MTI true color image

Final MTI Data Report: Pilgrim Nuclear Station (U)

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

August 2002

Prepared for the U. S. Department of Energy under contract no. DE-AC09-96SR18500

Final MTI Data Report: Pilgrim Nuclear Station (U)

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INTRODUCTION

During the period from May 2000 to September 2001, ocean surface water temperature data was collected at the Pilgrim Nuclear Power Station near Plymouth, MA (Figure 1). This effort was led by the Savannah River Technology Center (SRTC) with the assistance of a local sub-contractor, Marine BioControl Corporation of Sandwich, MA. Permission for setting up the monitoring system was granted by Entergy Corporation, which owns the plant site. This work was done in support SRTC's ground truth mission for the US Department of Energy's Multispectral Thermal Imager (MTI) satellite (Garrett, et al, 1999). Data described in this report are available from the authors (contact information provided at the end of report).

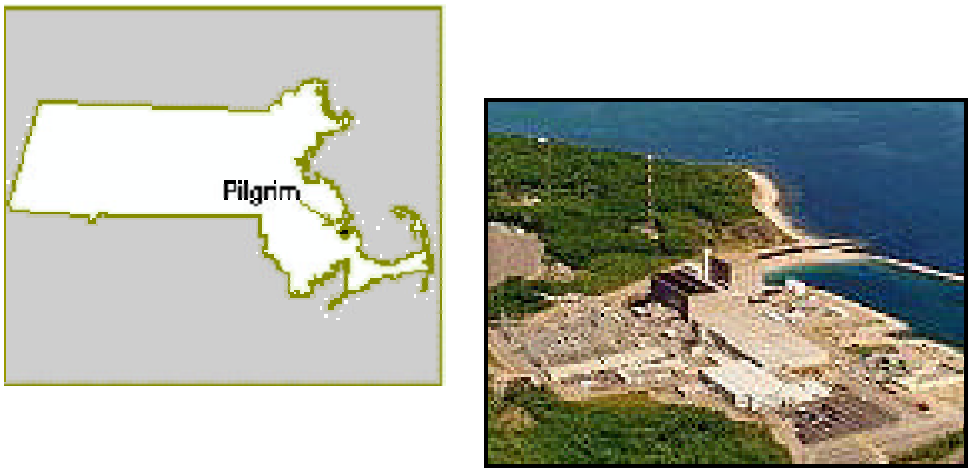

Figure 1. The Pilgrim Nuclear Power Station near Plymouth, MA.

SURFACE WATER TEMPERATURE MEASUREMENTS

Six monitoring long-term monitoring sites are shown as letters A through F in Figure 2. Sites A and B were located in the partially protected plant water intake bay. Sites C, D, and E were located in the open Atlantic Ocean, a short distance beyond the warm-water discharge where site F was located. The general reasoning behind the selection of these sites was to obtain data that captured the greatest temperature extremes near the plant (intake and discharge) and the location of the warm-water discharge plume in the Atlantic Ocean.

Data described in this report are available from the authors.

