819.08	133	5.08	133	-99.9 *	-99 *
59	5.34	145	-99.9 *	-99 *	819.08	141	5.14	140	-99.9 *	-99 *
60	5.57	153	-99.9 *	-99 *	819.08	153	5.31	150	-99.9 *	-99 *
61	5.59	202	-99.9 *	-99 *	-99.9 *	-99 *	5.44	200	-99.9 *	-99 *
62	-99.9 *	-99 *	-99.9 *	-99 *	819.15	219	-99.9 *	-99 *	-99.9 *	-99 *
63	6.07	220	-99.9 *	-99 *	819.15	223	5.71	223	-99.9 *	-99 *
64	6	230	-99.9 *	-99 *	819.29	232	5.51	239	-99.9 *	-99 *
65	6.25	339	-99.9 *	-99 *	819.63	332	6.06	334	-99.9 *	-99 *
66	6.26	340	-99.9 *	-99 *	819.72	340	6	349	-99.9 *	-99 *
67	6.15	351	-99.9 *	-99 *	819.83	350	6	350	-99.9 *	-99 *
68	6.27	408	-99.9 *	-99 *	819.86	400	5.93	409	-99.9 *	-99 *
69	6.35	412	-99.9 *	-99 *	819.88	412	5.91	410	-99.9 *	-99 *

Cols:	129	131	as	pi	ra	tr	21x	137	139	141	143	145	147
Rows	Insolation	Precip		80	50	2	St	80Turbulen	50Turbulen	20Turbulen	10Turbulen	5Turbulen	2Turbulen
1	42000	500		T	T	T	T	0.176	0.162	0.245	0.319	0.337	0.435
2	0	0		T	T	T	T	0.143	0.07	0.214	0.236	0.272	0.339
3	41999	499		T	T	T	T	0.176 *	0.162 *	0.245 *	0.319 *	0.337 *	0.435 *
4	1	1		T	T	T	T	0.143 *	0.07 *	0.214 *	0.236 *	0.272 *	0.339 *
5	42001 *	501 *		T	T	T	T	0.176	0.162	0.245	0.319	0.337	0.435
6	-1 *	-1 *		T	T	T	T	0.143	0.07	0.214	0.236	0.272	0.339
7	2003.9	0		T	T	T	T	0.162	0.167	0.228	0.294	0.295	0.364
8	2783.5	0		T	T	T	T	0.156	0.155	0.154	0.165	0.185	0.239
9	3187.8	0		T	T	T	T	0.175	0.179	0.154	0.16	0.172	0.193
10	3587.7	0		T	T	T	T	0.158	0.14	0.138	0.174	0.2	0.228
11	4030.8	0		T	T	T	T	0.131	0.125	0.141	0.161	0.174	0.193
12	5429.9	0		T	T	T	T	0.143	0.162	0.172	0.189	0.211	0.228
13	0	0		T	T	T	T	0.143	0.07	0.214	0.236	0.272	0.339
14	0	0		F	T	T	T	0.176	0.162	0.245	0.319	0.337	0.435
15	0	0		T	F	T	T	0.144	0.1	0.151	0.136	0.168	0.211
16	0	0		F	F	T	T	0.192	0.122	0.166	0.177	0.202	0.297
17	0	0		T	T	F	T	0.195	0.16	0.203	0.267	0.277	0.365
18	0	0		F	T	F	T	0.237	0.147	0.196	0.34	0.386	0.312
19	0	0		T	F	F	T	0.326	1.12	0.121	0.185	0.174	0.252
20	0	0		F	F	F	T	0.367	0.771	0.184	0.15	0.104	0.116
21	0	0		F	T	T	T	0.34	0.244	0.121	0.094	0.12	0.163
22	0	0		F	T	T	T	0.107	0.071	0.121	0.146	0.167	0.186
23	0	0		T	F	T	T	0.073	0.041	0.049	0.063	0.088	0.116
24	0	0		T	F	T	T	0.026	0.023	0.06	0.063	0.081	0.115
25	0	0		F	F	T	T	0.032	0.026	0.073	0.111	0.119	0.134
26	0	0		F	F	T	T	0.11	0.085	0.091	0.113	0.125	0.156
27	0	0		T	T	F	T	0.054	0.05	0.137	0.155	0.144	0.144
28	0	0		T	T	F	T	0.076	0.15	0.207	0.193	0.189	0.233
29	0	0.25		F	T	F	T	0.083	0.138	0.112	0.112	0.127	0.137
30	0	0.25		F	T	F	T	0.138	0.13	0.127	0.167	0.167	0.194
31	0	0.25		T	F	F	T	0.098	0.061	0.139	0.172	0.166	0.192
32	0	0.25		T	F	F	T	0.192	0.131	0.16	0.154	0.155	0.174
33	0	0.25		F	F	F	T	0.18	0.135	0.134	0.12	0.14	0.164
34	0	0.25		F	F	F	T	0.355	0.252	0.347	0.4	0.419	0.439
35	0	0.25		T	T	T	T	0.168	0.247	0.369	0.473	0.607	0.743
36	0	0.25		T	T	T	T	0.397	0.888	0.398	0.581	0.637	0.667
37	0	0.25		T	T	T	T	0.39	0.862	0.484	0.533	0.553	0.568
38	0	0.25		T	T	T	T	0.138	0.127	0.121	0.138	0.162	0.206
39	0	0.25		T	T	T	T	0.245	0.294	0.293	0.37	0.407	0.453
40	0	0.51		T	T	T	T	0.505	2.394	0.672	0.682	0.75	0.717
41	0	0.51		T	T	T	T	0.561	0.05	0.305	0	0	0
42	0	0.51		T	T	T	T	0.267	1.073	0.492	0.471	0.383	0.417
43	0.1	0.51		T	T	T	T	0.209	0.291	0.283	0.262	0.216	0.243
44	2.1	0.51		T	T	T	T	0.14	0.1	0.084	0.094	0.11	0.146
45	3.1	0.51		T	T	T	T	0.148	0.161	0.123	0.18	0.184	0.204
46	3.9	0.51		T	T	T	T	0.104	0.108	0.116	0.136	0.157	0.185
47	12.9	0.51		T	T	T	T	0.123	0.151	0.166	0.171	0.17	0.199
48	18.6	0.51		T	T	T	T	0.105	0.096	0.125	0.119	0.119	0.143
49	0	0		T	T	T	T	-99.9 *	0.098	0.11	0.13	0.14	0.153
50	0	0		T	T	T	T	0.094	-99.9 *	0.097	0.122	0.136	0.174
51	0	0		T	T	T	T	0.081	0.072	-99.9 *	0.106	0.125	0.146
52	0	0		T	T	T	T	0.051	0.055	0.057	-99.9 *	0.097	0.121
53	0	0		T	T	T	T	0.085	0.082	0.072	0.088	-99.9 *	0.139
54	0	0		T	T	T	T	0.085	0.089	0.09	0.126	0.153	-99.9 *
55	0	0		T	T	T	T	0.092	0.093	0.13	0.161	0.16	0.195
56	0	0		T	T	T	T	0.096	0.103	0.123	0.168	0.199	0.212
57	0	0		T	T	T	T	0.096	0.116	0.166	0.205	0.193	0.222
58	0	0		T	T	T	T	0.095	0.149	0.155	0.173	0.187	0.221
59	0	0		T	T	T	T	0.075	0.1	0.101	0.111	0.133	0.156
60	0	0		T	T	T	T	0.093	0.104	0.123	0.154	0.157	0.177
61	0	0		T	T	T	T	0.082	0.087	0.103	0.101	0.125	0.155
62	0	0		T	T	T	T	0.105	0.072	0.101	0.146	0.166	0.203
63	0	0		T	T	T	T	0.071	0.11	0.128	0.144	0.178	0.243
64	0	0		T	T	T	T	0.077	0.086	0.109	0.13	0.142	0.184
65	0	0		T	T	T	T	0.057	0.049	0.143	0.216	0.261	0.437
66	0	0		T	T	T	T	0.082	0.086	0.118	0.182	0.219	0.28
67	-99.9 *	0		T	T	T	T	0.089	0.084	0.104	0.147	0.133	0.172
68	0	-99.9 *		T	T	T	T	0.1	0.128	0.242	0.277	0.248	0.345
69	0	0		T	T	T	T	0.09	0.127	0.226	0.427	0.658	0.437



