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TFWTEMP COMPUTER MODEL: REVISION AND TESTING

By

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FOREWORD

The "TFWTEMP" temperature computer model, its documentation and user's manual, were developed to be used in the context of timber management in Washington state under the Timber/Fish/Wildlife Agreement. The model authors invite use of, and comments on, this software. We consider this to be shareware, available for T/F/W participants, and not to be sold.

The original TFWTEMP model, which incorporates Washington state stream channel characteristics, was written by John E. Tooley. TFWTEMP uses energy balance equations for stream heat exchange developed for the TEMPEST model by Terry Adams, with POWERBASIC (ver.3.0) code by Jeff Smith.

Regional profiles of solar insolation values were developed in part using the U.S. Fish & Wildlife Service, National Ecology Research Center, SRSOLAR computer model (Theurer and others, 1984).

The authors request that users of the model software give credit when appropriate to the authors and developers. (The correct citation for the research report is "Sullivan, K., J. Tooley, K. Doughty, J.E. Caldwell, and P. Knudsen, 1990. Evaluation of Prediction Models and Characterization of Stream Temperature Regimes in Washington. Washington Dept. of Natural Resources Timber/Fish/Wildlife Report TFW-WQ3-90-006.") All recipient-modified program source code and documentation should acknowledge the appropriate source of the parent computer system and algorithm. Recipients should not represent modified TFWTEMP programs as original products. Rather, reference should be made to the TFWTEMP software and authors, as modified by the recipient.

The model's Washington-state specific stream data would not have been available without the data collection efforts, financial support, and patience of a large number of T/F/W co-operators. These co-operators also provided site specific data upon which the revised model could be tested.

ACKNOWLEDGEMENTS

The following people, agencies and tribes provided site specific stream temperature and channel data used for model testing. Without the dedicated efforts of these individuals this project would not have been possible. Any subsequent use of data reported herein should only be made with the original investigator's consent.

Mr. Ed Rashin. Washington Dept. of Ecology. Data from 1990 RMZ temperature investigations and project management.

Mr. Jim Hatten. Hoh Tribe. Data from the Hoh and Clearwater basins.

Mr. Bruce Baxter. Quinalt Indian Nation. Data from the Clearwater basins.

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Mr. Mike McHenry. Elwah-Klallam Tribe. Data from north coastal streams.

Mr. Phil DeCillis. Quileute Tribe. Data for Olympic coastal streams.

Mr. Jim Matthews. Yakima Indian Nation. Data from eastern Washington.

Mr. Dan Neff. Lummi Indian Nation. Data from Nooksack basin streams.

TFW temperature Work Group. Many TFW co-operators, Kate Sullivan (Weyerhaeuser), John Tooley (DOE), Jean Caldwell (Caldwell Associates), Kent Doughty (Cascades Environmental Services.)

ABSTRACT

In 1988 a study of available stream temperature models was initiated by TFW cooperators. The TEMPEST model was found to perform well and be the most practical stream temperature model available. Although less restrictive than many other models the TEMPEST model requires substantial site specific information including hourly air temperature data. The TFWTEMP model is an adaptation of the TEMPEST model to reduce the data input requirements for modelling stream temperatures. The TFWTEMP model uses regional climate data and estimates of stream channel characteristics to internally generate values for input variables necessary to solve the energy balance equations for stream heat exchange. The model user simply provides information readily available from maps (location, elevation, water quality classification, distance from watershed divide) along with estimates of riparian shade conditions.

The product of this project is TFWTEMP version 7.0. This model, available on diskette, runs on IBM compatible computers. It is designed to evaluate if the incremental increase in stream temperature associated with the harvest of riparian shade trees complies with the Washington water quality standards. The model is applicable to Washington streams only. Modifications in the latest version include improvements to the user interface computer screen prompts and a physical process model for estimating summer climatic conditions at sites to be modelled. Testing of the model at 75 sites throughout Washington indicated average model precision to be 1.9°C, 1.6°C, and 2.7°C for coastal, western, and eastern Washington ecoregions respectively.

INTRODUCTION

A study was undertaken in 1988 by the Temperature Work Group (TWG) of the Cooperative, Monitoring, and Evaluation (CMER) Committee to develop a method to investigate stream temperature on a site and basin scale. Members represented the Departments of Ecology and Fisheries, the forest industry, and the tribes.

The temperature study was designed to generate information for two primary purposes: data was collected from forest streams extensively (92 sites) throughout the state to develop a method to screen for streams potentially exceeding the water quality maximum temperature standard and intensively at a smaller number of sites (33) to evaluate the predictive capabilities of existing reach and basin temperature models. Study sites represented Type 1-3 streams located in all regions of the state having a variety of riparian shading conditions ranging from mature conifer forest to sites completely open and devoid of shade. Results of this project are reported in Sullivan and others (1990).

Subsequent to this study TFW co-operators have been conducting temperature monitoring programs throughout Washington state. A large data base of summer water temperature regimes and the channel conditions affecting these regimes has been collected.

Two products of the original TWG study have been adopted by the Washington Forest Practices Board for review of stream temperature effects from harvest of riparian shade trees. A non-computer based graphical screen is used to evaluate probable maximum stream temperature before and after harvest relative to the water quality standards for maximum water temperature. The primary purpose of the TFWTEMP model is to determine if the incremental change in water temperature associated with harvesting of riparian shade trees is compatible with water quality standards.

Management decisions must be routinely made on a large number of forest practices potentially affecting stream temperatures. The volume and scheduling of forest practice applications does not allow extensive site monitoring for stream temperature modelling; nor are extensive temperature studies typically warranted. In testing five predictive models, Sullivan and others (1990) found the TEMPEST model to perform well and be the most practical stream temperature model available. Although less restrictive than many other models the TEMPEST model requires substantial site specific information including hourly air temperature data. The TFWTEMP model is an adaptation of the TEMPEST model to reduce the data input requirements for modelling stream temperatures. The TFWTEMP model uses regional climate data and estimates of stream channel characteristics to internally generate values for input variables necessary to solve the energy balance equations for stream heat exchange. The model user simply provides information readily available from maps along with estimates of riparian shade conditions.

Preliminary use of the original TFWTEMP model by TFW co-operators quickly identified concerns with the model's mechanics and predictive capabilities. The original model was designed to select an hourly air temperature profile from seven possible regional climate profiles. Selection was based upon a regression relationship between maximum air temperature, elevation and distance of the site from watershed divide, with the user specifying the latter two variables. This regression relationship was developed from the 1988 TWG data. The seven climate profiles differed by a 2°C increment in the maximum daily air temperature. Users expressed concern that the model consistently selected only the two coolest air temperature profiles regardless of user specified site conditions. The model was consistently under-predicting water temperatures; a condition attributed to the problems with selecting a proper climate profile.

There are several purposes to this project. Investigations are made to determine if the model's predictive capability can be improved. Other model improvements have been made to make the model more user friendly. Use of the growing database of Washington stream temperature regimes for testing of the TFWTEMP model is also part of this project.

MODEL REVISIONS

The rational and analytical process for each of the model revisions is discussed. Model revisions are also documented in the source code for the model. Original source code has been left in the document file but is not activated within the program. Leaving old code allows users and programmers to follow the logical progression of model development and changes. The source code is contained in a computer file named tfwtemp.bas. The source code is also printed as an appendix to this report.

Climate Profile Selection

A sensitivity test of the regression equation used to select the air temperature profile demonstrated that for sites typical of the range in conditions at most forested areas only a single profile would be selected. The air temperature profile selected was not consistent with the expected range in climatic conditions along forested streams in Washington. The model's inability to select from the full range of profiles is but one of two problems with the original regression based approach for generating site climate conditions. Air temperature and relative humidity are interdependent and both strongly influence predicted water temperature. Adjusting air temperature without accounting for the corresponding change in relative humidity would seriously affect model predictions.

Developing a physical process model for generating site specific climatic conditions was elected rather than continuing to rely on a regression approach. A physical process model more directly describes the cause and effect relationship between climate and conditions at a particular site.

The National Oceanographic and Atmosphere Administration (NOAA) maintains weather stations throughout the state. Sullivan and others (1990) found the daily air temperature data at three NOAA stations to be most consistently related to a range of forested stream study sites; Olympia for the western Washington, Quillayute for coastal Washington, and Yakima for eastern Washington. The "30 year normal" climate statistics for these three NOAA stations are used by the revised TFWTEMP model as the three base station climate profiles from which site specific climate profiles are generated.

Next, the hourly air temperature profiles required by the TFWTEMP model were constructed. We began with a review of the published 30 year normal monthly maximum and minimum air temperatures at each of the three NOAA stations for July and August. The higher of the two monthly values was then selected. The time of day of the maximum daily temperature was identified. Maximum daily air temperature is reached, on average, at 15 and 14.7 hours for inland sites during July and August respectively (Satterlund and Beach, 1983). No significant difference exists between eastern and western Washington. Maximum daily temperature occurs, on average, at 14.2 hours for coastal areas in July and August. The period between daily maximum and preceding daily minimum air temperature during these months is 10.9 hours for inland areas and 10.2 hours for coastal areas (Satterlund and Beach, 1983).

The equation for describing a Pearson type III distribution was used to generate hourly air temperature profiles based on the 30 year normal maximum NOAA temperature values. When tested against hourly values for a given day the following equation provided the best fit.

$$T_t = T_m + T_r \, [e^{-yt}(1 + t/a)^{ya}]$$

where T = temperature

- t = time, hours before or after time of temperature maximum; subject to $t<0, t \leq a$ and $t>0$, $t \leq 24-a$.
- m = minimum
- a = length (hours) of rising temperature
- r = range
- y = an empirically derived coefficient
  (0.24 @ $t<0$) (0.68 inland; 0.7 coast @ $t>0$), and
- e = base of the natural logarithm (2.718...).

The constructed hourly air temperature profiles for the three NOAA stations are provided in Appendix A.

Air temperature and elevation are correlated because of adiabatic heating (Lutgens and Tarbuck, 1992) with higher elevations typically being cooler. Hourly lapse rates were applied to the NOAA air temperature profile to generate a site specific air temperature profile for model use. (Sufficient data is not available from the TFW data set to develop regional lapse rates.) The lapse rate for the maximum daily air temperature (maxlap) is set at 15.2°C/1,000 m following trial and error testing. The lapse rate for minimum daily temperature is set at 2.8°C/1,000m. Hourly lapse rates for hours between the maximum and minimum daily temperatures are interpolated. These lapse rates can be updated in the future should better information become available. While the maximum lapse rate may be representative for a wide geographic range (Hungerford and others, 1987) the minimum lapse rate is likely low when adjusting from a valley bottom NOAA station to higher elevation creek bottoms. Cool night air tends to sink into the latter locations. However, a higher lapse rate would likely under-predict moderate elevation stream sites.

No adjustment to air temperature was made to account for site aspect. Slopes with a forest canopy exhibit virtually no slope-related differences in surface temperature when the surface is an actively transpiring tree canopy (Kaufmann 1984; Sader, 1986). Insufficient information is available to determine if a minimum riparian shade level exists below which surface temperatures could be affected by site aspect. Any probable effect would likely be of only minor significance, at most, on water temperature.

The lower range of the 30 year normal daily dewpoint for August forms the basis from which site specific relative humidity is calculated. Hungerford and others (1987) report fairly wide horizontal geographic homogeneity in daily dewpoint values. Dewpoint at the NOAA station is corrected for elevation at the model site by a lapse rate of 2.7°C/1,000 m modified slightly to account for radiation load (Finklin, 1983). The estimated site specific dewpoint and air temperature are then combined to calculate the site specific average daylight relative humidity. The daylight relative humidity is further reduced by a fixed percentage to account for daily range in daylight relative humidity. The percentage reduction was determined in the following manner. The TFWTEMP model assumes a constant relative humidity. Since daylight relative humidity does not stay constant during summer months a value most closely approximating relative humidity at the hottest part of the day is selected. An analysis of several years of NOAA data for July and August consistently indicates the following ratios between daylight relative humidity and relative humidity near 4 pm: Quillayute 90%, Olympia 75%, Yakima 70%. Reducing the average daylight relative humidity by this percentage for each region will tend to improve maximum water temperature predictions but may result in under-predicting summer minimum daily water temperatures. The actual equations for calculation of relative humidity can be found in the source code documentation (Appendix B).

Wind speed influences evaporation rate, particularly when relative humidity is low. The TFWTEMP model uses a default wind speed of 6.7 m/s (15 miles/hour).

<u>Model Calculated Channel Conditions</u>

Model input parameters representing stream channel characteristics were calculated as follows. The TFWTEMP model uses regional regression relationships to estimate stream depth as a function of distance from watershed divide. The latter value is readily obtained from a topographic map. Derivation of the regression relationships is reported in Sullivan and others (1990). Revising the regression equations calculating stream depth for coastal and western Washington was investigated; combining new data provided by TFW cooperators with the 1990 TWG data set. Insufficient additional stream depth information was available for eastern Washington sites to merit revision. Predictive ability for stream depth was not improved for coastal and western regions with the combined data set.

The original TFWTEMP model (Sullivan and others, 1990) also used a regression equation to estimate groundwater inflow rate. The inflow rate was subsequently changed to an average value of 0.009 cms/km prior to this model revision. No further investigation of estimating techniques for groundwater inflow rates was made as part of this study. Stream discharge measurements are available only for some of the recent temperature data sets, and do not provide enough data to warrant revision of this value in the model. Summer low flow groundwater inflow rates are known to show considerable local variation and stream discharge measurement techniques are likely to vary considerably between investigators.

Post Harvest Shade Recommendation

The model allows the user to predict stream temperatures for before and after harvest conditions. The user initially provides an estimate of post-harvest shade. If the predicted maximum temperature does not meet the water quality standards the revised model calculates the minimum shade level required to comply with the water quality standard for maximum allowable incremental temperature increase for non-point sources. The required shade level is selected through an iterative modelling process in which the shade level is increased in two percent increments. Model users may find this step to be slow when using older computers with slower processing speeds.

