Table D1.4 SLD1 Program Listing and Input Data.

```
//ARWACSLU JOB 3,CLASS=E
/*JOBPARM      P=BLK4,R=73
//     EXEC FORTXCLG,PARM='NOSOURCE'
//FORT.SYSIN DD *
      REAL N2F,N2WSTG,N2EFFL,N2FKG,N2REQ
      DIMENSION NAME(35)
      KIN= 5
      KOUT= 6
C
      READ(KIN,4000)NAME
 4000 FORMAT(35A2)
C
C---------------READ IN DESIGN PARAMETERS--
      READ(KIN,5000)AENGY,ASLDG,BSSOX,BO2OX,SRMVL,FMRAT,SNBIO,ALKLF,N2F,
     1PF
 5000 FORMAT(6F5.5,4F6.0)
C---------------READ IN CONCENTRATIONS VSS, NVSS--
      READ(KIN,5100)XVA,XVU,XVF,XNVF,XNVE
 5100 FORMAT(5F6.0)
C---------------READ IN CONCENTRATIONS B O D AND FLOW RATE--
      READ(KIN,5200)SFRESH,SEFFL,QFRESH
 5200 FORMAT(3F5.0)
C
      K=0
      L=0
      M=0
      N=0
C
C---------------CALCULATE SLUDGE RECYCLE RATIO (STEP 1)
C----------------1. SUBSTRATE REMOVAL RATE CONTROLLING(EQ 5.114)
      RAT1 = (XVA-ASLDG*(SFRESH-SEFFL)+BSSOX*(SFRESH-SEFFL)/SRMVL/(SEFFL
     1-SNBIO)-XVF)/(XVU-XVA)
C----------------2. OPTIMAL FLOCCULATING CONDNS. CONTROLLING(EQ 5.115)
      RAT2= (XVA- ASLDG*(SFRESH-SEFFL)+BSSOX*SFRESH/FMRAT-XVF)/(XVU-XVA-
     1BSSOX*SEFFL/FMRAT)
C
C---------------CALCULATE COMBINED VSS CONCENTRATIONS(STEP2,EQ 5.96)
C----------------1. SUBSTRATE REMOVAL RATE CONTROLLING
      SCOM1= (SFRESH+RAT1*SEFFL)/(1.+RAT1)
C----------------2. OPTIMUM FLOCCULATION CONDNS. CONTROLLING
      SCOM2= (SFRESH+RAT2*SEFFL)/(1.+RAT2)
C
C---------------CALCULATE RESIDENCE TIME(STEP 3)
C----------------1. SUBSTRATE REMOVAL RATE CONTROLLING(EQ 5.100)
      TRES1= (SCOM1-SEFFL)/(SRMVL*XVA*(SEFFL-SNBIO))
C----------------2. OPTIMUM FLOCCULATION CONDNS. CONTROLLING(EQ 5.101)
      TRES2= SCOM2/(XVA*FMRAT)
C
C---------------SELECT CONTROLLING CONDITIONS
      IF (TRES1-TRES2)30,10,20
   10 IF (RAT1-RAT2)20,30,30
   20 RATIO = RAT1
      SCOMB = SCOM1
      TRES = TRES1
      GOTO 40
   30 RATIO = RAT2
      SCOMB = SCOM2
      TRES = TRES2
C
C---------------CHECK F/M RATIO--
   40 FM= SCOMB/(XVA*TRES)
      IF (FM-.5)50,50,60
   50 IF (FM-.3)60,70,70
   60 K = 1
C
C---------------CALC. THROUGHPUT RATE & REACTOR VOL(STEP 4,EQ 5.5 & 5.104)
   70 Q= QFRESH*(1.+RATIO)
      VOL= Q*TRES
C
C---------------CALCULATE NET YIELD MLVSS (STEP 5,EQ 5.105)
      DELXV= Q*(ASLDG*(SCOMB-SEFFL)-BSSOX*XVA*TRES)*0.001
C
C---------------MATERIAL BALANCE CHECK--
      XVO= (XVF+RATIO*XVU)/(1.+RATIO)
      IF ((ABS(XVA-XVO)*Q*0.001-DELXV)/DELXV*100.-2.)90,90,80
   80 L = 1
C
C---------------CALC. WASTAGE Q2 &NET EFFLUENT Q1(STEP 6,EQ 5.74 & 5.95)
   90 Q2= (DELXV+0.001*QFRESH*XVF)/(.001*XVU)
      Q1= QFRESH-Q2
C
C---------------CALC. WASTAGE NVSS & TOTAL SLUDGE YIELD(STEP 7,EQ 5.72 &
C                                                                 5.1)
      DELXNV= (QFRESH*(XNVF-XNVE)+Q2*XNVE)*0.001
      DELXT= DELXV+DELXNV+QFRESH*XVF*0.001
C
C---------------CHECK MATERIAL BALANCE FOR NVSS IN EFFLUENT
      A= ABS((QFRESH*XNVF-Q1*XNVE)*0.001-DELXNV)/(Q1*XNVE*0.001)
      IF (A*100.-2.)110,110,100
  100 M = 1
C
C---------------CALC. NVSS IN SECONDARY CLARIFIER UNDERFLOW AND
C                                IN NET EFFLUENT(EQ 5.74)
  110 XNVU= DELXNV/(0.001*Q2)
      XNVO= (XNVF+RATIO*XNVU)/(1.+RATIO)
C
C---------------CALCULATE OXYGEN REQUIREMENTS(STEP 9,EQ 5.64)
      O2REQ= (AENGY*(SCOMB-SEFFL)*Q+BO2OX*XVA*VOL)*0.001
C
C---------------CHECK NEUTRALISATION REQUIREMENTS (STEP 10)--
      ALKREM= (SFRESH - SEFFL)*QFRESH*0.001*0.5
      ALKNTY= ALKLF*QFRESH*0.001
      IF (ALKNTY - ALKREM)130,130,120
  120 N = 1
C
C---------------EVALUATE NUTRIENT REQUIREMENTS (STEP 11)--
C----------------1. NITROGEN REQUIREMENTS (EQ 5.116)
  130 N2WSTG= 0.12*DELXV
      N2EFFL= 1.*QFRESH*0.001
      N2FKG= N2F*QFRESH*0.001
C     WRITE(KOUT,9990)N2WSTG,N2EFFL,N2FKG
      IF (N2WSTG+N2EFFL-N2FKG)150,150,140
C----------------CALCULATE NITROGEN REQUIRED--
  140 N2REQ = N2WSTG+N2EFFL-N2FKG
C     WRITE(KOUT,9991)N2REQ
 9991 FORMAT('0',F10.1)
 9990 FORMAT('1',3F10.3)
C----------------2. PHOSPHORUS REQUIREMENTS (EQ 5.117)
  150 PWSTG= 0.02*DELXV
      PEFFL= 0.5*QFRESH*0.001
      PFKG= PF*QFRESH*0.001
      IF (PWSTG+PEFFL-PFKG)170,170,160
C----------------CALCULATE PHOSPHORUS REQUIRED
  160 PREQ= PWSTG+PEFFL-PFKG
C
C
C---------------PROGRAM OUTPUT
C
  170 WRITE(KOUT,5300)AENGY,ASLDG,BSSOX,BO2OX,SRMVL,FMRAT,SNBIO,ALKLF,N2
     1F,PF
 5300 FORMAT('    INPUT DATA'/3X,10('*')////5X,'AENGY=',F6.5,' ASLDG=',F
     16.5,' BSSOX=',F6.5,' BO2OX=',F6.5,' SRMVL=',F6.5//5X,'FMRAT=',F6.5
     2,' SNBIO=',F5.0,' ALKLF=',F5.0,'    N2F=',F5.0,'     PF=',F5.0)
      WRITE(KOUT,5400)XVA,XVU,XVF,XNVF,XNVE,SFRESH,SEFFL,QFRESH
 5400 FORMAT('0',4X,'   XVA=',F5.0,'    XVU=',F6.0,'    XVF=',F5.0,'   XNVF=
     1',F6.0,'   XNVE=',F5.0//4X,'SFRESH=',F6.0,' SEFFL=',F6.0,' QFRESH=',
     2F6.0)
C
      WRITE(KOUT,5500)NAME,VOL,O2REQ,TRES
 5500 FORMAT('1',35A2////2X,'REACTOR:'/2X,7('*')///3X,'REACTOR VOLUME',
     117X,'VOL=',F10.1,' CU.M'//3X,'OXYGEN REQUIREMENTS',10X,'O2REQ=',F1
     20.1,' KG/DAY'//3X,'RESIDENCE TIME',16X,'TRES=',F10.3,' DAYS')
C
      WRITE(KOUT,5600)Q,Q1,Q2,RATIO
 5600 FORMAT('0'///2X,'FLOW RATES:'/2X,10('*')///3X,'COMBINED FEED',20X,'
     1Q=',F10.2,' CU.M/DAY'//3X,'NET EFFLUENT',20X,'Q1=',F10.2,' CU.M/DA
     2Y'//3X,'WASTAGE',25X,'Q2=',F10.2,' CU.M/DAY'//3X,'RECYCLE RATIO',1
     36X,'RATIO=',F10.3)
C
      WRITE(KOUT,5700)SCOMB
 5700 FORMAT('0'//2X,'CONCENTRATIONS OF SOLUBLE B O D:'/2X,31('*')///3X,
     1'COMBINED FEED',15X,'SCOMB=',F10.1,' MG/L')
C
      WRITE(KOUT,5800)XVO
 5800 FORMAT('0'//2X,'CONCENTRATIONS OF V S S:'/2X,23('*')///3X,'COMBINE
     1D FEED',15X,'XVO=',F10.1,' MG/L')
C
      WRITE(KOUT,5900)XNVO,XNVU
 5900 FORMAT('0'//2X,'CONCENTRATIONS OF N V S S:'/2X,23('*')///3X,'COMBI
     1NED FEED',17X,'XNVO=',F10.1,' MG/L'//3X,'SECONDARY CLARIFIER'/5X,'
```