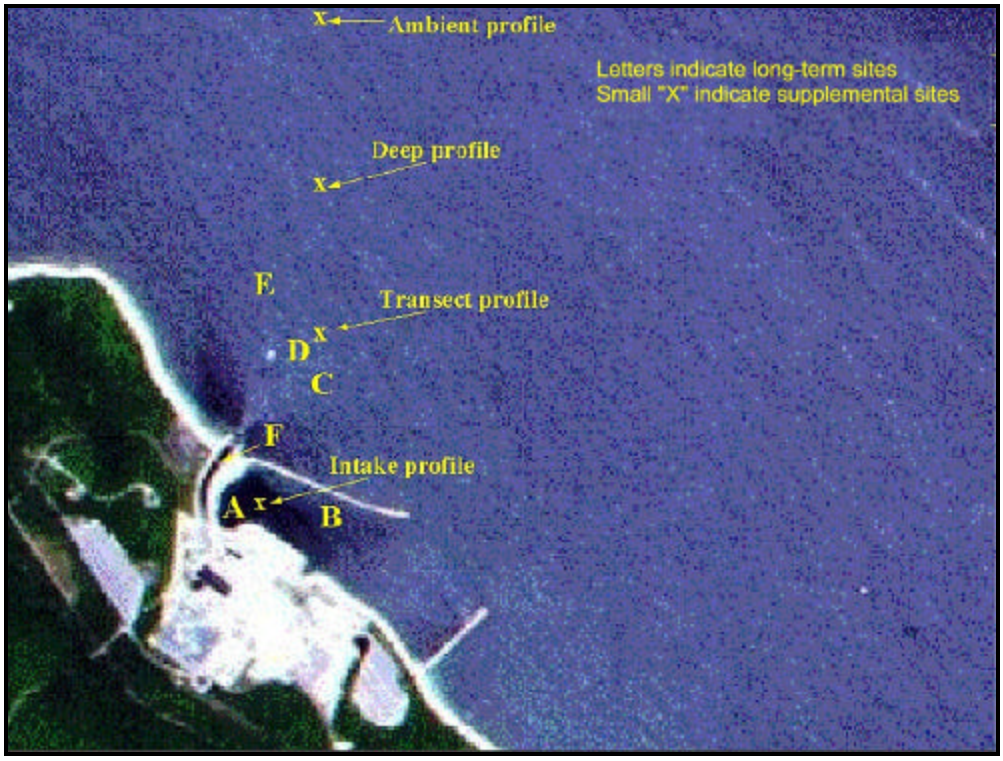

Figure 2. Monitoring site locations.

Temperature measurements were made with the StowAway® TidbiT® (Figure 3) manufactured by Onset Computer (www.onsetcomputer.com). The sensors used for surface water measurements (Sites A, B, C, D and E) were suspended approximately 30 cm below (Figures 4 and 5) anchored buoys (Figure 5). Similarly, the sensors used for the supplemental profile measurements were attached to anchor mooring line at various depths (see Table I). Measurements taken at Site F were made by attaching a protective case with the TidbiT® to a permanent steel beam within the discharge canal.

Figure 3. The StowAwayÒ TidbiTÒ (front view, left, and rear view, right).

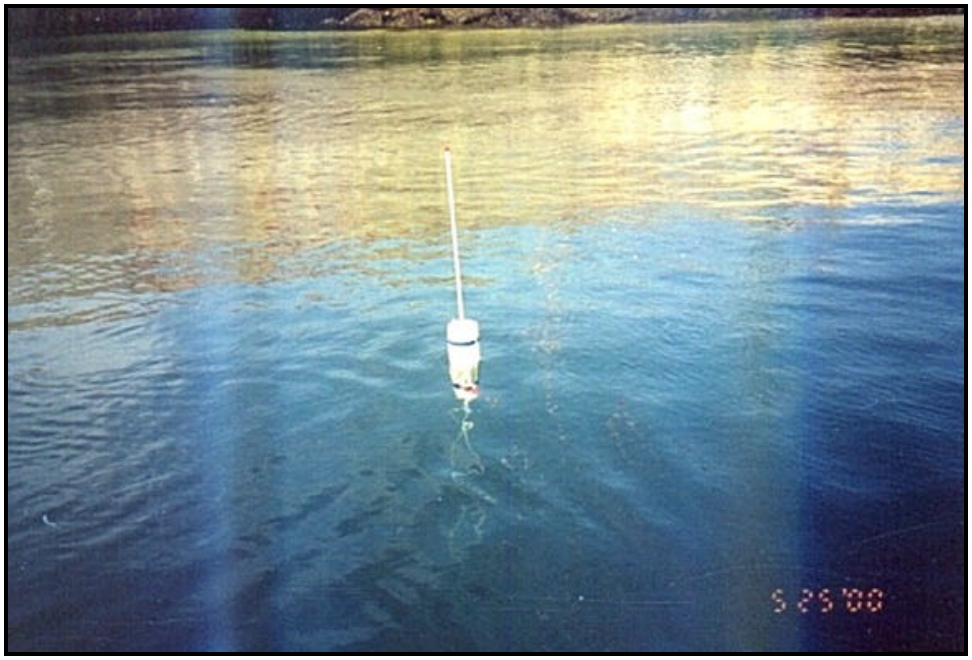

Figure 4. TidbiTÒ suspended below buoy.