MODEL TESTING

Selection of Test Sites

Temperature records from a total of 130 sites were available for model testing. Data had been collected in various formats: hourly, two-hourly, and maximum/minimum values. A subset of 75 datasets was chosen for model testing; 25 each from coastal Washington, Western Washington, and Eastern ecoregions (figure 1). Since not all sites could be used, the sites were chosen to include as many basins as possible, to include data from all investigators if possible, and to test the revised model over a range of site elevations and shade combinations. Inclusion of the 1990 TWG study sites was considered advantageous in that comparisons between the TEMPEST model predictions and the TFWTEMP model predictions were possible. This comparison allows easier identification of natural variability verses model unpredictability.

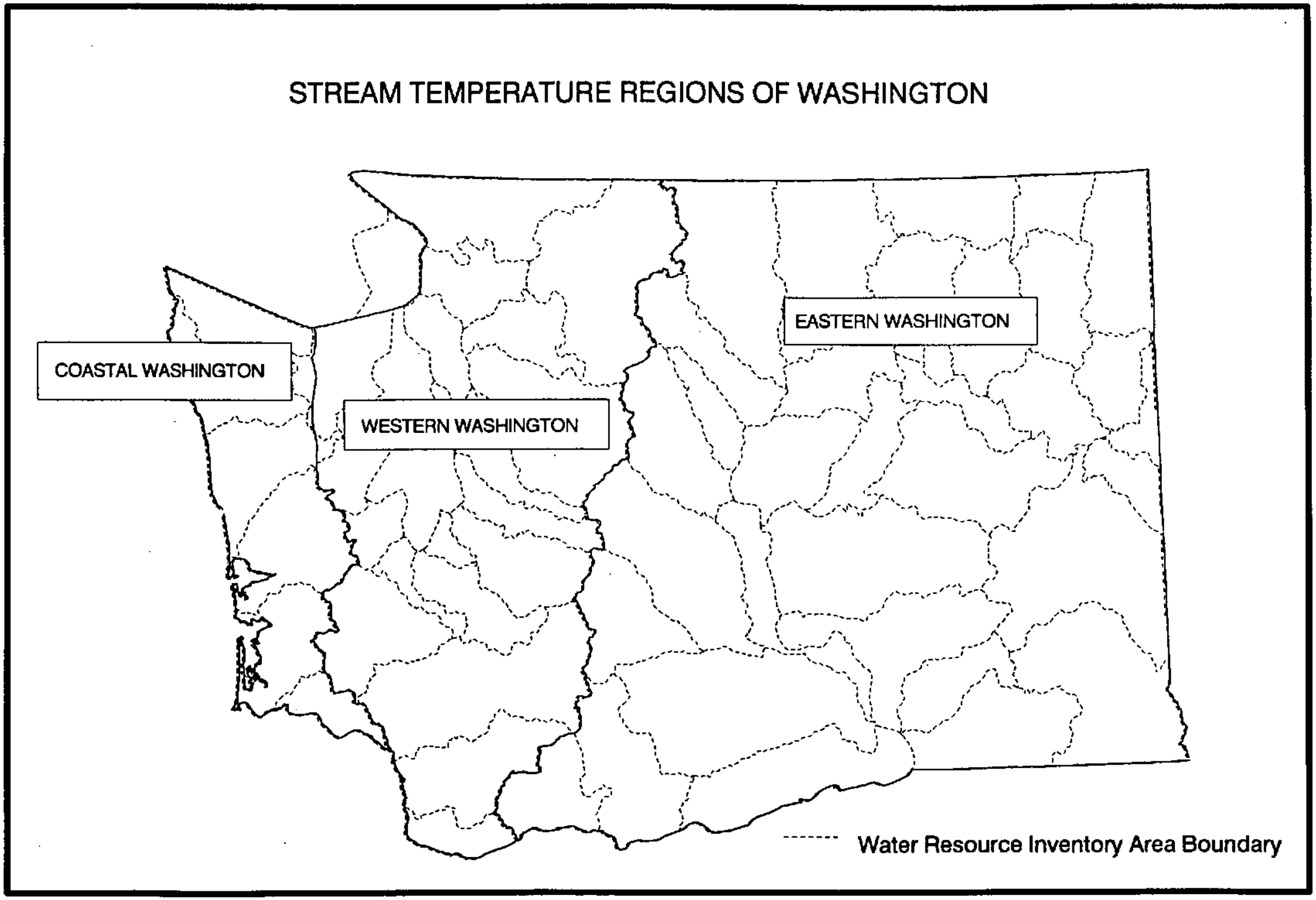

Figure 1: Regional Designations for TFWTEMP Model Testing and Application

Identification of Maximum Recorded and Maximum Equilibrium Temperatures

The TFWTEMP model predictions were tested against two maximum temperature values at each of the sites. The actual recorded maximum temperatures for the period of record as reported by the investigators were used in testing. Days with an obvious extreme outlier were not used. In addition the same data during the period of record within July 15 through August 15 were used after correction for possible instrument error and adjustment for identification of the maximum equilibrium temperature. The logic behind correcting for possible instrument error is intuitive. Adjustment for maximum equilibrium temperature provides a better test of what the model is actually designed to predict. Water temperature can slightly exceed the maximum equilibrium temperature (i.e., the maximum water temperature consistently resulting from the heat flux processes for the site conditions during the hottest period). A short, minor exceedance can result from the heat storage capacity of water and environmental/climatic perturbations of short duration. The TFWTEMP model is a steady state model. It is designed to account for the readily describable heat exchange processes but does not account for short duration perturbations or errors from equipment operation. A discussion of the "adjusted" data set used in testing follows.

Maximum recorded temperatures were chosen as discussed below, and may differ from those reported by each investigator. Elevation, shading level, water quality class and channel data are unmodified from that reported by the investigator and are assumed to be correct.

In order to correctly identify the maximum recorded temperatures, observations from July 15 through August 30 (or whatever portion of that period had a data record) were examined. Data were graphed to check for instrument drift, a single-event high temperature (more likely to be instrument error than correct observation), or periods where a probe was responding oddly (i.e., staying at the same temperature over a diurnal cycle without a corresponding air temperature profile). Data with instrument drift or unexplained long-term errors were not used. Data with single-event high temperatures, or suspect periods, were used with the suspect data deleted. Data where it was noted that investigators had adjusted values from recorded values were not used, unless the investigator clearly stated the reason for the adjustment. Data provided in incompatible spreadsheet format could not be analyzed.

After correcting for instrument error, the maximum equilibrium temperatures were calculated from the recorded data in the following manner. The hourly or two-hourly data sets were imported into STATISTIX 4.0, a simple analytical software program (Siegel, 1985). A frequency analysis was done, using the range of recorded temperatures and 0.5°C steps. An example is in Table 1. The equilibrium maximum temperature for this site was chosen as 19°C, since the top 8% of observations occurred between 18 and 19°C. The two observations above 19°C were not chosen as the maximum temperature, since they are more likely derived from instrumentation error than actual temperatures.

For calculating the maximum equilibrium temperature from the datasets based on maximum/minimum temperature observations, the highest recorded temperature was not used, and the rest of the maximum observations were averaged to estimate the equilibrium maximum. This step was done to try to compensate for the difficulty in reading max/min thermometers the same way over a number of observations or different observers, and the sensitivity of max/min thermometers themselves.

Table 1. Example of output from frequency analysis, using data from Shuett-Hames and McHenry (DOE/Lower elwah), Lower Deep Creek.

FREQUENCY DISTRIBUTION OF HOURLY TEMPERATURES (C°)

Bin Range Low	High	Freq.	Percent	Cumulative Freq.	Cumulative Percent
12.5	13.0	0	0.0	0	0.0
13.0	13.5	0	0.0	0	0.0
13.5	14.0	6	1.0	6	1.0
14.0	14.5	8	1.4	14	2.4
14.5	15.0	12	5.6	46	8.0
15.0	15.5	58	10.1	104	18.2
15.5	16.0	93	16.2	197	34.4
16.0	16.5	95	16.6	292	51.0
16.5	17.0	89	15.5	381	66.5
17.0	17.5	69	12.0	450	78.5
17.5	18.0	73	12.7	523	91.3
18.0	18.5	32	5.6	555	96.9
18.5	19.0	16	2.8	571	99.7
19.0	19.5	2	0.3	573	100.0
19.5	20.0	0	0.0	573	100.0
20.0	20.5	0	0.0	573	100.0
20.5	21.0	0	0.0	573	100.0
Total		573	100.0		100.0

The frequency analysis was done on hourly or two hourly data increments rather than daily maximum values. It was not possible to define daily maximum temperatures in all the data sets due to differences in data format. The use of hourly data is not considered to compromise the results of the frequency analysis in defining the maximum equilibrium temperature.

Maximum Temperature Predictions

Model performance was evaluated by examining the accuracy, precision, consistency, and bias of predicted maximum temperatures. Daily mean and minimum temperatures were not analyzed. The reported results are the highest daily water temperature predictions for the study sites compared to the equilibrium maximum water temperatures. The measure of accuracy used throughout the model testing analysis is the difference between the predicted and recorded temperature, referred to in graphs and tables as the WSTAT, or W-statistic, for convenience. A positive WSTAT indicates the model predicted a higher temperature than actually recorded and the value indicates the magnitude of the difference in degrees centigrade. A WSTAT equal to zero indicates a perfect prediction. Accuracy is the sum of the individual site WSTATS divided by the number of study sites in the testing set. Precision is a measure of how exactly the result is determined, its reproducibility, and is therefor an indicator of confidence in model results. Precision, as measured in this study, is the average error calculated as the absolute value of the WSTAT divided by the number of study sites in the testing set. Consistency represents how well the model performs at a range of sites with varying conditions. Consistency is scored as the percentage of sites where the model predicted the maximum temperature within 1.5°C of the recorded maximum temperature.

Model testing was performed after major modifications to the formulas used by the model. Further adjustment in lapse rates and constant variables used by the model were then made in an effort to improve performance. Following each round of modifications, the testing was repeated.

The results of the latest model testing are reported in figure 2 and table 2. Model accuracy was, on average, within 0.5°C. Precision is a better indicator of model performance since it measures the absolute error (i.e., both over-predictions and under-predictions are accounted for). Precision values are 1.9°C, 1.6°C, and 2.7°C for coastal Washington, Western Washington, and Eastern ecoregions respectively. It is of interest to note that when tested against only the 1990 TWG sites the model had a precision of 1.5°C; comparable with similar precision for the TEMPEST model.

A comparison between testing the model against observed maximum equilibrium temperatures and maximum recorded temperatures showed only minor and insignificant differences with the exception of consistency for predictions at coastal sites. Model consistency with the maximum equilibrium data was 64% compared with 48% when tested against the maximum recorded data. Otherwise, a 0.1°C improvement in the WSTAT performance was observed with testing against the maximum equilibrium data.

Table 2. TFWTEMP model test sites and results.

	COASTAL	DATA SOURCE	TRIB TO	WQ CLASS	ELEVATION (m)	DISTANCE DIVIDE (Km)	SHADE LEVEL (%)	EQUILIBRIUM MAX TEMP (deg C)	RECORDED MAX TEMP (deg C)	PREDICTED MAX TEMP (deg C)	EQUIL. WSTAT (deg C)	RECORDED WSTAT (deg C)	FLOW (cms)	DEPTH (m)
1	Smith Cr BD	TWG	Willapa Bay	A	67	12.8	7	20.2	20.2	18	-2.2	-2.2	0.1	0.6
2	Naselle R BC	TWG	Willapa Bay	A	288	4.1	41	14.4	14.4	18	3.6	3.6	0.02	0.18
3	Bear R BE	TWG	Willapa Bay	A	92	3.5	81	14.5	14.5	17	2.5	2.5	0.03	0.19
4	Ward Cr. Trib. C	RL/TWG	Willapa R	A	12	0.9	95	17	17	17	0.0	0.0	0.005	0.09
5	Green Cr. E	RL/TWG	Pysht River	AA	109	5.1	85	17.1	17.1	16	-1.1	-1.1	0.0051	0.25
6	JimmyComeLately E	RL/TWG	Sequim Bay	A	326	1.8	90	16.2	16.2	16	-0.2	-0.2	0.0065	0.18
7	Maxfield Cr	Quileute	Soleduck R	AA	6	11.6	64	21.0	21.2	17	-4.0	-4.2		
8	Upper Lake Cr	Quileute	Soleduck R	AA	122	5.5	83	14.5	15	16	1.5	1.0		
9	Fluharty Cr	Quileute		A	110	3.2	44	14.9	15.6	19	4.1	3.4		
10	MF Dickey R.	Quileute	Quillayute R	A	85	5.5	80	17.5	18.4	17	-0.5	-1.4		
11	Lower Deep Creek	DOE/L.Elwa	N Coast	AA	3	14.3	67	19.0	19.4	16	-3.0	-3.4		
12	Upper Deep Creek	DOE/L.Elwa	N Coast	AA	37	9.7	58	19	19.9	17	-2.0	-2.9		
13	EF Deep Creek	DOE/L.Elwa	N Coast	AA	37	4.5	28	19.5	19.6	20	0.5	0.4		
14	Maple Cr	Hoh	Hoh	AA	114	8.7	74	16.1	16.8	16	-0.1	-0.8	0.1359	0.18
15	Fisher Cr	Hoh	Hoh	AA	183	2.4	37	21.1	21.9	20	-1.1	-1.9	0.0085	0.06
16	Hoot Cr	Hoh	Hoh	AA	256	2.1	64	17.8	17.8	18	0.2	0.2	0.0170	0.09
17	Owl Cr	Hoh	Hoh	AA	94	11.3	43	18.3	18.9	17	-1.3	-1.9	0.3823	0.18
18	Line Cr	Hoh	Hoh	AA	256	2.5	45	18.0	18.3	19	1.0	0.7	0.0396	0.12
19	Alder Cr	Hoh	Hoh	AA	73	7.6	73	18.1	18.6	17	-1.1	-1.6	0.0340	0.12
20	Canyon Cr	Hoh	Hoh	AA	122	4.0	69	16.2	16.6	18	1.8	1.4	0.0566	0.15
21	Willoughby Cr	Hoh	Hoh	AA	79	4.6	71	18.1	18.8	17	-1.1	-1.8	0.0595	0.12
22	Split Cr	Hoh	Hoh	AA	171	2.7	24	22.5	24.1	21	-1.5	-3.1	0.0170	0.24
23	EF Wilson Cr	Hoh	Clrwtr.	A	293	2.3	67	17.6	18.1	18	0.4	-0.1		
24	Kumamast Cr	Hoh	Clrwtr.	A	195	4.3	36	17.5	18.3	19	1.5	0.7		
25	WF Wilson	Hoh	Clrwtr.	A	293	2.3	33	15.0	15.2	20	5.0	4.8		

Data sources.