SLD1 Listing (Continued)

```
      2UNDERFLO='.19X,'ANVU=',F10.1,' MG/L')
C
      WRITE(KOUT,6000)DELXV,DELXNV,DELXT
 6000 FORMAT('1'//2X,'WASTAGE'/2X,7('*')///3X,'NET YIELD MLVSS IN REACT
     1OR',3X,'DELXV=',F10.1,' KG/DAY'//3X,'WASTAGE OF NVSS',13X,'DELXNV=
     2',F10.1,' KG/DAY'//3X,'TOTAL SLUDGE YIELD',11X,'DELXT=',F10.1,' KG
     3/DAY')
C
      WRITE(KOUT,6100)
 6100 FORMAT('0'//2X,'NEUTRALISATION REQUIREMENTS:'/2X,27('*'))
C
      IF (N-1)180,190,180
  180 WRITE(KOUT,6200)
 6200 FORMAT('0'///5X,'NO NEUTRALISATION REQUIRED')
      GOTO 200
  190 WRITE(KOUT,6300)
 6300 FORMAT('0'///5X,'NEUTRALISATION REQUIRED')
  200 WRITE(KOUT,6400)ALKNTY,ALKREM
 6400 FORMAT('0'//3X,'ALKALINITY IN FRESH FEED',4X,'ALKNTY=',F10.1,' KG/
     1DAY'//3X,'ALKALINITY REMOVED',10X,'ALKREM=',F10.1,' KG/DAY')
C
      WRITE(KOUT,6500)N2REQ,PREQ
 6500 FORMAT('2'//2X,'NUTRIENT REQUIREMENTS:'/2X,21('*')///3X,'NITROGEN
     1REQUIREMENTS',8X,'N2REQ=',F10.1,' KG/DAY'//3X,'PHOSPHORUS REQUIREM
     2ENT',8X,'PREQ=',F10.1,' KG/DAY')
C
      IF (K-1)220,210,220
  210 WRITE(KOUT,6600)FM
 6600 FORMAT('0'///2X,'N.B. CALCULATED F/M RATIO NOT COMPATIBLE WITH GOO
     1D FLOCCULATION'/10X,'F/M=',F8.3)
  220 IF (L-1)240,230,240
  230 WRITE(KOUT,6700)
 6700 FORMAT('0'//2X,'N.B. MLVSS MATERIAL BALANCE DOES NOT CHECK')
  240 IF (M-1)260,250,260
  250 WRITE(KOUT,6800)
 6800 FORMAT('0'//2X,'N.B. NVSS MATERIAL BALANCE DOES NOT CHECK')
C
  260 STOP
      END
/*
//G.SYSIN DD *
 DESIGN PROCEDURE FOR ACTIVATED SLUDGE PLANT (RAMALHO E 7) RUN 7
   .79  .100  .075   .15 .0161    .6   10.   20.   33.    3.
 3000.16300.    0.    30.   20.
 1200.    40. 5578.
//
```

TABLE D2.1 KLIP6 PROGRAM INPUT DESCRIPTION

Card Set Repeat	Card Repeat	Symbol	Units	Description	Format	Symbol Repeat on Card
	1	RUN		Simulation run number	I3	1
		IPHO		≠0 Diurnal variation of photosynthesis used =0 Diurnal variation of photosynthesis not used	I2	1
		MNTH		Month of the year (= 1,2,.....,12)	I2	1
		START	hours. mins.	Time of day at start of simulation	X,F4.2	1
	1	NR		Number of homogeneous sub-reaches (maximum of 9)	I2	1
	NR	ENDR( )	km	Chainage at end of reach	F5.3	1
		DFFN( )	km^2/day	Longitudinal dispersion coefficient	F5.2	1
		VEL( )	km/day	Average velocity over reach	F5.2	1
		BODK( )	1/day	Deoxygenation coefficient	F5.2	1
		AERK( )	1/day	Reaeration coefficient	F5.2	1
		SINK( )	mg/l/day	BOD sink (+ve) or source (-ve)	F5.2	1
		SOURCE( )	mg/l/day	DO sink (-ve) or source (+ve)	F5.2	1
		PDO( )	mg/l/day	Photosynthetic DO production (always positive)	F5.2	1
		SINKI( )	mg/l/day	Inert COD sink (+ve) or source (-ve)	F5.2	1
	1	DELX	km	Space interval required for output	F5.3	1
		DELT	hours	Time increment for computation	F7.4	1
		IT		Integer by which DELT must be divided to assure stability of step 2 of calculations	X, I2	1
	1	NL		Number of sampling stations	I3	1
		DOSAT	mg/l	Dissolved oxygen saturation value	2X, F5.2	1
		ICOD		≠0 COD input used =0 COD input not used	I1	1
		DINRT1		Fraction of inert COD for input (Only required if ICOD ≠0)	4X, F5.2	1
		DINRT2		Assumed initial fraction of inert COD at downstream end (Only required if ICOD ≠0)	F5.2	1
NL	1	STN( )		Name or number of sampling station	A4	1
		XSTN( )	km	Chainage of station	X,F5.3	1
		NBOD( )		Number of BOD observed values at station	I2	1
		NDO( )		Number of DO observed values at station	I2	1
	NBOD/8	BOD( )	mg/l	Observed BOD concentration	F5.0	)
		TBOD( )	hours	Time of observed BOD concentration from start of simulation	F5.0	) 8X2)
	NDO/8	DO( )	mg/l	Observed DO concentrations	F5.0	)
		TDO( )	hours	Time of observed DO concentrations from start of simulation	F5.0	) 8X2)
	1	INTBD		≠0 Initial BOD concentrations at sampling stations are to be read in =0 Initial BOD concentrations not read in	I1	1
		INTDO		≠0 Initial DO concentrations of sampling stations are to be read in =0 Initial DO concentrations not read in	I1	1
	0 if INTBD=0 1 if INTBD≠0	BODZRO( )	mg/l	Initial BOD concentrations at sampling stations	F5.2	NL
	0 if INTDO=0 1 if INTDO≠0	DOZRO( ) DOZRO( )	mg/l	Initial DO concentrations at sampling stations	F5.2	NL
	1	NTOUT		Number of output times required	I2	1

TABLE D2.1 (Cont.)

Card Set Repeat	Card Repeat	Symbol	Units	Description	Format	Symbol Repeat on Card
	NTOUT/16	TIMES( )	hours	Times at which output is required in hours from start of simulation	F5.2	16
	1	NBODIN		Number of BOD input values	I2	1
		NDOIN		Number of DO input values	I2	1
	NBODIN/8	BODIN( )	mg/l	Input BOD concentrations at upstream point	F5.0)	8X2
		TBODIN( )	hours	Times of input BOD concentrations	F5.0)	
	NDOIN/8	DOIN( )	mg/l	Input DO concentrations at upstream point	F5.0)	8X2
		TDOIN( )	hours	Times of input DO concentrations	F5.0)	
	1	IPLT		Output requirements =0 No plotted output required =1 Plotted output required =2 No longitudinal output required	I1	1
		IPLT1		=0 Tabulation of results required =1 No tabulation of results required	I1	1
		ISCALE		Scale for BOD concentration on y-axis =1 BOD range 0 - 80 mg/l =2 BOD range 0 - 40 mg/l =3 BOD range 0 - 20 mg/l =4 BOD range 0 - 160 mg/l	I1	1

Table D2.2 KLIP6 Program Input Data

(a) Sample Survey 18 July 1978 - COD

```
L.0001  30 1 3  6.
L.0002   3
L.0003  1.7510.0 24.8  0.35 2.0   0.   8.   0.  -150.
L.0004  3.75 0.4 32.7  1.3  2.7   0.  13.   0.   175.
L.0005  5.5010.0 20.2  3.3  3.0   0.   0.   0.   80.
L.0006   .25 .2291? 5
L.0007   4  11.3 1      0.4  0.9
L.0008 E       7.      7 7
L.0009 45.0   3.0 77.0  2.5 51.0  5.0 36.0  7.5 41.0 10.0 56.0 12.5 61.0 15.0
L.0010  4.4   0.    3.9  2.5  4.9  5.    5.8  7.5  5.9 10.   5.7 12.5  5.0 15.0
L.0011 P       1.85 7 7
L.0012 50.0   0.5 56 1  3.0 81.0  5.3366.0  7.5 46.0 10.3336.0 12.3356.0 15.5
L.0013  4.0   0.5    3  3.    5.5  5.33 0.5  7.5  6.  10.33 5.9 12.83 5.0 15.0
L.0014 G       3.4     7
L.0015 56.0   3.3341.0  5.3336.0  7.8326.0 10.3336.0 12.8341.0 15.33
L.0016  5.2   0.33 5.5  2.83 6.3  5.33 3.2  7.83 6.1 10.33 6.5 12.83 6.0 15.33
L.0017 H       5.3  7 7
L.0018 25.0   1.7525.0  3.5 46.0  5.0 41.0  8.5 41.0 11.0 10.0 13.5 36.0 15.83
L.0019  7.4   1.75 7.4  3.5  7.7  0.    7.9  0.8  7.9 11.   7.1 13.5  7.7 15.83
L.0020 00
L.0021 16
L.0022  0.0   1.0  2.0  3.0  4.0  5.0  6.0  7.0  8.0  9.0 10.0 11.0 12.0 13.0 14.0 15.0
L.0023  7 7
L.0024 45.0   3.0 77.0  2.5 51.0  5.0 36.0  7.5 41.0 10.0 56.0 12.5 61.0 15.0
L.0025  4.4   0.    3.9  2.5  4.9  5.    5.8  7.5  5.9 10.   5.7 12.5  5.0 15.0
L.0026 211
```