Figure 5. Deployed buoy (near intake at Site A).

Supplemental data were collected at four additional sites, shown as "x" in Figure 2, over the period from mid-August 2001 to early September 2001. The objective was to collect temperature data at different depths, or profiles, within the water intake bay ("Intake" profile), near site "D" ("Transect" profile), just beyond site "D" ("Deep" profile), and at a site ("Ambient" profile) presumably unaffected by the warm-water discharge and well beyond the other sites. Measurement depths ranged from just a few centimeters below the water's surface down to the ocean bottom. Part of this period occurred when the plant was not operating and continued when the plant was restarted. Coordinates for all monitoring sites are provided in Table I.

Table I. Coordinates for Monitoring Sites

Site	Coordinates (WGS-84)
A	N 41° 56.76', W 70° 34.75'
B	N 41° 56.77', W 70° 34.62'
C	N 41° 56.91'. W 70° 34.63'
D	N 41° 56.95', W 70° 34.68'
E	N 41° 56.98', W 70° 34.73'
F	N 41° 56.801', W 70° 34.780'
Intake profile	N° 41 56.762', W° 70 34.704'
Transect profile	N° 41 56.948', W° 70 34.676'
Deep profile	N° 41 57.068', W° 70 34.675'
Ambient profile	N° 41 57.313', W° 70 34.739'

Additionally, Pilgrim personnel supplied plant operating and meteorological data for the entire period of study. These data were merged with the water temperature data and are stored in a spreadsheet (see the "Data Description" section of this document).

TIME STAMPS

Data were collected with time stamps corresponding to local Eastern (Standard or Daylight) Time. Time stamps associated with the Tidbits® were used as the time stamp for all data. Given this requirement, the meteorological and plant operating data that most closely corresponded with the time stamp of the Tidbit® data were

merged as though they had an identical time stamp. In the majority of cases, the actual difference between the various data types was less than 10-15 minutes making relevant comparisons appropriate.

Plant operating data were sub-sampled to correspond to the water temperature data, and the meteorological data are reported as hourly averages.

DATA DESCRIPTION

The following table summarizes the headings in the file called QA_Pfull.xls (available from the authors), which contains surface water temperature data, meteorological data, and plant operating data.

Table II. Description of Data Nomenclature

SURFACE WATER TEMPERATURES

Name	Description (All temperatures °C)
A	Surface water temperature at location A near the plant water intake
B	Surface water temperature at location B to the northeast of the plant intake but within the protected area
C	Surface water temperature at location C to the southeast of the discharge flow into the open ocean
D	Surface water temperature at location D to the east of the dis charge flow into the open ocean
E	Surface water temperature at location E to the northeast of the discharge flow into the open ocean
F	Discharge water temperature at location F in the plant discharge canal

HOURLY METEOROLOGICAL DATA

Name	Description
WD220	Wind direction (degrees) at 220 ft
WS220	Wind speed (mph) at 220 ft
WD220/33	Wind direction (degrees) at 33 ft on the 220 ft tower
T220/33	Temperature (°F)at 33 ft on the 220 ft tower
DELTA220	Temperature difference (Delta-T) (°F)on the 220 ft tower
WD160	Wind direction (degrees) at 160 ft
WS160	Wind speed (mph) at 160 ft