Cols:	149	151	153	155	157	159	161	163	164
Rows	RIHumidity	2-50Rich	50-80Rich	2-80Rich	Ustar	SurfRough	UstarR^2	2-80PrCoef	
1	100 *	3.813 *	10 *	7.697 *	0.261	0.309	0.926	0.182	
2	100 *	-0.993 *	-10 *	-2.442 *	0.336	0.591	0.937	0.176	
3	100	3.79 *	10 *	7.65 *	0.261 *	0.309 *	0.926	0.182 *	
4	100	-0.967 *	-10 *	-2.381 *	0.336 *	0.591 *	0.937	0.176 *	
5	100 *	3.837 *	10 *	7.745 *	0.261	0.309	0.926	0.182	
6	100 *	-1.018 *	-10 *	-2.504 *	0.336	0.591	0.937	0.176	
7	66.3	-0.47	10	-0.28	0.058	-99.9	0.965	0.064	
8	65.8	-0.473	7.29	-0.34	0.093	-99.9	0.978	0.047	
9	65.1	-0.399	10	-0.253	0.094	-99.9	0.948	0.029	
10	65.1	-0.219	10	-0.15	0.111	-99.9	0.963	0.072	
11	65.4	-0.2	7.733	-0.145	0.121	-99.9	0.963	0.048	
12	64.4	-0.226	-1.553	-0.175	0.157	-99.9	0.997	0.088	
13	75.6	0.482	2.116	0.61	0.336	0.591	0.937	0.176	
14	74.2	0.659	10 *	0.801 *	0.261	0.309	0.926	0.182	
15	74.8	0.455 *	9.296 *	0.489 *	0.253	0.239	0.97	0.172	
16	73.2	0.602 *	5 *	0.695 *	0.18	0.075	0.992	0.115	
17	70.8 *	0.778 *	0.595 *	0.952 *	0.158	0.107	0.988	0.036	
18	69.8 *	1.769 *	0.498 *	2.034 *	0.118	0.168	0.977	0.038	
19	72.9 *	2.027 *	0.261 *	2.399 *	0.089	0.028	1	-0.101	
20	78.8 *	2.794 *	0.158 *	4.243 *	0.138	0.031	0.968	-0.563	
21	82.1	0.374	0.308 *	0.383 *	0.191	0.009	0.999	0.007	
22	80.7	0.252	2.076 *	0.245 *	0.194	0.008	1	0.086	
23	81.9	0.215 *	0.74 *	0.191 *	0.244	0.059	0.998	0.125	
24	82.9	0.194 *	8.02 *	0.157 *	0.217	0.021	0.967	0.149	
25	81.8	0.252 *	5.225 *	0.206 *	0.232	0.031	0.977	0.157	
26	81.5	0.224 *	10 *	0.206 *	0.346	0.194	0.974	0.188	
27	80.6 *	0.237 *	10 *	0.197 *	0.413	0.357	0.942	0.199	
28	80 *	0.315 *	0.325 *	0.26 *	0.349	0.52	0.936	0.284	
29	84.2 *	0.528 *	10 *	0.428 *	0.246	0.096	0.97	0.16	
30	86.8 *	0.664 *	10 *	0.617 *	0.198	0.255	0.965	0.189	
31	88.9 *	0.979 *	10 *	1.314 *	0.177	0.203	0.923	0.129	
32	89 *	0.969 *	10 *	1.228 *	0.13	0.065	0.974	0.139	
33	88.4 *	2.481 *	10 *	2.702 *	0.089	0.013	0.924	0.099	
34	86.7 *	0.294 *	10 *	0.299 *	0.194	0.091	0.993	0.163	
35	85.1	0.21	-0.007	0.145	0.21	0.293	0.993	0.283	
36	86.3	1.377	-0.901	0.732	0.152	0.782	0.948	0.303	
37	88.5	1.276	-0.214	0.6	0.132	0.184	0.911	0.226	
38	90.8	0.562	1.316	0.436	0.078	-99.9	0.985	0.107	
39	92.1	0.502	10	0.49	0.068	-99.9	0.912	0.095	
40	92.9	10	3.58	10	-99.9	-99.9	0.912	-0.132	
41	94	10	2.427	10	0.038	0.572	0.579	0.247	
42	95.1	10	0.146	10	0.126	-99.9	0.84	0.412	
43	94.4	0.787	10	0.726	0.108	0.053	0.977	0.15	
44	95.3	0.396	0.182	0.371	0.112	0.004	0.971	0.037	
45	94	0.253	0.337	0.19	0.202	0.117	0.991	0.223	
46	93	0.18	0.391	0.14	0.254	0.126	0.985	0.209	
47	91.8	0.174	0.113	0.124	0.349	0.101	0.97	0.2	
48	88.4	0.153	0.649	0.123	0.299	0.034	0.992	0.161	
49	61.9	-99.9	-99.9	-99.9	0.36	0.426	0.986	0.312	
50	62.4	-99.9	-99.9	-99.9	-99.9 *	11.566 *	-0.422 *	0.333	
51	62.7	-99.9	-99.9	-99.9	-99.9 *	13.521 *	-0.096 *	0.26	
52	63.2	-99.9	-99.9	-99.9	83.466 *	15.1 *	0.145 *	0.166	
53	62.5	-99.9	-99.9	-99.9	31.161 *	16.813 *	0.389 *	0.236	
54	61.9	-99.9	-99.9	-99.9	17.327	18.977	0.706	0.243	
55	61.7	0.118	0.533	0.098	0.422	0.162	0.986	0.214	
56	61.6	0.082	0.332	0.067	0.413	0.089	0.991	0.195	
57	62.8	0.087	0.259	0.071	0.429	0.122	0.987	0.21	
58	64.2	0.09	0.273	0.074	0.45	0.202	0.986	0.234	
59	64.8	0.144	0.489	0.12	0.391	0.194	0.979	0.222	
60	64.6	0.102	0.4	0.086	0.344	0.148	0.992	0.226	
61	64.8 *	-99.9 *	-99.9 *	-99.9 *	0.371	0.228	0.984	0.256	
62	-99.9 *	0.085 *	0.296 *	0.071 *	0.311	0.222	0.993	0.266	
63	67.8	0.082	0.261 *	0.071 *	0.469	0.635	0.982	0.333	
64	-99.9 *	-99.9 *	-99.9	-99.9 *	0.452	0.266	0.993	0.259	
65	73.7	-99.9	-99.9 *	-99.9 *	0.376	1.205	0.988	0.423	
66	72.6	-99.9 *	-99.9	-99.9 *	0.341	0.528	0.992	0.301	
67	71.6	0.098	-0.229	0.072	0.305	0.512	0.993	0.297	
68	71.7	0.124	0.314	0.096	0.276	0.728	0.979	0.325	
69	72.1	0.152	0.236	0.117	0.304	2.141	0.971	0.564	

## **APPENDIX D**

### **Software Requirements Document**

## **Appendix D – Software Requirements Document**

# **Design Requirements for Processing of NREL/NWTC 80-Meter Meteorological Tower Data**

**N.D. Kelley**

### **Background**

The National Wind Technology Center (NWTC) of the National Renewable Energy Laboratory (NREL) operates two 80-meter (m) meteorological towers at its site on a plateau 13 kilometers south of Boulder, Colorado. The NWTC site is unique in that the wind environment is strongly influenced by the terrain upwind of the site – mountainous to the west and low, rolling hills to the east. Such conditions are ideal for the testing of wind turbines because the turbulence characteristics associated with westerly and easterly flows are structurally much different. Two meteorological towers have been installed near the western and eastern boundaries of the NWTC site. Measurements made from these towers will be used to develop a climatological database of the conditions seen in the first 80 m of the atmospheric boundary layer in which the wind turbines under test reside.

### **Instrumentation and Data Acquisition**

The orientation of the wind measuring instrumentation on the West Tower (M2) is optimized for westerly flows and the prevailing site wind direction of 292° w.r.t. true north (west-northwest) in particular. The East Tower (M3) is located on the eastern perimeter of the site and has its wind measuring instrumentation oriented directly towards the east (090°). The purpose of these specific orientations is to minimize the influence of the supporting tower structure. The wind speed and direction are measured by cup anemometers and wind vanes at six, logarithmically spaced elevations (2, 5, 10, 20, 50, and 80 m) on each of the towers. Dry-bulb and dew point temperatures are measured within fan-aspirated radiation shields along with the barometric pressure at an elevation of 2 m. The difference in temperatures between the elevations of 2 and 50 m and 50 and 80 m as well as the air temperature at a height of 50 m are also measured. The West or M2 Tower, in addition to the above, also includes ground-based instruments to measure incoming total global solar radiation (insolation) and the depth of liquid precipitation.

The measurements from each tower are recorded using a Campbell Scientific 21X data logger. The 21X logger is a programmable, microprocessor-based device that interfaces with a range of electrical signal types, applies scale factors online, and uses the scaled information to calculate various statistics of these signals and to derive new ones. Readings from the tower instrumentation are collected at a rate of once per second. The fundamental recording period is 10 minutes. At the end of a 10-minute period, the means, standard deviations, and extreme values and time of occurrence are calculated, annotated with the Julian Date and local standard time, and written to an external nonvolatile storage device. The global solar radiation or insolation and the liquid precipitation are integrated or totaled over a 24-hour period that is reset at midnight. The

majority of the measurements connected to the 21X logger present a dc voltage, however, the cup anemometers output a string of pulses whose frequency is proportional to the wind speed. A reed switch in the rain gauge momentarily closes for each 0.01 inch (0.25 mm) of liquid precipitation passing through. Frequency counters incorporated within the 21X are used to summarize these pulses over one second to which the appropriate frequency-to-speed scaling factor is then applied.

Typically, a week's data is stored in the external memory device before it is transferred to a read/write disk storage media as well as uploaded on to the disk array of the NWTC UNIX computer system. The data transfer is usually performed on Monday mornings unless that day is a holiday or the effort is weather impacted. During the time the collected data is being transferred from the external storage device, the system is placed into a calibration mode of operation. While in this mode, the internal clock of the 21X logger is checked, and the signal translators for the dry-bulb temperature, temperature differences, dewpoint temperature, and wind direction measurements are checked and adjusted to specification if necessary.

One of the signals connected to the data logger is a sine wave that is derived from the power line frequency. This signal is used to indicate the source of the electrical power (grid or local backup generator) or if the system is in the calibration mode. In normal operation, during which power is supplied by the commercial grid, the measured frequency is twice the nominal power line frequency, or about 120 Hz. During the calibration mode, the frequency measured will be the nominal line frequency of 60 Hz. A zero frequency will be measured when the system is being powered by either an uninterruptible power supply (UPS) or a local backup generator.

During the time when the earliest records were collected, the backup generators were not available or only available on an intermittent basis. The purpose of the UPS is to provide clean power during electrical buss transfers associated with the backup generator engaging or disengaging after a grid failure or interruption. The UPS does not have sufficient capacity to provide all of the necessary power. Initially, some loads, such as the aspirator fan motors and resistive heating elements, were left without power during a grid outage, as a result only those measurements of barometric pressure and wind speed and direction were accurate. While all the affected signals continued to be recorded, their accuracy was often diminished or at least unreliable; a fact which needs to be indicated in the final, archival data sets. The power transfer systems were rewired and the backup generators made much more reliable after a period of about a year. However, construction at the NWTC and interruptions of the commercial power grid often resulted in extended power outages in which data was occasionally lost.

Another signal is used to indicate the operational status of the three fan-ventilated aspirator radiation shields at the 2-, 50-, and 80-meter tower levels. The operational status of each of the aspirators is communicated through the value of a dc voltage, whose overall range is 0 to 5 Vdc.

## **Program Objectives**

The overall objective of this software development activity is to provide a processing path from raw, scaled measurements to the constituents of a database of meteorological parameters that describe the meteorological environment associated with wind turbine testing at the NWTC. Specific objectives of the software routines to be developed include:

- 1) Reading the raw data records recorded by the Campbell Scientific data loggers.
- 2) Providing a means to signal the processing programs that a particular parameter or group of parameters in the input record is either missing or faulty and not to be used. Flag such data by

replacing the input value with the constant -99.9.

- 3) Applying specified actions based on the particular tower (M2 or M3) and the date the information was recorded.
- 4) Applying a series of reasonableness tests to specific input parameters to aid in establishing their validity for subsequent processing and archival by means of setting a data quality (QC) flag for each required parameter.
- 5) Computing a number of specified derived parameters from particular values contained in the original, raw data record. If any of the independent variables used in these derived calculations are missing (-99.9 value) or considered questionable (QC flag on), the resulting derived quantities shall be so identified.
- 6) Storing the final, processed 10-minute record in the specified format (validated parameters plus derived quantities) as a disk file available for archival and further processing by both the Unix system and as an exported file to PC computers.
- 7) Summarizing specified parameters (original and derived) in individual 10-minute records into hourly (6), daily (144), and monthly (4032 for 28 days to 4464 for 31 days) logs and placing them in corresponding disk files.
- 8) Automating the process using a FORTRAN main program or a UNIX shell or *Perl* script that can be operated by an NWTC meteorological technician.
- 9) In developing the program, source code documentation as practiced by the NWTC shall be and a report describing the code and its operation shall be furnished at the conclusion of the project.

The proposed process is schematically diagrammed in the following flowchart shown in Figure D-1.