(b) Sample Survey 21 March 1979 - COD

```
L.001  384 1 3  6.
L.002   3
L.003   1.7515.0 23.4  0.05 2.0 -180.  8.  3.  -150.
L.004   3.75 0.4 27.8  1.3  2.7  330. 10.  0.   175.
L.005   5.3010.0 20.0  3.3  1.0  100.  0.  0.    80.
L.006  0.250  .2343' 6
L.007   4     7.3H      0.6  3.9
L.008  E      0.   2520
L.009  59.   0.4238.    1.4248.    2.3338.    3.2554.    4.0843.    5.1743.    6.0043.    7.00
L.010  43.   8.0043.    9.0048.    9.9254.   11.0054.   12.1275.   13.0858.   13.9569.   15.00
L.011  94.  16.0321.   17.0074.   18.0053.   18.9727.   20.0037.   21.0050.   22.0048.   23.03
L.012  49.  24.34
L.013   2.85 0.42 2.7  1.42 3.   2.33 3.2  3.25 3.5  4.08 3.7  5.17 3.9  6.00 3.7  7.00
L.014   3.9  8.33 4.0  9.00 3.8  9.92 3.8511.00 3.8 12.12 3.4 13.08 3.1 13.93 3.3 15.00
L.015   2.8517.00 2.9 18.37 2.7 21.00 2.8 23.03
L.016  P      1.352520
L.017  58.   1.3053.    1.9253.    2.7853.    3.6758.    4.5858.    5.4764.    6.4259.    7.42
L.018  58.   8.4264.    9.4253.   10.4264.   11.5458.   12.5764.   13.5358.   14.3759.   15.40
L.019  55.  16.5753.   17.5070.   18.4054.   19.3 53.   20.3712.   21.4553.   22.3353.   23.35
L.020  37.  24.37
L.021   3.8  1.03 4.0  1.92 4.0  2.78 4.15 3  7 4.5  4.58 4.5  5.67 4.5  6.42 4.6  7.42
L.022   4.65 8.42 4.6  9.42 4.2 10.42 4.3 1   8 3.9712.57 3.7213.53 3.9 14.37 3.7 15.40
L.023   3.2517.53 3.6 19.37 3.6 21.45 3.652 .35
L.024  G      2.4 2521
L.025  27.   0.4233.    1.5043.    2.5032.    3.5027.    4.5043.    5.5027.    6.5022.    7.50
L.026  27.   8.5027.    9.5022.   10.5027.   11.5027.   12.5527.   13.5022.   14.5232.   15.45
L.027  27.  16.5022.   17.5327.   18.5022.   19.5322.   20.4827.   21.4830.   22.4732.   23.50
L.028  32.  24.52
L.029   4.1  0.42 4.1  1.50 4.3  2.50 4.35 3.50 4.5  4.50 4.6  5.50 4.7  6.50 4.7  7.50
L.030   4.7  8.50 4.8  9.54 4.5 10.50 4.5 11.50 4.4 12.55 4.3 13.55 4.1 14.55 4.0 15.45
L.031   4.0516.50 4.1 18.50 4.0 20.48 4.1 22.47 4.1 24.52
L.032  H(A)   5.1 2522
L.033  16.   1.0422.    2.0422.    3.0619.    4.0816.    5.0816.    6.0822.    7.0816.    8.08
L.034  16.   9.3822.   10.0827.   11.0816.   12.0822.   13.0711.   14.1022.   15.0527.   16.07
L.035  32.  17.0310.   18.0316.   19.0822.   20.0216.   21.1511.   22.2716.   23.3022.   24.35
L.036  20.  25.00
L.037   4.8  1.08 4.9  2.03 5.0  3.04 5.5  4.08 5.5  5.08 5.5  6.09 5.6  7.03 5.6  9.00
L.038   5.4  9.04 5.3 10.05 5.1511.08 5.012.08 5.0 13.08 4.8 14.08 4.9 15.03 4.9 15.07
L.039   4.5 17.13 4.5519.03 4.5520.02 4.6022.07 4.6524.05 4.7 25.00
L.040  03
L.041  26
L.042   0.   1.   2.   3.   4.   5.   6.   7.   8.   9.  10.  11.  12.  13.  14.  15.
L.043  16.  17.  18.  19.  20.  21.  22.  23.  24.  25.
L.044  2520
L.045  59.   0.4238.    1.4248.    2.3338.    3.2554.    4.0843.    5.1743.    6.0[illegible]    7.00
L.046  43.   8.0043.    9.0048.    9.9254.   11.0054.   12.1275.   13.0858.   13.9[illegible]   15.00
L.047  64.  16.0321.   17.0074.   18.0053.   18.9727.   20.0037.   21.0058.   22.0[illegible]   23.03
L.048  49.  24.04
L.049   2.85 0.42 2.7  1.42 3.   2.33 3.2  3.25 3.5  4.08 3.7  5.17 3.9  6.[illegible] 3.7  7.00
L.050   3.9  8.33 4.0  9.00 3.8  9.92 3.8511.00 3.8 12.12 3.4 13.08 3.1 13.[illegible]   15.00
L.051   2.8517.00 2.9 18.37 2.7 21.00 2.8 23.03
L.052  101
```

(c) Sample Survey 21 March 1979 - BOD

```
L.007  240 1 3  5.
L.008   3
L.009   1.7512.5 23.4  3.0  2.0 75.   40.   7.
L.010   3.75 0.4 37.8  2.0  2.7 30.   10.   5.
L.011   5.3010.0 23.0  4.0  7.0 -50.  39.   5.
L.012    .25 .23931  6
L.013    4    7.39
L.014  E      0.    720
L.015  24.7   0.4217.9  3.2314.5  5.0 20.3  9.0 18.9 12.12 8.7 13.6 14.3 18.0
L.016   2.85 0.42 2.7  1.42 3.   2.33 3.2  3.25 3.5  4.08 3.7  5.1[illegible] 3.8  6.00 3.7  7.00
L.017   3.9  8.33 4.0  9.00 3.8  9.92 3.8511.00 3.8 12.12 3.4 13.08 3.1 13.95 3.[illegible] 15.00
L.018   2.8517.00 2.9 18.37 2.7 21.00 2.8 23.03
L.019  P      1.35 720
L.020  13.1   1.3213.1  4.39 5.8  7.4210.2 10.42 8.7 13.5316.0 15.4011.0 19.[illegible] 5.8 2[illegible]
L.021   3.8   1.03 4.0  1.92 4.0  2.78 4.15 3.07 4.5  4.58 4.5  5.57 4.5  6.42 4.6  7.42
L.022   4.65 8.42 4.6  9.42 4.2 10.42 4.3 11.08 3.9712.57 3.7213.53 3.9 14.37 3.7 15.40
L.023   3.2517.35 3.6 19.37 3.6 21.45 3.6523.35
L.024  G      3.4   721
L.025   7.3   2.5 [illegible]
L.026   4.1   0.42 4.1  1.50 4.3  2.50 4.35 3.50 4.5  4.50 4.6  5.50 4.7  6.50 4.7  7.50
L.027   4.7   8.50 4.8  9.54 4.5 10.50 4.5 11.50 4.4 12.55 4.3 13.55 4.1 14.55 4.0 15.45
L.028   4.0516.50 4.1 18.50 4.0 20.48 4.1 22.47 4.1 24.52
L.029  H(A)   5.1   722
L.030  14.5   [illegible]
L.031   4.8   1.08 4.9  2.03 5.0  3.04 5.6  4.08 5.5  5.08 5.5  6.09 [illegible]  7.03 5.6  9.00
L.032   5.4   9.04 5.3 10.05 5.1511.05 5.0212.08 5.0 13.08 4.8 14.08 4.8 15.05 4.8 15.07
L.033   4.5 17.13 4.6519.03 4.5520.02 4.6522.07 4.6524.05 4.7 25.00
L.034  03
L.035  19
L.036   0.   1.   2.   3.   4.   5.   6.   7.   8.   9.  10.  11.  12.  13.  14.  15.
L.037  16.  17.  18.
L.038   720
L.039  24.7   0.4217.9  3.2314.5  5.0 20.3  9.0 18.9 12.12 8.7 15.0 14.3 18.0
L.040   2.85 0.42 2.7  1.42 3.   2.33 3.2  3.25 3.5  4.08 3.7  5.17 3.8  6.00 3.7  7.00
L.041   3.9   8.33 4.0  9.00 3.8  9.92 3.8511.00 3.8 12.12 3.4 13.08 3.1 13.93 3.3 15.00
L.042   2.8517.00 2.9 18.37 2.7 21.00 2.8 23.03
L.043  212
```

Table D2.3 KLIP6 Program Output

(A) Data Listing (for COD)

```
K L I P  R I V E R  S I M U L A T I O N  -RUN 384

REACH NO 1
   END OF REACH          ENDR =  1.73 KM
   MEAN VELOCITY         VEL  = 23.40 KM/DAY
   DISPERSION COEFFT     DPFN = 10.00 KM*2/D
   BOD DECAY COEFFT      BDK  = 0.050 1/DAY
   REAERATION COEFFT     AERK = 2.00  1/DAY
   BOD SOURCES & SINKS   SINK =-150.0 MG/L/DAY
   DO SOURCES & SINKS    SOURCE =   0.0 MG/L/DAY
   PHOTOSYNTHESIS DO     PDO  =   0.0 MG/L/DAY
   INERT SOURCES & SINKS SINK1 =-150.0 MG/L/DAY


REACH NO 2
   END OF REACH          ENDR =  3.75 KM
   MEAN VELOCITY         VEL  = 27.50 KM/DAY
   DISPERSION COEFFT     DPFN =  0.40 KM*2/D
   BOD DECAY COEFFT      BDK  = 1.300 1/DAY
   REAERATION COEFFT     AERK = 2.70  1/DAY
   BOD SOURCES & SINKS   SINK = 350.0 MG/L/DAY
   DO SOURCES & SINKS    SOURCE =  10.0 MG/L/DAY
   PHOTOSYNTHESIS DO     PDO  =   0.0 MG/L/DAY
   INERT SOURCES & SINKS SINK1 = 175.0 MG/L/DAY


REACH NO 3
   END OF REACH          ENDR =  5.30 KM
   MEAN VELOCITY         VEL  = 28.00 KM/DAY
   DISPERSION COEFFT     DPFN = 15.00 KM*2/D
   BOD DECAY COEFFT      BDK  = 3.000 1/DAY
   REAERATION COEFFT     AERK = 3.00  1/DAY
   BOD SOURCES & SINKS   SINK = 100.0 MG/L/DAY
   DO SOURCES & SINKS    SOURCE =   0.0 MG/L/DAY
   PHOTOSYNTHESIS DO     PDO  =   0.0 MG/L/DAY
   INERT SOURCES & SINKS SINK1 =  80.0 MG/L/DAY


INERT FRACTION:  50.00  97.00  %

 DIURNAL VARIATION OF PHOTOSYNTHESIS USED (PDO +VE, IPHO=1)

 DELTA 0.003 DAYS

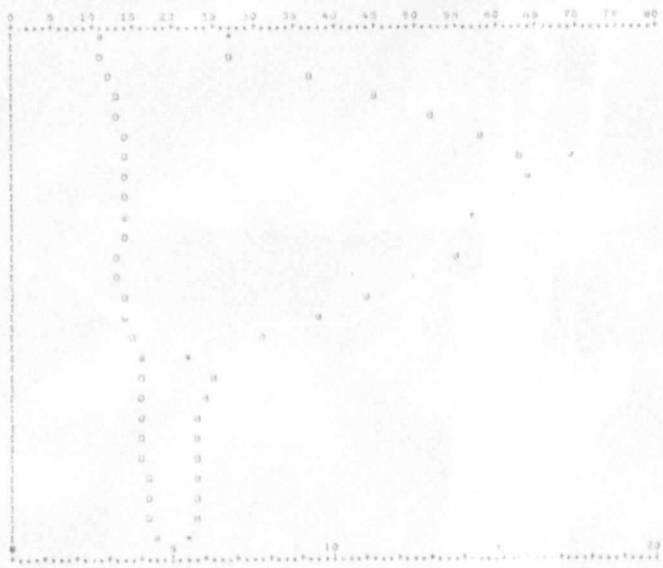
   DELX(1)= 0.203 KM
   DELX(2)= 0.261 KM
   DELX(3)= 0.174 KM

 NO OF SPACE INTERVALS NX = 27
 NO OF TIME INTERVALS  NT = 6125
```

