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Comparison of Model Predictions and Consumptive Water Use of Closed Cycle Cooling Systems

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EPA REVIEW NOTICE

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Comparison of Model Predictions and Consumptive Water Use of Closed Cycle Cooling Systems

by

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ABSTRACT

The objectives of this project conducted by Versar, Inc. were: (1) to survey, verify, and calibrate, if necessary, simple generic cooling system evaporation computer models and (2) to compare water evaporation predictions made by cooling tower and cooling pond/lake models in the same water resource region. Models were to be identified that accurately predict evaporation rates within ±15 percent of actual operation. Seven water resource regions were included in the study. The project was conducted from the fall of 1977, through the summer of 1979.

The following conclusions were drawn from this study:

- The Leung and Moore cooling tower model generally predicted evaporation rates within ±15 percent of mass balance calculated evaporation rates, (i.e., evaporation = makeup - blowdown - drift), for cooling towers on baseload power plants. However, the model tended to overpredict evaporation rates for cooling towers on power plants with low capacity factors. It was assumed that the average make-up and blowdown flow rates provided by the utilities were accurate representations of cooling tower operation. These data served as the basis for testing the accuracy of computer model predictions.
- The Harbeck-Koberg-Hughes model (Lake Colorado City study) and the Meyer model produced the best results for predicting cooling pond/lake evaporation when compared to water balance calculations using field data. Both models generally predicted rates with a ±15 percent accuracy.

- Evaporation rates normalized per surface area were quite consistent with all the cooling pond/lake models' results. Summer evaporation rates between .067-.073 cu m/min-ha (0.027-0.030 cu m/min-acre) were found for all lakes and ponds studied. Annual values were about 0.04-0.05 cu m/min-ha (0.02 cu m/min-acre) for cooling ponds/lakes in southern locations and 0.03-0.04 cu m/min-ha (0.012-0.015 cu m/min-acre) for northern region ponds/lakes. Results from all models showed that natural evaporation is between 30-80 percent of total evaporation, depending upon location, time of year and power plant load.

- Cooling ponds/lakes generally evaporate more water than cooling towers. This relationship was true for all regional comparisons where the cooling pond/lake area per unit power (ha/MW) ratio was greater than 0.6 and the differences increased as the ratio increased.

- For use as simple, generic cooling system models, we would recommend the Leung and Moore model for cooling towers and the Meyer model or Harbeck-Koberg-Hughes model for cooling ponds/lakes.

- The results presented in the Espey, Huston & Associates, Inc. (EH&A) study show cooling ponds/lakes consume less water than cooling towers. This study indicates that cooling ponds/lakes evaporate more water than cooling towers. Differences in conclusions drawn by both studies were due mainly to the EH&A definition of consumptive water use which includes a credit term for rainfall runoff added to the pond/lake. This rainfall runoff term causes a significant decrease in predicted consumptive water use as compared to predicted evaporation rates.

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ACKNOWLEDGMENTS

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SECTION 1

INTRODUCTION

This project was initiated through the Industrial Environmental Research Laboratory of the EPA Office of Research and Development at Research Triangle Park, North Carolina. This is one of several projects supported by the laboratory to assist EPA's updating of effluent guidelines for the steam-electric generating industry.

As a part of this updating, the EPA evaluated models that predict the site specific water evaporation caused by steam-electric generating plants. The first step in this evaluation was to survey and analyze existing simple, generic computer models that predict evaporative losses from power plant closed-cycle cooling systems.

The second phase of the program was to verify and calibrate, if necessary, the simple and generic cooling system evaporation models selected earlier. The third phase of the program was to compare water evaporation from closed cycle cooling ponds/lakes and towers on a regional basis and to provide a simple regional classification.

Five tasks were performed to satisfy the requirements of this project. The first task was to obtain actual operating data on cooling towers and cooling ponds/lakes at representative steam-electric power plants. The type of data requested provided input to cooling system models and allowed calculation of water balances around the cooling system. The information obtained from the utilities was used as received, unless it appeared to be inconsistent or questionable. In such cases, the utility was contacted for verification of its data. Because of time constraints, only data from power plants in five water resource regions were obtained. The seven regions were the Upper Mississippi, Ohio, Mid Atlantic, South Atlantic-Gulf, Texas Gulf, Rio Grande and Lower Colorado.

The second task used the actual operating data to test the accuracy of the simple, generic models selected. Model prediction evaluations involved comparison of model results with mass balance calculations of evaporation rates or evaporation values provided by the utilities themselves. The percent deviation of computer-predicted values from given or mass balance-calculated values was determined and any major deviations were analyzed to determine possible causes.

Since a major tool in causal determinations is sensitivity analysis, the third task was to perform sensitivity analyses on the parameters within the cooling models. Cooling pond/lake model sensitivity analyses were performed using data on pond temperature, plant heat rejection rate and load factor. Sensitivity analyses were also conducted for the mechanical draft cooling tower model.

For the fourth task, a comparison was made of evaporation from power plant cooling towers and ponds/lakes in the same water resource region. The comparisons were performed on annual, seasonal and monthly time periods. To eliminate size and efficiency differences between power plants, the evaporation values were compared on a per MWe (unit power output) and kcal/hr (heat rejection rate) basis. In addition, cooling pond/lake evaporation rates were compared on a unit area and area/MWe basis.

The final task involved comparing the evaporative losses for cooling systems between water resource regions to determine which type of cooling system evaporates less water and what factors may affect the regional differences. The results were compared to those from a similar study performed for the Utility Water Act Group by Espey, Huston & Associates, Inc.[22]

SECTION 2

CONCLUSIONS

Analysis of the data for cooling systems used at 16 power plants provided several conclusions concerning cooling system model accuracy and evaporation rates. These conclusions are summarized below:

- Results from the Leung and Moore cooling tower model[10] were generally within ±15 percent of the material balance calculated evaporation rate for mechanical draft cooling towers on baseload power plants. A plant is defined as baseload when it has a capacity factor greater than or equal to 50 percent. For these plants the ratio of the Leung and Moore model evaporation predictions to evaporation rates obtained from material balance calculations ranged from 0.67 to 1.5.

- The Leung and Moore cooling tower model did not accurately predict evaporation rates for cooling towers on power plants with low capacity factors (i.e., peaking or intermediate load plants). For annual capacity factors below 50 percent, the model overpredicted evaporation rates by several hundred percent.

- The Leung and Moore model proved adequate for predicting evaporation rates from natural draft cooling towers. Utilities typically do not have the kind of information needed for input to the natural draft tower cooling model developed by EPA's Environmental Research Laboratory at Corvallis, Oregon.[23]

- The Harbeck-Koberg-Hughes model and Meyer model gave predictions within ±15 percent of the actual value and appear appropriate for preliminary designs or studies. The results obtained using the five cooling pond/lake models showed that: (1) the Marciano-Harbeck model (Lake Hefner study)[20] produced consistently lower evaporation rates than the other models and also lower rates than the material balance results; (2) the Brady model[12] and the Harbeck nomograph plus natural evaporation[9] also produced consistently low results, but these were less pronounced than the Marciano-Harbeck model predictions; and (3) the Harbeck-Koberg-Hughes model (Lake Colorado City study)[8] and the Meyer model[12] produced the best results when compared to industry-provided or material balance calculated evaporation rates.

- There was excellent agreement between the model-predicted values (using the most appropriate model) for cooling pond/lake normalized summer evaporation rates in cu m/min-ha. The values for the four ponds/lakes analyzed were between 0.067 and 0.073 cu m/min-ha (0.027 and 0.030 cu m/min-acre). In addition the annual values showed good consistency: southern region ponds/lakes, normalized evaporation rates of 0.04-0.05 cu m/min-ha (about 0.020 cu m/min-acre); and northern region ponds ranging from 0.03 to 0.04 cu m/min-ha (0.01 to 0.02 cu m/min-acre). This narrow range of values, regardless of pond geometry or area per unit power output, indicates that a significant portion of the cooling pond/lake evaporation is natural evaporation. The lower annual evaporation rate differential in the northern regions is probably caused by the cold winter weather which produces a 50 percent reduction in natural evaporation as compared to the summer weather.

- A cooling pond/lake used by a power plant with an area to power ratio greater than 0.6 ha/MW results in the cooling pond/lake evaporating more water than a cooling tower on an electric generating unit of comparable size. This is primarily due to the larger increase in natural evaporation as compared to the slight decrease in forced evaporation as the area to unit power output ratio increases.

- Many results and conclusions of this study could be strengthened or better defined if more confidence could be placed on the utility-supplied data. At present, the utilities do not measure many of the parameters needed for improving water balance estimates, especially with respect to cooling ponds/lakes. Because the data were supplied by the utility and not measured directly by the EPA contractor, confidence limits could not be determined. The data supplied by various utilities also differed significantly in completeness, accuracy, and form. Consequently, a consistent methodology was developed by Versar to permit material balance calculations. However, since most of the utility-supplied information is routinely needed for power plant operation, the contractor assumed that these data were sufficiently accurate for the purposes of the study. The appropriateness of this assumption is supported by the good general agreement of model predictions with field-data-based values for total evaporation rates and the generally consistent trends of these evaporation values despite their being based on varied sources.

- This study indicates that cooling ponds generally evaporate more water than cooling towers. The results presented in the Espey, Huston and Associates, Inc. study show that single purpose cooling ponds/lakes consume less water than cooling towers. Differences in conclusions drawn by these studies are due to the EH&A definition of consumptive water use which includes a credit term for rainfall runoff added to the pond/lake which offsets evaporation. This rainfall runoff term causes a significant decrease in predicted consumptive water use. If consumptive water use is predicted using the EH&A formula, $C=E + (r-1) P$, the consumptive rate (C) reflects a credit term for rainfall runoff that provides for increased water availability for downstream usage. This term, however, is site and time specific and its application over large drainage basins requires further analysis. There is also some question among hydrologists about the applicability of the term while the results of this study do not support using the credit term.

SECTION 3

RECOMMENDATIONS

The results from this study provide answers and insights to many questions and concerns regarding water evaporation by power plant cooling systems. The results can be used in the evaluation of power plant operation on regional water resources. Regional EPA personnel may use these results as a tool for licensing new plants and planning regional activities relative to water utilization. A note of caution is, however, that the results of the study are based on limited data within unspecified accuracies and therefore more material balance data for cooling ponds/lakes would be useful for further verification of results.

Based on the findings of this report, the following recommendations are made:

- The Leung and Moore cooling tower model should be used as a simple, generic model for estimating evaporation rates from baseload power plants (i.e., capacity factor greater than 50 percent). No adjustment of results is needed to provide accuracy of ±15 percent.
- In most cases, evaporation rates from cooling ponds/lakes were predicted to within ±15 percent of material balance values for both the Harbeck-Koberg-Hughes model (Lake Colorado City study) and the Meyer model. It is recommended that, in general, either the Harbeck-Koberg-Hughes or Meyer model be used for determining evaporation rates and consumptive water use for future power plants using single purpose cooling ponds/lakes.
- The normalized evaporation rate coefficients (based on actual operating capacity) for cooling towers and cooling ponds/lakes should be compared with accurate material balances around cooling systems in regions of the U.S. not covered by this study. This is

especially true for the normalized summer and annual evaporation rates for cooling ponds/lakes in cu m/min-ha, which proved to be relatively constant within the southern and northern regions, respectively.

- The normalized cooling pond/lake ratio (area per unit power) which produces evaporation rates in cooling ponds/lakes approximately equal to cooling towers for the same operating conditions and in the same region should be determined in future investigations. This study showed that the ratio is less than 0.6 ha/MWe (1.5 acres/MWe), but could not define it further. Note that as this ratio decreases, the thermal loading on the pond/lake increases which correspondingly increases the forced evaporation rate; however, this increase is more than offset by the reduced natural evaporation rate produced by a smaller pond/lake surface area.

- Further studies should be performed to determine the validity of the rainfall runoff credit term (P(r-1)) applied on a regional basis to cooling pond/lake consumptive water use. The study should attempt to quantify the confidence limits of the credit term, if determined to be applicable. These limits may be substantial since the site-specific rainfall-runoff coefficient is applied on a regional basis.

SECTION 4

PROJECT METHODOLOGY

Five tasks were performed to accomplish the project. Collection of actual operating data from various power plant closed-cycle cooling systems was the first task. The second and third tasks involved verifying evaporation predictor models with actual operating data and performing sensitivity analyses to show the critical variables within each model. The fourth task was to compare evaporation from cooling towers and cooling ponds/lakes in a water resource region. The study culminated in a regional comparison of evaporation rates and model accuracy.

MODELS USED

The evaporation predictor model selection process for this program was based upon three criteria. The first was that the models should be mathematical and non-iterative with respect to input data. The second was that the models should be generic, although any cooling system model that could be calibrated for regional differences was acceptable. The third criterion was the need for simple, understandable models. Since general understanding by the public is desirable in the decision-making process and licensing requirements for siting and operating power plants, complex computer models were not considered responsive to the objectives of this program. Simplicity was defined in terms of the definition of variables and allowance for site-specific deviations, rather than the requirement for a simple relationship between variables.

One model was selected for evaluation of cooling towers and five for cooling ponds/lakes. The model selected for cooling towers was the mechanical draft cooling tower model developed by Paul Leung and Raymond Moore[10] from studies performed for the Navajo Station in northern Arizona. In addition, the algebraic approximations presented in the October 1973 EPA review document[14] were included for comparison of results.

The model selected satisfies the three EPA criteria and has the added benefit of having been used previously for effluent guidelines formulation or subsequent hearings. The Leung and Moore model is also widely accepted throughout the utility industry.

The five cooling pond/lake models chosen also satisfied the criteria. Four of the models are presented in the Littleton Research and Engineering Corporation (May 1970) report[12] for predicting the temperature of a thermally loaded captive pond/lake. These four models fit the general mass transfer equation:

$$Q_e = f(w)(e_s - e_a)A$$

where Q_e = evaporation rate, cfs

$f(w)$ = wind speed function, where w is wind speed in miles per hour, ft^3/acre-sec-in. Hg

e_s = water vapor pressure in air at the pond/lake water surface temperature , in. Hg

e_a = water vapor pressure in the ambient air, in. Hg

A = pond/lake size, acres

For each model a different empirical value for f(w) is used. The four models and their respective values for f(w) are:

Equation	f(w)
Marciano-Harbeck[20] (Lake Hefner)	$(2.25 \times 10^{-3})w$
Harbeck-Koberg-Hughes[8] (Lake Colorado City)	$(3.31 \times 10^{-3})w$
Meyer[12]	$1.44 \times 10^{-2} + (1.44 \times 10^{-3})w$
Brady et al[12]	$1.38 \times 10^{-2} + (1.38 \times 10^{-3})w^2$

The four general mass transfer models were not developed using comparable wind measurement heights. The two Harbeck models use 8-meter wind speeds (i.e., wind speeds measured 8 meters above the water surface), the Meyer model is based on 9-meter wind speeds and the Brady model requires 4.5-meter wind speeds. As a result, wind velocity data were adjusted for the specified heights before being input to each model. To adjust National

Weather Service (NWS) wind speed data to the appropriate height for use in each model, the power law of Deacon was used.[26] This expression is: $u/u_1 = (Z/Z_1)^p$, where u is the wind speed at altitude Z, u_1 is the wind speed at altitude Z_1, and p is equal to 0.16 for flat country and lakes.

The fifth cooling pond model uses the Harbeck nomograph, developed by G.E. Harbeck from studies at Lake Colorado City[9], in conjunction with natural evaporation rates. The nomograph is presented as Figure 1. Based on energy balance concepts, the Harbeck nomograph permits the estimation of forced evaporation rates resulting from the addition of heat by a power plant to a cooling pond/lake. To use the nomograph, the heat rejection rate, air temperature, and wind speed at the plant must be known. Given this information, the percentage of heat added that is utilized in increasing evaporation can be obtained from the nomograph as a function of wind speed and water surface temperature. Dividing this value by the product of the latent heat of vaporization and water density gives the rate of forced evaporation. The total evaporation rate is then calculated as the sum of the forced and natural evaporation.

For calculating natural evaporation, pan evaporation rates were obtained from data provided by the National Weather Service, the U.S. Climatic Atlas or from the utilities themselves. Note that a pan coefficient of 0.7 as recommended in Reference 25 was applied to the measured pan evaporation data to get the correct cooling pond/lake natural evaporation rate.

All models used in this project were verified using literature-provided data to check systems analysis and computer programming efforts.[9,10,20] The computer programs were written in Fortran IV and are presented in Appendix A.

DATA ACQUISITION

Actual cooling tower and cooling pond/lake operating data were solicited from utilities, cooling tower vendors, spray module vendors and architect/engineering firms. The utilities contacted represented all regions of the country; twenty-one utilities gave positive responses to the data requests. Twelve utilities responded in time to be included in this program study representing 18 operating power plants.

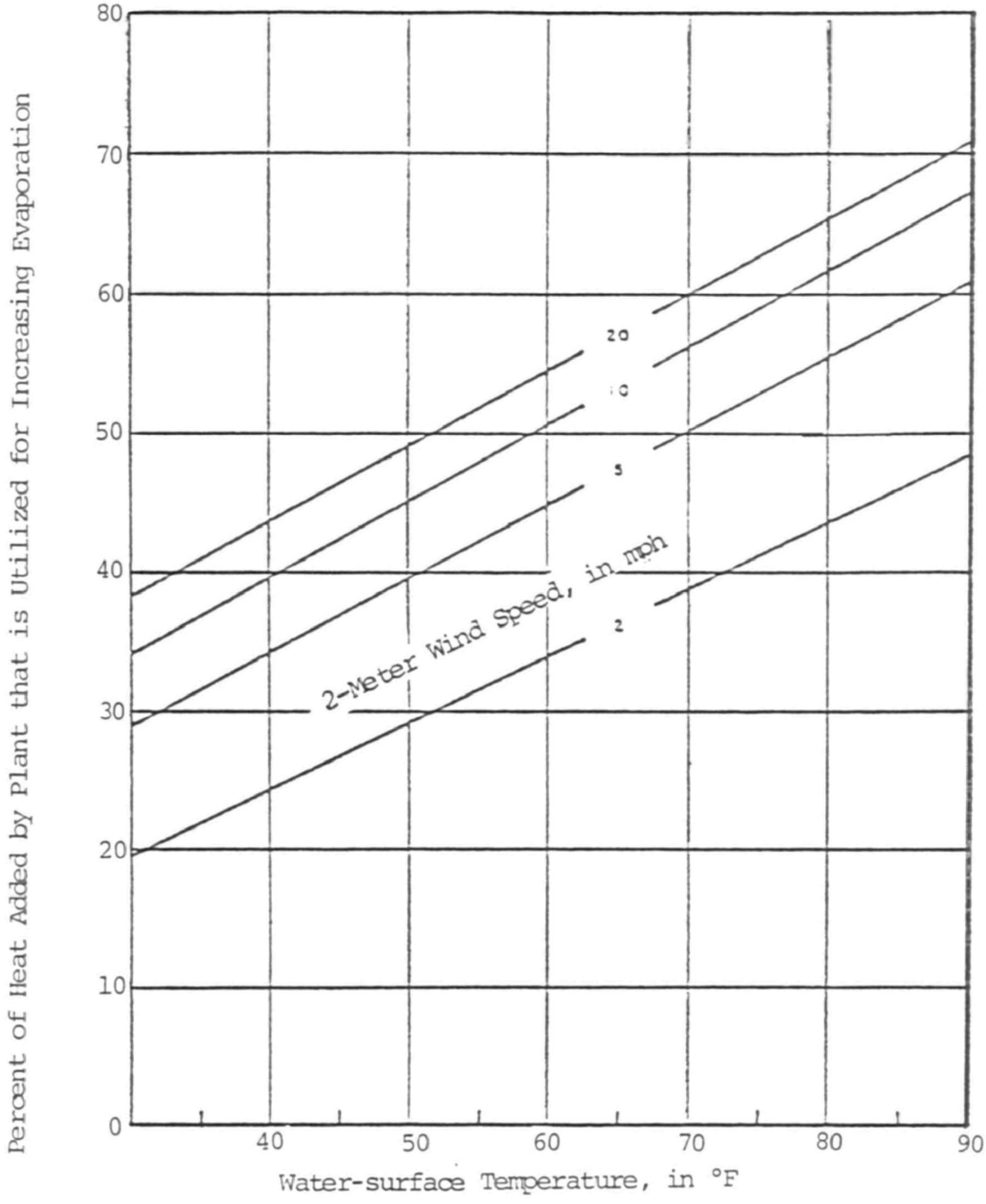

Figure 1. Estimated increase in reservoir evaporation resulting from the addition of heat by a power plant.[9]

The type of data solicited and received ranged from hourly to annual periods.

EVAPORATION PREDICTION

One intent of this study was to determine the accuracy of the various cooling system models. The accuracy was determined by comparing evaporation rate estimates based on material balance calculations with model predictions. Therefore the ability to reliably and accurately measure inflow and outflow streams to the cooling system had a major effect on the accuracy determination.

For performance tests on cooling towers, correct flow data are important to the vendor and utility , if flow rates with a ±5 percent accuracy are to be obtained. For monthly or annual data it was assumed that the averaging effect is provided by a sufficient approximation of station operation and an adequate estimation of consumptive water use. The primary concern with material balance data is short term estimation of flows which, if based on pump curves, indirect flow measurements or experience, may be accurate to within only ±10 or ±15 percent. Thus, the error factor in pump flow alone may be as large as the ±15 percent accuracy requirement of the models. Since there is no alternative for independently measuring operating data provided by the utilities, this study assumes the reliability of the utility-provided data is sufficient for comparison purposes in this study. Also, random measurement errors should average out with the sample size of 18 power plants used in this study.

Cooling Tower Model Input Data

Input cooling tower parameters for model prediction were heat rejection rate to the cooling tower, make-up and blowdown water flow rate, range, approach, cooling tower basin temperature, outlet air temperature, air flow rate and an approximation of drift. Evaporation rates measured during performance tests or estimated in design specifications were also requested from the utilities as an independent source for comparison with model predictions.

Concurrent meteorological data required for the Leung and Moore model were ambient dry and wet bulb temperature and relative humidity. Meteorological data were obtained from on-site measurements or the nearest National Weather Service (NWS) meteorological station.

Cooling Pond/Lake Model Input Data

The cooling pond/lake model operating data required were pond/lake temperature (measured), pond/lake inflow and outflow, pond/lake surface area, pond/lake elevation, drainage area, estimates of runoff coefficients and seepage. Since surface water temperatures were not usually available, inlet water temperature to the condenser was used when the surface temperature was unavailable. Evaporation rates, if previously predicted or measured by the utility, were also requested as an independent check on model predictions. Meteorological input parameters were precipitation, dry bulb temperature, relative humidity, wind speed and barometric pressure.

Evaporation Rate Estimates - Material Balance

Since evaporation rate is not measured directly, material balances were used to calculate consumptive water use. That is, evaporation rate is the difference between inflow (i.e., for towers it is make-up water to tower; for lakes it is stream flow to the lake, runoff, and direct precipitation) and outflow (i.e., for towers it is blowdown from tower and drift; for ponds/lakes it is pond/lake outflow and seepage) associated with the cooling system. Steady-state conditions were assumed to be maintained throughout the operating period. For one set of cooling tower data, however, the time period was sufficiently short that steady-state conditions could not be assumed. For that data set an adjustment was made for basin drawdown (as measured by the utility).

There was considerable discussion between the contractor and the utilities concerning the ability to determine evaporation rates on cooling ponds/lakes. It was noted that most natural ponds or lakes had feeder creeks, underground springs, and indeterminant runoff conditions that caused makeup water values to be gross estimates at best. Lake drawdown from seepage and outflowing streams was also considered difficult to measure or estimate. As a result, the overriding belief was that water balances around cooling ponds/lakes would be inaccurate. To overcome this concern, data from man-made lakes or ponds with known make-up and outflow rates were sought.

The water balance used the following generalized equation:

$$E = SF + DR + DP - OF - LE$$

where:

E = evaporation

SF = stream flow into the pond/lake

DR = direct runoff into the pond/lake

DP = direct precipitation on the pond/lake

OF = dam outflow

LE = change in lake volume (elevation) over the period of concern.

All values in the equation are expressed in cu m/min. Note that seepage is not included in the equation, since it is assumed negligible. If data were available on seepage, they were included in the value 0.

The cooling pond/lake material balance values for stream flow, runoff and dam flow were estimates based on USGS hydrologic data. The USGS hydrologic data provide empirical equations that quantify the daily stream flows. According to the USGS, these equations are accurate to within ±5 percent. Precipitation for each site was obtained from the nearest National Weather Service station. The material balance included changes in pond/lake elevation where available.

COMPARISON OF ACTUAL MEASUREMENTS AND PREDICTED RESULTS

Received data were checked against model requirements, and any deficiencies were referred back to the source for clarification or correction. Except for outlet air temperatures and outlet air flow rates for cooling towers and stream flows and surface water temperature for cooling ponds/lakes, the utilities were able to provide most of the requested data. To estimate outlet air conditions, rating factor curves extracted from a Marley Cooling Tower Reference Manual[13] were used. These curves provide outlet wet bulb temperatures and outlet air (dry) flow rates as a function of ambient wet bulb, design and operating range, design approach, and heat load on the tower. In many cases the heat load data (Kcal/kwh) provided were for the total plant. For those circumstances an assumption of 50 percent of the total energy input rate to the plant is heat rejected to the circulating water system. This heat rejection rate to the cooling system is taken from Table B-V-1 in the Development Document for the Steam Electric Power Generating Point Source Category.[5]

To estimate the average surface water temperature on a pond/lake, the inlet water temperature to the condenser was used. The intake structure is usually near the shoreline, and pumps provide surface or near-surface water to the condenser. The inlet water is therefore considered to be a best estimate of average surface water temperature.

Evaporation predictions were made by the appropriate models only after data collection was complete. For mechanical draft towers and natural draft towers, the Leung and Moore model was used. Cooling pond/lake data were applied to the five cooling pond/lake evaporation rate prediction equations, after adjusting for the elevation of wind speed measurements. The model results were then compared to water-balance-derived evaporation rates. The comparisons are discussed in Section 5.

If the comparison of actual measurements and predicted results indicated a critical relationship existed for a particular variable, sensitivity analyses were performed on that parameter. The sensitivity analyses were designed to show the variation in evaporation rates as a function of the parameter being tested, with all other variables held constant. Sensitivity analyses were performed on the following cooling tower parameters: outlet air temperature, inlet dry bulb, relative humidity and heat rejection rate. For the cooling pond/lake models, sensitivity analyses were conducted using pond temperature, wind speed, heat rejection rate and load factor as variables. The results of these analyses are presented in Sections 5 and 6.

COMPARISON OF COOLING TOWERS AND COOLING PONDS/LAKES

Upon completion of the model accuracy analyses, the predicted evaporation rates for cooling towers and cooling ponds/lakes were compared. Since the power plants differed in size, efficiency and regional meteorology, the comparisons were made on common bases. Towers and ponds/lakes in the same meteorological area were studied together, and evaporation rates were normalized with respect to capacity and heat rejection rate (correcting for capacity factor), i.e., cu m/min-MW and cu m/10^6 kcal. Both model-predicted and material balance evaporation rates were used.

The normalized evaporation rates were also compared between regions to illustrate regional variations for each cooling system and identify consumptive water use differences for towers and ponds/lakes. A regional classification of relative evaporation rates was generated as a result of these comparisons.

The data analyses presented in the following sections were based on one or more of the following assumptions and bases:

- Marley nomographs of outlet air flow rate and temperature for mechanical draft and natural draft cooling towers were valid approximations, since these data were generally not provided by the utilities.
- When not provided, constant heat rejection rates of 50 percent of the plant energy input rate were used.
- For monthly and annual evaporation rate calculations, average monthly meteorological data were used.
- Data at the nearest National Weather Service (NWS) station characterized the on-site meteorology.
- Cooling pond/lake surface temperature was characterized by one value, generally the inlet water temperature to the condenser, since it is usually the only water temperature parameter measured besides discharge temperature.

- A water balance around a cooling pond/lake including inlet stream flow, direct runoff to the pond/lake, direct precipitation and pond/lake outflow provided a reasonable estimate of pond/lake evaporation. Seepage was negligible unless noted otherwise by the utility.

SECTION 5

DATA EVALUATION AND RESULTS

Power plant operating data received from 12 utilities were included in the analysis of cooling system models. These 12 utilities presented actual operating data for 14 mechanical draft cooling tower systems, one natural draft cooling tower system, seven cooling ponds/lakes, and one cooling canal. In addition, design data were available on another natural draft cooling tower system.

A summary of the data received follows:

- Average annual data on mechanical draft cooling towers for a 400-MW unit operated by Utah Power and Light Company at Huntington Station.
- Hourly performance test data for induced draft towers operated by the Salt River Project at Navajo Generating Station.
- A one-week performance test on mechanical draft cooling towers for a 75-MW unit operated by Texas Electric Service Company at its North Main Station and a six-hour performance test on a mechanical draft cooling tower for a 110-MW unit at its Permian Station.
- One month of summer data for six mechanical draft cooling towers operated by El Paso Electric Company at its Rio Grande Station and Newman Stations.
- Monthly and annual data on three mechanical draft cooling towers operated by Arkansas Power and Light Company at Moses, Couch and Lynch Stations.
- Hourly data for two months (January and August) on mechanical draft towers operated by Minnesota Power and Light Company at Clay Boswell Unit 3.
- Daily data for three months (January, April and July) on natural draft towers operated by Pennsylvania Electric Company at its Homer City Station

- Monthly data averaged over a three-year period on a cooling pond at Arizona Public Service Company's Cholla Station.
- Monthly data for 10 months on a cooling lake at Texas Electric Service Company's at Morgan Creek Station.
- Average annual data on a cooling pond and lake at Commonwealth Edison's Kincaid and Powerton Stations, respectively.
- Daily data for two months (January and July) on a cooling lake at Virginia Electric and Power Company's Mt. Storm Station.
- Daily data for one year on a cooling at Duke Power Company's at Belews Creek Steam Station.
- Monthly data for one year on a cooling lake at Carolina Power and Light Company's H.B. Robinson Plant.
- Monthly data on one cooling canal at New Hampshire Public Service Company's Merrimack Station.
- Design data on one natural draft cooling tower being built for Wisconsin Electric Power Company at Koshkonong

The following two subsections present the operating data supplied and the results of the model analysis and sensitivity analysis for each cooling system. The subsections are divided into cooling tower data and results and cooling pond/lake data and results. The meteorological data are provided in Appendix B. The actual computer printouts of the model predictions for cooling towers and cooling ponds/lakes are provided in Appendices C and D, respectively.

COOLING TOWER DATA AND RESULTS

Mechanical Draft Cooling Towers

Utah Power and Light Company, Huntington Station--

The Huntington Station has a 400-MW unit. A mechanical draft cooling tower system has been in operation for two years. The utility sent average values for the 1976 operation which are presented in Table 1. Make-up water flow and blowdown rates were given as average values, while the remaining data were given at design conditions. The cooling tower is operated at about 12 cycles of concentration. The make-up flow rate is held constant, while the blowdown varies as a function of water quality in the circulating water system. An evaporation rate value of 12.5 cu m/min

TABLE 1. COOLING TOWER OPERATING DATA FOR UTAH POWER AND LIGHT CO. HUNTINGTON STATION (AVERAGE 1976 DATA)

	Unit 1
Plant Capacity (MW)	400
Plant Capacity Factor (%)	80
Unit Heat Rejection Rate kcal/kWh (BTU/kWh)	1,300 (5,100) (est.)
Circulating Water Flow Rate, cu m/min (GPM)	704 (185,800)
Make-up Flow Rate, cu m/min (GPM)	15.1(4,000)
Blowdown Flow Rate, cu m/min (GPM)	1.21 (320)
Range, °C (°F)	13.3 (23.9)
Approach, °C (°F)	9.7 (17.5)
Air Flow Rate, std cu m/min (SCFM)	5.0×10^5 (18×10^6)
Outlet Air Temperature, °C (°F)	varied 28 - 36 (82 - 97)
Approximate Drift Losses, cu m/min (GPM)	1.41 (372)
Evaporation Rate, cu m/min (GPM)	
Material Balance	12.5 (3,300)
Model Prediction	12.8 (3,380)

(7.37 cfs) was calculated from a water balance around the tower (i.e., make-up - blowdown - drift = evaporation).

Meteorological parameters were obtained from the National Weather Service station at Grand Junction, Colorado. The weather station is located over 150 kilometers (100 miles) from Huntington and is at 1,525 meters (msl), (425 meters below the power plant). The monthly meteorological conditions used as input are presented in Appendix B. A pressure correction was made because of the 1,950 meter (msl) elevation of this plant.

Since temperature rise (range) in the condenser and approach were assumed to vary minimally throughout the year for this baseload plant, compared to meteorological conditions, the range and approach were held constant for all model calculations. The variable which appeared most sensitive to meteorology and to the model was outlet air temperature. Five computer calculations using the Leung and Moore model were performed with the outlet air temperature ranging from 28°C to 36°C. For these runs, the outlet air temperature that most closely approximated the average annual evaporation was 36°C (97°F), or 8°C above design basin temperature. This result is merely an average value, however, since outlet air temperature is a function of inlet conditions and therefore varies over a large range throughout the year.

The results do confirm that monthly evaporation rates vary directly with meteorology and differ by as much as 50 percent. One implication of this variation is that for drought conditions the consumptive water use can be as much as 25 percent above annual average conditions as shown on Figure 2.

A sixth case was investigated for Huntington Station involving the sensitivity of the model to heat load. The outlet air temperature calculated using the Marley nomographs of 36°C (97°F) was used in the model (Case V of Figure 2), but the heat rejection rate to the tower was increased by 10 percent. This produced a 10 percent increase in predicted evaporation.

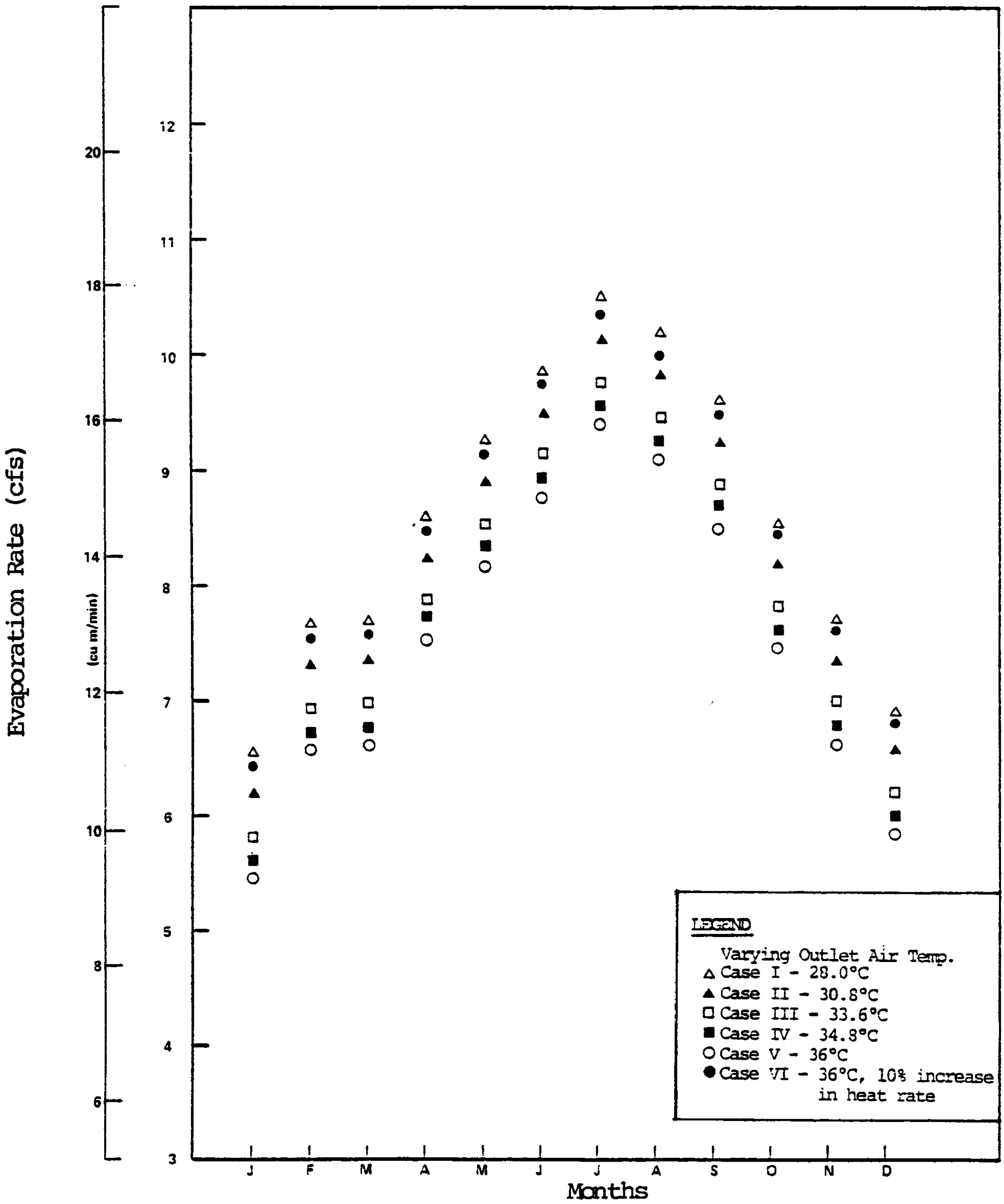

Figure 2. Cooling tower evaporation rates calculated for various outlet air temperatures and heat loads at Huntington Creek Station (Utah).

Air flow rates and outlet water temperatures in mechanical draft cooling towers also vary with meteorology but over a smaller range than other variables. The impact of these parameters was not investigated using the Huntington Station data.

In conclusion, as shown on Figure 2, an increasing outlet air temperature decreases water consumption and an increasing heat rejection rate increases consumptive water use in cooling towers (all other parameters being constant). Overall, the Leung and Moore model predicted evaporation rates relatively well. For Cases I through V, the evaporation predictions were within 17 percent of the calculated water balance evaporation rate. A primary concern, however, is that no data were available on outlet air temperature variation throughout the year. Since this parameter can be expected to vary by as much as 22°C (40°F) over the year at the Huntington Station, the accuracy of evaporation rate calculations based on constant outlet air temperature needs further study. Air flow rate is another variable which is held constant in the Leung and Moore model but which varies throughout the year. The validity of this assumption should also be investigated.

Salt River Project, Navajo Generating Station--

Performance test data were received from the Salt River Project for the Navajo Generating Station. These data were of special interest because the Leung and Moore mechanical draft tower model was based on the design conditions for the Navajo towers. The data, presented in Table 2, consisted of two performance tests conducted on each of the two mechanical draft tower cells - Tower 1-A and 1-B. The first performance test was conducted on August 6, 1977, for one-hour duration. The second test for a duration of two hours was performed on August 20, 1977. Both tests were performed at or above 100 percent rated electrical capacity of the generating unit.

Meteorological data and material balances were part of the test results. Some meteorological data were supplemented by information from the NWS station at Winslow, Arizona. For both tests, material balance results for Tower 1-B were questionable.

TABLE 2. COOLING TOWER PERFORMANCE TEST DATA FOR ARIZONA PUBLIC SERVICE CO., NAVAJO PLANT (August 1977)

	Test 1A (One-hour duration)	Test 2A (Two-hour duration)
Plant Capacity (MW)	750	750
Plant Capacity Factor (%)	107	100
Unit Heat Rejection Rate kcal/kWh (BTU/kWh)	1,130 (4,480)	1,130 (4,480)
Circulating Water Flow Rate, cu m/min (GPM)	551 (145,326)	558 (147,306)
Make-up Flow Rate, cu m/min (GPM)	13.2 (3,482)	13.0 (3,432)
Blowdown Flow Rate, cu m/min (GPM)	0	0
Range, °C (°F)	15.6 (28.1)	15.4 (27.7)
Approach, °C (°F)	11.3 (20.3)	12.6 (22.7)
Air Flow Rate, std cu m/min (SCFM)	7.8×10^5 (2.8×10^7)	8.0×10^5 (2.9×10^7)
Outlet Air Temperature, °C (°F)	34.9 (94.8)	33.3 (92.0)
Approximate Drift Losses, cu m/min (GPM)	1.11 (293)	1.12 (295)
Evaporation Rate, cu m/min (GPM)		
Model predicted	14.1 (3,720)	13.8 (3,640)
Material Balance	12.1 (3,190)	11.9 (3,140)
Marley Predicted	12.6 (3,330)	12.3 (3,250)

The computer model results overpredicted by almost 17 percent the actual water consumption rates as measured directly from circulating water flows and changes in basin level. Using the data from Tower 1-A for performance tests 1 and 2, the computer model predicted evaporation rates of 14.1 cu m/min and 13.8 cu m/min respectively. These compare to material balance results of 12.1 and 11.9 cu m/min.

A third set of results can be included based on performance curves used by the cooling tower vendor (The Marley Company) during the test. The cooling tower vendor predictions for the same two tests were 12.6 and 12.3 cu m/min. The Leung and Moore model overpredicted these evaporation rates by 12 and 13 percent, respectively. The vendor predictions and material balance values were within four percent in both cases.

The utility later found that the circulating water flows and heat rejection rates were about 10 percent above the design values. This may account for the differences in predicted and calculated evaporation rates, since the (increased) heat rejection rate is input to the model, but circulating water flow rate is not. The model may compensate for the increased heat rejection rate by overpredicting evaporation.

From the standpoint of evaporation rate, the Navajo plant produced the lowest value of any tower analyzed - 0.015 cu m/min-MW. This low unit evaporation rate is probably a function of the high capacity factor (100 percent) during the tests and the high efficiency of this new, large power plant, which has a low heat rejection rate of 1,130 kcal/kWh (4,480 BTU/kWh).

Texas Electric Service Company, North Main Steam Electric Station--

To study the variations in air temperature, air flow rate, and heat rejection rate over a short time period, an analysis of performance test data from Texas Electric Service Company's North Main Station in Fort Worth, Texas, was made. The North Main Station has a mechanical draft cooling tower on its 75-MWe generating Unit No. 4. A performance test was made during January 21-26, 1960, to determine tower capabilities over a large range of heat rejection rate and meteorology. During the test the unit generated up to 86 MWe gross capacity. The data for these tests are presented in Table 3.

TABLE 3. COOLING TOWER OPERATING DATA FOR TEXAS ELECTRIC SERVICE CO., NORTH MAIN STATION [1-Week Performance Test - January 21 - 26, 1960]

Test No.	1	2	3	4	5	6
Plant Capacity (MW)	85.85	85.85	85.85	85.85	85.85	85.85
Plant Capacity Factor (%)	48	63	35	76	82.5	100
Unit Heat Rejection Rate, kcal/kWh (BTU/ kwh)	1,517 (6,018)	1,507 (5,979)	1,591 (6,315)	1,499 (5,948)	1,528 (6,063)	1,542 (6,119)
Circulating Water Flow Rate, cu m/min (GPM)	251 (66,244)	239 (63,116)	242 (64,092)	240 (63,429)	243 (64,189)	241 (63,765)
Make-up Flow Rate, cu m/min (GPM)	1.92 (508)	2.04 (535)	2.1 (553)	1.92 (509)	2.46 (644)	2.7 (710)
Blowdown Flow Rate, cu m/min (GPM)	.78 (201)	.96 (250)	.96 (250)	.54 (141)	.54 (141)	.54 (148)
Range, °C (°F)	4.3 (7.8)	5.6 10.0)	3.3 (6.0)	6.7 (12.0)	7.8 (14.0)	9.1 (16.4)
Approach, °C (°F)	8.8 (15.9)	12.1 (21.9)	7.6 (13.7)	12.3 (22.2)	12.3 (22.1)	12.9 (23.3)
Air Flow Rate, std. cu m/min (SCFM)	1.0×10^5 (3.5×10^6)	1.0×10^5 (3.5×10^6)	1.0×10^5 (3.5×10^6)	1.0×10^5 (3.5×10^6)	1.0×10^5 (3.5×10^6)	1.0×10^5 (3.5×10^6)
Outlet Air Temperature, °C (°F)	19 (66)	22 (71.5)	18 (64)	26 (78)	29 (84)	33 (91.5)
Approximate Drift Losses and Evaporation Rate, cu m/min (GPM)	0.97 (256)	0.99 (260)	0.90 (237.8)	1.85 (489.1)	1.56 (412.8)	2.53 (668.7)
Relative Humidity %	25	70	78	90	80	68
Test Date	1/21/60	1/25/60	1/25/60	1/26/60	1/26/60	1/26/60

The data were obtained over 6 two-hour test periods. Evaporation rates were calculated by the utility and were measured from a material balance around the tower, including water level fluctuations in the cooling tower basin. Drift losses could not be measured and drift loss guarantees were not provided. However, since drift losses in modern cooling towers are typically less then one percent of the evaporation rate, the lack of drift data should not affect the results significantly.

Meteorological values were measured on-site during the test, but relative humidity was extracted from a psychrometric chart, based on given dry and wet bulb temperatures and assuming standard atmospheric pressure. Figure B-2 (Appendix B) provides these data.

The comparison of the Leung and Moore model prediction for evaporation and actual measurements is shown on Figure 3. This comparison reveals the following:

- The model overpredicted evaporation in all cases except that of design conditions.
- For three tests (numbers 3,4 and 6) the computer model over-predicted evaporation by as much as 15 percent of measured values.
- For test numbers 1,2 and 5, the model overpredicted by 70, 60 and 55 percent, respectively.
- The actual measured evaporation for test number 5 was unaccountably low for the given conditions.
- The evaporation prediction formula developed by EPA[14] also over-predicted the evaporation rate in all test cases (but it is within 15 percent of the Leung and Moore predictions for all test runs).
- The meteorological variations and, therefore, evaporation rates over the one-week period were large. Constant evaporation over short time periods (weekly) cannot be assumed. Thus, monthly values may prove to be insufficient for water resource-drought-effect calculations.

An initial observation of these results was that under all meteorological and operating conditions, the Leung and Moore model tended to overpredict evaporation.

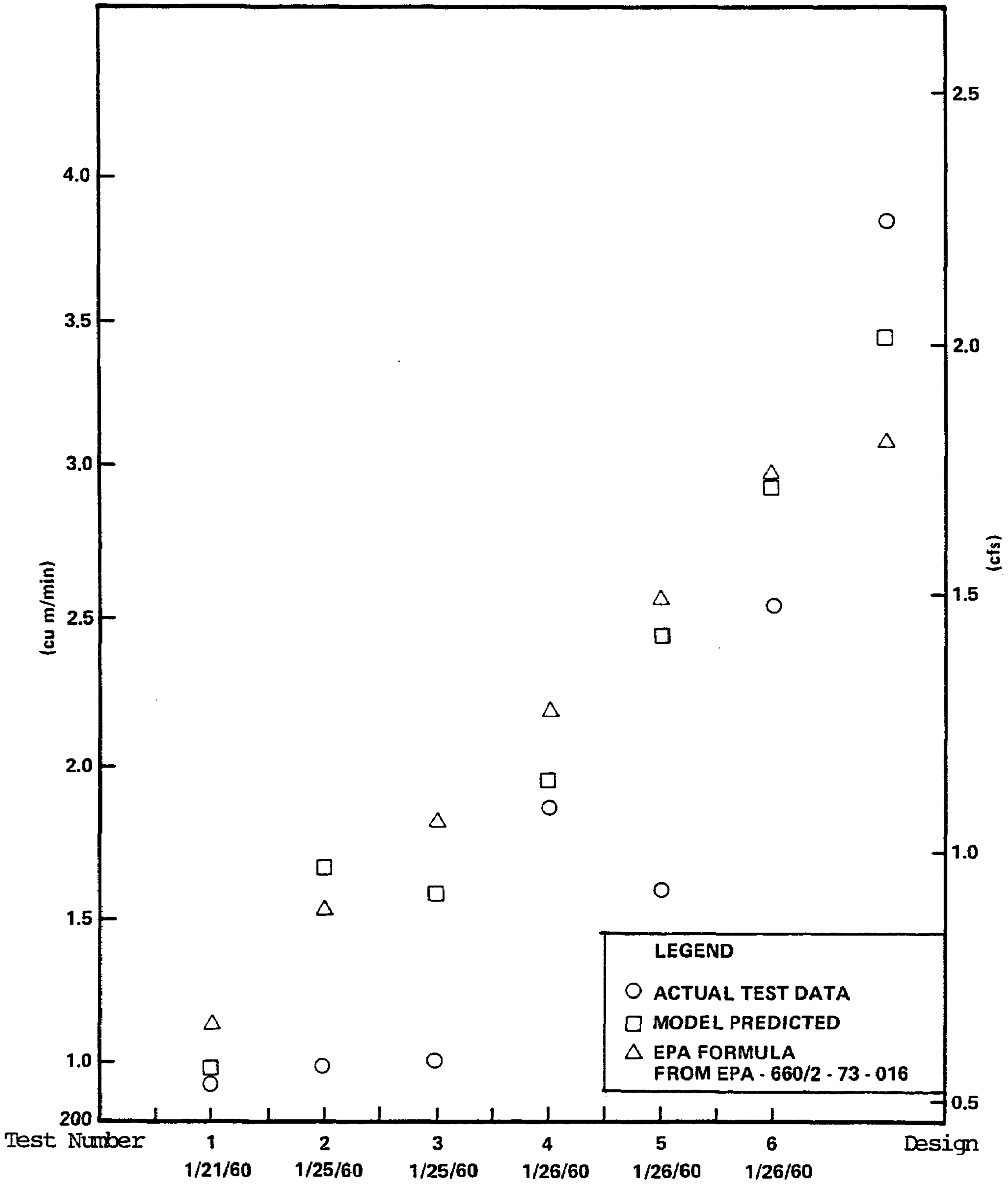

Figure 3. Comparison of predicted and actual cooling tower evaporation rates at North Main Steam Electric Station (Texas).

One possible explanation for the overprediction is that the low relative humidity characteristic of this location may preclude a saturated outlet air stream. Since unsaturated air contains less water at the same temperature than saturated air and the Leung and Moore model assumes the outlet air is 100 percent saturated, the model-predicted evaporation rates will exceed actual evaporation rates for unsaturated air outlet conditions.

Another possible explanation is that the circulating water system is sufficiently large that it reacts slowly to meteorological variations. Thus, for rapidly changing meteorological conditions, the cooling system parameters lag, causing the model to overpredict in some circumstances and underpredict in others. This system lag could produce incorrect input values for parameters which must be calculated using nomographs based on steady-state meteorological conditions. Such parameters are outlet air temperature and outlet air flow rate.

Any lag would be especially pronounced for this performance test because of the large variation in input parameters over the six-day period. For example, inlet water temperature to the tower varied by 18°C (33°F), tower water basin temperature varied by 12°C (22°F), and heat load increased by a factor of three throughout the week. Meteorological conditions also changed significantly with wet bulb temperature varying by 7°C, dry bulb varying almost 11°C (20°F), and relative humidity increasing from 25 to 90 percent and then decreasing to 70 percent as the week progressed. Over longer time periods, one would expect this lag to have less effect on results.

A calculation using the Leung and Moore model, assuming the station operated under full load conditions for the entire test period, showed that the predicted evaporation rate would have varied by 25 percent. The maximum evaporation rate occurred during the lowest relative humidity period and was 17 percent greater than the mean evaporation. Figure 4 presents the model results from these synthesized full load data. It should be noted that the circulating water flow rate, range, air flow rate, outlet water temperature and heat load were held constant for these calculations.