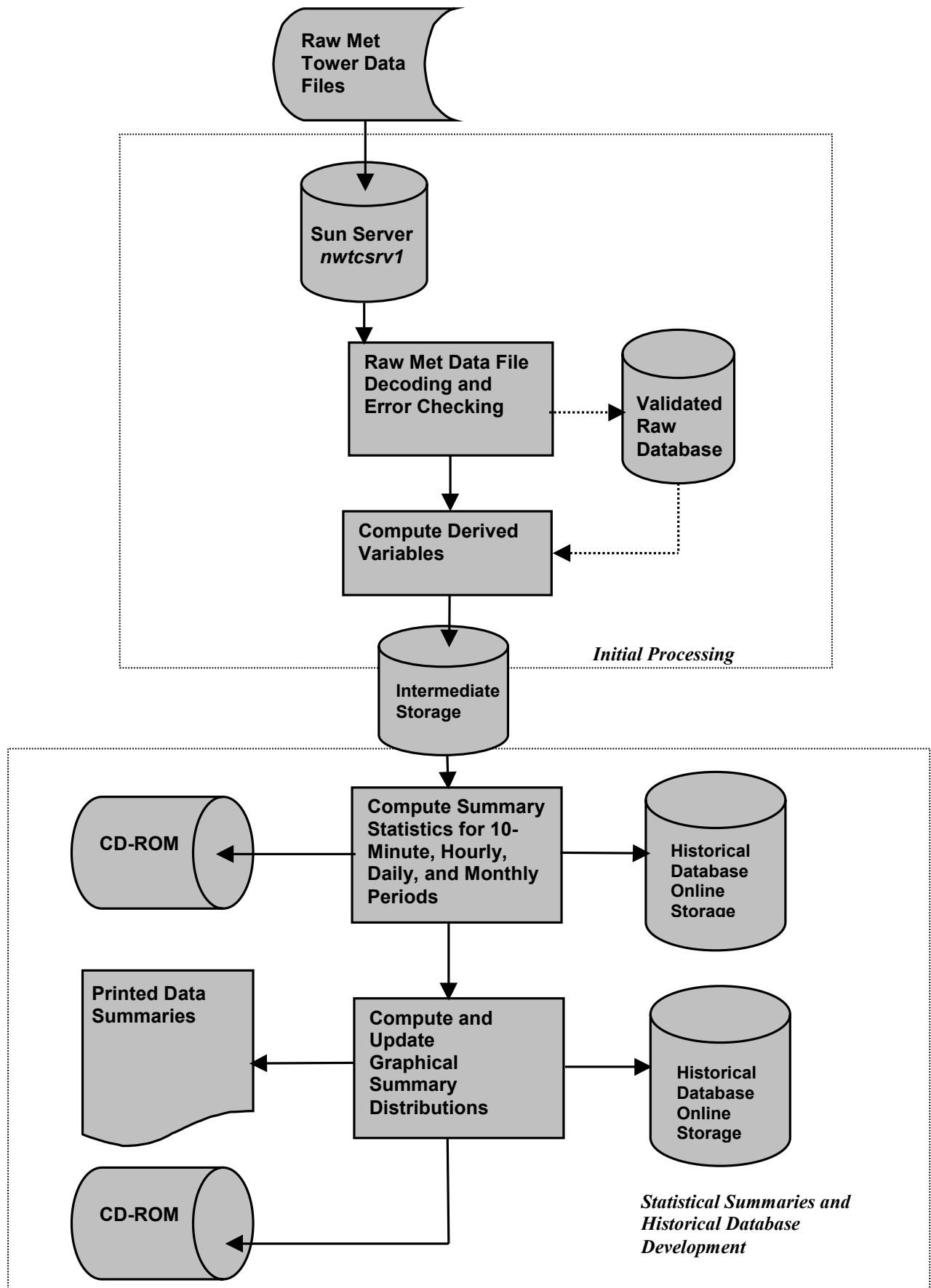


Figure D-1. Overall processing flow diagram

## Coding Language Requirements

The necessary codes shall be prepared in accordance with the following:

- The target computer shall be the NWTC Sun Microsystems E2000 Server *nwtcsrv1* running under Solaris 5.5.1.
- All software programs shall be developed in FORTRAN-90 using the Sun Microsystems 2.0 FORTRAN-90 compiler as the primary computer language. Subroutines callable from FORTRAN using well-documented codes written in the C or C++ languages are acceptable.

## Description of Input Records

Each raw input data record for the M2 (West) Tower consists of a matrix of 73<sup>1</sup> comma-delimited columns by the order of 1000 rows. A row is generated every 10 minutes and the total number of rows in the record varies depending on the time between its initiation and when the data was downloaded. This period is typically seven days but may be longer or shorter depending on the situation. The length of records (rows) should be considered a variable, whereas the number of columns is generally constant over a longer period whose boundaries can be defined. The input record prior to January 1, 1999, for the M2 Tower is listed in Appendix A, Table 1. The bulk of the information prior to this date was collected in this format. The date when this format was first initiated appears to have been at 13:20 on Julian Day 323 (November 20, 1996). The only difference between this format and any after this date is the inclusion of the calendar year as the second parameter (column). The current format is listed in Appendix A, Table 2.

The term "sigma" refers to the standard deviation and the units of HHMM refer to the format of Hours-Minutes. The first column or parameter containing the 21X identification (ID) word for the M2 tower records is **121** for the formats shown in Appendix A, Tables 1 and 2 starting on Julian Day 323 (November 18, 1996). The value earlier was **118** for data collected between Julian Day 122 (May 1, 1996) and 13:00 on Julian Day 177 (June 25, 1996). It was **114** for data collected between 13:10 on Julian Day 177 (June 25, 1996) and 13:00 on Julian Day 323 (November 18, 1996).

The raw input data record for the M3 (East) Tower consists of a matrix of 661 comma-delimited columns similar to the format of the M2 Tower. The difference is accounted for by the lack of the solar radiation, rain gage, and associated unused parameters. The input record prior to January 1, 1999, is listed in Appendix A, Table 3, and after in Appendix A, Table 4. The M3 Tower did not begin recording until sometime after M2. The M3 records from 1996 to late June 1997 (through mid Julian day 174) contained record lengths of one hour instead of 10 minutes. The first parameter ID for the M3 tower is **112**.

The raw data records are loaded on the disk subsystem of the NWTC Sun server, *nwtcsrv1*, nominally each Monday morning into the `/vol01/neil_data/nwtc_met_data/rawdata` subdirectory. This subdirectory is further subdivided into M2 and M3 directories and again by calendar year (i.e., 1996–1999). The format of the file name associated with the raw records

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<sup>1</sup> While generally fixed, the number parameters (columns) were different during the first few months of operation and have become 74 for the M2 Tower and 67 for M3 after January 1, 1999, in order to include the calendar year within the record.

prior to January 1, 1999, is **MxdddYØn.DAT**. This code is read as **x** being either 2 or 3 (M2 or M3); **ddd** is the Julian Date on the day the record was removed; **y** is the last digit of the calendar year (6,7,8, or 9); and **Øn** (Ø indicates the number zero or 0) **n** is either a 1 or a 2. A new version of the Campbell data acquisition software was installed at the beginning of March 1999 and the **Ø(1 or 2)** characters no longer appear in the file names and the uppercase **M** and file extension and **DAT** became lowercase characters as well. Starting with January 1, 2000, a new file name nomenclature will be necessary, such as **mxdddyy** where **yy** = 00, 01, 02.

### Required Processing Operations

The initial processing operations are shown in the upper portion of Figure 1. These include providing for signaling the processing program to set faulty or missing input parameters or channels to the error flag value of -99.9, as well as other bookkeeping information such as input and output file names and current input record format. The processing should take place on a record-by-record basis; no carryover information from previous or future records is necessary.

A suggested detail-processing sequence is shown in Figure D-2. Initially, runtime information is entered including the input and output file names, parameters that are missing or faulty and should be set to the -99.9 flag, and any other pertinent information about the data set being processed. The operations, applied to each 10-minute record, include the following:

1. Reading in a raw record.
2. Making sure the value of the **21X battery voltage** (Input Parameters 73/74 for M2, 66/67 for M3) is greater than 10 V. If not, enter error message in QC Summary File and ignore record and read in next one.
3. Checking to see if system is in calibrate mode; if so, ignore record and read next one.
4. Entering runtime information into QC Summary File for documentation purposes.
5. Setting requested faulty channels or parameters to error flag value of -99.9.
6. Establishing the operational status of each of the three aspirators (2, 50, and 80 meter levels) using the table below. An aspirator is considered inoperative (flag set to false) if the aspirator status signal voltage (Input parameters 72/73 for M2 and 65/66 for M3) is within  $\pm 15$  mV of any of the values shown below.

Aspirator Level	Values (mV) Indicating Aspirator Failure $\pm 15$ mV (Derived from Aspirator status signal parameter)			
<b>80 m</b>	313	938	1563	2188
<b>50 m</b>	625	938	1875	2188
<b>2 m</b>	1250	1563	1875	2188

7. Applying the validation or QC criteria to each required record in accordance with the criteria listed in Appendix B and set the accompanying QC parameter accordingly (T = parameters OK and QC parameter set to a blank, F = failed and QC parameter set to an asterisk ). Enter information into the QC Summary (log) File regarding any parameter not meeting the QC



criteria, including the record date and time and the criteria not met.

8. Applying any data corrections as required.
9. Computing the 2-, 5-, 10-, 20-, 50-, and 80-m turbulence intensities from the ratios of the corresponding wind speed sigmas and mean values for each level, multiplied by 100.
10. Computing the remaining derived parameters and associated QC flags using the THERMODYNAMICS, RICH\_NO, and BLPARMS subroutines.
11. Assembling the output record in the required format and write to an intermediate disk file.
12. Repeating the above steps until the records in the input file are exhausted.

The FORTRAN-90-compatible source codes, for the three subroutines needed to generate the derived parameters, are listed for M2 and M3 in Appendix C. The THERMODYNAMICS subroutine calculates several atmospheric moist thermodynamics parameters. These parameters are used by the RICH\_NO and BLPARMS subroutines to calculate: (1) the Richardson number stability parameters, (2) estimates of the surface layer friction velocity or  $u_*$  and surface roughness parameters, and (3) the mean shear power law coefficient in the 2-80 m layer.