(b) Typical Longitudinal Output

```
K L I P  R I V E R  S I M U L A T I O N  -RUN 384     TIME= 23.00 HRS

  DISTANCE          SIMULATED   OBSERVED
  DOWNSTREAM        BOD    DO   BOD    DO
     STATION NO 2                27.6   2.8
  0.0               27.9   2.8
  0.250             36.6   3.0
  0.500             49.3   3.2
  0.750             52.3   3.3
  1.000             53.4   3.5
  1.250             52.7   3.8
  1.500             52.3   3.8
  1.750             52.4   3.9
     STATION NO 3                57.1   3.6
  2.000             58.8   3.4
  2.250             56.6   3.1
  2.500             49.7   3.3
  2.750             44.0   3.4
  3.000             37.6   3.5
  3.250             33.9   3.7
     STATION NO 4                22.0   4.0
  3.500             24.5   3.9
  3.750             24.0   3.9
  4.000             23.3   4.0
  4.250             22.9   4.1
  4.500             22.9   4.1
  4.750             23.0   4.2
  5.000             23.2   4.2
  5.250             23.3   4.2
     STATION NO (EXI          21.9   4.6
```



(c) Typical Time Variation Output

KLIP RIVER SIMULATION -RUN 386

BOD AND DO VARIATION WITH TIME AT STATION 8

TIME	SIMULATED		OBSERVED	
HRS	BOD	DO	BOD	DO
0.0	57.68	3.58	56.05	3.48
1.04	59.69	3.48	58.00	3.81
2.09	57.55	3.92	58.00	4.00
2.92	53.24	3.65	50.00	4.02
3.95	50.68	3.91	55.00	4.20
5.00	52.24	3.21	58.00	4.50
6.04	52.55	4.47	60.37	4.50
7.09	50.35	4.56	60.00	4.57
7.92	49.75	4.71	58.00	4.62
8.96	49.32	4.76	61.23	4.62
10.00	49.91	4.78	57.62	4.37
11.04	51.86	4.65	59.69	4.25
12.04	55.93	4.48	60.95	4.13
12.92	59.33	4.35	60.17	3.88
13.96	65.50	4.06	60.94	3.81
15.00	68.45	3.76	58.00	3.78
16.04	70.40	3.65	56.90	3.54
17.09	68.38	3.65	54.34	3.34
17.92	65.32	3.54	60.46	3.33
18.96	59.95	3.69	66.55	3.52
20.00	60.98	3.63	57.07	3.60
21.04	49.00	3.63	39.95	3.60
22.08	43.18	3.50	47.13	3.62
22.92	51.33	3.46	53.00	3.64
23.96	54.12	3.43	37.50	3.55
25.00	54.54	3.46	27.76	3.39

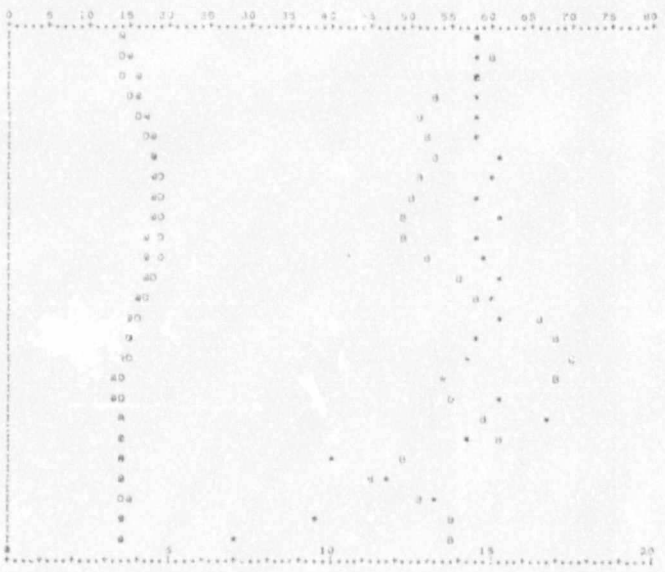


TABLE D2.4 KLIP6 GLOSSARY OF IMPORTANT CONSTANTS, PARAMETERS AND VARIABLES

(a) Constants

NR	Number of homogeneous sub-reaches
ENDR( )	Chainage of end of sub-reach (km)
NL	Number of sampling stations
STN( )	Name or number of sampling station
XST( )	Chainage of sampling station (km)
MNTH	Month during which simulation is run (=1,2,..... ,12)
START	Time of day at which simulation begins (hours.minutes)
VEL( )	Average velocity along sub-reach (km/day)
DOSAT	Dissolved oxygen saturation concentration (km/L)

(b) Computation control constants

IT	Integer by which time step is subdivided into smaller time steps for stability of step 2 computation in the two-step finite difference method
DELT	Time step for step 1 of the two step finite difference method
DELX( )	Space interval for finite difference grid for each sub-reach

(c) Parameters

AERK( )	Reaeration coefficient (1/day) for sub-reach
BODK( )	Deoxygenation coefficient (1/day) for sub-reach
DFFN( )	Longitudinal dispersion coefficient for sub-reach (km^2/d)
DINRT1	Fraction of non-biodegradable COD in input data.

DINRT2	Assumed initial fraction of non-biodegradable COD at downstream end of reach
PDO( )	Daily photosynthetic production of DO (mg/l/d)
SINK( )	BOD source/sink term (mg/l/d)
SINKI( )	Source/sink term for non-biodegradable fraction of COD (mg/l/d)
SOURCE( )	DO source/sink term (mg/l/d)

(d) Input variables

BOD(,)	Observed BOD concentrations (mg/l)
BODIN( )	Forcing BOD concentrations (mg/l)
DO(,)	Observed DO concentrations (mg/l)
DOIN( )	Forcing DO concentrations (mg/l)
NBOD( )	Number of observed BOD concentrations at a station
NDO( )	Number of observed DO concentrations at a station
TBOD(,)	Times of observed BOD concentrations (h)
TBODIN( )	Times of forcing BOD concentrations (h)
TDO(,)	Times of observed DO concentrations (h)
TDOIN( )	Times of forcing DO concentrations (h)

(e) State Variables

BODZRO( )	Initial BOD concentrations at sampling stations (mg/l)
DOZRO( )	Initial DO concentrations at sampling stations (mg/l)
XBOD( )	BOD concentrations along reach/mg/l)
XDO( )	DO concentrations along reach (mg/l)
DPHO( )	Photosynthetic DO production (mg/l/d)

(f) Finite difference variables

A1, A2, A2A B1, B2, DENOM)	Finite difference coefficients for sub-reach

BOD1( )	Initial BOD concentrations at finite difference grid points (mg/l)
DO1( )	Initial DO concentrations at finite difference grid points (mg/l)
CBOD( )	Forcing BOD concentration at each time step (mg/l)
CDO( )	Forcing DO concentration at each time step (mg/l)

(g) Output variables

CBW	Simulated BOD concentrations along reach (mg/l)
CDW	Simulated DO concentrations along reach (mg/l)
PBP	Simulated BOD concentrations at sampling stations (mg/l)
PDP	Simulated DO concentrations at sampling stations (mg/l)

