PROGRAM ESTU:
A METHOD FOR ESTIMATING ESTUARINE
TEMPERATURE DISTRIBUTIONS FOR
HARLEMAN'S CLOSED-FORM,
ONE-DIMENSIONAL MODEL

R. P. Wichner

OAK RIDGE NATIONAL LABORATORY

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APRIL 1974

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FOREWORD

Oak Ridge National Laboratory is providing technical assistance to the U. S. Atomic Energy Commission Directorate of Licensing in its analyses of the environmental impact of power reactors as required by the National Environmental Policy Act. The assessment of the environmental impact of a nuclear station has required the development of new analytical techniques and the expansion of many existing ones.

This document is one of the spin-off benefits of this effort by the Commission and its National Laboratories to protect the environment. The work reported here, while originally completed in support of the analysis of a particular nuclear plant, has wide application in other areas.

Other documents in this series are listed below:

1. L. Dresner, Steady Temperature Distributions in the Far-Field Region Obtained by Solution of the Equation of Convective Diffusion in Two Dimensions, USAEC Report ORNL-TM-4119, Oak Ridge National Laboratory, April 1973.
2. D. A. Pilati, Transient Cooling of a One-Dimensional Thermal Plume and its Application for Determining Cold Shock, USAEC Report ORNL-TM-4160, Oak Ridge National Laboratory, May 1973.
3. L. Dresner, V. R. Cain, and W. Davis, Jr., INTAKE: A Numerical Program to Calculate Fluid Velocity Profiles Near a Rectangular Inlet in a Stream with Cross Flow, USAEC Report ORNL-TM-4185, Oak Ridge National Laboratory, July 1973.
4. L. Dresner, One-Dimensional Analysis of Heat Dissipation in a Sidearm of a Cooling Lake, USAEC Report ORNL-TM-4287, Oak Ridge National Laboratory, October 1973.
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1. W. Davis, Jr., Row of Buoyant Jets/Slot Jet Model of Koh and Fan on the IBM/360 Disk, ORNL-CF-72-11-36, Oak Ridge National Laboratory, November 22, 1972.

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NOMENCLATURE

A	cross-sectional area of estuary, ft^2
C	concentration, lb/lb
D	depth, ft
E_L	longitudinal dispersion coefficient, ft^2/sec
$F(x,t,\tau)$	function defined for Eq. (5)
$g(\theta)$	function defined in Eq. (7)
K	surface loss coefficient, $\text{Btu}/\text{ft}^2 \cdot \text{sec} \cdot ^\circ\text{F}$
K_d	decay constant, sec^{-1}
Q_c	condenser flow rate, ft^3/sec
Q_n	net or time-average flow rate, ft^3/sec
t	time, sec
T	time of tidal cycle, sec
ΔT	temperature rise above ambient, $^\circ\text{F}$
ΔT_c	condenser ΔT
U_n	net or time-average velocity, ft/sec
U_T	maximum tidal velocity, ft/sec
w	pollutant inflow rate, lb/sec
x	distance downstream from outfall, ft
ρ	density, lb/ft^3
σ	tidal frequency, $\text{radians}/\text{sec}$
τ	time-integration variable, sec
θ	$\sqrt{t - \tau}$, $\text{sec}^{1/2}$

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ABSTRACT

A method is presented for obtaining accurate numerical results for Harleman's closed-form, one-dimensional estuary model. The model applies to the case of a single-source input, steady net flow, and tidal flow varying sinusoidally with time. Though more sophisticated estuarine computational procedures are now available, this simple, closed-form model may continue to be useful for approximations and parameter surveys.

Some general characteristics of temperature distributions as a function of time within the tidal cycle in the vicinity of a warm input are discussed for a typical East Coast estuary. Temperature profiles for 15-min intervals throughout the tidal cycle are plotted revealing some interesting and not well-known features. It is shown that a tidal average maximum temperature peak occurs very close to the location of the outfall for the range of net flows and dispersion coefficients that were examined.

Keywords: estuary, model, discharge, dispersion, temperature, distribution.

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1. METHOD FOR OBTAINING NUMERICAL RESULTS FROM HARLEMAN'S
ONE-DIMENSIONAL ESTUARY MODEL

Harleman considers an idealized estuary with uniform cross section, constant longitudinal dispersion coefficient, constant net river velocity, and tidal velocities varying solely with time.¹ These simplifying assumptions allow a closed-form solution to the problem of describing the spread of a single, steady discharge of some pollutant into the estuary. Briefly, the following derivation is given.

The general scalar transport equation for the time-dependent, one-dimensional case with first-order decay simplifies to:

$$\frac{\partial C}{\partial t} + U \frac{\partial C}{\partial x} = E_L \frac{\partial^2 C}{\partial x^2} - K_d C \quad (1)$$

Here, K_d represents a decay constant for a pollutant of concentration, C . For consideration of temperature distributions, C will be changed to the analogous term enthalpy per unit volume and K_d related to the surface heat loss coefficient. If now one assumes a continuous discharge of pollutant at rate w , uniformly dispersing throughout the cross section, a location $x = 0$ beginning at time $= 0$ and additionally that the stream velocity may be expressed as

$$U(t) = U_n + U_T \sin \sigma t \quad ,$$

where U_n is the net velocity, U_T is the maximum tidal velocity, and σ is related to the tidal period, T , by $\sigma = 2\pi/T$, then Harleman¹ shows that $C(x,t)$ may be found from the expression

$$\frac{C(x,t)}{C_o} = \int_0^t \frac{U_n}{\sqrt{4\pi E_L(t-\tau)}} \exp [-F(x,t,\tau)] d\tau \quad , \quad (2-a)$$

where

$$F(x,t,\tau) = \frac{\left[x - U_n(t-\tau) + \frac{U_T}{\sigma} (\cos \sigma t - \cos \sigma \tau) \right]^2}{4E_L(t-\tau)} + K_d(t-\tau) \quad . \quad (2-b)$$

In the above, C_o is a normalized concentration based on the net stream flow; i.e.,

$$C_o \equiv \frac{w}{\rho A U_n} \quad (3)$$

Normalized in this manner, the ratio $C(x,t)/C_o$ may exceed unity during slack periods in the tidal cycle.