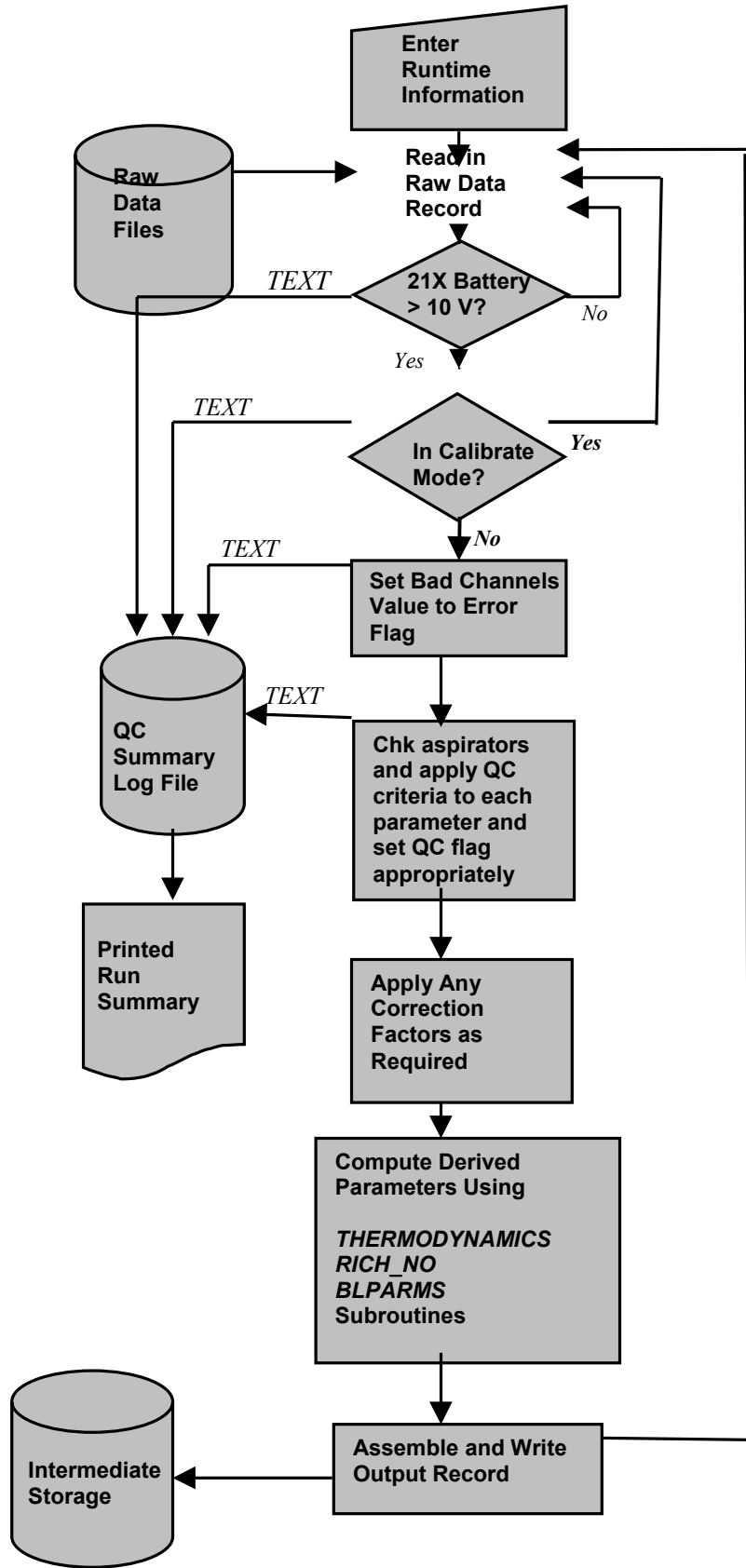


Figure D-2. Suggested basic processing operations

### **10-minute Output Records**

The format of the final, 10-minute output records has been arranged to allow easy access by other UNIX or PC-based programs such as spreadsheets. The output records from the M2 and M3 Towers will include 164 comma-delimited columns. The addition of 14 derived parameters and a column containing a QC flag character for most of the parameters accounts for the more than doubling of columns in comparison with the input record. The quality control flag character will either be a blank (data quality is acceptable) or an asterisk indicating it may have some questionable traits. Missing values will continue to be indicated by the constant -99.9. The final 10-minute output record from the M3 Tower is the same length as that from the M2 tower; however, the four columns assigned to the missing global solar radiation and precipitation parameters are left blank. This allows a common output format for both towers because the tower identification is included in the first parameter of the record. The requested output format is listed in Appendix E, Table 5.

## **APPENDIX E**

### **RECORD FORMATS**

## Appendix E – Record Formats

### TABLE 1

**M2 TOWER 21X INPUT DATA RECORD BEFORE  
JANUARY 1, 1999**

INPUT PARM NUMBER	PARAMETER IDENTIFICATION	UNITS
01	21X ID Word	-
02	Julian Date	-
03	Time at record end	HHMM
04	AC power status signal	Hz
05	80m mean wind speed	m/s
06	80m mean wind direction	deg
07	80m wind direction sigma	deg
08	50m mean wind speed	m/s
09	50m mean wind direction	deg
10	50m wind direction sigma	deg
11	20m mean wind speed	m/s
12	20m mean wind direction	deg
13	20m wind direction sigma	deg
14	10m mean wind speed	m/s
15	10m mean wind direction	deg
16	10m wind direction sigma	deg
17	5m mean wind speed	m/s
18	5m mean wind direction	deg
19	5m wind direction sigma	deg
20	2m mean wind speed	m/s
21	2m mean wind direction	deg
22	2m wind direction sigma	deg
23	80m wind speed sigma	m/s
24	50m wind speed sigma	m/s
25	20m wind speed sigma	m/s
26	10m wind speed sigma	m/s
27	5m wind speed sigma	m/s
28	2m wind speed sigma	m/s
29	2m mean baro pressure	hPa
30	2m mean dewpoint temp	C
31	(not used)	-
32	50m air temperature	C
33	2m air temperature	C
34	80-50m delta temp dif	C
35	50-2m delta temp dif	C
36	80m max wind speed	m/s
37	80m max gust time	HHMM
38	80m max gust direction	deg
39	50m max wind speed	m/s
40	50m max gust time	HHMM
41	50m max gust direction	deg
42	20m max wind speed	m/s
43	20m max gust time	HHMM
44	20m max gust direction	deg
45	10m max wind speed	m/s
46	10m max gust time	HHMM
47	10m max gust direction	deg
48	5m max wind speed	m/s

49	5m max gust time	HHMM
50	5m max gust direction	deg
51	2m max wind speed	m/s
52	2m max gust time	HHMM
53	2m max gust direction	deg
54	2m max baro pressure	hPa
55	2m max baro pressure time	HHMM
56	2m max dewpoint temp	C
57	2m max dewpoint temp time	HHMM
58	(not used)	-
59	(not used)	-
60	50m max air temperature	C
61	50m max air temperature time	HHMM
62	2m min baro pressure	mb
63	2m min baro pressure time	HHMM
64	2m min dewpoint temp	C
65	2m min dewpoint temp time	HHMM
66	(not used)	-
67	(not used)	-
68	50m min air temperature	C
69	50m min air temperature time	HHMM
70	total insolation	kW/m <sup>2</sup>
71	total liquid precip	mm
72	aspirator status signal	mV
73	21X battery voltage	V

**TABLE 2**

**M2 TOWER 21X INPUT DATA RECORD AFTER  
JANUARY 1, 1999**

INPUT PARM NUMBER	PARAMETER IDENTIFICATION	UNITS
01	21X ID Word	-
<b>02</b>	<b>Calendar Year</b>	<b>-</b>
03	Julian Date	-
04	Time at record end	HHMM
05	AC power status signal	Hz
06	80m mean wind speed	m/s
07	80m mean wind direction	deg
08	80m wind direction sigma	deg
09	50m mean wind speed	m/s
10	50m mean wind direction	deg
11	50m wind direction sigma	deg
12	20m mean wind speed	m/s
13	20m mean wind direction	deg
14	20m wind direction sigma	deg
15	10m mean wind speed	m/s
16	10m mean wind direction	deg
17	10m wind direction sigma	deg
18	5m mean wind speed	m/s
19	5m mean wind direction	deg
20	5m wind direction sigma	deg
21	2m mean wind speed	m/s
22	2m mean wind direction	deg
23	2m wind direction sigma	deg
24	80m wind speed sigma	m/s
25	50m wind speed sigma	m/s
26	20m wind speed sigma	m/s
27	10m wind speed sigma	m/s
28	5m wind speed sigma	m/s
29	2m wind speed sigma	m/s
30	2m mean baro pressure	hPa
31	2m mean dewpoint temp	C
32	(not used)	-
33	50m air temperature	C
34	2m air temperature	C
35	80-50m delta temp dif	C
36	50-2m delta temp dif	C
37	80m max wind speed	m/s
38	80m max gust time	HHMM
39	80m max gust direction	deg
40	50m max wind speed	m/s
41	50m max gust time	HHMM
42	50m max gust direction	deg
43	20m max wind speed	m/s
44	20m max gust time	HHMM
45	20m max gust direction	deg
46	10m max wind speed	m/s
47	10m max gust time	HHMM
48	10m max gust direction	deg

49	5m	max wind speed	m/s
50	5m	max gust time	HHMM
51	5m	max gust direction	deg
52	2m	max wind speed	m/s
53	2m	max gust time	HHMM
54	2m	max gust direction	deg
55	2m	max baro pressure	hPa
56	2m	max baro pressure time	HHMM
57	2m	max dewpoint temp	C
58	2m	max dewpoint temp time	HHMM
59		(not used)	-
60		(not used)	-
61	50m	max air temperature	C
62	50m	max air temperature time	HHMM
63	2m	min baro pressure	mb
64	2m	min baro pressure time	HHMM
65	2m	min dewpoint temp	C
66	2m	min dewpoint temp time	HHMM
67		(not used)	-
68		(not used)	-
69	50m	min air temperature	C
70	50m	min air temperature time	HHMM
71		total insolation	kW/m <sup>2</sup>
72		total liquid precip	mm
73		aspirator status signal	mV
74		21X battery voltage	V



**TABLE 3**

**M3 TOWER 21X INPUT DATA RECORD BEFORE  
JANUARY 1, 1999**

INPUT PARM NUMBER	PARAMETER IDENTIFICATION	UNITS
01	21X ID Word	-
02	Julian Date	-
03	Time at record end	HHMM
04	AC power status signal	Hz
05	80m mean wind speed	m/s
06	80m mean wind direction	deg
07	80m wind direction sigma	deg
08	50m mean wind speed	m/s
09	50m mean wind direction	deg
10	50m wind direction sigma	deg
11	20m mean wind speed	m/s
12	20m mean wind direction	deg
13	20m wind direction sigma	deg
14	10m mean wind speed	m/s
15	10m mean wind direction	deg
16	10m wind direction sigma	deg
17	5m mean wind speed	m/s
18	5m mean wind direction	deg
19	5m wind direction sigma	deg
20	2m mean wind speed	m/s
21	2m mean wind direction	deg
22	2m wind direction sigma	deg
23	80m wind speed sigma	m/s
24	50m wind speed sigma	m/s
25	20m wind speed sigma	m/s
26	10m wind speed sigma	m/s
27	5m wind speed sigma	m/s
28	2m wind speed sigma	m/s
29	2m mean baro pressure	hPa
30	2m mean dewpoint temp	C
31	50m air temperature	C
32	2m air temperature	C
33	80-50m delta temp dif	C
34	50-2m delta temp dif	C
35	80m max wind speed	m/s
36	80m max gust time	HHMM
37	80m max gust direction	deg
38	50m max wind speed	m/s
39	50m max gust time	HHMM
40	50m max gust direction	deg
41	20m max wind speed	m/s
42	20m max gust time	HHMM
43	20m max gust direction	deg
44	10m max wind speed	m/s
45	10m max gust time	HHMM
46	10m max gust direction	deg
47	5m max wind speed	m/s
48	5m max gust time	HHMM
49	5m max gust direction	deg
50	2m max wind speed	m/s

51	2m	max gust time	HHMM
52	2m	max gust direction	deg
53	2m	max baro pressure	hPa
54	2m	max baro pressure time	HHMM
55	2m	max dewpoint temp	C
56	2m	max dewpoint temp time	HHMM
57	50m	max air temperature	C
58	50m	max air temperature time	HHMM
59	2m	min baro pressure	hPa
60	2m	min baro pressure time	HHMM
61	2m	min dewpoint temp	C
62	2m	min dewpoint temp time	HHMM
63	50m	min air temperature	C
64	50m	min air temperature time	HHMM
65		aspirator status signal	mV
66		21X battery voltage	V