Hoh: Hatten, 1993.
TWG: Sullivan and others, 1990.
RL/TWG: Caldwell and others, 1991.
Quileute: Quileute Tribe, 1991.
DOE/L. Elwha: Elwha Klallam Tribe, 1992.

Table 2. TFWTEMP model test sites and results.

WESTERN	DATA SOURCE	TRIB TO	WQ CLASS	ELEVATION (m)	DISTANCE DIVIDE (Km)	SHADE LEVEL (%)	EQUILIBRIUM MAX TEMP (deg C)	RECORDED MAX TEMP (deg C)	PREDICTED MAX TEMP (deg C)	EQUIL. WSTAT (deg C)	RECORDED WSTAT (deg C)	FLOW (cms)	DEPTH (m)
1 Canyon Lake Cr.	Lummi	Nooksack	AA	116	9.5	16	19	20	20	1	0		
2 Hutchinson Cr.	Lummi	Nooksack	A	98	11.7	69	16	16	17	1	1		
3 SF Nooksack R.	Lummi	Nooksack	AA	146	35.4	55	22.5	24	19	-3.5	-5		
4 Gallop Cr.	Lummi	Nooksack	AA	270	6.0	59	20.5	21	18	-2.5	-3		
5 Hanaford F	RL/TWG	Skookumchuck	A	260	1.3	70	15	15	17	2	2	0.0275	0.14
6 Thorn H	RL/TWG	Deschutes	AA	363	4.9	50	12.5	12.5	17	4.5	4.5	0.0202	0.28
7 Abernathy BA	TWG	Lower Columbia	A	178	7.4	67	15.8	15.8	17	1.2	1.2	0.2	0.27
8 S Prairie IC	TWG	Puyallup	A	527	7.7	57	12.4	12.4	16	3.6	3.6	0.21	0.26
9 Herrington Cr. AO	TWG	Toutle	AA	375	6.3	36	17.1	17.1	18	0.9	0.9	0.07	0.19
10 Greenwater ID	TWG	White R	AA	705	21.0	5	15.7	15.7	17	1.3	1.3	0.77	0.25
11 Hoffstat Cr. AQ	TWG	Toutle	AA	587	7.3	0	22	22	19	-3	-3	0.1	0.23
12 Schultz Cr. AB	TWG	Toutle	AA	540	7.3	6	19.9	19.9	19	-0.9	-0.9	0.04	0.29
13 Pilchuck Cr DB	TWG	Pilchuck	A	49	16.5	63	16.2	17	17	0.8	0	0.1	0.21
14 Deschutes R. AF	TWG	Deschutes	A	168	26.5	33	18.6	18.6	18	-0.6	-0.6	1.14	0.29
15 Porter Cr AP	TWG	Chehalis	A	109	13.2	88	15.6	15.6	16	0.4	0.4	0.13	0.23
16 Thurston Cr. AD	TWG	Deschutes	A	292	5.2	60	14.8	14.8	17	2.2	2.2	0.12	0.22
17 Pilchuck R. DA	TWG	Pilchuck	A	38	18.5	5	19.1	19.1	20	0.9	0.9	1.78	0.5
18 L Deschutes Cr. AE	TWG	Deschutes	A	269	9.4	69	15.2	15.2	17	1.8	1.8	0.07	0.23
19 Coweeman R. AK	TWG	Columbia	AA	115	29.1	49	18.2	18.2	17	-1.2	-1.2	1.12	0.44
20 Coweeman AM	TWG	Columbia	A	27	43.8	28	19.1	19.1	18	-1.1	-1.1	1.57	0.54
21 Mulholland Cr AH	TWG	Coweeman	AA	111	13.7	61	18.2	18.2	17	-1.2	-1.2	0.16	0.3
22 Baird Cr AJ	TWG	Coweeman	AA	216	7.9	60	16.3	16.3	17	0.7	0.7	0.28	0.28
23 Huckleberry Cr. AC	TWG	Deschutes	A	197	5.8	83	13.6	13.6	16	2.4	2.4	0.03	0.13
24 Germany Creek BB	TWG	Lower Columbia	A	184	7.9	62	17.5	17.5	17	-0.5	-0.5	0.09	0.32

Data sources.

TWG: Sullivan and others, 1990.

RL/TWG: Caldwell and others, 1991.

Lummi: Lummi Indian Nation, 1992

Table 2. TFWTEMP model test sites and results.

	EASTERN	DATA SOURCE	TRIB TO	WQ CLASS	ELEVATION (m)	DISTANCE DIVIDE (Km)	SHADE LEVEL (%)	EQUILIBRIUM MAX TEMP (deg C)	RECORDED MAX TEMP (deg C)	PREDICTED MAX TEMP (deg C)	EQUIL. WSTAT (deg C)	RECORDED WSTAT (deg C)	FLOW (cms)	DEPTH (m)
1	SF Deep E4	DOE	Kettle River	AA	634	8.9	63	18	18.7	16	-2.0	-2.7		
2	Indian Cr E1	DOE	White Salmon	A	134	8.8	99	19.0	19.2	16	-3.0	-3.2		
3	Bear Cr CA	TWG	Little Naches	AA	956	7.9	37	14.2	14.2	18	3.8	3.8	0.07	0.24
4	SF L. Naches CB	TWG	Naches River	AA	949	16.2	56	13.9	13.9	14	0.1	0.1	0.16	0.26
5	L. Naches R. CC	TWG	Naches River	AA	813	30.0	19	17.1	17.1	17	-0.1	-0.1	1.32	0.37
6	CeeCeeAh Cr EA	TWG	Pend Oreille	A	1048	6.1	30	11.9	11.9	18	6.1	6.1	0.03	0.14
7	Chamokane Cr EB	TWG	Spokane R	A	446	46.4	7	20.1	20.1	17	-3.1	-3.1	0.72	0.28
8	WP L Klickitat WP1	YIN	Klickitat R	A	725	11.7	30	24.2	24.8	18	-6.2	-6.8		
9	WP L Klickitat WP2	YIN	Klickitat R	A	914	7.5	53	17.3	18	17	-0.3	-1		
10	Butler Creek BU1	YIN	Klickitat R	A	683	16.0	36	23	24.5	18	-5.0	-6.5		
11	Butler Creek BU2	YIN	Klickitat R	A	716	15.1	28	24.2	26	18	-6.2	-8		
12	EP L Klickitat EP1	YIN	Klickitat R	A	707	11.8	47	24	24.5	17	-7.0	-7.5		
13	EP L Klickitat EP2	YIN	Klickitat R	A	896	6.5	62	19.5	20.5	16	-3.5	-4.5		
14	SF Ahtanum SA1	YIN	Yakima R	A	936	14.3	60	15.2	15.6	15	-0.2	-0.6		
15	SF Ahtanum SA2	YIN	Yakima R	A	1106	8.7	64	11.9	12.2	15	3.1	2.8		
16	MF Ahtanum MA1	YIN	Yakima R	A	1006	15.6	38	15.6	15.6	16	0.4	0.4		
17	MF Ahtanum MA2	YIN	Yakima R	A	1271	9.7	55	11.7	11.7	15	3.3	3.3		
18	NF Ahtanum NF1	YIN	Yakima R	A	1000	16.4	43	16.1	16.1	16	-0.1	-0.1		
19	NF Ahtanum NF2	YIN	Yakima R	A	1292	8.3	38	12.8	13.3	16	3.2	2.7		
20	Foundation Cr FD1	YIN	Yakima R	A	994	11.0	61	15.6	15.6	15	-0.6	-0.6		
21	Nasty Creek NS1	YIN	Yakima R	A	939	10.2	80	16	16.1	14	-2.0	-2.1		
22	NF Taneum NTA1	YIN	Yakima R	AA	1134	8.5	55	14.5	15	15	0.5	0		
23	NF Taneum NTA2	YIN	Yakima R	AA	1183	6.2	1	15.3	16	20	4.7	4		
24	NF Taneum NTA3	YIN	Yakima R	AA	1244	4.9	48	14.5	14.5	16	1.5	1.5		
25	Lookout Creek LK1	YIN	Yakima R	AA	1195	3.8	6	18.6	19	20	1.4	1		
26	Rattlesnake Creek RS1	YIN		A	238	17.3	25	23.2	25	20	-3.2	-5		
27	Buck Creek BK1	YIN		A	213	8.0	80	16	16	17	1.0	1		

Data sources.

TWG: Sullivan and others, 1990.

YIN: Yakima Indian Nation, 1990-91.

DOE: Rashin and Graber, 1992

Figure 2. TFWTEMP model performance: 25 sites per region

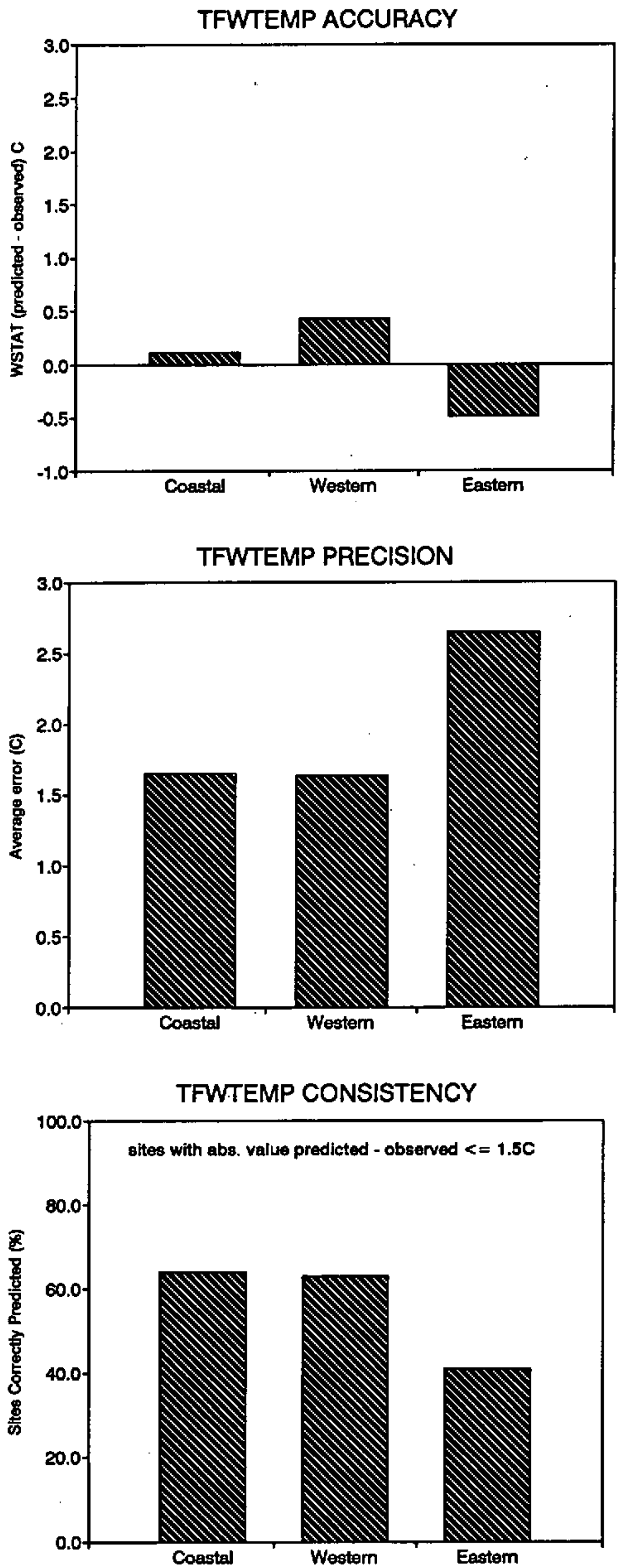

Table 3. Regression statistics testing bias of TFWTEMP maximum water temperature predictions.

		Slope	intercept	R^2	St. Error of coef.
COASTAL	Shade	-0.008	0.61	0.00	0.02
	Elevation	0.011	-1.45	0.27	0.00
	Distance from divide	-0.352	2.05	0.38	0.09
	Maximum recorded water temperature	-0.685	12.50	0.56	0.13
	Maximum equilibrium temperature	-0.774	13.77	0.60	0.13
WESTERN	Shade	0.021	-0.56	0.07	0.02
	Elevation	0.001	0.06	0.02	0.00
	Distance from divide	-0.087	1.59	0.22	0.03
	Maximum recorded water temperature	-0.618	11.11	0.84	0.06
	Maximum equilibrium temperature	-0.674	11.96	0.86	0.06
EASTERN	Shade	-0.014	0.13	0.01	0.03
	Elevation	0.006	-5.88	0.34	0.00
	Distance from divide	-0.129	1.10	0.11	0.07
	Maximum recorded water temperature	-0.711	12.02	0.79	0.07
	Maximum equilibrium temperature	-0.794	13.14	0.81	0.08

Linear regression analysis was used to test for bias in the model predictions (Table 3). Bias testing was done regionally for the following independent variables; shade, elevation, distance from divide, and maximum observed temperature (both equilibrium and recorded). Regression slopes significantly different than zero with a high R^2 value indicate bias in temperature predictions as a function of that variable. No bias occurred as a function of shade levels. A weak bias was noted for distance from divide for the coastal Washington region; possibly due to the effect of coastal fog. The model tended to over-predict the coolest sites which are likely influenced by higher groundwater rates which can not be accounted for in this generic application model. The model also under-predicted the hottest sites. Several reasons may be possible for this latter trend. The TFWTEMP model attempts to predict water temperatures based on a minimal amount of information specified by the user. Regional patterns are relied upon. Site specific conditions may vary from these regional patterns. A second possible explanation is that the model is a steady state model. Calculations are made on a one hour time step with air temperature adjusted accordingly. However, constant rates are used in calculating several of the heat exchange processes. These rates are, in part, temperature dependent.