Conclusions based on these data and predictions are:

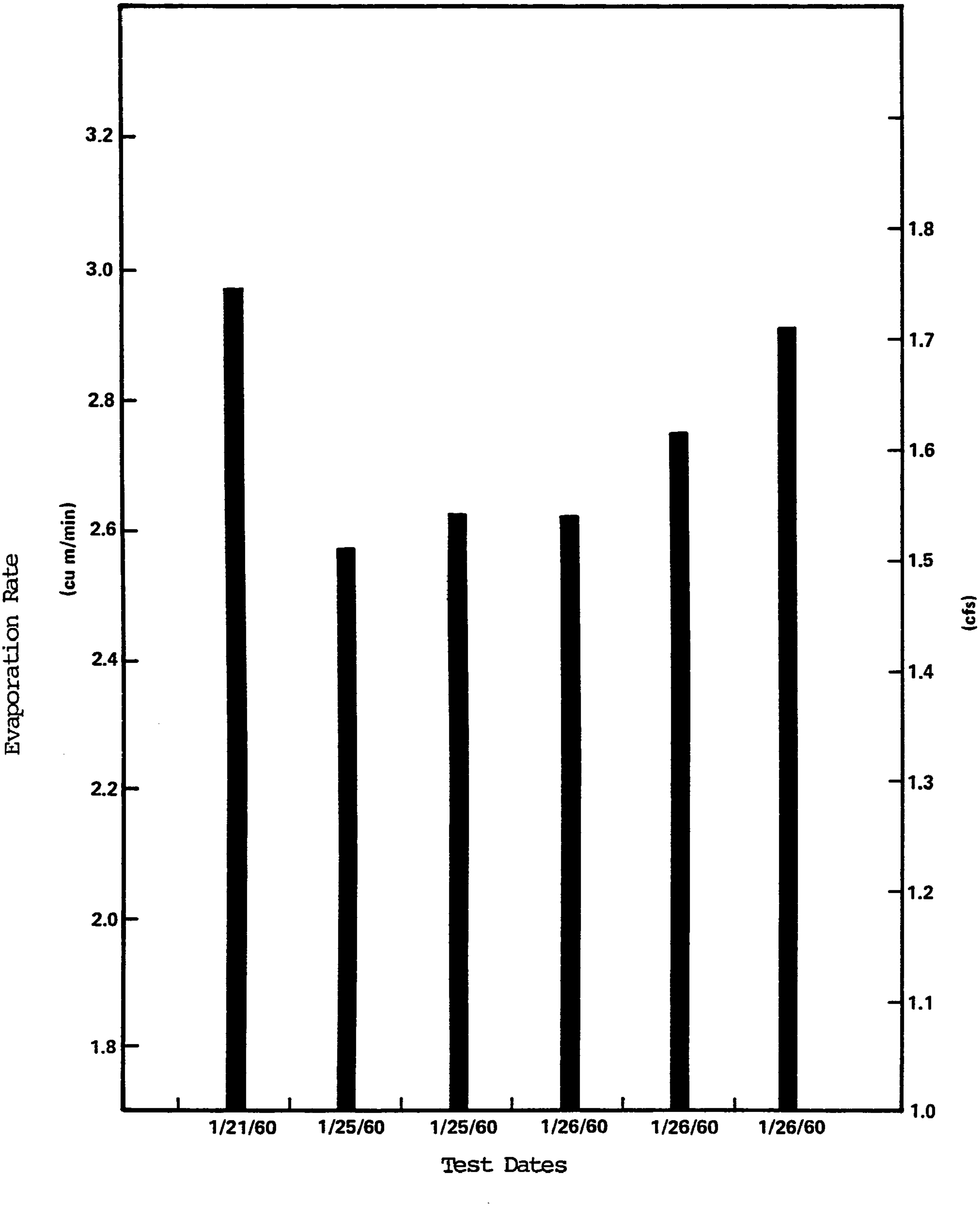

Figure 4. Prediction of cooling tower evaporation rate for synthesized full load conditions at North Main Steam Electric Station over a six-day period.

- The Leung and Moore model tended to overpredict actual evaporation, although it often gave values within 15 percent of the actual values.
- Unsaturated outlet air conditions could cause the Leung and Moore model to overpredict evaporation rates.
- Meteorological variations over a one-week time span were sufficient to cause a 25 percent change in evaporation rate.

Texas Electric Service Company, Permian Station--

Texas Electric also provided the results from a second mechanical draft tower performance test at Permian Station for a 100-MW load. Data for the 6-hour test period are given in Table 4. Sufficient data were supplied to predict evaporation using the Leung and Moore model. The results were similar to those above in that the cooling tower model slightly overpredicted evaporation rate. The computer model evaporation rate prediction was 3.1 cu m/min (1.80 cfs) versus a calculated evaporation rate of 3.0 cu m/min (1.76 cfs), only a two percent difference.

El Paso Electric Company, Newman and Rio Grande Stations--

El Paso Electric Company provided results for one summer month at two stations with three units, August 1977 data for Units 1-3 at the Newman Station and July 1977 data for Units 6-8 at the Rio Grande Station. The Newman Station units (1-3) have capacities of 86 MW, 90 MW and 110 MW respectively. Unit 1 is an intermediate load unit, while units 2 and 3 are baseload units. The Rio Grande units have capacities of 50 MW, 50 MW and 165 MW. All three had monthly capacity factors below 60 percent. The operating data for these six units are shown in Tables 5A and 5B.

Data received were average values for those months which El Paso Electric Company believed most closely approximated design conditions. Since the Leung and Moore model was generated using design conditions, one would expect the model to closely predict evaporation rates. This expectation was realized for the two baseload units. A comparison of model predictions versus calculated evaporation rates is shown for all six units in Table 6.

TABLE 4. COOLING TOWER OPERATING DATA FOR TEXAS ELECTRIC SERVICE CO., PERMIAN STATION (Six-hour Test Period November 5, 1958)

Plant Capacity (MW)	100
Plant Capacity Factor (%)	Not given
Unit Heat Rejection Rate Unit 1, kcal/kWh (BTU/kWh)	1,207 (4,788)
Circulating Water Flow Rate, cu m/min (GPM)	263 (69,550)
Make-up Flow Rate, cu m/min (GPM)	2.64
Blowdown Flow Rate, cu m/min (GPM)	0
Range, °C (°F)	7.7 (13.8)
Approach, °C (°F)	9.5 (17.2)
Air Flow Rate, std cu m/min (SCFM)	9.2×10^4 (3.3×10^6)
Outlet Air Temperature, °C (°F)	33 (92)
Approximate Drift Losses, cu m/min (GPM)	.0456 (12)
Evaporation Rate, cu m/min (GPM)	
Model Prediction	3.1 (812)
Material Balance	3.0 (794)

NOTE: During this test the water level in the cooling tower basin dropped 4.75 inches. This accounts for the differential between makeup flow-rate and evaporation rate for a zero blowdown condition.

TABLE 5A. COOLING TOWER OPERATING DATA FOR EL PASO ELECTRIC CO., NEWMAN STATION (August 1977)

	Unit 1	Unit 2	Unit 3
Plant Capacity (MW)	86	90	110
Plant Capacity Factor (%)	59.3	85.5	98.2
Unit Heat Rejection Rate kcal/kWh (BTU/kWh)	1,430 (5,680)	1,440 (5,715)	1,340 (5,310)
Circulating Water Flow Rate, cu m/min (GPM)	164 (43,300)	159 (42,000)	161 (42,500)
Make-up Flow Rate, cu m/min (GPM)	6 (1,580)	5.64 (1,484)	6.36 (1,672)
Blowdown Flow Rate, cu m/min (GPM)	1.44 (375)	1.32 (350)	1.50 (397)
Range, °C (°F)	14 (25)	14 (25)	16 (28)
Approach, °C (°F)	13 (24)	11 (20)	10 (18)
Air Flow Rate, std cu m/min (SCFM)	6.4×10^4 (2.3×10^6)	8.4×10^4 (3.0×10^6)	11.5×10^4 (4.1×10^6)
Outlet Air Temperature, °C (°F)	40 (104)	36 (97)	36 (97)
Approximate Drift Losses, cu m/min (GPM)	.330 (87)	.318 (84)	.324 (85)
Evaporation Rate, cu m/min (GPM)			
Material balance	4.2 (1,122)	4.0 (1,050)	4.5 (1,194)
Model prediction	3.7 (974)	3.9 (1,032)	4.5 (1,194)

TABLE 5B. COOLING TOWER OPERATING DATA FOR EL PASO ELECTRIC CO., RIO GRANDE STATION (July 1977)

	Unit 6	Unit 7	Unit 8
Plant Capacity (MW)	50	50	165
Plant Capacity Factor (%)	30.5	58.5	48
Unit Heat Rejection Rate kcal/kWh (BTU/kWh)	1,650 (6,545)	1,415 (5,615)	1,298 (5,150)
Circulating Water Flow Rate, cu m/min (GPM)	139 (36,800)	107 (28,350)	213 (56,300)
Make-up Flow Rate, cu m/min (GPM)	1.80 (500)	2.28 (608)	6.18 (1,627)
Blowdown Flow Rate, cu m/min (GPM)	0.54 (145)	0.66 (175)	1.56 (407)
Range, °C (°F)	6 (10)	8 (15)	12 (22)
Approach, °C (°F)	7 (12)	9 (16)	9 (17)
Air Flow Rate, std cu m/min (SCFM)	1.0×10^5 (3.5×10^6)	0.8×10^5 (3.0×10^6)	2.4×10^5 (8.7×10^6)
Outlet Air Temperature, °C (°F)	30 (86)	33 (91)	34 (94)
Approximate Drift Losses, cu m/min (GPM)	0.30 (74)	0.24 (57)	0.42 (113)
Evaporation Rate, cu m/min (GPM)			
Material balance	1.1 (283)	1.4 (377)	4.2 (1,108)
Model prediction	2.4 (646)	2.1 (561)	6.5 (1,714)

TABLE 6. EL PASO ELECTRIC CO. NEWMAN AND RIO GRANDE STATIONS EVAPORATION RESULTS

Unit No.	Calculated[a] cu m/min (GPM)	Computer Model[b] cu m/min (GPM)	EPA (1973)[c,d] cu m/min (GPM)		Capacity Factor (%)
Newman Station					
1	4.2 (1120)	3.7 (974)	3.2 (844)	3.8 (1,010)	59.3
2	4.0 (1,050)	3.9 (1,030)	3.0 (790)	3.6 (947)	83.7
3	4.5 (1,190)	4.5 (1,190)	3.4 (893)	4.1 (1,070)	98.1
Rio Grande Station					
6	1.1 (283)	2.4 (646)	1.1 (278)	1.3 (332)	30.5
7	1.4 (377)	2.1 (561)	1.2 (318)	1.5 (386)	58.5
8	4.2 (1,110)	6.5 (1,710)	3.5 (933)	4.2 (1,120)	48.0

a Calculated from water balances around the towers

b Results from Leung and Moore induced draft cooling tower model

c EPA model assuming 75% of waste heat is dissipated by latent heat transfer

d EPA model assuming 90% of waste heat is dissipated by latent heat transfer

For Unit 2 at the Newman Station, the model-predicted evaporation rate was within two percent of the evaporation rate calculated from a water balance around the tower. For Unit 3, which had a capacity factor of 98.2 percent, the model and water balance values were identical. These results imply that for high capacity units, the model is quite accurate. In contrast, Unit 1 had a capacity of only 59.3 percent. The model under-predicted evaporation by 13 percent.

The model results, in terms of percent deviation from calculated values, were similar at Rio Grande Station. For all three units the computer model overpredicted evaporation. The percent overprediction was 127 percent for Unit 6 (a 30.5 percent capacity factor), 50 percent for Unit 7 (a 58.5 percent capacity factor), and 55 percent for Unit 8 (a 48 percent capacity factor).

These results show that average evaporation prediction accuracy is a function of the capacity factor. Figure 5 shows this relationship for the six El Paso units. This figure indicates that a semi-logarithmic correction might be used to adjust for capacity factor.

Arkansas Power and Light Company, Moses Station, Couch Station and Lynch Station--

Arkansas Power and Light Company supplied annual and monthly operating data for three peak load plants. These were the Moses, Couch and Lynch Stations, which had plant capacities of 126 MW, 161 MW and 239 MW, respectively. Each plant uses a mechanical draft cooling tower system. The data for the average annual conditions are shown in Tables 7 through 9. The utility-provided make-up and blowdown flow rates were averaged during plant operation only. Therefore the capacity factor, which includes this down-time, was not applied to computer model input parameters. National Weather Service data were used to input monthly and annual values.

The results from these three plants were similar to the El Paso Electric results in that for low capacity factor power plants (peak and intermediate load plants), the model overpredicted evaporation. This is an expected result since the model is attempting to predict evaporation rate from a plant

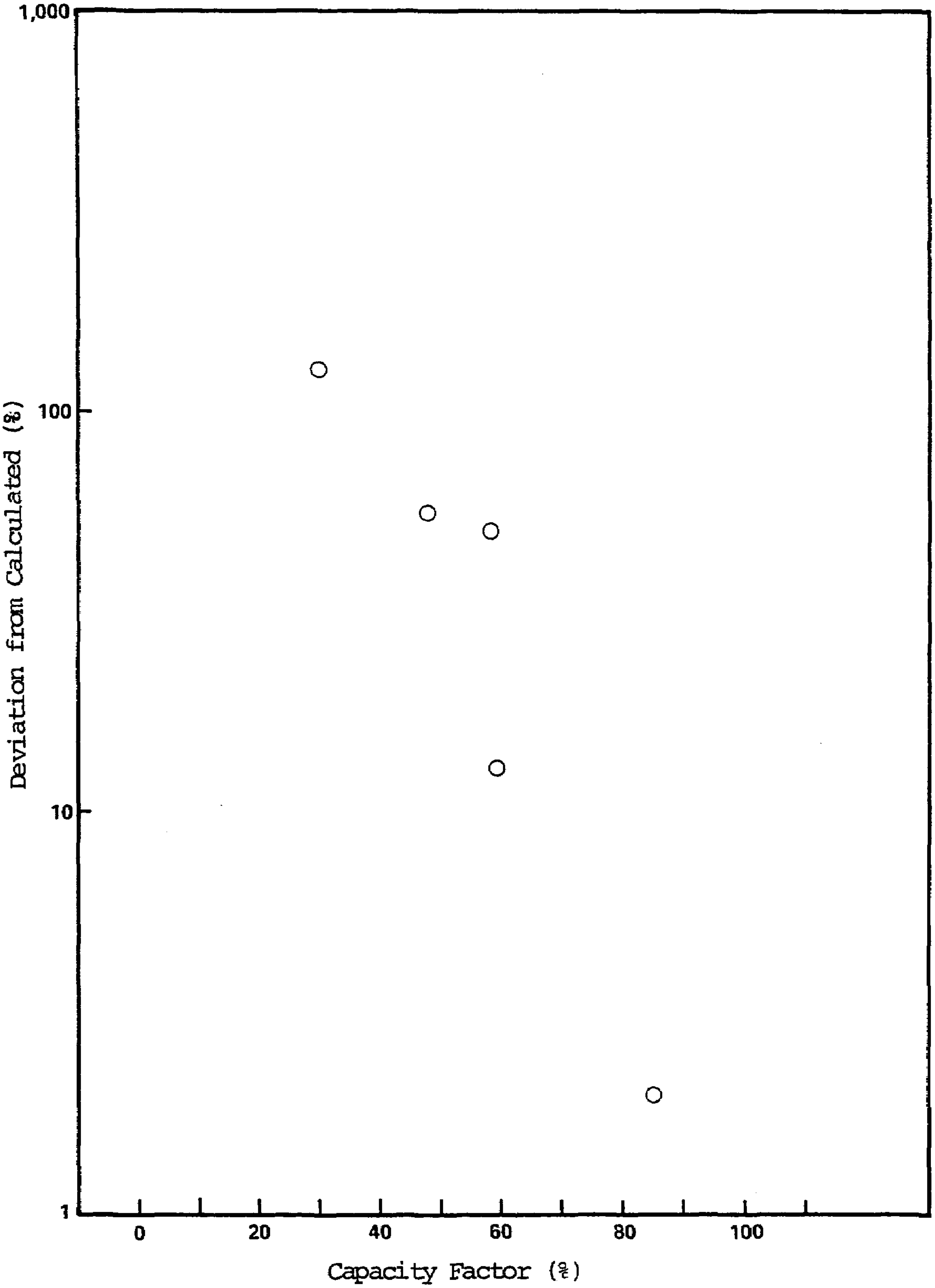

Figure 5. Percent deviation between predicted and material balance values for cooling tower evaporation rate for the El Paso Electric Co. Units.

TABLE 7. COOLING TOWER OPERATING DATA FOR ARKANSAS POWER AND LIGHT, MOSES STATION (Annual Data 1976)

	Units 1 & 2
Plant Capacity (MW)	126
Plant Capacity Factor (%)	11
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	
Unit 1	1,915 (7,600)
Unit 2	1,910 (7,575)
Circulating Water Flow Rate, cu m/min (GPM)	301.5 (79,650)
Make-up Flow Rate, cu m/min (GPM)	3.9 (1,030)
Blowdown Flow Rate, cu m/min (GPM)	0.84 (221)
Range, °C (°F)	4.7 (8.4)
Approach, °C (°F)	7.8 (14)
Air Flow Rate, std. cu m/min (SCFM)	2.5×10^5 (8.9×10^6)
Outlet Air Temperature, °C (°F)	19 (66)
Approximate Drift Losses, cu m/min (GPM)	0.6 (160)
Evaporation Rate, cu m/min (GPM)	
Model Prediction	7.2 (1907)
Material Balance	2.4 (646)
Model Prediction X Capacity Factor	0.79 (211)

TABLE 8. COOLING TOWER OPERATING DATA FOR ARKANSAS POWER AND LIGHT, COUCH STATION (Annual Data 1976)

	Units 1 & 2
Plant Capacity (MW)	161
Plant Capacity Factor (%)	29
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	
Unit 1	1,855 (7,370)
Unit 2	1,675 (6,650)
Circulating Water Flow Rate, cu m/min (GPM)	441 (116,500)
Make-up Flow Rate, cu m/min (GPM)	2.4(622)
Blowdown Flow Rate, cu m/min (GPM)	0.6(160)
Range, °C (°F)	7 (12)
Approach, °C (°F)	8 (14)
Air Flow Rate, std. cu m/min (SCFM)	3.2×10^5 (11.3×10^6)
Outlet Air Temperature, °C (°F)	28 (83)
Approximate Drift Losses, cu m/min (GPM)	0.18 (46.6)
Evaporation Rate, cu m/min (GPM)	
Model Prediction	7.6 (2,019)
Material Balance	1.6 (413)
Model Prediction X Capacity Factor	2.2 (583)

TABLE 9. COOLING TOWER OPERATING DATA FOR ARKANSAS POWER AND LIGHT, LYNCH STATION (Annual Data 1976)

	Units 1, 2 & 3
Plant Capacity (MW)	239
Plant Capacity Factor (%)	12
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	
Unit 1	2,395 (9,500)
Unit 2	2,040 (8,090)
Unit 3	2,000 (7,950)
Circulating Water Flow Rate, cu m/min (GPM)	622.8 (164,500)
Make-up Flow Rate, cu m/min (GPM)	4.5 (1,186)
Blowdown Flow Rate, cu m/min (GPM)	0 (0.1)
Range, °C (°F)	5.4 (9.8)
Approach, °C (°F)	7.8 (14)
Air Flow Rate, std. cu m/min (SCFM)	3.5×10^5 (12.5×10^6)
Outlet Air Temperature, °C (°F)	20 (68)
Approximate Drift Losses, cu m/min (GPM)	0.252 (66)
Evaporation Rate, cu m/min (GPM)	
Model Prediction	14.3 (3,770)
Material Balance	4.2 (1,120)
Model Prediction X Capacity Factor	1.7 (449)

operating at constant load, whereas peaking and intermediate plants spend considerable time relative to their total operating time building up to full load and shutting down. During these transition periods, the cooling system is rejecting varying heat loads at a fraction of full load conditions. The Leung and Moore model is not designed to handle these transition conditions.

In an attempt to correct the model for these transition conditions, a correction factor was applied to the model results. This correction factor was equal to the capacity factor. For example, the Moses Station had an 11 percent capacity factor for 1976 and the Leung and Moore model-predicted value for 1976 was 7.2 cu m/min. The corrected evaporation rate is therefore 7.2 x 0.11 = 0.79 cu m/min. A comparison of predicted, corrected, and material-balance calculated evaporation rates is provided in Table 10 for the three plants.

Minnesota Power and Light Company, Clay Boswell Unit 3--

Minnesota Power and Light Company provided hourly data for two months in 1977 for the Clay Boswell Unit 3 mechanical draft towers. The two months, January and August, represent meteorological extremes and were expected to show the minimum and maximum evaporation rates. The average for each month is shown on Table 11. Since make-up and blowdown rates to the towers were not measured on an hourly basis as part of the normal reporting activities of Minnesota Power and Light, only an annual average was obtained. As a result, hourly evaporation rates could be predicted by the model, but material balance calculations could only be performed for annual evaporation.

Meteorological data were measured on-site and were provided as part of the hourly data (see Appendix B, Figure B-3).

The results of the Leung and Moore model for January and August are shown in Figure 6. For January, the evaporation rate varied between 4.0 and 6.8 cu m/min. Although the values appear to be relatively constant, the range represents a difference of 20 percent. August evaporation is also relatively constant ranging from 7.0 to 9.5 cu m/min, a range variation of 35 percent. It is noteworthy that the maximum January and minimum August daily evaporation rates differ by only 2 percent, but the average August

TABLE 10. MODEL PREDICTED EVAPORATION RATE WITH AND WITHOUT CORRECTION FACTOR COMPARED WITH MATERIAL BALANCE CALCULATED EVAPORATION RATE FOR ARKANSAS POWER AND LIGHT PLANTS (All values in cu m/min).

PLANT/ EVAPORATION PREDICTION	MONTHS											
	J	F	M	A	M	J	J	A	S	O	N	D
MOSES												
Model Predicted [a]	7.0	7.4	9.2	7.7	7.0	7.3	7.0	7.1	7.0	7.7	7.0	6.8
Model Corrected [b]	1.6	1.3	0.3	1.0	1.0	0.5	1.3	1.9	-	0.2	0.4	2.5
Material Balance	1.7	2.2	2.8	2.9	2.7	2.8	3.1	3.2	-	1.4	1.3	2.8
COUCH												
Model Predicted [a]	6.3	6.4	7.6	7.2	7.7	8.4	9.6	9.8	7.4	6.8	6.5	6.9
Model Corrected [b]	1.7	1.4	2.2	1.9	1.7	2.2	3.1	3.3	2.1	1.3	2.7	3.0
Material Balance	2.0	1.5	2.0	1.7	1.6	1.8	2.2	2.2	1.9	1.3	2.6	2.9
LYNCH												
Model Predicted [a]	14.2	14.1	14.0	15.0	13.3	15.7	14.2	14.3	14.0	14.2	14.5	16.0
Model Corrected [b]	2.4	0.9	1.5	1.8	1.1	1.7	1.6	1.7	1.6	0.7	0.6	2.1
Material Balance	5.0	5.3	3.6	4.0	4.3	4.2	4.1	3.8	3.8	4.3	5.0	6.4

All values in cu m/min

[a] The model used was the Leung and Moore Model

[b] Model prediction x plant monthly capacity factor

TABLE 11. COOLING TOWER OPERATING DATA FOR MINNESOTA POWER AND LIGHT, CLAY BOSWELL PLANT, UNIT 3 (January and August 1977)

	Jan	Aug	Annual
Plant Capacity (MW)	350	350	
Plant Capacity Factor (%)	86	93	
Unit Heat Rejection Rate kcal/kWh (BTU/kWh)	1,293 (5,130)	1,251 (4,965)	
Circulating Water Flow Rate, cu m/min (GPM)	495.1 (130,800)	495.1 (130,781)	
Make-up Flow Rate, cu m/min (GPM)			9.9 (2,616)
Blowdown Flow Rate, cu m/min (GPM)	(500)		1.90 (500)
Range, °C (°F)	11.1 (20)	10.9 (15.6)	
Approach, °C (°F)	18.27 (32.9)	12.1 (21.8)	
Air Flow Rate, std cu m/min (SCFM)	3.4×10^5 (12×10^6)	3.4×10^5 (12×10^6)	
Outlet Air Temperature, °C (°F)	17.9 (64.25)	32.0 (89.5)	
Approximate Drift Losses, cu m/min (GPM)	0.049 (13)	0.049 (13)	
Evaporation Rate, cu m/min (GPM)			
Model Prediction	5.61 (1,470)	8.41 (2,220)	
Material Balance (Annual)			7.95 (2,100)

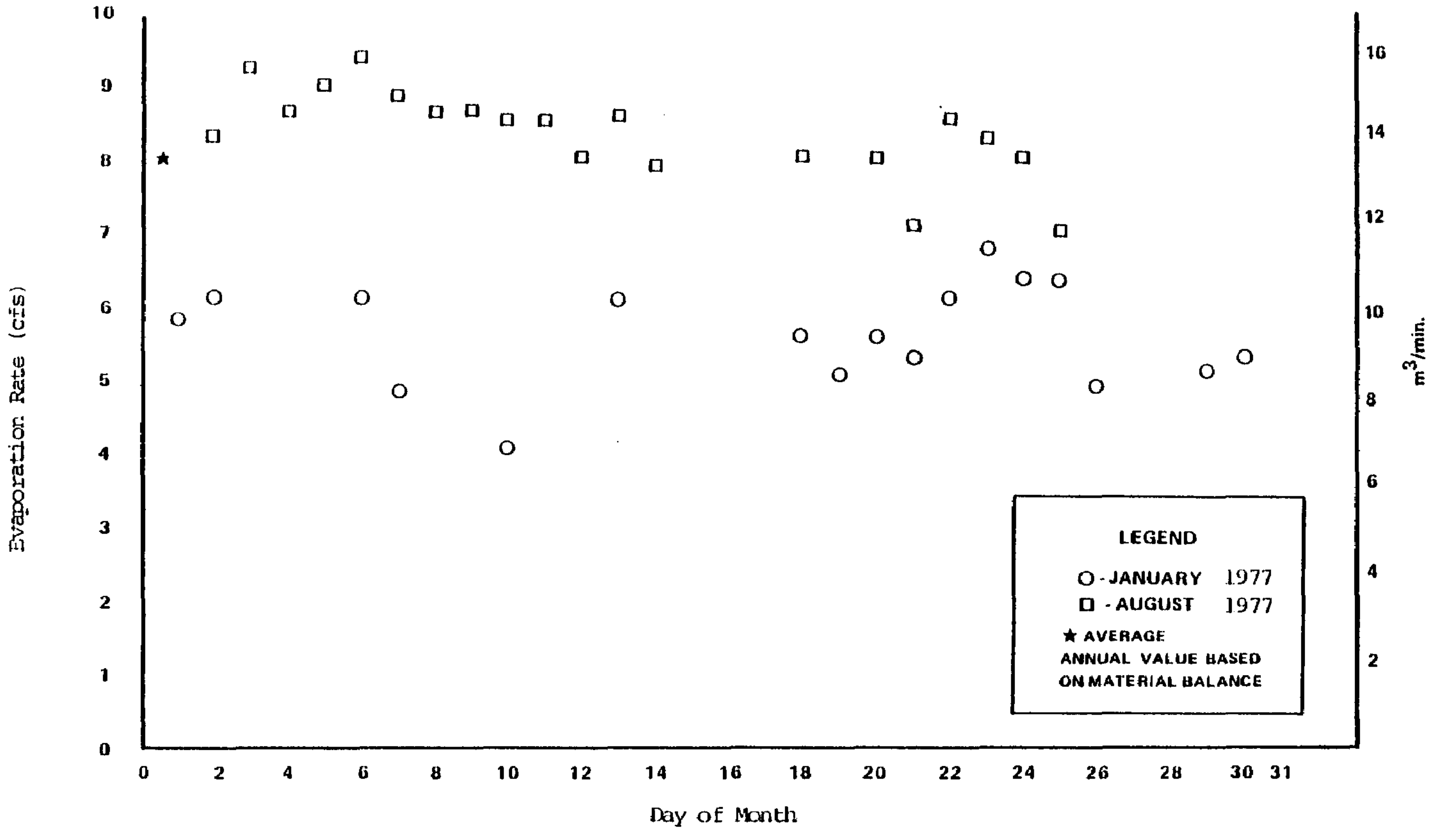

Figure 6. Cooling tower predicted evaporation rates based on actual operating data for Clay Boswell Station.

value is 50 percent greater than the January average (8.4 cu m/min vs. 5.6 cu m/min). Since the daily average of these two months, 7.0 cu m/min, is almost 1 cu m/min less than the calculated annual average, one may surmise that the model is underpredicting the evaporation rate for Clay Boswell Unit 3, but is within 15 percent of the actual evaporation rate. (Figure 6 illustrates this conclusion.)

On an evaporation loss per MW basis, the Clay Boswell Unit 3 value was consistent with other units (0.031 cu m/ min-MW) near its size and capacity factor. This relationship with other cooling tower systems is discussed further in Section 6.

Natural Draft Cooling Tower Data and Results

Pennsylvania Electric Company, Homer City Station--

Pennsylvania Electric Company provided daily natural draft cooling tower data for three months - January, April and July, 1977 - at Homer City Station, Units 1 and 2. These data were the only natural draft cooling tower operating data used in this study. The January and July average monthly operating conditions for these 664-MW units are presented in Table 12. The corresponding meteorological data, shown in Appendix B, were taken from the National Weather Service station at the Pittsburgh, Pennsylvania airport.

Figures 7 and 8 illustrate the daily predicted and material balance evaporation rates for January and July. These figures show that the Leung and Moore model generally underpredicts evaporation rate versus the material balance values. However, the material balance possibly produced considerably greater consumptive water use values because the make-up flow rates provided were for the entire station, and the utility could only estimate plant water use (500 gpm) and ash sluice water flows (800 gpm). The cu m/min-MW values (ranging from 0.027-0.040) are relatively high for these large power units (664 MW units). It is noted that the Leung and Moore model was initially developed for mechanical draft towers, but has been used in previous studies to predict evaporation for natural draft towers. Insufficient information was available from the utility to use the EPA natural draft cooling tower model developed by Winiarski.[23]

TABLE 12. COOLING TOWER OPERATING DATA FOR PENNSYLVANIA ELECTRIC COMPANY'S HOMER CITY PLANT (January, April, July 1977)

	1977		
	January	April	July
Plant Capacity (MW)	1,328	1,328	1,328
Plant Capacity Factor (%)	49.41	34.94	57.35
Unit Heat Rejection Rate kcal/kWh (BTU/kWh)	1,319 (5,238)	1,404 (5,576)	1,432 (5,685)
Circulating Water Flow Rate, cu m/min (GPM)	777.8 (205,500)	777.8 (205,500)	777.8 (205,500)
Make-up Flow Rate, cu m/min (GPM)	34.7 (9,186)	33.6 (8,889)	53.5 (14,150)
Blowdown Flow Rate, cu m/min (GPM)	9.84 (2,595)	10.08 (2,660)	10.74 (2,838)
Range, °C (°F)	19.4 (34.9)	15.6 (28.1)	15.7 (28.3)
Approach, °C (°F)	26.67 (48)	13.33 (24)	10 (18)
Air Flow Rate, Std. cu m/min (SCFM)	3.5×10^5 (12.38×10^6)	2.34×10^5 (8.25×10^6)	4.09×10^5 (14.44×10^6)
Outlet Air Temperature, °C (°F)	33.9 (93)	33.3 (92)	40.6 (105)
Approximate Drift Losses, cu m/min (GPM)	0.078 (20.6)	0.078 (20.6)	0.078 (20.6)
Evaporate Rate, cu m/min (GPM)			
Material Balance	18.5 (4,080)	18.0 (4,760)	39.5 (10,500)
Model Prediction	16.8 (4,440)	13.8 (3,640)	25.9 (6,870)
Vendor Design Curves	---	13.5 (3,550)	25.1 (6,640)

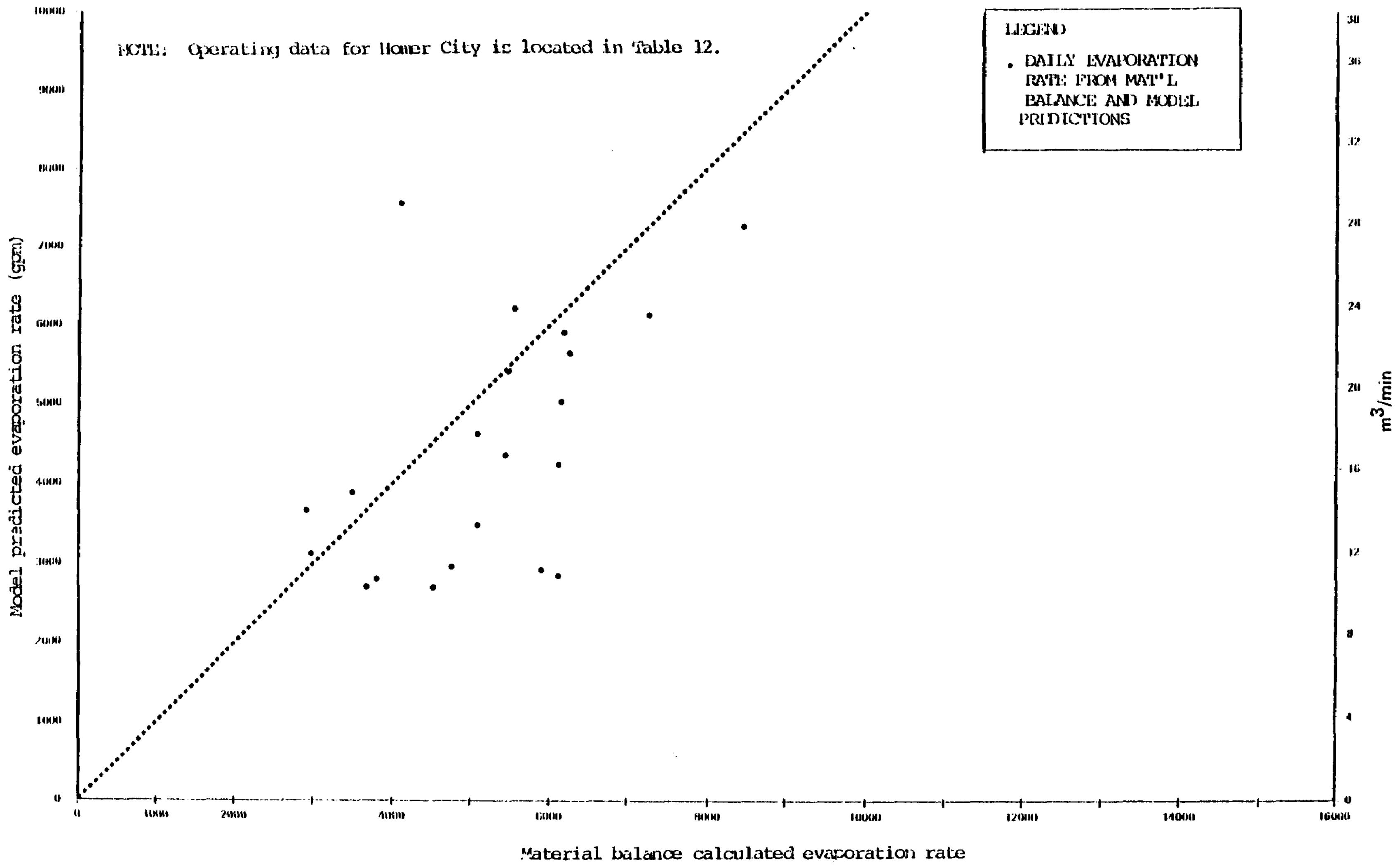

Figure 7. Evaporation rates for cooling towers for Homer City Steam Electric Station, Units 1 and 2 (January 1977).

NOTE: Operating data for Homer City is located in Table 12.

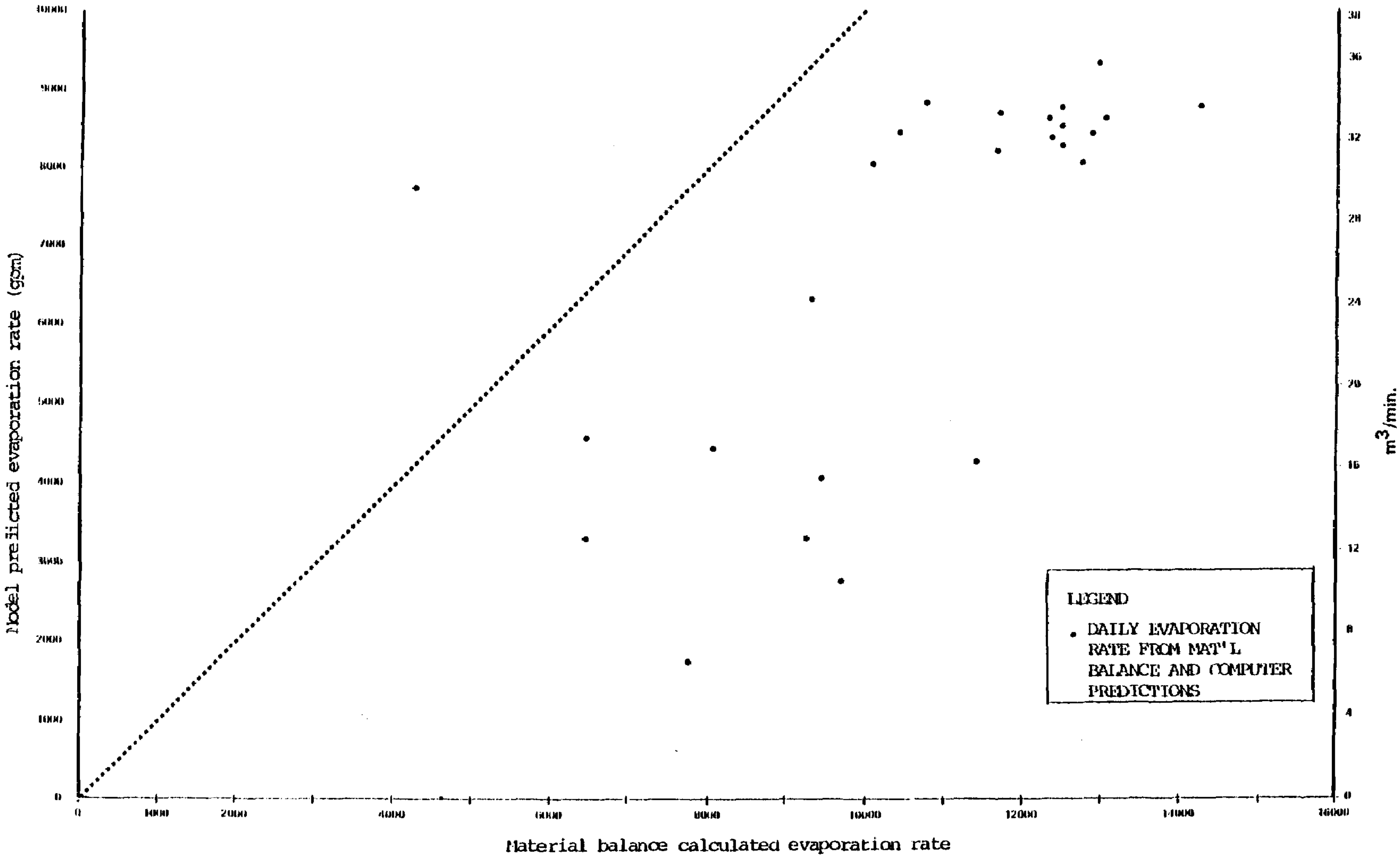

Figure 8. Evaporation rates for cooling towers for Homer City Steam Electric Station, Units 1 and 2 (July 1977).

For this plant a third source for estimating evaporation losses was available - vendor (Gilbert Associates) design evaporation loss curves which are presented in Appendix E. Table 12 also compares the Leung and Moore model predictions with the evaporation loss curve results. The model tends to overpredict when compared to this method of evaporation prediction.

Wisconsin Electric Power Company, Koshkonong Plant--

Design data were used for a natural draft cooling tower under construction to supplement the actual operating data received.

Natural draft tower design data were extracted from the Wisconsin Utilities Project Environmental Report (ER) for the Koshkonong Nuclear Plant located in southern Wisconsin.[24] The evaporation rates and input data presented in the ER were determined by Stone & Webster Engineering Corporation. These data are shown in Table 13. The data were found to be insufficient to meet the input requirements to the EPA natural draft cooling tower model.[23] This model is sensitive to heat transfer and friction coefficients and requires considerable information on inlet and tower packing geometry. To our knowledge, final verification of this model has not been performed using actual operating test data.

There was sufficient information for input to the Leung and Moore model. Since this model has been used to predict evaporation rates in natural draft towers as well as mechanical draft towers, a computer analysis was performed on the design data.

The Leung and Moore model predicted an evaporation rate of 42 cu m/min (24.6 cfs) versus the Stone & Webster prediction, using a more sophisticated energy balance model, of 40 cu m/min (23.8 cfs). The difference is less than four percent.

If the natural draft tower operating data received to date are representative of the type and extent available from the utilities, then it is believed there is insufficient input to conclusively test the applicability of the Winiarski generic model.[23] In particular, the data input to the EPA natural draft cooling tower model on packing geometry is not expected to be available from the utilities, but may be available from the vendors.

TABLE 13. COOLING TOWER OPERATING DATA FOR WISCONSIN ELECTRIC POWER COMPANY'S KOSHKONONG PLANT (Design Data)

	Unit 1
Plant Capacity (MW)	900
Plant Capacity Factor (%)	100
Unit Heat Rejection Rate kcal/kWh (BTU/kWh)	1,860 (7,383)
Circulating Water Flow Rate, cu m/min (GPM)	1,986 (524,100)
Make-up Flow Rate, cu m/min (GPM)	28.4 (12,500)
Blowdown Flow Rate, cu m/min (GPM)	7.2 (1,850)
Range, °C (°F)	14 (26)
Approach, °C (°F)	10 (18)
Air Flow Rate, std cu m/min (SCFM)	1.1×10^6 (40.2×10^6)
Outlet Air Temperature, °C (°F)	28 (32)
Approximate Drift Losses, cu m/min (GPM)	0.096 (26)
Evaporation Rate, cu m/min (GPM)	
Design Value	40 (10,700)
Model Prediction	42 (11,200)

COOLING POND/LAKE DATA AND RESULTS

The data obtained from utilities on cooling pond/lake and cooling canal operation reflect the inherent difficulties in measuring or accurately estimating evaporation. Unlike cooling towers that operate under controlled flow rate conditions, cooling pond/lake operation is affected by uncontrolled variables such as direct rainfall, runoff, intermittent and underground stream inflow, seepage, and variable natural evaporation. As a result, utilities in general only monitor cooling pond/lake elevation and condenser inlet and outlet water temperatures.

To perform material balances around cooling ponds/lakes without direct measurements from the utilities requires estimation of the following parameters: stream inflow and outflow, drainage area for the pond/lake, pond/lake level variations over time, and precipitation. In some cases many of these data were unobtainable, but for the Cholla Plant, H. B. Robinson Station, and Belews Creek Station a material balance for determining evaporation rate could be applied using available information.

The cooling pond/lake data and analyses of results are presented in this section on a plant-by-plant basis. Throughout this section the terms "cooling pond/lake model-predicted evaporation rates", or "Model Predictions" are used. These phrases denote results from each of the five cooling pond/lake models; Marciano-Harbeck (Lake Hefner Study-QH)[20] Harbeck-Koberg-hughes (Lake Colorado City Study-QC),[9] Meyer Model (QM);[12] Brady et al model (QB)[12], and the Harbeck Nomograph Method.[8] Where only one model is discussed and its results presented, the model is specified by author or study name. The letter designations are used in figures presenting model-predicted evaporation rates.

Arizona Public Service Company, Cholla Plant--

Arizona Public Service provided annual average operating data for the period 1974-1976 on the Cholla Plant located in the Lower Colorado region. The operation data are presented in Table 14. Actual evaporation rates were provided by the utility, the values provided being based on pan evaporation data. Representative meteorological data were obtained from Winslow, Arizona (see Appendix B).

TABLE 14. COOLING POND OPERATING DATA FOR ARIZONA PUBLIC SERVICE'S CHOLLA PLANT (Average 1974-1976)

Plant Capacity (MW)	120
Plant Capacity Factor (%)	70 (design)
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	1,215 (4,820)
Circulating Water Flow Rate, cu m/min (GPM)	105.2 (27,800)
Flow Rate into Pond, cu m/min (GPM)	6.42 (1,696)
Flow Rate out of Pond, cu m/min (GPM)	1.18 (313)
Range, °C (°F)	Not given
Condenser Make-up Water Temperature, °C (°F)	13.8 (56.9)
Surface Area of Cooling System, ha (acres)	135.7 (340)
Volume of Cooling System, cu m (acre-ft.)	Not given
Drainage Area	N/A
Evaporation, cu m/min (GPM)	
Material Balance	6.9 (1,840)
Model Predictions	
Lake Hefner (QH)	4.8 (1,260)
Lake Colorado City (QC)	6.9 (1,840)
Meyer (QM)	6.1 (1,620)
Brady (QB)	5.3 (1,390)
Harbeck Nomograph & Pan Evaporation (QHN)[a]	5.0 (1,300)

[a] The corrected pan evaporation rate was 3.5 cu m/min

The predicted monthly average evaporative losses are shown on Figure 9. The average evaporative loss provided by the utility was 6.9 cu m/min (4.1 cfs). This value is within ±15 percent of the predictions of the Lake Colorado City and the Meyer model values of 6.9 and 6.1 cu m/min (4.1 and 3.6 cfs), respectively. This cooling pond system is characterized by an area/MW ratio of 2.8, which is relatively high compared to most utility cooling pond systems. This larger ratio is reflected in a small difference between pond and ambient temperatures. The largest temperature variation occurs in the winter months when the pond remains a few degrees above freezing and ambient temperatures lie a few degrees below freezing.

Factors of special note that affect the results are:

- An accurate estimate of seepage and inflow was unobtainable, so utility estimates of evaporation were used. The confidence limit on the value is unknown. However, variations of ±30% would put all the models within the sought ±15% predictive range.
- A large pond size in comparison to the plant electrical load implies that natural evaporative loss contributes a major portion of the total evaporative loss. This is seen by comparing the historical annual average corrected pan evaporation of 3.5 cu m/min with the material balance value of 6.9 cu m/min (i.e., 51%).

Texas Electric Service Company, Morgan Creek Station--

Texas Electric Service Company was contacted to determine if cooling lake data were available comparable to the performance test data on their cooling towers. They suggested the cooling lake study conducted by G.E. Harbeck, J.S. Meyers, and G.H. Hughes at Lake Colorado City in 1960.[9] The Lake Colorado City model was generated from that and previous studies.

The Harbeck et al study[9] provides lake temperature, meteorological and evaporation data, but no plant operating data for the Morgan Creek Station that discharges to Lake Colorado City. To supplement the study,

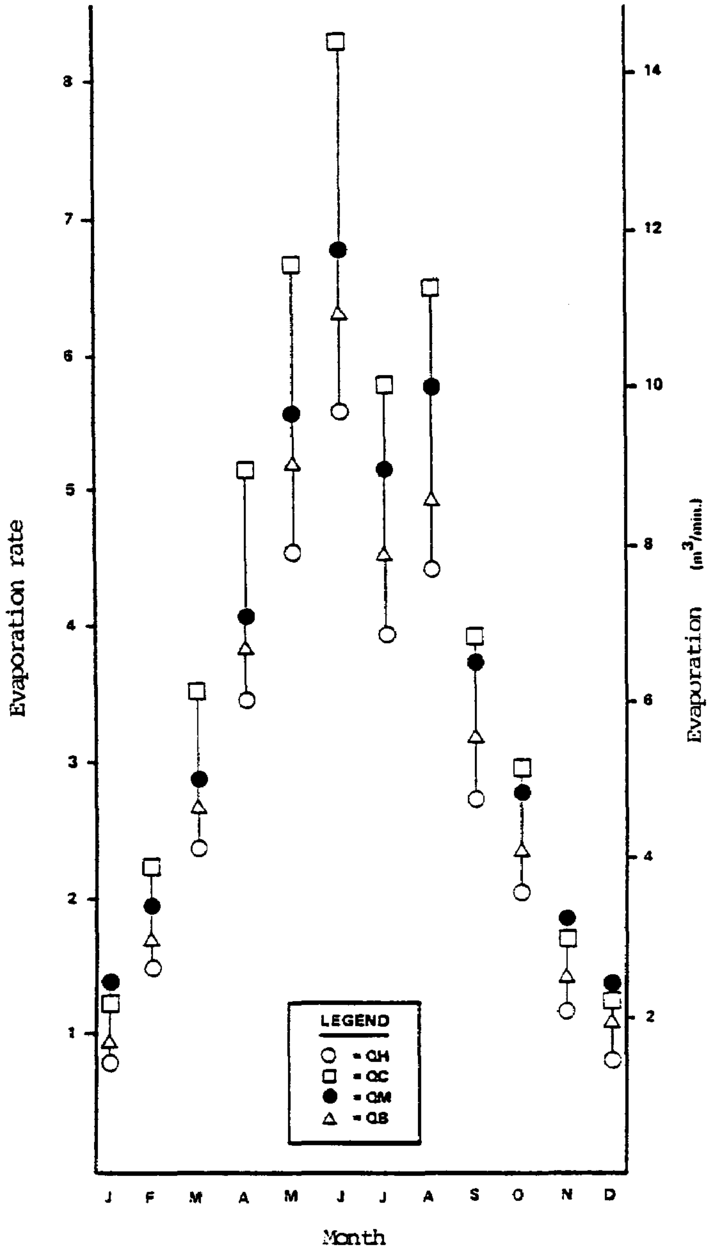

Figure 9. Cooling pond model predicted evaporation rates for Cholla Plant (1976).

operating data were obtained from the Steam-Electric Plant Air and Water Quality Control Data Summary Report published by the Federal Power Commission[15] (now the Federal Energy Regulatory Commission). The combined data are provided in Table 15. The meteorological data are presented in Appendix B.

Water balance and energy calculations were performed as part of the study for October through September, 1959 and 1960, and an annual cumulative evaporation of 252 cm (96.9 in.) is given. This is equivalent to 20.9 cu m/min (12.3 cfs).

The data were used to calculate predictions from all five models. The predictions are presented on Figure 10. As might be expected, the closest model to the actual evaporation rate of 20.9 cu m/min was the Lake Colorado City model at 17.9 cu m/min (within 14 percent).

The 1960 study used a nearby reservoir and energy balances to determine that forced evaporation accounted for about 15 percent of the total lake evaporation. This is lower than, but consistent with, forced evaporation results found at other cooling ponds/lakes in this study.

Commonwealth Edison Company, Kincaid Generating Station—

Commonwealth Edison Company provided operating cooling lake data from the Kincaid Generating Station on Sangchris Lake. The data were primarily annual average operating data for July 1, 1976 - June 30, 1977. Table 16 presents these data. Monthly lake and plant discharge temperatures were also provided.

Table 16 also lists a utility-calculated evaporation rate of 36.2 cu m/min (21.3 cfs). This value was provided by Commonwealth Edison Company and based on thermal modeling of the reservoir and is an average for the years 1971-1975. Because no relevant gaging station data were available from the USGS and the data for verifying the utility-derived evaporation rate were not provided, the value could neither be verified nor adjusted for the January 1976 through June 1977 period for which operating data were provided. Since the

TABLE 15. COOLING LAKE OPERATION DATA FOR TEXAS ELECTRIC SERVICE COMPANY'S, MORGAN CREEK PLANT, LAKE COLORADO CITY (1959-1960)

Plant Capacity (MW) (equivalent)[a]	102
Plant Capacity Factor (%)	N.A.
Annual Heat Rejection Rate, kWh/yr (BTU/hr)	1.64×10^9 (5.62×10^{12})
Circulating Water Flow Rate, cu m/min (GPM)	1,869 (493,714)
Flow Rate into Pond, cu m/min (GPM)	23.1 (6,075)
Flow Rate out of Pond, cu m/min (GPM)	3.24 (860)
Range, °C (°F)	Not Given
Condenser Make-up Water Temperature, °C (°F)	
Range	6-26 (43-79)
Average	20 (68)
Surface Area of Cooling System, ha (acres)	445 (1,100)
Volume of Cooling System, cu m (acre-ft)	38,223,000 (31,000)
Drainage Area, sq km (sq.mi.)	846 (326)
Evaporation, cu m/min (GPM)	
Material Balance	20.9 (5,520)
Model Predictions	
Lake Hefner (QH)	12.2 (3,230)
Lake Colorado City (QC)	17.9 (4,710)
Meyer (QM)	15.0 (3,950)
Brady (QB)	13.9 (3,640)
Harbeck Nomograph & Pan Evaporation (QHN)[b]	14.7 (3,860)

[a] Based on 1.64×10^9 kwh/yr rejected to Lake Colorado City.[9]

[b] The corrected pan evaporation rate was 12.3 cu m/min.

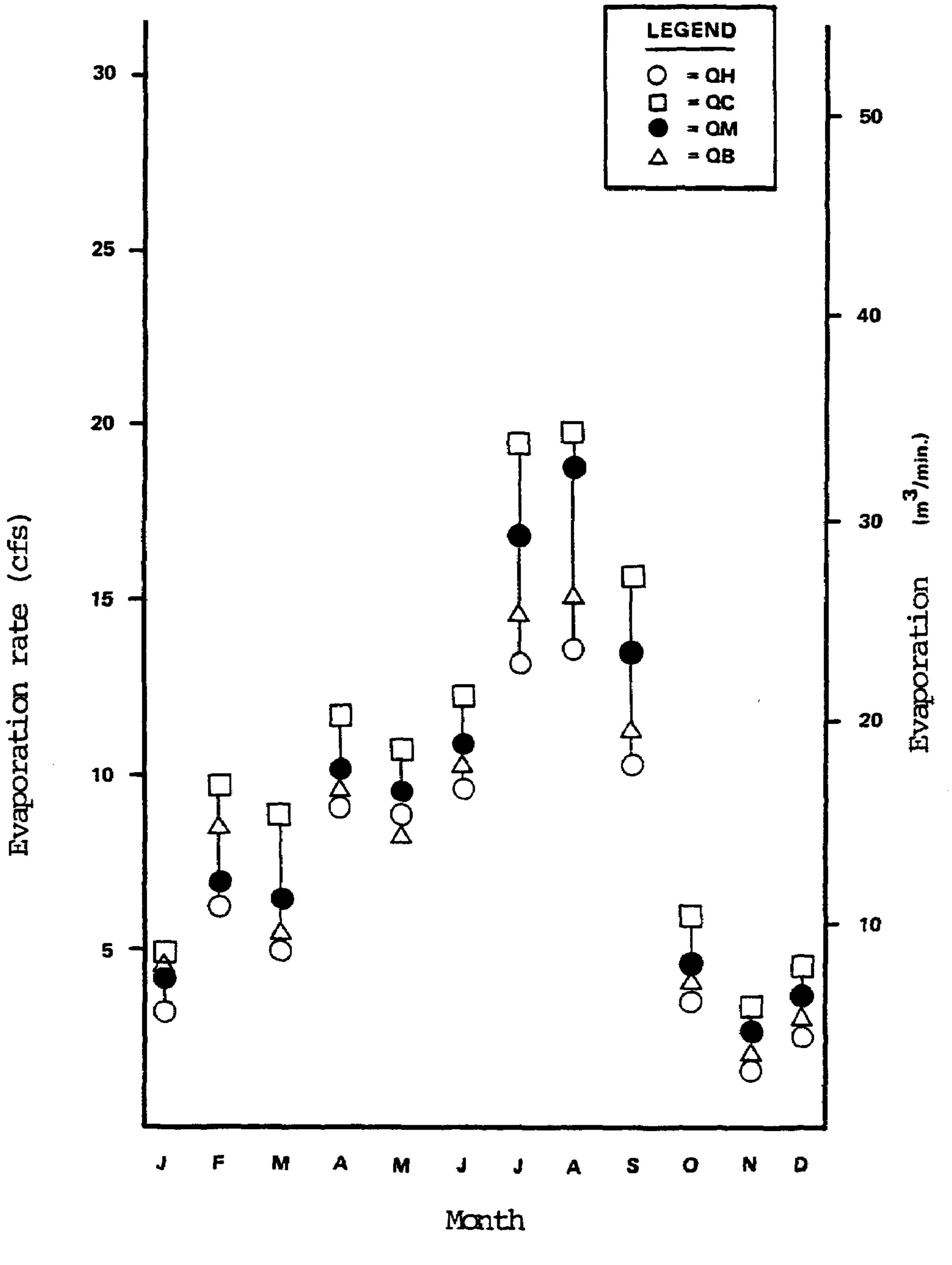

Figure 10. Cooling pond model predicted evaporation rates for Morgan Creek Station (1960).