HOURLY METEOROLOGICAL DATA

Name	Description
WD220	Wind direction (degrees) at 220 ft
WS220	Wind speed (mph) at 220 ft
WD220/33	Wind direction (degrees) at 33 ft on the 220 ft tower
WS220/33	Wind speed (mph) at 33 ft on the 220 ft tower
T220/33	Temperature (°F)at 33 ft on the 220 ft tower
DELTA220	Temperature difference (Delta-T) (°F)on the 220 ft tower
WD160	Wind direction (degrees) at 160 ft
WS160	Wind speed (mph) at 160 ft
WD160/33	Wind direction (degrees) at 33 ft on the 160 ft tower
WS160/33	Wind speed (mph) at 33 ft on the 160 ft tower
T160/33	Temperature (°F)at 33 ft on the 160 ft tower
DELTA160	Temperature difference (Delta-T) (°F) on the 160 ft tower

PLANT OPERATING DATA READINGS

Name	Description
C003T	Reactor power (MW)
C017T	Reactor power (MW)
CWS002	Inlet temperature (°F)
CWS004	Inlet temperature (°F)
CWS006	Discharge temperature (°F)
CWS008	Discharge temperature (°F)
CWS518	Reactor operating status (RUN/OFF)
CWS520	Reactor operating status (RUN/OFF)

SUPPLEMENTAL WATER TEMPERATURE DATA

Name	Description (All temperatures °C)
A10cm	"Ambient" profile at the 10 cm level
A3m	"Ambient" profile at the 3 m level
A5.5m	"Ambient" profile at the 5.5 m level
A8m	"Ambient" profile at the 8 m level
A10.5m	"Ambient" profile at the 10.5 m level
A13m	"Ambient" profile at the 13m level (on the sea floor)
DP10cm	"Deep Profile" at the 10 cm level
DP1.5m	"Deep Profile" at the 1.5 m level
DP3m	"Deep Profile" at the 3 m level
DP4.5m	"Deep Profile" at the 4.5 m level
DP6m	"Deep Profile" at the 6 m level
DP7.5m	"Deep Profile" at the 7.5 m level
DP9m	"Deep Profile" at the 9 m level
DP10.5m	"Deep Profile" at the 10.5 m level
I10cm	"Intake" profile at the 10 cm level
I1.5m	"Intake" profile at the 1.5 m level
I3m	"Intake" profile at the 3 m level
I4.5m	"Intake" profile at the 4.5 m level
I6m	"Intake" profile at the 6 m level
I7.5m	"Intake" profile at the 7.5 m level
I9m	"Intake" profile at the 9 m level
TD10cm	"Transect" profile near the D-buoy at the 10 cm level
TD1m	"Transect" profile near the D-buoy at the 1 m level
TD2m	"Transect" profile near the D-buoy at the 2 m level
TD3m	"Transect" profile near the D-buoy at the 3 m level
TD4m	"Transect" profile near the D-buoy at the 4 m level
TD5m	"Transect" profile near the D-buoy at the 5 m level
TD6m	"Transect" profile near the D-buoy at the 6 m level
TD7m	"Transect" profile near the D-buoy at the 7 m level
TD8m	"Transect" profile near the D-buoy at the 8 m level

QUALITY ASSURANCE

Data quality assurance was performed on all surface water temperature measurements. The first source of identifying unusable data was via a maintenance log kept by Marine BioControl. Then, time series plots of data were reviewed for obvious outliers or other problematic data. Problematic data were deleted and appear as blanks within the data files. Another source of missing (blank) data occurred during the March 3-20, 2001 period when the A, B, C, D, and E sensors were removed due an approaching nor'easter.

EXAMPLE DATA PLOTS

The following figures (6-12) show examples of data plotted from the quality assured spreadsheet (QA_Pfull.xls). Items of interest are noted on the plots.