Based on maximum equilibrium temperatures, the model correctly identified acceptable and unacceptable stream temperature conditions relative to the water quality maximum temperature standard for a majority of the sites; coastal 19 out of 25 (76%), western 21 out of 24 (88%), and eastern 18 out of 27 (67%). Performance relative to the water quality standard was even better when comparing to the maximum recorded temperatures.

Information from the field investigators on site specific conditions and comparisons between similar sites suggests that site specific conditions may have caused poor predictions by the regionalized TFWTEMP model at several of the sites. The TFWTEMP model maximum temperature predictions for coastal Washington streams differed from reported maximum temperatures by more than 3.0°C for four of the sites tested. Of these sites Maxfield Creek and Fluharty Creek were both reported by the investigator as being unusual with respect to observed temperatures for the coast. Recorded water temperatures on the two forks of Wilson Creek suggest that groundwater may more strongly affect maximum water temperatures in WF Wilson. The latter site has less shade but cooler temperatures than a site at the same elevation in the east fork. This possible groundwater effect may account for the large over-prediction by the TFWTEMP model for WF Wilson Creek. Both the TEMPEST model and TFWTEMP substantially over-predicted maximum water temperatures for the Naselle River; 2°C by the TEMPEST model in the TWG study (Sullivan and others, 1990) compared to a 3.6°C over-prediction by the TFWTEMP model. Both models calculate the heat flux in an identical manner. However, the TEMPEST model uses site specific data whereas the TFWTEMP model uses regional climate and groundwater data. The results of the TEMPEST model represent the upper limit in predictive expectations for the TFWTEMP model.

The TFWTEMP model over-predicted two sites in western Washington by more than 3.0°C. Both of these sites are likely groundwater influenced as evidenced by the cool maximum water temperatures and small diurnal fluctuation. The model under-predicted maximum temperatures recorded on the South Fork Nooksack River. This river is very wide and shallow. The cause of the under-prediction is not known.

The largest differences between predicted and observed temperatures for the eastern Washington sites occurred within the Klickitat River Basin. Climate conditions for this area are reported to be considerably warmer than at the Yakima NOAA station used in the TFWTEMP model. Air temperature data for the Klickitat River sites were not available but it is assumed that localized climate conditions are the cause for the TFWTEMP under-predictions at these sites. A strong groundwater influence on CeeCeeAh Creek (Sullivan and others, 1990) is the likely cause for over-predicted maximum temperatures by the TFWTEMP model on this creek. Four sites on the North Fork Taneum Creek were tested. Two of these sites have approximately 50% shade and are located above and below a clear cut. Of the other two sites (both in the same clear cut and having little or no shade) only Lookout Creek showed a sharp response in temperature to reduced shade. The model over-predicted the site in the clear cut (NTA2) which was reported as not markedly responding to reduced shade. It is possible that the field data may not have accounted for actual temperatures or conditions controlling temperature at this site, i.e. shade due to brush, groundwater, etc. The TFWTEMP model also substantially over-predicted the maximum temperature for the upper sites on the South and Middle Fork Ahtanum Creek (SA2 and

MA2). Comparing recorded temperatures at this site to other eastern Washington stream temperature data for sites with similar elevation and shade suggests that temperatures at this site are groundwater dominated.

RECOMMENDATIONS

The TFWTEMP model is one of two primary tools recommended for use in assessing the effect on stream temperature by Washington forest practices involving the harvest of riparian shade trees. A temperature graphical "screen" is used to determine maximum stream temperature relative to the Washington water quality standards for maximum temperature. The TFWTEMP computer model is recommended for use in identifying when a harvest of riparian shade trees is likely to result in exceedance of the maximum allowable incremental increase in temperature from non-point sources. Situations may occur when the temperature screen and the TFWTEMP model produce conflicting results on the prediction of maximum stream temperature relative the water quality standard for maximum temperature. In these situations it is recommended that the temperature screen is used to evaluate maximum temperatures and the computer model is used to evaluate incremental temperature changes. It is recommended that TFW managers consider leaving additional shade beyond the minimum requirements as a safety buffer when the two prediction tools give conflicting results. Alternatively, more detailed investigations of stream temperature effects may be warranted.

The TFWTEMP model uses the same heat balance equations and modelling procedures as the TEMPEST model; the latter having been tested and its performance proven in predicting stream temperature for Washington forested streams. The TFWTEMP model incorporates regional climate and basin geomorphic regimes to provide a means of predicting stream temperature while minimizing the need for site specific data. The TFWTEMP model is only recommended for use in Washington since the climate data used by the model is not likely to be applicable elsewhere. Users interested in evaluating shade tree removal effects on stream temperature outside of Washington are directed to the TEMPEST model (Sullivan and Adams, 1988). Users evaluating the stream temperature effects of activities other than harvest of shade trees also should not use the TFWTEMP model.

The TFWTEMP model has only been tested for a limited number of sites (approximately 25 sites per each of three regions in the state.) If adopted for use in forest practices, periodic review of the model's performance is recommended. Review should include both an evaluation of the ease of use and how well the shade recommendations balance opportunities for harvest with maintenance of water quality standards for stream temperature. When evaluating the model's predictive performance through site monitoring it will be important to document that the before and after harvest shade levels actually occurring are the same as those modelled.

No improvements to the TFWTEMP model are recommended at this time. Stream depth data from TFW ambient monitoring programs may be compiled in the future to determine if the model's regression formula for calculating stream depth based on distance from divide can be improved on a regional basis. Currently available information did not improve stream depth predictions. However, there was a lack of adequate data to analyze stream depth regressions for eastern Washington.

The program code for the model has been written so that lapse rates associated with elevation (changes in relative humidity and air temperature as a function of elevation) can be adjusted should better information become available. A recommended research level topic related to stream temperature is an analysis of air temperature and relative humidity as it is affected by forest practices on a basin scale. Both of these climatic factors strongly influence stream temperature.

It is recommended that the Forest Practices Board adopt the TFWTEMP model (version 7.0) as a replacement to version 6.0, for use in the context of RMZ rules. Users are reminded that the model uses regional data. Site specific conditions may result in maximum stream temperatures both significantly warmer and cooler than predicted temperatures. Wise management of our state's natural resources relies on interpretation of the results of computer models such as TFWTEMP by local managers with a thorough knowledge of local conditions.

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APPENDIX A: CLIMATE DATA

HOURLY AIR TEMPERATURE PROFILES
SYNTHESIZED FROM NOAA DATA FROM
MONTHLY MAXIMUM AND MINIMUM 30 YE
NORMAL AIR TEMPERATURES

hour	Quillayute (C)	Olympia (C)	Yakima (C)	Elevation lapse Rate (C/1000m
0	11.4	11.9	15.8	6.615
1	11.0	11.3	14.8	5.662
2	10.6	10.8	13.8	4.708
3	10.2	10.3	12.7	3.754
4	9.7	9.7	11.7	2.800
5	9.8	9.8	12.5	3.927
6	10.5	10.6	14.3	5.055
7	11.8	12.4	16.8	6.182
8	13.4	14.8	19.6	7.309
9	15.1	17.3	22.4	8.436
10	16.7	19.6	24.8	9.564
11	18.0	21.6	26.9	10.691
12	19.1	23.2	28.5	11.818
13	19.8	24.3	29.6	12.945
14	20.2	24.9	30.2	14.073
15	20.3	25.1	30.4	15.200
16	20.2	24.9	30.2	14.246
17	19.8	24.3	29.6	13.292
18	19.1	23.2	28.5	12.338
19	18.0	21.6	26.9	11.385
20	16.7	19.6	24.8	10.431
21	15.1	17.3	22.4	9.477
22	13.4	14.8	19.6	8.523
23	11.8	12.4	16.8	7.569

	Quillayute	Olympia	Yakima
Daylight avg. air temp. (C)	16.3	19.2	23.9
Elevation at NOAA station	55	122	321
Dewpoint (C)	11.44	9.72	6.61
Mean daily air temp. (C)	15.11	17.39	18.6

Other model climate data constants

solar radiation
coastal = 256 - 250
western = 273 - 267
eastern = 305 - 298

wind speed = 6.7 m/s

Site specific climate conditions are calculated from NOAA station data using formulas listed in source code (appendix B)