TABLE 16. COOLING LAKE OPERATING DATA FOR COMMONWEALTH EDISON'S, KINCAID STATION (1977 Annual Data)

Plant Capacity (MW)	1,319
Plant Capacity Factor (%)	34 (47.8, 1971-1975)
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	1,310 (5,200)
Circulating Water Flow Rate, cu m/min (GPM)	1,817 (479,981)
Flow Rate into Pond, cu m/min (GPM)	109.2 (28,800)
Flow Rate out of Pond, cu m/min (GPM)	73.2 (19,300)
Range, °C (°F)	7.7 (13.8)
Condenser Make-up Water Temperature, °C (°F)	16.7 (62.0)
Surface Area of Cooling System, ha (acres)	972* (2,400)
Volume of Cooling System, cu m (acre-ft.)	41,305,500 (33,500)
Drainage Area, sq. km. (sq. mi.)	198 (76.6)
Evaporation, cu m/min (GPM)	
1976 Annual Average	36.2 (9,560)
Model Predictions	
Lake Hefner (QH)	26.4 (6,960)
Lake Colorado City (QC)	39.0 (1,030)
Meyer (QM)	34.4 (9,070)
Brady (QB)	30.1 (7,940)
Harbeck Nomograph & Pan Evaporation (QHN)	19.8 (5,340)

[a] NOTE: 2,165 acres was the effective area used as suggested by Commonwealth Edison. The available cooling area was reduced because one arm of Sangchris Lake is not available for cooling.

[b] The corrected pan evaporation rate was 12.6 cu m/min.

evaporation rate is an independently derived value based on an accepted thermal model, it was used for comparison with the predictions from the five models.

Meteorological data (shown in Appendix B) were obtained from the NWS at Springfield, Illinois, about 20 miles south of the plant.

Using the 1976 data, model predictions of the evaporation rate were made and are presented on Figure 11. Based on a map of the lake and information from the utility, one arm of the lake (about 10 percent of the surface area) was not included in the evaporation calculation because it was not available for cooling.

As with most other pond results, the model predictions understate the evaporation from the cooling lake. Two cooling lake models were within ±15 percent of the utility-provided 36.2 cu m/min evaporation rate; the Harbeck et al (Lake Colorado City) model predicted a value of 39.0 cu m/min, while the Meyer model predicted 34.4 cu m/min.

A comparison of meteorological and operating data between the period 1971-1975 vs. 1976 shows generally cooler ambient temperatures and lower pond temperatures for 1976. This will normally result in less evaporation and may account for some of the cooling lake models underestimating the evaporation rate. The fact that the capacity factor for 1971-1975 was 48 percent versus a capacity factor of 34 percent for 1976 probably caused some decrease in pond temperature for 1976.

Commonwealth Edison, Powerton Generating Station--

Commonwealth Edison also provided operating data shown in Table 17 for two units at the Powerton Generating Station and the associated cooling pond. The man-made pond uses levees to contain water pumped to the pond, but considerable seepage occurs which acts as a blowdown stream. This seepage has been estimated by the utility to be 56 cu m/min (32.9 cfs). The pond is baffled to enhance mixing and direct flow.

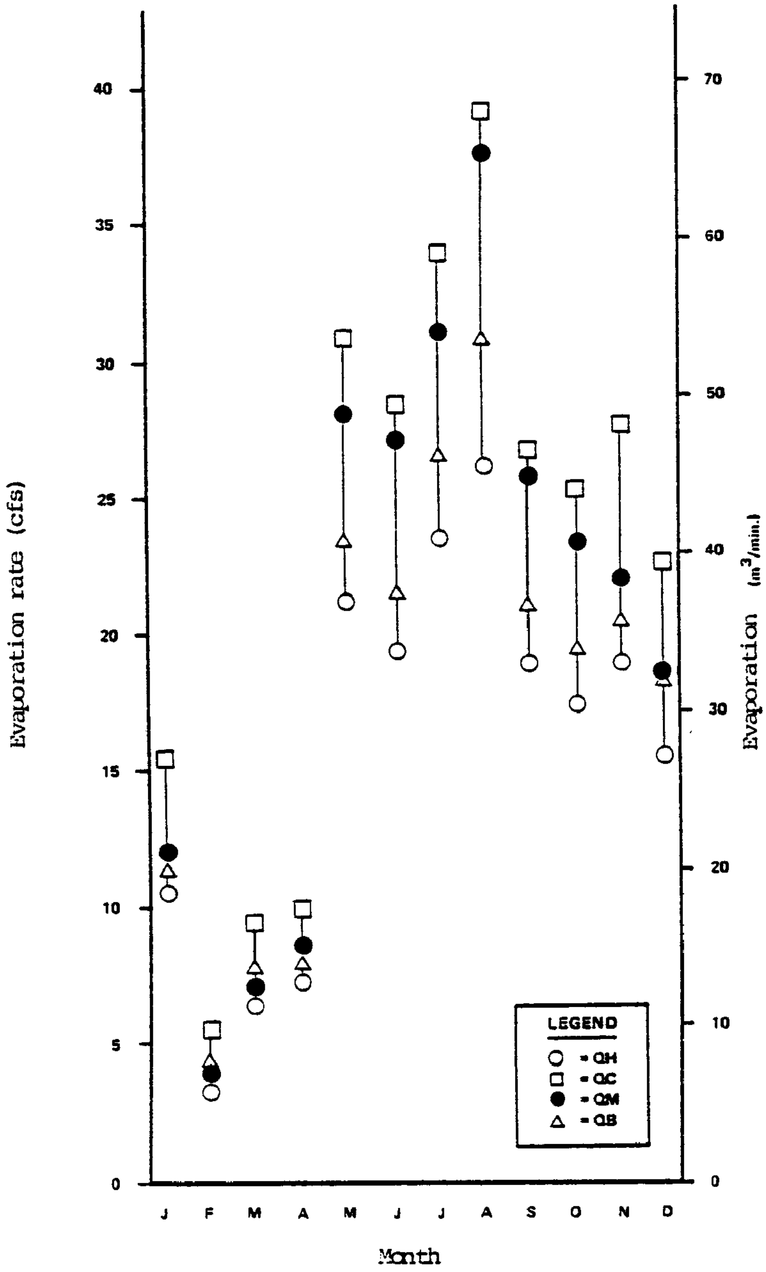

Figure 11. Cooling pond model predicted evaporation rates for Kincaid Station (1976).

The operating data were average values for the time period September 1971 through February 1974 and the 12 months ending June 30, 1977. For comparison purposes, the utility provided 1973 pond temperature data when only Unit 5 discharged to the pond (840-MW unit) and 1977 pond temperature data when Unit 6 (945-MW) also discharged to the pond. Meteorological data for 1973 were obtained from the NWS at Peoria, Illinois and are presented in Appendix B.

The evaporation and seepage values from the cooling pond were determined by Commonwealth Edison Company for the period September 1972 through February 1974. The evaporation rate was calculated as the difference between make-up from the Illinois River plus direct precipitation and estimated seepage losses. An annual average value of 18.5 cu m/min (10.9 cfs) was provided by the utility as the cooling pond evaporation rate during this period.

The model values, shown on Figure 12, predict an average annual evaporation rate for 1973 (Unit 5 only) from 12.6 to 18.0 cu m/min. The Lake Colorado City and Meyer models were within ±15 percent of the water balance value provided by Commonwealth Edison. The evaporation rate predicted by that Lake Colorado City model was 18.0 cu m/min (10.6 cfs), underestimating evaporation by 3 percent, while the Meyer model predicted evaporation of 15.7 cu m/min (9.2 cfs), a difference of -15 percent.

The 1977 operating data provided an opportunity to approximate the increase in forced evaporation from this cooling pond when Unit 6 was added. Its effect on evaporation is reflected in the 1977 model predictions. The values below show the difference between 1973 and 1977 evaporation rates predicted by the Lake Colorado City and Meyer models.

Model-predicted evaporation rate for January through August 1977 (cu m/min)

MODEL	1977	1973	Difference in Evaporation Rate	Increase In Evaporation
Lake Colorado City	27.4	18.0	9.4	52%
Meyer	24.1	15.8	8.3	53%

TABLE 17. COOLING POND OPERATING DATA FOR COMMONWEALTH EDISON, POWERTON STATION (Unit No. 5 and No. 6 1977 Annual Data)

	(1973) Unit No. 5	(1977) Unit No. 6
Plant Capacity (MW)	840	945
Plant Capacity Factor (%)	51.7	47.1
Unit Heat Rejection Rate,	1,140 (4,540)[a]	
Circulating Water Flow Rate, kcal/kWh (BTU/kWh)	2,614.4 (690,562)[a]	
Flow Rate into Pond, cu m/min (GPM)	74.4 (19,666.2)[a]	
Flow Rate out of Pond, cu m/min (GPM)	55.9 (14,772.1)[a]	
Range, °C (°F)	10.4 (18.8)	10.7 (19.3)
Condenser Make-up Water Temperature, °C (°F)	34.1 (61.5)	33.6 (60.6)
Surface Area of Cooling System, ha (acres)	577 (1,426)[a]	
Volume of Cooling System, cu m (acre-ft.)	712,094 (15,600)[a]	
Drainage Area	N/A	N/A
Evaporation, cu m/min (GPM)		
9/71 - 2/74 Average Annual (Utility-provided)	18.5 (4,891.9	N/A
Model Predictions (1973) - Unit No. 5		
Lake Hefner (QH)	12.6 (3,320)	
Lake Colorado City (QC)	18.0 (4,760)	
Meyers (QM)	15.7 (4,130)	
Brady (QB)	14.0 (3,680)	
Harbeck Nomograph + Pan Evaporation (QHN)[b]	14.0 (3,680)	
Model Predicted Evaporation - (1/77-8/77) - Units 5 and 6		
Lake Colorado City (QC)	27.6 (7,270)	
Meyer (QM)	24.2 (6,370)	

[a] Values placed between Units No. 5 and No. 6 correspond to average data for the year ending 6/30/77.

[b] The corrected pan evaporation rate was 7.1 cu m/min.

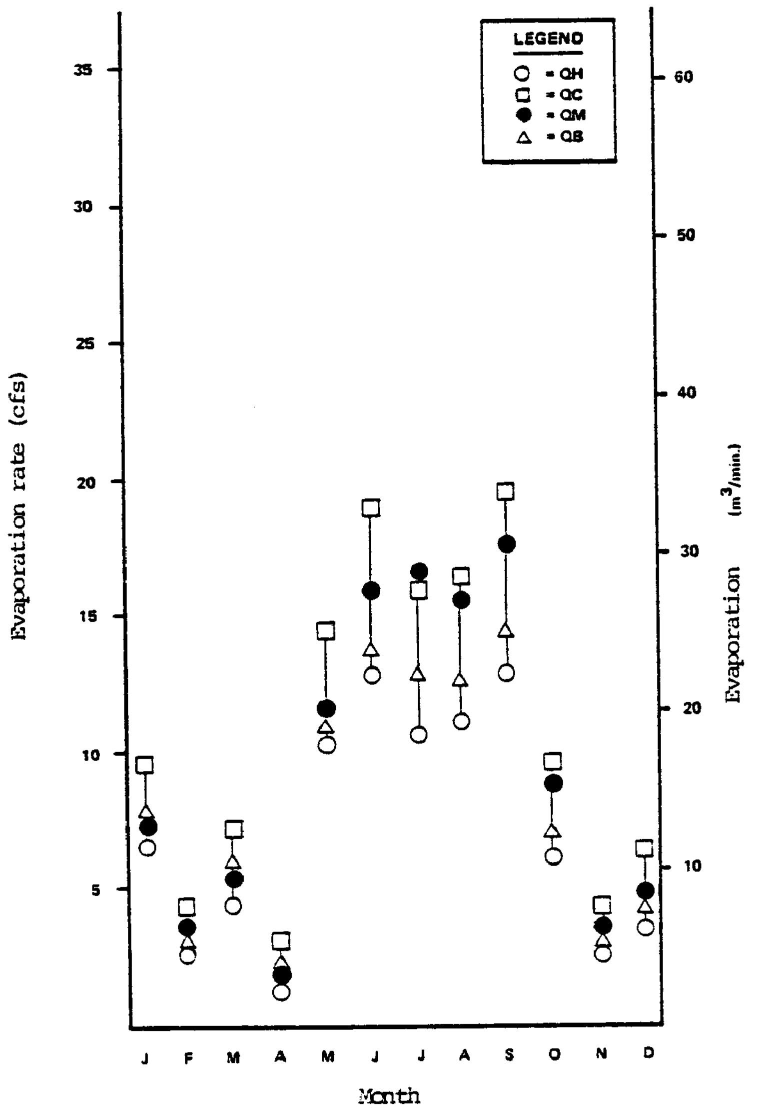

Figure 12. Cooling pond model predicted evaporation rates for Powerton Station (1973).

Comparing 1977 and 1973 meteorology shows that 1973 was generally warmer, more humid, and more windy. These three factors should act to narrow the difference between the two years. It appears therefore that Unit No. 6 by doubling the plant produced at least a 50 percent increase in the total evaporation rate.

Virginia Electric and Power Company, Mt. Storm Station--

The utility supplied relevant operating data for two months, January and July 1977, for Mt. Storm Station which are shown in Table 18. These data have restricted use for evaluating which of the four models better describes actual evaporative loss for a geographic region without concurrent flow or evaporation data. Since the utility did not provide actual field data, USGS stream data were relied upon for performing a material balance. The components used for the water balance equation are:

- Gaged inflow from creeks or tributaries
- Drainage basin areas and runoff rates
- Seepage, if any
- Gaged outflow

A USGS gaging station is located 7½ miles downstream from the Mt. Storm Lake dam; this distance adds another 17 square miles of drainage basin that must be subtracted to obtain dam flows. The actual lake drainage basin area is known, but not the flows in Stony Creek which is the major inflow to the lake. An attempt was made to estimate flows in Stony Creek from USGS-provided data on other nearby creeks with similar flows. Abram Creek, Patterson Creek, the North Branch of the Potomac River and the Blackwater River were chosen. January and July flows were obtained for Stony Creek, but the estimated flow varied by 30 to 70 percent depending upon which of the five similar creeks were used in the determination. Therefore, the estimated Stony Creek flows added large uncertainties to the material balance.

The water balance-calculated evaporation rates for Mt. Storm Lake were -2.0 cu m/min for January and 4.7 cu m/min for July. The negative evaporation rate and low summer evaporation rate were attributed to the

TABLE 18. COOLING LAKE OPERATING DATA FOR VIRGINIA ELECTRIC AND POWER'S MT. STORM PLANT (January and July 1977).

	January	July
Plant Capacity (MW)	1,662 MW	
Plant Capacity Factor (%)		
Unit 1	68.8%	
Unit 2	61.2%	
Unit 3	35.4%	
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	1,078 (4,280)	1,078 (4,280)
Circulating Water Flow Rate, cu m/min (GPM)	3,366 (889,020)	3,366 (889,020)
Flow Rate into Pond, cu m/min (GPM)	692 (182,743)	539 (142,378)
Flow Rate out of Pond, cu m/min (GPM)	29.0 (7,676)	11.8 (3,124)
Annual Range, °C (°F)	18.5 (33.3)	
Condenser Make-up Water Temperature, °C (°F)	5.7 (42.2)	28.4 (83.1)
Surface Area of Cooling System, ha (acres)	457.6 (1,130)	
Volume of Cooling System, cu m (acre-ft.)	6.0×10^7 (4.9×10^4)	
Drainage Area, sq. km. (sq. mi.)	78 (30)	
Evaporation, cu m/min (GPM)		
Material Balance	-2.0 (-539)[a]	4.7 (1,260)
Model Prediction		
Lake Hefner (QH)	7.7 (2,020)	10.9 (2,870)
Lake Colorado City (QC)	11.2 (2,960)	16.2 (4,260)
Meyer (QM)	10.6 (2,780)	24.3 (6,420)
Brady (QB)	10.0 (2,650)	19.2 (5,070)

[a] The negative material balance value was caused by uncertainties in the estimated flows in Stony Creek.

[b] The lack of monthly pan evaporation data precluded calculation of model-predicted values.

uncertainties in the estimated flows in Stony Creek and the lack of information concerning lake level changes during the period.

Nevertheless, model predictions were made based on meteorological data from the NWS at Elkins, West Virginia (Appendix B). The results obtained from the models are presented in Figure 13 and 14.

For the month of January, three of the four models predicted about 10-11 cu m/min, with the Lake Hefner model producing a lower value of 7.7 cu m/min. The model results for July varied by more than a factor of two with the Lake Hefner model predicting only an 10.9 cu m/min rate, while the Meyer model produced an evaporation rate of 24.3 cu m/min compared to the material balance computation of 4.7 cu m/min.

For a 1,660-MW generating station, these evaporation rates are relatively low compared to other power plants studied in this program. This is probably due to the low area per unit power (acre/MWe) ratio which in effect reduces natural evaporation more than the increased lake thermal loading increases forced evaporation. A further discussion of the effect of area per unit power on cooling pond/lake evaporation rate is provided in Chapter 6. A definitive analysis of these model predictions, however, needs more reliable field measurements to characterize the water mass balance around the Mt. Storm cooling lake.

Carolina Power and Light Company, H.B. Robinson Station--

Carolina Power and Light operates two units at its H.B. Robinson Station with a total capacity of 885 MW. The cooling lake contains 2,250 acres of surface area and 173 square miles of drainage. The utility performed a study of its cooling system discharge for the Robinson impoundment for the period April 1975 through March 1976.[3] This study provided operating and meteorological input data for the computer models and material balance calculations. Table 19 presents the annual average operating data for this station. Concurrent meteorology is provided in Appendix B.

The various components of the water balance around the impoundment were available from the Section 316 Demonstration Study.[3] An estimate of the evaporative loss was computed as follows:

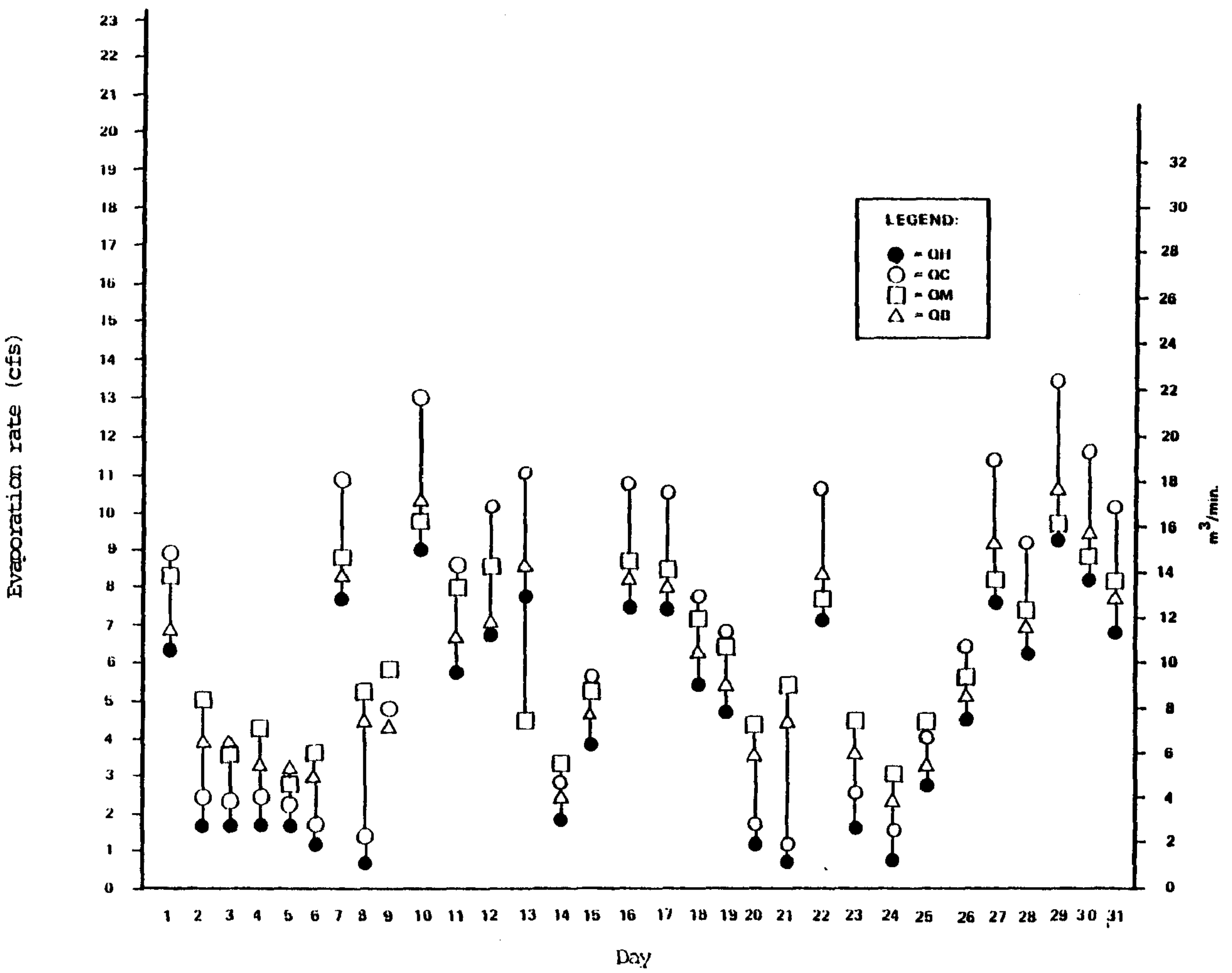

Figure 13. Cooling lake model predicted evaporation rates for Mt. Storm Station (January 1977)

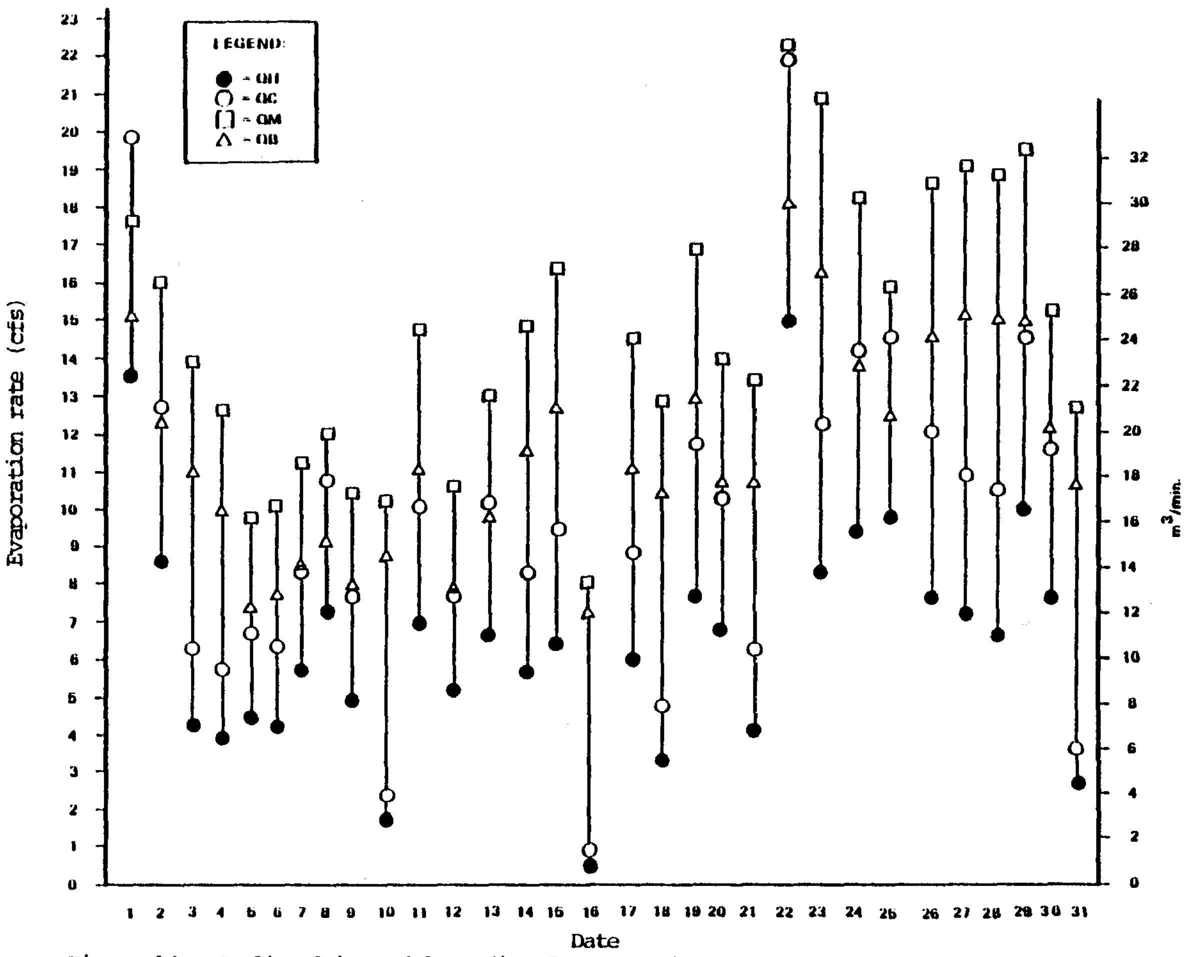

Figure 14. Cooling lake model predicted evaporation rates for Mt. Storm Station (July 1977)

TABLE 19. COOLING LAKE OPERATING DATA FOR CAROLINA POWER AND LIGHT COMPANY'S H.B. ROBINSON PLANT (April 1975 - March 1976).

Plant Capacity (MW)	885
Plant Capacity Factor (%)	67
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	1,230 (4,900)
Circulating Water Flow Rate, cu m/min (GPM)	1,896.4 (500,923)
Flow Rate into Pond, cu m/min (GPM)	496.7 (131,202)
Flow Rate out of Pond, cu m/min (GPM)	474.1 (125,232)
Range, °C (°F)	7.8 (14.1)
Condenser Make-up Water Temperature, °C (°F)	22.0 (71.6)
Surface Area of Cooling System, ha (acres)	911.2 (2,250)
Volume of Cooling System, cu m (acre-ft.)	5.06×10^7 (41,000)
Drainage Area, sq. km. (sq. mi.)	448 (173)
Evaporation, cu m/min (GPM)	
Material Balance	44.6 (11,800)
Model Predictions	
Lake Hefner (QH)	26.0 (6,870)
Lake Colorado City (QC)	38.3 (10,100)
Meyer (QM)	40.2 (10,600)
Brady (QB)	34.0 (8,980)
Harbeck Nomograph & Pan Evaporation (QHN)[a]	26.8 (7,090)

[a]The corrected pan evaporation rate was 16.0 cu m/min.

Evaporative loss = Inflow from Black Creek and others + precipitation
- flow over the dam ± changes in pond level.

In 1975, the annual average loss was calculated to be 44.6 cu m/min (26.2 cfs).

The model predictions based on actual monthly operating data are presented in Figure 15. The annual average model-predicted evaporation and the material balance results (all in cu m/min) are compared below:

Model				
Lake Hefner	Lake Colorado City	Meyer	Brady	Material Balance
26.0	38.3	40.2	34.0	44.6

The relatively good agreement of the Lake Colorado City and Meyer models with the material balance values on an annual basis does not reflect the fact that for some months the model predicted evaporative losses differed from the material balance values by as much as 50 cu m/min.

The utility provided measured temperature data in its Section 316 Demonstration such that the net temperature rise in the pond due to the power plant heat rejection could be calculated by comparing a baseline year (1960) when the plant was not in operation with average temperatures for three years when the plant was operating (1972-1974). Under summer conditions, the power plant discharge caused an average 1.8°C rise in lake discharge temperature and 2.8°C for winter months.[3] The models were exercised using data for baseline (1960) and one operating year (1973) which provided the following annual averages in cu m/min.

Model	Total Evaporation	Natural Evaporation	Forced Evaporation	Forced Evaporation, %
Lake Colorado City	42.4	32.5	9.7	23
Meyer	45.6	35.2	10.4	23

These values do not reflect the variations that arise on a month-to-month basis. The power plant discharge accounts for an evaporation rate of

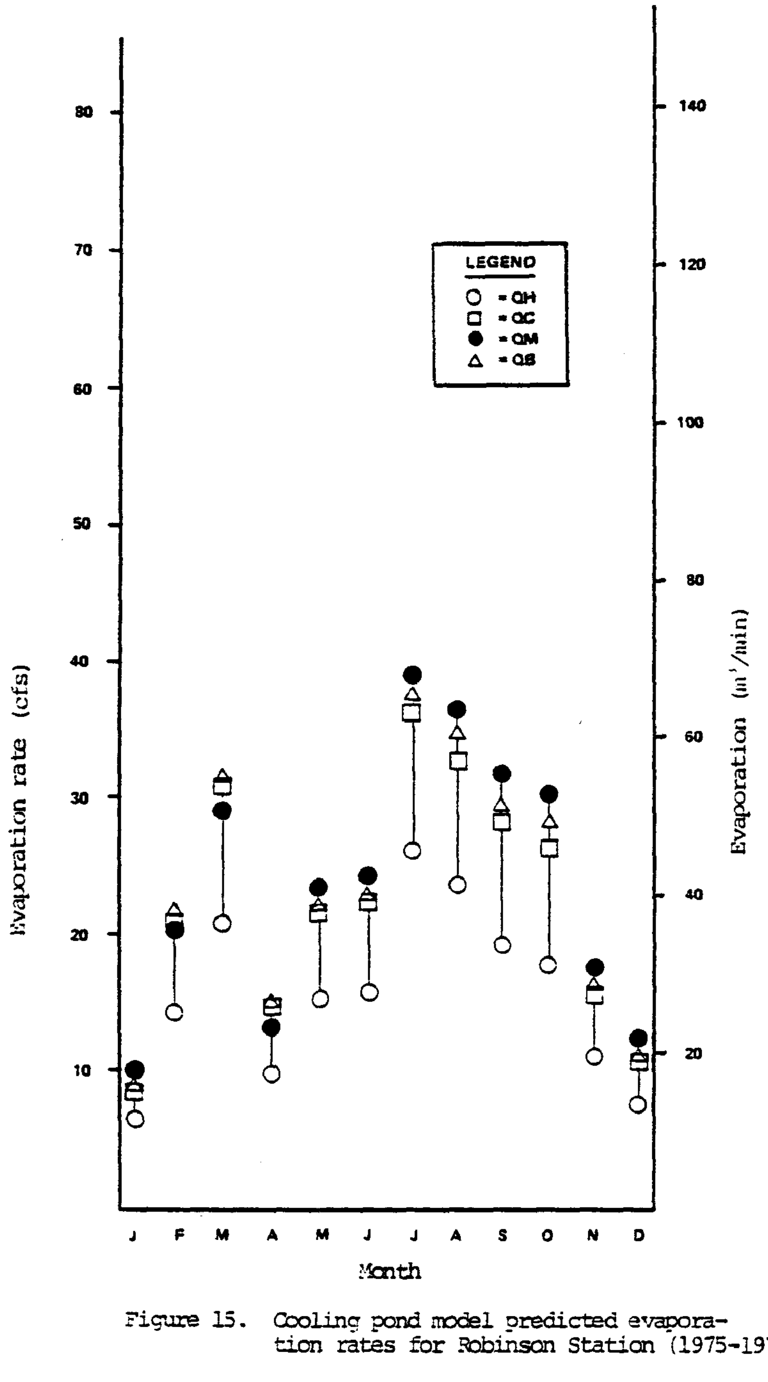

Figure 15. Cooling pond model predicted evaporation rates for Robinson Station (1975-1976)

about 10 cu m/min (6 cfs) on a yearly average, which is about 20-25 percent of the total evaporative loss. Since the lake was constructed primarily as part of the cooling system, the total evaporative loss has been attributed to the plant.

Duke Power Company, Belews Creek Station--

Duke Power operates two units with a total capacity of 2,286 MW, on a large lake serving a dual purpose as a cooling lake and a recreational facility. The annual average operating data for 1977 are presented in Table 20.

The topographic layout of the plant's intake and discharge points are so arranged that the total area of the lake (3,550 acres) should not be included in the model computations for evaporative loss. It is difficult to arrive at the effective surface area, since no estimate could be made of the flow characteristics around the power plant. This uncertainty impacts the calculation of the forced evaporation rate. The total surface area contributes to the natural evaporative loss.

The utility provided operating data on a daily basis for the year 1977. This represents the most extensive data for a cooling pond used in this study. In conjunction with the operating data, dam flows, lake levels, inflows and precipitation were given. A material balance calculation yielded an average evaporative loss of 91 cu m/min (54 cfs). This value is considerably larger than a water budget value of 31 cfs which was presented by the utility and North Carolina Geological Survey at regulatory hearings. Duke Power Company believes that the 31 cfs value may be low, however.

The meteorological data were provided by the utility from a meteorological tower situated in the middle of the cooling lake. The average monthly meteorological data are shown in Appendix B. The averages of the model predictions for each month are presented in Figure 16.

TABLE 20. COOLING LAKE OPERATING DATA FOR DUKE POWER COMPANY'S BELEWS CREEK STATION (1977 Annual Average)

Plant Capacity (MW)	2,286
Plant Capacity Factor (%)	66
Unit Heat Rejection Rate, kcal/kWh (BTU/kWh)	1,065 (4,225)
Circulating Water Flow Rate, cu m/min (GPM)	3,976.5 (1,050,332)
Flow Rate into Pond, cu m/min (GPM)	99.3 (26,222)
Flow Rate out of Pond, cu m/min (GPM)	43.1 (11,381)
Range, °C (°F)	10.2 (18.4)
Condenser Make-up Water Temperature, °C (°F)	19.9 (67.9)
Surface Area of Cooling System, ha (acres)	1,439 (3,553)
Volume of Cooling System, cu m (acre-ft.)	2.17×10^8 (176,000)
Drainage Area , sq. km. (sq. mi.)	114 (70.9)
Evaporation, cu m/min (GPM)	
Material Balance	90.9 (24,000)
Model Predictions	
Lake Hefner (QH)	37.8 (9,960)
Lake Colorado City (QC)	55.5 (14,600)
Meyer (QM)	58.7 (15,500)
Brady (QB)	46.5 (12,300)
Harbeck Nomograph & Pan Evaporation (QHN)[a]	48.8 (12,900)

[a] The corrected pan evaporation value was 24.1 cu m/min.

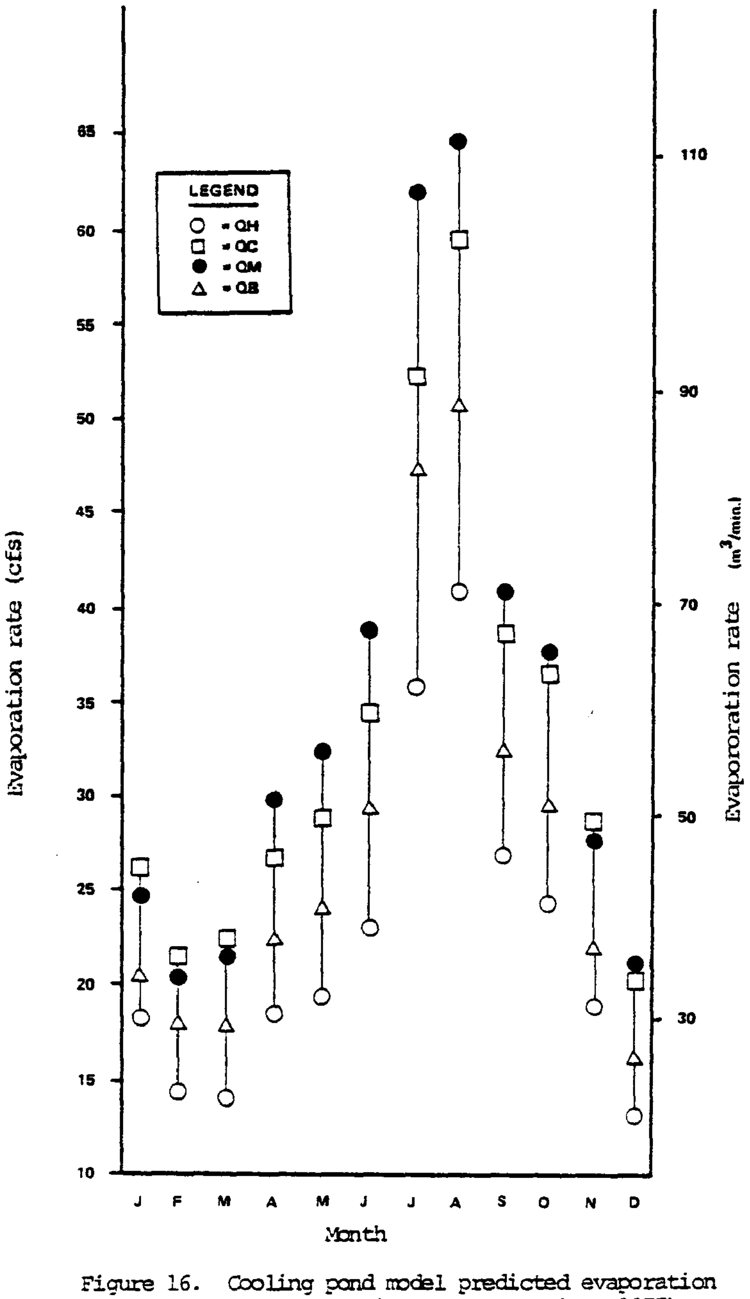

Figure 16. Cooling pond model predicted evaporation rates for Belews Creek Station (1977)

A comparison of the annual predicted evaporation versus material balance calculations show that the model predictions range from 35 to 58 percent lower. The Meyer model provided the best estimate, 58.7 cu m/min or an underestimation of 35 percent.

To investigate evaporation during extreme meteorological conditions, material balance and predicted evaporation rate values for the months of January and August were compared. For January, the material balance provided a value of 64 cu m/min. The Harbeck et al (Lake Colorado City) model and Meyer model predicted evaporation rates of 45 and 42 cu m/min, respectively, a 30-35 percent underestimation. In contrast, for August, the computer model-predicted evaporation rates ranged from 31 percent to 2 percent lower than the material balance value of 99 cu m/min. The Hefner model prediction of 68 cu m/min was the only model-predicted value not within ±15 percent of the water balance calculated result. The Lake Colorado City model value of 108 cu m/min was the most accurate prediction.

A possible reason for the underprediction is the method for estimating lake inflow. The USGS data for area streams are used to predict inflow, based on a historical correction factor for runoff and drainage area differences between streams. According to the USGS, these stream flow values are accurate within ±5 percent. Gaging station data from four similar streams in the vicinity of Lake Belews were used to estimate pond inflow. The inaccuracy and uncertainty of averaging similar stream flows could cause an error in the water balance greater than the desired ±15 percent model accuracy. This hypothesis is strengthened by the fact that for August when stream flows are low and less varied, the computer model predictions and water balance values are quite close.

A further discussion and sensitivity analysis on Lake Belews is provided in Section 6.

SECTION 6

MODEL ACCURACY AND SENSITIVITY ANALYSES

To compare evaporation rates for different sized power plants with unequal capacity factors, a common (normalized) basis is needed. The two normalizing parameters used here were average hourly power generation (MW, or MWH/hr) and unit heat rejection (10^6 kcal/hr). These parameters were divided into the predicted or given evaporation rates to normalize the results (i.e., cu m/min-MW and cu m/10^6 kcal).

COOLING TOWERS

A comparison of cooling tower evaporation rates on a common basis (i.e.,normalized) was made to further investigate the variables that impact consumptive water use. Table 21 lists each power plant's cooling tower evaporation rate on a unit power (per MW) and unit heat rejection (per 10^6 kcal) basis. The accuracy of the Leung and Moore model relative to material balance values is also illustrated.

On the average, the Leung and Moore model was within ±15 percent of the material balance data when those power plants with capacity factors less than 50 percent were excluded. The previous discussion concerning Arkansas Power and Light's peaking and intermediate units is relevant here. That is, the varying heat load and inherent inefficiencies in peaking operation are not well simulated by the simple Leung and Moore model. The necessity for steady-state data input to the model precludes modeling of peaking and possibly intermediate units.

With the exclusion of the non-baseload units, the mean of the ratios of material balance calculation values to model-predicted values is 1.02. This might be interpreted as indicating the overall accuracy of the Leung and Moore model is better than ±15 percent. However, there are several units, including North Main Station and Homer City (summer), that were outside

TABLE 21. COMPARISON OF ALL COOLING TOWER EVAPORATION RATES AS CALCULATED AND NORMALIZED

Plant/Unit Size (MW)	Time Period	Material Balance (cu m/min)	Model Prediction (cu m/min)	Ratio Model/ Material Balance	Normalized Evaporation cu m/min-MW Material Balance	Normalized Evaporation cu m/min-MW Model	Normalized Evaporation cu m/10⁶ kcal Material Balance	Normalized Evaporation cu m/10⁶ kcal Model
Huntington/400	annual	12.5[b]	12.8	1.02	0.039	0.040	1.84[b]	1.88
Navajo/750	hourly-summer	12.6 (12.2)[c]	13.8	1.10	0.016	0.018	0.85 0.88[c]	0.96
N. Main/85	hourly-summer	1.46	1.96	1.34	0.025	0.034	0.99	1.32
Permian/100	hourly-summer	3.0	3.1	1.03	0.030	0.031	1.49	1.54
Newman-1/86	August	4.2	3.7	0.88	0.082	0.072	3.44	3.02
-2/90	August	4.0	3.9	0.98	0.052	0.051	2.17	2.15
-3/110	August	4.5	4.5	1.00	0.042	0.042	1.86	1.86
Rio Grande-6/50[a]	July	1.1	2.4	2.18	0.072	0.157	2.62	5.73
-7/50	July	1.4	2.1	1.50	0.050	0.075	2.11	3.17
-8/165[a]	July	4.2	6.5	1.55	0.053	0.082	2.45	3.79
Moses/126[a]	annual	2.45	7.2 (0.85)[e]	3.0 (0.35)[e]	0.177	0.531 (0.061)[e]	5.54	16.5 (1.92)[e]
Lynch/239[a]	annual	4.16	14.4 (1.7)[e]	3.5 (0.41)[e]	0.145	0.508 (0.047)[e]	4.93	17.3 (1.60)[e]
Couch/161[a]	annual	1.62	7.6 (2.2)[e]	4.7 (1.35)[e]	0.035	0.163 (0.059)[e]	1.02	4.77 (1.73)[e]
Homer City/1328	January July	16.9 40.5 (18.6)[d]	14.7 26.0	0.87 0.67 (1.44)[d]	0.030 0.054 (0.026)[d]	0.026 0.036	1.19 2.62 (1.20)[d]	1.04 1.68
Clay Boswell/350	January August annual	 7.95	5.61 8.41	 0.88	 0.031	0.019 0.026	 1.50	0.86 1.24
Koshkonong Nuclear/900	annual	40	42	1.05	0.044	0.046	1.43	1.50

a Units with capacity factors less than 50 percent
b Based on constant outlet air temperature
c Marley test results
d Gilbert Assoc. curves
e Results X capacity factor

the ±15 percent limits. In fact, for summer conditions, the average ratio of the Leung and Moore model to material balance results was 1.15. This illustrates the tendency of this generic model to overpredict slightly during the summer months. The summer evaporation rate was underpredicted for only one case, by 12 percent, at Newman Station No. 1.

The normalized evaporation rates for cooling towers vary over a large range as shown in Table 21. There is a marked tendency for the large, baseload units with high capacity factors to have the lowest evaporation rate per MW. This is probably due to their lower heat rate (higher efficiency) during operation. The five units that operated at or near 100 percent capacity (Navajo, North Main Station, Permian, Newman No. 3, and Clay Boswell Unit 3) also had low normalized evaporation rates. Based on model predicted values, the peaking and intermediate units of the Arkansas Power and Light Company and the two Rio Grande units with less than 50 percent capacity factors had the highest normalized evaporation rates.

For baseload units, a value of 0.040 cu m/min-MW and 1.3 cu m/10^6 kcal appear to be adequate approximations of summer evaporation rates. An annual factor of 0.040 cu m/min-MW is supported by these data. Regional variations between cooling towers appear to be insignificant (this is consistent with the fact that cooling towers are designed to reject between 70 to 90 percent of the heat load as latent heat based on regional meteorology).

COOLING PONDS/LAKES

Table 22 is the summary of annual and summer month evaporation rates as calculated and normalized (i.e., on a common basis and corrected for capacity factor) for cooling ponds/lakes. In contrast to the cooling towers discussed in this report, the power plants associated with the cooling ponds/lakes were generally large baseload units. Only two plants, Morgan Creek and Kincaid, had annual capacity factors less than 50 percent.

A major point highlighted in this table is the relative accuracy of the Lake Colorado City (Harbeck-Koberg-Hughes) and Meyer models.

TABLE 22. SUMMARY OF COOLING POND/LAKE MATERIAL BALANCE AND COMPUTER MODEL EVAPORATION VALUES ON AN 'AS IS' AND NORMALIZED BASIS.

Plant/Unit or Station Size (MW)	Time Period	Material Balance cu m/min	Model Predicted cu m/min					Evaporation Rate Ratio Model/Material Balance					Area/Power Acres/MW	Normalized Evaporation Rate For Best Model Prediction		
			QH	QC	QM	QB	QHN	QH	QC	QM	QB	QHN	ha/MW	cu m/min-MW	cu m/min-ha	kcal(cu m/10
Cholla/120	July	----	6.8	9.9	8.7	7.6							(2.83)	0.103	0.073	5.81
	annual	6.9	4.3	6.3	6.0	5.3	5.0	0.62	0.91	0.87	0.77	0.72	1.15	0.075	0.046	3.70
Morgan Creek/102 (equivalent)	August	29.8	22.6	33.3	30.0	25.6		0.76	1.12	1.01	0.86		(4)	0.294	0.067	11.1
	annual	21.0	12.2	17.9	15.0	13.9	14.7	0.58	0.85	0.71	0.66	0.70	1.62	0.201	0.043	7.60
H.B. Robinson/885	August	76.5	38.1	56.0	62.9			0.50	0.73	0.82			(2.54)	0.089	0.069	4.37
	annual	44.6	26.0	38.3	40.2	34.0	26.8	0.58	0.86	0.90	0.76	0.65	1.03	0.068	0.046	3.31
Belews Creek/ 2,286	August	99.1	68.5	101	109	83.5		0.69	1.02	1.09	0.86		(1.64)	0.062	0.070	3.45
	annual	90.9	37.8	55.5	58.7	46.5	48.8	0.42	0.61	0.65	0.51	0.54	0.66	0.039(0.060)[a]	(0.041)[a]	2.19
															(0.063)[a]	
Mt. Storm/1,662	January		7.7	11.2	10.6	10.0							(0.68)	(0.012-0.026)	(0.019-0.024)	0.45-0.68
	July		10.9	16.2	24.3	19.2							0.275		(0.024-0.053)	0.66-1.5
Kincaid/1,319	August		44.7	65.8	63.1	51.5							(1.64)			
	annual	36.2	26.4	39.0	34.4	30.1	19.8	0.73	1.08	0.95	0.83	0.55	0.664	0.077	0.035	3.51
Powerton/840	August		18.8	27.6	26.1	21.5							(1.70)			
	annual (1973)	18.5	12.6	18.0	15.7	14.0	14.0	0.68	0.97	0.85	0.76	0.76	0.689	0.046		2.40

[a] Based on material balance evaporation calculation
QH - Marciano and Harbeck model (Lake Hefner)
QC - Harbeck et al model (Lake Colorado City)
QM - Meyer model
QB - Brady et al model
QHN - Harbeck Nomograph plus Pan Evaporation

The Lake Colorado City (Harbeck-Koberg-Hughes) model predictions are with ±15 percent of the annual average values for 5 of the 6 plants for which independently-provided values were available. The one exception is for the Belews Creek Station, although here the model is within 15 percent of the water budget value estimated by the North Carolina Geological Survey. The Meyer model is within ±15 percent of annual average values for 4 of the 6 plants. In contrast, neither the Marciano-Harbeck model nor Brady model is within ±15 percent of the given or calculated value for any plant. The Harbeck nomograph plus pan evaporation method was not within ±15 percent for any plants.

For plants where summer month values were given or could be calculated by material balances, the Lake Colorado City and Meyer models showed about the same accuracy (i.e., within ±15 percent of summer material balance values for 2 of 3 plants).

Based on this discussion, it is suggested that estimates of the Lake Colorado City and Meyer models generally predict evaporation rates within ±15 of material balance or thermal model calculated values.

A second finding is the consistency of the normalized values for evaporation rate in cu m/min-ha for both summer and annual values. These values are grouped into two distinct classes; those associated with a southern climate (Cholla, Morgan Creek, H.B. Robinson and Belews) have summer evaporation rates between 0.067 and 0.073 cu m/min-ha (0.027 and 0.030 cu m/min-acre) and annual rates of 0.04 and 0.05 cu m/min-ha (about 0.020 cu m/min-acre), while northern cooling ponds have annual values of between 0.03 and 0.04 cu m/min-ha (0.01 and 0.02 cu m/min-acre). This consistency in evaporation values may be attributed to two factors:

- A large percentage of evaporation per acre is natural and therefore is dependent on climate but not power plant thermal discharges.
- The relatively constant area per unit power (ha/MW) ratio which varies between 0.66 and 1.15, excluding Mt. Storm and Morgan Creek.

On the other hand, the normalized evaporation rate per megawatt is not as consistent. The annual average values range over a factor of about four from 0.046 to 0.175 cu m/min-MW. Based on a constant area per unit power (ha/MW) value, there is some similarity in the results. Figure 17 shows a relatively second-order relationship between evaporation rate per unit power (cu m/min-MW) and area per unit power (ha/MW). This curve may be useful for estimating evaporation rates for similar cooling ponds/lakes at power plants with capacity factors of 0.5 to 0.7; however, further data and analyses are needed to support this finding.

Although the different models utilized in this study share the same basic variables such as thermal driving force and wind speed, the Harbeck et al and Brady equations are more sensitive to wind speed.