The integral given in Eq. (2) is impossible to evaluate analytically and is quite difficult to evaluate numerically as it stands. Integration routines available on disk at the ORNL Computing Center yield highly inaccurate results when applied directly to Eq. (2). Hence, the integral must be modified to allow the integration to proceed with some strategy

that guarantees reasonably accurate results. First, we change the dependent variable from concentration to temperature, and also more conveniently normalize with respect to the condenser discharge temperature instead of the fictitious mixed-mean temperature based on fresh water flow. Substitute the definition of C_0 into Eq. (2-a) to yield:

$$C(x,t) = \int_0^t \frac{w}{\rho A \sqrt{4\pi E_L(t-\tau)}} \exp [-F(x,t,\tau)] d\tau \quad (4)$$

To convert to temperature distributions, make the following changes:

$$\begin{aligned} c_p \Delta T(x,t), \text{ Btu/lb}_m & \quad \text{for} \quad C(x,t), \text{ lb}_m/\text{lb}_m, \\ Q_c \rho c_p \Delta T_c, \text{ Btu/sec} & \quad \text{for} \quad w, \text{ lb}_m/\text{sec}, \\ K/\rho c_p D, \text{ sec}^{-1} & \quad \text{for} \quad K_d, \text{ sec}^{-1}. \end{aligned}$$

Above, Q_c and ΔT_c are the condenser volume flow rate and temperature rise, respectively; K is the surface heat exchange coefficient. In substituting the term $k/\rho c_p D$ for the pollutant decay term, K_d , we effectively assume that heat loss from the surface is obtained uniformly from throughout depth, D . Making these substitutions yields the temperature distribution expression analogous to Eq. (2) with modified normalization,

$$\frac{\Delta T(x,t)}{\Delta T_c} = \int_0^t \frac{Q_c}{A \sqrt{4\pi E_L(t-\tau)}} \exp [-F(x,t,\tau)] d\tau, \quad (5-a)$$

where

$$F(x,t,\tau) = \frac{\left[x - U_n(t-\tau) + \frac{U_T}{\sigma} (\cos \sigma t - \cos \sigma \tau) \right]^2}{4E_L(t-\tau)} + \frac{K(t-\tau)}{\rho c_p D} \quad (5-b)$$

It is now suggested* that the transformation of independent variables given by

$$\theta = \sqrt{t - \tau} \quad (6)$$

---

*The author is grateful to John V. Wilson of the Reactor Division, Oak Ridge National Laboratory, for suggesting this transformation.

results in a helpful simplification of Eq. (5). After some algebra, the following modified integral is obtained:

$$\frac{\Delta T(x,t)}{\Delta T_0} = \frac{Q_c}{A \sqrt{\pi E_L}} \int_0^{\sqrt{t}} \left[\exp - \frac{\left(U_n \theta - \frac{x}{\theta} - g(\theta) \frac{U_T}{\sigma \theta} \right)^2}{4 E_L} - \frac{K \theta^2}{\rho c_p D} \right] d\theta, \quad (7)$$

where

$$g(\theta) = \cos \sigma t - \cos \sigma(t - \theta^2) \quad .$$

Trial integrations using subroutine SQUANK,² which employs an adaptive Simpson quadrature procedure, shows clearly that Eq. (7) is a more promising starting point for numerical integration than Eq. (5), its algebraic equivalent. At least, initial trial runs yielded more nearly correct results using this modified form of the integrand.

Even so, Eq. (7) presents a severe trial for available numerical integration programs. The integrand is positive and in general diminishes with increasing θ due to the term containing K . However, the factor, $g(\theta)$, introduces an oscillation that frequently brings the integrand very nearly to zero in the interval, $0 < \theta < \sqrt{t}$. The portions of the domain of integration for which the integrand has significant value depend on the value of the parameters U_T , U_n and particularly the location, x . A successful numerical integration requires that the subdivision of the region $0 < \theta < \sqrt{t}$ by the subroutine avoid selecting these zero points as boundaries. Otherwise, the integrand appears to the subprogram to possess zero value in between.

A simple recipe for satisfactory integration, which has worked well at least for the parameters investigated, is to subdivide the span of θ into fourths, perform four integrations and add the result. The user should beware, however, that abrupt computed reductions in temperature at locations other than the outfall probably signify that the integration procedure is omitting significant spans of the domain. The easiest remedy in that case is further subdivision of the region.

It is interesting to verify the algebra of Eq. (7) for the following limiting case: $x = Q_T = E_L = K = 0$ and $t \rightarrow \text{large}$. This is simply the case of steady river flow and no longitudinal dispersion or surface

heat loss. The result should be simply the predictable mixed-mean temperature rise. For this case, Eq. (7) reduces to

$$\frac{\Delta T(x = 0, t \rightarrow \infty)}{\Delta T_c} = \frac{Q_c}{A \sqrt{\pi E_L}} \int_0^\infty \exp\left(-\frac{U_n^2 \theta^2}{4 E_L}\right) d\theta \quad (8)$$

Carrying out the integration, yields as expected

$$\Delta T(0, \infty) = \Delta T_c \cdot \frac{Q_c}{Q_n} \quad (9)$$

2. SOME CHARACTERISTICS OF ONE-DIMENSIONAL ESTUARINE TEMPERATURE DISTRIBUTIONS

A description of the computer program for evaluating temperature distributions from Eq. (7) is given in Appendix A. The program has the feature of calling for a CALCØMP plot of an axial distribution for as many as ten predesignated times in the tidal cycle. In addition, a tidal average temperature distribution is plotted.

Figures 1 through 8 illustrate axial temperature profiles obtained at ~15-min intervals throughout the 12-hr tidal cycle. The curves pertain to the following assumed conditions:

$$\begin{aligned} E_L &= 100 \text{ ft}^2/\text{sec}, \\ Q_n &= 40,000 \text{ ft}^3/\text{sec}, \\ Q_T &= 250,000 \text{ ft}^3/\text{sec}, \\ A &= 160,000 \text{ ft}^2, \\ Q_c &= 670 \text{ ft}^3/\text{sec}, \\ K &= 4.6 \text{ Btu/ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}, \\ \text{TSF} &= 6.^{\dagger} \end{aligned}$$

[†]The parameter TSF (thermal stratification factor) is used as a corrective factor to account for nonuniform distribution of heat with depth. The effective heat loss coefficient becomes TSF x K. The validity of this concept is not a question here. The results presented are intended solely for illustration.

Fig. 1. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flow conditions: $Q_F = 40,000$ cfs, $E_L = 100$ ft²/sec, $Q_T = 250,000$ cfs, $A = 160,000$ ft², $Q_C = 670$ cfs, $K = 4.6$ Btu/ft²·hr·°F, TSF = 6. HWS $\rightarrow$ 1:15.

Fig. 2. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flcw conditions: $Q_F = 40,000 \text{ cfs}$, $E_L = 100 \text{ ft}^2/\text{sec}$, $Q_T = 250,000 \text{ cfs}$, $A = 160,000 \text{ ft}^2$, $Q_C = 670 \text{ cfs}$, $K = 4.6 \text{ Btu/ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}$, $\text{TSF} = 6$. 1:30 $\rightarrow$ 2:45.

Fig. 3. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flow conditions: $Q_T = 40,000 \text{ cfs}$, $E_L = 100 \text{ ft}^2/\text{sec}$, $Q_C = 250,000 \text{ cfs}$, $A = 160,000 \text{ ft}^2$, $Q_C = 670 \text{ cfs}$, $K = 4.6 \text{ Btu/ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}$, $\text{TSF} = 6$. 3:00 → 4:15.

Fig. 4. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flow conditions: $Q_F = 40,000 \text{ cfs}$, $E_L = 100 \text{ ft}^2/\text{sec}$, $Q_T = 250,000 \text{ cfs}$, $A = 160,000 \text{ ft}^2$, $Q_C = 670 \text{ cfs}$, $K = 4.6 \text{ Btu}/\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}$, $\text{TSF} = 6$. $4:30 \rightarrow 5:45$.