Table D2.5 KLIP6 - Program Listing

```
//AR#KLPCI JOB 1,CLASS=4,MSGLEVEL=(0,0)
/*JOBPARM    R=BLK+,R=7)
/*ROUTE  PRINT HOLD
//    EXEC #ITSTJOB
//SYSUT1 DD DSN=&&KLIP01,UNIT=SYSSRT,DISP=(NEW,PASS),
//    DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),SPACE=(CYL,(1,1))
//SYSIN DD *
N KLC21J
//    EXEC FORTXCLG,PARM.FORT='NOSOURCE'
//FORT.SYSIN DD *
      COMMON RUN,NR,ENDR(10),DFFN(10),VEL(10),BOOK(10),AERK(10),SINK(10
     1,RDD(10),DELP,DELT,KOTA,NL,STN(10),XSTN(10),NBOD(10),NDD(10),BOD(1
     20,50),TBOD(10,50),DD(10,50),TDD(10,50),NX,INTBO,INTDO,BODZRO(10),D
     3DZRO(10),DDI(400),NTOUT,DDIN(50),NINP,BODIN(50),TBODIN(50),CB0(40
     40),CD0(400),KOUT,XBOD(500),CB(500),CBX,NT,XDD(500),NJ,CD(500),CDX,
     5XJ,M(9),TIMES(50),TDDIN(50),BOD1(500),JNX,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,MNTH,START,RBOPT(10,50),RDDIPT(10,50),BOPT(10,50),DOPT(1
     70,50),TIMP(10,50),MM,CI(500),SINKI(10),KIN(500),DINRT2,ICOD,IPHO,D
     8ELX(10),ECOMPR(10),CBI(500),CDI(500),CBA(500),CIA(500),IT,JJB,DPHO
     9,CDA(500),J2,IPLTI,ISTOP,CDA1,CIA1,CBA1,SOURCE(10)
      KIN= 10
      KWRT= 6
      MI= 0
      ISTOP=0
C
C***********READ IN RUN NO AND REACH PARAMETERS
      READ(KIN, 5000)RUN,IPHO,MNTH,START
 5000 FORMAT(I3,I2,I2,X,F4.2)
      ISTART= START
      START= ISTART + (START-FLOAT(ISTART))/60.
      READ(KIN,5050)NR
 5050 FORMAT(I2)
      DO 300 L=1,NR
      READ(KIN,5100)ENDR(L),DFFN(L),VEL(L),BOOK(L),AERK(L),SINK(L),SOURC
     1E(L),PDD(L),SINKI(L)
      IF(IPHO.NE.0.AND.PDD(L).LT.0)WRITE(KWRT,5075)
 5075 FORMAT('1',//////,5X,'*****ERROR- PDD MUST BE +VE IF IPHO=1*****')
      IF(IPHO.NE.0.AND.PDD(L).LT.0)STOP
  300 CONTINUE
 5100 FORMAT(F5.3,8F5.2)
C
C***********READ IN TIME AND SPACE INTERVALS
      READ(KIN,5200)DELP,DELT,IT
 5200 FORMAT(F5.3,F7.4,X,I2)
      DELT= DELT/24.
C-----------CALCULATE SPACE INTERVALS FOR EACH REACH
      DO 330 L=1,NR
      DELX(L)= VEL(L)*DELT
  330 CONTINUE
C
C***********READ IN OBSERVED VALUES
      READ(KIN,5300)NL,DOSAT,ICOD,DINRT1,DINRT2
 5300 FORMAT(I3,2X,F5.2,I1,4X,2F5.2)
      DO 332 L=1,NR
      SINK1= SINK(L)
      IF(ICOD.NE.0.AND.SINKI(L).EQ.0.AND.SINK1.LE.0)SINK(L)= SINK1*(1.-D
     1INRT1)
      IF(ICOD.NE.0.AND.SINKI(L).EQ.0.AND.SINK1.LE.0)SINKI(L)= SINK1*DINR
     1T1
  332 CONTINUE
      DO 342 I=1,NL
      READ(KIN,5400)STN(I),XSTN(I),NBOD(I),NDD(I)
 5400 FORMAT(A4,X,F5.3,2I2)
      MM= -7
      N = 0
  335 MM= MM+8
      N = N+8
      READ(KIN,5500)(BOD(I,J),TBOD(I,J),J=MM,N)
 5500 FORMAT(16F5.0)
      IF(N.LT.NBOD(I))GO TO 335
      MM= -7
      N = 0
  331 MM= MM+8
      N = N+8
      READ(KIN,5500)(DD(I,J),TDD(I,J),J=MM,N)
      IF(N.LT.NDD(I))GO TO 331
  340 CONTINUE
      DO 347 I=1,NL
      JNBOD=NBOD(I)
      DO 345 J=1,JNBOD
  345 TBOD(I,J)= TBOD(I,J)/24.
      JNDD=NDD(I)
      DO 346 J=1,JNDD
      DD(I,J)= DOSAT-DD(I,J)
  346 TDD(I,J)= TDD(I,J)/24.
  347 CONTINUE
C-----------ALLOW ADDITIONAL SAMPLE POINT IF FINAL SAMPLE POINT NOT AT END OF
C                                          STUDY REACH
      DELX(NR+1)= DELX(NR)
      DFFN(NR+1)= DFFN(NR)
      BOOK(NR+1)= BOOK(NR)
      ENDR(NR+1)= ENDR(NR) + 3.*DELX(NR)
      AERK(NR+1)= AERK(NR)
      SINK(NR+1)= SINK(NR)
      PDD(NR+1) = PDD(NR)
      SINKI(NR+1)=SINKI(NR)
      XSTN(NL+1)= ENDR(NR+1)
C
C**********DETERMINE INITIAL VALUES EITHER FROM GIVEN VALUES OR FROM
C                                          OBSERVED VALUES
      READ(KIN,5600)INTBO,INTDO
 5600 FORMAT(2I1)
C-----------(A) B O D INITIAL VALUES
      IF (INTBO)350,360,350
  350 READ(KIN,5700)(BODZRO(I),I=1,NL)
 5700 FORMAT(16F5.2)
      GO TO 380
  360 DO 370 J=1,NL
      BODZRO(J)= (BOD(J,1)-BOD(J,2))*TBOD(J,2)/(TBOD(J,2)-TBOD(J,1))+BOD
     1(J,2)
  370 CONTINUE
  380 K=1
      KR=1
      XXJ= 0
      JJ= 0
      NX= 0
      J=1
      BODZRO(NL+1)= BODZRO(NL)
  390 BOD1(J)=(BODZRO(K+1)-BODZRO(K))*(FLOAT(J-1-JJ)*DELX(KR) + XXJ-XSTN
     1(K))/(XSTN(K+1)-XSTN(K))+BODZRO(K)
      J=J+1
      NX=J
      IF (KR.EQ.NL)NX=JJ+1
      IF (J-(NX+2))400,400,420
  400 IF((J-1-JJ)*DELX(KR) + XXJ.LT.ENDR(KR))GO TO 405
      IF(KR.EQ.1)ECOMPR(KR)= DELX(KR)*(J-1)
      IF(KR.GT.1)ECOMPR(KR)= ECOMPR(KR-1) + DELX(KR)*(J-1-JJ)
      JJ= J-1
      M(KR)= JJ
      KR=KR+1
      IF(KR.GT.1)XXJ=ECOMPR(KR-1)
  405 IF (FLOAT(J-1-JJ)*DELX(KR) + XXJ-XSTN(K+1))390,410,410
  410 K=K+1
      GO TO 390
C-----------(B) D O D INITIAL VALUES
  420 IF(INTDO)430,440,430
  430 READ(KIN,5700)(DOZRO(J),J=1,NL)
      DO 435 J=1,NL
  435 DOZRO(J)= DOSAT-DOZRO(J)
      GO TO 460
  440 DO 450 J=1,NL
      DOZRO(J)= (DD(J,1)-DD(J,2))*TDD(J,2)/(TDD(J,2)-TDD(J,1))+DD(J,2)
  450 CONTINUE
  460 K=1
      KR=1
      JJ=0
      XXJ=0
      J=1
      DOZRO(NL+1)= DOZRO(NL) '
  470 DDI(J)=(DOZRO(K+1)-DOZRO(K))*(FLOAT(J-1-JJ)*DELX(KR) + XXJ-XSTN(K)
     1)/(XSTN(K+1)-XSTN(K))+DOZRO(K)
      J=J+1
      IF (J-(NX+2))480,480,500
  480 IF((J-1-JJ)*DELX(KR) + XXJ.LT.ENDR(KR))GO TO 485
      JJ= J-1
      KR=KR+1
      IF(KR.GT.1)XXJ= ECOMPR(KR-1)
  485 IF (FLOAT(J-1-JJ)*DELX(KR) + XXJ-XSTN(K+1))470,490,490
  490 K=K+1
      GO TO 470
```

KLIP6 Listing (Continued)

```
C
C***********READ IN TIMES AT WHICH OUTPUT IS REQUIRED
  500 READ(KIN,5800)NTOUT
 5800 FORMAT(I2)
      MM= -15
      N = 0
  504 MM= MM+15
      N = N+15
      READ(KIN,5825)(TIMES(J),J=MM,N)
 5825 FORMAT(16F5.2)
      IF(N.LT.NTOUT)GO TO 504
      DO 510 J=1,NTOUT
      TIMES(J)= TIMES(J)/24.
  510 CONTINUE
C
C***********READ IN B O D INPUT DATA AT UPSTREAM POINT
      READ(KIN,5850)NBODIN,NDOIN
 5850 FORMAT(2I2)
      MM= -7
      N = 0
  513 MM= MM+8
      N = N+8
      READ(KIN,5900)(BODIN(J),TBODIN(J),J=MM,N)
 5900 FORMAT(16F5.0)
      IF(N.LT.NBODIN)GO TO 513
      DO 515 J=1,NBODIN
  515 TBODIN(J)= TBODIN(J)/24.
C-----------CALCULATE NO OF TIME STEPS
      NT= TIMES(NTOUT)/DELT + 1
C-----------INTERPOLATE B O D INTERMEDIATE INPUT VALUES LINEARLY
      J=1
      CBOD(J)= BODI(1)
      K=1
  520 J=J+1
      IF (FLOAT(J-1)*DELT-TBODIN(K))530,540,540
  530 CBOD(J)= (BODIN(K)-CBOD(1))*FLOAT(J-1)*DELT/TBODIN(K)   CBOD(1)
      GO TO 520
  540 IF ((K+1).LE.NBODIN)GO TO 542
      K= K-1
  542 CBOD(J)= (BODIN(K+1)-BODIN(K))*(FLOAT(J-1)*DELT-TBODIN(K))/(TBODIN
     1(K+1)-TBODIN(K)) + BODIN(K)
      J=J+1
      IF (J-(NT+1))550,570,570
  550 IF (FLOAT(J-1)*DELT-TBODIN(K+1))540,560,560
  560 K=K+1
      GO TO 540
C
C***********READ IN D O INPUT DATA AT UPSTREAM POINT
  570 MM= -7
      N = 0
  571 MM= MM+8
      N = N+8
      READ(KIN,5900)(DOIN(J),TDOIN(J),J=MM,N)
      IF(N.LT.NDOIN)GO TO 571
      DO 580 J=1,NDOIN
      DOIN(J)= DOSAT - DOIN(J)
  580 TDOIN(J)= TDOIN(J)/24.
C-----------INTERPOLATE D O INTERMEDIATE INPUT VALUES LINEARLY
      J=1
      COD(J)= DOI(1)
      K=1
  590 J=J+1
      IF (FLOAT(J-1)*DELT-TDOIN(K))600,610,610
  600 COD(J)= (DOIN(K)-COD(1))*FLOAT(J-1)*DELT/TDOIN(K) + COD(1)
      GO TO 590
  610 IF((K+1).LE.NDOIN)GO TO 612
      K= K-1
  612 COD(J)= (DOIN(K+1)-DOIN(K))*(FLOAT(J-1)*DELT-TDOIN(K))/(TDOIN(K+1
     1)-TDOIN(K)) + DOIN(K)
      J=J+1
      IF (J-(NT+1))620,640,640
  620 IF (FLOAT(J-1)*DELT-TDOIN(K+1))610,630,630
  630 K=K+1
      GO TO 610
C
C***********READ PLOTTING REQUIREMENTS
  640 READ(KIN,5950)IPLT,IPLT1,ISCALE
 5950 FORMAT(3I1)
C
C***********PRINT DATA
      CALL WRTDTA
C
C***********CALL BOD-DO CALCULATIONS
      CALL BODC
      IF(IPLT.NE.0)CALL PLTPT
      STOP
      END
C
C*********************************************************************
C
      SUBROUTINE BODCAL
      COMMON RUN,NR,ENDR(10),DFFN(10),VEL(10),BODK(10),AERK(10),SINK(10)
     1,POD(10),DELP,DELT,KDTA,NL,STN(10),XSTN(10),NBOD(10),NDO(10),BOD(1
     20,50),TBOD(10,50),DO(10,50),TDO(10,50),NX,INTBO,INTDO,BODZRO(10),D
     3OZRO(10),DOI(500),NTOUT,DOIN(50),NINP,BODIN(50),TBODIN(50),CBOD(80
     40),COD(800),KOUT,XBOD(500),CB(500),CBX,NT,XDO(500),NB,CD(500),CDX,
     5XJ,M(7),TIMES(50),TDOIN(50),BODI(500),JNX,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,MNTH,START,BODPT(10,50),RDOIPT(10,50),DOPT(10,50),DOPT(1
     70,50),TIMP(10,50),MO,CI(500),SINK1(10),XIN(500),DINRT2,ICOD,IPHO,D
     8ELX(10),CCUMPN(10),CBI(500),CDI(500),CBA(500),CIA(500),IT,JJB,DPHO
     9,CDA(500),J2,IPLT1,ISTOP,CDA1,CIA1,CBA1,SOURCE(10)
      KOUT= 1
      NB= 1
C
C***********SET UP INITIAL VALUES
      JNX=NX+1
      DO 110 JB=1,JNX
      DINRTX= DINRT1 + (DINRT2 - DINRT1)*(JB-1)/JNX
      IF(ICOD.EQ.0)DINRTX= 0.
      XBOD(JB)= BODI(JB)*(1.-DINRTX)
  110 CONTINUE
      CBA1= BODI(1)*(1.-DINRT1)
C-----------SELECT BOD VALUE AT UPSTREAM END
  118 JJB= 1
  120 IB= 2
      LB= 1
      IF(JJB.GT.1)GO TO 140
      CB(1)= CBOD(NB)*(1.-DINRT1)
      IF(ICOD.EQ.0)CB(1)= CBOD(NB)
      DO 125 JB=2,JNX
      CB(JB)= XBOD(JB)
  125 CONTINUE
C
C***********(1) PERFORM CONVECTION STEP
      CBA(2)= CBA1
      CBA(1)=CBOD(NB+1)*(1.-DINRT1)
      IF(ICOD.EQ.0)CBA(1)= CBOD(NB+1)
      CBA1= CBA(1)
      DO 130 JB=3,JNX
      CBA(JB)= CB(JB-1)
  130 CONTINUE
C-----------CALCULATE FINITE DIFFERENCE EQUATION COEFFTS FOR REACH
  140 A1= DFFN(LB)*DELT/IT/DELX(LB)/DELX(LB)
      A2= 1.- (2.*DFFN(LB)/DELX(LB)/DELX(LB) + BODK(LB)/2.)*DELT/IT
      DENOM= 1. + BODK(LB)*DELT/IT/2.
      A2A= 1. - 2.*DFFN(LB)/DELX(LB)/DELX(LB)*DELT/IT
C
C***********(2) PERFORM OTHER CALCULATIONS
  150 CBX= (CBA(IB-1)*A1 + CBA(IB)*A2 + CBA(IB+1)*A1 - SINK(LB)*DELT/IT)
     1/DENOM
      IF(XDO(IB).GT.DOSAT.AND.AERK(LB)*DOSAT+(SOURCE(LB)*DPHO).LT.BODK(L
     1B)*CBA(IB))CBX= (CBA(IB-1)*A1 + CBA(IB)*A2A + CBA(IB+1)*A1 - (AERK
     2(LB)*DOSAT + (SOURCE(LB)*DPHO) + SINK(LB))*DELT/IT)
      IF(CBX.LT.0)CBX= 0
      XBOD(IB)= CBX
      IB= IB+1
      IF (IB-NX)160,160,180
C-----------CHECK IF NEW CONSTANTS REQUIRED
  160 IF (IB-1-M(LB))150,170,150
  170 LB= LB+1
      GO TO 140
C-----------EXTRAPOLATE TO GET FINAL POINT
  180 XBOD(NX+1)= 2.*XBOD(NX)-XBOD(NX-1)
      CALL DOSAG
      IF(ICOD.NE.0)CALL INERT
      JJB= JJB + 1
      IF (JJB.GT.IT)GO TO 184
      DO 182 JB=2,JNX
      CB(JB)= XBOD(JB)
  182 CONTINUE
```