The dominant variable, however, in computing cooling pond/lake evaporative loss is the pond/lake equilibrium temperature. This is particularly true in the hot summer months when evaporation is several times higher than in winter. High summer evaporation rates are directly attributed to the non-linear behavior of the thermal driving force. To demonstrate this behavior, several hypothetical computations using the Lake Colorado City model were performed for Mt. Storm using data for the extreme meteorological condition months of January and July. Wind speeds in January average more than twice the magnitude of July; yet for all five models, July evaporative loss computations are twice as large as January. The average ambient temperatures for January were about -8°C (18°F) and for July were about 24°C (75°F). If ΔT is defined as being the difference between average ambient air and pond/lake temperatures, the following results can be calculated:

Time Period	Lake Temp,°C	Ambient Temp,°C	ΔT,°C	Evaporation Rate, (cu m/min)
January 1977	5.7	-8.3	14	11.2
July 1977	28	21	7	16.2

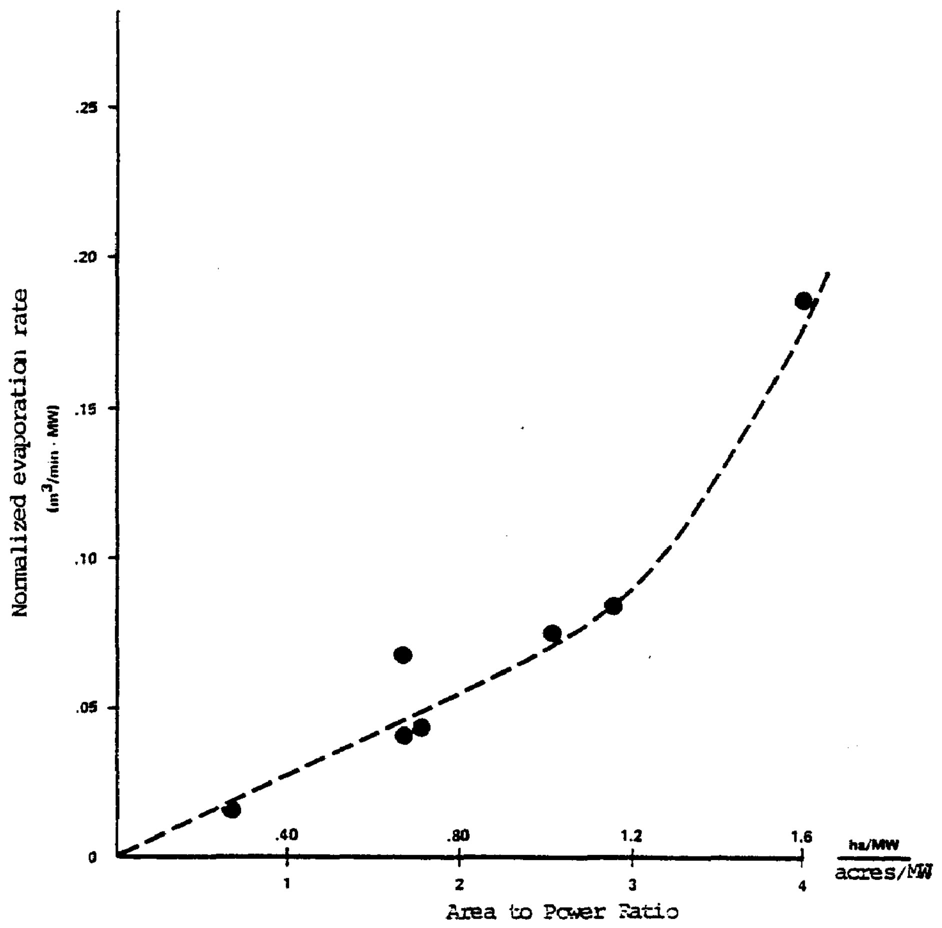

Figure 17. Normalized annual evaporation rates for cooling ponds

An increase in the pond/lake temperature of 10 percent (approximately 3°C) during the summer months caused a 60 percent increase in the evaporative loss. A 10% wind speed increase only produced up to a 10% greater evaporation rate as would be expected when using a model having a linear evaporation rate-wind speed function relationship.

As a second rough estimate of the relationship between wind speed and pond temperature concerning evaporative loss, Lake Colorado City model predictions were made on Lake Belews data for the month of August. These computations indicated that an average increase of wind speed of 50 percent had the same effect on pond evaporation rate as a 2°C (3.6°F) increase in pond temperature.

Since meteorology is uncontrollable, pond temperature emerges as the variable that can be controlled to limit evaporative loss.

Even if pond/lake temperatures were minimized, natural evaporation would cause significant water consumption. This water consumption is caused by exposing large water surfaces to solar radiation and wind currents. Natural evaporation from the cooling ponds/lakes investigated were estimated using National Weather Service pan evaporation data and applying a correction coefficient of 0.7.[25] Table 23 compares adjusted monthly pan evaporation data and the Lake Colorado City cooling pond/lake model-predicted values.

The table shows that the monthly natural evaporation can be as low as 25 percent of total monthly evaporation or as high as 110 percent depending on location, time of year, and plant load. Two monthly values where natural evaporation exceeds total evaporation at Morgan Creek reflect the fact, as noted by Harbeck,[9] that at this location total evaporation exceeds natural evaporation by only 5 to 10 percent in the summer months. Potential inaccuracies of pan evaporation values and small variations in model predictions could readily account for these anomalies. Extended power plant down times for annual maintenance are reflected in the table when total and natural evaporation are nearly equal (e.g., Cholla and Morgan Creek plants in June and Robinson in April). For the hotter, dryer climatic regions, represented by Cholla and Morgan Creek, natural evaporation is about 60-80 percent of total evaporation in the summer and 50-60 percent in the autumn and winter. In contrast, for the more temperate climatic regions, natural

TABLE 23. MONTHLY ADJUSTED PAN EVAPORATION DATA COMPARED TO COOLING POND MODEL TOTAL EVAPORATION PREDICTIONS (m^3/min)

Plant	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Cholla					7.44	9.22	5.93	5.18	3.98	2.58	1.47	
Morgan Creek	4.5			17.9	19.7	25.7	21.3	22.1	17.4	11.6	7.9	5.2
Kincaid					25.86	33.4	35.77	25.2	23.63	14.4		
Powerton					12.53	18.9	18.1	15.64	10.5			
H. B. Robinson		18.2	19.7	27.8	26.5	30.9	25.2	27.5	19.8	15.34	11.5	7.2
Belews Creek			25.3	38.7	40.2	42.3	55.1	43.3	34.8	20.7		
Mt. Storm					10.4	9.1	10.7	9.1	6.02	4.4		
Model Predicted Total Evaporation[a]												
Cholla	1.94	3.69	5.91	8.60	11.37	13.89	9.94	10.98	6.77	5.04	2.96	2.21
Morgan Creek	8.5	11.0	5.4	21.2	17.9	25.6	26.1	33.7	32.8	21.5	14.7	7.8
Kincaid	26.8	8.7	15.8	16.7	53.1	47.4	57.8	65.8	46.0	43.8	46.5	39.0
Powerton	16.0	7.0	12.2	4.4	25.2	32.0	26.6	27.6	32.3	15.7	6.8	10.4
H. B. Robinson	15.3	35.0	52.1	29.7	37.2	37.4	62.9	56.0	48.2	45.7	27.2	18.0
Belews Creek	45.0	36.7	36.2	44.9	47.2	58.4	88.7	101	65.3	61.9	46.1	34.4
Mt. Storm	11.2						16.2					

[a]Using Lake Colorado City (Harbeck-Koberg-Hughes) model

evaporation ranges from 35 to 70 percent in the summer. Pan evaporation values are typically not measured from November through April in northern climatic areas.

SECTION 7

REGIONAL COMPARISON

A primary objective of this study is to compare consumptive water use from cooling towers and cooling ponds/lakes on a regional basis. The 18 U.S. water resource regions are shown on Figure 18. The 16 cooling systems investigated provide comparisons for seven water resource regions. These regions are the Lower Colorado, Texas Gulf, Rio Grande, South Atlantic Gulf, Upper Mississippi, Ohio, and Mid-Atlantic.

A major problem in comparing these cooling systems is that they are of different sizes and capacity factors. Therefore, the normalized values presented in Section 6 were used in the comparison instead of actual evaporation rates.

Another point of concern is how natural evaporation from cooling ponds/lakes should be charged to the power plant. In this study the natural evaporation has been included in total plant consumptive water use, because the cooling systems were built specifically to accommodate the power plants. Several ponds/lakes are used for recreational purposes as well. If only forced evaporation was considered, then annual evaporation rates would decrease by as much as 80 percent (shown by the Lake Colorado City (Harbeck-Koberg-Hughes) model at Morgan Creek) and at least by 45 percent (at H.B. Robinson Plant). For 5 of the 6 cooling ponds, the natural evaporation is between 45 and 51 percent of the best model-predicted result.

The comparison of cooling ponds and cooling towers is presented in Table 24. The values in the table generally show that evaporation rates for cooling towers are lower than cooling ponds/lakes. This relationship is strongest in the southern regions due to high natural evaporation rates and area per unit power ratios above 0.6 ha/MW (1.5 ac/MW). For the

WATER RESOURCE REGIONS

Figure 18. Water resource regions showing areas studied

NOTE: Shaded areas represent water resource regions containing cooling systems included in the regional comparison.

TABLE 24. REGIONAL COMPARISON OF COOLING SYSTEM EVAPORATION RATE

Water Resource Region	Plant	Cooling System[a]	Plant Size (MW)	Capacity Factor	Model Predicted/ Material Balance Evaporation[b,c] (m^3/min)	Summer Normalized Evaporation Rate (m^3/min-MW)	Summer Normalized Evaporation Rate ($m^3/10^6$ kcal)	Annual Normalized Evaporation Rate (m^3/min-MW)	Annual Normalized Evaporation Rate ($m^3/10^6$ kcal)
Lower Colorado	Huntington	T	400	80	12.8/12.5	--	--	0.04	1.88
	Navajo	T	750	100	13.8/12.6	0.018	1.68	--	--
	Cholla	P	120	0.7	6.3/6.9[d]	0.103	5.81	0.075	3.70
Texas Gulf Rio Grande	Newman-Unit 1	T	86	59	3.7/4.2	0.072	2.88	--	--
	Newman-Unit 2	T	90	86	3.9/4.0	0.024	2.00	--	--
	Newman-Unit 3	T	110	98	4.5/4.5	0.025	1.86	--	--
	Rio Grande-Unit 6	T	50	30	2.4/1.1	0.292	5.73	--	--
	Rio Grande-Unit 7	T	50	58	2.1/1.4	0.075	3.17	--	--
	Rio Grande-Unit 8	T	165	48	6.5/4.2	0.101	3.96	--	--
	North Main	T	85	100	2.9/2.5	0.034	1.89	--	--
	Permian	T	100	--	3.1/3.0	0.031	1.54	--	--
	Morgan Creek	L	102	12	20.5/17.9[d]	0.29	11.1	0.201	7.60
South Atlantic Gulf	H.B. Robinson	L	885	67	40.2/44.6[e]	0.089	4.4	0.068	3.31
	Lake Bellews	L	2,286	66	58.7/90.2[e]	0.062	3.5	0.039	2.19
Upper Mississippi	Clay-Boswell	T	350	93	8.4/7.95[f]	0.026	1.35	--	--
	Koshkonong	T	900	100	42/40	--	--	0.04	1.50
	Kincaid	L	1,319	34	34.4/36.2[e]	--	--	0.077	3.51
	Powerton-Unit 5	P	840	47	8.0/18.5[d]	--	--	0.046	2.40
Ohio Mid-Atlantic	Homer City	T	664	57	25.9/39.5[f]	0.036	1.68	0.03	1.40
	Mt. Storm	L	1,662	55	--	0.012-0.026	0.66-1.5	--	--

a Cooling Tower (T); Cooling Pond (P); and Cooling Lake (L).

b For cooling towers the Leung and Moore model was used. For cooling ponds, the Harbeck-Koberg-Hughes, or Meyer model, or the Harbeck nomograph was used depending upon which model more closely approximates material-balance values. The Harbeck nomograph was calibrated using Morgan Creek data

c Annual values are shown, except for performance test results on cooling towers which are based on full capacity test.

d Harbeck-Koberg-Hughes model

e Meyer model

f Summer value

Upper Mississippi region, the normalized cooling pond evaporation rate begins to approach the cooling tower value, and for the Ohio region the Mt. Storm normalized predicted evaporation rate is less than that for Homer City Station. This result is consistent with the low ha/MW value. A reason that the Mt. Storm cooling pond evaporation rate is lower than that for the Homer City Station cooling tower may be a result of its unusually low area per unit power ratio of 0.28 ha/MW, which reduces natural evaporation relative to forced evaporation.

It can be interpolated from the table that the cooling system evaporation rate equivalency point (tower evaporation = pond evaporation) would occur where the area per unit power value is less than 0.60 ha/MW. Certainly further work must be performed to verify this conclusion and obtain a better estimate, regionally, of the evaporation rate equivalency point.

FURTHER DISCUSSION OF EVAPORATION RATE PREDICTIONS AND CONSUMPTIVE WATER USE

The evaporation results from cooling ponds/lakes and cooling towers in this study differed from the results presented in earlier studies by Espey, Huston & Associates, Inc. (EH&A) for the Utility Water Act Group.[4,22] The EH&A studies presented predictions which indicate that cooling towers consume more water than cooling ponds/lakes for large baseload units. However, similar models for determining water consumption by cooling ponds/lakes were used in the two studies and the same cooling tower model (i.e., Leung and Moore model) was used.

Since the disparity between the EH&A method (i.e., Harbeck nomograph plus pan evaporation) and material balance results were 2 to 45 percent below material balance values, further investigations were performed into the procedures used in the EH&A report. The differences in conclusions in this study and the EH&A reports are partially due to the fact that consumption by cooling ponds/lakes, as defined in the EH&A report, includes a credit term for rainfall runoff.

The EH&A study defined consumptive water use as evaporation losses minus a rainfall runoff term which conceptually accounts for increased water availability downstream of the cooling pond/lake. The equation used by EH&A was:

$$C = E + (r-1)\,P$$

where: C = consumptive water use

E = forced evaporation (from the Harbeck nomograph) plus natural evaporation (from pan evaporation data)

r = runoff coefficient (always less than 1)

P = precipitation falling directly on the cooling water surface.

Evaporation rates were calculated as the sum of forced evaporation values obtained from the Harbeck nomograph and natural evaporation values taken from National Weather Service pan evaporation data (described in Section 4.0).

The credit term, (r-1) P, always negative, represents the storage of water that would otherwise be lost to evapotranspiration, soil moisture and groundwater (i.e., basin recharge). The assumption made by EH&A is that r can represent the runoff for an entire water resource region, despite the fact that r is a function of the following variables that change with site location, time and climatic conditions:

- Soil infiltration capacity
- Antecedent precipitation
- Vegetation cover and type
- Duration of rainfall
- Terrain

Simple rainfall runoff relations such as given above, infiltration indices, and runoff coefficients are normally applicable only to a single small river basin. More complex rainfall runoff relations have, however, been applied to large areas, including a number of basins.[11]

The magnitude of this credit term can be seen by comparing the results for similar plants in the two studies. A comparison was made for the 885-MW H.B. Robinson plant of Carolina Power and Light Company and the 1,319-MW Kincaid Plant of Commonwealth Edison Company and the hypothetical plants in Richmond, Virginia and Columbus, Ohio, presented in the EH&A report. The values presented in Table 25 permit comparison of evaporated of an operational and hypothetical plant in adjacent water resource regions, since the report by EH&A did not present values for cities in the water resource regions where cooling ponds covered by this study were situated.

Table 25 shows that the credit term can cause about 40-50 percent decrease in water consumption by the cooling pond/lake. Since the rainfall runoff term alone reduced consumptive water use in the examples by up to 50 percent, the accuracy of the credit term used in the EH&A method for determining water consumption by cooling ponds/lakes was studied by Versar.

No corroborating field data or studies were found that indicate what degree of precision could be expected using the simple rainfall runoff credit term on a large river basin scale. Until further studies verify that the term can be used for large basins, it is suggested that the rainfall runoff credit term be used only on a site-specific basis, as it was intended.

This study generally supports the use of model-predicted values (i.e., Lake Colorado City or Meyer model) for evaporation rates and water consumption from cooling ponds/lakes for the following reasons:

- Field data-derived evaporation rates agree more closely with model-predicted evaporation rates without the rainfall runoff credit in the water consumption equation.
- Hydrologists consulted during this study questioned the general use and significance of this rainfall runoff credit term[27].
- The rainfall runoff credit term has not been validated for large water basins and its value with a general model is unproven.

TABLE 25. COMPARISON OF EH&A METHOD WITH AND WITHOUT RAINFALL RUNOFF METHOD

PLANT	LOCATION	SIZE (MW)	CAPACITY FACTOR (%)	AREA (acres)	CALCULATED EVAPORATION EH&A METHOD	MATERIAL BALANCE (m^3/min)
H.B. Robinson	Darlington, S.C.	848	67	2,250	28.8[a]	44.6
Hypothetical	Richmond, Va.	1,000	80	2,000	15.0[b]/ 12.0[b,c]	
Kincaid	Springfield, IL.	1,310	34	2,400	23.5[a]	36.2
Hypothetical	Columbus, OH.	1,000	80	2,000	13.6[b]/9.2[b,c]	

[a]Excludes rainfall runoff term.

[b]Includes rainfall runoff term.

[c]Linear correction for plant capacity and pond acreage based on operating plant comparison values.

SECTION 8

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SECTION 9

GLOSSARY

approach: The temperature differential between the inlet air wet bulb temperature and the outlet water temperature from the cooling tower. It indicates how close the tower is to the theoretical equilibrium between the cooling air and circulating water.

blowdown: The discharged water stream taken from the circulating water system, needed to avoid the buildup of dissolved solids in cooling towers.

circulating water system: Water used to draw off heat from the power plant condenser(s) and reject that heat to the cooling system.

cooling pond: A surface water impoundment which accepts the heat rejected from the plant by the circulating water system.

cooling tower: A heat exchange structure in which the circulating water contacts ambient air for the purpose of cooling the water by vaporization and conductive heat transfer. The air may be drawn into the system by an induced-draft fan (mechanical) or by convective forces produced by the temperature differential between the inlet and outlet air (natural).

evaporation loss in the cooling pond - (Natural): Water vaporization from the cooling pond surface caused by the natural forces of the sun's radiation, wind, and other natural forces. (Forced): The increase in water vaporization from the cooling pond surface due to increased water temperature, caused by rejection of the power plant's heat.

heat rejection rate: The amount of energy per unit time accepted by the circulating water system from the condenser(s) and delivered to the cooling system.

makeup: The water constantly added to the circulating water system to replace losses due to evaporation, blowdown, and drift.

plant capacity factor: The percentage of the power plant's full load electrical output rating which was actually delivered during the period of concern.

range: The water temperature differential between the circulating water system inlet and outlet at the cooling tower.

APPENDIX A

COMPUTER PROGRAMS FOR COOLING SYSTEM MODELS

INDUCED DRAFT COOLING TOWER MODEL, Computer Program

```
C      PROGRAM TO COMPUTE THE EVAPORATIVE LOSSES FROM A MECHANICAL
C      DRAFT TOWER. REFERENCE: LEUNG AND MOORE IN THE PROCEEDINGS
C      OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, JOURNAL OF THE
C      POWER DIVISION VOL 97, PAGES 749-766.
C      THE REQUIRED VARIABLES : AIR INLET TEMPERATURE, AIR EXIT
C      TEMPERATURE,WATER BASIN TEMPERATURE, PERCENT RELATIVE
C      HUMIDITY, HEAT LOAD IN BTU/HR, WATER AND AIR FLOW RATES IN
C      LBS/HR, AND THE ATMOSPHERIC PRESSURE IN INCHES.
       DIMENSION TI(12),TEX(12),PH(12),WF(12),HL(12),TB(12),AF(12)
       READ(5,200) (TI(I),I=1,12)
       READ(5,200) (TEX(I),I=1,12)
       READ(5,200) (TB(I),I=1,12)
       READ(5,200) (PH(I),I=1,12)
       READ(5,200) (WF(I),I=1,12)
       READ(5,200) (HL(I),I=1,12)
       READ(5,200) (AF(I),I=1,12)
       READ(5,200) P
       CP=0.24
       ATMOS=(14.696/29.92)*P
       SUM=0.0
       DO 10 I=1,12
       TIN=TI(I)
       HLOAD=HL(I)
       TBASIN=TB(I)
       TOUT=TEX(I)
       WFLOW=WF(I)
       PHI=PH(I)/100.0
C      SUBROUTINE THERMO RETURNS THE VALUES FOR THE VAPOR PRESSURE
C      AND ENTHALPY AT THE AIR INLET AND WATER BASIN TEMPERATURES.
C      THE DATA IS TAKEN FROM THE CHEMICAL ENGINEERS' HANDBOOK 1973.
       CALL THERMO(TIN,TBASIN,ENT,PS)
       PW=PHI*PS
       AIRM=AF(I)
       QT=HLOAD+(WFLOW*ENT)
       W1=(0.622*PW)/(ATMOS-PW)
       HA1=(CP*TIN)+(W1*(1061.80+(0.44*TIN)))
       HA2=(QT/AIRM)+HA1
       W2=(HA2-(CP*TOUT))/(1061.80+(0.44*TOUT))
       GPM=(AIRM/500.0)*(W2-W1)
       CFS=GPM/448.8
       SUM=SUM+CFS
       WRITE(6,104) TIN,PH(I)
       WRITE(6,107) GPM,CFS
       WRITE(6,100) AIRM
       WRITE(6,101) WFLOW
       WRITE(6,102) HLOAD
       WRITE(6,103) P
       WRITE(6,105) TBASIN
       WRITE(6,106) TOUT
10     CONTINUE
       AVG=SUM/12.0
       WRITE(6,108) AVG
100    FORMAT(' AIR FLOW IN POUNDS PER HOUR =',T45,1E12.4)
101    FORMAT(' MAKE-UP WATER FLOW IN POUNDS PER HOUR =',T45,1E12.4)
102    FORMAT(' HEAT LOAD IN BTU PER HOUR =',T45,1E12.4)
103    FORMAT(' ATMOSPHERIC PRESSURE IN INCHES =',T45,1E12.4)
104    FORMAT(' INLET TEMPERATURE =',1F6.2,' PERCENT HUMIDITY =',
      11F6.2)
105    FORMAT(' BASIN TEMPERATURE IN DEGREES F=',T45,1E12.4)
106    FORMAT(' AIR OUTLET TEMPERATURE IN DEGREES F =',T45,1E12.4)
107    FORMAT(' EVAPORATION IN GPM =',1E12.4,' IN CFS =',1E12.4)
108    FORMAT(' AVERAGE EVAPORATION IN CFS =',T45,1F8.3)
200    FORMAT(12E12.5)
       STOP
       END
```

```
C  FOR DESCRIPTION, SEE PACIFIC NORTHWEST WATER LABORATORY PAPER
C  NUMBER 16130 GKF, DATED 12/70
C
C*********************************************************************
      REAL LBVLBA,LBW,LAMBDA,N,LBVLBS,LBVI,KAL
      LOGICAL PRITER,EXTAFL,EXTWTO,PRSTEP,PRINP,READIN,INHIB,ENDFLG,
     *  PPP,PRIN
      DIMENSION READIN(37),VALS(37),VNAMES(37)
      DOUBLE PRECISION VNAMES,VN
      EQUIVALENCE(WTRTI,VALS(1)),(AIRTI,VALS(2)),(HTOWER,VALS(3)),
     *  (DTOWER,VALS(4)),(HAIRIN,VALS(5)),(HUM,VALS(6)),(WTRFT,VALS(7)),
     *  (WTRF,VALS(8)),(AIRF,VALS(9)),(WTRTO,VALS(10)),
     *  (STEPS,VALS(11)),(TOLERT,VALS(12)),(TOLERH,VALS(13)),
     *  (AFIN,VALS(14)),(AFOT,VALS(15)),(AFSL,VALS(16)),
     *  (ADIN,VALS(17)),(ADOT,VALS(18)),(ADSL,VALS(19)),
     *  (CDIN,VALS(20)),(CDOT,VALS(21)),(CDSL,VALS(22)),
     *  (CP,VALS(23)),(ATMOS,VALS(24)),
     *  (DNSARI,VALS(25)),(THICK,VALS(26)),(SPACE,VALS(27)),
     *  (ATOTAL,VALS(28)),(AFPK,VALS(29)),(ADPK,VALS(30)),
     *  (HPACK,VALS(31)),(LAMBDA,VALS(32)),(N,VALS(33)),
     *  (P13,VALS(34)),(P23,VALS(35)),(P16,VALS(36)),(P26,VALS(37))
      DATA (VALS(I),I=1,30)/97.,90.,350.,300.,20.,.37,8.5E7,
     *   1200.,2*0.,20.,
     *  .1,10.,3*1.,6*0.,.24,14.493,3*0.,235.,.75,314./
      DATA STAR,BLANK/1H*,1H /,IPG,LITER,LSTEP/0,32,50/,
     *  INHIB,ENDFLG,EXTAFL,EXTWTO/4*.FALSE./
      DATA VNAMES/5HWTRTI,5HAIRTI,6HHTOWER,6HDTOWER,6HHAIRIN,5HHUM   ,
     *  5HWTRFT,5HWTRF ,5HAIRF ,5HWTRTO,5HSTEPS,6HTOLERT,6HTOLERH,
     *  5HAFIN ,5HAFOT ,5HAFSL ,5HADIN ,5HADOT ,5HADSL ,5HCDIN ,
     *  5HCDOT ,5HCDSL ,5HCP   ,5HATMOS,6HDNSARI,5HTHICK,
     *  5HSPACE,6HATOTAL,5HAFPK ,5HADPK ,5HHPACK,6HLAMBDA,5HN    ,
     *  5HP13  ,5HP23  ,5HP16  ,5HP26  /
C*********************************************************************
C  THE RATHER LONG INPUT SECTION IS DESIGNED TO INSURE THAT
C  APPROPRIATE COMBINATIONS OF VALUES ARE INPUT.  ALL VARIABLES
C  HAVE  DEFAULT VALUE, AND ONLY THOSE WHICH NEED TO BE CHANGED
C  MUST BE INPUT
C*********************************************************************
      EXTAFL=.FALSE.
      EXTWTO=.FALSE.
      WRITE(6,104)
  104 FORMAT(1H1)
      JY=1
      JM=1
      JD=1
      DO 70 I=1,37
   70 READIN(I)=.FALSE.
      READ(5,71,END=101)PRITER,PRSTEP,PRINP
      GO TO 101
  101 PRITER=.TRUE.
      PRSTEP=.FALSE.
      PRINP=.TRUE.
      GO TO 80
   71 FORMAT(3L1)
   77 READ(5,72,END=75)VN,VV
   72 FORMAT(A8,F10.0)
      DO 73 I=1,37
      IF(VN.EQ.VNAMES(I))GO TO 74
   73 CONTINUE
      WRITE(6,76)VN
   76 FORMAT('ONO VARIABLE NAMED ',A8)
      INHIB=.TRUE.
      GO TO 77
```

```
   74 VALS(I)=VV
      READIN(I)=.TRUE.
      GO TO 77
   75 DO 78 I=1,7
      IF(READIN(I))GO TO 81
   78 CONTINUE
   80 WRITE(6,79)
   79 FORMAT('ONONE OF THE ESSENTIAL INPUT DATA PROVIDED.  THIS',
     *  ' WILL BE RUN AS A TEST CASE')
      NB=28
      NE=30
      GO TO 84
   81 DO 82 I=1,7
      IF(READIN(I))GO TO 82
      IF(I.EQ.7.AND.READIN(8))GO TO 82
      INHIB=.TRUE.
      WRITE(6,83)VNAMES(I)
   83 FORMAT('OINPUT VARIABLE ',A8,' IS ESSENTIAL AND WAS NOT READ IN.')
   82 CONTINUE
   84 ATOWER=DTOWER*DTOWER*.785398
      IF(.NOT.READIN(7))WTRFT=WTRF*ATOWER
      IF(.NOT.READIN(8))WTRF=WTRFT/ATOWER
      IF(.NOT.READIN(10))WTRTO=WTRTI-25.
      IF(.NOT.READIN(9))AIRF=WTRF
      AIRT=AIRTI
      NOITER=0
      VHVC=.167*(DTOWER/HAIRIN)**2
      VPRES=HUM*PSAT(AIRT)
      LBVLBA=.622*VPRES/(ATMOS-VPRES)
      VPENT=1061.+.444*AIRT
      ENTI=CP*(AIRT-32.)+VPENT*LBVLBA
      VPRESI=VPRES
      LBVI=LBVLBA
      DNSARI=((ATMOS-VPRES)/53.3+VPRES/85.7)*144./(460.+AIRT)
      IF(.NOT.PRINP)GO TO 94
      IPG=IPG+1
      WRITE(6,88)JM,JD,JY,IPG
   88 FORMAT('1COOLING TOWER PROGRAM  -  LISTING OF INITIAL VARIABLES',
     *  47X,I2,2(1H/I2),' PAGE',I3//'OVARIABLE NAME          VALUE'/)
      DO 89 I=1,25
      FND=BLANK
      IF(.NOT.READIN(I))FND=STAR
   89 WRITE(6,90)VNAMES(I),VALS(I),FND
   90 FORMAT(4X,A8,3X,F17.6,1X,A1)
C***********************************************************************
C  DETERMINE PACKING TYPE
C***********************************************************************
   94 PPP=.TRUE.
      PRIN=.FALSE.
      NB=29
      NE=30
      IF(READIN(28))GO TO 11
      IF(.NOT.READIN(26).AND..NOT.READIN(27))GO TO 3
      IF(READIN(26))GO TO 5
      WRITE(6,83)VNAMES(26)
      INHIB=.TRUE.
    5 IF(READIN(27))GO TO 8
      WRITE(6,83)VNAMES(27)
      STOP
    8 IF(INHIB)STOP
      NB=26
      NE=31
      ATOTAL=24.*HPACK/SPACE
      AFPK=(SPACE-THICK)/SPACE
      ADPK=ATOTAL/AFPK
      GO TO 2
```

```
    3 IF(.NOT.READIN(32).AND..NOT.READIN(33))GO TO 2
      PPP=.FALSE.
      ATOTAL=HPACK
      NB=29
      NE=33
      IF(.NOT.READIN(34).AND..NOT.READIN(35).AND..NOT.READIN(36)
     *  .AND..NOT.READIN(37))GO TO 11
      PRIN=.TRUE.
      NB=31
      NE=37
   11 DO 9 I=NB,NE
      IF(READIN(I))GO TO 9
      WRITE(6,83)VNAMES(I)
      INHIB=.TRUE.
    9 CONTINUE
      IF(INHIB)STOP
      WRITE(6,12)
   12 FORMAT('0(PARALLEL PLATE PACKING NOT ASSUMED)'/)
    2 IF(PPP)WRITE(6,13)
   13 FORMAT('0(PARALLEL PLATE PACKING ASSUMED)'/)
      IF(.NOT.PRINP)GO TO 93
      DO 14 I=NB,NE
      FND=BLANK
      IF(.NOT.READIN(I))FND=STAR
   14 WRITE(6,90)VNAMES(I),VALS(I),FND
      WRITE(6,91)
   91 FORMAT('0',20X,'*VALUE CALCULATED FROM OTHER INPUT OR ASSUMED')
   93 DA=ATOTAL/STEPS
      AIRFL=0.
      IF(INHIB)STOP
C*********************************************************************
C     END INPUT AND INITIALIZATION
C     START ITERATION
C*********************************************************************
   95 VNOM=AIRF/(DNSARI*3600.)
      VHSP=.16*HAIRIN*(WTRF/AIRF)**1.32
      IF(PPP)GO TO 16
      KAL=HPACK*LAMBDA*(AIRF/WTRF)**N
      HG=CP*WTRF*KAL/HPACK
      HGOUT=0.
      IF(.NOT.PRIN)GO TO 16
      T1=VNOM/3.-1.
      P1=(P16-P13)*T1+P13
      P2=(P26-P23)*T1+P23
      VHLPK=((P2-P1)*(WTRF-1000.)/1000.+P1)*HPACK
      CF=0.
      GO TO 15
   16 CF=.0192*(WTRF/AIRF)**.3
      IF(.NOT.PPP)GO TO 15
      HG=CP*AIRF*CF/(2.+CF*71.6*(AIRF/WTRF)**.25)
      KAL=HG*ATOTAL/(CP*WTRF)
      HGOUT=HG
   15 WTRT=WTRTO
      ENT=ENTI
      HUMI=HUM
      A=0.
      LBVLBA=LBVI
      VPRES=VPRESI
      CONWTR=0.
      AIRT=AIRTI
C*********************************************************************
C     INTEGRATION LOOP BEGINS WITH STATEMENT 6
C*********************************************************************
    6 PSW=PSAT(WTRT)
      IF(PSW.EQ.0.)GO TO 110
      ENTSAT=CP*(WTRT-32.)+(1061.+.444*WTRT)*.622*PSW/(ATMOS-PSW)
```

```
      C=HG*DA*(ENTSAT-ENT)/CP
      IF(.NOT.PRSTEP.OR.EXTWTO.OR.EXTAFL)GO TO 35
      IF(LSTEP.LT.47)GO TO 36
      IPG=IPG+1
      WRITE(6,37)JM,JD,JY,IPG
   37 FORMAT('1COOLING TOWER PROGRAM  -  STEP BY STEP RESULTS OF ONE'
     *  ,' ITERATION',38X,I2,2(1H/I2),' PAGE',I3/
     *  '0         WATER     AIR   SATUR   ACTUAL REL PNDS WTR/  VAPOR'/
     *  '    AREA    TEMP    TEMP ENTHAL   ENTHAL HUM  PNDS AIR  PRES'/)
      LSTEP=0
      LITER=52
   36 LSTEP=LSTEP+1
      WRITE(6,38)A,WTRT,AIRT,ENTSAT,ENT,HUMI,LBVLBA,VPRES
   38 FORMAT(5F7.1,F6.3,F9.5,F7.4)
   35 DWTRT=C/WTRF
      DENT=C/AIRF
      DAIRT=HG*DA*(WTRT-AIRT)/(AIRF*CP)
      WTRT=WTRT+DWTRT
      ENT=ENT+DENT
      AIRT=AIRT+DAIRT
      A=A+DA
      VPENT=1061.+.444*AIRT
      LBVLBA=(ENT-CP*(AIRT-32.))/VPENT
      PSA=PSAT(AIRT)
      IF(PSA.EQ.0.)GO TO 110
      LBVLBS=.622*PSA/(ATMOS-PSA)
      HUMI=LBVLBA*(.622+LBVLBS)/(LBVLBS*(.622+LBVLBA))
      VPRES=HUMI*PSA
      IF(HUMI.LE.1.)GO TO 99
C*********************************************************************
C  IF MIXTURE IS SUPER-SATURATED, RAISE TEMPERATURE TO
C  A POINT WHERE MIXTURE IS JUST SATURATED, KEEPING THE TOTAL
C  ENTHALPY CONSTANT
C*********************************************************************
      T=AIRT
   97 T=T+.01
      PSAH=PSAT(T)
      IF(PSAH.EQ.0.)GO TO 110
      VPEN=1061.+.444*T
      LBW=.622*PSAH/(ATMOS-PSAH)
      ENTSA=CP*(T-32.)+VPEN*LBW
      HENT=(LBVLBA-LBW+CONWTR)*(T-32.)+ENTSA
      IF(ENT.GT.HENT)GO TO 97
      CONWTR=LBVLBA-LBW+CONWTR
      ENT=ENTSA
      AIRT=T
   99 IF(A.LT.ATOTAL)GO TO 6
C*********************************************************************
C     END INTEGRATION SECTION
C
C  COMPUTE PRESSURE LOSSES FOR THIS ITERATION
C*********************************************************************
  100 IF(EXTWTO)GO TO 24
      VPENT=1061.+.444*AIRT
      LBVLBA=(ENT-CP*(AIRT-32.))/VPENT
      WTRLT=AIRF*(LBVLBA+CONWTR-LBVI)
      VPRES=LBVLBA*ATMOS/(.622+LBVLBA)
      DNSARO=((ATMOS-VPRES)/53.3+VPRES/85.7)*144./(460.+AIRT)
      DNSARO=DNSARO*(1.+CONWTR)/(1.+CONWTR*DNSARO/62.4)
      DNSAVG=(DNSARI+DNSARO)/2.
      VIN=VNOM/AFIN
      VOT=AIRF/(DNSARO*AFOT*3600.)
      VSL=AIRF/(DNSARO*AFSL*3600.)
      PRLIN=CDIN*DNSARI*.016126*ADIN*VIN**2
      IF(PRIN)GO TO 102
      VPK=AIRF/(DNSAVG*AFPK*3600.)
```

```
      PRLPK=CF*DNSAVG*.016126*ADPK*VPK**2
      GO TO 103
  102 PRLPK=DNSARI*.016126*VHLPK*VNOM**2
      VPK=VNOM
  103 PRLOT=CDOT*DNSARO*.016126*ADOT*VOT**2
      PRLSL=CDSL*DNSARO*.016126*ADSL*VSL**2
      PRLVC=VHVC*DNSARI*.016126*VNOM**2
      PRLSP=VHSP*DNSARI*.016126*VNOM*VNOM
      PRLPR=PRLOT+PRLIN+PRLSL
      H=(PRLPR+PRLPK+PRLSP+PRLVC)/(DNSARI-DNSARO)
      IF(ENDFLG)GO TO 40
      NOITER=NOITER+1
      IF(.NOT.PRITER.OR.EXTAFL)GO TO 21
   40 IF(LITER.LT.52)GO TO 30
      LSTEP=50
      LITER=0
      IPG=IPG+1
      WRITE(6,31)JM,JD,JY,IPG
   31 FORMAT('1COOLING TOWER PROGRAM  -  RESULTS OF ITERATIONS',53X,
     *  I2,2(1H/I2),' PAGE',I3/'0',22X,'AIR  CALC   TOWER'/
     *'              OUTLET  VELCTY HEAT  CHARAC-   SKIN            INLET',
     *' OUTLET OUTLET PROFILE  PACKING    SPRAY  VENA CON'/
     *' ITER  WATER   AIR     IN    TRANS TERISTIC FRICTION RELAT WATER',
     *'  AIR    AIR   PRESSURE PRESSURE PRESSURE PRESSURE TOWER'/
     *'  NO   LOSS  DENSITY PAKING COEFF (K*A/L)   COEFF   HUMID TEMP ',
     *'  TEMP  ENTHAL   LOSS      LOSS      LOSS     LOSS    HEIGHT')
   30 WRITE(6,32)NOITER,WTRLT,DNSARO,VPK,HGOUT,KAL,CF,HUMI,WTRT,AIRT,
     *  ENT,PRLPR,PRLPK,PRLSP,PRLVC,H
   32 FORMAT('0',I4,F6.2,F9.6,F7.3,F6.3,F8.4,F9.5,F7.3,F6.1,
     *  F6.1,F7.1,F10.6,3F9.6,F7.0)
      LITER=LITER+2
      IF(ENDFLG)GO TO 33
C**********************************************************************
C     END PRINTING RESULTS OF ONE ITERATION
C**********************************************************************
   21 IF(NOITER.LE.100)GO TO 39
      WRITE(6,98)
   98 FORMAT('-MORE THAN 100 ITERATIONS.  EXECUTION TERMINATED')
      STOP
C**********************************************************************
C     NOW FIND IF SPECIFICED TOLERANCES ARE MET, AND IF NOT, WHICH
C     OF AIRF OR WTRTO SHOULD BE ADJUSTED
C  PRINT A MESSAGE WHICH SHOWS VALUE FROM WHICH A NEW VALUE WILL
C  BE EXTRAPOLATED
C**********************************************************************
   39 IF(ABS(WTRT-WTRTI).LE.TOLERT)GO TO 27
      IF(.NOT.PRITER)GO TO 46
      IF(.NOT.EXTAFL)GO TO 48
      WRITE(6,42)WTRTO
   42 FORMAT('      (EXTRAPOLATING FROM WTRTO=',F6.1,')')
      LITER=LITER+1
      GO TO 46
   48 WRITE(6,43)WTRTO
      LITER=LITER+2
   43 FORMAT('0(EXTRAPOLATING FROM WTRTO=',F6.1,')')
   46 WTRT1=WTRT
      WTRTO=WTRTO+.001
      EXTWTO=.TRUE.
      GO TO 15
   27 IF(EXTAFL)GO TO 50
      IF(ABS(H-HTOWER).LE.TOLERH)GO TO 29
      IF(.NOT.PRITER)GO TO 44
      WRITE(6,41)AIRF
      LITER=LITER+2
   41 FORMAT('0(EXTRAPOLATING FROM AIRF=',F7.1,')')
   44 AIRFL=AIRF
```

```
      H1=H
      AIRF=AIRF+10.
      EXTAFL=.TRUE.
      GO TO 95
C***********************************************************************
C     A SAMPLE ITERATION HAS BEEN MADE TO ADJUST AIRF OR WTRTO
C     PRINT MESSAGE, AND DO ANOTHER ITERATION
C***********************************************************************
   50 H2=H
      DAFDH=10./(H2-H1)
      EXTAFL=.FALSE.
      OLAIRF=AIRF
      AIRF=AIRF+DAFDH*(HTOWER-H)
      IF(AIRF.LT.0.)AIRF=.1*OLAIRF
      IF(.NOT.PRITER)GO TO 95
      WRITE(6,55)AIRF
      LITER=LITER+1
   55 FORMAT(' (MODIFYING AIRF TO ',F7.1,')')
      GO TO 95
   24 WTRT2=WTRT
      DTODTI=.001/(WTRT2-WTRT1)
      EXTWTO=.FALSE.
      WTRTO=WTRTO+DTODTI*(WTRTI-WTRT)
      IF(.NOT.PRITER)GO TO15
      IF(.NOT.EXTAFL)GO TO 62
      WRITE(6,61)WTRTO
   61 FORMAT('      (MODIFYING WTRTO TO ',F6.1,')')
      LITER=LITER+1
      GO TO 15
   62 WRITE(6,60)WTRTO
      LITER=LITER+2
   60 FORMAT(' (MODIFYING WTRTO TO ',F6.1,')')
      GO TO 15
   29 IF(PRITER)GO TO 33
      ENDFLG=.TRUE.
      LITER=52
      GO TO 100
   33 WRITE(6,96)WTRTO,H
96    FORMAT(' END COOLING TOWER PROGRAM'/,
     *  'OFINAL OUTLET WATER TEMPERATURE IS',F6.1/
     *  'OFINAL TOWER HEIGHT IS',F7.0)
      STOP
  110 AIRF=(AIRF-AIRFL)/2.+AIRFL
      IF(.NOT.PRITER)GO TO 95
      WRITE(6,111)AIRF
      LITER=LITER+2
  111 FORMAT('O(ADJUSTING AIRF TO',F7.1,' FOR STABILITY)')
      GO TO 95
      END
$ASSM
PSAT  PROG
$FORT
      FUNCTION PSAT(T)
      DIMENSION V(181)
      DATA M/0/
      DATA V/.08854,.09223,.09603,.09995,.10401,.10821,.11256,.11705,.121
     *70,.12652,.13150,.13665,.14199,.14752,.15323,.15914,.16525,.17157,
     *.17811,.18486,.19182,.19900,.20642,.2141,.2220,.2302,.2386,.2473,.
     *2563,.2655,.2751,.2850,.2951,.3056,.3164,.3276,.3390,.3509,.3631,.
     *3756,.3886,.4019,.4156,.4298,.4443,.4593,.4747,.4906,.5069,.5237,.
     *5410,.5588,.5771,.5959,.6152,.6351,.6556,.6766,.6982,.7204,.7432,.
     *7666,.7906,.8153,.8407,.8668,.8935,.9210,.9492,.9781,1.0078,1.0382
     *,1.0695,1.1016,1.1345,1.1683,1.2029,1.2384,1.2748,1.3121,1.3504,1.
     *3896,1.4298,1.4709,1.5130,1.5563,1.6006,1.6459,1.6924,1.7400,1.788
     *8,1.8387,1.8897,1.9420,1.9955,2.0503,2.1064,2.1638,2.2225,2.2826,2
     *.3440,2.4069,2.4712,2.5370,2.6042,2.6729,2.7432,2.8151,2.8886,2.96
```

```
     *37,3.0404,3.1188,3.1990,3.281,3.365,3.450,3.537,3.627,3.718,3.811,
     *3.906,4.003,4.102,4.203,4.306,4.411,4.519,4.629,4.741,4.855,4.971,
     *5.090,5.212,5.335,5.461,5.590,5.721,5.855,5.992,6.131,6.273,6.417,
     *6.565,6.715,6.868,7.024,7.183,7.345,7.510,7.678,7.850,8.024,8.202,
     *8.383,8.567,8.755,8.946,9.141,9.339,9.541,9.746,9.955,10.168,10.38
     *5,10.605,10.830,11.058,11.290,11.526,11.769,12.011,12.262,12.512,1
     *2.771,13.031,13.300,13.568,13.845,14.123,14.410,14.696/
      NT=T
      PSAT=0.
      IF(NT.GT.31)GO TO 5
      PSAT=V(1)
      WRITE(6,2)T
    2 FORMAT('0ERROR IN PSAT: TABLE EXCEEDED.  T=',F8.2)
    4 M=M+1
      IF(M.LE.50)RETURN
      WRITE(6,3)
    3 FORMAT('0 MORE THAN 50 ERRORS IN PSAT -- EXECUTION TERMINATED')
      STOP
    5 IF(NT.GE.212)GO TO 4
    1 PSAT=V(NT-31)+(V(NT-30)-V(NT-31))*(T-NT)
      RETURN
      END
```

COOLING POND MODELS, Computer Program

```
C       PROGRAM TO COMPUTE COOLING POND EVAPORATION RATES IN CFS
C       VARIABLES REQUIRED: PERCENT HUMIDITY, AMBIENT TEMPERATURE
C       IN DEGREES F, WIND VELOCITY IN MILES/HOUR, POND TEMPERATURE
C       IN DEGREES F AND POND AREA IN ACRES.
C       IN INCHES
        REAL MEY
        DIMENSION HUM(12),TAMB(12),WIND(12),TP(12)
        READ(5,103) (HUM(I),I=1,12)
        READ(5,103) (TAMB(I),I=1,12)
        READ(5,103) (WIND(I),I=1,12)
        READ(5,103) (TP(I),I=1,12)
        READ(5,104) AREA
        SUM1=0.0
        SUM2=0.0
        SUM3=0.0
        SUM4=0.0
        DO 10 I=1,12
        TPOND=TP(I)
        HUMID=HUM(I)/100.0
        HEF=2.25E-3*WIND(I)
        COL=3.31E-3*WIND(I)
        MEY=1.44E-2+(1.44E-3*WIND(I))
        BRA=1.38E-2+(1.38E-4*WIND(I)*WIND(I))
C       THERMO RETURNS VALUES FOR THE VAPOR PRESSURE IN LBS/SQ. IN.
C       AS TAKEN FROM PERRY AND CHILTON ENGINEERS' HANDBOOK, 1973
        CALL THERMO(TPOND,TPOND,DUMMY,PS)
        CALL THERMO(TAMB(I),TAMB(I),DUMMY,PA)
        PA=PA*HUMID
        ES=PS*(29.92/14.696)
        EA=PA*(29.92/14.696)
        TEMP=(ES-EA)*AREA
C       THE MASS TRANSFER EQUATIONS ARE GIVEN IN REPORT NO.:
C       EPA-660/2-73-016 ON PAGE 42
        QH=HEF*TEMP
        QC=COL*TEMP
        QM=MEY*TEMP
        QB=BRA*TEMP
        SUM1=SUM1+QH
        SUM2=SUM2+QC
        SUM3=SUM3+QM
        SUM4=SUM4+QB
        WRITE(6,101) TAMB(I),HUM(I),WIND(I),QH,QC,QM,QB
10      CONTINUE
        AV1=SUM1/12.
        AV2=SUM2/12.
        AV3=SUM3/12.
        AV4=SUM4/12.
        WRITE(6,102) AV1,AV2,AV3,AV4
100     FORMAT(1F10.1,'  ACRES',6X,1F6.2,'  POND TEMPERATURE ')
101     FORMAT(3F7.2,4X,4(1F7.2,2X))
102     FORMAT(4(1F7.1,3X))
103     FORMAT(12F6.2)
104     FORMAT(1E8.2)
        END
        STOP
```

APPENDIX B

METEOROLOGICAL DATA USED FOR MODEL PREDICTIONS

FIGURES

APPENDIX B

FIGURES

(Continued)

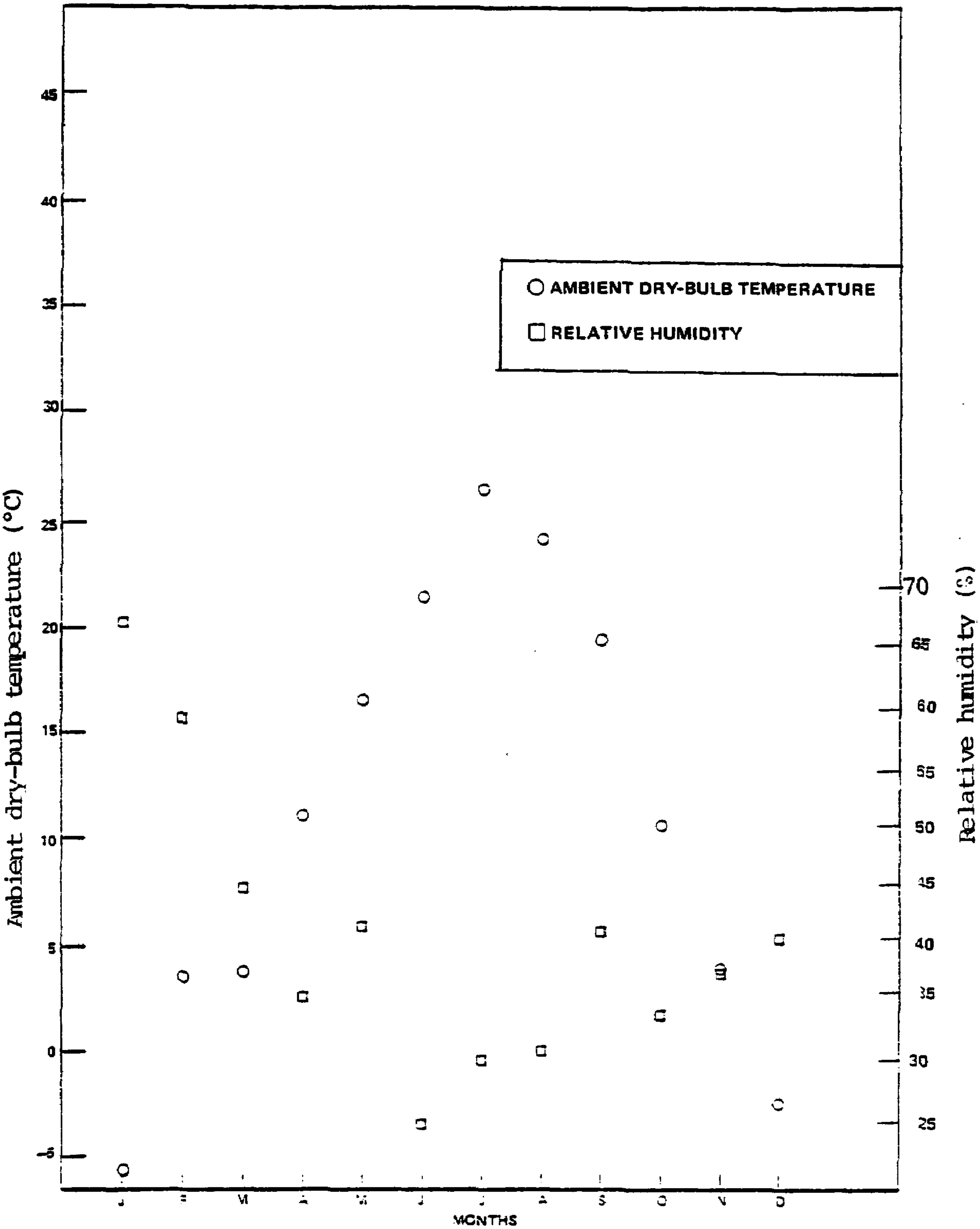

Figure B-1. Ambient dry-bulb temperature and relative humidity for Huntington Creek Station evaporation rate calculations (1976).

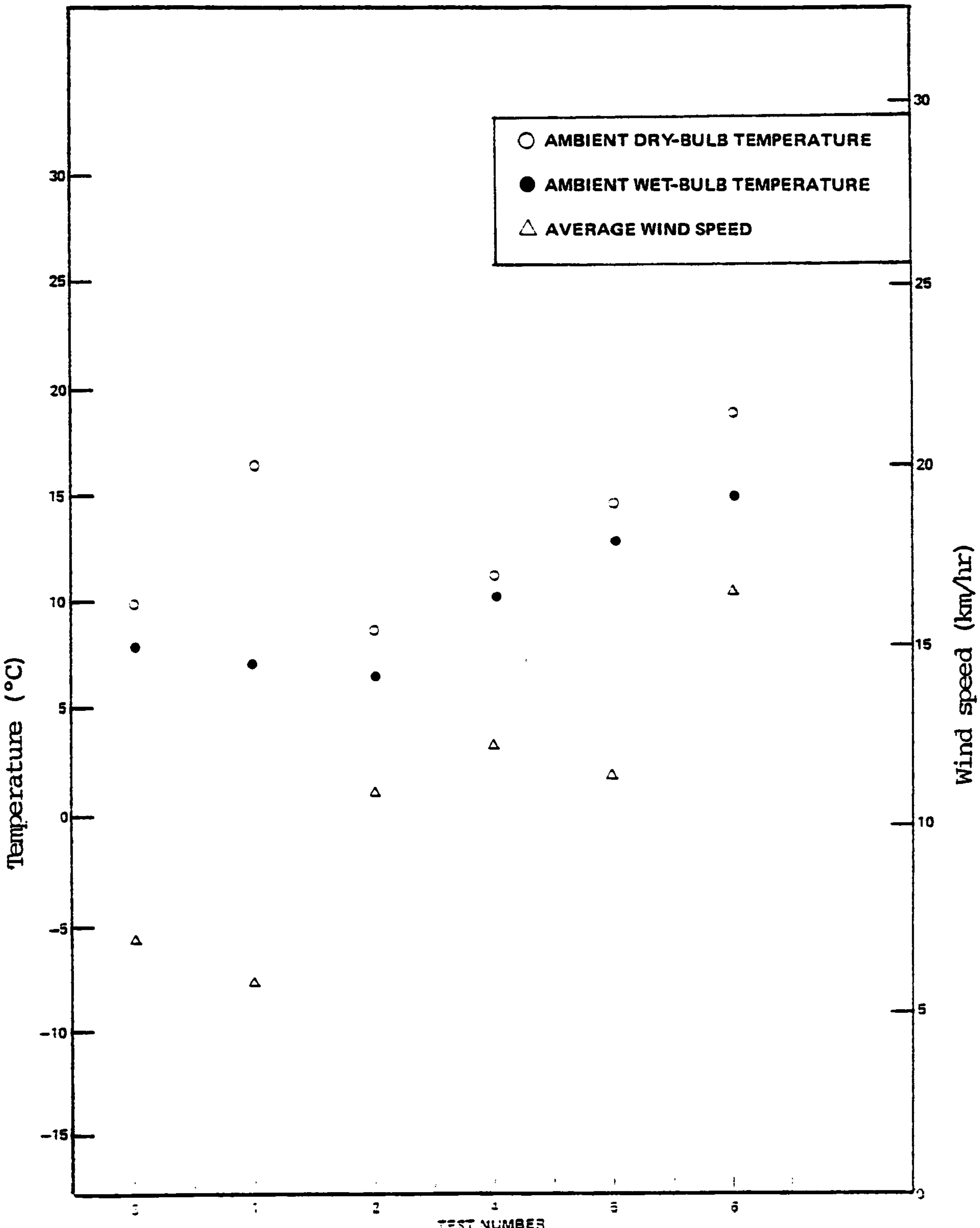

Figure B-2. Ambient dry-bulb temperature, ambient wet-bulb temperature and average wind speed for North Main Steam Electric Station evaporation rate calculations (1960).