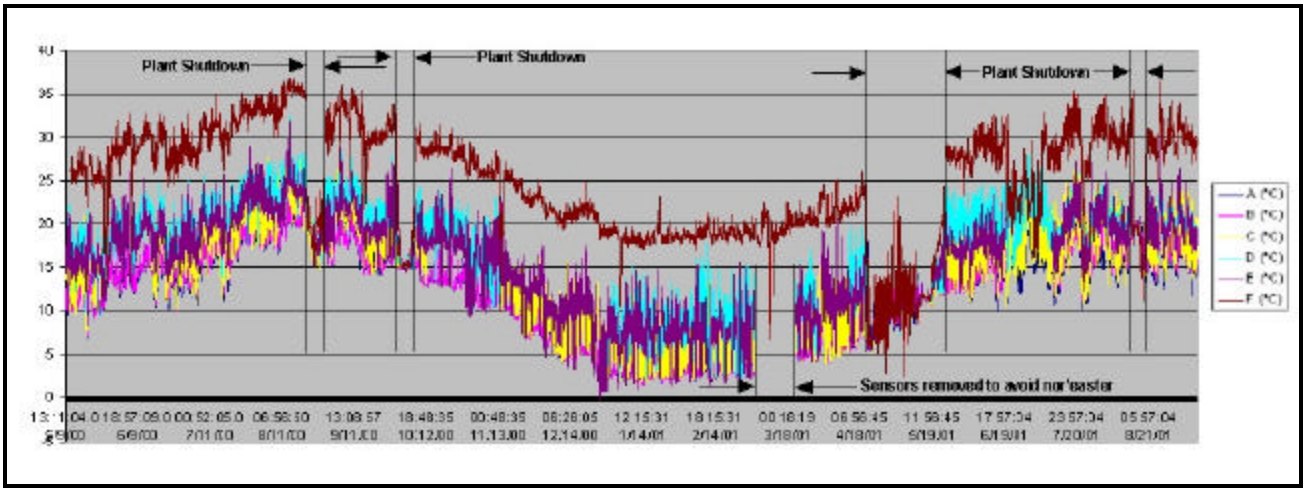

Figure 6. Time series plot of water temperature data collected during the May 2000-September 2001 period.

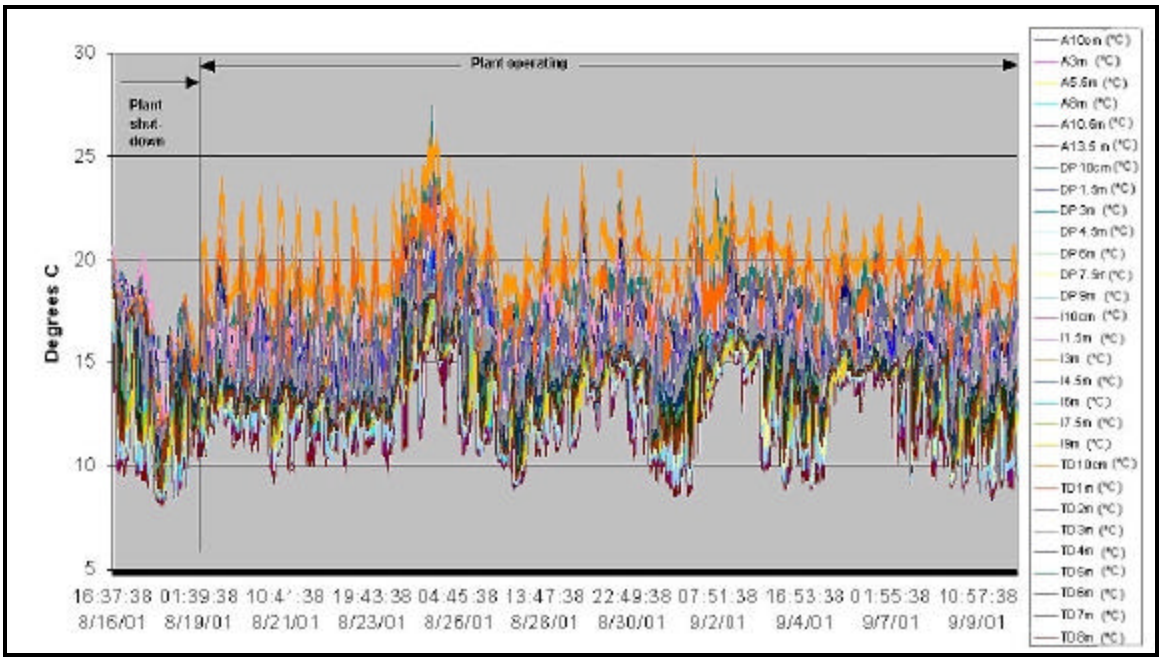

Figure 7. Supplemental water temperature measurements during the August-September, 2001 period. Note the differences between the period when power was not being generated (near the beginning of the plot) and the period when the plant was generating power.