KLIP6 Listing (Continued)

```
      GO TO 123
  184 CONTINUE
C
C**********PRINT RESULTS IF REQUIRED
      IF ((FLOAT(NB-1)+.5)*DELT-TIMPS(KOUT))186,185,185
C 185 IF(NB.GE.19.AND.NB.LE.20)CALL WRITE
  185 CALL WRITE
      KOUT= KOUT+1
      IF(KOUT.GT.NTOUT+2)RETURN
  186 NB= NB+1
      XODD(1)=CODD(NB)*(1.-DINRT1)
      IF(ICOD.EQ.0)XODD(1)= CODD(NB)
      IF (NB-NT)110,190,190
  190 RETURN
      END
C
C**********************************************************************
C
      SUBROUTINE DOSAG
      COMMON RUN,NB,ENDR(10),DFFN(10),VEL(10),BOOK(10),AERK(10),SINK(10)
     1,POD(10),DELP,DELT,KOTA,NL,STN(10),XSTN(10),NHOD(10),NOD(10),BOD(1
     20,50),TBOD(10,50),DO(10,50),TDO(10,50),NX,INTBD,INTDO,BODZRO(10),D
     3OZRO(10),DO1(500),NTOUT,DOIN(50),NINP,BODIN(50),TBODIN(50),CBOD(50
     40),CDO(500),KOUT,XBOD(500),CB(500),CBX,NT,XDO(500),NU,CD(500),CDX,
     5X),M(10),TIMES(50),TDOIN(50),BOD1(500),JNX,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,MNTH,START,RBOPT(10,50),RDOPT(10,50),BOPT(10,50),DOPT(1
     70,50),TIMP(10,50),MU,CI(500),SINKI(10),XIN(500),DINRT2,ICOD,IPHO,D
     8ELX(10),PCOMP(10),CBI(500),CDI(500),CBA(500),CTA(500),IT,JJB,DPHO
     9,CDA(500),J2,IPLT1,ISTOP,CDA1,CIA1,CBA1,SOURCE(10)
      IF(NB-1)210,210,230
C
C**********SET UP INITIAL VALUES
  210 IF(JJB.GT.1)GO TO 230
      DO 220 JD=1,JNX
      XDD(JD)= DO1(JD)
  220 CONTINUE
      CDA1= DO1(1)
C----------SELECT DO VALUE AT UPSTREAM END
  230 ID= 2
      LD= 1
      IF(JJB.GT.1)GO TO 250
      CD(1)= CDD(NB)
      DO 235 JD=2,JNX
  235 CD(JD)= XDD(JD)
C
C**********(1) PERFORM CONVECTION STEP
      CDA(2)= CDA1
      CDA(1)= CDD(NB+1)
      CDA1= CDA(1)
      DO 240 JD=3,JNX
      CDA(JD)= CD(JD-1)
  240 CONTINUE
C----------CALCULATE FINITE DIFFERENCE EQUATION COEFFTS FOR REACH
  250 D1= DFFN(LD)*DELT/IT/DELX(LD)/DELX(LD)
      D2= 1. - (2.*DFFN(LD)/DELX(LD)/DELX(LD) + AERK(LD)/2.)*DELT/IT
      DENOM= 1. + AERK(LD)*DELT/IT/2.
C
C**********(2) PERFORM OTHER CALCULATIONS
      PI= 3.14159
      D= .1913*SIN(PI/6.*FLOAT(MNTH+3))
      PHO= PCOMP(LD)/(24./PI*(COS(ARSIN(D))+D*ARSIN(D)) + 12.*D)
      PH= SIN(2.*PI*((NB-1)*DELT + START - 6.))
      DPHO= PHO/2.*(ABS(PH+D) + (PH+D))*24.
      IF(IPHO.EQ.0)DPHO= 0
  260 CDX=(CDA(ID-1)*D1 + CDA(ID)*D2 + CDA(ID+1)*D1 + BOOK(LD)*(CBA(ID)
     1+ XBOD(ID))*DELT/IT/2 - (SOURCE(LD)+DPHO)*DELT/IT)/DENOM
      IF(CDX.LT.0)CDX= 0
      IF(CDX.GT.DOSAT)CDX= DOSAT
      XDD(ID)= CDX
      ID= ID+1
      IF (ID-NX)280,280,270
C----------EXTRAPOLATE TO GET END VALUE
  270 XDD(NX+1)= 2.*XDD(NX)-XDD(NX-1)
      XDD(1)= CDD(NB+1)
      IF(JJB.GE.IT)RETURN
      DO 275 JD=2,JNX
  275 CDA(JD)= XDD(JD)
      RETURN
C----------CHECK IF NEW CONSTANTS REQUIRED
  280 IF (ID-1-M(LD))260,290,260
  290 LD= LD+1
      GO TO 250
      END
C
C**********************************************************************
C
      SUBROUTINE INERT
      COMMON RUN,NB,ENDR(10),DFFN(10),VEL(10),BOOK(10),AERK(10),SINK(10)
     1,POD(10),DELP,DELT,KOTA,NL,STN(10),XSTN(10),NHOD(10),NOD(10),BOD(1
     20,50),TBOD(10,50),DO(10,50),TDO(10,50),NX,INTBD,INTDO,BODZRO(10),D
     3OZRO(10),DO1(500),NTOUT,DOIN(50),NINP,BODIN(50),TBODIN(50),CBOD(50
     40),CDO(500),KOUT,XBOD(500),CB(500),CBX,NT,XDO(500),NU,CD(500),CDX,
     5X),M(10),TIMES(50),TDOIN(50),BOD1(500),JNX,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,MNTH,START,RBOPT(10,50),RDOPT(10,50),BOPT(10,50),DOPT(1
     70,50),TIMP(10,50),MU,CI(500),SINKI(10),XIN(500),DINRT2,ICOD,IPHO,D
     8ELX(10),PCOMP(10),CBI(500),CDI(500),CBA(500),CIA(500),IT,JJB,DPHO
     9,CDA(500),J2,IPLT1,ISTOP,CDA1,CIA1,CBA1,SOURCE(10)
      IF(NB-1)1010,1010,1030
 1010 IF(JJB.GT.1)GO TO 1030
C
C**********SET UP INITIAL VALUES
      DO 1020 JI=1,JNX
      XIN(JI)= BOD1(JI)*(DINRT1 + (DINRT2 - DINRT1)*(JI-1)/JNX)
 1020 CONTINUE
      CIA1 = BOD1(1)*DINRT1
C----------SELECT INERT VALUE AT UPSTREAM END
 1030 II= 2
      LI= 1
      IF (JJB.GT.1) GO TO 1050
      DO 1035 JI=2,JNX
 1035 CI(JI)= XIN(JI)
      CI(1)= CBOD(NB)*DINRT1
C
C**********(1) PERFORM CONVECTION STEP
      CIA(2)= CIA1
      CIA(1)= CBOD(NB+1)*DINRT1
      CIA1= CIA(1)
      DO 1040 JI=3,JNX
      CIA(JI)= CI(JI-1)
 1040 CONTINUE
C----------CALCULATE FINITE DIFFERENCE EQUATION COEFFICIENTS FOR REACH
 1050 C1= DFFN(LI)*DELT/IT/DELX(LI)/DELX(LI)
      C2= 1. - 2.*DFFN(LI)*DELT/IT/DELX(LI)/DELX(LI)
C
C**********(2) PERFORM OTHER CALCULATIONS
 1060 CIX= CIA(II-1)*C1 + CIA(II)*C2 + CIA(II+1)*C1 - SINKI(LI)*DELT/IT
      IF(CIX.LT.0)CIX= 0
      XIN(II)= CIX
      II= II+1
      IF(II-NX)1080,1080,1070
C----------EXTRAPOLATE TO GET END VALUE
 1070 XIN(NX+1)= 2.*XIN(NX) - XIN(NX-1)
      IF(JJB.GT.IT)RETURN
      DO 1075 JI=2,JNX
 1075 CIA(JI)= XIN(JI)
      RETURN
C----------CHECK IF NEW CONSTANTS REQUIRED
 1080 IF(II-1-M(LI))1060,1090,1050
 1090 LI= LI+1
      GO TO 1050
      END
C
C**********************************************************************
C
      SUBROUTINE WRITE
      COMMON RUN,NB,ENDR(10),DFFN(10),VEL(10),BOOK(10),AERK(10),SINK(10)
     1,POD(10),DELP,DELT,KOTA,NL,STN(10),XSTN(10),NHOD(10),NOD(10),BOD(1
     20,50),TBOD(10,50),DO(10,50),TDO(10,50),NX,INTBD,INTDO,BODZRO(10),D
     3OZRO(10),DO1(500),NTOUT,DOIN(50),NINP,BODIN(50),TBODIN(50),CBOD(50
     40),CDO(500),KOUT,XBOD(500),CB(500),CBX,NT,XDO(500),NU,CD(500),CDX,
     5X),M(10),TIMES(50),TDOIN(50),BOD1(500),JNX,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,MNTH,START,RBOPT(10,50),RDOPT(10,50),BOPT(10,50),DOPT(1
     70,50),TIMP(10,50),MU,CI(500),SINKI(10),XIN(500),DINRT2,ICOD,IPHO,D
     8ELX(10),PCOMP(10),CBI(500),CDI(500),CBA(500),CIA(500),IT,JJB,DPHO
     9,CDA(500),J2,IPLT1,ISTOP,CDA1,CIA1,CBA1,SOURCE(10)
C
C**********PRINT RUN ID AND HEADINGS
      TM= FLOAT(NB-1)*DELT*24.
      IF(IPLT.NE.2)WRITE(KWRT,6000)RUN,TM
 6000 FORMAT(1H1,'K L I P   R I V E R   S I M U L A T I O N  -RUN ',I3,
```