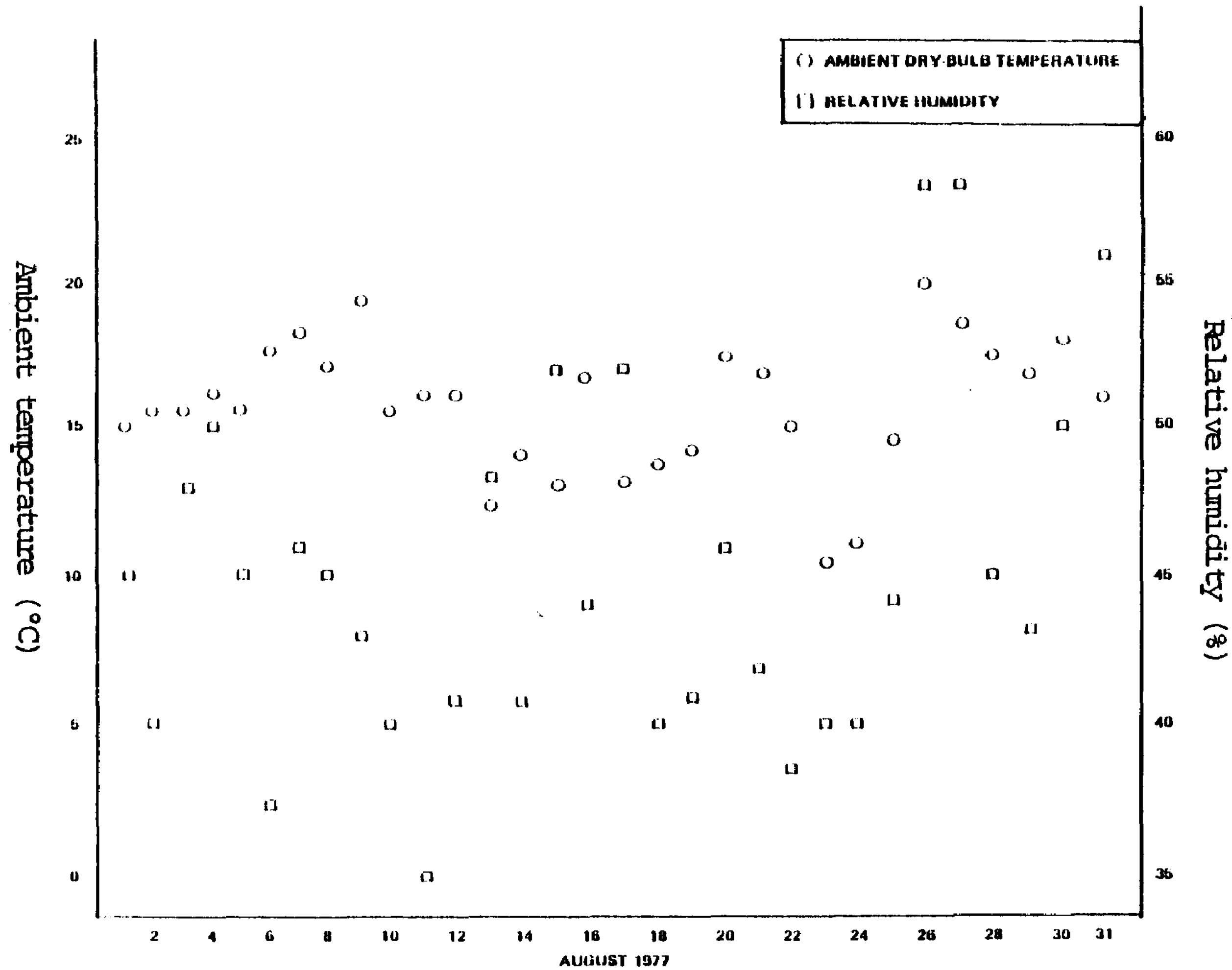

Figure B-3. Ambient dry-bulb temperature and relative humidity for Clay Boswell Steam Electric Station evaporation rate calculations (1977).

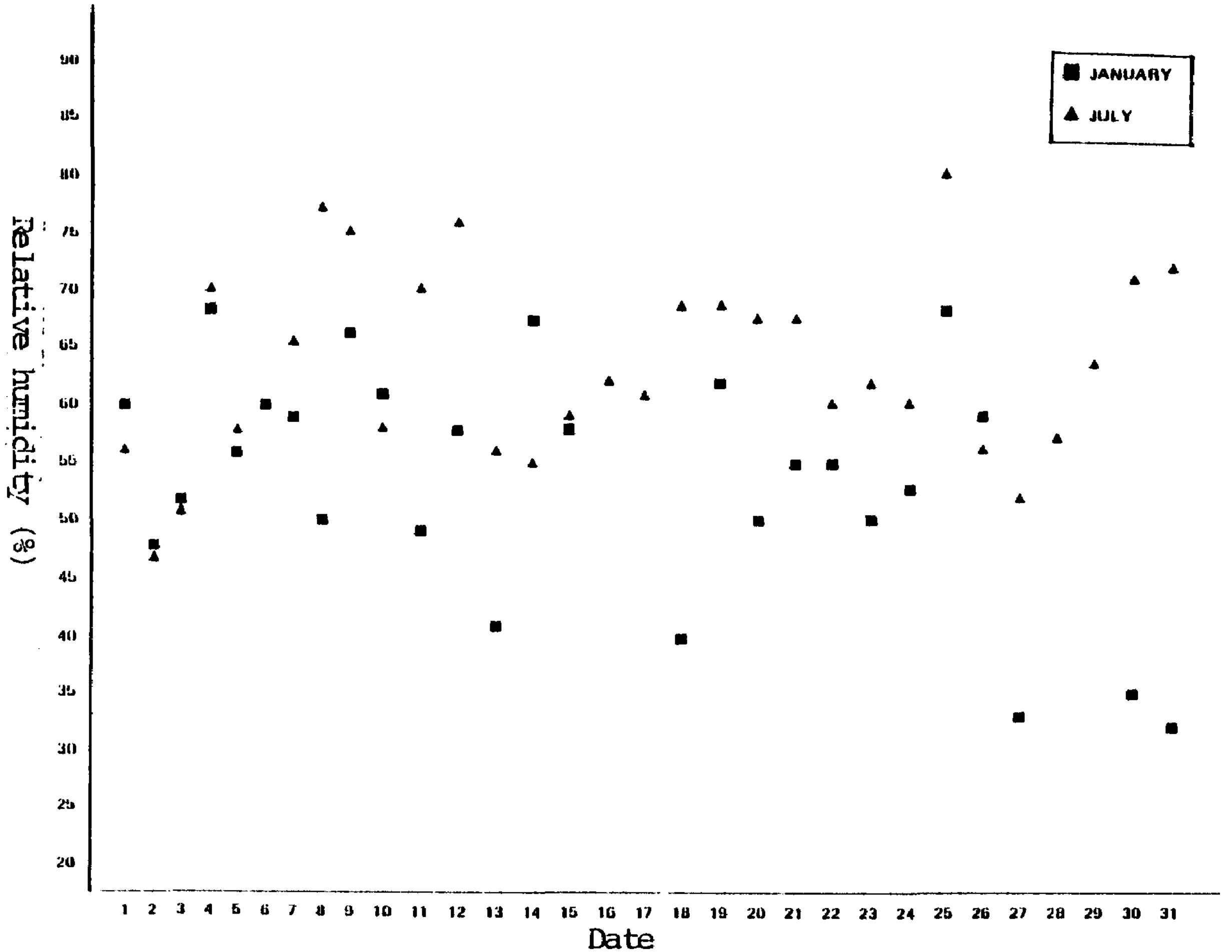

Figure B-4. Two months of relative humidity (January, July) for Homer City Steam Electric Station evaporation rate calculations (1977).

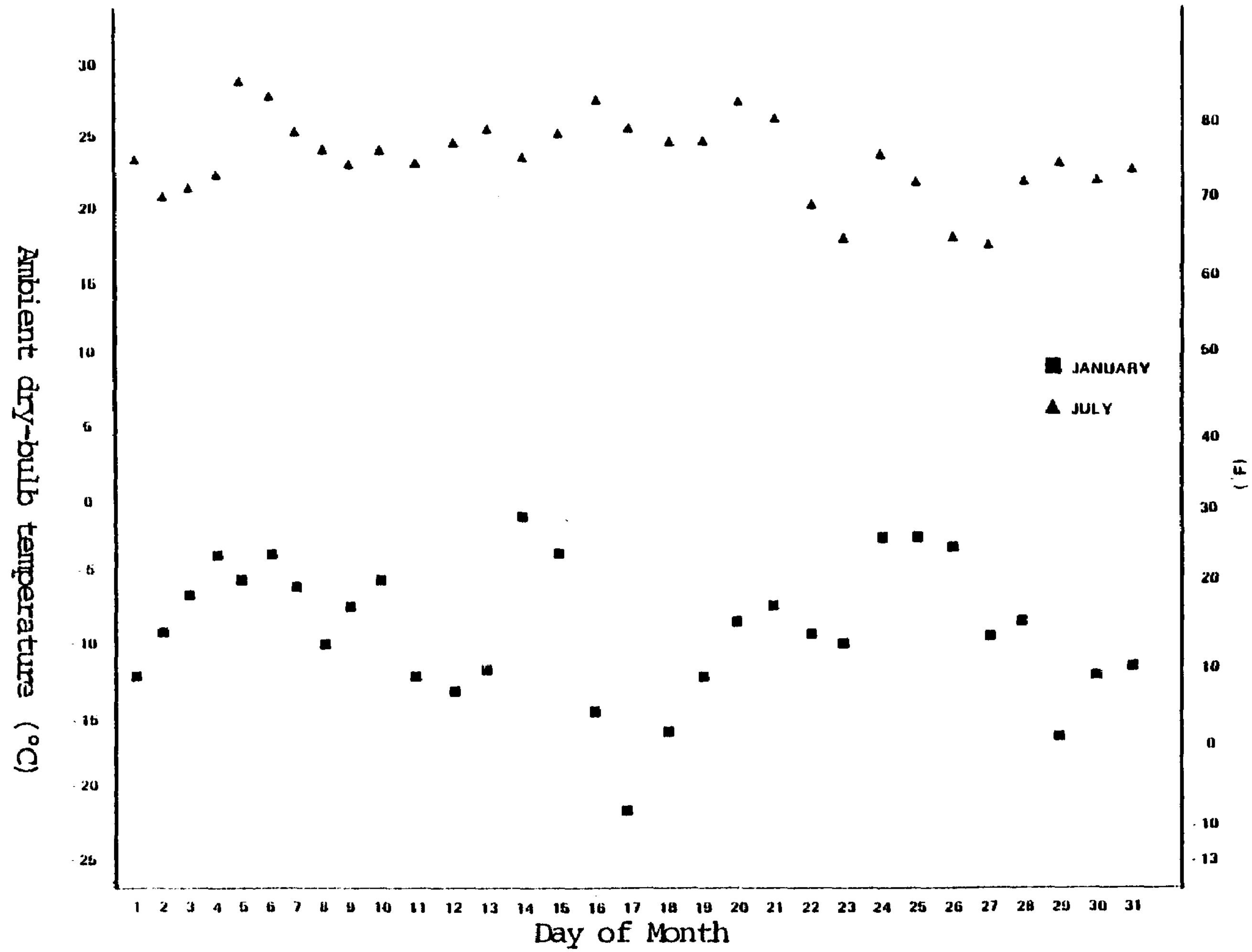

Figure B-5. Ambient dry-bulb temperatures for Homer City Station (1977).

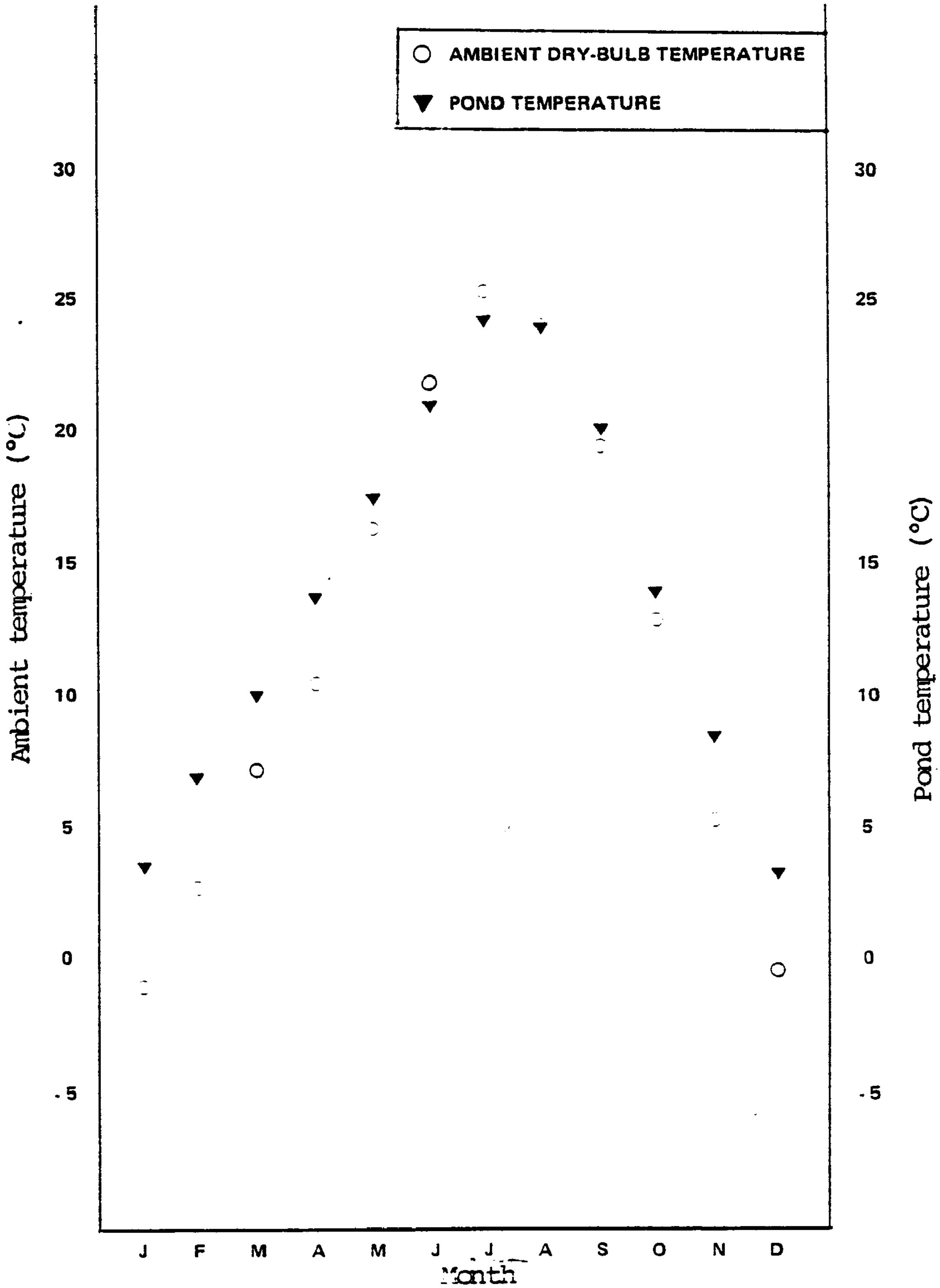

Figure B-6. Ambient dry-bulb and pond temperatures for Cholla Plant (1974-1976)

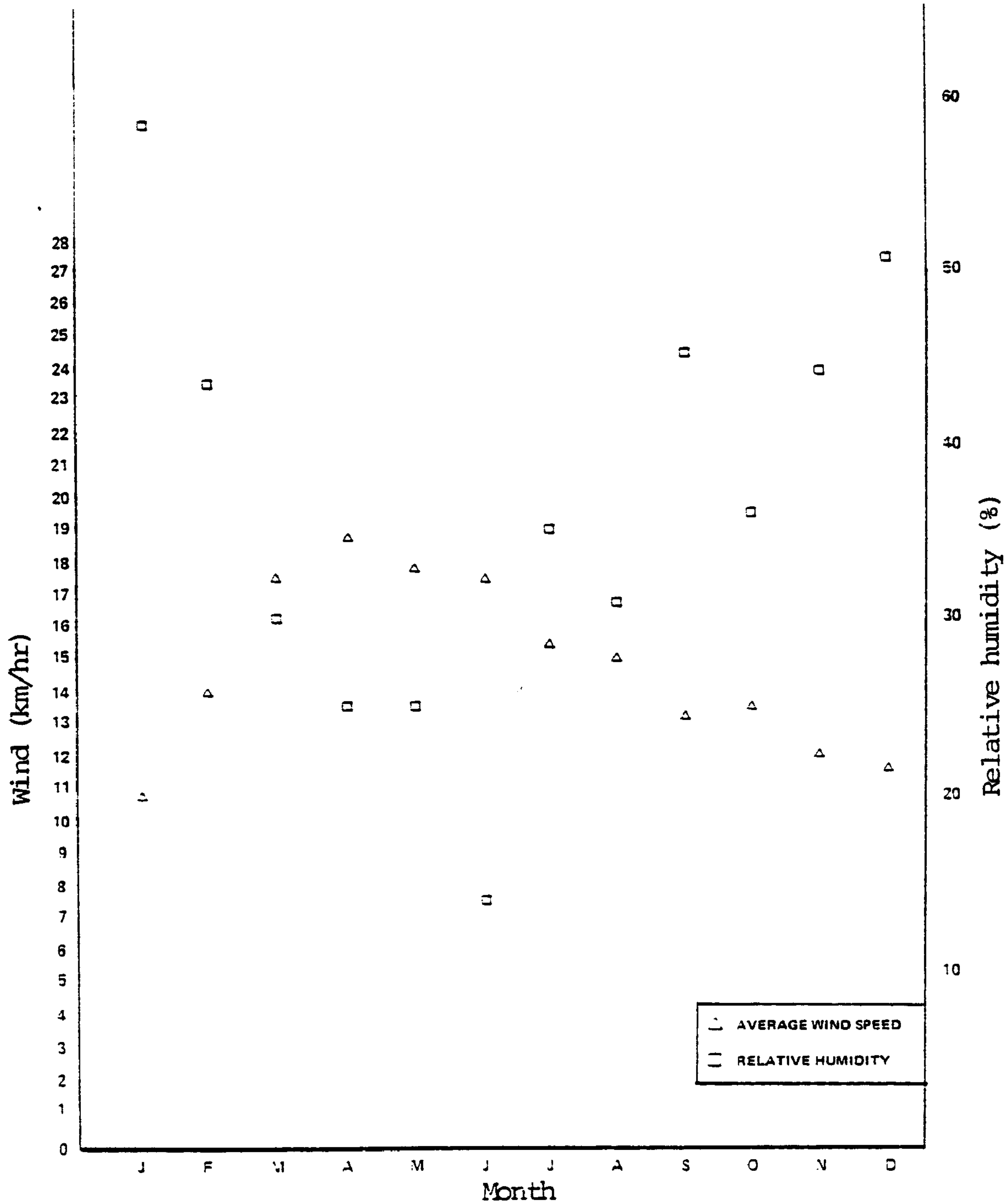

Figure B-7. Average wind speed and relative humidity for Cholla Steam Electric Station evaporation rate calculations (1974-1976).

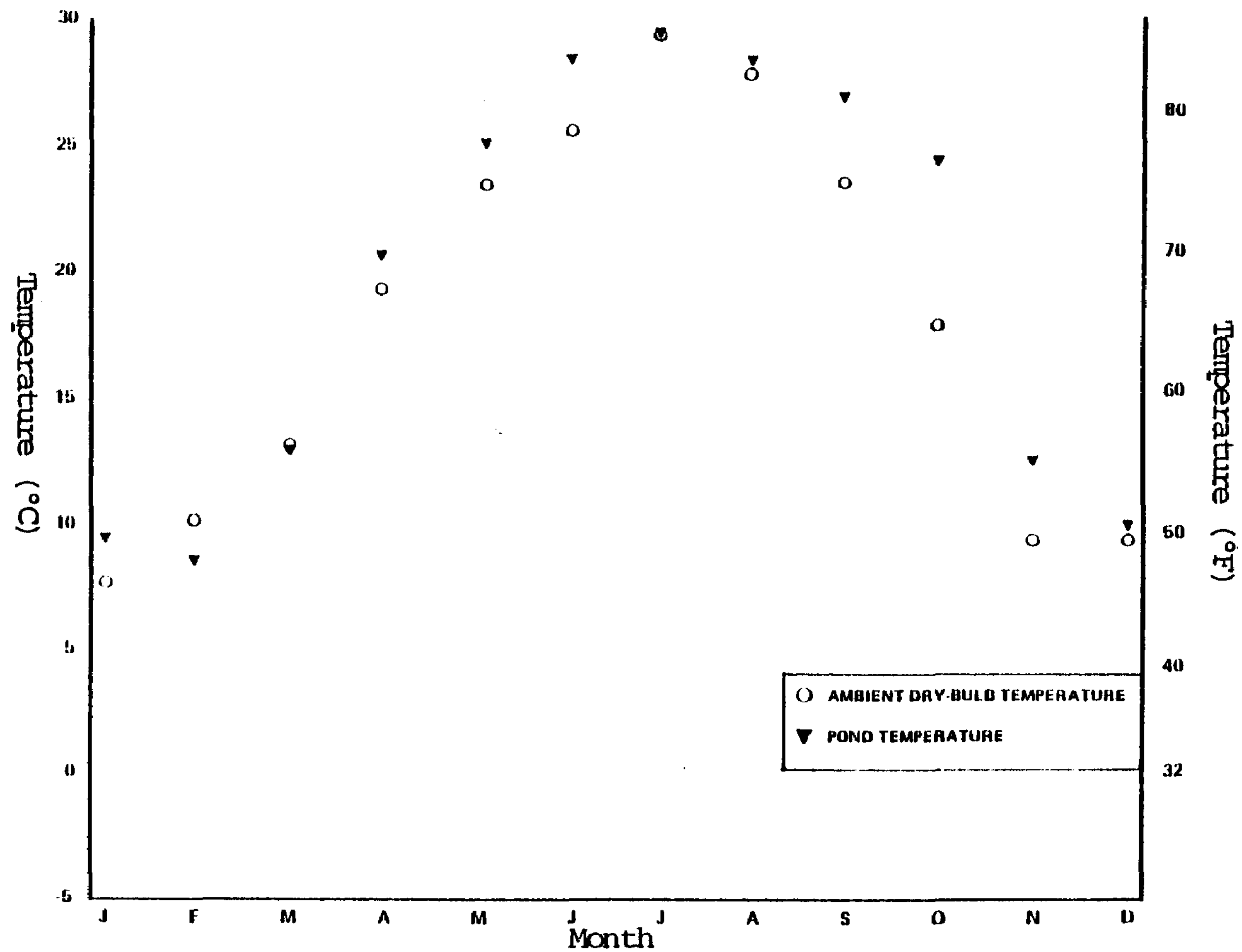

Figure B-8. Ambient dry-bulb temperatures and pond temperatures for Morgan Creek Station (1960).

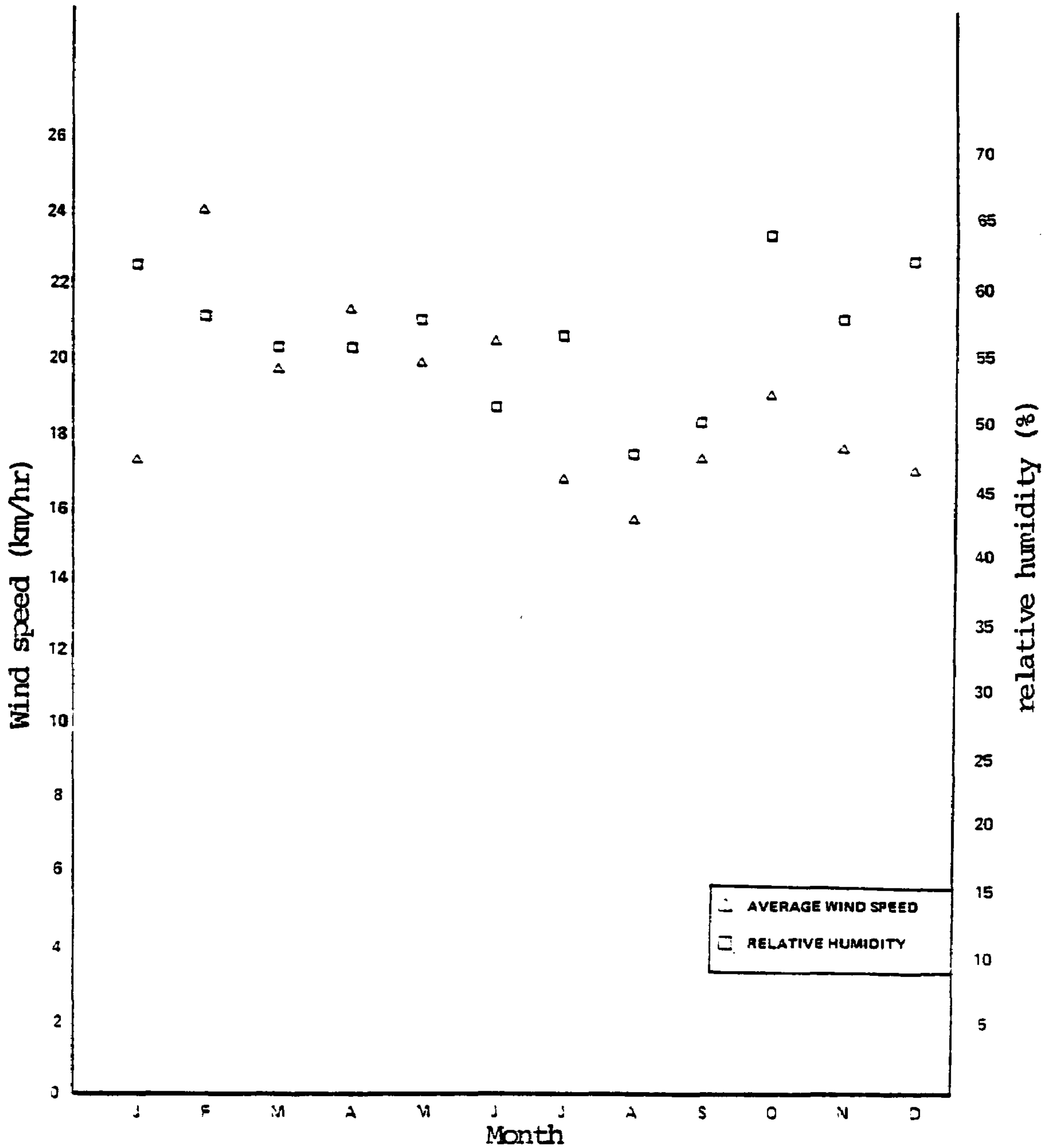

Figure B-9. Average wind speed and relative humidity for Morgan Creek Steam Electric Station evaporation rate calculations (1960).

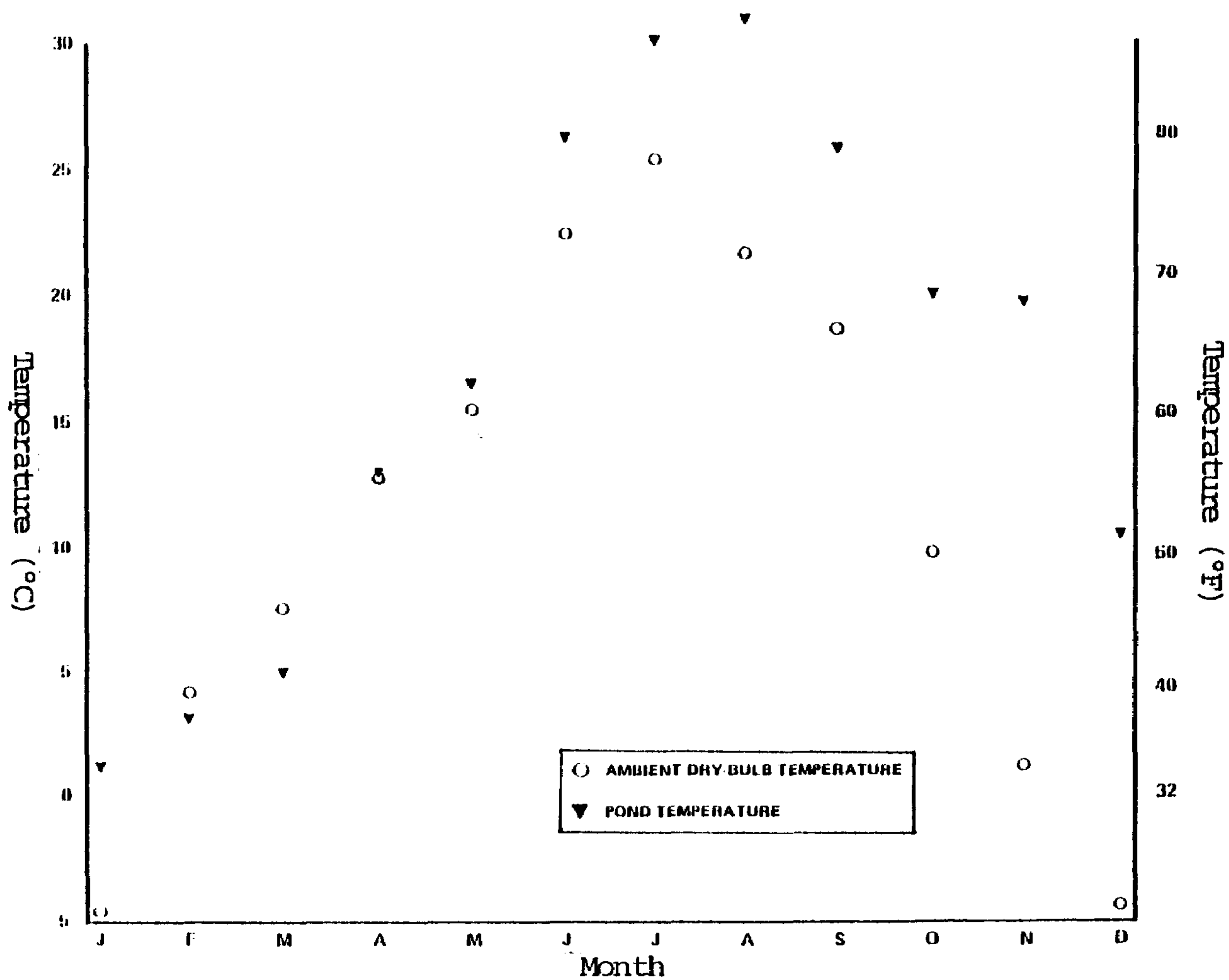

Figure B-10. Ambient dry-bulb temperatures and pond temperatures for Kincaid Station (1976).

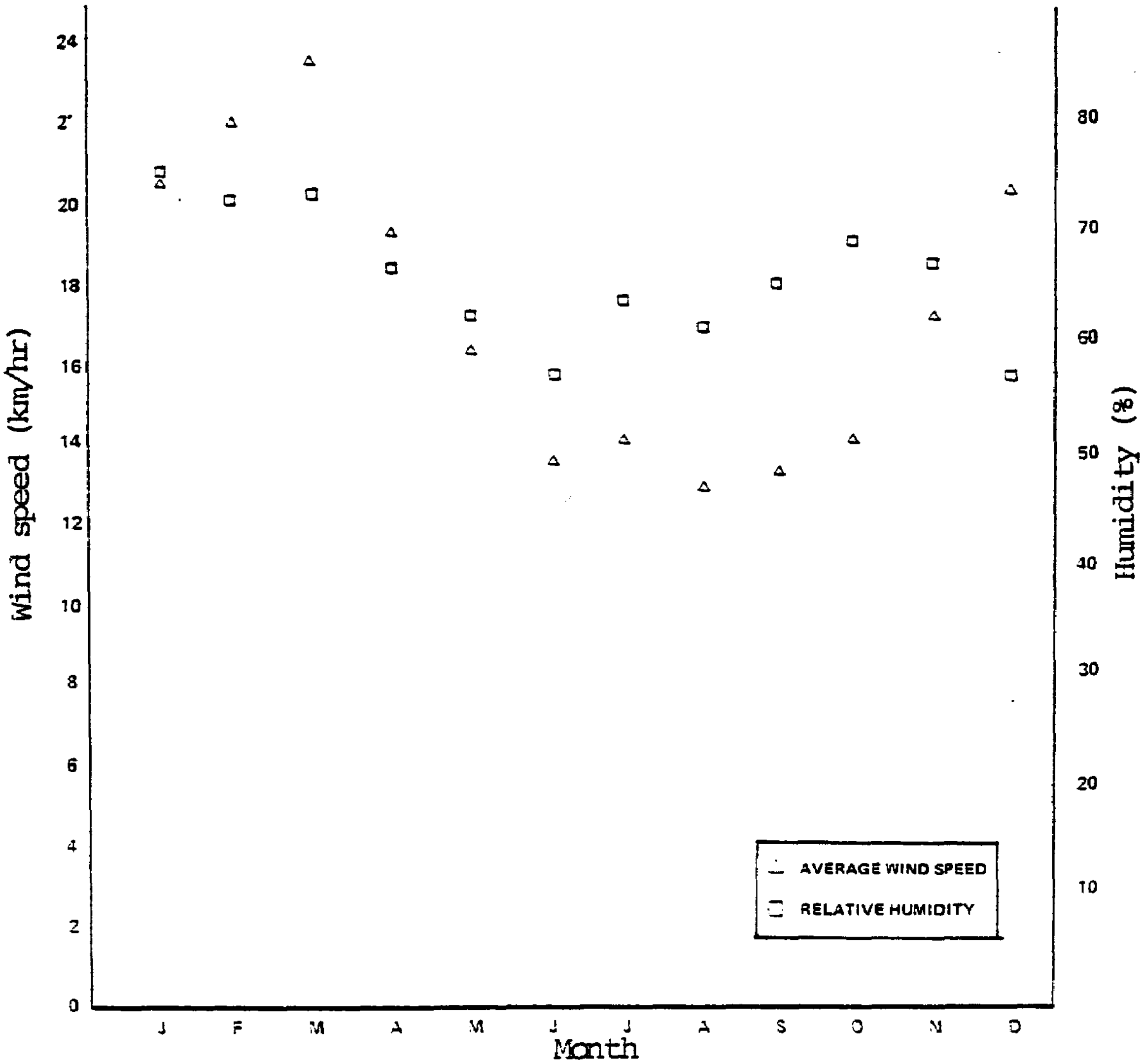

Figure B-11. Average wind speed and relative humidity for Kincaid Steam Electric Station evaporation rate calculations (1976).

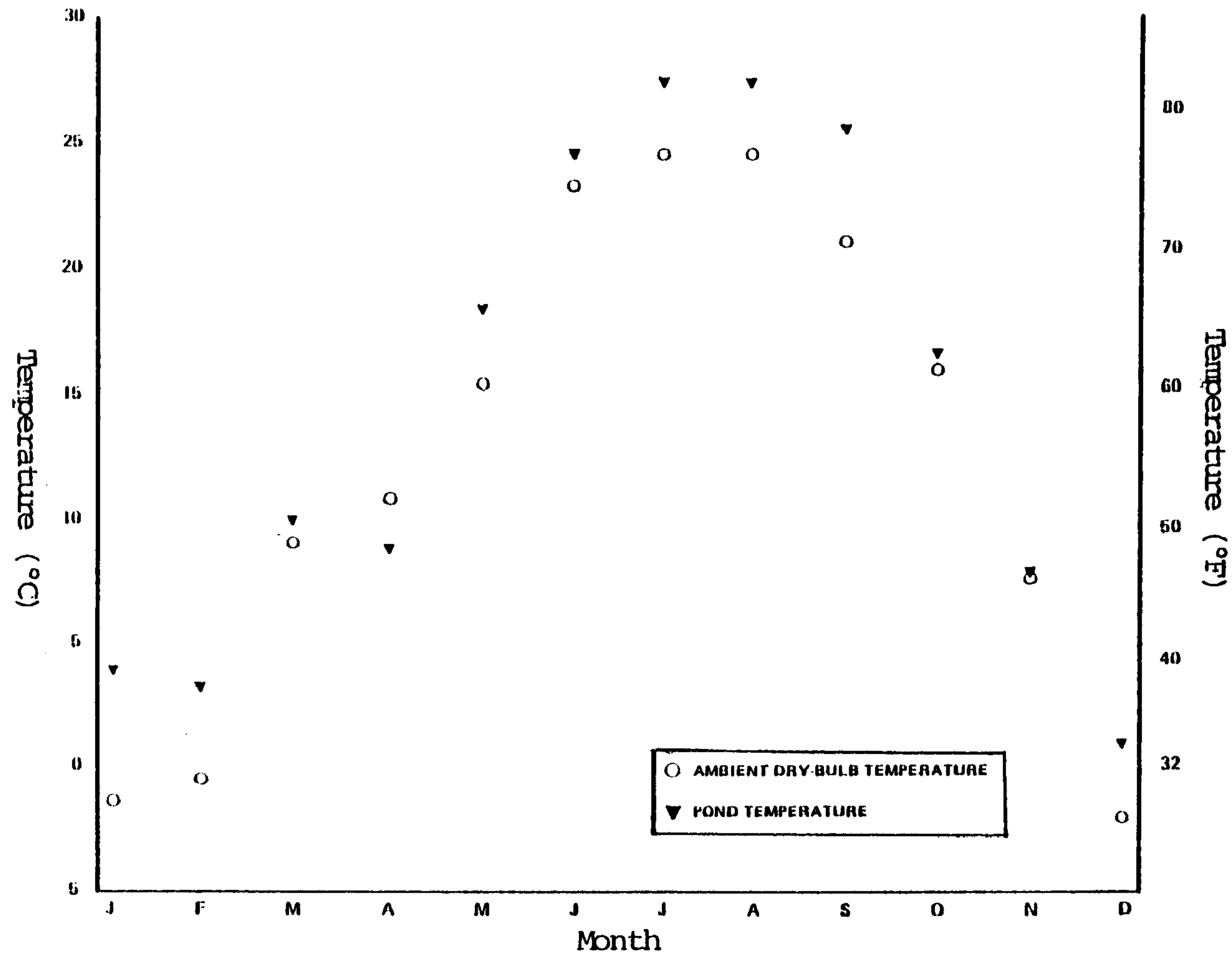

Figure B-12. Ambient dry-bulb temperatures and pond temperatures for Powerton Station (1973).

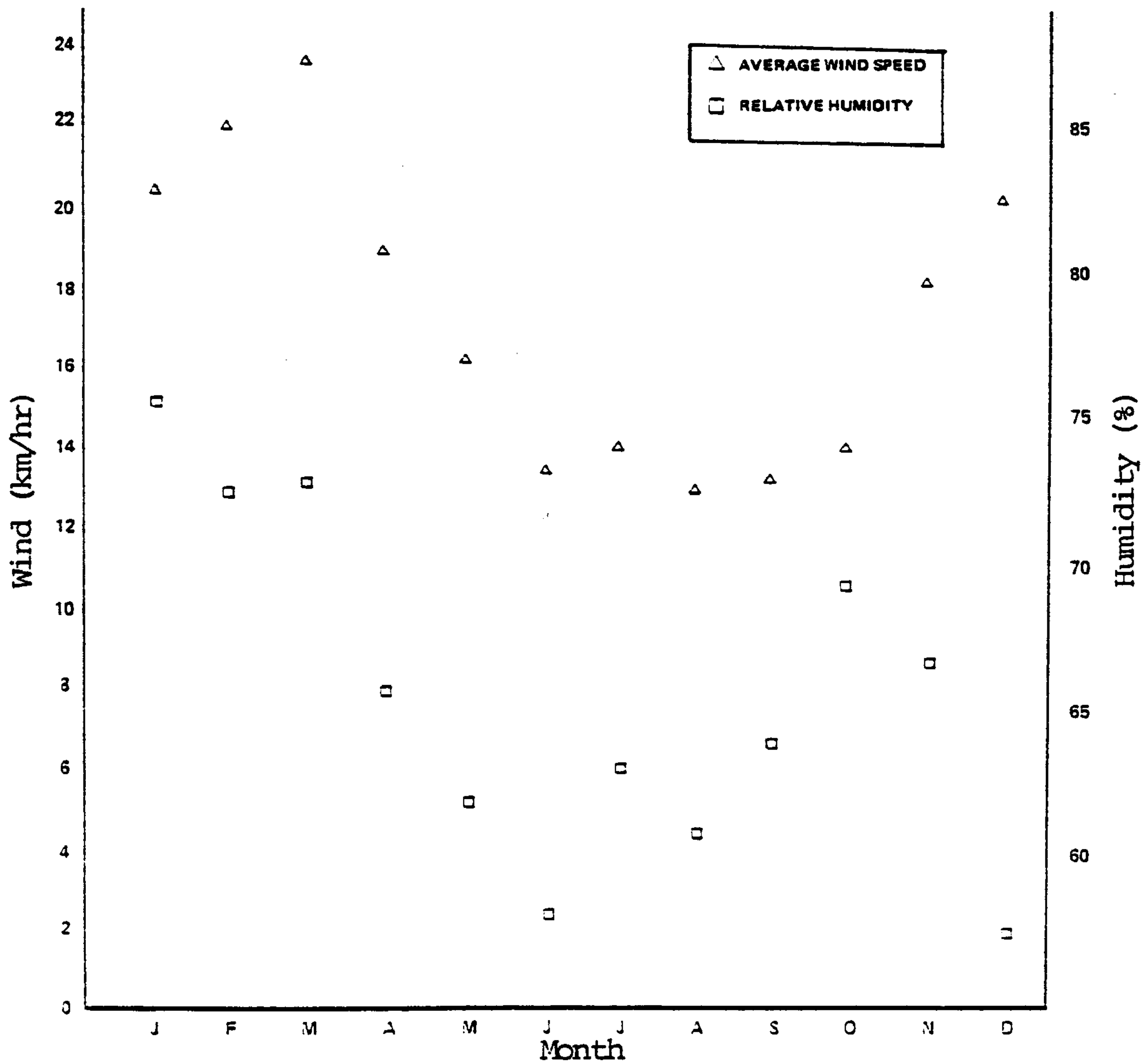

Figure B-13. Average wind speed and relative humidity for Powerton Steam Electric Station evaporation rate calculations (1973).

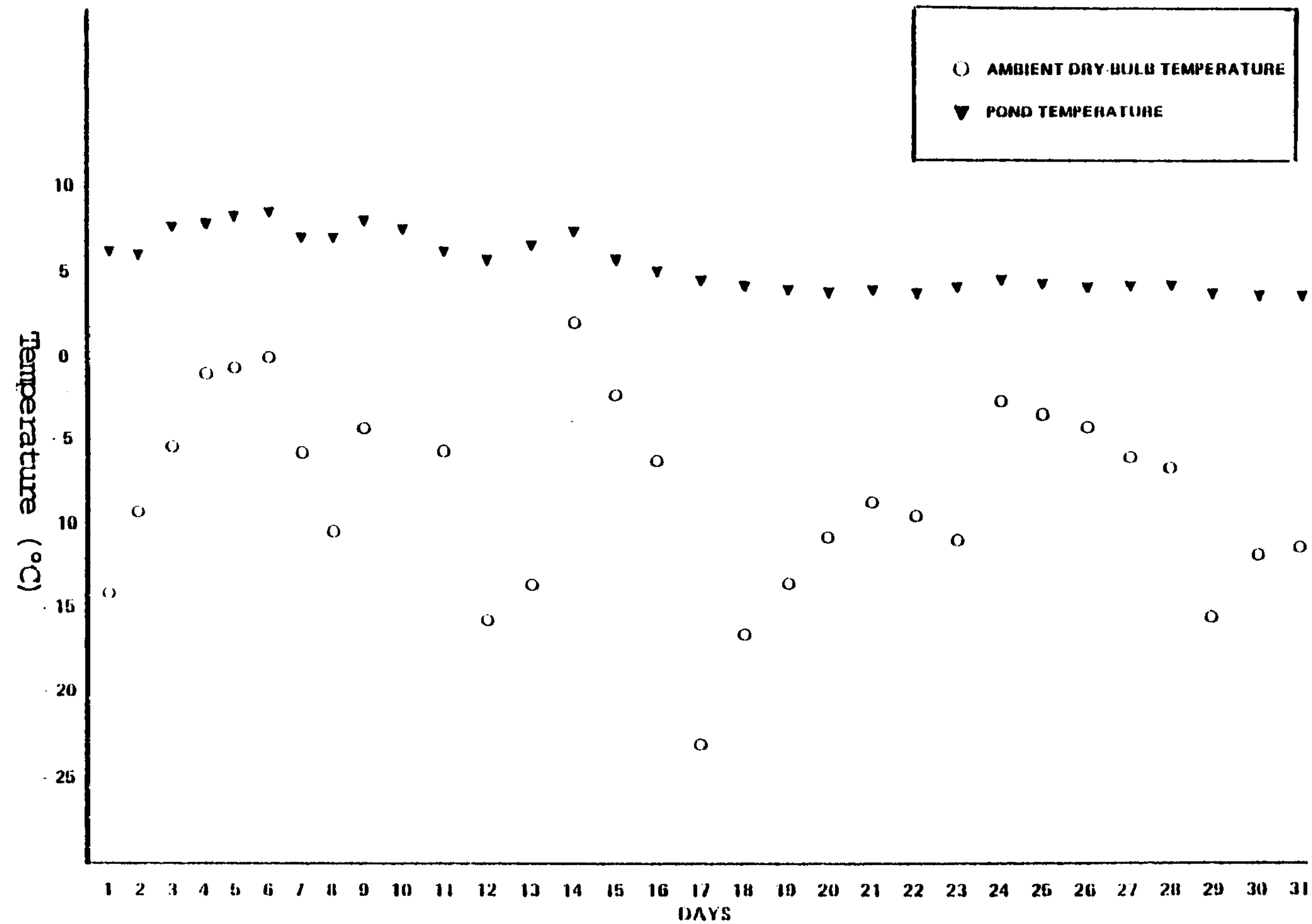

Figure B-14. Comparison of ambient dry-bulb temperature with pond temperature for Mt. Storm Station (January 1977).

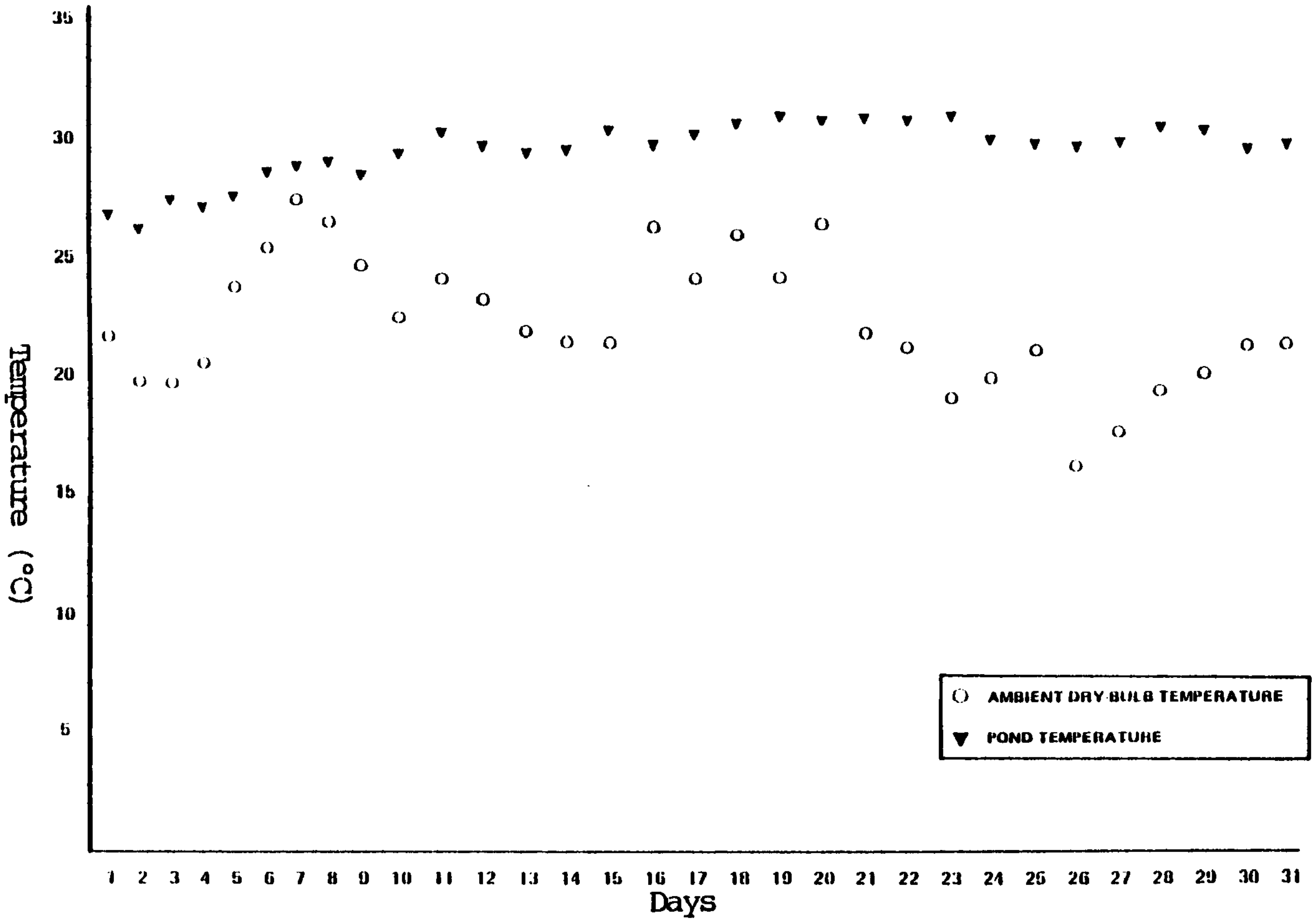

Figure B-15. Comparison of ambient dry-bulb temperature with pond temperature for Mt. Storm Station (July 1977).