APPENDIX B
SOURCE CODE DOCUMENTATION

```
'TFWTEMP5.BAS
'Version 7.0
'JULY 1993
'TIMBER/FISH/WILDLIFE REACH TEMPERATURE STUDY
'Recommended reach temperature model
'Written by John E. Tooley with:
'Energy balance equations by Terry Adams  (from TEMPEST model)
'Energy balance QuickBASIC code by Steve Washburn (from STREAM.BAS)
'with revisions recommended by K.Sullivan and T.Adams.  Recoded into
'Power Basic (TFWTemp) by Jeffrey W. Smith.
'This version has the following features:

        'A 8 day simulation period based on July 15 to August 15 1988 data
        'Internal 8-day, hourly air temperature profiles
        'Internal normal solar profile
        'Internal relative humidity and cloudcover profiles
        'TFW Temperature criteria calculations
        'ASCII file export of calculated hourly and daily values
        'Air temperature profile sensitivity analysis

'This model contains the following changes from the initial TEMPEST model:

' The QSOLAR calculation contains a Clearness Factor of 1.0 due to the
' skycover correction in the solar profile




$STACK 4000
$STRING 32
 DEFINT a - z'Best to do.

' The next few assignments are necessary, except as noted
 %False = 0     'in unit and include, so not necessary here
 %True  = NOT %False  'ditto

'DIM Air#(7,744)
DIM AIR#(4,192)
'DIM TOD%(744)                          'dim generic air profile array
DIM TOD%(192)
'DIM MeanAir#(7)                         'mean air temp for each profile
DIM Solar#(3,31)                        'dim solar insolation
DIM RH#(3,31)                           'dim relative humidity profile
DIM Item$(20,1)


$INCLUDE "Window.BAS"
$INCLUDE "READ.INC"
$segment
$INCLUDE "DISPLAY.bas"                      'Include Open.Window
$INCLUDE "Help.bas"
$INCLUDE "Picklst.bas"
$segment
$INCLUDE "ENTRY-U.BAS"
$INCLUDE "MakeMenu.inc"

SELECT CASE InitializeHelp("TFWTEMP.Hlp")
        CASE 1
                PRINT "Help file not found: TFWTEMP.HLP":END
        CASE 2
                PRINT "Incorrect help file format":END
END SELECT
'*******************************************************************************


'max.ts% = 744                          'set number of timesteps
'max.profiles% = 7                      'set number of air temperature profiles



'DIM max.calc(32)                       'array to hold daily maximums
DIM Water.Mean#(31)                      'daily values arrays
DIM Water.Max#(31)
DIM Water.Min#(31)
DIM DepthSlope#(3), DepthIntercept#(3)          'dim constants for depth function
DIM GH2oTempC#(3)                       'dim regional gw temp
DIM BmAir#(3), BavgAir#(3), Belev%(3), Bdew#(3)
```

```
SHARED GH2oInflux#, GH2oTempK#, Temp.Initial#, MeanAirTempK#, _
                        AirTempK#, Air#(), TOD%(), Solar#(), RHMod!, MeanSolarInsolation#,_
                        Relhum#
' MeanAir#()
' RH#()
'       Water.Min#()
' RelHum#
'       Water.Calculated#,  Pro%, Water.Mean#(), Water.Max#(),
Holdit! = TIMER
CALL OPEN.SCREEN
CALL Profiles                             'fill air array
CALL Skysolar                               'fill skycover array
ELEV# = -1
DIVIDE.KM# = -1
BHSL# = -1
AHSL# = -1
VIEWFACTOR# = -1
DO UNTIL TIMER-Holdit! => 2:loop
CALL RestoreScreen

GO:
ITERATION% = 1

DO.AGAIN:                          'loop point to run analysis again
CALL open.window
CALL Input.Values                                                       'interactive input.values
BHMax.Water# = -1
DO.RETRY:
        depthslope#(1) = .0453          'coast
        depthslope#(2) = .0075          'west
        depthslope#(3) = .0093          'east
        depthintercept#(1) = .018       'coast
        depthintercept#(2) = .195       'west
        depthintercept#(3) = .097       'east
        GH2oTempC#(1) = 11                      'enter regional basin groundwater temperature3
        GH2oTempC#(2) = 11
        GH2oTempC#(3) = 8

'
GH2oTempK# = GH2oTempC#(TEMP.REGION%) + 273          'set regional groundwater temperature Kelvin

streamdepth# = depthintercept#(TEMP.REGION%) + depthslope#(TEMP.REGION%) * DIVIDE.KM#
wet.width# = .97 + .326 * DIVIDE.KM#                 'WETTED WIDTH
'view.mature# = 13.1 + 1.95 * DIVIDE.KM#              'skyviewfactor mature canopy
'NO OTHER REFERENCES FOR VIEW.MATURE#
'bankfull.width = 5.1 + .519 * DIVIDE.KM#            'bankfull width
air.max# = (.237 * DIVIDE.KM#) + (.0027 * elevation)_
                        - (.308 * wet.width#) + 18.6                'air profile pointer

'Q.CMS = (.03174195# * DIVIDE.KM#) - .0742          'flow
REM TOOK OUT OF USE BECAUSE OF DUPLICATE STATEMENTS
'Gh2oInflux# = (Q.CMS - (.03174195# * (DIVIDE.KM# - 1) - .0742)) / wet.width#

Gh2oInflux# = .002                                     'median value from


Pro% = Temp.Region%


                BmAir#(1) = 15.11
                BmAir#(2) = 17.39
                BmAir#(3) = 18.6
                BavgAir#(1) = 16.3
                BavgAir#(2) = 19.2
                BavgAir#(3) = 23.9
                Belev%(1) = 55
                Belev%(2) = 122
                Belev%(3) = 321
                Bdew#(1) = 11.44
                Bdew#(2) = 9.72
                Bdew#(3) = 6.61
                TLapse# = 5.76
                SDEW# = Bdew#(Pro%) - 2.7* ((ELEV#-Belev%(Pro%))/1000)
                ES# = 6.1078*(2.718^((17.269*SDEW#)/(237+SDEW)))
'                  ====================================================
'                          ---------------------------------------------
```

```
'                 1       23                  4    4      5              6    653
'            ESD# = 6.1078 * (2.718^((17.269*BavgAir#(Pro%)*5.74*(ELEV#-Belev%(Pro%))_
'                                          /(237+BavgAir#(Pro%)*5.74*(ELEV#-Belev%(Pro%))))) change to below formula 06/02/93
'          7             8    8      9              0    09721
'          -------------------------------------------
'         =============================================
            Atmp# =17.269*BavgAir#(Pro%)-TLapse#*((ELEV#-Belev%(Pro%))/1000)
            Btmp# =237.3+BavgAir#(Pro%)-TLapse#*((ELEV#-Belev%(Pro%))/1000)
            Ctmp# = Atmp#/Btmp#
            ESD# = 6.1078*(2.718^(Ctmp#))
            Relhum# = (ES#/ESD#) * RHMod!

MeanAirTempK# = (BmAir#(Pro%)-.00576*(ELEV#-Belev%(Pro%)))+273
'MeanAirTempK# = meanAir#(pro%) + 273            'redefine meanair for profile
'




ITERATION% = 0
DO.HIGHER:
Day.Max# = 0                                     'reset max daily comparer
Day.Min# = 99                                    'reset minimum daily comparer
day.counter% = 0                                'reset day counter
Degree.hr.day# = 0                               'reset daily mean accumulator

Temp.Initial# = GH2oTempK#                         'set starting temp to gw temp
                                                'set up computed temperature view
IF Retry% = 0 THEN
        Style% = 2
        Title$ = ""
        Shdw% = 1
        Attr% = 0+(16*7)
        CALL MakeWindow(15,10,8,56,Attr%,Style%,Shdw%,.01)
        CALL WCprint(1,14+(16*7)+128,"Computing, please wait . . .")
END IF

FOR ts% = 1 TO 192   '744                                'increment timestep

        IF TOD%(ts%) = 0 THEN                              'increment and update at midnight
                INCR day.counter%                          'increment day pointer at 0:00 hours
                'Clearness = sky(TEMP.REGION%, day.counter%)  'redefine for current day and region
                'RelHum# = RH#(TEMP.REGION%, day.counter%)      'changed to above calcs
                MeanSolarInsolation# = Solar#(TEMP.REGION%, day.counter%)        'redefine for current day and region
 END IF

 time.of.day = TOD%(ts%)                           'get time of day
' AirTempK# = AIR#(pro%, ts%) + 273   'changed to below config
htLapse% = 4
'+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
AirTempK# = (AIR#(Pro%,ts%)-(AIR#(htLapse%,ts%)*((ELEV#-Belev%(Pro%))/1000)))+273
'+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 '------------------
 CALL COMPUTE.NEXT                    'GOSUB COMPUTE.NEXT  :JUMP TO ENERGY BUDGET
 '------------------

                                                                            'add degree-hour if greater than 15.6
 IF Water.Calculated# < Day.Min# THEN Day.Min# = Water.Calculated#
 IF Water.Calculated# > Day.Max# THEN Day.Max# = Water.Calculated#

 Degree.hr.day# = Degree.hr.day# + Water.Calculated#        'add hourly value to accumulator
 IF (TOD%(ts%) = 23) THEN
        Water.Mean#(day.counter%) = Degree.hr.day# / 24   'compute mean
        Water.Max#(day.counter%) = Day.Max#              'store max
        Water.Min#(day.counter%) = Day.Min#              'store min


        Day.Max# = 0                                                                   'reset daily comparers
        Day.Min# = 99
        Degree.hr.day# = 0
 END IF

NEXT ts%
```

```
IF HARVEST$ = "AFTER HARVEST" AND BHSL# <> -1 THEN
        Max.Temp.Report# = 0
        FOR report.day% = 1 TO 8      '31
                IF Water.Max#(Report.day%) > Max.Temp.Report# THEN Max.Temp.Report# = Water.Max#(Report.day%)
        NEXT report.day%

        IF Max.Temp.Report# - BHMax.Water# > 2.8 THEN
                IF VIEWFACTOR# > 0 THEN
                        AHSL# = 100-(AHSL#*100)
                        INCR AHSL#, 2
                        IF AHSL# > 100 THEN AHSL# = 100
                        AHSL# = (100-AHSL#)/100
                        VIEWFACTOR# = AHSL#
                        INCR Retry%
                        IF Retry% = 1 THEN
                                CALL Wprint(1,2,4+16*7,"The increase in maximum water temperature has")
                                CALL Wprint(2,2,4+16*7,"exceeded the allowable amount.  The Model will ")
                                CALL Wprint(3,2,4+16*7,"increase the shade level in 2% increments until the")
                                CALL Wprint(4,2,4+16*7,"predicted increase in maximum water temperature is")
                                CALL Wprint(5,2,4+16*7,"within the allowable range.")
                                CALL WCprint(6,0+16*7+128,"ANY KEY TO CONTINUE")
                                WHILE NOT INSTAT:WEND
                                A$ = INKEY$
                                CALL WCprint(6,0+16*7+128,"Recomputing, please wait...")
                        END IF
                        Iteration% = 1
                        GOTO DO.RETRY
                END IF
        END IF
END IF
Retry% = 0


IF HARVEST$ = "BEFORE HARVEST" AND AHSL# <> -1 THEN  'User put both pre-harvest and post-harvest
        CALL Generate.Report                    'calculate criteria and write output
        CALL RESULT.SCREEN
        CALL RESTORESCREEN
        BHMax.Water# = Max.Water#                 ' hold max water temp from pre harvest
        HARVEST$ = "AFTER HARVEST"              ' set for next calculation
        VIEWFACTOR# = AHSL#
        GOTO DO.RETRY
END IF
AHMax.Water# = Max.Temp.Report#                 'set after harvest for comparison
CALL RESTORESCREEN
CALL Generate.Report
CALL RESULT.SCREEN
CALL RESTORESCREEN



        Topic% = 8
        Attr% = 7+(16*1)
        HiAttr% = 0+(16*7)
        WinAttr% = 15+(16*1)                    'SUGGESTIONS
        CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
 GOTO GO

SYSTEM

'>>>>>>>>>>>>>>>>>>>>>>>>>>>> energy budget <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

SUB COMPUTE.NEXT

LOCAL SoilHtc#, StefanBoltzmann#, H2oDens%, H2oEmissivity#, SpHH2o%,_
                Pi, AirVelocity!, Blocking%, Todf#, Qsolar#, X#, Tsky#, Qsky#, Qveg#,_
                ConvHtc#, Qconv#, Qevap#, Qsoil#, Qnet#, H2oTempC#, H2oTempK#