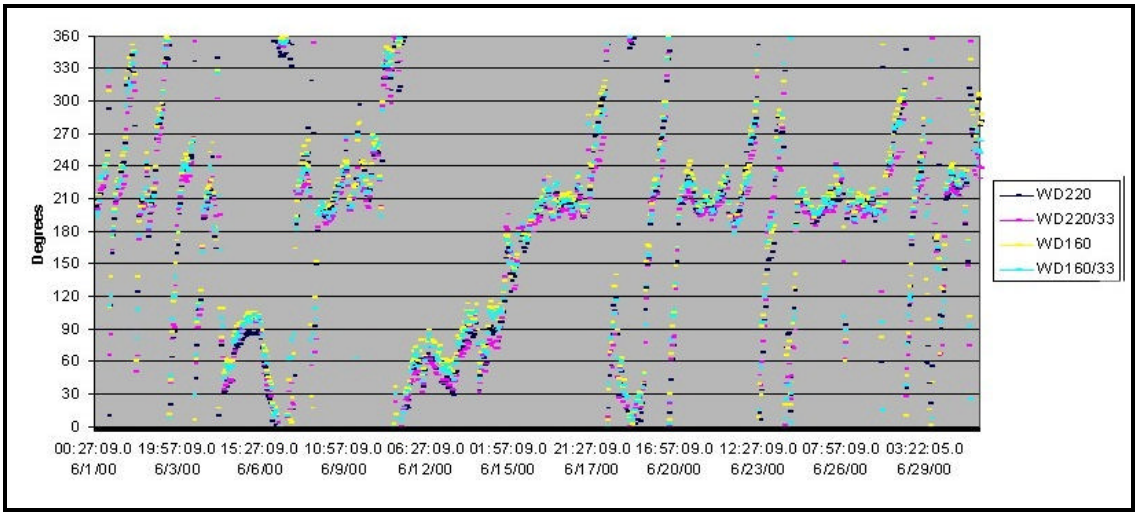

Figure 8. Example of wind direction data collected at 220 ft and 33 ft on Pilgrim's 220 ft tower and at 160 ft and 33 ft on Pilgrim's 160 ft tower. Data are from June 2000.