Fig. 5. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flow conditions: $Q_F = 40,000 \text{ cfs}$, $E_L = 100 \text{ ft}^2/\text{sec}$, $Q_T = 250,000 \text{ cfs}$, $A = 160,000 \text{ ft}^2$, $Q_C = 670 \text{ cfs}$, $K = 4.6 \text{ Btu}/\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}$, $\text{TSF} = 6$. 6:00 → LWS → 7:15.

Fig. 6. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flow conditions: $Q_F = 40,000 \text{ cfs}$, $E_L = 100 \text{ ft}^2/\text{sec}$, $Q_T = 250,000 \text{ cfs}$, $A = 160,000 \text{ ft}^2$, $Q_C = 670 \text{ cfs}$, $K = 4.6 \text{ Btu/ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}$, $\text{TSF} = 6$. $7:30 \rightarrow 8:45$.

Fig. 7. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flow conditions: $Q_T = 40,000 \text{ cfs}$, $E_L = 100 \text{ ft}^2/\text{sec}$, $Q_T = 250,000 \text{ cfs}$, $A = 160,000 \text{ ft}^2$, $Q_C = 670 \text{ cfs}$, $K = 4.6 \text{ Btu/ft}^2 \cdot \text{hr} \cdot ^\circ\text{F}$, $\text{TSF} = 6$. 9:00 $\rightarrow$ 10:30.

Fig. 8. Illustrative axial temperature profiles at 15-min intervals throughout the tidal cycle. Flow conditions: $Q_T = 40,000$ cfs, $E_L = 100$ ft²/sec, $Q_T = 250,000$ cfs, $A = 160,000$ ft², $Q_C = 670$ cfs, $K = 4.6$ Btu/ft²·hr·°F, TSF = 6. 10:45 $\rightarrow$ 12:15.

These conditions are typical for a small, older generation reactor located on an eastern estuary during a time of high river flow. The effluent point is at $x = 0$, with negative x signifying the upstream direction.

It is interesting to go through one tidal cycle in some detail for qualitative observation of the nature of the predicted profiles. Much more detail is presented in these figures than previously shown for profiles computed from Harleman's model; for example, see Figs. 2.17 and 2.18 of Ref. 1. It is believed that this added detail results directly from an improved capability for obtaining numerical results using the modified form of the model presented in Eq. (7). Figure 1 begins with the curve labeled high water slack (HWS), which is obtained after 200 tidal cycles have lapsed to assure that quasi-equilibrium conditions have been attained. Since this is a slack water time, it is natural to anticipate a peak at the outfall point, $x = 0$. As time progresses, ebb flow begins, as may be noted by the downstream move of this peak for a distance of ~ 2000 ft during this hour.

A curious secondary peak is formed centered about the $-11,000$ -ft location in this first hour following HWS. Physically, the cause of this upstream peak, the appearance of which is quite unexpected, is the opposing directions for convective and diffusive heat flow.

Figure 2 extends from 1 hr, 30 min to 2 hr, 45 min following HWS, the latter being the time of maximum ebb flow. Note that both the original slack water peak and secondary upstream peak translate downstream and spread. Figure 3 extends from 3 hr to 4 hr, 15 min following HWS, a period of lessening ebb flow. The original slack water peak has moved to $\sim x = 12,000$ ft, while back at $x = 0$ there begins to be a hint of a new slack water peak forming. Figure 4 brings the cycle to approximately one-half hour before low water slack (LWS). A new slack water peak begins to form at $x = 0$; the original HWS peak remains at $x = 12,000$ ft, while the original upstream peak has been obliterated by diffusion.

Figure 5 goes through the LWS period. The time 6 hr and 15 min corresponds to the null point of the oscillating component of the flow. However, approximately another hour passes before the flood flow overcomes the river flow at ~ 7 hr and 15 min. Note that the LWS peak is

smaller than the HWS peak. This appears to be due to the fact that the LWS peak builds from zero temperature excess, the ebb flow having driven the heated zone completely downstream from the effluent point. On the other hand, the HWS peak builds over an area that is already above the ambient temperature. The flood flow preceding HWS brings the heated zone upstream, straddling the point of discharge.

Figure 6 is a time of flood flow. The new LWS peak and older, still discernable HWS peak, translate upstream and spread. Figures 7 and 8 carry the cycle back to HWS.

The time-average axial temperature distribution is depicted in Fig. 9. A significant feature of the profile is the existence of a time-average temperature peak at $x = 0$ and an extremely broad maximum approximately 22,000 ft downstream. This peak appears at the point of outfall because of the dominating effect of the two slack water that develop during each tidal cycle.

3. EFFECT OF Q_n ON THE RATE OF ESTABLISHMENT OF STEADY, TIDAL-AVERAGE AXIAL TEMPERATURE PROFILES

The rate of approach to quasi-steady temperature equilibrium in the estuary preceding reactor startup is shown in Figs. 10 and 11 for low- and high-net flow conditions, respectively. For both figures the same dispersion coefficient of $100 \text{ ft}^2/\text{sec}$ was used, as well as identical estuarine dimensions and oscillatory flows.

For Fig. 10 a net flow of 10,000 cfs was assumed. It may be seen that 20 tidal cycles must elapse before the tidal average temperature profile steadies out fully. However, only about 10 tidal cycles are required to achieve a stable time-average profile in the immediate vicinity of the outfall.

Four times the net flow or 40,000 cfs was assumed in Fig. 11. Note that the approach to quasi-steady state is faster at the higher net flow rate. Only 8 tidal cycles are required to steady the complete profile, while the discharge zone steadies within 4 tidal cycles. It is interesting to observe that a temperature peak occurs at the outfall at both net flows, with the peak being lower in value but significantly more prominent at the higher flow. The value of the temperature peak is 2.23% at

Fig. 9. Tidal average temperature profile. Conditions same as for Fig. 8.

Fig. 10. Transient startup. Time-average axial temperature distributions at end of 1st, 2nd, 4th, 10th, 20th, and 40th tidal cycles after reactor startup. Flow conditions: same as for Fig. 9 except $Q_n = 10,000$ cfs.

Fig. 11. Transient startup. Time-average axial temperature distributions at end of 1st, 2nd, 4th, 8th, and 10th tidal cycles after reactor startup. Flow conditions: same as for Fig. 10 except $Q_n = 40,000$ cfs.

at 10,000 cfs net flow and is reduced to 0.99% at 40,000 cfs net flow. Hence, it may be possible to use the time-average temperature at the outfall as a measure of the net estuary flow if the effect of dispersion coefficient can be separated out.

4. EFFECT OF E_L ON THE TIME-AVERAGE LONGITUDINAL TEMPERATURE PROFILE

Figures 12 and 13 show the effect of varying longitudinal dispersion coefficient on the time-average axial temperature profile at low (10,000 cfs) and high (40,000 cfs) fresh water flows. All other flow parameters are the same as used throughout this report.

In general, no pronounced effect of E_L on the time-average temperature distribution is seen at either flow rate for the range of parameters covered here. In particular, at a net flow of 10,000 cfs only 2% change occurred in the maximum temperature at $x = 0$ over a factor of 8 variation in E_L . At the higher flow rate, a factor of 6 variation in E_L caused a 10% change in the temperature peak at $x = 0$.