SHARED  VIEWFACTOR#, streamdepth#,        Time.of.day, AirTempK#,_
                MAXts%, ITERATION%, MeanAirTempK#,_
                GH2oTempC#(), depthslope#(), depthintercept#()

SoilHtc# = 6.5                  'is there a better number?
StefanBoltzmann# = 5.68E-08
H2oDens% = 1000
H2oEmissivity# = .95            'set other basin-wide constants
```

```
 SpHH2o% = 4186
 'pi# = 3.1415923                                    'add regional profile if valid
 AirVelocity! = 6.7

 H2oTempK# = Temp.Initial#  'SET STARTING TEMPERATURE TO value from upstream node

 'AirTempK = airtempc + 273!

                 Blocking% = 0
                 IF (ABS(time.of.day - 12) < 6) THEN Blocking% = 1
                 todf# = COS(3.1415923 * ((time.of.day * 3600 / 43200) + 1))

                 'X# = Clearness * Blocking% * todf#       'Clearness does = 1
                         X# = 1 * Blocking% * todf#                'REMOVE CLOUD COVER FROM SOLAR

                 qsolar# = 2.7 * MeanSolarInsolation# * H2oEmissivity# * X# * VIEWFACTOR#

 'THE EQUATION:   TSky# = .0522 * AirTempK# ^ 1.5
 'WAS REPLACED BY THE FOLLOWING AS PER K.SULLIVAN INSTRUCTIONS

                         TSky# = .0522 * AirTempK# ^ 1.5
                         'TSky# = .056 * AirTempK# ^ 1.5

                 X# = TSky# ^ 4 - H2oTempK# ^ 4
                 Qsky# = VIEWFACTOR# * H2oEmissivity# * StefanBoltzmann# * X#

                 X# = AirTempK# ^ 4 - H2oTempK# ^ 4
                 Qveg# = (1 - VIEWFACTOR#) * H2oEmissivity# * StefanBoltzmann# * X#

         ConvHtc# = 1.7 + (7.35 * (AirVelocity! / 3) ^ .8)
                 Qconv# = ConvHtc# * (AirTempK# - H2oTempK#)

         Qevap# = 48.8 * ConvHtc# * (RelHum# - EXP(.0653 * (H2oTempK# - 298)))

                 Qsoil# = SoilHtc# * (MeanAirTempK# - 2! - H2oTempK#)

                 Qnet# = qsolar# + Qsky# + Qveg# + Qconv# + Qevap# + Qsoil#


 REM  DELTA T IS ONE HOUR OR 3600 SECONDS

         X# = H2oDens% * streamdepth#
         Y# = (Qnet# / SpHH2o% + Gh2oInflux# * (GH2oTempK# - H2oTempK#)) / X#

 rem temporary change              H2oTempK# = Temp.Initial# + 3600! * Y#      'changed for z3.bas

        h2oTempK# = h2oTempK# + 3600! * Y#         'from z2.bas

         Temp.Initial# = H2oTempK#       'store value in array for later plotting

         H2oTempC# = H2oTempK# - 273!
         Water.Calculated# = H2oTempC#          'for use in criteria
 INCR ITERATION%

 END SUB                     'END COMPUTE.NEXT

 '>>>>>>>>>>>>>>>>>>>>>>>>>> budget end <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<



 SUB INPUT.VALUES                                       'input values routine

 'LOCAL Divide.eng#, Elev.eng#

 SHARED Site.ID$, User.ID$, Temp.Region%, DIVIDE.KM#, ELEV#,_
                         BHSL#, AHSL#, Measure$, TEMP.REGION$, Harvest$, Mitem%, Class$,_
                         VIEWFACTOR#, Depthslope#(), depthintercept#(), GH2oTempC#(),_
                         CurntPos%, DIVIDE.ENG#, ELEV.FT#, LI%

  Attr% = 9+(16*7)
  CALL  MakeWindow(6,38,11,35,Attr%,3,0,0)
  CALL  TitleWindow(2,0+16*7,"SELECTIONS")
  Attr% = 0+16*7
                                                                                  'PUT
 ALL THE PARAMETERS ON THE SCREEN
  IF USER.ID$ <> "" THEN CALL Wprint(1,2,Attr%,USER.ID$+SPACE$(32-LEN(USER.ID$)))
```

```
IF SITE.ID$ <> "" THEN CALL Wprint(2,2,Attr%,SITE.ID$+SPACE$(32-LEN(SITE.ID$)))
IF CLASS$ <> "" THEN CALL Wprint(3,2,Attr%,"CLASS "+CLASS$+SPACE$(32-6-LEN(CLASS$)))
IF TEMP.REGION$ <> "" THEN CALL Wprint(4,2,Attr%,TEMP.REGION$+SPACE$(32-LEN(TEMP.REGION$)))
IF MEASURE$ <> "" THEN CALL Wprint(5,2,Attr%,MEASURE$+SPACE$(32-LEN(MEASURE$)))

IF DIVIDE.KM# > 0 THEN
        IF MEASURE$ = "ENGLISH" THEN
                CALL Wprint(6,2,Attr%,STR$(ROUND(DIVIDE.ENG#,1))+" MILES")
        ELSE
                CALL Wprint(6,2,Attr%,STR$(ROUND(DIVIDE.KM#,1))+" KILOMETERS")
        END IF
END IF

IF ELEV# > 0 THEN
        IF MEASURE$ = "ENGLISH" THEN
                CALL Wprint(7,2,Attr%,STR$(ROUND(ELEV.FT#,1))+" FEET")
        ELSE
                CALL Wprint(7,2,Attr%,STR$(ROUND(ELEV#,1))+" METERS")
        END IF
END IF

'IF HARVEST$ <> "" THEN CALL Wprint(8,2,Attr%,HARVEST$+SPACE$(32-LEN(HARVEST$)))
'IF BHSL#> -1 OR VIEWFACTOR# > -1 THEN CALL Wprint(9,2,Attr%,"L="+STR$(LBANK#) + ": R="+STR$(RBANK#) + " :
TOTAL="+STR$((LBANK#+RBANK#)/2))
        BHSL# = -1
        AHSL# = -1

DO UNTIL Curntpos% = 10            'LOAD THE MENU
        REDIM Item$(10,1)
Item$(0,1) = "MAIN MENU"                                              ':Item$(0,0) = "30"
Item$(1,1) = "USER IDENTIFICATION"      :Item$(1,0) = "1"
Item$(2,1) = "SITE IDENTIFICATION"      :Item$(2,0) = "1"
Item$(3,1) = "STREAM CLASS"                         :Item$(3,0) = "8"
Item$(4,1) = "TEMPERATURE REGION"       :Item$(4,0) = "1"
Item$(5,1) = "MEASUREMENT"                                :Item$(5,0) = "1"
Item$(6,1) = "DISTANCE FROM DIVIDE":Item$(6,0) = "1"
Item$(7,1) = "ELEVATION"                                       :Item$(7,0) = "1"
Item$(8,1) = "SHADE PERCENT"                        :Item$(8,0) = "7"
Item$(9,1) = "GENERATE REPORT"                :Item$(9,0) = "1"
Item$(10,1)= "QUIT"                                                 :Item$(10,0) = "1"

'Item$(8,1) = "HARVEST TIME"                        :Item$(8,0) = "1"

HiAttr% = 15+(16*4)
Attr% = 0+(16*7)
WinAttr% = 1+16*7
Style% = 2
Shdw% = 0
Zoom! = 0
CALL MakeMenu(6,10,Item$(),Curntpos%,Hiattr%,Attr%,WinAttr%,Style%,Shdw%,Zoom!)
SELECT CASE Curntpos%
        CASE 1
                CALL USER
                CALL RESTORESCREEN
                CALL Wprint(1,2,Attr%,USER.ID$+SPACE$(32-LEN(USER.ID$)))
        CASE 2
                CALL SITE
   CALL RESTORESCREEN
                CALL Wprint(2,2,Attr%,SITE.ID$+SPACE$(32-LEN(SITE.ID$)))
        CASE 3
                CALL STREAM.CLASS
   CALL RESTORESCREEN
                CALL Wprint(3,2,Attr%,"CLASS "+CLASS$+SPACE$(32-6-LEN(CLASS$)))
        CASE 4
                CALL T.REGION
   CALL RESTORESCREEN
                CALL Wprint(4,2,Attr%,TEMP.REGION$+SPACE$(32-LEN(TEMP.REGION$)))
        CASE 5
                CALL RIGHT.MEASURE
                CALL RESTORESCREEN
                CALL Wprint(5,2,Attr%,MEASURE$+SPACE$(32-LEN(MEASURE$)))
                CALL Wprint(6,2,Attr%,SPACE$(32))
                CALL Wprint(7,2,Attr%,SPACE$(32))
                IF Measure$ = "METRIC" THEN
                        IF DIVIDE.KM# < 0 THEN DIVIDE.KM# = 0
                        IF ELEV# < 0 THEN ELEV# = 0
                        CALL Wprint(6,2,Attr%,STR$(ROUND(DIVIDE.KM#,1))+" KILOMETERS")
```

```
                CALL Wprint(7,2,Attr%,STR$(ROUND(ELEV#,1))+" METERS")
        ELSEIF Measure$ = "ENGLISH" THEN
                CALL Wprint(6,2,Attr%,STR$(ROUND(DIVIDE.ENG#,1))+" MILES")
                CALL Wprint(7,2,Attr%,STR$(ROUND(ELEV.FT#,1))+" FEET")
        END IF
    CASE 6
        CALL DIV.DIST
        CALL RESTORESCREEN
        CALL Wprint(6,2,Attr%,SPACE$(32))
        IF MEASURE$ = "ENGLISH" THEN
                CALL Wprint(6,2,Attr%,STR$(ROUND(DIVIDE.ENG#,1))+" MILES")
        ELSE
                CALL Wprint(6,2,Attr%,STR$(ROUND(DIVIDE.KM#,1))+" KILOMETERS")
        END IF
    CASE 7
        CALL SITE.ELEV
        CALL RESTORESCREEN
        CALL Wprint(7,2,Attr%,SPACE$(32))
        IF MEASURE$ = "ENGLISH" THEN
                CALL Wprint(7,2,Attr%,STR$(ROUND(ELEV.FT#,1))+" FEET")
        ELSE
                CALL Wprint(7,2,Attr%,STR$(ROUND(ELEV#,1))+" METERS")
        END IF
    CASE 8
        CALL VIEW.FACT
  CALL RESTORESCREEN
        CALL Wprint(8,2,Attr%,SPACE$(32))
        IF BHSL# <> -1 THEN CALL Wprint(8,2,Attr%,"BEFORE="+STR$(100-(BHSL#*100)))
        IF AHSL# <> -1 THEN CALL Wprint(8,14,Attr%,": AFTER="+STR$(100-(AHSL#*100)))
    CASE 9
        IF USER.ID$ <> "" AND SITE.ID$ <> "" AND MEASURE$ <> "" AND TEMP.REGION% > 0 AND_
                DIVIDE.KM# = > -1 AND ELEV# > -1 AND (BHSL# > -1 OR AHSL# > -1) THEN
                        Curntpos% = 1
                CALL RESTORESCREEN
                CALL RESTORESCREEN
                IF BHSL# <> -1 THEN
                        HARVEST$ = "BEFORE HARVEST"
                        VIEWFACTOR# = BHSL#
                ELSE
                        HARVEST$ = "AFTER HARVEST"
                        VIEWFACTOR# = AHSL#
                END IF
                EXIT SUB
        ELSE
                CALL MakeWindow(16,11,3,40,12+16*4,2,1,0)
                CALL WCprint(1,0+16*4,"YOU MUST FIRST SELECT OPTIONS 1-8")
                WHILE INKEY$ = "":WEND
                CALL RESTORESCREEN
                CALL RESTORESCREEN
        END IF
    CASE 10
        COLOR 7,0
        FOR RS% = 1 TO LI%
                CALL RESTORESCREEN
        NEXT RS%
        END
    CASE ELSE
        CALL RESTORESCREEN
    END SELECT
LOOP
END SUB


SUB USER
SHARED USER.ID$,Msg$

 CALL MakeWindow(19,4,6,74,4+16*7,3,1,0)
 CALL TitleWindow(3,4+16*7,"USER DESCRIPTION")
 CALL TitleWindow(5,0+16*7,"F1 = HELP")
 Attr% = 0+16*7
 CALL Wprint(2,2,Attr%,"Please enter your name or identification to be used in documenting")
 CALL Wprint(3,2,Attr%,"this analysis.  Maximum thirty characters")

 Attr% = 0+16*7
 CALL MakeWindow(8,20,3,55,Attr%,1,1,0)
 CALL TitleWindow(1,Attr%,"USER ID INPUT")
```

```
 CALL TitleWindow(5,Attr%,"F1 = HELP")


 USER.over:
 LOCATE 9,21:COLOR 0,7
 Msg$ = "F1"
 CALL ENTERSTRING(USER.ID$,30,Msg$)
 LOCATE ,,0
 IF Msg$ = "HELP!" THEN
        'CALL RESTORESCREEN
        Topic% = 1
        Attr% = 7+(16*1)
        HiAttr% = 0+(16*7)
        WinAttr% = 15+(16*1)
        CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)

        GOTO USER.over
 END IF
 CALL RESTORESCREEN
 CALL RESTORESCREEN

END SUB


SUB SITE
SHARED SITE.ID$
 Attr% = 0+16*7
 CALL MakeWindow(19,4,6,74,Attr%,3,1,0)
 CALL TitleWindow(3,4+16*7,"SITE ID DESCRIPTION")

 CALL Wprint(2,2,Attr%,"Study site can be identified by name, Forest Application Number, or")
 CALL Wprint(3,2,Attr%,"any other coding.  maximum thirty characters")

 Attr% = 4+16*7
 CALL MakeWindow(9,20,3,55,Attr%,1,1,0)
 CALL TitleWindow(1,Attr%,"SITE ID INPUT")
 CALL TitleWindow(5,Attr%,"F1 = HELP")

 SITE.over:
 COLOR 0,7
 Msg$ = "F1"
 LOCATE 10,21: CALL ENTERSTRING(SITE.ID$,30,Msg$)
 LOCATE ,,0
 IF Msg$ = "HELP!" THEN
        'CALL RESTORESCREEN
        Topic% = 2
        Attr% = 7+(16*1)
        HiAttr% = 0+(16*7)
        WinAttr% = 15+(16*1)
        CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
        GOTO SITE.over
 END IF
 CALL RESTORESCREEN
 CALL RESTORESCREEN
END SUB


SUB STREAM.CLASS

SHARED CLASS$

 Attr% = 0+16*7
 CALL MakeWindow(19,4,6,74,Attr%,3,1,0)
 CALL TitleWindow(3,4+16*7,"STREAM CLASS DESCRIPTION")

 CALL Wprint(2,2,Attr%,"Stream classification listings are provided as support and are")
 CALL Wprint(3,2,Attr%,"also used to determine maximum temperatures.")

 CLASS.over:

 REDIM Item$(3,1)
 Item$(0,1) = "STREAM CLASS INPUT"
 Item$(1,1) = "CLASS A"        :Item$(1,0) = "0"
 Item$(2,1) = "CLASS AA" :Item$(2,0) = "0"
 Item$(3,1) = "HELP"                     :Item$(3,0) = "1"

        HiAttr% = 4+(16*0)
```

```
        Attr% = 0+(16*7)
        WinAttr% = 6+16*7
        Style% = 2
        Shdw% = 1
        Zoom! = 0
        CALL MakeMenu(10,7,Item$(),Curntpos%,Hiattr%,Attr%,WinAttr%,Style%,Shdw%,Zoom!)
 SELECT CASE CurntPos%
        CASE 1
                CLASS$ = "A"
        CASE 2
                CLASS$ = "AA"
        CASE 3
                 CALL RESTORESCREEN
                 Topic% = 11
                 Attr% = 7+(16*1)
                 HiAttr% = 0+(16*7)
                 WinAttr% = 15+(16*1)
                 CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