KLIP6 Listing (Continued)

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     15X,'TIME: ',F5.2,' HRS'/)
      IF(IPLT1.EQ.0.AND.IPLT.NE.2)WRITE(KWRT,6100)
 6100 FORMAT(' ',2X,'DISTANCE',10X,'SIMULATED',3X,'OBSERVED'//2X,'DOWNST
     1REAM',6X,'DO        DO     BOD      DO'/)
      IF(IPLT.EQ.2)GO TO 702
      IF (IPLT)701,702,701
  701 CALL YAXIS(IPLT1,ISCALE,KWRT)
  702 NX1= NX+1
      DO 703 IW=1,NX1
      IF(ICOD.EQ.0.)CI(IW)= 0.
      CBI(IW)= CO(IW) + CI(IW)
  703 COI(IW)= DOSAT - CO(IW)
      JW= 1
      LW= 1
      XXJ=0
      XW= 0
      JJ= 0
      KW= 1
      GO TO 713
  710 CBW= CBI(JW)
      COW= COI(JW)
      XW= XJ
C
C***********INTERPOLATE TO GET COMPUTED VALUES AT REQUESTED SPACE
C                                        INTERVALS
      IF(DELP.NE.0.)CALL INTER(JJ,JW,XXJ,CBI,COI,XW)
      IF(DELP.NE.0)CBW=CBI
      IF(DELP.NE.0)COW=COI
      IF(LW.GT.1)JJ= M(LW-1)
C
C***********PRINT AND/OR PLOT COMPUTED VALUES
      IF(IPLT1.EQ.0.AND.IPLT.NE.2)WRITE(KWRT,6200)XW,CBW,COW
 6200 FORMAT(' ',4X,F5.1,10X,F5.1,2X,F5.1)
      IF(IPLT.EQ.2)GO TO 712
      IF (IPLT)711,712,711
  711 CALL PLOT(IPLT1,ISCALE,DOSAT,CBW,COW,KWRT)
  712 JW= JW+1
      IF(LW.GT.1)XXJ= ECOMPR(LW-1)
  713 XJ= (FLOAT(JW)-1.-JJ)*DELX(LW) + XXJ
      IF(ISTOP.NE.3))STOP
      IF(DELP.NE.0.AND.(XW+DELP).GE.XSTN(KW))GO TO 715
      IF(DELP.NE.0.AND.(XW+DELP).LT.XSTN(KW))GO TO 732
      IF(XJ-XSTN(KW))732,720,720
  715 NX2=NX+5
      K= 1
      DO 716 JW1=1,NX2
      IF(JW1.GT.M(K))XXJ= ECOMPR(K)
      IF(JW1.GT.M(K))JJ=M(K)
      IF(JW1.GT.M(K))K=K+1
      LLL=1
      XJA= (JW1-1-JJ)*DELX(LW) + XXJ
      IF(XJA.GT.XSTN(KW))JW= JW1
      IF(XJA.GT.XSTN(KW))GO TO 720
  716 CONTINUE
C
C***********INTERPOLATE LINEARLY TO GET OBSERVED VALUES AT OUTPUT TIME
  720 XJ1= (FLOAT(JW)-2.-JJ)*DELX(LW) + XXJ
      XJ= (FLOAT(JW)-1.-JJ)*DELX(LW) + XXJ
      IF(KW.EQ.1)MB= MB+1
      LLL= 0
C-----------STORE COMPUTED VALUES FOR SUBROUTINE PLTPT
      IF(JW.LE.1)DOPT(KW,MB)= CO(JW) + CI(JW)
      IF(JW.LE.1)DOPT(KW,MB)= CO(JW)
      IF(JW.LE.1)GO TO 717
      DOPT(KW,MB)= (CO(JW)+CI(JW)-CO(JW-1)-CI(JW-1))*(XSTN(KW) -XJ1)/(XJ
     1-XJ1) + (CO(JW-1)+CI(JW-1))
      DOPT(KW,MB)= (CO(JW) - CO(JW-1))*(XSTN(KW) - XJ1)/(XJ-XJ1) + CO
     1(JW-1)
  717 TW= TM/24.
      MTW = 1
      IF (TW.LE.TBOD(KW,MTW))GO TO 723
      NNBOD= NBOD(KW)
      DO 721 MTW= 2,NNBOD
      IF (TW.LE.TBOD(KW,MTW))GO TO 722
  721 CONTINUE
  722 RBOD= BOD(KW,MTW) - (BOD(KW,MTW)-BOD(KW,MTW-1))*(TBOD(KW,MTW)-TW)/
     1(TBOD(KW,MTW)-TBOD(KW,MTW-1))
      GO TO 719
  723 IF(TBOD(KW,MTW).EQ.0.)GO TO 718
      RBOD= BODZRO(KW) + (BOD(KW,MTW)-BODZRO(KW))*TW/TBOD(KW,MTW)
      GO TO 719
  718 RBOD= BODZRO(KW)
  719 TW= TM/24.
      MTW = 1
      IF (TW.LE.TDO(KW,MTW))GO TO 726
      NNDO= NDO(KW)
      DO 724 MTW= 2,NNDO
      IF (TW.LE.TDO(KW,MTW))GO TO 725
  724 CONTINUE
  725 RDO= DO(KW,MTW) - (DO(KW,MTW)-DO(KW,MTW-1))*(TDO(KW,MTW)-TW)/(TDO(
     1KW,MTW)-TDO(KW,MTW-1))
      GO TO 727
  726 IF(TDO(KW,MTW).EQ.0.)GO TO 728
      RDO= DOZRO(KW) + (DO(KW,MTW)-DOZRO(KW))*TW/TDO(KW,MTW)
      GO TO 727
  728 RDO= DOZRO(KW)
  727 RDO1= DOSAT - RDO
      TIMP(KW,MB)= TM
C-----------STORE OBSERVED VALUES FOR SUBROUTINE PLTPT
      RBOPT(KW,MB)= RBOD
      RDO1PT(KW,MB)= RDO1
      IF(IPLT1.EQ.0.AND.IPLT.NE.2)WRITE(KWRT,6300)STN(KW),RBOD,RDO1
 6300 FORMAT(' ',6X,'STATION NO ',A4,10X,F5.1,2X,F5.1)
      IF(IPLT.EQ.2)GO TO 731
      IF (IPLT)730,731,730
  730 CALL PLTOBS(IPLT1,ISCALE,DOSAT,RBOD,RDO1,KWRT)
  731 KW= KW+1
  732 IF(XJ.GE.ENDR(LW))JJ= JW-1
      IF(XJ.GE.ENDR(LW))LW= LW+1
      IF(DELP.EQ.0)GO TO 735
      IF(XW+DELP-XSTN(NL))710,740,740
  735 IF (JW-(NX+1))710,740,740
  740 IF(IPLT.EQ.2)GO TO 750
      IF(IPLT)745,750,745
  745 IF(IPLT.NE.2)CALL DOAXIS(IPLT1,ISCALE,KWRT)
  750 RETURN
      END
C
C**************************************************************************
C
      SUBROUTINE WRTDTA
      COMMON RUN,NR,ENDR(10),DFFN(10),VEL(10),BOOK(10),AER(10),SINK(10)
     1,PDO(10),DELP,DELT,KDTA,NL,STN(10),XSTN(10),NBOD(10),NDO(10),BOD(1
     20,50),TBOD(10,50),DO(10,50),TDO(10,50),NX,INTBD,INTDO,BODZRO(10),D
     3OZRO(10),DO1(500),NTOUT,DOIN(50),NINP,BODIN(50),TBODIN(50),CBOD(50
     40),COD(500),KOUT,XBOD(500),CO(500),COX,NT,XDO(500),NB,CD(500),COX,
     5XJ,M(10),TIMES(50),TDOIN(50),BOD1(500),JNX,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,MNTH,START,RBOPT(10,50),RDO1PT(10,50),DOPT(10,50),DOPT(1
     70,50),TIMP(10,50),MB,CI(500),SINK1(10),XIN(500),DINRT2,ICOD,IPHO,D
     8ELX(10),ECOMPR(10),CBI(500),COI(500),CHA(500),CIA(500),IT,JJO,DPHO
     9,COA(500),J2,IPLT1,ISTOP,COA1,CIA1,CBA1,SOURCE(10)
      WRITE(KWRT,6020)RUN
 6020 FORMAT(1H1,'K L I P   R I V E R   S I M U L A T I O N    RUN ',I3/
     1//)
C
C***********LIST REACH DATA
      DO 400 KDTA=1,NR
      WRITE(KWRT,6400) KDTA,ENDR(KDTA),VEL(KDTA),DFFN(KDTA),BOOK(KDTA),A
     1ERK(KDTA),SINK(KDTA),SOURCE(KDTA)
 6400 FORMAT(1H ,2X,'REACH NO',I2/6X,'END OF REACH  ',3X,'ENDR =',F6.2,'
     1 KM'/6X,'MEAN VELOCITY',10X,'VEL   =',F6.2,' KM/DAY'/6X,'DISPERSION
     2 COEFFT',6X,'DFFN =',F6.2,' KM/DAY'/6X,'BOD DECAY COEFFT',7X,'BOOK
     3 =',F6.3,' 1/DAY'/6X,'REAERATION COEFFT',6X,'AERK =',F5.2,' 1/DAY'
     4/6X,'BOD SOURCES & SINKS',4X,'SINK =',F6.1,' MG/L/DAY'/6X,'DO SOUR
     5CES & SINKS',3X,'SOURCE =',F6.1,' MG/L/DAY')
      IF(IPHO.NE.0)WRITE(KWRT,6410)PDO(KDTA)
 6410 FORMAT('       PHOTOSYNTHESIS DO        PDO  =',F6.1,' MG/L/DAY')
      IF(ICOD.EQ.0.)GO TO 803
      WRITE(KWRT,6425)SINK1(KDTA)
 6425 FORMAT('       INERT SOURCES & SINKS SINK1 =',F6.1,' MG/L/DAY')
  803 WRITE(KWRT,6430)
 6430 FORMAT(' '////)
  400 CONTINUE
      IF (ICOD.EQ.0.)GO TO 805
      D1= DINRT1*100.
      D2= DINRT2*100.
      WRITE(KWRT,6475)D1,D2
 6475 FORMAT(' ',2X,'INERT FRACTION   ',2(F5.2,2X),' %'//)
  805 IF(IPHO).NE.0)WRITE(KWRT,6480)
 6480 FORMAT('      DIURNAL VARIATION OF PHOTOSYNTHESIS USED (PDO +VE, IP
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KLIP6 Listing (Continued)