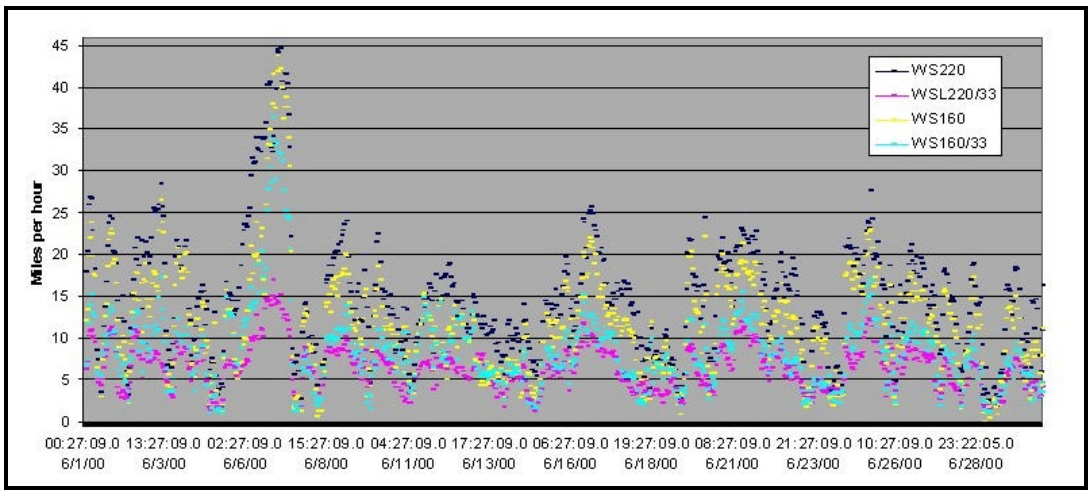

Figure 9. Example of wind speed data collected at 220 ft and 33 ft on Pilgrim's 220 ft tower and at 160 ft and 33 ft on Pilgrim's 160 ft tower. Data are from June 2000.

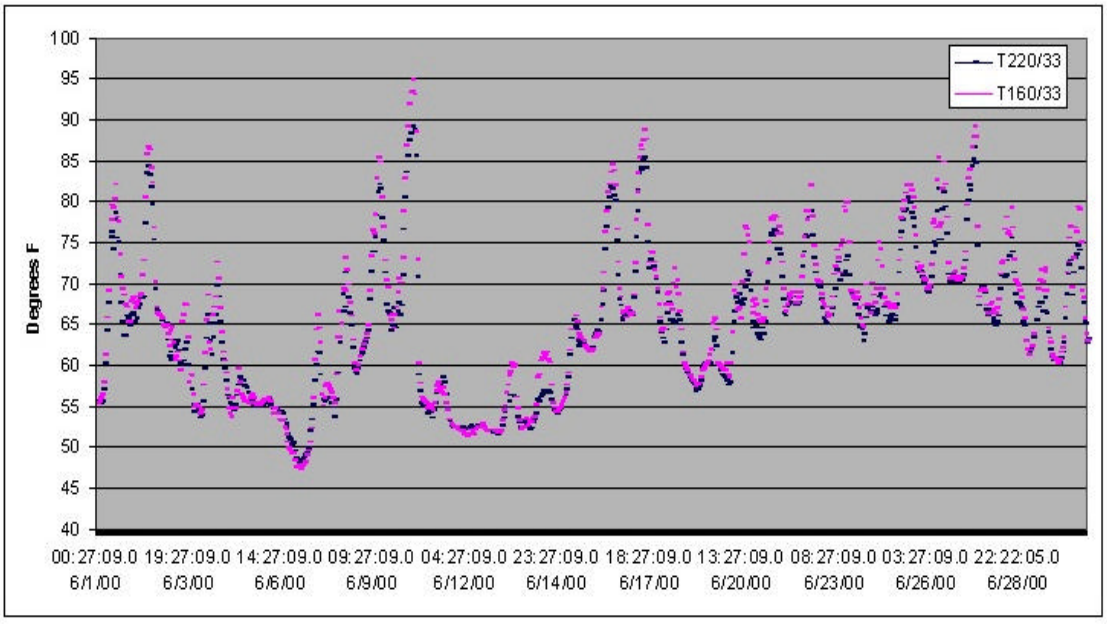

Figure 10. Example of air temperature data collected at 33 ft on Pilgrim's 220 ft and 160 ft tower sites in June 2000.