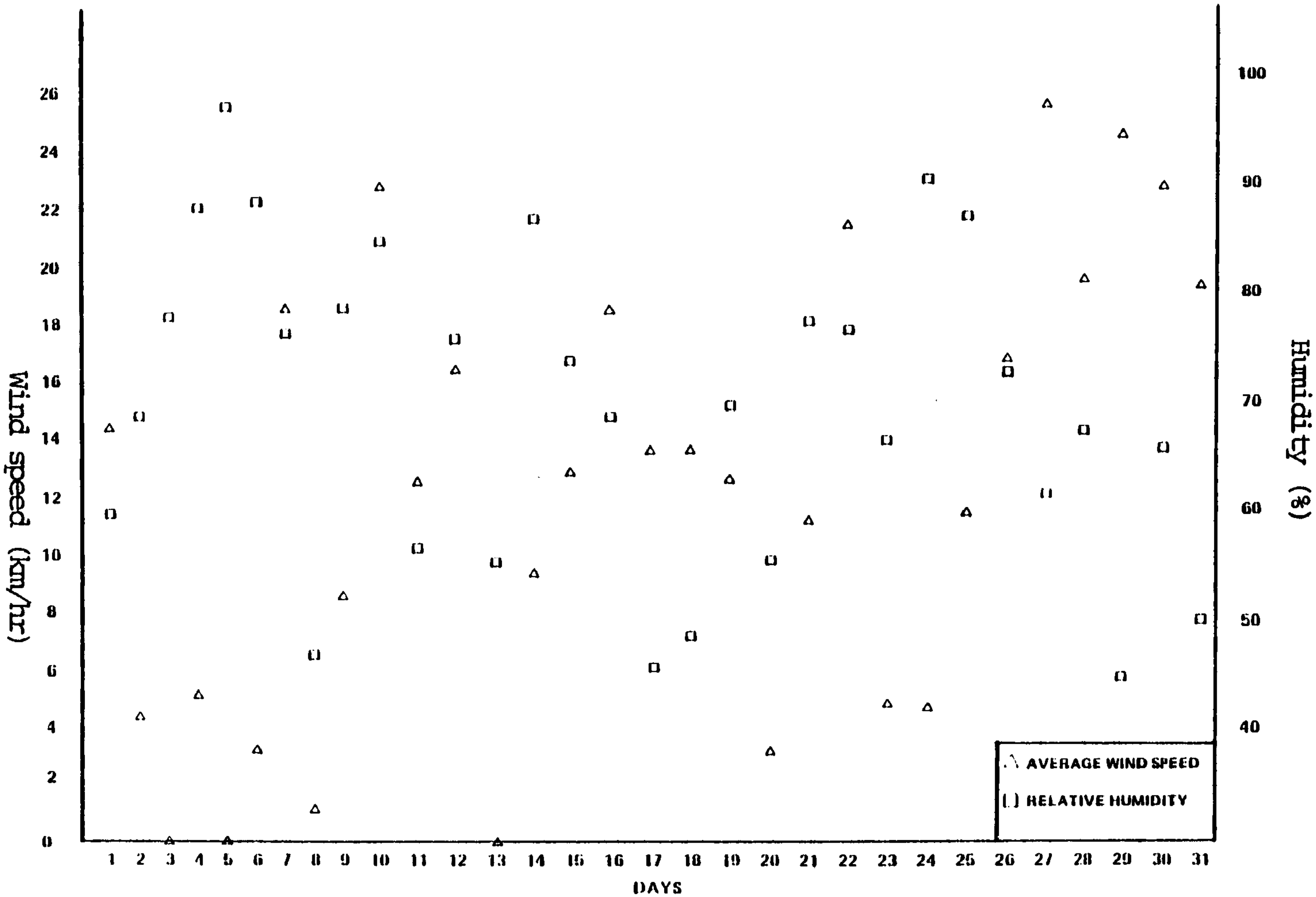

Figure B-16. Average wind speed and relative humidity for Mt. Storm Steam Electric Station evaporation calculations (January 1977).

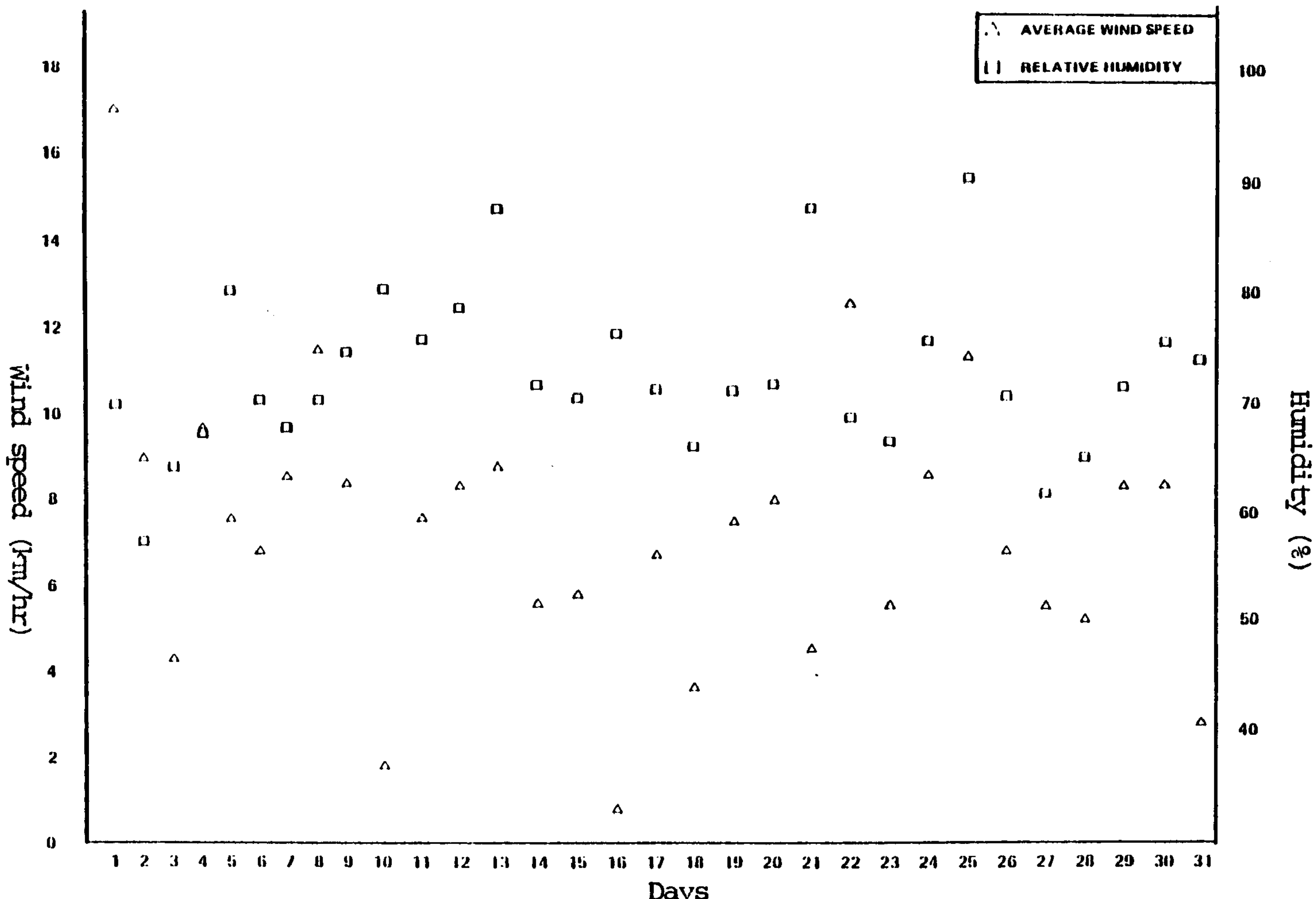

Figure B-17. Average wind speed and relative humidity for Mt. Storm Steam Electric evaporation rate calculations (July 1977).

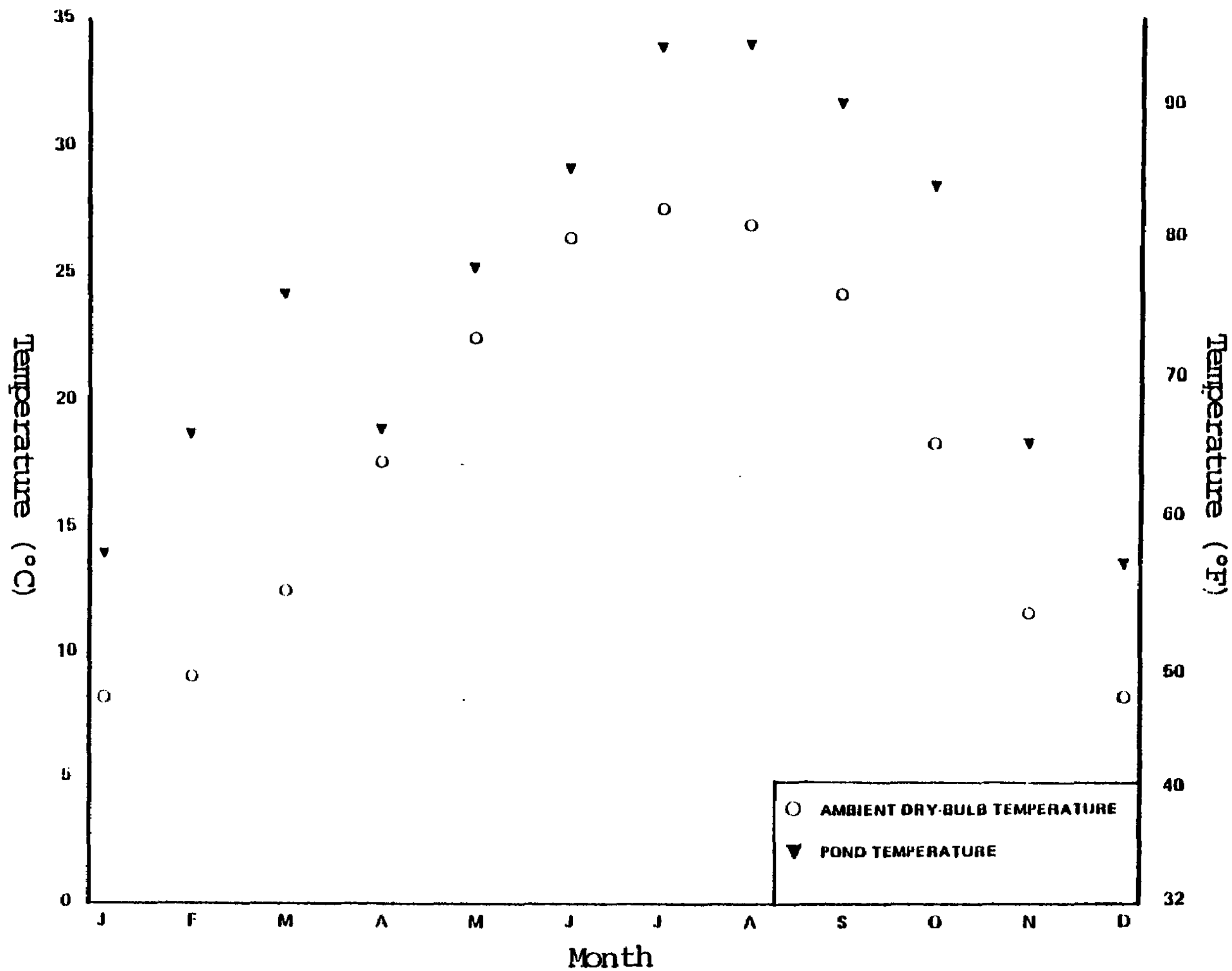

Figure B-18. Ambient dry-bulb temperatures and pond temperatures for Robinson Station (1975-1976).

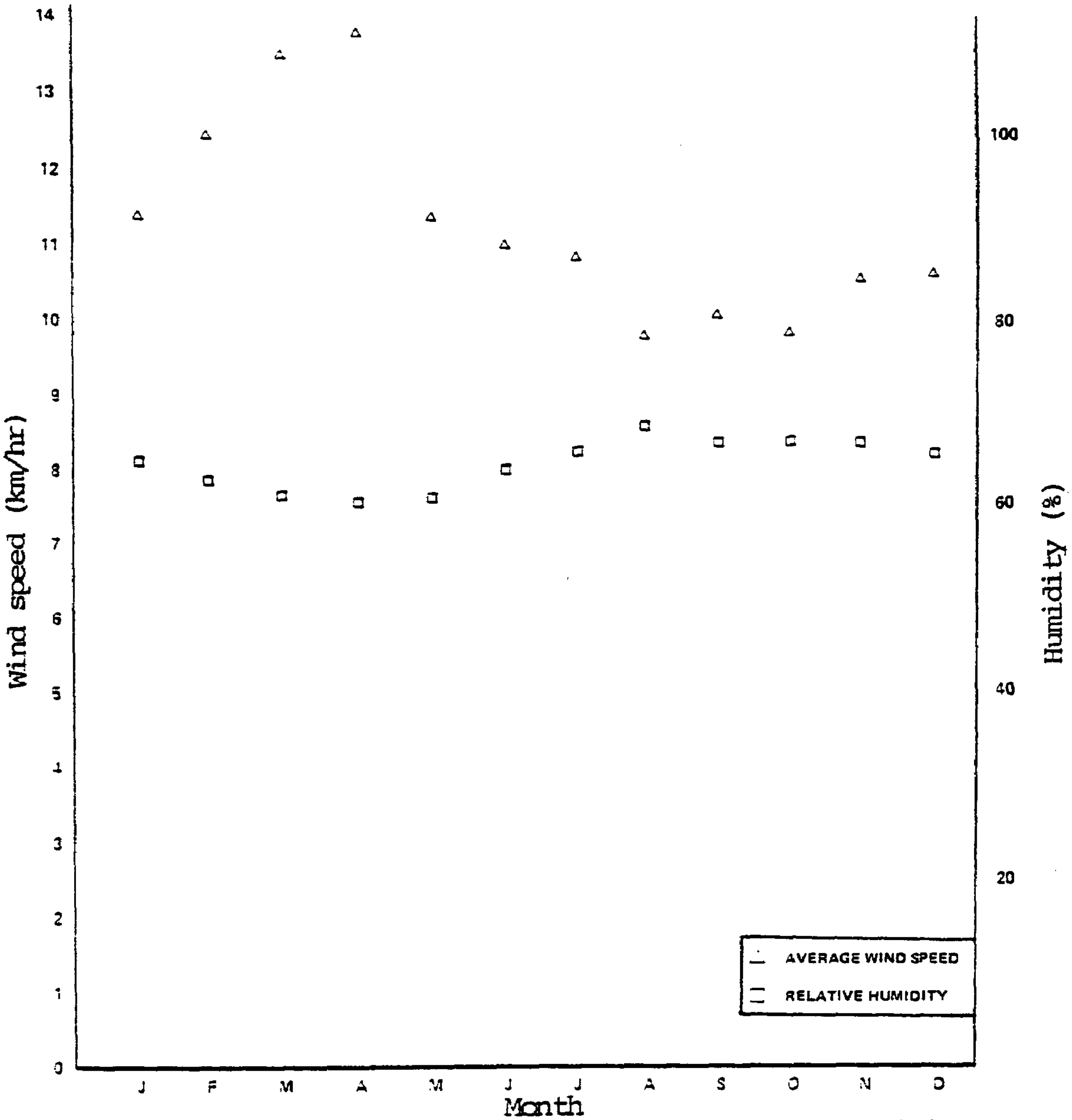

Figure B-19. Average wind speed and relative humidity for Robinson Steam Electric evaporation rate calculations (1975-1976).

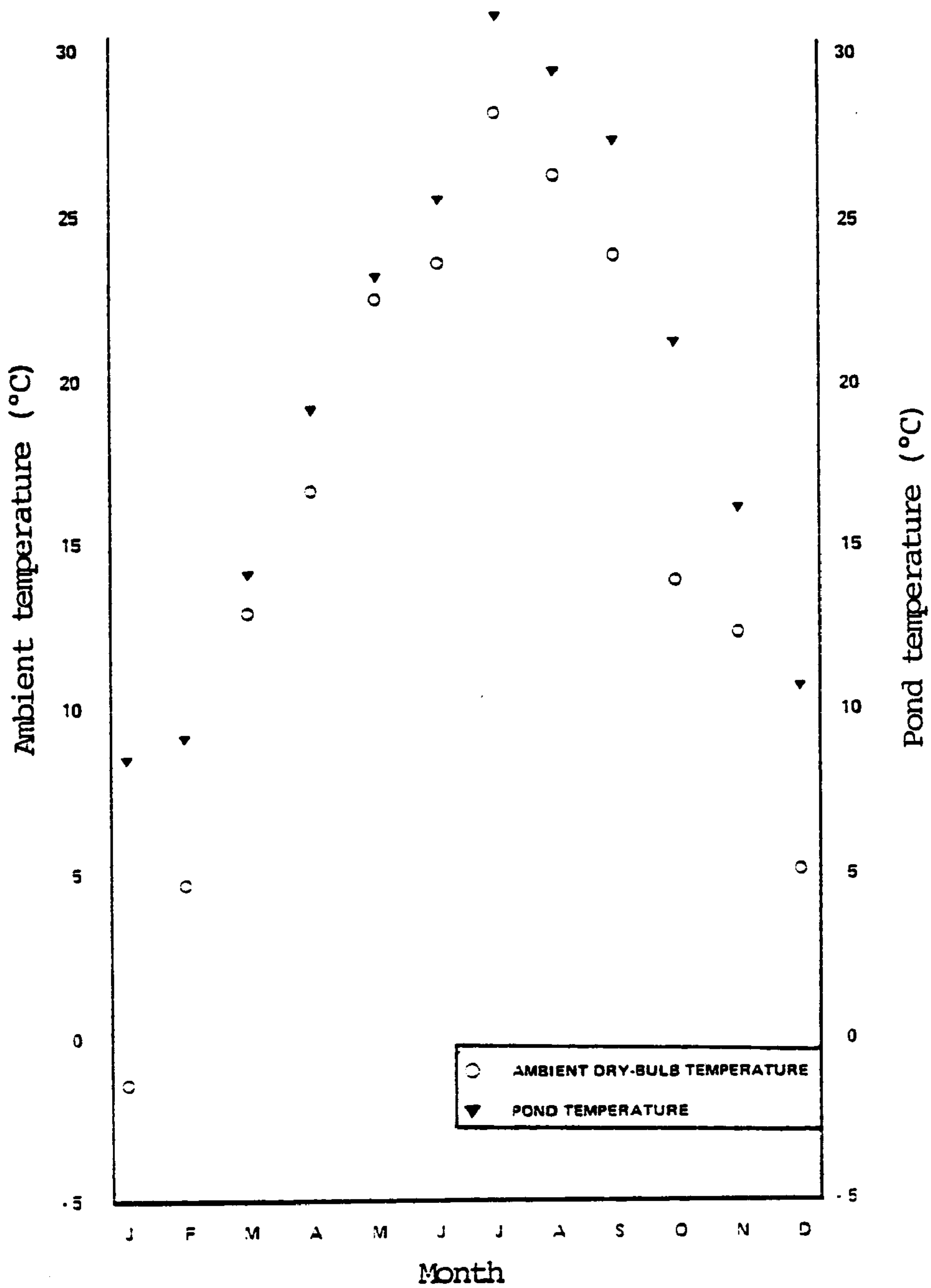

Figure B-20. Ambient dry-bulb temperatures and pond temperatures for Lake Belews Station (1977).

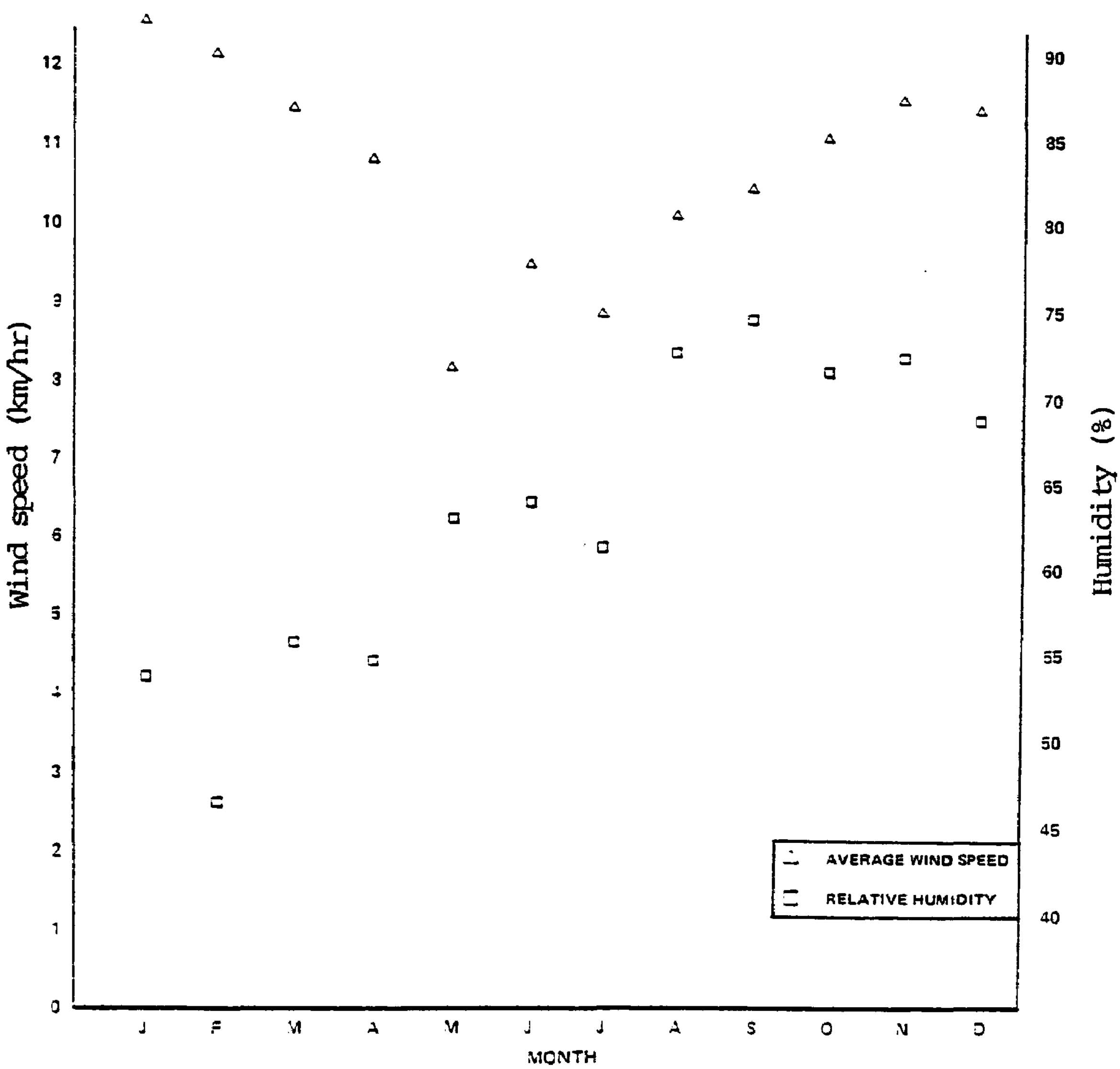

Figure B-21. Average wind speed and relative humidity for Lake Belews Steam Electric Station evaporation rate calculations (1977).

APPENDIX C

COMPUTER PRINTOUTS FOR COOLING TOWER MODEL

DEFINITIONS FOR LEUNG AND MOORE PROGRAM OUTPUT

Parameter	Definition
Inlet Temperature	Ambient Dry Bulb Air Temperature in °F
Percent Humidity	Ambient Relative Humidity
Evaporation in GPM	Leung & Moore model evaporation prediction in gallons per minute
Evaporation in CFS	Leung & Moore model evaporation prediction in cubic feet per second
Air Flow in Pounds Per Hour	Air flow rate through the tower in pounds of air per hour
Head Load in BTU Per Hour	Heat rejected to cooling tower in BTU per hour
Atmospheric Pressure in Inches	Ambient barometric pressure in inches of Hg
Basin Temperature in Degrees F	Circulating water temperature out of cooling tower - °F
Air Outlet Temperature in Degrees F	Temperature of air exiting from cooling tower - °F
Average Evaporation in CFS	Average Model Predicted values for total run.

Dates shown are day-month-year (e.g. January 8, 1977 is 080177)

HUNTINGTON STATION

SENSITIVITY ANALYSIS

CASE I - AIR OUTLET TEMPERATURE AT 82.5°

```
 0.5053E+02  0.8865E-01
INLET TEMPERATURE = 21.70 PERCENT HUMIDITY = 68.20
EVAPORATION IN GPM =  0.2944E+04 IN CFS =  0.6561E+01
 0.5053E+02  0.1138E+00
INLET TEMPERATURE = 38.20 PERCENT HUMIDITY = 60.50
EVAPORATION IN GPM =  0.3445E+04 IN CFS =  0.7675E+01
 0.5053E+02  0.1160E+00
INLET TEMPERATURE = 38.70 PERCENT HUMIDITY = 45.70
EVAPORATION IN GPM =  0.3462E+04 IN CFS =  0.7714E+01
 0.5053E+02  0.1916E+00
INLET TEMPERATURE = 51.90 PERCENT HUMIDITY = 36.50
EVAPORATION IN GPM =  0.3861E+04 IN CFS =  0.8603E+01
 0.5053E+02  0.2739E+00
INLET TEMPERATURE = 61.80 PERCENT HUMIDITY = 42.50
EVAPORATION IN GPM =  0.4160E+04 IN CFS =  0.9268E+01
 0.5053E+02  0.3683E+00
INLET TEMPERATURE = 70.40 PERCENT HUMIDITY = 25.70
EVAPORATION IN GPM =  0.4423E+04 IN CFS =  0.9855E+01
 0.5053E+02  0.5007E+00
INLET TEMPERATURE = 79.60 PERCENT HUMIDITY = 31.20
EVAPORATION IN GPM =  0.4703E+04 IN CFS =  0.1048E+02
 0.5053E+02  0.4343E+00
INLET TEMPERATURE = 75.30 PERCENT HUMIDITY = 32.00
EVAPORATION IN GPM =  0.4571E+04 IN CFS =  0.1019E+02
 0.5053E+02  0.3273E+00
INLET TEMPERATURE = 66.90 PERCENT HUMIDITY = 42.20
EVAPORATION IN GPM =  0.4314E+04 IN CFS =  0.9613E+01
 0.5053E+02  0.1866E+00
INLET TEMPERATURE = 51.20 PERCENT HUMIDITY = 35.00
EVAPORATION IN GPM =  0.3840E+04 IN CFS =  0.8557E+01
 0.5053E+02  0.1177E+00
INLET TEMPERATURE = 39.10 PERCENT HUMIDITY = 38.50
EVAPORATION IN GPM =  0.3475E+04 IN CFS =  0.7743E+01
 0.5053E+02  0.8865E-01
INLET TEMPERATURE = 27.60 PERCENT HUMIDITY = 41.70
EVAPORATION IN GPM =  0.3127E+04 IN CFS =  0.6968E+01
AVERAGE EVAPORATION IN CFS =                   8.602
AIR FLOW IN CUBIC FEET PER HOUR =            0.1080E+10
WATER FLOW IN GALLONS PER MINUTE =           0.1997E+07
HEAT LOAD IN BTU PER HOUR =                  0.2530E+10
ATMOSPHERIC PRESSURE IN INCHES =             0.2535E+02
BASIN TEMPERATURE IN DEGREES F=              0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =        0.8250E+02
STOP
END OF TASK     0
```

HUNTINGTON STATION

SENSITIVITY ANALYSIS

CASE III - AIR OUTLET TEMPERATURE AT 92.5°

```
 0.5053E+02  0.8865E-01
INLET TEMPERATURE = 21.70 PERCENT HUMIDITY = 68.20
EVAPORATION IN GPM =  0.2630E+04 IN CFS =  0.5860E+01
 0.5053E+02  0.1138E+00
INLET TEMPERATURE = 38.20 PERCENT HUMIDITY = 60.50
EVAPORATION IN GPM =  0.3128E+04 IN CFS =  0.6970E+01
 0.5053E+02  0.1160E+00
INLET TEMPERATURE = 38.70 PERCENT HUMIDITY = 45.70
EVAPORATION IN GPM =  0.3146E+04 IN CFS =  0.7009E+01
 0.5053E+02  0.1916E+00
INLET TEMPERATURE = 51.90 PERCENT HUMIDITY = 36.50
EVAPORATION IN GPM =  0.3543E+04 IN CFS =  0.7894E+01
 0.5053E+02  0.2739E+00
INLET TEMPERATURE = 61.80 PERCENT HUMIDITY = 42.50
EVAPORATION IN GPM =  0.3839E+04 IN CFS =  0.8553E+01
 0.5053E+02  0.3683E+00
INLET TEMPERATURE = 70.40 PERCENT HUMIDITY = 25.70
EVAPORATION IN GPM =  0.4102E+04 IN CFS =  0.9139E+01
 0.5053E+02  0.5007E+00
INLET TEMPERATURE = 79.60 PERCENT HUMIDITY = 31.20
EVAPORATION IN GPM =  0.4379E+04 IN CFS =  0.9757E+01
 0.5053E+02  0.4343E+00
INLET TEMPERATURE = 75.30 PERCENT HUMIDITY = 32.00

INLET TEMPERATURE = 75.30 PERCENT HUMIDITY = 32.00
EVAPORATION IN GPM =  0.4248E+04 IN CFS =  0.9466E+01
 0.5053E+02  0.3273E+00
INLET TEMPERATURE = 66.90 PERCENT HUMIDITY = 42.20
EVAPORATION IN GPM =  0.3992E+04 IN CFS =  0.8896E+01
 0.5053E+02  0.1866E+00
INLET TEMPERATURE = 51.20 PERCENT HUMIDITY = 35.00
EVAPORATION IN GPM =  0.3522E+04 IN CFS =  0.7848E+01
 0.5053E+02  0.1177E+00
INLET TEMPERATURE = 39.10 PERCENT HUMIDITY = 38.50
EVAPORATION IN GPM =  0.3159E+04 IN CFS =  0.7038E+01
 0.5053E+02  0.8865E-01
INLET TEMPERATURE = 27.60 PERCENT HUMIDITY = 41.70
EVAPORATION IN GPM =  0.2813E+04 IN CFS =  0.6267E+01
AVERAGE EVAPORATION IN CFS =                     7.891
AIR FLOW IN CUBIC FEET PER HOUR =               0.1080E+10
WATER FLOW IN GALLONS PER MINUTE =              0.1997E+07
HEAT LOAD IN BTU PER HOUR =                     0.2530E+10
ATMOSPHERIC PRESSURE IN INCHES =                0.2535E+02
BASIN TEMPERATURE IN DEGREES F=                 0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =           0.9250E+02
```

```
     0.5053E+02  0.4999E-01
JAN  INLET TEMPERATURE = 21.70 PERCENT HUMIDITY = 68.20
     EVAPORATION IN GPM =  0.2549E+04 IN CFS =  0.5679E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.1138E+00
FEB  INLET TEMPERATURE = 38.20 PERCENT HUMIDITY = 60.50
     EVAPORATION IN GPM =  0.3041E+04 IN CFS =  0.6776E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.1160E+00
MAR  INLET TEMPERATURE = 38.70 PERCENT HUMIDITY = 45.70
     EVAPORATION IN GPM =  0.3059E+04 IN CFS =  0.6815E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.1916E+00
APR  INLET TEMPERATURE = 51.90 PERCENT HUMIDITY = 36.50
     EVAPORATION IN GPM =  0.3455E+04 IN CFS =  0.7699E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.2739E+00
MAY  INLET TEMPERATURE = 61.80 PERCENT HUMIDITY = 42.50
     EVAPORATION IN GPM =  0.3751E+04 IN CFS =  0.8357E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.3683E+00
JUNE INLET TEMPERATURE = 70.40 PERCENT HUMIDITY = 25.70
     EVAPORATION IN GPM =  0.4014E+04 IN CFS =  0.8943E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.5007E+00
JULY INLET TEMPERATURE = 79.60 PERCENT HUMIDITY = 31.20
     EVAPORATION IN GPM =  0.4290E+04 IN CFS =  0.9559E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.4343E+00
AUG  INLET TEMPERATURE = 75.30 PERCENT HUMIDITY = 32.00
     EVAPORATION IN GPM =  0.4160E+04 IN CFS =  0.9269E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.3273E+00
SEPT INLET TEMPERATURE = 66.90 PERCENT HUMIDITY = 42.20
     EVAPORATION IN GPM =  0.3904E+04 IN CFS =  0.8699E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.1866E+00
OCT  INLET TEMPERATURE = 51.20 PERCENT HUMIDITY = 35.00
     EVAPORATION IN GPM =  0.3435E+04 IN CFS =  0.7653E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.1177E+00
NOV  INLET TEMPERATURE = 39.10 PERCENT HUMIDITY = 38.50
     EVAPORATION IN GPM =  0.3072E+04 IN CFS =  0.6844E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     0.5053E+02  0.7214E-01
DEC  INLET TEMPERATURE = 27.60 PERCENT HUMIDITY = 41.70
     EVAPORATION IN GPM =  0.2727E+04 IN CFS =  0.6077E+01
     AIR FLOW IN CUBIC FEET PER HOUR =              0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                    0.2520E+10
     ATMOSPHERIC PRESSURE IN INCHES =               0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =          0.9470E+02
     AVERAGE EVAPORATION IN CFS =                    7.697
    STOP
    END OF TASK      0
```

HUNTINGTON STATION

CASE IV - 94.7°F OUTLET AIR

HUNTINGTON STATION - CASE V - 97°F OUTLET AIR

```
 0.5053E+02  0.4999E-01
INLET TEMPERATURE = 21.70 PERCENT HUMIDITY = 68.20
EVAPORATION IN GPM =  0.2477E+04 IN CFS =  0.5519E+01
AIR FLOW*
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.1138E+00
INLET TEMPERATURE = 38.20 PERCENT HUMIDITY = 60.50
EVAPORATION IN GPM =  0.2969E+04 IN CFS =  0.6615E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.1160E+00
INLET TEMPERATURE = 38.70 PERCENT HUMIDITY = 45.70
EVAPORATION IN GPM =  0.2986E+04 IN CFS =  0.6654E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.1916E+00
INLET TEMPERATURE = 51.90 PERCENT HUMIDITY = 36.50
EVAPORATION IN GPM =  0.3383E+04 IN CFS =  0.7537E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.2739E+00
INLET TEMPERATURE = 61.80 PERCENT HUMIDITY = 42.50
EVAPORATION IN GPM =  0.3677E+04 IN CFS =  0.8194E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.3683E+00
INLET TEMPERATURE = 70.40 PERCENT HUMIDITY = 25.70
EVAPORATION IN GPM =  0.3940E+04 IN CFS =  0.8779E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.5007E+00
INLET TEMPERATURE = 79.60 PERCENT HUMIDITY = 31.20
EVAPORATION IN GPM =  0.4216E+04 IN CFS =  0.9394E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.4343E+00
INLET TEMPERATURE = 75.30 PERCENT HUMIDITY = 32.00
EVAPORATION IN GPM =  0.4086E+04 IN CFS =  0.9104E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.3273E+00
INLET TEMPERATURE = 66.90 PERCENT HUMIDITY = 42.20
EVAPORATION IN GPM =  0.3830E+04 IN CFS =  0.8535E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.1866E+00
INLET TEMPERATURE = 51.20 PERCENT HUMIDITY = 35.00
EVAPORATION IN GPM =  0.3362E+04 IN CFS =  0.7491E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.1177E+00
INLET TEMPERATURE = 39.10 PERCENT HUMIDITY = 38.50
EVAPORATION IN GPM =  0.3000E+04 IN CFS =  0.6684E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.5053E+02  0.7214E-01
INLET TEMPERATURE = 27.60 PERCENT HUMIDITY = 41.70
EVAPORATION IN GPM =  0.2656E+04 IN CFS =  0.5917E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
AVERAGE EVAPORATION IN CFS =                      7.535
STOP
END OF TASK      0
```

```
     0.5053E+02  0.4999E-01
JAN  INLET TEMPERATURE = 21.70 PERCENT HUMIDITY = 68.20
     EVAPORATION IN GPM =  0.2912E+04 IN CFS =  0.6488E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.1138E+00
FEB  INLET TEMPERATURE = 38.20 PERCENT HUMIDITY = 60.50
     EVAPORATION IN GPM =  0.3403E+04 IN CFS =  0.7583E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.1160E+00
MAR  INLET TEMPERATURE = 38.70 PERCENT HUMIDITY = 45.70
     EVAPORATION IN GPM =  0.3421E+04 IN CFS =  0.7622E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.1916E+00
APR  INLET TEMPERATURE = 51.90 PERCENT HUMIDITY = 36.50
     EVAPORATION IN GPM =  0.3817E+04 IN CFS =  0.8505E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.2739E+00
MAY  INLET TEMPERATURE = 61.80 PERCENT HUMIDITY = 42.50
     EVAPORATION IN GPM =  0.4112E+04 IN CFS =  0.9162E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.3683E+00
JUNE INLET TEMPERATURE = 70.40 PERCENT HUMIDITY = 25.70
     EVAPORATION IN GPM =  0.4375E+04 IN CFS =  0.9748E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.5007E+00
JULY INLET TEMPERATURE = 79.60 PERCENT HUMIDITY = 31.20
     EVAPORATION IN GPM =  0.4651E+04 IN CFS =  0.1036E+02
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.4343E+00
AUG  INLET TEMPERATURE = 75.30 PERCENT HUMIDITY = 32.00
     EVAPORATION IN GPM =  0.4521E+04 IN CFS =  0.1007E+02
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.3273E+00
SEPT INLET TEMPERATURE = 66.90 PERCENT HUMIDITY = 42.20
     EVAPORATION IN GPM =  0.4265E+04 IN CFS =  0.9503E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.1866E+00
OCT  INLET TEMPERATURE = 51.20 PERCENT HUMIDITY = 35.00
     EVAPORATION IN GPM =  0.3797E+04 IN CFS =  0.8460E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.1177E+00
NOV  INLET TEMPERAT*
     INLET TEMPERATURE = 39.10 PERCENT HUMIDITY = 38.50
     EVAPORATION IN GPM =  0.3434E+04 IN CFS =  0.7652E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
      0.5053E+02  0.7214E-01
DEC  INLET TEMPERATURE = 27.60 PERCENT HUMIDITY = 41.70
     EVAPORATION IN GPM =  0.3090E+04 IN CFS =  0.6885E+01
     AIR FLOW IN CUBIC FEET PER HOUR =                0.1080E+10
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2000E+07
     HEAT LOAD IN BTU PER HOUR =                      0.2760E+10
     ATMOSPHERIC PRESSURE IN INCHES =                 0.2540E+02
     BASIN TEMPERATURE IN DEGREES F=                  0.8250E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
     AVERAGE EVAPORATION IN CFS =                     8.504
    STOP
```

HUNTINGTON STATION

CASE VI AIR OUTLET TEMPERATURE - 97°F

NAVAJO STATION PERFORMANCE TESTS - AUGUST 1975

PREDICTED EVAPORATION PER TEST

INLET TEMPERATURE = 90.00 PERCENT HUMIDITY = 21.00
EVAPORATION IN GPM = 0.3730E+04 IN CFS = 0.8311E+01
AIR FLOW IN POUNDS PER HOUR = 0.6000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1740E+07
HEAT LOAD IN BTU PER HOUR = 0.2040E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2560E+02
BASIN TEMPERATURE IN DEGREES F= 0.8260E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9480E+02

Test 1A

INLET TEMPERATURE = 90.00 PERCENT HUMIDITY = 21.00
EVAPORATION IN GPM = 0.3643E+04 IN CFS = 0.8118E+01
AIR FLOW IN POUNDS PER HOUR = 0.6200E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1290E+07
HEAT LOAD IN BTU PER HOUR = 0.2010E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2560E+02
BASIN TEMPERATURE IN DEGREES F= 0.8080E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9420E+02

Test 1B

INLET TEMPERATURE = 85.00 PERCENT HUMIDITY = 39.00
EVAPORATION IN GPM = 0.3661E+04 IN CFS = 0.8158E+01
AIR FLOW IN POUNDS PER HOUR = 0.6200E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1710E+07
HEAT LOAD IN BTU PER HOUR = 0.2040E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2560E+02
BASIN TEMPERATURE IN DEGREES F= 0.8130E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9200E+02

Test 2A

INLET TEMPERATURE = 85.00 PERCENT HUMIDITY = 39.00
EVAPORATION IN GPM = 0.3578E+04 IN CFS = 0.7972E+01
AIR FLOW IN POUNDS PER HOUR = 0.6300E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.2070E+07
HEAT LOAD IN BTU PER HOUR = 0.1980E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2560E+02
BASIN TEMPERATURE IN DEGREES F= 0.8030E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9200E+02

Test 2B

NORTH MAIN STATION
PERFORMANCE TEST DATA 1-6
JANUARY 21-26, 1960

Test

1 0.2806E+02 0.1773E+00
INLET TEMPERATURE = 49.90 PERCENT HUMIDITY = 78.00
EVAPORATION IN GPM = 0.2490E+03 IN CFS = 0.5549E+00
AIR FLOW IN POUNDS PER HOUR = 0.1900E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.2750E+06
HEAT LOAD IN BTU PER HOUR = 0.1930E+09
ATMOSPHERIC PRESSURE IN INCHES = 0.2970E+02
BASIN TEMPERATURE IN DEGREES F= 0.6000E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.6400E+02
0.2876E+02 0.2729E+00

2 INLET TEMPERATURE = 61.70 PERCENT HUMIDITY = 25.00
EVAPORATION IN GPM = 0.4301E+03 IN CFS = 0.9584E+00
AIR FLOW IN POUNDS PER HOUR = 0.1900E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.2540E+06
HEAT LOAD IN BTU PER HOUR = 0.2470E+09
ATMOSPHERIC PRESSURE IN INCHES = 0.2970E+02
BASIN TEMPERATURE IN DEGREES F= 0.6070E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.6600E+02
0.3406E+02 0.1645E+00

3 INLET TEMPERATURE = 47.80 PERCENT HUMIDITY = 70.00
EVAPORATION IN GPM = 0.4077E+03 IN CFS = 0.9085E+00
AIR FLOW IN POUNDS PER HOUR = 0.1900E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.2625E+06
HEAT LOAD IN BTU PER HOUR = 0.3230E+09
ATMOSPHERIC PRESSURE IN INCHES = 0.2970E+02
BASIN TEMPERATURE IN DEGREES F= 0.6600E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.7150E+02
0.4125E+02 0.1952E+00

4 INLET TEMPERATURE = 52.40 PERCENT HUMIDITY = 90.00
EVAPORATION IN GPM = 0.5093E+03 IN CFS = 0.1135E+01
AIR FLOW IN POUNDS PER HOUR = 0.1900E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.2541E+06
HEAT LOAD IN BTU PER HOUR = 0.3870E+09
ATMOSPHERIC PRESSURE IN INCHES = 0.2970E+02
BASIN TEMPERATURE IN DEGREES F= 0.7320E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.7800E+02
0.4554E+02 0.2435E+00

5 INLET TEMPERATURE = 58.50 PERCENT HUMIDITY = 80.00
EVAPORATION IN GPM = 0.6418E+03 IN CFS = 0.1430E+01
AIR FLOW IN POUNDS PER HOUR = 0.1900E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.3216E+06
HEAT LOAD IN BTU PER HOUR = 0.4560E+09
ATMOSPHERIC PRESSURE IN INCHES = 0.2970E+02
BASIN TEMPERATURE IN DEGREES F= 0.7750E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.8400E+02
0.5053E+02 0.3204E+00

6 INLET TEMPERATURE = 66.30 PERCENT HUMIDITY = 68.00
EVAPORATION IN GPM = 0.7732E+03 IN CFS = 0.1723E+01
AIR FLOW IN POUNDS PER HOUR = 0.1900E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.3549E+06
HEAT LOAD IN BTU PER HOUR = 0.5250E+09
ATMOSPHERIC PRESSURE IN INCHES = 0.2970E+02
BASIN TEMPERATURE IN DEGREES F= 0.8250E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9150E+02
AVERAGE EVAPORATION IN CFS = 1.363

NORTH MAIN STATION
SYNTHESIZED FULL LOAD RUN

```
Test No.
 3 INLET TEMPERATURE = 49.90 PERCENT HUMIDITY = 78.00
   EVAPORATION IN GPM =  0.6887E+03 IN CFS =  0.1535E+01
   AIR FLOW IN POUNDS PER HOUR =                  0.1700E+08
   MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3550E+06
   HEAT LOAD IN BTU PER HOUR =                    0.5250E+09
   ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
   BASIN TEMPERATURE IN DEGREES F=                0.6930E+02
   AIR OUTLET TEMPERATURE IN DEGREES F =          0.8850E+02
    0.3585E+02  0.2729E+00
 1 INLET TEMPERATURE = 61.70 PERCENT HUMIDITY = 25.00
   EVAPORATION IN GPM =  0.7812E+03 IN CFS =  0.1741E+01
   AIR FLOW IN POUNDS PER HOUR =                  0.1700E+08
   MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3550E+06
   HEAT LOAD IN BTU PER HOUR =                    0.5250E+09
   ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
   BASIN TEMPERATURE IN DEGREES F=                0.6780E+02
   AIR OUTLET TEMPERATURE IN DEGREES F =          0.8800E+02
    0.3585E+02  0.1645E+00
 2 INLET TEMPERATURE = 47.80 PERCENT HUMIDITY = 70.00
   EVAPORATION IN GPM =  0.6765E+03 IN CFS =  0.1507E+01
   AIR FLOW IN POUNDS PER HOUR =                  0.1700E+08
   MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3550E+06
   HEAT LOAD IN BTU PER HOUR =                    0.5250E+09
   ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
   BASIN TEMPERATURE IN DEGREES F=                0.6780E+02
   AIR OUTLET TEMPERATURE IN DEGREES F =          0.8800E+02
    0.4205E+02  0.1952E+00
 4 INLET TEMPERATURE = 52.40 PERCENT HUMIDITY = 90.00
   EVAPORATION IN GPM =  0.6902E+03 IN CFS =  0.1538E+01
   AIR FLOW IN POUNDS PER HOUR =                  0.1700E+08
   MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3550E+06
   HEAT LOAD IN BTU PER HOUR =                    0.5250E+09
   ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
   BASIN TEMPERATURE IN DEGREES F=                0.7400E+02
   AIR OUTLET TEMPERATURE IN DEGREES F =          0.9100E+02
    0.4644E+02  0.2435E+00
 5 INLET TEMPERATURE = 58.50 PERCENT HUMIDITY = 80.00
   EVAPORATION IN GPM =  0.7229E+03 IN CFS =  0.1611E+01
   AIR FLOW IN POUNDS PER HOUR =                  0.1700E+08
   MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3550E+06
   HEAT LOAD IN BTU PER HOUR =                    0.5250E+09
   ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
   BASIN TEMPERATURE IN DEGREES F=                0.7840E+02
   AIR OUTLET TEMPERATURE IN DEGREES F =          0.9300E+02
    0.5053E+02  0.3204E+00
 6 INLET TEMPERATURE = 66.30 PERCENT HUMIDITY = 68.00
   EVAPORATION IN GPM =  0.7681E+03 IN CFS =  0.1711E+01
   AIR FLOW IN POUNDS PER HOUR =                  0.1700E+08
   MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3550E+06
   HEAT LOAD IN BTU PER HOUR =                    0.5250E+09
   ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
   BASIN TEMPERATURE IN DEGREES F=                0.8250E+02
   AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
```

PERMIAN STATION
PERFORMANCE TEST
(ASSUMED 100% LOAD)

```
INLET TEMPERATURE = 80.60 PERCENT HUMIDITY = 54.00
EVAPORATION IN GPM =  0.8127E+03 IN CFS =  0.1811E+01
AIR FLOW IN POUNDS PER HOUR =                     0.1800E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.3520E+06
HEAT LOAD IN BTU PER HOUR =                       0.4800E+09
ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
BASIN TEMPERATURE IN DEGREES F=                   0.8380E+02
AIR OUTLET TEMPERATURE IN DEGREES F =             0.9200E+02
 0.5183E+02  0.5175E+00
```

NEWMAN STATION
UNITS #1, #2, #3

RIO GRANDE STATION
UNITS #6, #7, #8

```
 0.4804E+02  0.4868E+00
INLET TEMPERATURE = 78.70 PERCENT HUMIDITY = 43.25
EVAPORATION IN GPM =  0.9728E+03 IN CFS =  0.2168E+01
AIR FLOW IN POUNDS PER HOUR =                    0.1000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.7899E+06
HEAT LOAD IN BTU PER HOUR =                      0.5640E+09
ATMOSPHERIC PRESSURE IN INCHES =                 0.2610E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.1045E+03
 0.4804E+02  0.4868E+00
INLET TEMPERATURE = 78.70 PERCENT HUMIDITY = 43.25
EVAPORATION IN GPM =  0.1033E+04 IN CFS =  0.2302E+01
AIR FLOW IN POUNDS PER HOUR =                    0.1300E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.7419E+06
HEAT LOAD IN BTU PER HOUR =                      0.5930E+09
ATMOSPHERIC PRESSURE IN INCHES =                 0.2610E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.4804E+02  0.4868E+00
INLET TEMPERATURE = 78.70 PERCENT HUMIDITY = 43.25
EVAPORATION IN GPM =  0.1196E+04 IN CFS =  0.2665E+01
AIR FLOW IN POUNDS PER HOUR =                    0.1800E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.8359E+06
HEAT LOAD IN BTU PER HOUR =                      0.7010E+09
ATMOSPHERIC PRESSURE IN INCHES =                 0.2610E+02
BASIN TEMPERATURE IN DEGREES F=                  0.8000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
 0.4304E+02  0.5478E+00
INLET TEMPERATURE = 82.30 PERCENT HUMIDITY = 44.75
EVAPORATION IN GPM =  0.6441E+03 IN CFS =  0.1435E+01
AIR FLOW IN POUNDS PER HOUR =                    0.1500E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.2500E+06
HEAT LOAD IN BTU PER HOUR =                      0.3570E+09
ATMOSPHERIC PRESSURE IN INCHES =                 0.2610E+02
BASIN TEMPERATURE IN DEGREES F=                  0.7500E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.8600E+02
 0.4304E+02  0.5478E+00
INLET TEMPERATURE = 82.30 PERCENT HUMIDITY = 44.75
EVAPORATION IN GPM =  0.5615E+03 IN CFS =  0.1251E+01
AIR FLOW IN POUNDS PER HOUR =                    0.1300E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.3040E+06
HEAT LOAD IN BTU PER HOUR =                      0.3240E+09
ATMOSPHERIC PRESSURE IN INCHES =                 0.2610E+02
BASIN TEMPERATURE IN DEGREES F=                  0.7500E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9100E+02
 0.4304E+02  0.5478E+00
INLET TEMPERATURE = 82.30 PERCENT HUMIDITY = 44.75
EVAPORATION IN GPM =  0.1715E+04 IN CFS =  0.3821E+01
AIR FLOW IN POUNDS PER HOUR =                    0.3800E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR -          0.8134E+06
HEAT LOAD IN BTU PER HOUR =                      0.1020E+09
ATMOSPHERIC PRESSURE IN INCHES =                 0.2610E+02
BASIN TEMPERATURE IN DEGREES F=                  0.7500E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9400E+02
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     0.5303E+02   0.1203E+00
JAN  INLET TEMPERATURE = 30.70 PERCENT HUMIDITY = 68.00
     EVAPORATION IN GPM =   0.1698E+04 IN CFS =   0.3784E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.3800E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.3091E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1304E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.8500E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.8200E+02
     0.5103E+02   0.1959E+00
FEB  INLET TEMPERATURE = 52.50 PERCENT HUMIDITY = 68.50
     EVAPORATION IN GPM =   0.1727E+04 IN CFS =   0.3849E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.4400E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.2791E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1304E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.8300E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.8700E+02
     0.5702E+02   0.2266E+00
MAR  INLET TEMPERATURE = 56.50 PERCENT HUMIDITY = 67.00
     EVAPORATION IN GPM =   0.2016E+04 IN CFS =   0.4493E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.7000E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.3791E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1449E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.8900E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.7800E+02
     0.5902E+02   0.2670E+00
APR  INLET TEMPERATURE = 61.10 PERCENT HUMIDITY = 63.50
     EVAPORATION IN GPM =   0.1902E+04 IN CFS =   0.4237E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.7000E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.2910E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1304E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9100E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.7750E+02
     0.5602E+02   0.3015E+00
MAY  INLET TEMPERATURE = 64.60 PERCENT HUMIDITY = 68.70
     EVAPORATION IN GPM =   0.2038E*
     EVAPORATION IN GPM =   0.2038E+04 IN CFS =   0.4540E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.8000E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.2916E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1352E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.8800E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.7750E+02
     0.6001E+02   0.4216E+00
JUNE INLET TEMPERATURE = 74.40 PERCENT HUMIDITY = 72.50
     EVAPORATION IN GPM =   0.2252E+04 IN CFS =   0.5018E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.7800E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.3580E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1449E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9200E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.8650E+02
     0.6500E+02   0.5104E+00
JULY INLET TEMPERATURE = 80.20 PERCENT HUMIDITY = 69.50
     EVAPORATION IN GPM =   0.2517E+04 IN CFS =   0.5608E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.7800E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.4430E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1546E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9700E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.9000E+02
     0.6600E+02   0.4868E+00
AUG  INLET TEMPERATURE = 78.70 PERCENT HUMIDITY = 69.50
     EVAPORATION IN GPM =   0.2572E+04 IN CFS =   0.5730E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.7200E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.4270E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1546E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9800E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.8770E+02
     0.6401E+02   0.3909E+00
SEP  INLET TEMPERATURE = 72.10 PERCENT HUMIDITY = 72.50
     EVAPORATION IN GPM =   0.1971E+04 IN CFS =   0.4391E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.5200E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.3570E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1304E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9600E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.9100E+02
     0.6001E+02   0.2375E+00
OCT  INLET TEMPERATURE = 57.80 PERCENT HUMIDITY = 64.00
     EVAPORATION IN GPM =   0.1823E+04 IN CFS =   0.4062E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.5000E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.2370E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1352E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9200E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.8770E+02
     0.5902E+02   0.1520E+00
NOV  INLET TEMPERATURE = 45.90 PERCENT HUMIDITY = 58.70
     EVAPORATION IN GPM =   0.1745E+04 IN CFS =   0.3889E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.4900E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.4520E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1304E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9100E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.7750E+02
     0.6001E+02   0.1314E+00
DEC  INLET TEMPERATURE = 41.90 PERCENT HUMIDITY = 55.00
     EVAPORATION IN GPM =   0.1866E+04 IN CFS =   0.4158E+01
     AIR FLOW IN POUNDS PER HOUR =                 0.5300E+08
     MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.5120E+06
     HEAT LOAD IN BTU PER HOUR =                   0.1401E+10
     ATMOSPHERIC PRESSURE IN INCHES =              0.2970E+02
     BASIN TEMPERATURE IN DEGREES F=               0.9200E+02
     AIR OUTLET TEMPERATURE IN DEGREES F =         0.7400E+02
     AVERAGE EVAPORATION IN CFS =                  4.480
     STOP
     END OF TASK
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COUCH PLANT

MONTHLY EVAPORATION - 1976