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Fig. 12. Effect of E_L on time-average axial temperature profile.
Flow conditions: $Q_n = 10,000$ cfs; others same as for previous figures.

Fig. 13. Effect of E_L on time-average axial temperature profile.
Flow conditions: $Q_n = 40,000$ cfs; others same as for previous figures.

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APPENDIXES

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APPENDIX A

INPUT CARDS REQUIRED FOR PROGRAM ESTU

	<u>Variables</u>	<u>Format</u>
Card 1	"Title"	9A8
2	UF,EL,KD,TSF,D,QC,WIDTH,UT	8F10.0
3	DY,NY,TINIT,NTEST(10)	F5.0,I5,F5.0,10I5
4	"72" in columns 4 and 5	
5	Repeat card 1 for plot 1	
6	Repeat card 4 for plot 2	
7	Repeat card 1 for plot 2	

Definitions

DY [*]	Interval width on ordinate (temperature axis)
NY [*]	Number of intervals on ordinate
TINIT	Initial value of the number of tidal cycles over which the thermal input has occurred prior to initiation of calculation
NTEST(10)	Selected tidal phases for printing and plotting. NTEST = 1 is HWS. NTEST = 26 is LWS. Highest allowable value is 50, which is about 15 min before the next HWS following TINIT

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*Values of DY,NY are required for the plotting package, INTRIGUE II-C,³ which the main program calls from disk storage.

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APPENDIX B

COMPUTER PROGRAM FOR CALCULATING AND PLOTTING ESTUARINE TEMPERATURE
DISTRIBUTIONS FROM HARLEMAN'S ONE-DIMENSIONAL MODEL

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//RPWB JOB (14120), 'Y-12 5204-1 WICHNER ', CLASS=D JGB 457

// EXEC FORTHCLG, PARM.FORT='XREF', PARM.GO='EU=-1',

// REGION.GO=120K

XX PROC PRIM=600, SEC=0, SYS1=8, SYS2=1 00000010

XXFORT EXEC PGM=IEKAA00, REGION=270K 00000020

XXSYSPRINT DD SYSOUT=A, DCB=(RECFM=VBA, LRECL=137, BLKSIZE=3288), X00000030

XX SPACE=(3288, (600, 200), RLSE) 00000040

XXSYSPUNCH DD SYSOUT=B, SPACE=(3520, (200, 0), RLSE), *00000050

XX DCB=(RECFM=FB, LRECL=80, BLKSIZE=3520) 00000060

XXSYSLIN DD DSN=66UT30, UNIT=SYSDA, DISP=(MOD, PASS), X00000070

XX DCB=(RECFM=FB, LRECL=80, BLKSIZE=3200), SPACE=(3200, (100, 50), RLSE) 00000080

XXSYSDAT1 DD UNIT=SYSDA, SPACE=(3150, (20, 30), RLSE), X00000090

XX DCB=(RECFM=FB, LRECL=105, BLKSIZE=3150) 00000100

XXSYSDAT2 DD UNIT=SYSDA, SPACE=(TRK, (50, 5), RLSE) 00000110

//FORT.SYSIN DD *

IEF236I ALLOC. FOR RPWB FORT

IEF237I 064 ALLOCATED TO SYSPRINT

IEF237I 0A9 ALLOCATED TO SYSPUNCH

IEF237I 232 ALLOCATED TO SYSLIN

IEF237I 235 ALLOCATED TO SYSDAT1

IEF237I 232 ALLOCATED TO SYSDAT2

IEF237I 07F ALLOCATED TO SYSIN

IEF142I - STEP WAS EXECUTED - COND CODE 0000

IEF285I SYS73232.T103255.RV000.RPWB.LT30 PASSEC

IEF285I VOL SER NOS= TTTTTT.

IEF285I SYS73232.T103255.RV000.RPWB.R0009221 DELETED

IEF285I VOL SER NOS= MMMMMM.

IEF285I SYS73232.T103255.RV000.RPWB.R0009222 DELETED

IEF285I VOL SER NOS= TTTTTT.

RPWB FORT 20.24.04 08-20-73 MAIN 270K LCS OK LCS-FACTOR= 1/ 1 **RUF= 8/ 10
CPU SEC.= 1.68// I/O REQUESTS= 687// REGION ALLOC.= 270K// MACH. USE SEC.= 2.31// REGION USED= 268K

XXLINK EXEC PGM=IEWL, REGION=150K, PARM='MAP, LIST', CCNC=(4, LT, FCRT) 00000120

//LINK.SYSLIB DD DSN=LABELIB, DISP=SHR

X/SYSLIB DD DSN=LABELIB, DISP=SHR 00000130

// DD DSN=BROOKS.LOAD.MODULES, UNIT=2314,

// VOLUME=SER=ZZZZZ, DISP=SHR

XXSYSPRINT DD SYSOUT=A, DCB=(RECFM=FB, LRECL=121, BLKSIZE=3509), *00000140

XX SPACE=(3509, (600, 200), RLSE) 00000150

XXSYSDAT1 DD UNIT=SYSDA, SPACE=(CYL, (6, 1)) 00000160

XXSYSLMOD DD DSN=66FJUBLIB(NAMEX), DISP=(NEW, PASS), UNIT=SYSDA, 00000170

XX SPACE=(CYL, (6, SYSL, &SYSL, 1), RLSE) 00000180

IEF653I SUBSTITUTION JCL - SPACE=(CYL, (8, 1, 1), RLSE)

XXSYSLIN DD DSN=66UT30, DISP=(OLD, DELETE) 00000190

XX DD DSN=SYSIN 00000200

//LINK.FT33FU01 DD DISP=SHR, DSN=UNLINEA.MBE13253.INTRIGZC

//LINK.PLOTSUBS DD DISP=(SHR, PASS), DSN=JGSPLGTH

//LINK.SYSIN DD *

IEF236I ALLOC. FOR RPWB LINK

IEF237I 237 ALLOCATED TO SYSLIB

IEF237I 344 ALLOCATED TO

IEF237I 064 ALLOCATED TO SYSPRINT

IEF237I 232 ALLOCATED TO SYSUT1
 IEF237I 235 ALLOCATED TO SYSLMOD
 IEF237I 232 ALLOCATED TO SYSLIN
 IEF237I 080 ALLOCATED TO
 IEF237I 347 ALLOCATED TO FT33F001
 IEF237I 344 ALLOCATED TO PLDTSURS

IEF142I - STEP WAS EXECUTED - COND CODE 0000
 IEF285I LABLIB KEPT
 IEF285I VOL SER NOS= MVT21P.
 IEF285I BROOKS.LOAD.MODULES KEPT
 IEF285I VOL SER NOS= ZZZZZZ.
 IEF285I SYS73232.T103255.RV000.RPWB.R0005225 DELETED
 IEF285I VOL SER NOS= TTTTTT.
 IEF285I SYS73232.T103255.RV000.RPWB.FJOBLIB PASSEC
 IEF285I VOL SER NOS= MMMMMM.
 IEF285I SYS73232.T103255.RV000.RPWB.LT30 DELETED
 IEF285I VOL SER NOS= TTTTTT.
 IEF285I ONLINSA.MHE13253.INTRIG2C KEPT
 IEF285I VOL SER NOS= AZZZZZ.
 IEF285I JGSPLOTH PASSEC
 IEF285I VOL SER NOS= ZZZZZZ.