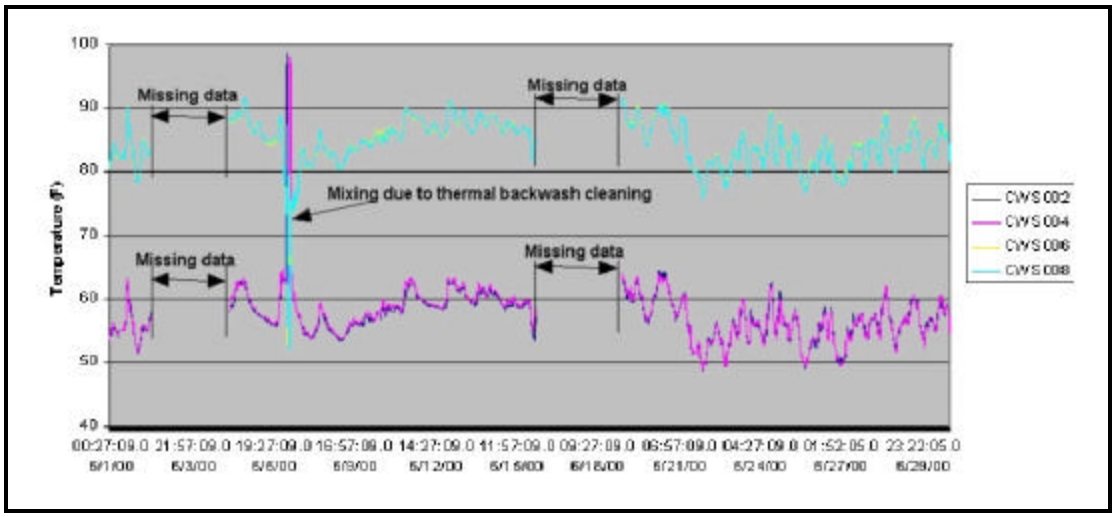

Figure 11. Example of plant water intake and outfall temperatures for June 2000. Note the mixing that occurred during the thermal-backwash cleaning event on June 7, 2000.

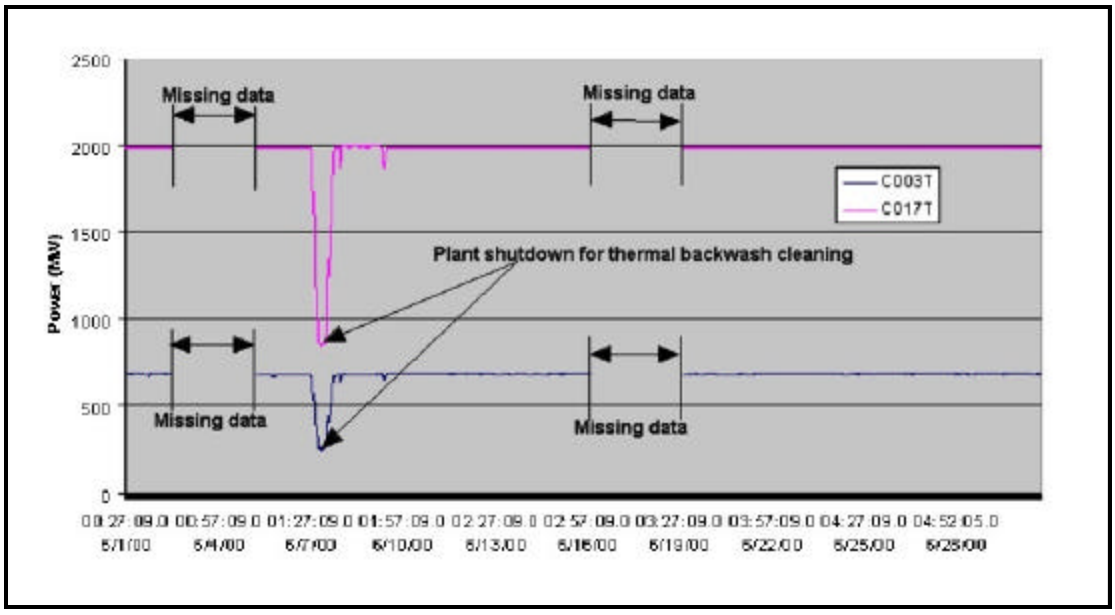

Figure 12. Example of plant power data for June 2000. Note the brief shutdown during the thermal-backwash cleaning event on June 7, 2000.

ACKNOWLEDGEMENTS

of Sandwich, MA for their tireless work in obtaining water temperature data and to Ken Sejkora of Entergy for providing plant operating and meteorological data. Thanks also to Kuo-Fu Chen of SRTC for assisting with data quality assurance.

REFERENCES

Villa-Aleman, 1999: Ground-Truth Measurements Plan for the Multispectal Thermal Imager (MTI) Satellite. WSRC-TR-99-00455. Westinghouse Savannah River Company, Aiken, SC.