```
    0.5103E+02  0.1195E+00
JAN INLET TEMPERATURE = 39.50 PERCENT HUMIDITY = 60.50
    EVAPORATION IN GPM =  0.1875E+04 IN CFS =  0.4178E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4199E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1021E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8300E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.4300E+02
    0.4504E+02  0.2053E+00
FEB INLET TEMPERATURE = 53.80 PERCENT HUMIDITY = 59.00
    EVAPORATION IN GPM =  0.1976E+04 IN CFS =  0.4403E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4791E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1096E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.7700E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.5900E+02
    0.4704E+02  0.2435E+00
MAR INLET TEMPERATURE = 58.50 PERCENT HUMIDITY = 61.00
    EVAPORATION IN GPM =  0.2420E+04 IN CFS =  0.5391E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4999E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1323E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.7900E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.6200E+02
    0.5003E+02  0.2916E+00
APR INLET TEMPERATURE = 63.60 PERCENT HUMIDITY = 55.50
    EVAPORATION IN GPM =  0.2067E+04 IN CFS =  0.4605E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5899E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1126E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8200E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.6700E+02
    0.4804E+02  0.3123E+00
MAY INLET TEMPERATURE = 65.60 PERCENT HUMIDITY = 62.00
    EVAPORATION IN GPM =  0.1871E+04 IN CFS =  0.4169E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5532E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1058E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8000E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.7300E+02
    0.5303E+02  0.4513E+00
JUNE INLET TEMPERATURE = 76.40 PERCENT HUMIDITY = 65.00
    EVAPORATION IN GPM =  0.1949E+04 IN CFS =  0.4342E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5524E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1096E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8500E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.8300E+02
    0.5502E+02  0.5335E+00
JULY INLET TEMPERATURE = 81.50 PERCENT HUMIDITY = 62.50
    EVAPORATION IN GPM =  0.1853E+04 IN CFS =  0.4130E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.6824E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1028E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8700E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.8700E+02
    0.5303E+02  0.4898E+00
AUG INLET TEMPERATURE = 78.90 PERCENT HUMIDITY = 60.20
    EVAPORATION IN GPM =  0.1889E+04 IN CFS =  0.4210E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.6582E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1028E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8500E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.8200E+02
    0.5203E+02  0.4030E+00
SEPT INLET TEMPERATURE = 73.00 PERCENT HUMIDITY = 69.00
    EVAPORATION IN GPM =  0.1836E+04 IN CFS =  0.4091E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5499E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1028E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8400E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.7900E+02
    0.5103E+02  0.2468E+00
OCT INLET TEMPERATURE = 58.90 PERCENT HUMIDITY = 63.20
    EVAPORATION IN GPM =  0.2018E+04 IN CFS =  0.4496E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3274E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1134E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.8300E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.6500E+02
    0.4005E+02  0.1505E+00
NOV INLET TEMPERATURE = 45.50 PERCENT HUMIDITY = 57.70
    EVAPORATION IN GPM =  0.1839E+04 IN CFS =  0.4099E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3316E+06
    HEAT LOAD IN BTU PER HOUR =                    0.1021E+10
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.7200E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.5000E+02
    0.4504E+02  0.1314E+00
DEC INLET TEMPERATURE = 41.90 PERCENT HUMIDITY = 59.70
    EVAPORATION IN GPM =  0.1766E+04 IN CFS =  0.3934E+01
    AIR FLOW IN CUBIC FEET PER HOUR =              0.5330E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5716E+06
    HEAT LOAD IN BTU PER HOUR =                    0.9374E+09
    ATMOSPHERIC PRESSURE IN INCHES =               0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                0.7700E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =          0.4300E+02
    AVERAGE EVAPORATION IN CFS =                    4.337
    STOP
    END OF TASK      0
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MOSES STATION - 1976

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JAN INLET TEMPERATURE = 39.70 PERCENT HUMIDITY = 68.00
    EVAPORATION IN GPM =  0.3730E+04 IN CFS =  0.8312E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.7066E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2146E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.7800E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.5300E+02
     0.5103E+02  0.1959E+00
FEB INLET TEMPERATURE = 52.50 PERCENT HUMIDITY = 68.50
    EVAPORATION IN GPM =  0.3718E+04 IN CFS =  0.8284E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.4874E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2160E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.8300E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.6600E+02
     0.5702E+02  0.2266E+00
MAR INLET TEMPERATURE = 56.50 PERCENT HUMIDITY = 67.00
    EVAPORATION IN GPM =  0.3701E+04 IN CFS =  0.8247E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.7257E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2088E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.8900E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.6600E+02
     0.4604E+02  0.2670E+00
APR INLET TEMPERATURE = 61.10 PERCENT HUMIDITY = 63.50
    EVAPORATION IN GPM =  0.3967E+04 IN CFS =  0.8838E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.5707E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2232E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.7800E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.6900E+02
     0.4304E+02  0.3015E+00
MAY INLET TEMPERATURE = 64.60 PERCENT HUMIDITY = 68.70
    EVAPORATION IN GPM =  0.3495E+04 IN CFS =  0.7787E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.6141E+06
    HEAT LOAD IN BTU PER HOUR =                       0.1958E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.7500E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.7100E+02
     0.5403E+02  0.4216E+00
JUNE INLET TEMPERATURE = 74.40 PERCENT HUMIDITY = 72.50
    EVAPORATION IN GPM =  0.4092E+04 IN CFS =  0.9119E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.5957E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2304E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.8600E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.8200E+02
     0.5203E+02  0.5104E+00
JULY INLET TEMPERATURE = 80.20 PERCENT HUMIDITY = 69.50
    EVAPORATION IN GPM =  0.3752E+04 IN CFS =  0.8359E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.5924E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2088E:10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.8400E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.8500E+02
     0.5103E+02  0.4868E+00
AUG INLET TEMPERATURE = 78.70 PERCENT HUMIDITY = 60.50
    EVAPORATION IN GPM =  0.3759E+04 IN CFS =  0.8375E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.5249E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2088E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.8300E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.8300E+02
     0.4704E+02  0.3909E+00
SEPT INLET TEMPERATURE = 72.10 PERCENT HUMIDITY = 72.50
    EVAPORATION IN GPM =  0.3636E+04 IN CFS =  0.8101E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.5183E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2088E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.7900E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.8200E+02
     0.4804E+02  0.2375E+00
OCT INLET TEMPERATURE = 57.80 PERCENT HUMIDITY = 64.00
    EVAPORATION IN GPM =  0.3745E+04 IN CFS =  0.8345E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.5266E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2088E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.8000E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.6400E+02
     0.4804E+02  0.1529E+00
NOV INLET TEMPERATURE = 45.90 PERCENT HUMIDITY = 58.70
    EVAPORATION IN GPM =  0.3829E+04 IN CFS =  0.8532E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.7191E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2088E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.8000E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.5000E+02
     0.3705E+02  0.1314E+00
DEC INLET TEMPERATURE = 41.90 PERCENT HUMIDITY = 55.00
    EVAPORATION IN GPM =  0.4230E+04 IN CFS =  0.9426E+01
    AIR FLOW IN CUBIC FEET PER HOUR =                 0.7500E+09
    MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.5324E+06
    HEAT LOAD IN BTU PER HOUR =                       0.2304E+10
    ATMOSPHERIC PRESSURE IN INCHES =                  0.2970E+02
    BASIN TEMPERATURE IN DEGREES F=                   0.6900E+02
    AIR OUTLET TEMPERATURE IN DEGREES F =             0.4500E+02
    AVERAGE EVAPORATION IN CFS =                      8.477
```

LINCH PLANT
MONTHLY EVAPORATION

CLAY BOSWELL UNIT 3
DAILY PREDICTED VALUES
JANUARY 1-12, 1977

```
 0.8027E+01 -0.1269E-01
INLET TEMPERATURE =  5.00 PERCENT HUMIDITY = 67.00
EVAPORATION IN GPM =  0.1545E+04 IN CFS =  0.3443E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1710E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6600E+02
 0.8027E+01  0.9530E-02
INLET TEMPERATURE = 11.00 PERCENT HUMIDITY = 83.00
EVAPORATION IN GPM =  0.1636E+04 IN CFS =  0.3644E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1820E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.7100E+02
 DATA BAD ON  30177
 DATA BAD ON  40177
 DATA BAD ON  50177
 0.9030E+01 -0.1644E-01
INLET TEMPERATURE =  4.00 PERCENT HUMIDITY = 60.00
EVAPORATION IN GPM =  0.1613E+04 IN CFS =  0.3594E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1820E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4100E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6700E+02
 0.9030E+01 -0.6148E-01
INLET TEMPERATURE = -8.00 PERCENT HUMIDITY = 85.00
EVAPORATION IN GPM =  0.1273E+04 IN CFS =  0.2836E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1820E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4100E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6200E+02
 DATA BAD ON  80177
 DATA BAD ON  90177
 0.7524E+01 -0.6148E-01
INLET TEMPERATURE = -8.00 PERCENT HUMIDITY = 52.00
EVAPORATION IN GPM =  0.1064E+04 IN CFS =  0.2371E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1630E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.3950E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.5200E+02
 DATA BAD ON 110177
 DATA BAD ON 120177
 0.9030E+01 -0.2770E-01
```

```
INLET TEMPERATURE = [illegible] PERCENT HUMIDITY = [illegible]
EVAPORATION IN GPM =  0.1625E+04 IN CFS =  0.3620E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1750E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4100E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6300E+02
 DATA BAD ON 140177
 DATA BAD ON 150177
 DATA BAD ON 160177
 DATA BAD ON 170177
 0.8027E+01 -0.8936E-02
```

```
INLET TEMPERATURE =  6.00 PERCENT HUMIDITY = [illegible]
EVAPORATION IN GPM =  0.1476E+04 IN CFS =  0.3288E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1720E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6200E+02
 0.8529E+01 -0.1644E-01
```

```
INLET TEMPERATURE =  4.00 PERCENT HUMIDITY = 72.00
EVAPORATION IN GPM =  0.1331E+04 IN CFS =  0.2966E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1500E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4050E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.5700E+02
 0.9532E+01  0.3235E-01
```

```
INLET TEMPERATURE = 17.00 PERCENT HUMIDITY = 76.00
EVAPORATION IN GPM =  0.1466E+04 IN CFS =  0.3265E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1600E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4150E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6400E+02
 0.1003E+02 -0.5183E-02
```

```
INLET TEMPERATURE =  7.00 PERCENT HUMIDITY = [illegible]
EVAPORATION IN GPM =  0.1395E+04 IN CFS =  0.3108E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1620E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4200E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6300E+02
 0.1003E+02 -0.5183E-02
```

```
INLET TEMPERATURE =  7.00 PERCENT HUMIDITY = [illegible]
EVAPORATION IN GPM =  0.1635E+04 IN CFS =  0.3643E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1630E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.4200E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.6300E+02
 0.1003E+02  0.5112E-01
```

CLAY BOSWELL UNIT 3 (cont'd)

JANUARY 23-31, 1977

INLET TEMPERATURE = 22.00 PERCENT HUMIDITY = 82.00
EVAPORATION IN GPM = 0.1806E+04 IN CFS = 0.4023E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1650E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.4200E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.7300E+02
0.1003E+02 0.5487E-01

INLET TEMPERATURE = 23.00 PERCENT HUMIDITY = 80.00
EVAPORATION IN GPM = 0.1690E+04 IN CFS = 0.3766E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1560E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.4200E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.7200E+02
DATA BAD ON 250177
0.9030E+01 -0.1644E-01

INLET TEMPERATURE = 4.00 PERCENT HUMIDITY = 59.00
EVAPORATION IN GPM = 0.1295E+04 IN CFS = 0.2886E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1650E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.4100E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.6100E+02
DATA BAD ON 270177
DATA BAD ON 280177
0.8027E+01 -0.3521E-01

INLET TEMPERATURE = -1.00 PERCENT HUMIDITY = 60.00
EVAPORATION IN GPM = 0.1353E+04 IN CFS = 0.3014E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1660E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.4000E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.6500E+02
0.8529E+01 -0.2020E-01

INLET TEMPERATURE = 3.00 PERCENT HUMIDITY = 60.00
EVAPORATION IN GPM = 0.1394E+04 IN CFS = 0.3105E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1670E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.4050E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.6700E+02
DATA BAD ON 310177
AVERAGE EVAPORATION IN CFS = 3.286

CLAY BOSWELL UNIT 3
DAILY PREDICTED EVAPORATION
AUGUST 1-6, 1977

INLET TEMPERATURE = 59.00 PERCENT HUMIDITY = 45.00
EVAPORATION IN GPM = 0.2197E+04 IN CFS = 0.4894E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1520E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.7200E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.8500E+02
0.4005E+02 0.2392E+00

INLET TEMPERATURE = 58.00 PERCENT HUMIDITY = 45.00
EVAPORATION IN GPM = 0.2463E+04 IN CFS = 0.5488E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1720E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.7200E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9100E+02
0.4055E+02 0.2561E+00

INLET TEMPERATURE = 60.00 PERCENT HUMIDITY = 48.00
EVAPORATION IN GPM = 0.2300E+04 IN CFS = 0.5125E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1650E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.7250E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9100E+02
0.4055E+02 0.2660E+00

INLET TEMPERATURE = 61.00 PERCENT HUMIDITY = 50.00
EVAPORATION IN GPM = 0.2403E+04 IN CFS = 0.5355E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1670E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.7250E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9200E+02
0.4005E+02 0.2561E+00

INLET TEMPERATURE = 60.00 PERCENT HUMIDITY = 45.00
EVAPORATION IN GPM = 0.2045E+04 IN CFS = 0.4557E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1600E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.7200E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9100E+02
0.4005E+02 0.2956E+00

INLET TEMPERATURE = 64.00 PERCENT HUMIDITY = 37.00
EVAPORATION IN GPM = 0.2503E+04 IN CFS = 0.5577E+01
AIR FLOW IN CUBIC FEET PER HOUR = 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR = 0.1310E+07
HEAT LOAD IN BTU PER HOUR = 0.1700E+10
ATMOSPHERIC PRESSURE IN INCHES = 0.2840E+02
BASIN TEMPERATURE IN DEGREES F= 0.7200E+02
AIR OUTLET TEMPERATURE IN DEGREES F = 0.9200E+02
0.4055E+02 0.3054E+00

CLAY BOSWELL UNIT 3 (cont'd)
AUGUST 7-12, 1977

```
INLET TEMPERATURE = 65.00 PERCENT HUMIDITY = 46.00
EVAPORATION IN GPM =  0.2356E+04 IN CFS =  0.5250E+01
AIR FLOW IN CUBIC FEET PER HOUR =                 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.1310E+07
HEAT LOAD IN BTU PER HOUR =                       0.1620E+10
ATMOSPHERIC PRESSURE IN INCHES =                  0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                   0.7250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =             0.9300E+02
 0.4055E+02  0.2857E+00
```

```
INLET TEMPERATURE = 63.00 PERCENT HUMIDITY = 45.00
EVAPORATION IN GPM =  0.2286E+04 IN CFS =  0.5093E+01
AIR FLOW IN CUBIC FEET PER HOUR =                 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.1310E+07
HEAT LOAD IN BTU PER HOUR =                       0.1600E+10
ATMOSPHERIC PRESSURE IN INCHES =                  0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                   0.7250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =             0.9100E+02
 0.4055E+02  0.3284E+00
```

```
INLET TEMPERATURE = 67.00 PERCENT HUMIDITY = 43.00
EVAPORATION IN GPM =  0.2289E+04 IN CFS =  0.5100E+01
AIR FLOW IN CUBIC FEET PER HOUR =                 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.1310E+07
HEAT LOAD IN BTU PER HOUR =                       0.1540E+10
ATMOSPHERIC PRESSURE IN INCHES =                  0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                   0.7250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =             0.9100E+02
 0.4055E+02  0.2561E+00
```

```
INLET TEMPERATURE = 60.00 PERCENT HUMIDITY = 40.00
EVAPORATION IN GPM =  0.2259E+04 IN CFS =  0.5032E+01
AIR FLOW IN CUBIC FEET PER HOUR =                 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.1310E+07
HEAT LOAD IN BTU PER HOUR =                       0.1590E+10
ATMOSPHERIC PRESSURE IN INCHES =                  0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                   0.7250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =             0.9000E+02
 0.4055E+02  0.2660E+00
```

```
INLET TEMPERATURE = 61.00 PERCENT HUMIDITY = 35.00
EVAPORATION IN GPM =  0.2249E+04 IN CFS =  0.5011E+01
AIR FLOW IN CUBIC FEET PER HOUR =                 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.1310E+07
HEAT LOAD IN BTU PER HOUR =                       0.1550E+10
ATMOSPHERIC PRESSURE IN INCHES =                  0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                   0.7250E+02
AIR OUTLET TEMPERATURE IN DEGREES F =             0.8800E+02
 0.3955E+02  0.2660E+00
```

```
INLET TEMPERATURE = 61.00 PERCENT HUMIDITY = 41.00
EVAPORATION IN GPM =  0.2123E+04 IN CFS =  0.4731E+01
AIR FLOW IN CUBIC FEET PER HOUR =                 0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.1310E+07
HEAT LOAD IN BTU PER HOUR =                       0.1490E+10
ATMOSPHERIC PRESSURE IN INCHES =                  0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                   0.7150E+02
AIR OUTLET TEMPERATURE IN DEGREES F =             0.8900E+02
 0.4005E+02  0.2067E+00
```

```
INLET TEMPERATURE = 54.00 PERCENT HUMIDITY = 48.00
EVAPORATION IN GPM =  0.2275E+04 IN CFS =  0.5069E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.1310E+07
HEAT LOAD IN BTU PER HOUR =                    0.1660E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                0.7200E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.8800E+02
 0.3805E+02  0.2308E+00
```

```
INLET TEMPERATURE = 57.00 PERCENT HUMIDITY = 41.00
EVAPORATION IN GPM =  0.2090E+04 IN CFS =  0.4657E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.1310E+07
HEAT LOAD IN BTU PER HOUR =                    0.1480E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                0.7000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9100E+02
 DATA BAD ON 150877
 DATA BAD ON 160877
 DATA BAD ON 170877
 0.3605E+02  0.2224E+00
```

```
INLET TEMPERATURE = 56.00 PERCENT HUMIDITY = 40.00
EVAPORATION IN GPM =  0.2129E+04 IN CFS =  0.4745E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.1310E+07
HEAT LOAD IN BTU PER HOUR =                    0.1550E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                0.6800E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.8800E+02
 0.3605E+02  0.2308E+00
```

```
INLET TEMPERATURE = 57.00 PERCENT HUMIDITY = 41.00
EVAPORATION IN GPM =  0.2436E+04 IN CFS =  0.5428E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.1310E+07
HEAT LOAD IN BTU PER HOUR =                    0.1820E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                0.6800E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.8900E+02
 0.3705E+02  0.2857E+00
```

```
INLET TEMPERATURE = 63.00 PERCENT HUMIDITY = 46.00
EVAPORATION IN GPM =  0.2127E+04 IN CFS =  0.4739E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.1310E+07
HEAT LOAD IN BTU PER HOUR =                    0.1470E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                0.6900E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9000E+02
 0.3705E+02  0.2758E+00
```

```
INLET TEMPERATURE = 62.00 PERCENT HUMIDITY = 42.00
EVAPORATION IN GPM =  0.1861E+04 IN CFS =  0.4146E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.1310E+07
HEAT LOAD IN BTU PER HOUR =                    0.1290E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                0.6900E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.8700E+02
 0.3705E+02  0.2477E+00
```

CLAY BOSWELL UNIT 3 (cont'd)
AUGUST 22-31, 1977

```
INLET TEMPERATURE = 59.00 PERCENT HUMIDITY = 38.00
EVAPORATION IN GPM =  0.2252E+04 IN CFS =  0.5017E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1590E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.6900E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.8900E+02
 0.3605E+02  0.1852E+00
INLET TEMPERATURE = 51.00 PERCENT HUMIDITY = 40.00
EVAPORATION IN GPM =  0.2214E+04 IN CFS =  0.4933E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1690E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.6800E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.9000E+02
 0.3505E+02  0.1995E+00
INLET TEMPERATURE = 53.00 PERCENT HUMIDITY = 40.00
EVAPORATION IN GPM =  0.2123E+04 IN CFS =  0.4730E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1600E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.6700E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.8500E+02
 0.3406E+02  0.2392E+00
INLET TEMPERATURE = 58.00 PERCENT HUMIDITY = 44.00
EVAPORATION IN GPM =  0.1847E+04 IN CFS =  0.4116E+01
AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.1310E+07
HEAT LOAD IN BTU PER HOUR =                      0.1400E+10
ATMOSPHERIC PRESSURE IN INCHES =                 0.2840E+02
BASIN TEMPERATURE IN DEGREES F=                  0.6600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =            0.8900E+02
 DATA BAD ON 260877
 DATA BAD ON 270877
 DATA BAD ON 280877
 DATA BAD ON 290877
 DATA BAD ON 300877
 DATA BAD ON 310877
AVERAGE EVAPORATION IN CFS =                       4.945
```

HOMER CITY STATION
DAILY MODEL PREDICTIONS
JANUARY 1-8, 1977

```
 0.3406E+02  0.6077E-02
INLET TEMPERATURE = 10.00 PERCENT HUMIDITY = 60.00
EVAPORATION IN GPM =  0.2677E+04 IN CFS =  0.5964E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4200E+07
HEAT LOAD IN BTU PER HOUR =                    0.2140E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9400E+02
 0.3406E+02  0.2860E-01
INLET TEMPERATURE = 16.00 PERCENT HUMIDITY = 48.00
EVAPORATION IN GPM =  0.2743E+04 IN CFS =  0.6112E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4200E+07
HEAT LOAD IN BTU PER HOUR =                    0.2140E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9600E+02
 0.3505E+02  0.4361E-01
INLET TEMPERATURE = 20.00 PERCENT HUMIDITY = 52.00
EVAPORATION IN GPM =  0.2915E+04 IN CFS =  0.6496E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4000E+07
HEAT LOAD IN BTU PER HOUR =                    0.2200E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6700E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9600E+02
 0.3006E+02  0.6238E-01
INLET TEMPERATURE = 25.00 PERCENT HUMIDITY = 68.00
EVAPORATION IN GPM =  0.2898E+04 IN CFS =  0.6456E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4100E+07
HEAT LOAD IN BTU PER HOUR =                    0.2150E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6200E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.2806E+02  0.5112E-01
INLET TEMPERATURE = 22.00 PERCENT HUMIDITY = 56.00
EVAPORATION IN GPM =  0.6213E+04 IN CFS =  0.1384E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4400E+07
HEAT LOAD IN BTU PER HOUR =                    0.4710E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.3106E+02  0.6238E-01
INLET TEMPERATURE = 25.00 PERCENT HUMIDITY = 60.00
EVAPORATION IN GPM =  0.5452E+04 IN CFS =  0.1215E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4400E+07
HEAT LOAD IN BTU PER HOUR =                    0.4220E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.2706E+02  0.4736E-01
INLET TEMPERATURE = 21.00 PERCENT HUMIDITY = 59.00
EVAPORATION IN GPM =  0.6106E+04 IN CFS =  0.1361E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5300E+07
HEAT LOAD IN BTU PER HOUR =                    0.4650E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.5900E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.3306E+02  0.2109E-01
INLET TEMPERATURE = 14.00 PERCENT HUMIDITY = 50.00
EVAPORATION IN GPM =  0.5065E+04 IN CFS =  0.1129E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5100E+07
HEAT LOAD IN BTU PER HOUR =                    0.4000E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6500E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.8600E+02
 0.3805E+02  0.3996E-01
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 0.2706E+02  0.2484E-01
INLET TEMPERATURE = 15.00 PERCENT HUMIDITY = 55.00
EVAPORATION IN GPM =  0.3549E+04 IN CFS =  0.7907E+01
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.5800E+07
HEAT LOAD IN BTU PER HOUR =                   0.2570E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.5900E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9500E+02
 0.2806E+02  0.2109E-01
INLET TEMPERATURE = 14.00 PERCENT HUMIDITY = 50.00
EVAPORATION IN GPM =  0.3710E+04 IN CFS =  0.8267E+01
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.4800E+07
HEAT LOAD IN BTU PER HOUR =                   0.2670E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.6000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9300E+02
 0.2706E+02  0.6988E-01
INLET TEMPERATURE = 27.00 PERCENT HUMIDITY = 53.00
EVAPORATION IN GPM =  0.3884E+04 IN CFS =  0.8654E+01
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.5100E+07
HEAT LOAD IN BTU PER HOUR =                   0.2660E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.5900E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9500E+02
 0.3006E+02  0.6988E-01
INLET TEMPERATURE = 27.00 PERCENT HUMIDITY = 68.00
EVAPORATION IN GPM =  0.3773E+04 IN CFS =  0.8407E+01
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.3900E+07
HEAT LOAD IN BTU PER HOUR =                   0.2620E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.6200E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9500E+02
 0.3106E+02  0.6613E-01
INLET TEMPERATURE = 26.00 PERCENT HUMIDITY = 59.00
EVAPORATION IN GPM = -0.4207E+04 IN CFS = -0.9373E+01
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.4600E+07
HEAT LOAD IN BTU PER HOUR =                   0.5510E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.6300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9500E+02
 0.3106E+02  0.2484E-01
INLET TEMPERATURE = 15.00 PERCENT HUMIDITY = 33.00
EVAPORATION IN GPM =  0.5644E+04 IN CFS =  0.1258E+02
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.5200E+07
HEAT LOAD IN BTU PER HOUR =                   0.4490E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.6300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9500E+02
 DATA BAD ON 280177
 DATA BAD ON 290177
 0.3406E+02  0.6077E-02
INLET TEMPERATURE = 10.00 PERCENT HUMIDITY = 35.00
EVAPORATION IN GPM =  0.7265E+04 IN CFS =  0.1619E+02
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.6200E+07
HEAT LOAD IN BTU PER HOUR =                   0.5430E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.6600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9500E+02
 0.3406E+02  0.9830E-02
INLET TEMPERATURE = 11.00 PERCENT HUMIDITY = 32.00
EVAPORATION IN GPM =  0.4306E+04 IN CFS =  0.9594E+01
AIR FLOW IN CUBIC FEET PER HOUR =             0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.4600E+07
HEAT LOAD IN BTU PER HOUR =                   0.3530E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2860E+02
BASIN TEMPERATURE IN DEGREES F=               0.6600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.9500E+02
AVERAGE EVAPORATION IN CFS =                   8.633
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INLET TEMPERATURE = 19.00 PERCENT HUMIDITY = 66.00
EVAPORATION IN GPM =  0.4728E+04 IN CFS =  0.1053E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4500E+07
HEAT LOAD IN BTU PER HOUR =                    0.3900E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.7000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 DATA BAD ON 100177.
 0.3206E+02  0.6077E-02
INLET TEMPERATURE = 10.00 PERCENT HUMIDITY = 49.00
EVAPORATION IN GPM =  0.5892E+04 IN CFS =  0.1313E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5100E+07
HEAT LOAD IN BTU PER HOUR =                    0.4720E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6400E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.3406E+02 -0.1430E-02
INLET TEMPERATURE =  8.00 PERCENT HUMIDITY = 58.00
EVAPORATION IN GPM =  0.7541E+04 IN CFS =  0.1680E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4000E+07
HEAT LOAD IN BTU PER HOUR =                    0.4860E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.3306E+02  0.9830E-02
INLET TEMPERATURE = 11.00 PERCENT HUMIDITY = 41.00
EVAPORATION IN GPM =  0.2777E+04 IN CFS =  0.6187E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3900E+07
HEAT LOAD IN BTU PER HOUR =                    0.2210E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6500E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.3206E+02  0.7739E-01
INLET TEMPERATURE = 29.00 PERCENT HUMIDITY = 67.00
EVAPORATION IN GPM =  0.2939E+04 IN CFS =  0.6549E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4000E+07
HEAT LOAD IN BTU PER HOUR =                    0.2130E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6400E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.2806E+02  0.6238E-01
INLET TEMPERATURE = 25.00 PERCENT HUMIDITY = 58.00
EVAPORATION IN GPM =  0.3146E+04 IN CFS =  0.7011E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3500E+07
HEAT LOAD IN BTU PER HOUR =                    0.2250E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.6000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.8900E+02
 DATA BAD ON 160177
 DATA BAD ON 170177
 DATA BAD ON 180177
 DATA BAD ON 190177
 DATA BAD ON 200177
 0.2606E+02  0.3986E-01
INLET TEMPERATURE = 19.00 PERCENT HUMIDITY = 55.00
EVAPORATION IN GPM =  0.9096E+02 IN CFS =  0.2027E+00
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5100E+07
HEAT LOAD IN BTU PER HOUR =                    0.6000E+09
ATMOSPHERIC PRESSURE IN INCHES =               0.2860E+02
BASIN TEMPERATURE IN DEGREES F=                0.5800E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9000E+02
 0.2706E+02  0.2484E-01
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HOMER CITY STATION
DAILY MODEL PREDICTIONS
APRIL 1-7, 1977

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END OF TASK      0
*RES CL
*LO PAK1:TOWR.OBJ
*AS 6,CRT:
*AS 10,PAK1:HOCAPR.FTN
*ST
  0.3006E+02  0.1780E+00
 INLET TEMPERATURE = 50.00 PERCENT HUMIDITY = 44.00
 EVAPORATION IN GPM =  0.4075E+04 IN CFS =  0.9079E+01
 AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.4800E+07
 HEAT LOAD IN BTU PER HOUR =                      0.2560E+10
 ATMOSPHERIC PRESSURE IN INCHES =                 0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                  0.6200E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =            0.9700E+02
  0.3805E+02  0.2067E+00
 INLET TEMPERATURE = 54.00 PERCENT HUMIDITY = 76.00
 EVAPORATION IN GPM =  0.3942E+04 IN CFS =  0.8784E+01
 AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.4200E+07
 HEAT LOAD IN BTU PER HOUR =                      0.2520E+10
 ATMOSPHERIC PRESSURE IN INCHES =                 0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                  0.7000E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =            0.1050E+03
  0.3605E+02  0.1780E+00
 INLET TEMPERATURE = 50.00 PERCENT HUMIDITY = 50.00
 EVAPORATION IN GPM =  0.4011E+04 IN CFS =  0.8937E+01
 AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.4100E+07
 HEAT LOAD IN BTU PER HOUR =                      0.2490E+10
 ATMOSPHERIC PRESSURE IN INCHES =                 0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                  0.6800E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =            0.9400E+02
  0.3206E+02  0.1320E+00
 INLET TEMPERATURE = 42.00 PERCENT HUMIDITY = 85.00
 EVAPORATION IN GPM =  0.4001E+04 IN CFS =  0.8914E+01
 AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.4000E+07
 HEAT LOAD IN BTU PER HOUR =                      0.2540E+10
 ATMOSPHERIC PRESSURE IN INCHES =                 0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                  0.6400E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =            0.9000E+02
  DATA BAD ON  50477
  0.2806E+02  0.9616E-01
 INLET TEMPERATURE = 34.00 PERCENT HUMIDITY = 56.00
 EVAPORATION IN GPM =  0.3801E+04 IN CFS =  0.8468E+01
 AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.3600E+07
 HEAT LOAD IN BTU PER HOUR =                      0.2490E+10
 ATMOSPHERIC PRESSURE IN INCHES =                 0.2880E+02
 BASIN TEMPERATURE IN DEGREES  =                  0.6000E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =            0.8600E+02
  0.2406E+02  0.9991E-01
 INLET TEMPERATURE = 35.00 PERCENT HUMIDITY = 56.00
 EVAPORATION IN GPM =  0.3571E+04 IN CFS =  0.7958E+01
 AIR FLOW IN CUBIC FEET PER HOUR =                0.1000E+01
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =          0.6100E+07
 HEAT LOAD IN BTU PER HOUR =                      0.2340E+10
 ATMOSPHERIC PRESSURE IN INCHES =                 0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                  0.5600E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =            0.8900E+02
  0.2106E+02  0.8865E-01
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 0.2106E+02  0.8865E-01
INLET TEMPERATURE = 32.00 PERCENT HUMIDITY = 48.00
EVAPORATION IN GPM =  0.2970E+04 IN CFS =  0.6617E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4100E+07
HEAT LOAD IN BTU PER HOUR =                    0.1850E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.5300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.7500E+02
 DATA BAD ON  90477
 DATA BAD ON 100477
 DATA BAD ON 110477
 0.4504E+02  0.4451E+00
INLET TEMPERATURE = 76.00 PERCENT HUMIDITY = 29.00
EVAPORATION IN GPM =  0.2696E+04 IN CFS =  0.6007E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4300E+07
HEAT LOAD IN BTU PER HOUR =                    0.1440E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7700E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9600E+02
 0.4604E+02  0.3629E+00
INLET TEMPERATURE = 70.00 PERCENT HUMIDITY = 34.00
EVAPORATION IN GPM =  0.4566E+04 IN CFS =  0.1017E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3800E+07
HEAT LOAD IN BTU PER HOUR =                    0.2630E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7800E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9900E+02
 0.4105E+02  0.2660E+00
INLET TEMPERATURE = 61.00 PERCENT HUMIDITY = 45.00
EVAPORATION IN GPM =  0.4270E+04 IN CFS =  0.9515E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3800E+07
HEAT LOAD IN BTU PER HOUR =                    0.2530E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.3805E+02  0.2392E+00
INLET TEMPERATURE = 58.00 PERCENT HUMIDITY = 23.00
EVAPORATION IN GPM =  0.4451E+04 IN CFS =  0.9918E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4000E+07
HEAT LOAD IN BTU PER HOUR =                    0.2650E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9400E+02
 0.3805E+02  0.2224E+00
INLET TEMPERATURE = 56.00 PERCENT HUMIDITY = 39.00
EVAPORATION IN GPM =  0.4401E+04 IN CFS =  0.9807E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4600E+07
HEAT LOAD IN BTU PER HOUR =                    0.2620E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9400E+02
 0.3705E+02  0.2477E+00
INLET TEMPERATURE = 59.00 PERCENT HUMIDITY = 40.00
EVAPORATION IN GPM =  0.3081E+04 IN CFS =  0.6866E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4100E+07
HEAT LOAD IN BTU PER HOUR =                    0.1770E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.6900E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9000E+02
 DATA BAD ON 180477
 DATA BAD ON 190477
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HOMER CITY STATION (cont'd)
APRIL 20-30, 1977

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 DATA BAD ON 200477
 DATA BAD ON 210477
 DATA BAD ON 220477
 0.4604E+02  0.2561E+00
INLET TEMPERATURE = 60.00 PERCENT HUMIDITY = 78.00
EVAPORATION IN GPM =  0.3536E+04 IN CFS =  0.7879E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4500E+07
HEAT LOAD IN BTU PER HOUR =                    0.2080E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7800E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9900E+02
 0.4005E+02  0.1852E+00
INLET TEMPERATURE = 51.00 PERCENT HUMIDITY = 80.00
EVAPORATION IN GPM =  0.4253E+04 IN CFS =  0.9476E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5000E+07
HEAT LOAD IN BTU PER HOUR =                    0.2530E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7200E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9600E+02
 0.3505E+02  0.1719E+00
INLET TEMPERATURE = 49.00 PERCENT HUMIDITY = 63.00
EVAPORATION IN GPM =  0.4304E+04 IN CFS =  0.9591E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.6700E+07
HEAT LOAD IN BTU PER HOUR =                    0.2530E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.6700E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9500E+02
 0.3106E+02  0.1474E+00
INLET TEMPERATURE = 45.00 PERCENT HUMIDITY = 70.00
EVAPORATION IN GPM =  0.3073E+04 IN CFS =  0.6848E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4600E+07
HEAT LOAD IN BTU PER HOUR =                    0.1940E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.6300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9100E+02
 DATA BAD ON 270477
 DATA BAD ON 280477
 0.2906E+02  0.1474E+00
INLET TEMPERATURE = 45.00 PERCENT HUMIDITY = 45.00
EVAPORATION IN GPM =  0.1335E+04 IN CFS =  0.2975E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.3900E+07
HEAT LOAD IN BTU PER HOUR =                    0.6900E+09
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.6100E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.7500E+02
 0.2906E+02  0.1923E+00
INLET TEMPERATURE = 52.00 PERCENT HUMIDITY = 40.00
EVAPORATION IN GPM =  0.3019E+04 IN CFS =  0.6726E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.1000E+01
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.4100E+07
HEAT LOAD IN BTU PER HOUR =                    0.1700E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.6100E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.7500E+02
AVERAGE EVAPORATION IN CFS =                    8.134
STOP
END OF TASK     0
```

HOMER CITY STATION
DAILY MODEL PREDICTIONS
JULY 1-10, 1977

```
*LO PAK1:TOWR.OBJ
*AS 6,CRT:
*AS 10,PAK1:HOCJUL.FTN
*ST
  DATA BAD ON  10777
  DATA BAD ON  20777
  DATA BAD ON  30777
  DATA BAD ON  40777
  0.5502E+02  0.5780E+00
 INLET TEMPERATURE = 84.00 PERCENT HUMIDITY = 58.00
 EVAPORATION IN GPM =  0.7569E+04 IN CFS =  0.1687E+02
 AIR FLOW IN CUBIC FEET PER HOUR =                 0.4000E+08
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.7900E+07
 HEAT LOAD IN BTU PER HOUR =                       0.4280E+10
 ATMOSPHERIC PRESSURE IN INCHES =                  0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                   0.8700E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =             0.1100E+03
  0.5303E+02  0.5424E+00
 INLET TEMPERATURE = 82.00 PERCENT HUMIDITY = 60.00
 EVAPORATION IN GPM =  0.6689E+04 IN CFS =  0.1490E+02
 AIR FLOW IN CUBIC FEET PER HOUR =                 0.4000E+08
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.6800E+07
 HEAT LOAD IN BTU PER HOUR =                       0.3870E+10
 ATMOSPHERIC PRESSURE IN INCHES =                  0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                   0.8500E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =             0.1100E+03
  0.5502E+02  0.4760E+00
 INLET TEMPERATURE = 78.00 PERCENT HUMIDITY = 65.00
 EVAPORATION IN GPM =  0.8705E+04 IN CFS =  0.1940E+02
 AIR FLOW IN CUBIC FEET PER HOUR =                 0.4000E+08
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.8400E+07
 HEAT LOAD IN BTU PER HOUR =                       0.5000E+10
 ATMOSPHERIC PRESSURE IN INCHES =                  0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                   0.8700E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =             0.1100E+03
  0.5303E+02  0.4296E+00
 INLET TEMPERATURE = 75.00 PERCENT HUMIDITY = 77.00
 EVAPORATION IN GPM =  0.8664E+04 IN CFS =  0.1930E+02
 AIR FLOW IN CUBIC FEET PER HOUR =                 0.4000E+08
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.8100E+07
 HEAT LOAD IN BTU PER HOUR =                       0.5070E+10
 ATMOSPHERIC PRESSURE IN INCHES =                  0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                   0.8500E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =             0.1100E+03
  0.5203E+02  0.4030E+00
 INLET TEMPERATURE = 73.00 PERCENT HUMIDITY = 75.00
 EVAPORATION IN GPM =  0.8069E+04 IN CFS =  0.1798E+02
 AIR FLOW IN CUBIC FEET PER HOUR =                 0.4000E+08
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.8600E+07
 HEAT LOAD IN BTU PER HOUR =                       0.4760E+10
 ATMOSPHERIC PRESSURE IN INCHES =                  0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                   0.8400E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =             0.1100E+03
  0.5303E+02  0.4296E+00
 INLET TEMPERATURE = 75.00 PERCENT HUMIDITY = 58.00
 EVAPORATION IN GPM =  0.8684E 04 IN CFS =  0.1935E+02
 AIR FLOW IN CUBIC FEET PER HOUR =                 0.4000E+08
 MAKE-UP WATER FLOW IN POUNDS PER HOUR =           0.8600E+07
 HEAT LOAD IN BTU PER HOUR =                       0.5050E+10
 ATMOSPHERIC PRESSURE IN INCHES =                  0.2880E+02
 BASIN TEMPERATURE IN DEGREES F=                   0.8500E+02
 AIR OUTLET TEMPERATURE IN DEGREES F =             0.1100E+03
  0.5303E+02  0.4030E+00
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 0.5203E+02  0.4451E+00
INLET TEMPERATURE = 76.00 PERCENT HUMIDITY = 68.00
EVAPORATION IN GPM =  0.3171E+04 IN CFS =  0.7066E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.7800E+07
HEAT LOAD IN BTU PER HOUR =                    0.1460E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8400E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9900E+02
 0.5403E+02  0.5246E+00
INLET TEMPERATURE = 81.00 PERCENT HUMIDITY = 67.00
EVAPORATION IN GPM =  0.3315E+04 IN CFS =  0.7387E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5600E+07
HEAT LOAD IN BTU PER HOUR =                    0.1630E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1010E+03
 0.5602E+02  0.4914E+00
INLET TEMPERATURE = 79.00 PERCENT HUMIDITY = 67.00
EVAPORATION IN GPM =  0.2787E+04 IN CFS =  0.6210E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.7000E+07
HEAT LOAD IN BTU PER HOUR =                    0.1280E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8800E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1050E+03
 DATA BAD ON 220777
 0.4304E+02  0.2956E+00
INLET TEMPERATURE = 64.00 PERCENT HUMIDITY = 62.00
EVAPORATION IN GPM =  0.4108E+04 IN CFS =  0.9153E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.6800E+07
HEAT LOAD IN BTU PER HOUR =                    0.2340E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7500E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1010E+03
 0.5103E+02  0.4163E+00
INLET TEMPERATURE = 74.00 PERCENT HUMIDITY = 60.00
EVAPORATION IN GPM =  0.8220E+04 IN CFS =  0.1832E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.6100E+07
HEAT LOAD IN BTU PER HOUR =                    0.4850E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1050E+03
 0.5203E+02  0.3763E+00
INLET TEMPERATURE = 71.00 PERCENT HUMIDITY = 80.00
EVAPORATION IN GPM =  0.8404E+04 IN CFS =  0.1873E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.7100E+07
HEAT LOAD IN BTU PER HOUR =                    0.5020E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8400E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1080E+03
 0.4504E+02  0.2956E+00
INLET TEMPERATURE = 64.00 PERCENT HUMIDITY = 56.00
EVAPORATION IN GPM =  0.4403E+04 IN CFS =  0.9810E+01
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5000E+07
HEAT LOAD IN BTU PER HOUR =                    0.2570E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7700E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1010E+03
 0.4404E+02  0.2857E+00
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```
 0.4404E+02  0.2857E+00
INLET TEMPERATURE = 63.00 PERCENT HUMIDITY = 52.00
EVAPORATION IN GPM =  0.8018E+04 IN CFS =  0.1787E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5700E+07
HEAT LOAD IN BTU PER HOUR =                    0.4880E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.7600E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.9900E+02
 0.4804E+02  0.3763E+00
INLET TEMPERATURE = 71.00 PERCENT HUMIDITY = 57.00
EVAPORATION IN GPM =  0.8471E+04 IN CFS =  0.1887E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.6600E+07
HEAT LOAD IN BTU PER HOUR =                    0.5040E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8000E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1050E+03
 0.5003E+02  0.4030E+00
INLET TEMPERATURE = 73.00 PERCENT HUMIDITY = 63.00
EVAPORATION IN GPM =  0.8471E+04 IN CFS =  0.1888E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.5800E+07
HEAT LOAD IN BTU PER HOUR =                    0.5030E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8200E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1050E+03
 0.5103E+02  0.3763E+00
INLET TEMPERATURE = 71.00 PERCENT HUMIDITY = 71.00
EVAPORATION IN GPM =  0.8792E+04 IN CFS =  0.1959E+02
AIR FLOW IN CUBIC FEET PER HOUR =              0.4000E+08
MAKE-UP WATER FLOW IN POUNDS PER HOUR =        0.7800E+07
HEAT LOAD IN BTU PER HOUR =                    0.5140E+10
ATMOSPHERIC PRESSURE IN INCHES =               0.2880E+02
BASIN TEMPERATURE IN DEGREES F=                0.8300E+02
AIR OUTLET TEMPERATURE IN DEGREES F =          0.1050E+03
 DATA BAD ON 310777
AVERAGE EVAPORATION IN CFS =                   15.278
STOP
END OF TASK      0
```

KOSHKONONG NUCLEAR PLANT

DESIGN DATA