**TABLE 4**

**M3 TOWER 21X INPUT DATA RECORD AFTER  
JANUARY 1, 1999**

INPUT PARM NUMBER	PARAMETER IDENTIFICATION	UNITS
01	21X ID Word	-
<b>02</b>	<b>Calendar Year</b>	<b>-</b>
03	Julian Date	-
04	Time at record end	HHMM
05	AC power status signal	Hz
06	80m mean wind speed	m/s
07	80m mean wind direction	deg
08	80m wind direction sigma	deg
09	50m mean wind speed	m/s
10	50m mean wind direction	deg
11	50m wind direction sigma	deg
12	20m mean wind speed	m/s
13	20m mean wind direction	deg
14	20m wind direction sigma	deg
15	10m mean wind speed	m/s
16	10m mean wind direction	deg
17	10m wind direction sigma	deg
18	5m mean wind speed	m/s
19	5m mean wind direction	deg
20	5m wind direction sigma	deg
21	2m mean wind speed	m/s
22	2m mean wind direction	deg
23	2m wind direction sigma	deg
24	80m wind speed sigma	m/s
25	50m wind speed sigma	m/s
26	20m wind speed sigma	m/s
27	10m wind speed sigma	m/s
28	5m wind speed sigma	m/s
29	2m wind speed sigma	m/s
30	2m mean baro pressure	hPa
31	2m mean dewpoint temp	C
32	50m air temperature	C
33	2m air temperature	C
34	80-50m delta temp dif	C
35	50-2m delta temp dif	C
36	80m max wind speed	m/s
37	80m max gust time	HHMM
38	80m max gust direction	deg
39	50m max wind speed	m/s
40	50m max gust time	HHMM
41	50m max gust direction	deg
42	20m max wind speed	m/s
43	20m max gust time	HHMM
44	20m max gust direction	deg
45	10m max wind speed	m/s
46	10m max gust time	HHMM
47	10m max gust direction	deg
48	5m max wind speed	m/s
49	5m max gust time	HHMM
50	5m max gust direction	deg

51	2m	max wind speed	m/s
52	2m	max gust time	HHMM
53	2m	max gust direction	deg
54	2m	max baro pressure	hPa
55	2m	max baro pressure time	HHMM
56	2m	max dewpoint temp	C
57	2m	max dewpoint temp time	HHMM
58	50m	max air temperature	C
59	50m	max air temperature time	HHMM
60	2m	min baro pressure	hPa
61	2m	min baro pressure time	HHMM
62	2m	min dewpoint temp	C
63	2m	min dewpoint temp time	HHMM
64	50m	min air temperature	C
65	50m	min air temperature time	HHMM
66		aspirator status signal	mV
67		21X battery voltage	V

**TABLE 5**

M2/M3 MET DATA 10-MIN OUTPUT DATA RECORD

OUTPUT COLUMN NUMBER	PARAMETER IDENTIFICATION	UNITS	REMARKS
01	Tower Identification	-	
02	Calendar year	-	
03	Julian date	-	
04	Julian date qc flag	-	
05	10-min record number (1-144)	-	
06	Time at record end	HHMM	
07	Time qc flag	-	
08	AC power status signal	Hz	
09	80m mean wind speed	m/s	
10	80m mean wind speed qc flag	-	
11	80m mean wind direction	deg	
12	80m mean wind dir qc flag	-	
13	80m wind direction sigma	deg	
14	80m wind dir sigma qc flag	-	
15	50m mean wind speed	m/s	
16	50m mean wind speed qc flag	-	
17	50m mean wind direction	deg	
18	50m mean wind dir qc flag	-	
19	50m wind direction sigma	deg	
20	50m wind dir sigma qc flag	-	
21	20m mean wind speed	m/s	
22	20m mean wind speed qc flag	-	
23	20m mean wind direction	deg	
24	20m mean wind dir qc flag	-	
25	20m wind direction sigma	deg	
26	20m wind dir sigma qc flag	-	
27	10m mean wind speed	m/s	
28	10m mean wind speed qc flag	-	
29	10m mean wind direction	deg	
30	10m mean wind dir qc flag	-	
31	10m mean wind direction sigma	deg	
32	10m wind dir sigma qc flag	-	
33	5m mean wind speed	m/s	
34	5m mean wind speed qc flag	-	
35	5m mean wind direction	deg	
36	5m mean wind dir qc flag	-	
37	5m wind direction sigma	deg	
38	5m wind dir sigma qc flag	-	
39	2m mean wind speed	m/s	
40	2m mean wind speed qc flag	-	
41	2m mean wind direction	deg	
42	2m mean wind dir qc flag	-	
43	2m wind direction sigma	deg	
44	2m wind dir sigma qc flag	-	
45	80m wind speed sigma	m/s	

46	80m wind speed sigma qc flag	-
47	50m wind speed sigma	m/s
48	50m wind speed sigma qc flag	-
49	20m wind speed sigma	m/s
50	20m wind speed sigma qc flag	-
51	10m wind speed sigma	m/s
52	10m wind speed sigma qc flag	-
53	5m wind speed sigma	m/s
54	5m wind speed sigma qc flag	-
55	2m wind speed sigma	m/s
56	2m wind speed sigma qc flag	-
57	2m mean baro pressure	hPa
58	2m mean baro presr qc flag	-
59	2m mean dewpoint temp	C
60	2m mean dewpt temp qc flag	-
61	50m air temperature	C
62	50m air temperature qc flag	-
63	2m air temperature	C
64	2m air temperature qc flag	-
65	80-50m delta temp	C
66	80-50m delta temp qc flag	-
67	50-2m delta temp	C
68	50-2m delta temp qc flag	-
69	80m max wind speed	m/s
70	80m max wind speed qc flag	-
71	80m max gust time	HHMM
72	80m max gust time qc flag	-
73	80m max gust direction	deg
74	80m max gust dir qc flag	-
75	50m max wind speed	m/s
76	50m max wind speed qc flag	-
77	50m max gust time	HHMM
78	50m max gust time qc flag	-
79	50m max gust direction	deg
80	50m max gust dir qc flag	-
81	20m max wind speed	m/s
82	20m max wind speed qc flag	-
83	20m max gust time	HHMM
84	20m max gust time qc flag	-
85	20m max gust direction	deg
86	20m max gust dir qc flag	-
87	10m max wind speed	m/s
88	10m max wind speed qc flag	-
89	10m max gust time	HHMM
90	10m max gust time qc flag	-
91	10m max gust direction	deg
92	10m max gust dir qc flag	-
93	5m max wind speed	m/s
94	5m max wind speed qc flag	-
95	5m max gust time	HHMM
96	5m max gust time qc flag	-
97	5m max gust direction	deg
98	5m max gust dir qc flag	-
99	2m max wind speed	m/s

100	2m max wind speed qc flag	-	
101	2m max gust time	HHMM	
102	2m max gust time qc flag	-	
103	2m max gust direction	deg	
104	2m max gust dir qc flag	-	
105	2m max baro pressure	mb	
106	2m max baro presr qc flag	-	
107	2m max baro pressure time	HHMM	
108	2m max baro presr time qc	-	
109	2m max dewpoint temp	C	
110	2m max dewpoint temp qc flg	-	
111	2m max dewpoint temp time	HHMM	
112	2m max dewpt temp time qc	-	
<b>113</b>	<b>2m max air temperature</b>	<b>C</b>	<b>(N/A set to -99.9)</b>
<b>114</b>	<b>2m max air temp qc flag</b>	<b>-</b>	<b>(N/A set to -99.9)</b>
<b>115</b>	<b>2m max air temperature time</b>	<b>HHMM</b>	<b>(N/A set to -99.9)</b>
<b>116</b>	<b>2m max air temp time qc flag</b>	<b>-</b>	<b>(N/A set to -99.9)</b>
117	2m min baro pressure	hPa	
118	2m min baro presr qc flag	-	
119	2m min baro pressure time	HHMM	
120	2m min baro presr time qc	-	
121	2m min dewpoint temp	C	
122	2m min dewpt temp qc flag	-	
123	2m min dewpoint temp time	HHMM	
124	2m min dewpt temp time qc	-	
<b>125</b>	<b>2m min air temperature</b>	<b>C</b>	<b>(N/A set to -99.9)</b>
<b>126</b>	<b>2m min air temp qc flag</b>	<b>-</b>	<b>(N/A set to -99.9)</b>
<b>127</b>	<b>2m min air temperature time</b>	<b>HHMM</b>	<b>(N/A set to -99.9)</b>
<b>128</b>	<b>2m min air temp time qc flag</b>	<b>-</b>	<b>(N/A set to -99.9)</b>
<b>129</b>	<b>total insolation</b>	<b>kW/m^2</b>	<b>(blank for M3)</b>
<b>130</b>	<b>total insolation qc flag</b>	<b>-</b>	<b>(blank for M3)</b>
<b>131</b>	<b>total liquid precip</b>	<b>mm</b>	<b>(blank for M3)</b>
<b>132</b>	<b>total liquid precip qc flag</b>	<b>-</b>	<b>(blank for M3)</b>
133	80m aspirator status	T/F	
134	50m aspirator status	T/F	
135	2 m aspirator status	T/F	
136	21X battery voltage status	T/F	
137	80m turbulence intensity	-	
138	80m turbulence int qc flag	-	
139	50m turbulence intensity	-	
140	50m turbulence int qc flag	-	
141	20m turbulence intensity	-	
142	20m turbulence int qc flag	-	
143	10m turbulence intensity	-	
144	10m turbulence int qc flag	-	
145	5m turbulence intensity	-	
146	5m turbulence int qc flag	-	
147	2m turbulence intensity	-	
148	2m turbulence int qc flag	-	

149	2m relative humidity	%
150	2m relative humidity qc flg	-
151	2-50m Richardson number	-
152	2-50m Richardson No qc flg	-
153	50-80m Richardson number	-
154	50-80m Richardson No qc flg	-
155	2-80m Richardson number	-
156	2-80m Richardson No qc flg	-
157	friction velocity, $u^*$	m/s
158	friction velocity qc flag	-
159	surface roughness estimate	m
160	surface roughness qc flag	-
161	$u^*$ quality control, $r^2$	-
162	$u^*$ quality control qc flg	-
163	2-80m mean pwr law coef	-
164	2-80m pwr law coef qc flg	-