RPWB LINK 20.24.28 08-20-73 MAIN 150K LCS OK LCS-FACTOR= 1/ 1 **RUF= 8/ 10
 CPU SEC.= 1.02// I/O REQUESTS= 63E// REGION ALLOC.= 150K// MACH. USE SEC.= 1.31// REGION USED= 148K

XXGO EXEC PGM=*.LINK.SYSLMOD,COND=((4,LT,FORT),(5,LT,LINK)). X00000210
 XX REGION=150K 00000220
 XXFT51F001 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3458), *00000230
 XX SPACE=(3458,(&PRIM,&SEC),RLSE) 00000240
 IEF653I SUBSTITUTION JCL - SPACE=(3458,(600,0),RLSE)
 XXFT53F001 DD DSN=*&FJOBLIB(NAMEX),DISP=(CLD,DELETE), X00000250
 XX DCB=(RECFM=U,BLKSIZE=256),LABEL=(...,IN) 00000260
 XXDUMP DD SYSOUT=A,DCB=(RECFM=FA,BLKSIZE=133) 00000270
 //GD,FT49F001 DD UNIT=IN20U2,DCB=(RECFM=VS,LRECL=3204,BLKSIZE=3208),
 // DISP=(NEW,KEEP),SPACE=(3208,30,RLSE),DSN=PLCTOC.E>CB
 //GD,FT50F001 DD *
 //

IEF236I ALLOC. FOR RPWB GU
 IEF237I 235 ALLOCATED TO PGM=*.DD
 IEF237I 064 ALLOCATED TO FT31F001
 IEF237I 235 ALLOCATED TO FT53F001
 IEF237I 065 ALLOCATED TO DUMP
 IEF237I 232 ALLOCATED TO FT49F001
 IEF237I 082 ALLOCATED TO FT59F001
 IEF142I - STEP WAS EXECUTED - COND CODE 0000
 IEF285I SYS73232.T103255.RV000.RPWB.FJOBLIB PASSEC
 IEF285I VOL SER NOS= MMMMMM.
 IEF285I SYS73232.T103255.RV000.RPWB.FJOBLIB DELETED
 IEF285I VOL SER NOS= MMMMMM.
 IEF285I PLUTOO.EXCB KEPT
 IEF285I VOL SER NOS= TTTTTT.

RPWB GO 20.41.33 08-20-73 MAIN 120K LCS .....OK LCS-FACTOR= 1/ 1 **RUF= .8/ 10
CPU MIN.= 6.02// I/O REQUESTS= 3349// REGION ALLOC.= 120K// MACH. USE SEC.= 291.50// REGION USED= 118K

IEF2851 JGSPL0TH KEPT
IEF2851 VOL SER NOS= ZZZZZZ.

RPWB MODEL=91 14120 20.41.33 08-20-73 /// TCTAL JCB COST = 5 16.40(APPROXIMATE) ///
TOTAL CPU MIN.= 6.07//TOTAL I/O REQUESTS= 4674//MAX. REGION ALLOC.= 270K//TOTAL MACH. USE SEC.= 295.12//MAX. REGION USED= 268K

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,

SOURCE,EBCDIC,NGLIST,NODECK,LCAD,MAP,NOEDIT,NOID,XREF
 C TEMPERATURE DISTRIBUTION IN ESTUARIES RESULTING FROM CONTINUOUS WARM INPUT.
 C ONE-DIMENSIONAL 'REAL-TIME' MODEL OF HARLEMAN. TEMPS ARE NORMALIZED TO THE
 C CONDENSER TEMP RISE. DISTRIBUTIONS ARE PLOTTED AND PRINTED FOR UP TO 10
 C TIDAL PHASES. AT EACH OF THE 50 AXIAL LOCATIONS, THE TIDAL AVERAGE TEMPS
 C ARE COMPUTED AND PLOTTED.

```

ISN 0002      IMPLICIT REAL*8(A-H,O-Z)
ISN 0003      REAL*8 KD,NT
ISN 0004      DIMENSION XX(50),NTEST(10),TEM(50),TAVE(50),Z(7)
ISN 0005      DIMENSION TITLE(5)
ISN 0006      COMMON D5,TU,SIG,UF,X,UT,EL4,TFAC,FACTR
ISN 0007      EXTERNAL FUN
ISN 0008      DATA XX,TEM/100*0./
ISN 0009      DATA NTEST/10*0/
ISN 0010      TP=44712.
ISN 0011      PI=3.1415927
ISN 0012      C      SIG=2.*PI/TP
            SIG=.140525D-3
ISN 0013      EP=1.0-7
ISN 0014      THETA1=1.0-12
ISN 0015      DO 22 M=1,50
ISN 0016      22 XX(M)=-20000.*M*1000.
ISN 0017      C      READ CASE VARIABLES
            25 READ (50,20,END=9999) TITLE
ISN 0018      26 FORMAT(5A8)
ISN 0019      READ(50,27)UF,EL,KD,TSF,D,QC,WIDTH,UT
ISN 0020      27 FORMAT(8F10.0)
ISN 0021      C      READ NUMBERS OF TIDAL CYCLES TO BE PLOTTED.
            READ(50,29) DY,NY,TINIT,NTEST
ISN 0022      29 FORMAT(F5.0,15,F5.0,10I5)
ISN 0023      AFLOW=D*WIDTH
ISN 0024      EL4=4.*EL
ISN 0025      FACTR=QC/(AFLOW*DSQRT(PI*EL))
ISN 0026      C      TFAC=KD/(162.*D*3600.)*TSF
            TFAC=KD/(223200.*D)*TSF
ISN 0027      C      PREPARE CASE PRINTOUT
            WRITE(51,230)TITLE
ISN 0028      230 FORMAT(1H1,5A8)
ISN 0029      WRITE(51,30) UF,LT,EL,KD,D,TSF,QC
ISN 0030      30 FORMAT(1H0,
            1'FRESH WATER OR NET NONTIDAL VELOCITY(FT/SEC)=' ,F7.3/1H ,
            2'MAX SINUSOIDAL TIDAL VELOCITY(FT/SEC)=' ,F7.3/1H ,
            3'DISPERSION COEFFICIENT(FT/SEC)=' ,F7.1/1H ,
            4'SURFACE LOSS COEFFICIENT(B/HR-FISG-F)=' ,F7.3/1H ,
            5 'LIQUID DEPTH(FT) = ' ,F7.3/1H ,
            6 'THERMAL STRATIFICATION FACI= ' ,F7.3/1H ,
            7 'CONDENSER FLOWRATE (CFS) = ' ,F7.1)
ISN 0031      C      SET UP PLOT OF TEM VS X FOR NTEST TIDAL PHASES
            CALL LINEAR(0,DY, NY,-20000.,2000.,25,-14.,1,Z)
ISN 0032      CALL LETTER(0,43,43HTEMP RISE VS AXIAL LCC FOR VAR TIDAL PHASES,Z)
ISN 0033      CALL LETTER(1,43,43HAXIAL LCC- FT DNSTRM FROM INLET ,Z)
ISN 0034      CALL LETTER(2,43,43HTEMP RISE- PERCENT OF COND DELTA-T ,Z)
ISN 0035      CALL HOLLER(INL,TITLE,50)
ISN 0036      CALL SUBTLE(INL,TITLE,.5 ,.5 ,.?)
ISN 0037      DO 32 J=1,50
ISN 0038      32 TAVE(J)=0.
ISN 0039      KING=0