```
 0.6301E+02  0.6572E+00
INLET TEMPERATURE = 88.00 PERCENT HUMIDITY = 60.00
EVAPORATION IN GPM =  0.1102E+05 IN CFS =  0.2456E+02
AIR FLOW IN CUBIC FEET PER HOUR =             0.2400E+10
MAKE-UP WATER FLOW IN POUNDS PER HOUR =       0.6249E+07
HEAT LOAD IN BTU PER HOUR =                   0.6642E+10
ATMOSPHERIC PRESSURE IN INCHES =              0.2990E+02
BASIN TEMPERATURE IN DEGREES F=               0.9500E+02
AIR OUTLET TEMPERATURE IN DEGREES F =         0.1120E+03
```

APPENDIX D

COMPUTER PRINTOUTS FOR COOLING POND MODELS

DEFINITIONS FOR COOLING POND MODELS PROGRAM OUTPUT

Parameter	Definition
TAMB (column I)	Ambient Dry Bulb Air Temperature in °F
HUM	Ambient Relative Humidity
Wind	Ambient Wind Speed - miles per hour
QH	Marciano and Harbeck model (Lake Hefner) predicted evaporation in cubic feet per second
QC	Harbeck, Koberg, and Hughes model (Lake Colorado City) predicted evaporation in cubic feet per second
QM	Meyer model predicted evaporation in cubic feet per second
QB	Brady et al model predicted evaporation in cubic feet per second
Qual	Origin of data - 0.0 is utility and/or NWS data - 1.0 indicates data supplemented by engineering estimate of values. 2.0 means insufficient data for model prediction.
Acres	Surface area of cooling pond in acres

Bottom Line: Average values for QH QC QM QB Max. no. of values possible in period Actual no. of values used in average First Date Last Date

Dates shown are day·month·year (e.g. January 8, 1977 is 080177)

TAMB	HUM	WIND	QH	QC	QM	QB
30.00	59.00	7.10			1.21	
37.00	43.00	9.30			1.96	
45.00	30.00	11.60			2.86	
51.00	25.00	12.40			4.03	
62.00	15.00	11.60			5.51	
72.00	15.00	11.60			6.73	
78.00	36.00	10.20			5.14	
75.00	31.00	9.90			5.76	
67.00	45.00	8.70			3.73	
55.00	37.00	8.90			2.77	
42.00	44.00	8.00			1.75	
31.00	51.00	7.80			1.32	
			3.6			
30.00	59.00	7.00	0.77	1.14		
37.00	43.00	9.10	1.45	2.13		
45.00	30.00	11.40	2.36	3.47		
51.00	25.00	12.20	3.43	5.05		
62.00	15.00	11.40	4.54	6.68		
72.00	15.00	11.40	5.55	8.16		
78.00	36.00	10.00	3.97	5.84		
75.00	31.00	9.70	4.38	6.45		
67.00	45.00	8.60	2.71	3.98		
55.00	37.00	8.80	2.01	2.96		
42.00	44.00	7.80	1.18	1.74		
31.00	51.00	7.60	0.88	1.30		
2.8		4.1				
30.00	59.00	6.40				0.95
37.00	43.00	8.30				1.65
45.00	30.00	10.40				2.64
51.00	25.00	11.10				3.85
62.00	15.00	10.40				5.09
72.00	15.00	10.40				6.21
78.00	36.00	9.10				4.45
75.00	31.00	8.90				4.97
67.00	45.00	7.90				3.11
55.00	37.00	8.00				2.30
42.00	44.00	7.10				1.40
31.00	51.00	7.00				1.06
			3.1			

CHOLLA PLANT MONTHLY EVAPORATION PERIOD: 1974-1976

TAMB	HUM	WIND	QH	QC	QM	QB
45.50	62.00	10.60			3.97	
46.40	58.00	14.80			6.81	
58.10	56.00	12.10			6.27	
68.40	56.00	13.20			9.90	
80.40	58.00	12.20			8.59	
87.10	52.00	12.60			10.79	
82.90	57.00	10.30			16.96	
82.30	48.00	9.70			17.63	
81.60	50.00	10.60			13.67	
70.70	64.00	11.70			4.58	
51.90	58.00	10.80			2.60	
49.10	62.00	10.40			3.60	
			8.8			
45.50	62.00	10.40	3.13	4.61		
46.40	58.00	15.40	6.60	9.72		
58.10	56.00	11.90	5.28	7.76		
68.40	56.00	12.90	8.60	12.65		
80.40	58.00	12.00	7.25	10.67		
87.10	52.00	12.40	9.25	13.61		
82.90	57.00	10.00	13.05	19.20		
82.30	48.00	9.50	13.28	19.54		
81.60	50.00	10.40	10.78	15.86		
70.70	64.00	11.50	3.79	5.58		
51.90	58.00	10.60	2.07	3.04		
49.10	62.00	10.20	2.81	4.14		
7.2	10.5					
45.50	62.00	9.50				3.51
46.40	58.00	13.20				7.21
58.10	56.00	10.80				5.89
68.40	56.00	11.80				9.78
80.40	58.00	10.90				8.11
87.10	52.00	11.30				10.42
82.90	57.00	9.20				14.78
82.30	48.00	8.70				15.07
81.60	50.00	9.50				12.10
70.70	64.00	10.50				4.25
51.90	58.00	9.70				2.32
49.10	62.00	9.30				3.15
			8.1			

MORGAN CREEK STATION -- 1960 COMPUTER RUNS

TAMB	HUM	WIND	QB
6.60	60.00	8.30	6.85
15.00	69.00	2.40	3.98
22.60	78.20	2.40	3.87
30.20	88.60	3.10	3.16
31.00	96.40	3.10	3.00
32.00	89.80	2.20	2.95
21.80	74.40	11.20	8.31
13.20	46.20	0.90	4.40
24.60	79.00	4.80	4.35
21.80	85.20	13.60	10.25
4.20	56.40	7.70	6.53
8.80	74.00	9.00	6.82
7.80	54.40	9.90	8.35
36.20	87.80	5.50	2.49
27.60	74.60	7.70	4.48
3.60	69.20	11.00	8.23
-3.00	46.40	10.50	7.96
2.00	49.60	8.10	6.01
7.80	70.00	7.50	5.29
12.80	55.00	2.00	3.52
16.60	77.40	6.80	4.42
14.60	70.60	12.90	8.31
12.60	65.60	2.90	3.63
27.20	90.60	2.40	2.40
25.80	87.60	6.80	3.39
24.80	73.20	9.90	5.13
21.00	62.20	14.00	9.05
20.00	67.80	11.60	7.05
4.60	45.60	14.50	10.81
10.40	62.20	13.60	9.43
11.40	50.60	11.40	7.76

5.9

MT. STORM STATION - JANUARY 1977 - BRADY MODEL

TAMB	HUM	WIND	QB
71.20	71.30	9.10	14.96
67.50	58.30	4.80	12.17
67.20	65.30	2.30	10.75
69.00	68.20	2.40	9.76
74.00	80.20	4.00	7.26
77.70	70.80	3.50	7.52
81.30	65.80	4.40	8.33
79.70	70.70	5.90	8.93
76.30	75.70	4.30	7.70
72.20	80.70	1.00	8.66
75.00	76.20	4.10	10.94
73.80	79.30	4.30	7.85
71.50	88.70	4.60	9.65
70.80	72.30	3.00	11.32
70.50	71.50	3.10	12.45
79.20	77.00	0.50	7.04
75.00	72.20	3.50	10.85
78.50	66.20	1.80	10.35
75.00	72.00	3.80	12.85
79.30	72.70	4.30	10.59
71.30	88.50	2.30	10.54
70.80	69.80	6.80	17.61
65.50	66.00	3.10	15.96
67.50	76.30	4.40	13.67
70.00	90.20	5.90	12.17
60.70	70.80	3.50	14.13
63.50	63.20	3.00	14.74
65.80	65.20	2.80	14.68
67.70	72.70	4.40	14.50
70.80	75.20	4.40	11.42
70.00	73.50	1.30	10.68

11.3

MT. STORM STATION - JULY 1977 - BRADY MODEL

TAMB	HUM	WIND	QM
6.60	60.00	9.30	8.17
15.00	69.00	2.70	4.99
22.60	78.20	0.00	3.82
30.20	88.60	3.40	4.03
31.00	96.40	0.00	2.86
32.00	89.80	2.20	3.58
21.80	74.40	12.50	8.66
13.20	46.20	1.00	5.01
24.60	79.00	5.40	5.68
21.80	85.20	15.20	9.46
4.20	56.40	8.60	7.95
8.80	74.00	11.00	8.25
7.80	54.40	0.00	4.40
36.20	87.80	6.10	3.21
27.60	74.60	8.60	5.46
3.60	69.20	12.30	8.66
-3.00	46.40	11.80	8.61
2.00	49.60	9.10	7.24
7.80	70.00	8.30	6.46
12.80	55.00	2.20	4.31
16.60	77.40	7.60	5.55
14.60	70.60	14.50	7.97
12.60	65.60	3.20	4.61
27.20	90.60	2.70	3.00
25.80	87.60	7.60	4.25
24.80	73.20	11.00	5.67
21.00	62.20	15.70	8.20
20.00	67.80	13.00	7.22
4.60	45.60	16.20	9.53
10.40	62.20	15.20	8.71
11.40	50.60	12.70	8.00

MT. STORM STATION - JANUARY 1977 - MEYER MODEL

TAMB	HUM	WIND	QM
71.20	71.30	10.10	17.16
67.50	58.30	5.30	15.79
67.20	65.30	2.60	13.42
69.00	68.20	2.70	12.23
74.00	80.20	4.40	9.40
77.70	70.80	3.90	9.71
81.30	65.80	5.00	10.93
79.70	70.70	6.60	11.48
76.30	75.70	4.80	10.04
72.20	80.70	1.10	9.93
75.00	76.20	4.60	14.27
73.80	79.30	4.80	10.24
71.50	88.70	5.20	12.63
70.80	72.30	3.30	14.41
70.50	71.50	3.50	16.00
79.20	77.00	0.60	7.76
75.00	72.20	3.90	14.02
78.50	66.20	2.00	12.55
75.00	72.00	4.20	16.64
79.30	72.70	4.80	13.80
71.30	88.50	2.60	13.16
70.80	69.80	7.50	21.99
65.50	66.00	3.50	20.51
67.50	76.30	5.00	17.93
70.00	90.20	6.60	15.64
60.70	70.80	3.90	18.25
63.50	63.20	3.30	18.76
65.80	65.20	3.10	18.61
67.70	72.70	5.00	19.02
70.80	75.20	5.00	14.98
70.00	73.50	1.50	12.61

MT. STORM STATION - JULY 1977 - MEYER MODEL

TAMB	HUM	WIND	QH	QC
6.60	60.00	9.10	6.02	8.86
15.00	69.00	2.60	1.60	2.35
22.60	78.20	2.60	1.55	2.28
30.20	88.60	3.40	1.60	2.35
31.00	96.40	3.40	1.52	2.23
32.00	89.80	2.20	1.01	1.49
21.80	74.40	12.30	7.40	10.88
13.20	46.20	1.00	0.71	1.05
24.60	79.00	5.30	3.05	4.49
21.80	85.20	14.90	8.74	12.86
4.20	56.40	8.40	5.61	8.26
8.80	74.00	10.80	6.63	9.76
7.80	54.40	10.80	7.42	10.92
36.20	87.80	6.00	1.87	2.75
27.60	74.60	8.40	3.86	5.67
3.60	69.20	12.00	7.28	10.71
-3.00	46.40	11.60	7.16	10.53
2.00	49.60	8.90	5.27	7.75
7.80	70.00	8.20	4.52	6.66
12.80	55.00	2.20	1.22	1.79
16.60	77.40	1.50	0.74	1.09
14.60	70.60	14.20	7.22	10.62
12.60	65.60	3.10	1.69	2.49
27.20	90.60	2.60	0.96	1.41
25.80	87.60	7.50	2.83	4.17
24.80	73.20	10.80	4.56	6.71
21.00	62.20	15.40	7.68	11.30
20.00	67.80	12.80	6.28	9.23
4.60	45.60	15.90	9.03	13.29
10.40	62.20	14.90	8.04	11.83
11.40	50.60	12.50	6.88	10.12

4.5 6.6

MT. STORM STATION - JANUARY 1977 - LAKE HEFNER AND LAKE COLORADO CITY MODELS

TAMB	HUM	WIND	QH	QC
71.20	71.30	9.90	13.21	19.43
67.50	58.30	5.20	8.39	12.34
67.20	65.30	2.50	4.16	6.12
69.00	68.20	2.60	3.91	5.76
74.00	80.20	4.30	4.39	6.45
77.70	70.80	3.80	4.15	6.10
81.30	65.80	4.90	5.58	8.20
79.70	70.70	6.50	7.02	10.33
76.30	75.70	4.70	4.98	7.33
72.20	80.70	1.10	1.54	2.26
75.00	76.20	4.40	6.72	9.88
73.80	79.30	4.70	5.08	7.47
71.50	88.70	5.10	6.62	9.74
70.80	72.30	3.30	5.59	8.22
70.50	71.50	3.40	6.30	9.26
79.20	77.00	0.50	0.57	0.84
75.00	72.20	3.80	5.99	8.81
78.50	66.20	2.00	3.27	4.81
75.00	72.00	4.20	7.69	11.31
79.30	72.70	4.70	6.85	10.07
71.30	88.50	2.50	4.08	6.00
70.80	69.80	7.40	14.53	21.38
65.50	66.00	3.40	8.07	11.88
67.50	76.30	4.90	9.15	13.46
70.00	90.20	6.50	9.57	14.08
60.70	70.80	3.80	7.80	11.47
63.50	63.20	3.30	7.27	10.70
65.80	65.20	3.10	6.88	10.13
67.70	72.70	4.90	9.71	14.28
70.80	75.20	4.90	7.65	11.25
70.00	73.50	1.50	2.57	3.78
6.4		9.5		

MT. STORM STATION - JULY 1977 - LAKE HEFNER AND LAKE COLORADO CITY MODELS

TAMB	HUM	WIND	QH	QC	QM	QB
23.50	75.50	13.50			11.94	
39.30	72.80	14.50			3.85	
45.40	73.10	15.50			6.72	
55.00	65.80	12.70			7.82	
59.70	62.00	11.60			27.68	
72.40	58.20	8.80			26.16	
77.40	63.20	9.30			31.35	
71.60	60.80	8.50			37.05	
65.20	64.00	8.70			25.58	
49.60	69.40	9.30			23.73	
34.60	66.80	12.00			22.17	
24.10	57.40	13.40			18.10	
			20.2			
23.50	75.50	13.30	10.56	15.53		
39.30	72.80	14.20	3.48	5.13		
45.40	73.10	15.30	6.30	9.27		
55.50	65.80	12.40	6.68	9.82		
59.70	62.00	10.60	21.22	31.22		
72.40	58.20	8.70	18.92	27.83		
77.40	63.20	9.10	23.10	33.98		
71.60	60.80	8.40	26.28	38.66		
65.20	64.00	8.60	18.38	27.04		
49.60	69.40	9.10	17.48	25.72		
34.60	66.80	11.80	18.58	27.33		
24.10	57.40	12.90	15.59	22.93		
15.5	22.9					
23.50	75.50	12.10				11.99
39.30	72.80	13.00				4.05
45.40	73.10	13.90				7.40
55.00	65.80	11.30				7.52
59.70	62.00	9.60				23.60
72.40	58.20	7.90				21.66
77.40	63.20	8.30				26.29
71.60	60.80	7.60				30.27
65.20	64.00	7.80				21.09
49.60	69.40	8.30				19.90
34.60	66.80	10.80				20.92
24.10	57.40	12.00				18.09

KINCAID GENERATING STATION MONTHLY PREDICTED EVAPORATION 1976

TAMB	HUM	WIND	QH	QC	QM	QB
29.70	77.00	14.10			7.25	
30.70	80.00	12.60			3.28	
46.30	77.00	13.80			5.46	
51.90	70.00	14.50			1.91	
59.60	67.00	12.10			11.99	
73.20	69.00	11.30			15.69	
76.00	69.00	7.80			15.94	
76.00	73.00	8.70			15.33	
69.80	72.00	9.30			17.52	
60.70	68.00	9.80			8.28	
45.50	73.00	11.70			3.27	
28.00	77.00	13.30			4.74	
			9.2			
29.70	77.00	13.80	6.49	9.54		
30.70	80.00	12.30	2.79	4.10		
46.30	77.00	13.60	4.87	7.17		
51.90	70.00	14.20	1.73	2.54		
59.60	67.00	11.90	10.09	14.84		
73.20	69.00	11.10	12.77	18.79		
76.00	69.00	7.60	10.63	15.64		
76.00	73.00	8.60	11.02	16.21		
69.80	72.00	9.10	12.91	18.99		
60.70	68.00	9.60	6.27	9.23		
45.50	73.00	11.50	2.71	3.99		
28.00	77.00	13.10	4.17	6.13		
7.2	10.6					
29.70	77.00	12.60				7.46
30.70	80.00	11.20				3.14
46.30	77.00	12.40				5.58
51.90	70.00	13.00				2.01
59.60	67.00	10.90				11.38
73.20	69.00	10.10				14.26
76.00	69.00	7.00				12.78
76.00	73.00	7.80				12.64
69.80	72.00	8.30				14.69
60.70	68.00	8.80				7.11
45.50	73.00	10.50				3.04
28.00	77.00	11.90				4.71

POWERTON GENERATING STATION MONTHLY PREDICTED EVAPORATION 1973

*AS 10, PAK1______PAK1:POW77.FTN
*AS 11,PAK1:ASD.FTN
*ST

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
8.60	66.70	11.80	8.02	11.79	9.48	9.97	0.0
27.00	68.40	11.00	6.06	8.92	7.41	7.47	0.0
44.60	62.10	13.20	8.83	12.98	9.93	11.25	0.0
57.10	57.80	11.40	9.13	13.43	10.97	11.29	1.0
68.50	63.60	7.90	9.48	13.94	13.74	11.95	1.0
70.20	64.40	9.20	13.56	19.95	18.12	16.70	0.0
78.20	67.00	8.90	17.22	25.33	23.40	21.26	0.0
71.40	76.50	8.30	11.68	17.19	16.49	14.58	0.0

1430.0 ACRES

10.5 15.4 13.7 13.1 8 8 177 877

STOP
END OF TASK 0
*LO PAK1:POND.OBJ

POWERTON GENERATING STATION
MONTHLY PREDICTED EVAPORATION
1977

TAMB	HUM	WIND	QH	QC	QM	QB
46.90	65.00	7.50			9.34	
48.40	63.00	8.20			20.34	
54.40	61.00	8.90			28.59	
63.60	60.00	9.20			12.99	
72.20	61.00	7.50			22.80	
79.70	64.00	7.20			23.15	
81.60	66.00	7.10			39.29	
80.50	69.00	6.50			36.93	
75.30	67.00	6.70			31.22	
64.70	67.00	6.50			30.12	
53.70	67.00	6.90			17.30	
46.40	66.00	7.00			11.36	
			23.6			
46.90	65.00	7.30	6.09	8.96		
48.40	63.00	8.00	13.97	20.55		
54.40	61.00	8.80	20.80	30.60		
63.60	60.00	9.00	9.51	13.99		
72.20	61.00	7.30	14.86	21.86		
79.70	64.00	7.10	14.93	21.97		
81.60	66.00	7.00	25.13	36.97		
80.50	69.00	6.40	22.38	32.92		
75.30	67.00	6.60	19.28	28.36		
64.70	67.00	6.40	18.26	26.86		
53.70	67.00	6.80	10.88	16.00		
46.40	66.00	6.90	7.21	10.60		
15.3	22.5					
46.90	65.00	6.70				7.41
48.40	63.00	7.30				16.42
54.40	61.00	8.00				23.78
63.60	60.00	8.20				10.84
72.20	61.00	6.70				18.09
79.70	64.00	6.50				18.35
81.60	66.00	6.40				31.04
80.50	69.00	5.80				28.66
75.30	67.00	6.00				24.36
64.70	67.00	5.80				23.38
53.70	67.00	6.20				13.58
46.40	66.00	6.30				8.95

H.B. ROBINSON STATION, APRIL 1975 - MARCH 1976, MONTHLY EVAPORATION PREDICTION.

TAMB	HUM	WIND	QH	QC	QM	QB
28.90	53.00	9.20			24.56	
40.30	46.00	8.60			20.76	
54.50	54.00	8.20			21.09	
61.80	59.00	7.00			28.27	
69.20	63.00	5.80			31.87	
73.00	63.00	6.70			37.79	
80.70	60.00	6.20			60.53	
67.10	72.00	6.90			63.99	
73.00	74.00	7.00			41.09	
57.60	71.00	7.60			37.15	
51.90	71.00	8.20			26.83	
40.60	68.00	7.80			20.35	
			34.5			
28.90	53.00	9.00	17.99	26.46		
40.30	46.00	8.40	14.65	21.55		
54.50	54.00	8.00	14.48	21.30		
61.80	59.00	6.90	17.93	26.37		
69.20	63.00	5.70	18.86	27.75		
73.00	63.00	6.60	23.33	34.33		
80.70	60.00	6.10	35.42	52.11		
67.10	72.00	6.80	40.23	59.18		
73.00	74.00	6.90	26.06	38.34		
57.60	71.00	7.50	24.74	36.39		
51.90	71.00	8.00	18.43	27.11		
40.60	68.00	7.70	13.75	20.23		
22.2		32.6				
28.90	53.00	8.20				20.50
40.30	46.00	7.70				17.04
54.50	54.00	7.30				17.02
61.80	59.00	6.30				22.26
69.20	63.00	5.20				24.31
73.00	63.00	6.00				29.49
80.70	60.00	5.60				47.04
67.10	72.00	6.20				50.23
73.00	74.00	6.30				32.36
57.60	71.00	6.80				29.58
51.90	71.00	7.30				21.65
40.60	68.00	7.00				16.32

BELEWS CREEK STEAM STATION MONTHLY PREDICTION OF EVAPORATION RATE
JANUARY 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
29.90	37.00	8.50	19.37	28.50	26.98	24.08	.00
33.30	40.00	5.20	11.55	16.99	21.61	17.31	.00
37.50	40.00	10.00	21.07	31.00	26.97	25.85	.00
43.00	42.00	5.40	10.82	15.92	19.75	15.87	.00
35.70	39.00	12.10	26.64	39.18	31.14	33.27	.00
24.50	37.00	7.40	16.30	23.98	24.53	20.90	.00
25.40	37.00	6.80	14.10	20.74	22.29	18.59	.00
28.80	47.00	3.50	8.20	12.07	20.25	16.13	.00
27.60	46.00	4.90	12.91	18.99	25.13	20.04	.00
46.00	42.00	5.80	12.67	18.64	22.09	17.90	.00
47.20	45.00	3.90	8.38	12.33	19.12	15.19	.00
47.10	63.00	4.70	7.70	11.33	15.41	12.27	.00
48.20	34.00	8.90	20.45	30.09	27.80	25.26	.00
43.70	40.00	7.70	17.75	26.11	26.11	22.52	.00
40.20	44.00	8.40		DOES NOT COMPUTE			2.00
29.40	46.00	9.60		DOES NOT COMPUTE			2.00
28.00	40.00	6.00		DOES NOT COMPUTE			2.00
27.60	83.00	3.40		DOES NOT COMPUTE			2.00
40.70	60.00	4.50		DOES NOT COMPUTE			2.00
37.90	48.00	9.90		DOES NOT COMPUTE			2.00
32.70	41.00	7.50	18.19	26.76	27.17	23.25	.00
45.40	37.00	9.80	22.85	33.61	29.54	28.03	.00
33.30	40.00	8.80	17.73	26.08	24.24	21.93	.00
35.30	58.00	8.90	11.65	17.13	15.83	14.38	.00
53.40	33.00	9.60	20.07	29.52	26.22	24.64	.00
61.30	40.00	8.80	13.98	20.57	19.12	17.29	.00
56.20	76.00	9.30	6.49	9.55	8.62	7.98	.00
40.60	51.00	6.90	15.98	23.51	25.05	20.96	.00

3550.0 ACRES

15.2 22.4 23.0 20.2 28 22 10277 280277

BELEWS CREEK STEAM STATION (cont'd)
FEBRUARY 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
40.80	47.00	8.80	21.13	31.08	28.88	26.13	.00
39.80	44.00	3.20	13.11	19.29	24.53	19.64	.00
48.10	43.00	5.00	12.47	18.34	23.94	19.12	.00
58.70	37.00	8.90	2.57	3.78	3.49	3.17	.00
54.60	69.00	3.20	7.56	11.12	14.14	11.33	.00
47.90	86.00	3.10	5.07	7.46	13.71	11.00	.00
47.40	46.00	7.70	19.77	29.09	29.09	25.09	.00
46.50	39.00	4.80	14.63	21.52	28.87	23.00	.00
53.40	42.00	8.60	24.48	36.01	33.89	30.37	.00
54.10	73.00	5.00	8.91	13.11	17.11	13.67	.00
58.40	74.00	3.40	5.43	7.99	13.71	10.94	.00
61.00	85.00	5.00	5.17	7.61	9.93	7.93	.00
63.10	80.00	8.90	7.87	11.58	10.70	9.72	.00
58.20	59.00	4.90	11.20	16.48	21.80	17.39	.00
60.50	49.00	4.20	12.75	18.76	27.60	21.91	.00
62.60	37.00	9.50	31.08	45.73	40.83	38.18	.00
55.00	35.00	6.30	23.98	35.27	39.70	32.61	.00
63.90	22.00	15.90	60.69	89.28	63.27	82.60	.00
51.20	62.00	5.10	14.02	20.62	26.57	21.25	.00
52.70	52.00	7.30	21.50	31.63	32.61	27.69	.00
47.40	59.00	5.00	15.46	22.74	29.67	23.70	.00
46.50	62.00	12.10	34.59	50.89	40.43	43.21	.00
46.00	28.00	9.40	32.06	47.17	42.35	39.40	.00
51.00	29.00	6.60	29.69	43.68	41.09	36.83	.00
53.60	31.00	5.40	20.15	29.64	36.77	29.36	.00
56.20	34.00	3.90	15.27	22.46	34.83	27.67	.00
56.60	37.00	6.60	23.75	34.94	38.23	31.69	.00
62.90	63.00	13.80	27.85	40.97	30.74	35.95	.00
64.10	82.00	9.70	8.58	12.62	11.15	10.53	.00
64.20	89.00	8.30	6.72	9.89	9.49	8.39	.00
64.00	43.00	9.30	30.45	44.79	40.44	37.45	.00

3550.0 ACRES

18.3 27.0 27.7 25.1 31 31 10377 310377

BELEWS CREEK STEAM STATION (CONT'D,
MARCH 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
58.30	41.00	4.60	18.10	26.63	36.77	29.24	.00
64.30	80.00	10.30	18.67	27.46	23.55	22.91	.00
68.00	65.00	6.10	14.48	21.30	24.46	19.98	.00
51.30	95.00	7.90	18.74	27.57	27.18	23.63	.00
53.30	64.00	6.70	20.59	30.30	32.85	27.31	.00
47.50	38.00	0.00		DOES NOT COMPUTE			2.00
47.80	51.00	0.00		DOES NOT COMPUTE			2.00
k@							
57.50	36.00	0.00		DOES NOT COMPUTE			2.00
47.80	33.00	0.00		DOES NOT COMPUTE			2.00
59.30	47.00	0.00		DOES NOT COMPUTE			2.00
68.20	50.00	0.00		DOES NOT COMPUTE			2.00
68.70	50.00	3.90	10.23	15.05	23.34	18.54	.00
66.90	50.00	3.20	9.05	13.32	23.90	19.13	.00
70.20	47.00	0.00		DOES NOT COMPUTE			2.00
65.60	74.00	0.00		DOES NOT COMPUTE			2.00
66.00	54.00	0.00		DOES NOT COMPUTE			2.00
*							
67.60	58.00	0.00		DOES NOT COMPUTE			2.00
66.60	63.00	3.00	9.64	14.18	26.73	21.48	.00
68.50	67.00	4.30	12.35	18.18	26.30	20.88	.00
66.50	75.00	5.20	14.29	21.02	26.73	21.41	.00
66.50	77.00	4.10	11.46	16.85	25.22	20.02	.00
69.30	68.00	10.10	30.49	44.86	38.84	37.41	.00
67.40	83.00	10.10	24.95	36.70	31.77	30.60	.00
62.30	77.00	7.40	24.74	36.40	37.24	31.74	.00
58.10	50.00	6.10	28.86	42.45	48.75	39.81	.00
51.30	54.00	7.10	33.68	49.54	51.91	43.76	.00
57.90	49.00	8.40	35.81	52.67	50.20	44.59	.00
66.50	48.00	10.70	40.38	59.40	49.99	49.64	.00
0.00	0.00	5.90		DOES NOT COMPUTE			2.00
*							
0.00	0.00	4.10		DOES NOT COMPUTE			2.00

3550.0 ACRES

20.9 30.8 33.7 29.0 30 18 10477 300477

BELEWS CREEK STEAM STATION (cont'd)
APRIL 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
0.00	0.00	4.00		DOES NOT COMPUTE			2.00
72.10	67.00	7.50	18.34	26.98	27.39	23.43	.00
69.10	72.00	5.40	14.50	21.33	26.46	21.27	.00
69.00	76.00	5.90	16.19	23.82	27.92	22.69	.00
69.70	76.00	6.00	16.32	24.01	27.85	22.69	.00
73.20	65.00	4.20	13.35	19.64	28.89	22.94	.00
70.50	75.00	3.90	13.39	19.70	30.54	24.26	.00
69.00	57.00	5.30	24.16	35.54	44.63	35.31	.00
55.70	36.00	12.10	72.19	106.20	84.38	70.17	.00
52.20	42.00	8.70		DOES NOT COMPUTE			2.00
57.30	33.00	3.80		DOES NOT COMPUTE			2.00
62.30	43.00	4.10		DOES NOT COMPUTE			2.00
70.00	42.00	5.90		DOES NOT COMPUTE			2.00
73.70	48.00	4.70		DOES NOT COMPUTE			2.00
69.10	50.00	4.90		DOES NOT COMPUTE			2.00
67.10	60.00	4.60		DOES NOT COMPUTE			2.00
76.00	57.00	5.00	20.87	30.70	40.07	32.00	.00
75.70	57.00	3.00	13.33	19.64	37.02	29.74	.00
72.70	62.00	3.70	15.83	23.29	36.11	28.69	.00
74.00	61.00	3.70	23.52	34.60	40.57	32.77	.00
70.30	65.00	3.60	15.44	22.71	37.02	27.71	.00
72.10	68.00	3.70	15.62	22.98	35.64	[illegible]	[illegible]
72.10	72.00	3.90	14.74	21.69	33.65	22.71	[illegible]
66.30	83.00	7.00	25.27	37.18	39.28	32.[illegible]	.00
67.10	87.00	6.40	18.41	27.08	30.19	24.[illegible]	[illegible]
63.90	84.00	3.60	10.71	16.05	26.35	21.[illegible]	.00
70.60	75.00	3.50	11.59	17.05	25.61	22.30	.00
72.80	63.00	3.20	14.64	21.54	38.65	30.94	.00
75.90	66.00	3.70	14.70	21.63	34.84	27.71	.00
68.10	86.00	5.40	18.48	27.18	33.72	27.11	.00
70.00	85.00	3.80	11.59	17.05	26.94	21.41	.00

3550.0 ACRES

18.8 27.7 35.5 29.6 31 23 10577 310577

BELEWS CREEK STEAM STATION (cont'd)
MAY 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
[illegible]	[illegible]	7.20	22.95	[illegible]	[illegible]	27.73	[illegible]
72.70	[illegible]	4.40	21.27	[illegible]	[illegible]	[illegible]	.00
70.40	49.00	5.00	27.26	[illegible]	[illegible]	[illegible]	[illegible]
71.40	55.00	4.20	22.11	32.32	47.85	[illegible]	[illegible]
77.10	51.00	5.70	29.60	43.53	51.06	41.47	.00
73.20	62.00	9.00	41.02	60.34	55.42	50.80	.00
82.40	41.00	8.90		DOES NOT	COMPUTE		2.00
81.20	32.00	4.30		DOES NOT	COMPUTE		2.00
86.10	33.00	12.70		DOES NOT	COMPUTE		2.00
68.00	39.00	7.90	39.51	55.13	57.30	47.52	.00
68.30	48.00	4.40	19.72	29.[illegible]	41.31	32.81	.00
71.30	64.00	3.10	11.95	17.53	32.32	25.92	.00
73.70	63.00	3.70	13.52	19.89	32.04	25.40	.00
70.20	83.00	3.80	12.38	18.21	28.77	22.36	.00
72.00	77.00	4.20	13.49	19.85	29.20	23.18	.00
74.40	74.00	2.70	10.20	15.00	30.69	24.35	.00
76.10	70.00	6.80	26.20	38.54	41.42	34.56	.00
77.60	69.00	6.70	24.95	36.70	39.80	33.09	.00
80.10	56.00	6.90	30.90	45.46	48.44	40.55	.00
79.00	56.00	7.70	35.02	51.53	51.33	44.44	.00
78.20	47.00	7.30	39.36	57.90	59.69	50.69	.00
71.10	64.00	4.00	20.37	29.97	45.64	36.24	.00
64.20	92.00	6.70	27.53	40.50	43.91	36.51	.00
68.90	88.00	4.00	14.54	21.39	32.37	25.86	.00
73.70	85.00	3.40	16.86	24.80	30.77	24.73	.00
77.70	73.00	5.00	17.58	25.86	33.75	26.90	.00
77.70	71.00	3.20	12.02	17.68	31.73	25.39	.00
79.40	68.00	5.90		DOES NOT	COMPUTE		2.00
80.40	64.00	7.20		DOES NOT	COMPUTE		2.00
79.40	64.00	6.20		DOES NOT	COMPUTE		2.00

3550.0 ACRES

22.9 33.7 41.6 34.2 30 24 10677 300677

BELEWS CREEK STEAM STATION (cont'd)
JUNE 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
80.40	64.00	9.30		DOES NOT COMPUTE			2.00
76.40	60.00	4.20		DOES NOT COMPUTE			2.00
76.20	55.00	4.30		DOES NOT COMPUTE			2.00
80.50	58.00	5.30		DOES NOT COMPUTE			2.00
79.50	67.00	3.00		DOES NOT COMPUTE			2.00
84.00	59.00	3.90		DOES NOT COMPUTE			2.00
86.90	53.00	4.20		DOES NOT COMPUTE			2.00
87.50	54.00	4.00		DOES NOT COMPUTE			2.00
83.20	67.00	5.80		DOES NOT COMPUTE			2.00
80.00	68.00	4.80		DOES NOT COMPUTE			2.00
75.10	83.00	4.30		DOES NOT COMPUTE			2.00
77.80	71.00	4.60		DOES NOT COMPUTE			2.00
82.60	65.00	3.60		DOES NOT COMPUTE			2.00
84.40	66.00	2.60		DOES NOT COMPUTE			2.00
82.10	61.00	3.00		DOES NOT COMPUTE			2.00
83.80	58.00	2.90		DOES NOT COMPUTE			2.00
85.50	54.00	7.60		DOES NOT COMPUTE			2.00
86.10	55.00	7.90		DOES NOT COMPUTE			2.00
86.60	53.00	7.10		DOES NOT COMPUTE			2.00
87.20	53.00	6.20	51.56	75.86	84.23	70.62	.00
87.10	57.00	3.90	30.40	44.72	69.34	55.08	.00
78.90	71.00	5.40	39.82	58.58	72.65	58.41	.00
74.40	55.00	4.70	43.99	64.71	55.60	68.23	.00
78.80	52.00	8.60	71.63	105.38	99.15	88.87	.00
80.10	59.00	11.50	80.38	118.34	96.41	97.81	.00
78.00	55.00	6.10	45.13	66.41	76.26	62.28	.00
72.10	47.00	7.10	56.36	82.92	86.86	73.25	.00
71.90	56.00	4.20	32.99	48.53	71.39	56.82	.00
72.50	67.00	6.10	43.29	63.67	73.13	59.73	.00
78.40	60.00	6.50	42.78	62.94	69.51	57.43	.00
81.30	53.00	4.70	32.87	48.36	65.80	52.37	.00

3550.0 ACRES

47.6 70.1 79.4 66.9 31 12 10777 310777

BELEWS CREEK STEAM STATION (cont'd)
JULY 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
[illegible]	[illegible]	[illegible]	33.93	47.91	60.32	48.8[illegible]	[illegible]
78.[illegible]	[illegible]	8.30	37.[illegible]	53.45	62.07	[illegible]	[illegible]
78.30	77.00	5.10	44.24	72.[illegible]	58.16	[illegible]	[illegible]
77.00	72.00	7.70	51.73	73.[illegible]	[illegible]	48.71	[illegible]
81.00	60.00	5.10	40.71	60.21	58.53	51.71	[illegible]
83.80	62.00	7.30	40.21	59.15	60.05	51.[illegible]	[illegible]
84.20	62.00	8.90	43.36	71.43	65.79	59.97	[illegible]
80.40	67.00	5.00	44.67	65.75	64.36	55.20	[illegible]
78.60	65.00	3.10	30.72	43.20	58.22	46.34	.00
79.90	67.00	6.30	33.51	53.65	62.56	51.65	.00
77.30	71.00	6.40	38.75	57.04	65.59	52.38	.00
79.60	67.00	4.90	28.74	42.28	55.73	44.61	.00
78.30	67.00	7.60	43.12	66.47	65.99	57.14	.00
75.30	80.00	7.90	40.30	60.02	59.16	51.4[illegible]	.00
76.30	80.00	5.10	26.03	38.29	49.32	39.44	.00
77.30	80.00	5.60	27.08	39.84	48.28	38.96	.00
76.30	82.00	9.50	45.51	66.95	59.79	53.90	.00
67.80	80.00	4.10	24.45	35.96	53.80	42.70	.00
69.60	67.00	3.10	19.69	28.96	53.25	40.70	.00
72.10	63.00	3.40	20.91	30.76	52.74	42.05	.00
72.00	77.00	3.10	26.74	39.34	50.67	40.32	.00
72.90	80.00	3.30	27.48	40.43	49.87	39.92	.00
72.70	79.00	4.80	22.07	32.46	43.35	34.69	.00
74.00	78.00	7.20	34.88	51.31	53.32	45.11	.00
69.30	78.00	3.20	16.68	39.24	47.91	37.97	.00
70.30	77.00	3.50	17.53	25.79	43.27	34.48	.00
75.10	78.00	3.70	17.50	25.74	39.91	31.70	.00
77.50	74.00	6.00	26.32	38.73	44.93	36.60	.00
78.20	66.00	5.10	25.91	38.12	49.10	39.26	.00
78.60	70.00	5.60	26.68	39.25	47.57	38.37	.00

3550.0 ACRES

32.8 48.3 55.4 46.3 30 30 10877 [illegible]

BELEWS CREEK STEAM STATION (cont'd)

AUGUST 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
75.90	75.00	3.80	17.51	25.75	40.69	32.34	.00
80.30	67.00	4.20	21.45	31.56	46.41	36.33	.00
80.40	63.00	4.70	25.64	37.72	51.32	40.55	.00
79.60	67.00	5.50	28.60	42.07	51.38	41.34	.00
78.60	70.00	4.80	24.31	35.76	47.97	38.22	.00
77.80	74.00	6.40	31.77	46.74	52.10	42.72	.00
78.50	69.00	3.50	18.99	27.94	46.89	37.36	.00
72.00	94.00	6.00	24.00	35.31	40.96	33.36	.00
68.60	78.00	9.70	37.28	54.85	48.46	45.76	.00
67.30	93.00	7.50	29.16	42.90	43.55	37.26	.00
73.70	83.00	7.10	27.23	40.06	41.97	35.38	.00
70.10	55.00	6.20	36.29	53.38	60.68	49.69	.00
66.40	62.00	4.90	28.76	42.30	55.96	44.64	.00
71.70	70.00	9.70	44.95	66.13	58.43	55.17	.00
77.30	72.00	8.50	33.11	48.71	46.13	41.16	.00
70.40	78.00	5.90	26.36	38.78	45.47	36.95	.00
66.60	93.00	5.70	23.35	34.35	41.17	33.29	.00
74.20	87.00	6.10	21.89	32.20	36.97	30.20	.00
75.30	80.00	5.60	23.18	34.10	41.33	35.35	.00
76.80	72.00	6.90	30.59	45.00	47.95	40.14	.00
75.50	69.00	3.00	25.57	37.62	49.10	39.21	.00
69.10	63.00	5.80	35.25	51.85	61.45	49.81	.00
65.80	75.00	3.70	22.14	32.58	52.46	41.73	.00
69.20	76.00	4.70	26.09	38.38	52.22	41.56	.00
73.10	72.00	7.90	40.99	60.30	59.44	51.68	.00
75.10	71.00	6.80	33.84	49.79	53.51	44.64	.00
75.40	76.00	9.20	40.20	59.14	53.69	49.48	.00
73.20	70.00	5.90	29.75	43.77	51.32	41.70	.00
67.20	64.00	7.40	43.44	63.91	65.38	55.73	.00
63.90	63.00	4.10	24.27	35.70	53.41	42.40	.00

3550.0 ACRES

29.2 43.0 49.9 41.5 30 30 310877 290977

BELEWS CREEK STEAM STATION (cont'd)
SEPTEMBER 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
69.00	92.00	10.50	37.11	54.59	46.37	45.58	.00
72.30	78.00	8.90	32.78	48.23	44.56	40.49	.00
57.30	55.00	9.20	54.55	80.25	72.86	67.15	.00
57.50	36.00	5.40	30.19	44.41	55.07	44.23	.00
59.00	67.00	4.90	25.32	37.25	49.27	39.30	.00
61.60	73.00	5.20	23.46	34.52	43.89	35.16	.00
59.00	67.00	5.50	25.93	38.15	46.77	37.67	.00
59.20	88.00	3.80	14.71	21.64	34.18	27.16	.00
64.70	72.00	10.50	39.28	58.67	49.84	48.93	.00
51.90	69.00	4.60	22.48	33.07	45.66	36.31	.00
56.10	80.00	5.20	22.41	32.96	41.92	33.57	.00
55.00	64.00	6.10	29.50	43.39	49.83	40.69	.00
44.60	93.00	10.50	44.58	65.58	55.70	54.75	.00
49.60	79.00	8.80	35.72	52.55	48.84	44.18	.00
49.00	72.00	9.90	44.74	65.81	57.55	54.86	.00
0.00	0.00	8.30		DOES NOT	COMPUTE		2.00
52.00	36.00	9.00	43.18	63.52	58.34	53.26	.00
54.30	58.00	7.00	28.74	42.27	44.66	37.52	.00
55.50	57.00	7.00	28.37	41.74	44.10	37.04	.00
54.70	60.00	5.30	20.90	30.75	38.62	30.99	.00
53.90	74.00	3.30	12.51	18.41	32.27	25.79	.00
60.00	67.00	4.70	16.87	24.81	33.76	26.87	.00
58.20	70.00	7.20	23.68	34.84	36.21	30.63	.00
56.10	64.00	6.60	21.89	32.21	35.24	29.21	.00
59.60	79.00	6.40	16.15	23.76	26.49	21.82	.00
62.00	94.00	6.90	9.95	14.64	15.60	13.06	.00
63.80	93.00	5.40	10.94	16.09	19.96	16.05	.00
65.80	84.00	5.30	12.30	18.09	22.72	18.22	.00
61.20	60.00	7.70	26.65	39.20	39.21	33.81	.00
53.80	52.00	6.10	26.34	38.75	44.49	36.34	.00
50.60	70.00	8.10	29.03	42.71	41.52	36.40	.00

3550.0 ACRES

27.0 39.8 42.5 36.6 31 30 11077 311077

BELEWS CREEK STEAM STATION (cont'd)
OCTOBER 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
55.60	80.00	9.60	23.92	35.20	31.26	29.37	.00
59.80	97.00	7.70	10.22	15.04	15.04	12.97	.00
64.60	97.00	2.40	3.39	4.98	5.55	4.57	.00
69.10	92.00	4.60	2.98	4.39	6.06	4.82	.00
67.70	96.00	6.30	2.79	4.11	4.62	3.80	.00
65.70	93.00	8.00	5.10	7.50	7.34	6.41	.00
64.50	83.00	6.30	11.54	16.98	19.11	15.70	.00
62.00	88.00	3.30	7.02	10.33	18.11	14.47	.00
62.70	82.00	4.30	9.82	14.44	20.90	16.57	.00
59.70	60.00	14.00	45.66	67.17	50.10	57.21	.00
45.90	37.00	8.00	33.42	49.17	48.13	42.02	.00
40.10	44.00	9.60	39.30	57.81	51.35	48.24	.00
38.20	43.00	7.50	29.60	43.55	44.20	37.82	.00
48.30	49.00	6.70	22.72	33.42	36.24	30.14	.00
51.80	43.00	9.20	30.32	44.60	40.49	37.32	.00
58.10	63.00	10.90	22.26	32.75	27.32	27.41	.00
60.50	59.00	11.50	24.81	36.50	29.69	30.74	.00
52.20	31.00	7.40	27.03	39.77	40.68	34.68	.00
48.60	52.00	2.00	6.40	9.41	24.56	20.40	.00
47.40	65.00	3.20	9.44	13.88	24.91	19.94	.00
55.00	73.00	4.50	10.35	15.22	21.34	16.96	.00
52.10	89.00	5.60	10.91	16.05	17.45	15.70	.00
41.50	93.00	6.40	13.34	19.63	21.88	18.02	.00
51.90	86.00	5.20	8.39	12.34	15.69	12.57	.00
43.60	89.00	7.10	13.60	20.01	20.97	17.68	.00
32.60	50.00	11.50	34.66	50.99	41.47	42.93	.00
31.40	48.00	4.70	15.12	22.24	30.26	24.08	.00
42.00	77.00	5.20	12.14	17.86	22.71	18.19	.00
43.00	73.00	7.30	15.29	22.49	23.19	19.69	.00
40.90	97.00	7.30	10.68	15.72	16.20	13.76	.00

3530.0 ACRES

17.1 25.1 26.0 23.2 30 30 11177 301177

BELEWS CREEK STEAM STATION (cont'd)
NOVEMBER 1977

TAMB	HUM	WIND	QH	QC	QM	QB	QUAL
50.70	38.00	6.70	9.44	13.89	15.06	12.52	.00
48.20	60.00	4.90	13.95	19.20	25.40	20.26	.00
48.70	74.00	7.20	16.07	23.65	24.58	20.79	.00
51.10	70.00	5.90	12.01	17.67	20.71	16.83	.00
48.60	94.00	7.10	9.33	13.73	14.39	12.15	.00
41.10	60.00	11.30	31.09	45.73	37.20	33.51	.00
26.50	52.00	8.50	24.80	36.48	34.54	30.82	.00
32.60	50.00	6.70	18.36	27.00	29.28	24.35	.00
37.10	48.00	12.30	33.01	48.55	38.30	41.36	.00
25.10	47.00	5.80	16.42	24.16	28.63	23.21	.00
29.60	44.00	4.10	11.98	17.63	26.37	20.74	.00
33.80	49.00	7.20	20.96	30.83	32.04	27.11	.00
45.30	61.00	6.30	13.62	20.04	22.56	18.53	.00
53.90	95.00	5.60	4.35	6.40	7.75	6.26	.00
52.80	74.00	3.30	5.93	8.72	15.30	12.22	.00
43.90	87.00	4.00	7.59	11.17	17.01	13.51	.00
43.90	93.00	6.40	9.86	14.51	16.17	13.32	.00
47.60	90.00	5.40	7.88	11.59	14.38	11.36	.00
48.10	64.00	4.20	10.49	15.43	22.70	18.02	.00
39.90	93.00	5.30	10.26	15.09	18.95	15.21	.00
38.60	71.00	7.30	15.06	22.15	22.84	19.39	.00
35.50	55.00	7.40	21.12	31.07	31.78	27.09	.00
38.60	67.00	8.90	22.47	33.06	30.55	27.76	.00
48.20	77.00	9.50	16.05	23.62	21.09	19.72	.00
48.30	57.00	12.00	25.74	37.87	30.20	32.10	.00
27.30	48.00	9.10	25.23	37.11	33.39	31.09	.00
29.90	55.00	7.40	19.10	28.10	25.74	24.50	.00
27.60	54.00	6.20	16.19	23.82	27.07	22.17	.00
33.60	56.00	6.30	16.04	23.60	26.57	21.82	.00
35.40	83.00	5.30	10.73	15.79	19.83	15.91	.00
40.40	85.00	5.90	8.37	12.31	14.43	11.73	.00

3550.0 ACRES

15.6 22.9 24.1 21.0 31 31 11277 311277

BELEWS CREEK STEAM STATION (cont'd)
DECEMBER 1977

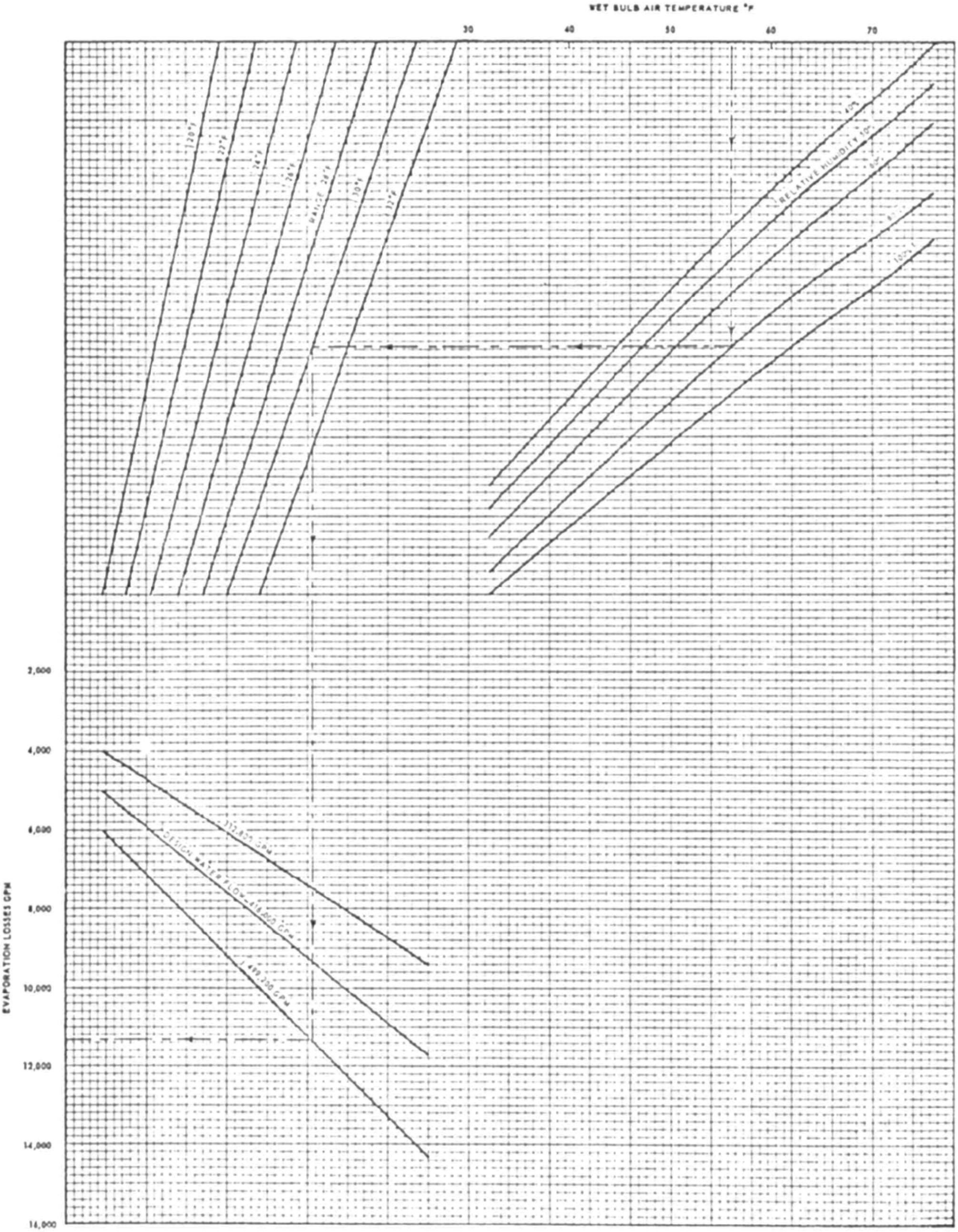
APPENDIX E

CURVES FOR DETERMINING HOMER CITY STATION COOLING TOWER EVAPORATION LOSSES

HOMER CITY STATION

UNITS 1 & 2

COOLING TOWERS EVAPORATION LOSSES

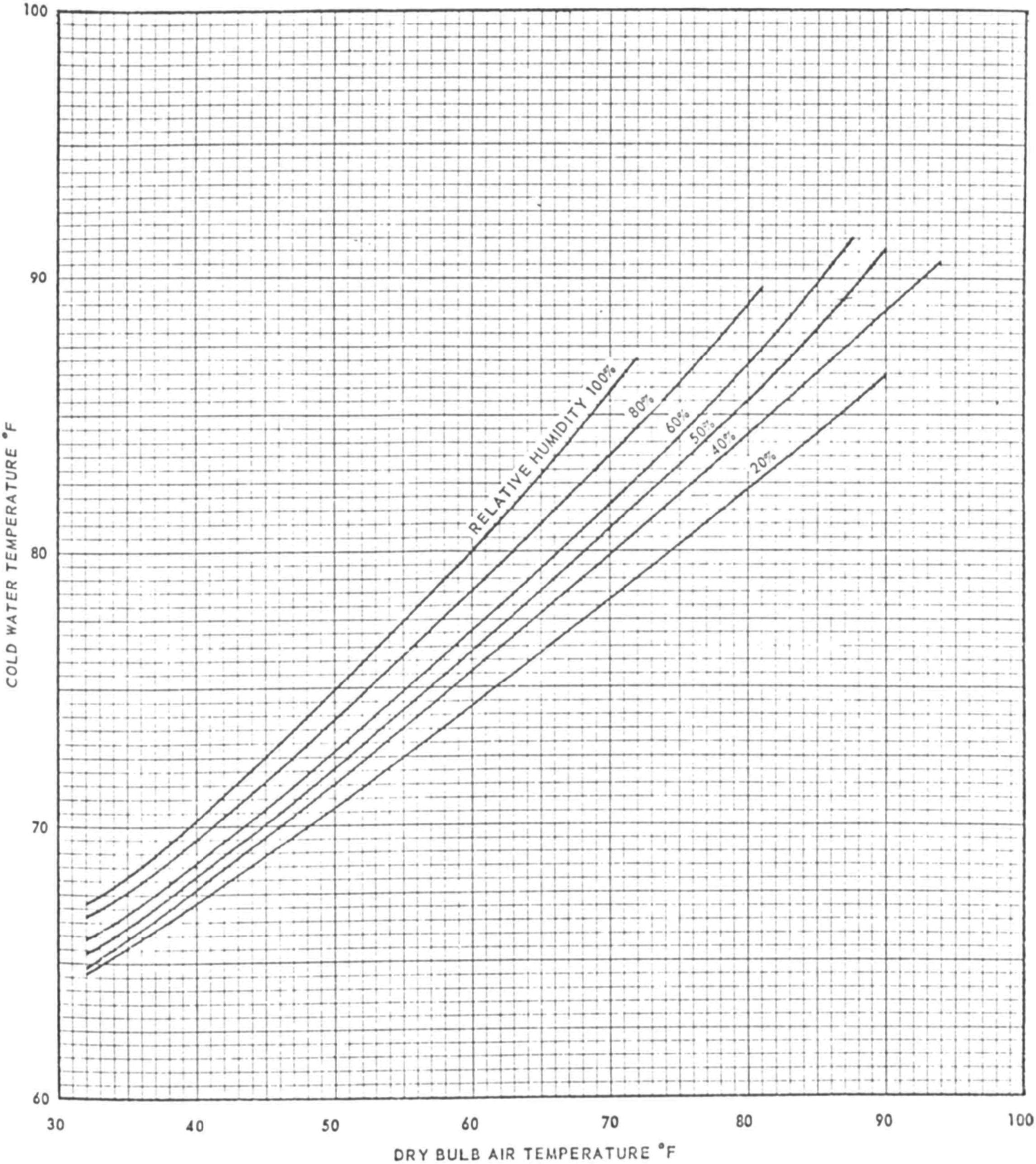


E-1

GILBERT ASSOCIATES, INC.

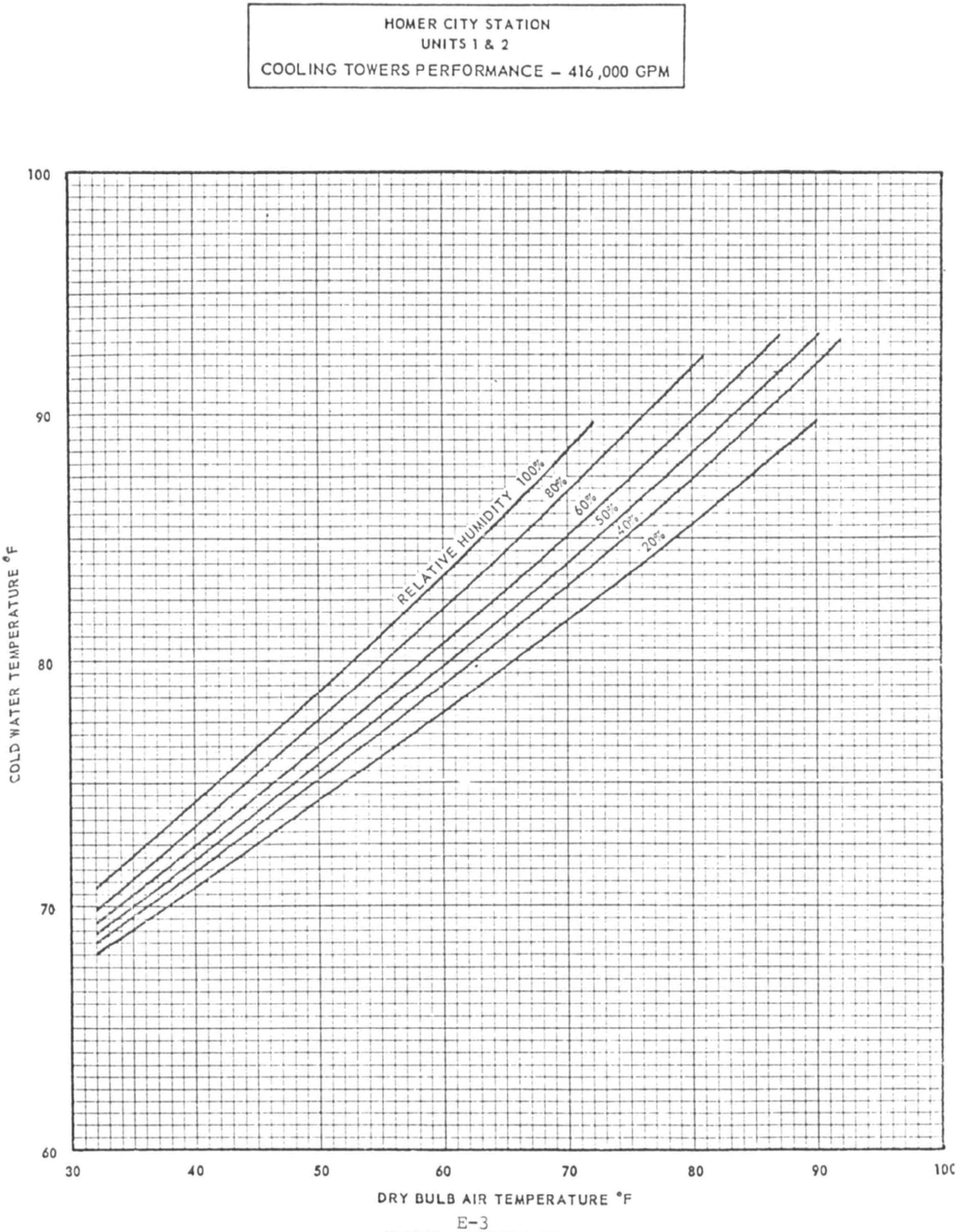
Figure E-1.

HOMER CITY STATION
UNITS 1 & 2
COOLING TOWERS PERFORMANCE – 332,800 GPM



GILBERT ASSOCIATES, INC. 4150-700-040

Figure E-2.



GILBERT ASSOCIATES, INC.

Figure E-3.

TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO. EPA-600/7-78-206	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Comparison of Model Predictions and Consumptive Water Use of closed Cycle Cooling Systems		5. REPORT DATE November 1978 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Jerome B. Strauss		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Versar, Inc. 6621 Electronic Drive Springfield, Virginia 22151		10. PROGRAM ELEMENT NO. EHE624A 11. CONTRACT/GRANT NO. 68-02-2618, Task 3
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15. SUPPLEMENTARY NOTES IERL-RTP project officer is Theodore G. Brna, Mail Drop 61, 919/541-2683.		

16. ABSTRACT The report gives results of a comparison of field-data-derived water evaporation rates with predictive model values for cooling towers and cooling ponds at steam-electric generating plants. The Leung Moore cooling tower model and five cooling pond models (Harbeck and Marciano; Harbeck; Harbeck, Koberg, and Hughes; Meyer; and Brady et al.) were used in the study. Plant data from 13 utilities (16 cooling tower systems and 7 cooling ponds) and for 5 water resource regions were utilized. Generally, the Leung and Moore tower model predicted evaporation rates to within + or - 15% of the plant-data-derived rates for baseload plants, but overpredicted evaporation rates for plants with low capacity factors. Of the pond models, the Harbeck, Koberg, and Hughes (Lake Colorado City) and the Meyer models best predicted evaporation rates, although neither was always within + or - 15% of the plant-data-derived rates. For the water resource regions included in the study, ponds generally exhibited higher consumptive water use than towers.

17. KEY WORDS AND DOCUMENT ANALYSIS			
a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution Cooling Systems Evaporation Water Consumption Mathematical Models Cooling Towers Ponds	Electric Power Plants	Pollution Control Stationary Sources	13B 13A 10B 07D 12A 07A 08H
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