## **APPENDIX F**

### **QUALITY CONTROL (QC) CRITERIA**

## Appendix F – Quality Control (QC) Criteria

### M2 TOWER QC CRITERIA

OUTPUT PARM No.	PARAMETER DESCRIPTION	ACCEPTABLE RANGE FOR QC STATUS	QC Parm No.
03	Julian Date (JD)	$000 \leq \text{PARM}(03) \leq 366 = T$	04
06	Time at record end	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 50 = T$	07
09	80 m mean wind speed	$092^\circ \leq \text{PARM} (11) \leq 132^\circ = T$	10
15	50 m mean wind speed	$092^\circ \leq \text{PARM} (17) \leq 132^\circ = T$	16
21	20 m mean wind speed	$092^\circ \leq \text{PARM} (23) \leq 132^\circ = T$	22
27	10 m mean wind speed	$092^\circ \leq \text{PARM} (29) \leq 132^\circ = T$	28
33	5 m mean wind speed	$092^\circ \leq \text{PARM} (35) \leq 132^\circ = T$	34
39	2 m mean wind speed	$092^\circ \leq \text{PARM} (41) \leq 132^\circ = T$	40
11	80 m mean wind direction	$\text{PARM}(10) = T$	12
17	50 m mean wind direction	$\text{PARM}(16) = T$	18
23	20 m mean wind direction	$\text{PARM}(22) = T$	24
29	10 m mean wind direction	$\text{PARM}(28) = T$	30
35	5 m mean wind direction	$\text{PARM}(34) = T$	36
41	2 m mean wind direction	$\text{PARM}(40) = T$	42
13	80 m wind direction sigma	$\text{PARM}(10) = T$	14
19	50 m wind direction sigma	$\text{PARM}(16) = T$	20
25	20 m wind direction sigma	$\text{PARM}(22) = T$	26
31	10 m wind direction sigma	$\text{PARM}(28) = T$	32
37	5 m wind direction sigma	$\text{PARM}(34) = T$	38
43	2 m wind direction sigma	$\text{PARM}(40) = T$	44
45	80 m wind speed sigma	$\text{PARM}(10) = T$	46
47	50 m wind speed sigma	$\text{PARM}(16) = T$	48
49	20 m wind speed sigma	$\text{PARM}(22) = T$	50
51	10 m wind speed sigma	$\text{PARM}(28) = T$	52
53	5 m wind speed sigma	$\text{PARM}(34) = T$	54
55	2 m wind speed sigma	$\text{PARM}(40) = T$	56
57	2 m barometric pressure	$741 < \text{PARM}(57) < 999 = T$	58
59	2 m dewpoint temperature	$-48 \leq \text{PARM}(59) \leq +48$ .AND. $\text{PARM}(135)=T$	60
61	50 m air temperature	$-48 \leq \text{PARM}(61) \leq +48$ .AND. $\text{PARM}(134)=T$	62
63	2 m air temperature	$-48 \leq \text{PARM}(63) \leq +48$ .AND. $\text{PARM}(135)=T$	64
65	80-50 m delta temperature	$-4.5 \leq \text{PARM}(65) \leq +14.5$ .AND. $\text{PARM}(133)$ .AND. $\text{PARM}(134)=T$	66
67	50-2 m delta temperature	$-4.5 \leq \text{PARM}(67) \leq +14.5$ .AND. $\text{PARM}(134)$ .AND. $\text{PARM}(135)=T$	68
69	80 m max wind speed	$\text{PARM}(10) = T$	70
75	50 m max wind speed	$\text{PARM}(16) = T$	76
81	20 m max wind speed	$\text{PARM}(22) = T$	82
87	10 m max wind speed	$\text{PARM}(28) = T$	88
93	5 m max wind speed	$\text{PARM}(34) = T$	94
99	2 m max wind speed	$\text{PARM}(40) = T$	100
71	80 m max wind speed time	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 59 = T$	72
77	50 m max wind speed time	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 59 = T$	78

OUTPUT PARM No.	PARAMETER DESCRIPTION	ACCEPTABLE RANGE OR QC STATUS	QC Parm No.
83	20 m max wind speed time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	84
89	10 m max wind speed time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	90
95	5 m max wind speed time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	96
101	2 m max wind speed time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	102
73	80 m max gust wind direction	PARM(10) = T	74
79	50 m max gust wind direction	PARM(16) = T	80
85	20 m max gust wind direction	PARM(22) = T	86
91	10 m max gust wind direction	PARM(28) = T	92
97	5 m max gust wind direction	PARM(34) = T	98
103	2 m max gust wind direction	PARM(40) = T	104
105	2 m max barometric pressure	PARM(58)= T	106
107	2 m max barometric pressure time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	108
109	2 m max dewpoint temperature	PARM(60) = T	110
111	2 m max dewpoint temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	112
113	2 m max air temperature	PARM(64) = T	114
115	2 m max air temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	116
117	2 m min barometric pressure	PARM(58)=T	118
119	2 m min barometric pressure time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	120
121	2 m min dewpoint temperature	PARM(60)=T	122
123	2 m min dewpoint temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	124
125	2 m min air temperature	PARM(64) = T	126
127	2 m min air temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	128
129	total insolation	$0 \leq \text{PARM}(129) \leq 42000 = T$	130
131	total precipitation	$0 \leq \text{PARM}(131) \leq 500 = T$	132
133	80 m aspirator status	T/F	-
134	50 m aspirator status	T/F	-
135	2 m aspirator status	T/F	-
136	21X battery voltage status	T/F	-
137	80 m turbulence intensity	PARM(10) = T	138
139	50 m turbulence intensity	PARM(16) = T	140
141	20 m turbulence intensity	PARM(22) = T	142
143	10 m turbulence intensity	PARM(28) = T	144
145	5 m turbulence intensity	PARM(34) = T	146
147	2 m turbulence intensity	PARM(40) = T	148
149	2 m relative humidity	PARM(64)=PARM(60)=PARM(58)=T	150
151	2-50 m Richardson number	PARM(64)=PARM(68)=PARM(60)= PARM(58)=PARM(10)=PARM(16)= PARM(22)=PARM(28)=PARM(34)= PARM(40)=T	152
153	50-80 m Richardson number	PARM(62)=PARM(66)=PARM(60)= PARM(58)=PARM(10)=PARM(16)= PARM(22)=PARM(28)=PARM(34)= PARM(40)=T	154
155	2-80 m Richardson number	PARM(62)=PARM(64)=PARM(60)= PARM(66)=PARM(68)=PARM(58)= PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)=T	156
157	friction velocity $u_*$	PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)= PARM(162)=T	158

159	surface roughness	PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)= PARM(162)=T	160
161	$u_*$ quality control $r^2$	PARM(161) > 0.50 = T	162
163	2-80 m mean power law coefficient	PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)=T	164

## M3 TOWER QC CRITERIA

OUTPUT PARM No.	PARAMETER DESCRIPTION	ACCEPTABLE RANGE FOR QC STATUS	QC Parm No.
03	Julian Date (JD)	$000 \leq \text{PARM}(03) \leq 366 = T$	04
06	Time at record end	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 50 = T$	07
09	80 m mean wind speed	$250^\circ \leq \text{PARM} (11) \leq 290^\circ = T$	10
15	50 m mean wind speed	$250^\circ \leq \text{PARM} (17) \leq 290^\circ = T$	16
21	20 m mean wind speed	$250^\circ \leq \text{PARM} (23) \leq 290^\circ = T$	22
27	10 m mean wind speed	$250^\circ \leq \text{PARM} (29) \leq 290^\circ = T$	28
33	5 m mean wind speed	$250^\circ \leq \text{PARM} (35) \leq 290^\circ = T$	34
39	2 m mean wind speed	$250^\circ \leq \text{PARM} (41) \leq 290^\circ = T$	40
11	80 m mean wind direction	$\text{PARM}(10) = T$	12
17	50 m mean wind direction	$\text{PARM}(16) = T$	18
23	20 m mean wind direction	$\text{PARM}(22) = T$	24
29	10 m mean wind direction	$\text{PARM}(28) = T$	30
35	5 m mean wind direction	$\text{PARM}(34) = T$	36
41	2 m mean wind direction	$\text{PARM}(40) = T$	42
13	80 m wind direction sigma	$\text{PARM}(10) = T$	14
19	50 m wind direction sigma	$\text{PARM}(16) = T$	20
25	20 m wind direction sigma	$\text{PARM}(22) = T$	26
31	10 m wind direction sigma	$\text{PARM}(28) = T$	32
37	5 m wind direction sigma	$\text{PARM}(34) = T$	38
43	2 m wind direction sigma	$\text{PARM}(40) = T$	44
45	80 m wind speed sigma	$\text{PARM}(10) = T$	46
47	50 m wind speed sigma	$\text{PARM}(16) = T$	48
49	20 m wind speed sigma	$\text{PARM}(22) = T$	50
51	10 m wind speed sigma	$\text{PARM}(28) = T$	52
53	5 m wind speed sigma	$\text{PARM}(34) = T$	54
55	2 m wind speed sigma	$\text{PARM}(40) = T$	56
57	2 m barometric pressure	$741 < \text{PARM}(57) < 999 = T$	58
59	2 m dewpoint temperature	$-48 \leq \text{PARM}(59) \leq +48$ .AND. $\text{PARM}(135)=T$	60
61	50 m air temperature	$-48 \leq \text{PARM}(61) \leq +48$ .AND. $\text{PARM}(134)=T$	62
63	2 m air temperature	$-48 \leq \text{PARM}(63) \leq +48$ .AND. $\text{PARM}(135)=T$	64
65	80-50 m delta temperature	$-4.5 \leq \text{PARM}(65) \leq +14.5$ .AND. $\text{PARM}(133)$ .AND. $\text{PARM}(134)=T$	66
67	50-2 m delta temperature	$-4.5 \leq \text{PARM}(67) \leq +14.5$ .AND. $\text{PARM}(134)$ .AND. $\text{PARM}(135)=T$	68
69	80 m max wind speed	$\text{PARM}(10) = T$	70
75	50 m max wind speed	$\text{PARM}(16) = T$	76
81	20 m max wind speed	$\text{PARM}(22) = T$	82
87	10 m max wind speed	$\text{PARM}(28) = T$	88
93	5 m max wind speed	$\text{PARM}(34) = T$	94
99	2 m max wind speed	$\text{PARM}(40) = T$	100
71	80 m max wind speed time	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 59 = T$	72
77	50 m max wind speed time	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 59 = T$	78
83	20 m max wind speed time	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 59 = T$	84
89	10 m max wind speed time	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 59 = T$	90
95	5 m max wind speed time	$00 \leq \text{HH} \leq 23$ .AND. $00 \leq \text{MM} \leq 59 = T$	96