                GOTO CLASS.over
 END SELECT
 CALL RESTORESCREEN
 CALL RESTORESCREEN
END SUB





SUB T.REGION
SHARED TEMP.REGION$, TEMP.REGION%, RHMod!
'color 0,7
 Attr% = 0+16*7
 CALL MakeWindow(19,4,6,74,Attr%,3,1,0)
 CALL TitleWindow(3,4+16*7,"TEMPERATURE REGION DESCRIPTION")
 CALL Wprint(2,2,Attr%,"Study site must be identified within one of three temperature regions,")
 CALL Wprint(3,2,Attr%,"see the users manual to determine the region.")

 T.REGION.over:
 REDIM Item$(4,1)
 Item$(0,1) = "REGION INPUT"
 Item$(1,1) = "COASTAL"  :Item$(1,0) = "1"
 Item$(2,1) = "WESTERN" :Item$(2,0) = "1"
 Item$(3,1) = "EASTERN" :Item$(3,0) = "1"
 Item$(4,1) = "HELP"    :Item$(4,0) = "1"

        HiAttr% = 4+(16*0)
        Attr% = 0+(16*7)
        WinAttr% = 6+16*7
        Style% = 2
        Shdw% = 1
        Zoom! = 0
        CALL MakeMenu(11,7,Item$(),Curntpos%,Hiattr%,Attr%,WinAttr%,Style%,Shdw%,Zoom!)
 SELECT CASE CurntPos%
        CASE 1
                TEMP.REGION% = 1
                TEMP.REGION$ = "COASTAL WASHINGTON"
                RHMod! = .75
        CASE 2
                TEMP.REGION% = 2
                TEMP.REGION$ = "WESTERN WASHINGTON"
                RHMod! = .75
        CASE 3
                TEMP.REGION% = 3
                TEMP.REGION$ = "EASTERN WASHINGTON"
                RHMod! = .7
        CASE 4
                CALL RESTORESCREEN
                Topic% = 3
                Attr% = 7+(16*1)
                HiAttr% = 0+(16*7)
                WinAttr% = 15+(16*1)
                CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
                GOTO T.REGION.over
 END SELECT
```

```
        CALL RESTORESCREEN
   CALL RESTORESCREEN
END SUB
```

```
SUB RIGHT.MEASURE

SHARED MEASURE$, DIVIDE.KM#, ELEV#

 Attr% = 0+16*7
 CALL MakeWindow(19,4,6,74,Attr%,3,1,0)
 CALL TitleWindow(3,4+16*7,"MEASUREMENT DESCRIPTION")
 CALL Wprint(2,2,Attr%,"English measurements are measured by feet and miles.")
 CALL Wprint(3,2,Attr%,"Metric measurements are measured by meters and kilometers.")
' COLOR 0,7

 RIGHT.MEASURE.over:
 REDIM Item$(3,1)
 Item$(0,1) = "MEASUREMENT INPUT"
 Item$(1,1) = "ENGLISH"  :Item$(1,0) = "1"
 Item$(2,1) = "METRIC"   :Item$(2,0) = "1"
 Item$(3,1) = "HELP"              :Item$(3,0) = "1"

        HiAttr% = 4+(16*0)
        Attr% = 0+(16*7)
        WinAttr% = 6+16*7
        Style% = 2
        Shdw% = 1
        Zoom! = 0
        CALL MakeMenu(12,20,Item$(),Curntpos%,Hiattr%,Attr%,WinAttr%,Style%,Shdw%,Zoom!)
 SELECT CASE CurntPos%
        CASE 1
                MEASURE$ = "ENGLISH"
        CASE 2
                MEASURE$ = "METRIC"
        CASE 3
                CALL RESTORESCREEN
                Topic% = 4
                Attr% = 7+(16*1)
                HiAttr% = 0+(16*7)
                WinAttr% = 15+(16*1)
                CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
                GOTO RIGHT.MEASURE.over
        END SELECT
 CALL RESTORESCREEN
 CALL RESTORESCREEN
END SUB
```

```
SUB DIV.DIST
SHARED MEASURE$,DIVIDE.KM#, DIVIDE.ENG#

 IF DIVIDE.KM# = -1 THEN DIVIDE.KM# = 0
 Attr% = 0+16*7
 CALL MakeWindow(19,4,6,74,Attr%,3,1,0)
 CALL TitleWindow(3,4+16*7,"DIVIDE DESCRIPTION")
 CALL Wprint(2,2,Attr%,"Measured stream distance from lower end of the site to the top of the")
 CALL Wprint(3,2,Attr%,"drainage divide.  See manual or press F1 for help.")

 DIV.DIST.over:
 Attr% = 0+16*7
 CALL MakeWindow(13,20,3,30,Attr%,1,1,0)
 CALL TitleWindow(1,Attr%,"DIVIDE INPUT")
 CALL TitleWindow(5,Attr%,"F1 = HELP")
 Msg$ = "F1"
 LOCATE 14,21:COLOR 0,7
 IF MEASURE$ = "ENGLISH" THEN
        CALL ENTERNUMBER(DIVIDE.ENG#,"##.#",Msg$)
 ELSE
```

```
        CALL ENTERNUMBER(DIVIDE.KM#,"##.#",Msg$)
 END IF
 LOCATE ,,0
 IF Msg$ = "HELP!" THEN
                CALL RESTORESCREEN
                Topic% = 5
                Attr% = 7+(16*1)
                HiAttr% = 0+(16*7)
                WinAttr% = 15+(16*1)
                CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
                GOTO DIV.DIST.over
 END IF
        IF DIVIDE.KM# < 0 THEN DIVIDE.KM# = 0
        IF DIVIDE.ENG# < 0 THEN DIVIDE.ENG# = 0
        IF MEASURES$ = "ENGLISH" THEN DIVIDE.KM# = DIVIDE.ENG# / .6214
        IF MEASURES$ = "METRIC" THEN DIVIDE.ENG# = DIVIDE.KM# * .6214
        IF DIVIDE.ENG# > 50 THEN DIVIDE.ENG# = 50
        IF DIVIDE.KM# > 80 THEN DIVIDE.KM# = 80
        IF MEASURES$ = "" THEN DIVIDE.KM# = 0
 CALL RESTORESCREEN
 CALL RESTORESCREEN
END SUB


SUB SITE.ELEV
SHARED MEASURES$, ELEV#, ELEV.FT#

 IF ELEV# = -1 THEN ELEV# = 0
 Attr% = 0+16*7
 CALL MakeWindow(19,4,6,74,Attr%,3,1,0)
 CALL TitleWindow(3,4+16*7,"ELEVATION DESCRIPTION")
 CALL Wprint(2,2,Attr%,"Elevation of study site is measured from a USGS topographic map at the")
 CALL Wprint(3,2,Attr%,"largest available scale.  You can enter up to 1500 meters or 5000 feet.")
 CALL Wprint(4,2,Attr%,"You must select either metric or english measurements first.")


 SITE.ELEV.over:
 Attr% = 0+16*7
 CALL MakeWindow(14,20,3,30,Attr%,1,1,0)
 CALL TitleWindow(1,Attr%,"ELEVATION INPUT")
 CALL TitleWindow(5,Attr%,"F1 = HELP")

 Msg$ = "F1"
 LOCATE 15,21:COLOR 0,7
 IF MEASURES$ = "ENGLISH" THEN
        CALL ENTERNUMBER(ELEV.FT#,"####.#",Msg$)
 ELSE
        CALL ENTERNUMBER(ELEV#,"####.#",Msg$)
 END IF
 LOCATE ,,0
 IF Msg$ = "HELP!" THEN
                CALL RESTORESCREEN
                Topic% = 6
                Attr% = 7+(16*1)
                HiAttr% = 0+(16*7)
                WinAttr% = 15+(16*1)
                CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
                GOTO SITE.ELEV.over
 END IF
        IF ELEV# < 0 THEN ELEV# = 0
        IF ELEV.FT# < 0 THEN ELEV.FT# = 0
        IF MEASURES$ = "ENGLISH" THEN ELEV# = ELEV.FT# *.3048
        IF MEASURES$ = "METRIC" THEN ELEV.FT# = ELEV# / .3048
        IF ELEV.FT# > 5000 THEN ELEV.FT# = 5000
        IF ELEV# > 1525 THEN ELEV# = 1525
        IF MEASURES$ = "" THEN ELEV# = 0
 CALL RESTORESCREEN
 CALL RESTORESCREEN
END SUB

'---METRIC CONVERSION-----------------
'KILO * .6214 = MILES
'MILES / .6214 = KILOS
'METERS / .3048 = FEET
'FEET *.3048 = METERS
'(CENT * 9/5) + 32 = FAREN    'TEMP
```

```
'(FAREN -32) *5/9 = CENT
'---END METRIC CONVERSION------------



SUB VIEW.FACT                        'SHADE INPUT
SHARED BHSL#, AHSL#

 Attr% = 0+16*7
 CALL MAkeWindow(19,4,6,74,Attr%,3,1,0)
 CALL TitleWindow(3,4+16*7,"SHADE DESCRIPTION")
 CALL Wprint(1,2,Attr%,"Put in the average shade value for the reach.  Values for both before")
 CALL Wprint(2,2,Attr%,"and after harvest shade levels should be entered, thus allowing for")
 CALL Wprint(3,2,Attr%,"the comparison of water temperatures.  If only one value is entered,")
 CALL Wprint(4,2,Attr%,"then only the corresponding shade input will be calculated.")


 DO UNTIL CurntPos% = 4 OR CurntPos% = 27

  REDIM Item$(4,1)
 Item$(0,1) = "SHADE INPUT"
 Item$(1,1) = "BEFORE HARVEST SHADE LEVEL"            :Item$(1,0) = "1"
 Item$(2,1) = "AFTER HARVEST SHADE LEVEL"        :Item$(2,0) = "1"
 Item$(3,1) = "HELP"                             :Item$(3,0) = "1"
 Item$(4,1) = "MAIN MENU"                :Item$(4,0) = "1"

        HiAttr% = 4+(16*0)
        Attr% = 0+(16*7)
        WinAttr% = 6+16*7
        Style% = 2
        Shdw% = 1
        Zoom! = 0
        CALL MakeMenu(9,7,Item$(),Curntpos%,Hiattr%,Attr%,WinAttr%,Style%,Shdw%,Zoom!)


 SELECT CASE CurntPos%
        CASE 1
                GOSUB BeforeHSL      'BEFORE HARVEST SHADE LEVEL
        CASE 2
                GOSUB AfterHSL      'AFTER HARVEST SHADE LEVEL
        CASE 3
                Topic% = 7
                Attr% = 7+(16*1)
                HiAttr% = 0+(16*7)
                WinAttr% = 15+(16*1)
                CALL DisplayHelp(3,20,4,Attr%,Winattr%,1,1,0,Hiattr%,Topic%)
        CASE 4
 END SELECT

CALL RESTORESCREEN

LOOP
'IF LBANK#  > -1 AND RBANK# > -1 THEN
'       VIEWFACTOR# = (100-((LBANK#+RBANK#)/2))/100
'END IF

CALL RESTORESCREEN
EXIT SUB

 BeforeHSL:
        KeepBHSL# = BHSL#
        IF BHSL# = -1 THEN
                BHSL# = 0
        ELSE
                BHSL# = 100-(BHSL#*100)
        END IF
        Attr% = 0+16*7
        CALL MakeWindow(10,12,3,30,Attr%,1,1,0)
        CALL TitleWindow(1,15+16*7,"BEFORE HARVEST SHADE INPUT")
        COLOR 0,7
        Msg$ = ""
        LOCATE 11,14:CALL ENTERNUMBER(BHSL#,"###",Msg$)
        LOCATE ,,0
        CALL RESTORESCREEN
        IF BHSL# <0 THEN BHSL# = -1
```

```
        IF BHSL# > 100 THEN BHSL# = 100
        IF BHSL# => 0 THEN BHSL# = (100-BHSL#)/100
  IF Msg$ = "ESC" THEN BHSL# = KeepBHSL#
 RETURN

 AfterHSL:
        KeepAHSL# = AHSL#
        IF AHSL# = -1 THEN
                AHSL# = 0
        ELSE
                AHSL# = 100-(AHSL#*100)
        END IF
        Attr% = 0+16*7
        CALL MakeWindow(11,12,3,30,Attr%,1,1,0)
        CALL TitleWindow(1,15+16*7,"AFTER HARVEST SHADE INPUT")
        Msg$ = ""
        COLOR 0,7
        LOCATE 12,14:CALL ENTERNUMBER(AHSL#,"###",Msg$)
        LOCATE ,,0
        CALL RESTORESCREEN
        IF AHSL# <0 THEN AHSL# = -1
        IF AHSL# > 100 THEN AHSL# = 100
        IF AHSL# => 0 THEN AHSL# = (100-AHSL#)/100
  IF Msg$ = "ESC" THEN AHSL# = KeepAHSL#
 RETURN

END SUB



SUB GENERATE.REPORT

LOCAL Max.Temp.Report#, Mean.Temp.Report#, Min.Temp.Report#,_
          Report.Day%

SHARED Temp.Region%, Site.ID$, User.ID$, VIEWFACTOR#, streamdepth#,_
                GH2oTempC#(), Temperature.Criteria$, Mean.Water#, Max.Water#,_
                Min.Water#, Measure$, depthslope#(), depthintercept#(), Class$,_
                BHMax.Water#, AHMax.Water#, Harvest$


Tempout% = FREEFILE
OPEN "tfwtemp.out" FOR APPEND AS Tempout%
Hourout% = FREEFILE
OPEN "tfwhour.out" FOR OUTPUT AS Hourout%


Max.Temp.Report# = 0
Mean.Temp.Report# = 0
Min.Temp.Report# = 0

Min.Temp.Report# = Water.Min#(1)
FOR report.day% = 1 TO 8      '31
        IF Water.Max#(report.day%) > Max.Temp.Report# THEN
                Max.Temp.Report# =  Water.Max#(report.day%)
        END IF
        Mean.Temp.Report# = Mean.Temp.Report# + Water.Mean#(report.day%)
        IF Water.Min#(report.day%) < Min.Temp.Report# THEN
                Min.Temp.Report# = Water.Min#(report.day%)
        END IF
NEXT report.day%



PRINT #HourOut%, "------------------------------------------------------------------------------"
PRINT #HourOut%, "TIMBER/FISH/WILDLIFE REACH TEMPERATURE MODEL"
PRINT #HourOut%, "                    VERSION 7.0"
PRINT #HourOut%, "                    DATE > "; DATE$
PRINT #HourOut%, "                    USER > "; USER.ID$
PRINT #HourOut%, "SITE/FPA IDENTIFIER > "; SITE.ID$
PRINT #HourOut%, "        STREAM CLASS > "; CLASS$
PRINT #HourOut%, "             HARVEST > "; Harvest$
'PRINT #HourOut%, "-------------------------------------------------------------------------------"
PRINT #HourOut%, "                     SHADE PERCENT > "; USING$("##.#",VIEWFACTOR# * 100)

IF MEASURE$ = "METRIC" THEN
```

```
 PRINT #HourOut%, "              DEPTH (meters) > "; USING$("###.###",streamdepth#)
 PRINT #HourOut%, "     AIR TEMPERATURE PROFILE > "; pro%
 PRINT #HourOut%, "GROUNDWATER TEMPERATURE (°C) > "; GH2oTempC#(TEMP.REGION%)
 PRINT #HourOut%, "     GROUNDWATER INFLOW RATE > 0.009 cms/km"  '"; ROUND(Gh2oInflux#,3)
 PRINT #HourOut%, "           TEMPERTURE REGION > "; TEMP.REGION%
 PRINT #HourOut%, "-------------------------------------------------------------------"

'4 12 19
PRINT #HourOut%, "HOURLY TEMPERATURES IN CELCIUS"
PRINT #HourOut%, "  MAX    AVG   MIN"

FOR report.day% = 1 TO 8      '31
        PRINT #HourOut%, USING "#####.#"; Water.Max#(report.day%); Water.Mean#(report.day%); Water.Min#(report.day%)
NEXT report.day%

ELSEIF MEASURES$ = "ENGLISH" THEN
PRINT #HourOut%, "               DEPTH (feet) > "; USING$("###.###",streamdepth# /.3048)