```

```

C BEGIN 200*TH TIDAL CYCLE AT HWS
ISN 0040      DO 200 NTI=1,50
ISN 0041      NT=TINIT+(NTI-1)/50.
C NT 200.0 200.1 200.2 200.3 200.4 200.5 200.6 200.7 200.8 200.9 200.98
C NTI 1      6      11      16      21      26      31      36      41      46      50.
C CALCULATE TEM AND 0.02*TAVE FOR ALL LOCATIONS
ISN 0042      TU=NT*TP
ISN 0043      D6=DCUS(SIG*TP)
ISN 0044      THUP=DSQRT(TU)
ISN 0045      DO 60 I=1,50
ISN 0046      X=XX(I)
ISN 0047      THETA2=THUP-1.0-10
C DIVIDE TIME INTERVAL INTO FOURTHS, CALL SQUANK 4 TIMES AND ADD.
ISN 0048      TEMP=0.
ISN 0049      DTHETA=(THETA2-THETA1)/4.
ISN 0050      DO50 J=1,4
ISN 0051      THLCWR=THETA1+(J-1)*DTHETA
ISN 0052      THUPPR=THETA1+J*DTHETA
ISN 0053      TEMP1=SQUANK(THLCWR,THUPPR,EP,FIFTH,NC,RUP,FUN)
ISN 0054      50 TEMP=TEMP+TEMP1
ISN 0055      TEM(I)=TEMP*100.
C      TAVE(I)=TAVE(I)+TEMP*100./50.
ISN 0056      TAVE(I)=TAVE(I)+TEMP*2.0
ISN 0057      60 CONTINUE
C SELECT NTEST TIDAL PHASES FOR PRINT AND PLOT
ISN 0058      DO 70 L=1,10
ISN 0059      IF (NTI.EQ.NTEST(L)) GO TO 68
ISN 0061      GO TO 70
ISN 0062      68 KIND=KIND+1
C PRINT AND PLOT TEM VS X FOR NTEST TIDAL PHASES
ISN 0063      WRITE(51,102)NT
ISN 0064      102 FORMAT(1H0,'NO. TIDAL CYCLES(WHOLE NO.=HWS,+.5=LWS)= ',F8.3)
ISN 0065      WRITE(51,104)
ISN 0066      104 FORMAT(1H0,' LONGIT DIST      T/TO'/
ISN 0067      11H,' FROM INPUT      PERCENT'/1H0)
ISN 0067      DO 110 J=1,50
ISN 0068      WRITE(51,72)XX(J),TEM(J)
ISN 0069      72 FORMAT(1H,2E14.4)
ISN 0070      110 CALL POINT( J,XX(J),TEM(J) ,KIND,0.12,0.,2,2)
ISN 0071      70 CONTINUE
ISN 0072      200 CONTINUE
ISN 0073      CALL ADVANC(Z)
C PRINT AND PLOT TAVE VS X (AVERAGE OVER TIDAL CYCLE)
ISN 0074      WRITE(51,210)
ISN 0075      210 FORMAT(1H0,' LONGIT DIST      TICAL AVE T/TO'/
ISN 0076      11H,' FROM INPUT      PERCENT'/1H0)
ISN 0076      CALL LINEAR(0.,DY, NY,-20000.,2000.,25,-14.,1,Z)
ISN 0077      CALL LETTER(0,43,43TIDAL AVERAGE TEMP VS DIST FROM INLET ,Z)
ISN 0078      CALL LETTER(1,43,43DISTANCE FROM INLET,FT ,Z)
ISN 0079      CALL LETTER(2,43,43TEMP RISE RELATIVE TO TCOND,PERCENT ,Z)
ISN 0080      CALL HOLLER(NL,TITLE,50)
ISN 0081      CALL SUBTLE(NL,TITLE,.5 ,0.5 ,2)
ISN 0082      DO 220 N=1,50
ISN 0083      WRITE(51,212) XX(N),TAVE(N)
ISN 0084      212 FORMAT(1H,2E14.4)
ISN 0085      220 CALL POINT(N,XX(N),TAVE(N),1,0.12,0.,2,2)
ISN 0086      CALL ADVANC(Z)
ISN 0087      GOTO 25

```

NXT CASE

ISN 0088 9999 STOP
ISN 0089 END

LEVEL 21.6 (DEC 72)

05/360 FORTRAN H

DATE 73.232/20.23.59

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,

SOURCE,EBCDIC,NCLIST,NODECK,LCAD,MAP,NGEDIT,NOIC,XREF

ISN 0002 DOUBLE PRECISION FUNCTION FUN(T)

ISN 0003 IMPLICIT REAL*8(A-H,O-Z)

ISN 0004 COMMON O6,TU,SIG,UF,X,LT,EL4,IFAC,FACTF

ISN 0005 TLOW=-1.D20

ISN 0006 10 D9=D6-DCOS(SIG*(TU-T**2))

C ARG=-(UF*T-X/T-D9*UT/(SIG*T))**2/EL4 -KD*T**2/(62.*D*3600.)*TSF

ISN 0007 ARG=-(UF*T-X/T-D5*UT/(SIG*T))**2/EL4-IFAC*T*T

ISN 0008 IF (ARG.LT.TLOW) GO TO 22

ISN 0010 GO TO 24

ISN 0011 22 FUN=0.

ISN 0012 RETURN

C FUN=QC/(A*D SQRT(PI*EL)) *DEXP(ARG)

ISN 0013 24 FUN=FACTF*DEXP(ARG)

ISN 0014 RETURN

ISN 0015 END

APPENDIX C

SAMPLE OF PRINTED OUTPUT

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WAS INTENTIONALLY
LEFT BLANK**