OUTPUT PARM No.	PARAMETER DESCRIPTION	ACCEPTABLE RANGE OR QC STATUS	QC Parm No.
101	2 m max wind speed time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	102
73	80 m max gust wind direction	PARM(10) = T	74
79	50 m max gust wind direction	PARM(16) = T	80
85	20 m max gust wind direction	PARM(22) = T	86
91	10 m max gust wind direction	PARM(28) = T	92
97	5 m max gust wind direction	PARM(34) = T	98
103	2 m max gust wind direction	PARM(40) = T	104
105	2 m max barometric pressure	PARM(58)=T	106
107	2 m max barometric pressure time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	108
109	2 m max dewpoint temperature	PARM(60) = T	110
111	2 m max dewpoint temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	112
113	2 m max air temperature	PARM(64) = T	114
115	2 m max air temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	116
117	2 m min barometric pressure	PARM(58)=T	118
119	2 m min barometric pressure time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	120
121	2 m min dewpoint temperature	PARM(60)=T	122
123	2 m min dewpoint temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	124
125	2 m min air temperature	PARM(64) = T	126
127	2 m min air temperature time	$00 \leq HH \leq 23$ .AND. $00 \leq MM \leq 59 = T$	128
<b>129</b>	<b>(not used)</b>	<b>(not used)</b>	<b>130</b>
<b>131</b>	<b>(not used)</b>	<b>(not used)</b>	<b>132</b>
133	80 m aspirator status	T/F	-
134	50 m aspirator status	T/F	-
135	2 m aspirator status	T/F	-
136	21X battery voltage status	T/F	-
137	80 m turbulence intensity	PARM(10) = T	138
139	50 m turbulence intensity	PARM(16) = T	140
141	20 m turbulence intensity	PARM(22) = T	142
143	10m turbulence intensity	PARM(28) = T	144
145	5 m turbulence intensity	PARM(34) = T	146
147	2 m turbulence intensity	PARM(40) = T	148
149	2 m relative humidity	PARM(64)=PARM(60)=PARM(58)=T	150
151	2-50 m Richardson number	PARM(64)=PARM(68)=PARM(60)= PARM(58)=PARM(10)=PARM(16)= PARM(22)=PARM(28)=PARM(34)= PARM(40)=T	152
153	50-80 m Richardson number	PARM(62)=PARM(66)=PARM(60)= PARM(58)=PARM(10)=PARM(16)= PARM(22)=PARM(28)=PARM(34)= PARM(40)=T	154
155	2-80 m Richardson number	PARM(62)=PARM(64)=PARM(60)= PARM(66)=PARM(68)=PARM(58)= PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)=T	156
157	friction velocity $u_*$	PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)= PARM(162)=T	158
159	surface roughness	PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)= PARM(162)=T	290

161	$u_*$ quality control $r^2$	PARM(161) > 0.50 = T	162
163	2-80 m mean power law coefficient	PARM(10)=PARM(16)=PARM(22)= PARM(28)=PARM(34)=PARM(40)=T	164

## **APPENDIX G**

**FORTRAN-90 Compliant Source Code Listings for**

**THERMODYNAMICS**

**RICH\_NO**

**BLPARMS**

**Subroutines**



# SUBROUTINE THERMODYNAMICS

-----

SUBROUTINE THERMODYNAMICS TO COMPUTE THE VIRTUAL POTENTIAL TEMPERATURES AT THE 2, 50, AND 80 METER ELEVATIONS ON THE M2 AND M3 METEOROLOGICAL TOWERS. THE ROUTINE USES MEASUREMENTS OF DRY-BULB AND DEWPOINT TEMPERATURES AND BAROMETRIC PRESSURE AT THE 2 METER LEVEL PLUS THE DRY-BULB TEMPERATURE AT 50 METERS AND 50-2 and 80-50 METER TEMPERATURE DIFFERENCES.

THE ROUTINE USES THE MEASURED VALUE OF THE DEWPOINT TEMPERATURE AT THE 2 METER ELEVATION TO APPLY TO ESTIMATES OF VIRTUAL TEMPERATURES AT THE 50 AND 80 METER ELEVATIONS FROM WHICH THE BAROMETRIC PRESSURE AT THESE HEIGHTS IS ESTIMATED AND THE VIRTUAL POTENTIAL TEMPERATURES AT EACH DERIVED. IF THE DEWPOINT IS NOT PRESENT OR IN ERROR, DRY AIR THERMODYNAMICS ARE INVOKED.

WRITTEN BY: N.D. Kelley, NREL/NWTC - 970814

MODIFICATION HISTORY:

990526- Some recoding, variable name modifications and documentation, no changes to basic program logic or equations, now F90 compliant. NDK

INPUT VARIABLES:

AT2	Dry-bulb air temperature at 2 m level,	deg C
AT50_o	Observed dry-bulb air temperature at 50m level	deg C
DTL	50-2M temperature difference (Delta_T)	deg C
DTH	80-50m temperature difference	deg C
BP	Barometric pressure at 2 m level	hPa
DPT	Dewpoint temperature at 2 m level	deg C
ErrVal	Error value	-

INTERNAL VARIABLES:

AT80	Calculated 80m dry-bulb temperature, AT50+ DLH	deg C
BP50	Calculated barometric pressure at 50 m	hPa
BP80	Calculated barometric pressure at 80 m	hPa
VT2	Virtual temperature at 2 m	deg K
E	Vapor pressure at 2 m	hPa
ES	Saturation vapor pressure at 2 m	hPa
SPHUM	Specific humidity at 2 m	-
A,B	Tetens Equation constants	-
DELPCHG	Calculated change in baro pressure w/height	hPa/m

OUTPUT VARIABLES:

AT50_c	Calculated 50m dry-bulb temperature, AT2 + DTL	deg C
RH	Relative humidity at 2 m level	percent

```

C          VPT2          Virtual potential temperature at 2 m          deg K
C          VPT50         Calculated virtual potential temperature at 50m deg K
C          VPT80         Calculated virtual potential temperature at 80m deg K
C
C

```

```

SUBROUTINE THERMODYNAMICS(AT2,AT50_o,AT50_c,AT80,DTL,DTU,DPT,
&                          BP,RH,VPT2,VPT50,VPT80,ErrVal)
IMPLICIT NONE
REAL AT2,AT50_o,AT50_c,AT80,DPT,BP,RH,E,ES,VPT2,VPT50,VPT80,
&    VT2,A,B,SPHUM,BP50,BP80,DELPCHG,DTL,DTU,
&    ErrVal

```

```

C          Check & obtain values of AT50 and AT80 from observed value
C          of AT50 (AT50_o) and calculated from AT2 + DeltaT

```

```

IF(DTL.GT.ErrVal .AND. AT2.GT.ErrVal) THEN
    AT50_c = AT2 + DTL
ELSE
    AT50_c = ErrVal
ENDIF

IF(DTU.GT.ErrVal .AND. AT50_o.GT.ErrVal) THEN
    AT80 = AT50_o + DTU
ELSEIF (DTU.GT.ErrVal .AND. DTL.GT.ErrVal .AND. AT2.GT.ErrVal)
& THEN
    AT80 = AT50_c + DTU
ELSE
    AT80 = ErrVal
ENDIF

```

```

C          Check to see if either DPT or AT2 is out-of-service (ErrVal)

```

```

IF(DPT.LE.ErrVal .OR. AT2.LE.ErrVal) THEN
    SPHUM = ErrVal
    RH = ErrVal
    GOTO 100
ENDIF

```

```

C          Check to see if DPT > AT2 and set to AT2 if it is

```

```

IF(DPT .GT. AT2) DPT = AT2

```

```

C          Calculate 2m saturation vapor pressure in hPa from
C          2m absolute air temp (C), AT2
C

```

```

IF(AT2.GE.0.) THEN
    A = 7.5
    B = 237.3
ELSE
    A = 9.5
    B = 265.5
ENDIF

```

```

      ES = 6.11*10.**((A*AT2)/(AT2+B))

C      Calculate actual vapor pressure in mb at 2m level from dewpoint
C      temp (C), DPT

      IF(DPT.GE.0.) THEN
        A = 7.5
        B = 237.3
      ELSE
        A = 9.5
        B = 265.5
      ENDIF

      E = 6.11*10.**((A*DPT)/(DPT+B))

C      Calculate relative humidity in percent at 2m level

      RH = 100.*(E/ES)
      IF (RH.GT.100.) RH=100.
      IF (RH.LT.0.) RH=0.

C      Calculate specific humidity at 2m level

      SPHUM = 0.622*(E/BP)

100 CONTINUE

C      Calculate the virtual temperature in K at 2m

      IF (SPHUM.LE.ErrVal .AND. AT2.GT.ErrVal) THEN
        VT2 = AT2+273.16
      ELSEIF (AT2.LE.ErrVal) THEN
        VT2 = ErrVal
      ELSE
        VT2 = (AT2+273.16) + 0.61*SPHUM*(AT2+273.16)
      ENDIF

C      Calculate virtual potential temperature at 2 m

      IF(SPHUM.GT.ErrVal .AND. AT2.GT.ErrVal .AND. BP.GT.ErrVal) THEN
        VPT2 = ((AT2+273.16)*(1000./BP)**0.286)*(1.+0.61*SPHUM)
      ELSEIF (SPHUM.LE.ErrVal .AND. AT2.GT.ErrVal) THEN
        VPT2 = (AT2+273.16)*(1000./BP)**0.286
      ELSE
        VPT2 = ErrVal
      ENDIF

C      Estimate the barometric pressures at the 50 and 80 meter heights

      IF(VT2.GT.ErrVal) THEN
        DELPCHG = (-0.0341416*BP)/VT2
      ELSE
        DELPCHG = -0.031
      ENDIF

```

C Estimate the barometric pressures at 50 and 80 meters

```
IF(BP.GT.ErrVal) THEN
  BP50 = BP + DELPCHG*48.
  BP80 = BP + DELPCHG*78.
ELSE
  BP50 = ErrVal
  BP80 = ErrVal
ENDIF
```

C Determine the temperatures at 80 m from AT50 + delta temp DTU

```
If(AT50_c.GT.ErrVal .AND. DTU.GT.ErrVal) THEN
  AT80 = AT50_c + DTU
ELSE
  AT80 = ErrVal
ENDIF
```

C Calculate estimated virtual potential temperature at 50 and 80 m

```
IF(AT50_c.LE.ErrVal .OR. BP.LE.ErrVal) THEN
  VPT50 = ErrVal
ELSEIF (SPHUM.LE.ErrVal) THEN
  VPT50 = (AT50_c+273.16)*(1000./BP50)**0.286
ELSE
  VPT50 = ((AT50_c+273.16)*(1000./BP50)**0.286)*(1.+0.61*SPHUM)
ENDIF
```

```
IF(AT80.LE.ErrVal .OR. BP.LE.ErrVal) THEN
  VPT80 = ErrVal
ELSEIF(SPHUM.LE.ErrVal) THEN
  VPT80 = (AT80+273.16)*(1000./BP80)**0.286
ELSE
  VPT80 = ((AT80+273.16)*(1000./BP80)**0.286)*(1.+0.61*SPHUM)
ENDIF
```

```
200 CONTINUE
RETURN
END
```