PRINT #HourOut%, "     AIR TEMPERATURE PROFILE > "; pro%
PRINT #HourOut%, "GROUNDWATER TEMPERATURE (°F)> "; (GH2oTempC#(TEMP.REGION%)*9/5)+32
PRINT #HourOut%, "     GROUNDWATER INFLOW RATE > 0.512 cfs/mile"   '"; ROUND(Gh2oInflux#,3)
PRINT #HourOut%, "           TEMPERTURE REGION > "; TEMP.REGION%
PRINT #HourOut%, "-------------------------------------------------------------------"

PRINT #HourOut%, "HOURLY TEMPERATURES IN FAHRENHEIT"
PRINT #HourOut%, "  MAX    AVG   MIN"


FOR report.day% = 1 TO 8       '31
  PRINT #HourOut%, USING "#####.#"; (Water.Max#(report.day%)*9/5)+32; (Water.Mean#(report.day%)*9/5)+32;
(Water.Min#(report.day%)*9/5)+32
NEXT report.day%

END IF

Mean.Water# = Mean.Temp.Report# / 8      '31
Max.Water# = Max.Temp.Report#            '/ 8      '31
Min.Water# = Min.Temp.Report#            '/ 8      '31


Temperature.criteria$ = "ACCEPTABLE"
IF CLASS$ = "AA" AND Max.Water# > 16.0 THEN Temperature.Criteria$ = "UNACCEPTABLE"
IF CLASS$ = "A" AND Max.Water# > 18.0 THEN Temperature.Criteria$ = "UNACCEPTABLE"



PRINT #TempOut%, "-------------------------------------------------------------------"
PRINT #TempOut%, "TIMBER/FISH/WILDLIFE REACH TEMPERATURE MODEL"
PRINT #TempOut%, "                VERSION 7.0
PRINT #TempOut%, "               DATE > "; DATE$; "     TIME > ";TIME$
PRINT #TempOut%, "               USER > "; USER.ID$
PRINT #TempOut%, "SITE/FPA IDENTIFIER > "; SITE.ID$
PRINT #TempOut%, "       STREAM CLASS > "; CLASS$
PRINT #TempOut%, "            HARVEST > "; Harvest$
PRINT #TempOut%, "             MAXIMUM TEMPERATURE CRITERIA = "; Temperature.criteria$
IF MEASURES$ = "METRIC" THEN
 IF BHMax.Water# <> -1 THEN
        PRINT #TempOut%, "  INCREASE IN MAX WATER TEMPERATURE (°C)= "; USING$("###.#",AHMax.Water#-BHMax.Water#)
 END IF
 PRINT #TempOut%, "   MEAN WATER TEMPERATURE SIMULATION (°C)= "; USING$("###.#",Mean.Water#)
 PRINT #TempOut%, "MAXIMUM WATER TEMPERATURE SIMULATION (°C)= "; USING$("###.#",Max.Water#)
 PRINT #TempOut%, "MINIMUM WATER TEMPERATURE SIMULATION (°C)= "; USING$("###.#",Min.Water#)
 PRINT #TempOut%, ""
' PRINT #TempOut%, "-------------------------------------------------------------------"
 PRINT #TempOut%, "              SHADE PERCENT > "; USING$("#####.#",VIEWFACTOR# * 100)
 PRINT #TempOut%, "              DEPTH (meters) > "; USING$("###.###",streamdepth#)
 PRINT #TempOut%, "     AIR TEMPERATURE PROFILE > "; pro%
 PRINT #TempOut%, "GROUNDWATER TEMPERATURE (°C) > "; USING$("###.#",GH2oTempC#(TEMP.REGION%))
 PRINT #TempOut%, "     GROUNDWATER INFLOW RATE > 0.009 cms/km"   '"; ROUND(Gh2oInflux#,3)
 PRINT #TempOut%, "           TEMPERTURE REGION > "; TEMP.REGION%
 PRINT #TempOut%, "-------------------------------------------------------------------"
ELSEIF MEASURES$ = "ENGLISH" THEN
 IF BHMax.Water# <> -1 THEN
        PRINT #TempOut%, "  INCREASE IN MAX WATER TEMPERATURE (°F)= ";
USING$("###.#",(AHMax.Water#*9/5+32)-(BHMax.Water#*9/5+32))
 END IF
 PRINT #TempOut%, "   MEAN WATER TEMPERATURE SIMULATION (°F)= "; USING$("###.#",(Mean.Water#*9/5)+32)
 PRINT #TempOut%, "MAXIMUM WATER TEMPERATURE SIMULATION (°F)= "; USING$("###.#",(Max.Water#*9/5)+32)
```

```
 PRINT #TempOut%, "MINIMUM WATER TEMPERATURE SIMULATION (°F)= "; USING$("###.#",(Min.Water#*9/5)+32)
 PRINT #TempOut%, ""
' PRINT #TempOut%, "------------------------------------------------------------------------"
 PRINT #TempOut%, "                 SHADE PERCENT > "; USING$("#####.#",VIEWFACTOR# * 100)
 PRINT #TempOut%, "                  DEPTH (feet) > "; USING$("###.###",streamdepth#/.3048)
 PRINT #TempOut%, "      AIR TEMPERATURE PROFILE > "; pro%
 PRINT #TempOut%, "GROUNDWATER TEMPERATURE (°F) > "; USING$("###.#",(GH2oTempC#(TEMP.REGION%)*9/5)+32)
 PRINT #TempOut%, "      GROUNDWATER INFLOW RATE > 0.512 cfs/mile"   '"; ROUND(Gh2oInflux#,3)
 PRINT #TempOut%, "            TEMPERTURE REGION > "; TEMP.REGION%
 PRINT #TempOut%, "------------------------------------------------------------------------"
END IF
CLOSE #Hourout%
CLOSE #Tempout%

END SUB                'END GENERATE.REPORT




SUB RESULT.SCREEN

LOCAL ln%
SHARED DIVIDE.KM#, ELEV#, VIEWFACTOR#, User.ID$, Site.ID$,_
           Temp.Region%, Temp.Region$, streamdepth#, GH2oTempC#(),_
                 Temperature.Criteria$, Measure$, Min.Water#, BHMax.Water#,_
                 Mean.Water#, Max.Water#, Harvest$, Class$, ELEV.FT#, AHMax.Water#


'CALL RESTORESCREEN
CALL RESTORESCREEN
Attr% = 0+16*7
CALL MakeWindow(1,1,25,80,Attr%,1,0,0)
CALL TitleWindow(2,4+16*7,"TIMBER/FISH/WILDLIFE REACH TEMPERATURE MODEL")
A$ = HARVEST$ + " RESULTS"
CALL WCprint(1,6+16*7,A$)
CALL Wprint(3,20,Attr%,"DATE > " + DATE$ + "  TIME > " + TIME$)
CALL Wprint(4,39,Attr%,"USER > "+USER.ID$)
CALL Wprint(5,24,Attr%,"SITE/FPA IDENTIFIER > " + SITE.ID$)
CALL Wprint(6,31,Attr%,"STREAM CLASS > " + CLASS$)
CALL Wprint(7,31,Attr%,"HARVEST TIME > " + HARVEST$)
CALL Wprint(8,21,15+16*7,"SHADE LEVEL IN PERCENT > " + USING$("##.#",100-(VIEWFACTOR# * 100)))
CALL Wprint(9,25,Attr%,"TEMPERATURE REGION > "+ TEMP.REGION$)

IF MEASURE$ = "METRIC" THEN
        IF DIVIDE.KM# > 9.9 THEN
                CALL Wprint(10,23,Attr%,"DISTANCE FROM DIVIDE > "+USING$("##.#",DIVIDE.KM#)+" Kilometers")
        ELSE
                CALL Wprint(10,23,Attr%,"DISTANCE FROM DIVIDE > "+USING$("#.#",DIVIDE.KM#)+" Kilometers")
        END IF
        IF ELEV# > 999.9 THEN
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("####.#",ELEV#)+ " Meters")
        ELSEIF ELEV# > 99.9 THEN
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("###.#",ELEV#)+ " Meters")
        ELSEIF ELEV# > 9.9 THEN
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("##.#",ELEV#)+ " Meters")
        ELSE
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("#.#",ELEV#)+ " Meters")
        END IF
        CALL Wprint(12,38,Attr%,"DEPTH > "+USING$("##.###",streamdepth#) + " Meters")
        CALL Wprint(13,13,Attr%,"AIR TEMPERATURE PROFILE NUMBER > "+STR$(PRO%))
        CALL Wprint(14,20,Attr%,"GROUNDWATER TEMPERATURE > "+STR$(GH2oTempC#(TEMP.REGION%)) + "°C")
        CALL Wprint(15,25,Attr%,"GROUNDWATER INFLOW > "+"0.009 cms/km")   'STR$(ROUND(Gh2oInflux#,3)))

        CALL Wprint(17,15,15+16*7,"MAXIMUM TEMPERATURE CRITERIA = "+ Temperature.criteria$)

        IF BHMax.Water# <> -1 AND Harvest$ = "AFTER HARVEST" THEN
                IF AHMax.Water#-BHMax.Water# < 2.8001 THEN
                        CALL Wprint(18,11,9+16*7,"INCREMENTAL TEMPERATURE CRITERIA = ACCEPTABLE")
                ELSE
                        CALL Wprint(18,11,9+16*7,"INCREMENTAL TEMPERATURE CRITERIA = UNACCEPTABLE")
                END IF
                CALL Wprint(19,10,9+16*7,"INCREASE IN MAX WATER TEMPERATURE = "+USING$("###.#",AHMax.Water#-BHMax.Water#)+
"°C")
        END IF
        CALL Wprint(20,7,Attr%,"MAXIMUM WATER TEMPERATURE SIMULATION = "+USING$("###.#",Max.Water#) + "°C")
```

```
        CALL Wprint(21,10,Attr%,"MEAN WATER TEMPERATURE SIMULATION = "+USING$("###.#",Mean.Water#)+ "°C")
        CALL Wprint(22,7,Attr%,"MINIMUM WATER TEMPERATURE SIMULATION = "+USING$("###.#",Min.Water#)+ "°C")
END IF

IF MEASURES$ = "ENGLISH" THEN
        IF DIVIDE.KM#*.6214 > 9.9 THEN
                CALL Wprint(10,23,Attr%,"DISTANCE FROM DIVIDE > "+USING$("##.#",DIVIDE.KM#*.6214)+" Miles")
        ELSE
                CALL Wprint(10,23,Attr%,"DISTANCE FROM DIVIDE > "+USING$("#.#",DIVIDE.KM#*.6214)+" Miles")
        END IF
        IF ELEV.FT# > 999.9 THEN
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("####.#",ELEV.FT#) + " Feet")
        ELSEIF ELEV.FT# > 99.9 THEN
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("###.#",ELEV.FT#) + " Feet")
        ELSEIF ELEV.FT# > 9.9 THEN
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("##.#",ELEV.FT#) + " Feet")
        ELSE
                CALL Wprint(11,29,Attr%,"SITE ELEVATION > "+USING$("#.#",ELEV.FT#) + " Feet")
        END IF

        CALL Wprint(12,38,Attr%,"DEPTH > "+USING$("##.###",streamdepth#/.3048) + " Feet")
        CALL Wprint(13,13,Attr%,"AIR TEMPERATURE PROFILE NUMBER > "+STR$(PRO%))
        CALL Wprint(14,20,Attr%,"GROUNDWATER TEMPERATURE > "+STR$((GH2oTempC#(TEMP.REGION%)*9/5)+32) + "°F")
        CALL Wprint(15,25,Attr%,"GROUNDWATER INFLOW > "+"0.512 cfs/mile")   'STR$(ROUND(Gh2oInflux#,3)))

        CALL Wprint(17,11,15+16*7,"INCREMENTAL TEMPERATURE CRITERIA = "+ Temperature.criteria$)
        IF BHMax.Water# <> -1 AND Harvest$ = "AFTER HARVEST" THEN
        IF AHMax.Water#-BHMax.Water# < 2.8001 THEN
                        CALL Wprint(18,11,9+16*7,"INCREMENTAL TEMPERATURE CRITERIA = ACCEPTABLE")
                ELSE
                        CALL Wprint(18,11,9+16*7,"INCREMENTAL TEMPERATURE CRITERIA = UNACCEPTABLE")
                END IF
                CALL Wprint(19,10,9+16*7,"INCREASE IN MAX WATER TEMPERATURE =
"+USING$("###.#",(AHMax.Water#*9/5+32)-(BHMax.Water#*9/5+32))+ "°F")
        END IF
        CALL Wprint(20,7,Attr%,"MAXIMUM WATER TEMPERATURE SIMULATION = "+USING$("##.#",(Max.Water# *9/5)+32)+ "°F")
        CALL Wprint(21,10,Attr%,"MEAN WATER TEMPERATURE SIMULATION = "+USING$("##.#",(Mean.Water# *9/5)+32)+ "°F")
        CALL Wprint(22,7,Attr%,"MINIMUM WATER TEMPERATURE SIMULATION = "+USING$("##.#",(Min.Water# *9/5)+32)+ "°F")
END IF

CALL TitleWindow(5,14+16*7,"*** press P to print; any other key to continue ***")
HOLD:
WHILE NOT INSTAT :WEND
IF UCASE$(INKEY$) = "P" THEN

 over.print:
        REDIM Item$(4,1)
        Item$(0,1) = "SELECT PARALLEL PORT"
        Item$(1,1) = "LPT1:"     :Item$(1,0) = "4"
        Item$(2,1) = "LPT2:"     :Item$(2,0) = "4"
        Item$(3,1) = "COM1:"     :Item$(3,0) = "4"
        Item$(4,1) = "COM2:"     :Item$(4,0) = "4"

        HiAttr% = 4+(16*0)
        Attr% = 0+(16*7)
        WinAttr%  = 6+16*7
        Style% = 2
        Shdw% = 1
        Zoom! = 0
        CALL MakeMenu(15,7,Item$(),Curntpos%,Hiattr%,Attr%,WinAttr%,Style%,Shdw%,Zoom!)

        CALL RESTORESCREEN
        ON ERROR GOTO NOPAPER
        IF Curntpos% =1 OR CurntPos% = 2 THEN
                lpt% = FREEFILE
                SELECT CASE CurntPos%
                        CASE 1
                                OPEN "LPT1:" FOR OUTPUT AS lpt%
                        CASE 2
                                OPEN "LPT2:" FOR OUTPUT AS lpt%
                        CASE 3
                                OPEN "COM1:" FOR OUTPUT AS lpt%
                        CASE 4
                                OPEN "COM2:" FOR OUTPUT AS lpt%
                END SELECT

                Retrylpt% = -1
```

```
                FOR L% = 1 TO 25
                        FOR J% = 1 TO 80
                                PRINT #lpt%, CHR$(SCREEN(L%,J%));
                                IF Retrylpt% = 1 then goto over.print
                                IF Retrylpt% = 0 then goto noprint
                        NEXT J%
                NEXT L%
                PRINT #lpt%, CHR$(12);
                CLOSE #lpt%
        END IF
END IF
noprint:
ON ERROR GOTO 0


EXIT SUB
NOPAPER:

        REDIM Item$(2,1)
        Item$(0,1) = "PRINTER ERROR"
        Item$(1,1) = "RETRY"      :Item$(1,0) = "1"
        Item$(2,1) = "ABORT"      :Item$(2,0) = "1"

        HiAttr% = 4+(16*0)
        Attr% = 0+(16*7)
        WinAttr%  = 6+16*7
        Style% = 2
        ShdW% = 1
        Zoom! = 0
        CALL MakeMenu(14,10,Item$(),Curntpos%,Hiattr%,Attr%,WinAttr%,Style%,ShdW%,Zoom!)
        CALL restorescreen

        SELECT CASE CurntPos%
                CASE 1
                        Retrylpt% = 1
                CASE 2
                        Retrylpt% = 0
        END SELECT
resume next


END SUB          'END RESULT.SCREEN


SYSTEM
```