EL=100 FSQ/SEC, QR=40000 CFS, NCYCLES = 1 (HWS) - 6

FRESH WATER OR NET NONTIDAL VELOCITY(FT/SEC)= 0.241

MAX SINUSOIDAL TIDAL VELOCITY(FT/SEC)= 1.510

DISPERSION COEFFICIENT(FTSQ/SEC)= 100.0

SURFACE LOSS COEFFICIENT(B/HR-FTSQ-F)= 4.600

LIQUID DEPTH(FT) = 40.000

THERMAL STRATIFICATION FACTOR = 6.000

CONDENSER FLOWRATE (CFS) = 567.8

PLOT CALL OUTSIDE LIMITS X=0.0

Y=-.5000E 00

IPEN= 3

NO. TIDAL CYCLES(WHOLE NO.=HWS,+.5=LWS)= 10.000

LONGIT DIST FROM INPUT	T/T0 PERCENT
-0.19000 05	0.15330 00
-0.18000 05	0.25970 00
-0.17000 05	0.48080 00
-0.16000 05	0.64250 00
-0.15000 05	0.73280 00
-0.14000 05	0.73980 00
-0.13000 05	0.69580 00
-0.12000 05	0.64540 00
-0.11000 05	0.61770 00
-0.10000 05	0.62110 00
-0.90000 04	0.65250 00
-0.80000 04	0.70530 00
-0.70000 04	0.77170 00
-0.60000 04	0.84400 00
-0.50000 04	0.91590 00
-0.40000 04	0.98440 00
-0.30000 04	0.10530 01
-0.20000 04	0.11370 01
-0.10000 04	0.12960 01
0.0	0.20750 01
0.10000 04	0.10020 01
0.20000 04	0.84080 00
0.30000 04	0.87820 00
0.40000 04	0.93410 00
0.50000 04	0.99930 00
0.60000 04	0.10680 01
0.70000 04	0.11330 01
0.80000 04	0.11830 01
0.90000 04	0.12070 01
0.10000 05	0.11990 01
0.11000 05	0.11610 01
0.12000 05	0.11040 01
0.13000 05	0.10410 01
0.14000 05	0.98910 00
0.15000 05	0.95590 00
0.16000 05	0.94340 00
0.17000 05	0.94680 00
0.18000 05	0.95800 00
0.19000 05	0.96900 00
0.20000 05	0.97390 00
0.21000 05	0.96980 00
0.22000 05	0.95690 00
0.23000 05	0.93730 00
0.24000 05	0.91460 00
0.25000 05	0.89210 00
0.26000 05	0.87270 00

0.2700D 05	0.8578D 00
0.2800D 05	0.8466D 00
0.2900D 05	0.8403D 00
0.3000D 05	0.8350D 00

NO. TIDAL CYCLES(WHOLE NO.=HWS,+.5=LWS)= 10.020

LONGIT DIST FROM INPUT	T/T0 PERCENT

-0.1900D 05	0.1253D 00
-0.1800D 05	0.2537D 00
-0.1700D 05	0.4244D 00
-0.1600D 05	0.5927D 00
-0.1500D 05	0.7052D 00
-0.1400D 05	0.7373D 00
-0.1300D 05	0.7079D 00
-0.1200D 05	0.6587D 00
-0.1100D 05	0.6238D 00
-0.1000D 05	0.6179D 00
-0.9000D 04	0.6409D 00
-0.8000D 04	0.6872D 00
-0.7000D 04	0.7495D 00
-0.6000D 04	0.8200D 00
-0.5000D 04	0.8919D 00
-0.4000D 04	0.9614D 00
-0.3000D 04	0.1030D 01
-0.2000D 04	0.1109D 01
-0.1000D 04	0.1249D 01
0.0	0.2132D 01
0.1000D 04	0.1302D 01
0.2000D 04	0.8722D 00
0.3000D 04	0.8639D 00
0.4000D 04	0.9147D 00
0.5000D 04	0.9768D 00
0.6000D 04	0.1045D 01
0.7000D 04	0.1110D 01
0.8000D 04	0.1165D 01
0.9000D 04	0.1197D 01
0.1000D 05	0.1199D 01
0.1100D 05	0.1170D 01
0.1200D 05	0.1118D 01
0.1300D 05	0.1057D 01
0.1400D 05	0.1002D 01
0.1500D 05	0.9628D 00
0.1600D 05	0.9441D 00
0.1700D 05	0.9429D 00
0.1800D 05	0.9519D 00
0.1900D 05	0.9630D 00
0.2000D 05	0.9699D 00
0.2100D 05	0.9685D 00
0.2200D 05	0.9583D 00
0.2300D 05	0.9406D 00
0.2400D 05	0.9189D 00
0.2500D 05	0.8963D 00
0.2600D 05	0.8760D 00
0.2700D 05	0.8598D 00
0.2800D 05	0.8481D 00
0.2900D 05	0.8401D 00
0.3000D 05	0.8343D 00

NO. TIDAL CYCLES(WHOLE NO.=HWS,+.5=LWS)= 10.040

LONGIT DIST FROM INPUT	T/T0 PERCENT

-0.19000	05	0.88430	-01
-0.18000	05	0.19110	00
-0.17000	05	0.34220	00
-0.16000	05	0.51220	00
-0.15000	05	0.65350	00
-0.14000	05	0.72310	00
-0.13000	05	0.72120	00
-0.12000	05	0.67990	00
-0.11000	05	0.63750	00
-0.10000	05	0.61780	00
-0.90000	04	0.62740	00
-0.80000	04	0.66300	00
-0.70000	04	0.71790	00
-0.60000	04	0.78460	00
-0.50000	04	0.85590	00
-0.40000	04	0.92640	00
-0.30000	04	0.99490	00
-0.20000	04	0.10680	01
-0.10000	04	0.11170	01
0.0		0.19980	01
0.10000	04	0.17060	01
0.20000	04	0.10400	01
0.30000	04	0.86130	00
0.40000	04	0.88790	00
0.50000	04	0.94480	00
0.60000	04	0.10100	01
0.70000	04	0.10770	01
0.80000	04	0.11360	01
0.90000	04	0.11780	01
0.10000	05	0.11960	01
0.11000	05	0.11810	01
0.12000	05	0.11400	01
0.13000	05	0.10830	01
0.14000	05	0.10250	01
0.15000	05	0.97770	00
0.16000	05	0.94950	00
0.17000	05	0.94030	00
0.18000	05	0.94480	00
0.19000	05	0.95530	00
0.20000	05	0.96430	00
0.21000	05	0.96680	00
0.22000	05	0.96070	00
0.23000	05	0.94630	00
0.24000	05	0.92660	00
0.25000	05	0.90430	00
0.26000	05	0.88300	00
0.27000	05	0.86480	00
0.28000	05	0.85100	00
0.29000	05	0.84130	00
0.30000	05	0.83460	00

NO. TIDAL CYCLES(WHOLE NO.=HWS,+.5=LWS)= 10.060

LONGIT DIST	T/T0
FROM INPUT	PERCENT
-0.19000	0.52470
-0.18000	0.12440
-0.17000	0.24510
-0.16000	0.43490
-0.15000	0.56530
-0.14000	0.67950
-0.13000	0.72190

-0.12000	05	0.70430	00
-0.11000	05	0.66180	00
-0.10000	05	0.62770	00
-0.90000	04	0.61890	00
-0.80000	04	0.63820	00
-0.70000	04	0.68090	00
-0.60000	04	0.74030	00
-0.50000	04	0.80860	00
-0.40000	04	0.87950	00
-0.30000	04	0.94900	00
-0.20000	04	0.10190	01
-0.10000	04	0.11040	01
0.0		0.17490	01
0.10000	04	0.15210	01
0.20000	04	0.14350	01
0.30000	04	0.96300	00
0.40000	04	0.86890	00
0.50000	04	0.90630	00
0.60000	04	0.96600	00
0.70000	04	0.10320	01
0.80000	04	0.10960	01
0.90000	04	0.11490	01
0.10000	05	0.11820	01
0.11000	05	0.11860	01
0.12000	05	0.11630	01
0.13000	05	0.11160	01
0.14000	05	0.10580	01
0.15000	05	0.10040	01
0.16000	05	0.96410	00
0.17000	05	0.94300	00
0.18000	05	0.93920	00
0.19000	05	0.94610	00
0.20000	05	0.95610	00
0.21000	05	0.96280	00
0.22000	05	0.96210	00
0.23000	05	0.95300	00
0.24000	05	0.93660	00
0.25000	05	0.91580	00
0.26000	05	0.89390	00
0.27000	05	0.87380	00
0.28000	05	0.85730	00
0.29000	05	0.84500	00
0.30000	05	0.83650	00