## SUBROUTINE RICH\_NO

```
C-----
C
C SUBROUTINE RICH_NO TO COMPUTE THE GRADIENT RICHARDSON NUMBER
C STABILITY PARAMETER IN THE 2 TO 50 METER, 50 TO 80 METER,
C AND 2-80 METER LAYERS.
C
C WRITTEN BY: N.D. Kelley, NREL/NWTC - 980829
C
C MODIFICATION HISTORY:
C 990528- Cleaned up code, added additional
C documentation, now F90 compliant. NDK
C
C
C REQUIRED PREVIOUS PROGRAMS: THERMODYNAMICS SUBROUTINE
C
C INPUT VARIABLES:
C
C 2,5,10,20,50,80 m mean wind speeds, WS(I=1,6), m/s
C 2 m virtual potential temperature, VPT2, deg K
C 50m virtual potential temperature, VPT50, deg K
C 80m virtual potential temperature, VPT80, deg K
C Error flag value, EV
C
C INTERNAL VARIABLES:
C
C 2-50, 50-80, 2-80 m layer mean virtual potential temps,
VPTBAR(I=1,3), deg K
C 2-50, 50-80, 2-80 m layer virtual potential gradients,
VPTGRAD(I=1,3), deg K
C 2-50, 50-80, 2-80 m layer vertical velocity shears,
USHEAR(I=1,3), 1/sec
C 2-50, 50-80, 2-80 m layer vertical velocity shears^2,
USHEAR2(I=1,3), 1/sec^2
C Layer height differences, DZ(I=1,5), m
C Gravity acceleration for NWTC Site, g, m/sec**2
C
C OUTPUT VARIABLES:
C
C 2-50, 50-80, 2-80 m layer Richardson numbers, Ri(I=1,3)
C
C
C SUBROUTINE RICH_NO(Ri,WS,VPT2,VPT50,VPT80,EV)
C IMPLICIT NONE
C REAL Ri(3),WS(6),VPT2,VPT50,VPT80,VPTBAR(3),
& VPTGRAD(3),USHEAR(3),USHEAR2(3),g,EV,DZ(5)
C INTEGER I
C PARAMETER (g=9.80169)
C DATA DZ/3.,5.,10.,30.,30./
C
C Check for valid input data
```

```

DO 10 I=1,6
  IF(WS(I).LE.EV) GOTO 100
10 CONTINUE

IF(VPT2.LE.EV .OR. VPT50.LE.EV .OR. VPT80.LE.EV) GOTO 100

c Calculate mean 2-50m vertical shear,USHEAR(1), using 2, 5, 10, 20, & 50 m
levels

USHEAR(1) = 0.
DO 15 I=1,4
  USHEAR(1) = USHEAR(1) + (WS(I+1)-WS(I))/DZ(I)
15 CONTINUE
USHEAR(1) = USHEAR(1)/4.
USHEAR2(1) = USHEAR(1)*USHEAR(1)
IF(USHEAR2(1).EQ.0.) USHEAR2(1)=1.E-04

c Calculate mean 50-80m vertical shear, USHEAR(2), using 50 and 80 m levels

USHEAR(2) = 0.
USHEAR(2) = (WS(6) - WS(5))/DZ(5)
USHEAR2(2) = USHEAR(2)*USHEAR(2)
IF(USHEAR2(2).EQ.0.) USHEAR2(2)=1.E-04

C Calculate mean 2-80m vertical shear, USHEAR(3), using 6 levels of wind
speed

USHEAR(3) = 0.
DO 20 I=1,5
  USHEAR(3) = USHEAR(3) + (WS(I+1)-WS(I))/DZ(I)
20 CONTINUE
USHEAR(3) = USHEAR(3)/5.
USHEAR2(3) = USHEAR(3)*USHEAR(3)
IF(USHEAR2(3).EQ.0.) USHEAR2(3)=1.E-05

C Calculate 2-50m, 50-80m, and 2-80m layer mean virtual potential temps

VPTBAR(1) = (VPT2 + VPT50)/2.
VPTBAR(2) = (VPT50 + VPT80)/2.
VPTBAR(3) = (VPTBAR(1) + VPTBAR(2))/2.

C Calculate 2-80m, 50-80m, and 2-80m layer mean vertical virt potential
temp C gradients

VPTGRAD(1) = (VPT50 - VPT2)/48.
VPTGRAD(2) = (VPT80 - VPT50)/30.
VPTGRAD(3) = (VPTGRAD(1) + VPTGRAD(2))/2.

C Calculate Ri's: 2-50m Ri(1); 50-80m Ri(2); 2-80m Ri(3)

DO 30 I=1,3

  Ri(I) = (g/VPTBAR(I))*(VPTGRAD(I)/USHEAR2(I))

```

```
C      Limit Ri's to +/- 10

        IF((Ri(I)). GT. 10.) Ri(I) =  10.
        IF((Ri(I)). LT. -10.) Ri(I) = -10.

30 CONTINUE

      RETURN

100 Ri(1) = EV
    Ri(2) = EV
    Ri(3) = EV

      RETURN
      END
```

## SUBROUTINE BLPARMS

```
C-----
C
C SUBROUTINE BLPARMS TO COMPUTE ESTIMATES OF FRICTION VELOCITY
C u* (Ustar) AND ROUGHNESS LENGTH, Zo, AND MEAN POWER LAW
C COEFFICIENT FOR 2-80 M LAYER
C
C WRITTEN BY: N.D. Kelley, NREL/NWTC - 970814
C
C MODIFICATION HISTORY:
C           980829- Added 2-50m Ri to argument list in order
C                   to set Zo to EV when > 1.0 m AND 2-50m
C                   Ri is +/- 10
C
C           990528- Cleaned up code, now F90 compatible
C
C INPUT VARIABLES:
C           2,5,10,20,50,80 m mean wind speeds, WS(I=1,6), (m/s)
C           2-50m Richardson number, Ri
C           Error Value, EV
C
C INTERNAL VARIABLES:
C           2-5,5-10,10-20,20-50,50-80m Pwr Law Coefs, PC(I=1,5)
C           Measurement elevations (2,5,10,20,50,80m), Z(I=1,6)
C           Slope of wind speed vs ln(z) curve, SLOPE
C
C OUTPUT VARIABLES:
C           Friction velocity,u*,estimate, Ustar, (m/s)
C           Surface roughness length estimate, Zo, (m)
C           2-80m mean power law coefficient, PCBAR
C           Lin-log regression correlation coef, USqc
C
C SUBROUTINE BLPARMS(WS,Ustar,Zo,PCBAR,R,Ri,EV)
C IMPLICIT NONE
C REAL WS(6),Z(6),Ustar,Zo,PC(5),Zmax,Umax,SLOPE,R,
C &    DEV,EV,PCBAR,Ri
C INTEGER NLVLS,NSHRL,Nmax,I
C DATA Z/2.,5.,10.,20.,50.,80./
C DATA NLVLS/6/
C
C Establish value of maximum profile wind speed
C
C Umax = -999.
C DO 10 I=1,NLVLS
C   IF(WS(I) .LT. Umax) GO TO 10
C   Umax = WS(I)
C   Zmax = Z(I)
C   Nmax = I
C 10 CONTINUE
C
C IF (Zmax .GT. Z(1)) GOTO 15
```



```

C      Maximum wind speed at lowest measurement level, cannot
C      determine Ustar and Zo

      Ustar = EV
      Zo    = EV
      GOTO 100

C      Maximum of profile above lowest measurement level,
C      estimate Ustar and Zo parameters

15 CALL LINLOG(Nmax,WS,Z,0.,SLOPE,Zo,R,Dev,EV)
   IF (SLOPE.GT.EV) THEN
       Ustar = 0.4/SLOPE
       Zo    = EXP(Zo)

C      Check reality of results

       IF(Ustar .LT. 0.01) Ustar = EV
       IF(Zo .LT. 0.001) Zo = EV
       IF(Zo .GT. 1.00 .AND. ABS(Ri).EQ. 10.) Zo = EV

   ELSE
       Ustar = EV
       Zo    = EV
       GOTO 100
   ENDIF

C      Calculate power law exponents for the 2-5, 5-10, 10-20, 20-50,
C      and 50-80 m levels and form the 2-80 m average

C      Estimate the power law coef below lowest anemometer

100 PCBAR = 0.
    NSHRL = 0

C      Calculate power law coefs for 5 layers

    DO 25 I=2,NLVLS
        IF((WS(I)/WS(I-1)) .GT. 0.) GOTO 20
        PC(I) = EV
        NSHRL = NSHRL + 1
        GOTO 25

20    PC(I-1) = ALOG(WS(I)/WS(I-1)) / ALOG(Z(I)/Z(I-1))
        PCBAR = PCBAR + PC(I-1)

25    CONTINUE
        PCBAR = PCBAR / (NLVLS-NSHRL-1)

200 RETURN
    END

```

```

C
C*****
C ROUTINE TO CALCULATE SLOPE (ka/u*) AND INTERCEPT (zo) FROM *
C LIN-LN OR U VS LN(Z) WIND PROFILE INCLUDING DIABATIC BIAS *
C TERM. *
C*****
C
C SUBROUTINE LINLOG TO FIT A LOG (Ln) PROFILE TO A WIND
C PROFILE DEFINED BY N LEVELS OF MEAN WIND SPEED.
C
C WRITTEN BY: N.D. Kelley, NREL/NWTC - 980829
C
C MODIFICATION HISTORY:
C          990528- Cleaned up code and added
C                  additional documentation
C                  now F90 compliant. NDK
C
C INPUT VARIABLES:
C
C   n      =  number of measurement heights (levels)
C   x      =  linear axis (mean wind speed), u(I=1,n)
C   z      =  linear height of wind speeds, z(I=1,n)
C   zbias  =  diabatic bias term (if used)
C   EV     =  Error Value value
C
C INTERNAL VARIABLES:
C
C   y      =  ln(z), y(I=1,6)
C   denom  =  expression denominator
C   xsum   =  temporary summing variable
C   ysum   =  temporary summing variable
C   x2sum  =  temporary square summing variable
C   y2sum  =  temporary square summing variable
C   xysum  =  temporary summing variable
C   ydev2  =  (observed - fitted deviation)^2
C
C OUTPUT VARIABLES:
C
C   slope  =  log-lin line (log wind profile) slope
C   b      =  line intercept on ln(z) axis (Zo)
C   r      =  correlation coefficient
C   ydev   =  sqrt(ydev2)
C
C
C   subroutine linlog(n,x,z,zbias,slope,b,r,ydev,EV)
C   implicit none
C   real x,y,z,zbias,slope,b,r,ydev,ydev2,EV,denom,
C   &      xsum,ysum,x2sum,y2sum,xysum,zbias
C   integer n,i
C   dimension x(n),y(6),z(n)
C
C Initialize sums
C
C   xsum = 0.
C   ysum = 0.
C   x2sum = 0.

```

```

y2sum = 0.
xysum = 0.
ydev = 0.
ydev2 = 0.
do 25 i=1,n
    y(i) = alog(z(i)) - zbias
    xsum = xsum + x(i)
    ysum = ysum + y(i)
    x2sum = x2sum + x(i)*x(i)
    y2sum = y2sum + y(i)*y(i)
    xysum = xysum + x(i)*y(i)
25  continue
denom = n*x2sum - xsum*xsum
if(denom.ne.0.) go to 50
    slope = EV
    b      = EV
    r      = EV
    ydev2 = EV
go to 100
50  slope = (n*xysum - xsum*ysum)/denom
    b      = (ysum*x2sum - xsum*xysum)/denom
    r      = (n*xysum-xsum*ysum)/sqrt((n*x2sum-xsum*xsum)*
&      (n*y2sum-ysum*ysum))
if(abs(r).gt.1.) r=1.
do 75 i=1,n
    ydev2 = ydev2 + (y(i) - slope*x(i)-b)**2
75  continue
ydev = exp(sqrt(ydev2))
100 return
end

```

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