NO. TIDAL CYCLES(WHOLE NO.=HWS,+.5=LWS)= 10.080

LONGIT DIST FROM INPUT	T/T0 PERCENT
-0.19000	05 0.25340-01
-0.18000	05 0.67430-01
-0.17000	05 0.14950 00
-0.16000	05 0.27890 00
-0.15000	05 0.43820 00
-0.14000	05 0.58800 00
-0.13000	05 0.68600 00
-0.12000	05 0.71530 00
-0.11000	05 0.69270 00
-0.10000	05 0.65250 00
-0.90000	04 0.62420 00
-0.80000	04 0.62150 00
-0.70000	04 0.64560 00
-0.60000	04 0.69170 00
-0.50000	04 0.75270 00
-0.40000	04 0.82140 00

-0.3000D 04	0.8917D 00
-0.2000D 04	0.9609D 00
-0.1000D 04	0.1033D 01
0.0	0.1519D 01
0.1000D 04	0.1793D 01
0.2000D 04	0.1801D 01
0.3000D 04	0.1321D 01
0.4000D 04	0.9477D 00
0.5000D 04	0.8773D 00
0.6000D 04	0.9167D 00
0.7000D 04	0.9773D 00
0.8000D 04	0.1043D 01
0.9000D 04	0.1104D 01
0.1000D 05	0.1153D 01
0.1100D 05	0.1179D 01
0.1200D 05	0.1179D 01
0.1300D 05	0.1150D 01
0.1400D 05	0.1104D 01
0.1500D 05	0.1044D 01
0.1600D 05	0.9929D 00
0.1700D 05	0.9571D 00
0.1800D 05	0.9399D 00
0.1900D 05	0.9382D 00
0.2000D 05	0.9457D 00
0.2100D 05	0.9549D 00
0.2200D 05	0.9600D 00
0.2300D 05	0.9575D 00
0.2400D 05	0.9469D 00
0.2500D 05	0.9306D 00
0.2600D 05	0.9087D 00
0.2700D 05	0.8872D 00
0.2800D 05	0.8679D 00
0.2900D 05	0.8524D 00
0.3000D 05	0.8410D 00

NO. TIDAL CYCLES(WHOLE NO.=HWS,+.5=LWS)= 10.100

LONGIT DIST FROM INPUT	T/TO PERCENT
-0.1900D 05	0.9603D-02
-0.1800D 05	0.2927D-01
-0.1700D 05	0.7472D-01
-0.1600D 05	0.1603D 00
-0.1500D 05	0.2900D 00
-0.1400D 05	0.4459D 00
-0.1300D 05	0.5893D 00
-0.1200D 05	0.6816D 00
-0.1100D 05	0.7086D 00
-0.1000D 05	0.6871D 00
-0.9000D 04	0.6496D 00
-0.8000D 04	0.6237D 00
-0.7000D 04	0.6229D 00
-0.6000D 04	0.6480D 00
-0.5000D 04	0.6945D 00
-0.4000D 04	0.7554D 00
-0.3000D 04	0.8235D 00
-0.2000D 04	0.8934D 00
-0.1000D 04	0.9628D 00
0.0	0.1356D 01
0.1000D 04	0.1540D 01
0.2000D 04	0.1776D 01
0.3000D 04	0.1731D 01
0.4000D 04	0.1301D 01
0.5000D 04	0.9611D 00

0.6000D 04	0.8840D 00
0.7000D 04	0.9191D 00
0.8000D 04	0.9789D 00
0.9000D 04	0.1043D 01
0.1000D 05	0.1103D 01
0.1100D 05	0.1150D 01
0.1200D 05	0.1176D 01
0.1300D 05	0.1172D 01
0.1400D 05	0.1142D 01
0.1500D 05	0.1094D 01
0.1600D 05	0.1038D 01
0.1700D 05	0.9888D 00
0.1800D 05	0.9546D 00
0.1900D 05	0.9381D 00
0.2000D 05	0.9367D 00
0.2100D 05	0.9438D 00
0.2200D 05	0.9523D 00
0.2300D 05	0.9567D 00
0.2400D 05	0.9537D 00
0.2500D 05	0.9428D 00
0.2600D 05	0.9256D 00
0.2700D 05	0.9048D 00
0.2800D 05	0.8837D 00
0.2900D 05	0.8648D 00
0.3000D 05	0.8496D 00

LONGIT DIST FROM INPUT	TIDAL AVE T/TO PERCENT

-0.1900D 05	0.2098D-01
-0.1800D 05	0.4589D-01
-0.1700D 05	0.8358D-01
-0.1600D 05	0.1289D 00
-0.1500D 05	0.1725D 00
-0.1400D 05	0.2069D 00
-0.1300D 05	0.2309D 00
-0.1200D 05	0.2482D 00
-0.1100D 05	0.2641D 00
-0.1000D 05	0.2819D 00
-0.9000D 04	0.3038D 00
-0.8000D 04	0.3308D 00
-0.7000D 04	0.3628D 00
-0.6000D 04	0.3994D 00
-0.5000D 04	0.4403D 00
-0.4000D 04	0.4850D 00
-0.3000D 04	0.5342D 00
-0.2000D 04	0.5914D 00
-0.1000D 04	0.6691D 00
0.0	0.9865D 00
0.1000D 04	0.7276D 00
0.2000D 04	0.7085D 00
0.3000D 04	0.7145D 00
0.4000D 04	0.7343D 00
0.5000D 04	0.7643D 00
0.6000D 04	0.8026D 00
0.7000D 04	0.8446D 00
0.8000D 04	0.8927D 00
0.9000D 04	0.9355D 00
0.1000D 05	0.9720D 00
0.1100D 05	0.9972D 00
0.1200D 05	0.1011D 01
0.1300D 05	0.1016D 01
0.1400D 05	0.1016D 01

0.1500D	05	0.1018D	01
0.1600D	05	0.1019D	01
0.1700D	05	0.1026D	01
0.1800D	05	0.1038D	01
0.1900D	05	0.1053D	01
0.2000D	05	0.1067D	01
0.2100D	05	0.1080D	01
0.2200D	05	0.1090D	01
0.2300D	05	0.1093D	01
0.2400D	05	0.1088D	01
0.2500D	05	0.1073D	01
0.2600D	05	0.1047D	01
0.2700D	05	0.1014D	01
0.2800D	05	0.9808D	00
0.2900D	05	0.9550D	00
0.3000D	05	0.9392D	00

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