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     1H)=1)'//)
C
C**********PRINT FINITE DIFFERENCE DATA
      WRITE(KWRT,6500)DELT
 6500 FORMAT(' ',4X,'DELT= ',F5.3,' DAYS'/)
      DO 806 JA=1,NR
      WRITE(KWRT,6550)JA,DELX(JA)
 6550 FORMAT(' ',7X,'DELX(',I1,')= ',F5.3,' KM')
  806 CONTINUE
      WRITE(KWRT,6450)NX,NT
 6450 FORMAT('0',5X,'NO OF SPACE INTERVALS NX =',I3/6X,'NO OF TIME INTER
     1VALS  NT =',I3)
      RETURN
      END
C
C*********************************************************************
C
      SUBROUTINE INTRP(JJ,JW,XKJ,CB2,CD2,X2)
      COMMON RUN,NR,ENDR(10),DFFN(10),VEL(10),BOOK(10),AERK(10),SINK(10)
     1,POD(10),DELP,DELT,KOTA,NL,STN(10),XSTN(10),NBOD(10),NOD(1[illegible]
     2),50),TBOD(10,50),DO(10,50),TDO(10,50),NX,INTBO,INTDO,BOD[illegible]
     3DZR3(10),DO1(500),NTOUT,DOIN(50),NINP,BODIN(50),TBODIN([illegible]),CU0D(50
     40),COD(800),KOUT,XBOD(500),CO(500),COX,NT,XDO(500),NB,[illegible](500),COX,
     5XJ,M(1),TIMES(50),TDOIN(50),BOD1(500),JNX,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,MNTH,START,RBOPT(10,50),RDOIPT(10,50),JOPT(10,50),DOPT(1
     70,50),TIMP(10,50),MB,CI(500),SINKI(10),XIN(500),DINRT2,IC(3),IRHO,D
     8ELX(10),ECOMPR(10),CB1(500),CD1(500),CDA(500),CIA(500),IT,JJB,DPHO
     9,CDX(500),J2,IPLT1,ISTOP,CDA1,CIA1,CBA1,SOURCE(10)
      IF(JW.GT.1)GO TO 10
      M(NR+1)= NX+2
      J2=1
      NK2=1
      CB2= CB1(1)
      CD2= CD1(1)
      X2= XJ
      RETURN
   10 J2= J2+1
      X2= DELP*FLOAT(J2-1)
      DO 20 I2=1,NR
      IF(X2.LT.ECOMPR(I2))II2= I2
      IF(X2.LT.ECOMPR(I2))GO TO 30
   20 CONTINUE
      II2= NR
   30 XXJ2= 0.
      K21= 1
      JJ= 0
      IF(II2.GT.1)JJ= M(II2-1)
      IF(II2.GT.1)K21= JJ
      IF(II2.GT.1)XXJ2= ECOMPR(II2-1)
      DO 40 K2= K21,NX
      XJ2= (FLOAT(K2-1)-JJ)*DELX(II2) + XXJ2
      IF(X2.LT.XJ2)L2= K2
      IF(X2.LT.XJ2)JW=K2
      IF(X2.LT.XJ2)GO TO 50
   40 CONTINUE
   50 XJ3= (FLOAT(L2)-2.-JJ)*DELX(II2) + XXJ2
      CB2= CB1(L2-1) + (CB1(L2)-CB1(L2-1))*(X2-XJ3)/(XJ2-XJ3)
      CD2= CD1(L2-1) + (CD1(L2)-CD1(L2-1))*(X2-XJ3)/(XJ2-XJ3)
      RETURN
      END
C
C*********************************************************************
C
      SUBROUTINE YAXIS(IPLT1,ISCALE,KWRT)
      IF(IPLT1.[illegible]) TO 813
      GO TO (810,820,830,840),ISCALE
  810 WRITE(KWRT,6600)(J,J=5,80,5)
 6600 FORMAT('+',49X,'0',16(2X,I3)/50X,'+',16('....+'))
      RETURN
  820 WRITE(KWRT,6700)(J,J=5,40,5)
 6700 FORMAT('+',49X,'0',8(8X,I2)/50X,'+',8('....+....I'))
      RETURN
  830 WRITE(KWRT,6400)(J,J=5,20,5)
 6800 FORMAT('+', 9X,'0',4(18X,I2)/50X,'+',4('...+...+...+...+...I'))
      RETURN
  840 WRITE(KWRT,6600)(J,J=10,160,10)
      RETURN
      ENTRY DOAXIS(IPLT1,ISCALE,KWRT)
      IF(IPLT1.EQ.0)GO TO 830
      IF(IPLT1.NE.0)GO TO 835
  813 GO TO(815,825,835,845),ISCALE
  815 WRITE(KWRT,6650)(J,J=5,80,5)
 6650 FORMAT('+0',16(2X,I3)/' +',16('....+'))
      RETURN
  825 WRITE(KWRT,6750)(J,J=5,40,5)
 6750 FORMAT('+0',8(8X,I2)/' +',8('....+....I'))
      RETURN
  835 WRITE(KWRT,6850)(J,J=5,20,5)
 6850 FORMAT('+0',4(18X,I2)/' +',4('...+...+...+...+...I'))
      RETURN
  845 WRITE(KWRT,6650)(J,J=10,160,10)
      RETURN
      END
C
C*********************************************************************
C
      SUBROUTINE PLOT(IPLT1,ISCALE,DOSAT,PCB,PCD,KWRT)
      DATA BLANK,PLOTB,PLOTD,PLOTOB,PLOTOD,PLOTC/1H ,1HB,1HD,1H*,1H0,1H*
     1/
      DIMENSION CHAR(80)
      DO 850 KP= 1,80
  850 CHAR(KP)=BLANK
C
C**********COMPUTED VALUES
C----------BOD PLOTTING POSITION
      CALL PLTPOS(IPLT1,ISCALE,PCB,IPB)
      IF(IPB.LE.0)GO TO 852
      CHAR(IPB)= PLOTB
C----------DO PLOTTING POSITION
  852 CALL PLOTDO(IPLT1,ISCALE,PCD,IPD)
      IF(IPD.LE.0)GO TO 870
      CHAR(IPD)= PLOTD
      IF (IPB.NE.IPD)GO TO 870
      CHAR(IPD)= PLOTC
      CHAR(IPD-1)= PLOTB
      CHAR(IPD+1)= PLOTD
      GO TO 870
C
C**********OBSERVED VALUES
      ENTRY PLTOBS(IPLT1,ISCALE,DOSAT,PBOD,PDO,KWRT)
      DO 860 KP=1,80
  860 CHAR(KP)=BLANK
C----------BOD PLOTTING POSITION
      CALL PLTPOS(IPLT1,ISCALE,PBOD,IPBOBS)
      CHAR(IPBOBS) = PLOTOB
C----------DO PLOTTING POSITIONS
      CALL PLOTDO(IPLT1,ISCALE,PDO,IPDOBS)
      CHAR(IPDOBS) = PLOTOD
      IF (IPBOBS.NE.IPDOBS) GO TO 870
      CHAR(IPBOBS)= PLOTC
      CHAR(IPBOBS-1)= PLOTOB
      CHAR(IPBOBS+1)= PLOTOD
  870 IF(IPLT1.EQ.0)WRITE(KWRT,6900)CHAR
      IF(IPLT1.NE.0)WRITE(KWRT,6950)CHAR
 6950 FORMAT('+I',80A1)
 6900 FORMAT('+',49X,'I',80A1/50X,'I')
      RETURN
      END
C
C*********************************************************************
C
      SUBROUTINE PLTPOS(IPLT1,ISCALE,C,IPP)
      GO TO (900,910,920,925),ISCALE
  900 IPP= C+.5
      RETURN
  910 IPP= C*2.+.5
      RETURN
  920 IPP= C*4.+.5
      RETURN
  925 IPP= C*0.5 + .5
      RETURN
      ENTRY PLOTDO(IPLT1,ISCALE,C,IPP)
      GO TO 920
      END
C
C*********************************************************************
C
      SUBROUTINE PLTPT
      COMMON RUN,NR,ENDR(10),DFFN(10),VEL(10),BOOK(10),AERK(10),SINK(10)
     1,POD(10),DELP,DELT,KOTA,NL,STN(10),XSTN(10),NBOD(10),NOD(10),BOD(1
```

KLIP6   Listing (Continued)

```
     2C,50),TOO(10,50),OO(10,50),TOO(10,50),NX,INTOO,INTOO,ODOZRO(10),O
     3OZRO(10),OUT(50),NTOUT,OOIN(10),NINP,BODIN(50),TOODIN(50),COOO(#0
     40),COO(500),KOUT,XBOD(500),CO(500),COX,NT,XOU(500),NO,CO(500),COX,
     5X),W(9),TIMES(50),TOOIN(50),BOD(500),JNA,KIN,KWRT,DOSAT,IPLT,ISCA
     6LE,DINRT1,WNTH,START,BODPT(10,50),RODIPT(10,50),BOPT(10,50),OOPT(1
     70,50),TIMP(10,50),MA,CI(500),SINKI(10),XIN(500),DINRT2,ICO,TPH),O
     8ELX(10),ZCOMPR(17),COI(500),COI(500),COA(500),CIA(500),IT,JJB,UPHO
     9,COA(500),J2,IPLT1,ISTOP,COA1,CIA1,CBA1,SOURCE(10)
      DATA BLNKP,PLTBP,PLTOP,PLTOBP,PLTOOP,PLTCP/1H ,1HB,1HO,1H*,1H#,1H*
     1/
      DIMENSION CHRP(80)
C
C***********PRINT RUN NUMBER AND HEADINGS
      DO 940 I=1,NL
      WRITE(KWRT,7000)RUN,STN(I)
 7000 FORMAT('1',' ','K L I P   R I V E R   S I M U L A T I O N   -RUN  ',I3,//
     15X,'BOD AND DO VARIATION WITH TIME AT STATION ',A4,/)
      IF(IPLT1.EQ.0)WRITE(KWRT,7050)
 7050 FORMAT(' ',4X,'TIME',12X,'SIMULATED',5X,'OBSERVED'//5X,'HRS',13X,'
     1BOD    DO          BOD     DO'/)
      CALL YAXIS(IPLT1,ISCALE,KWRT)
C
C***********DETERMINE PLOTTING POSITIONS - COMPUTED VALUES
      DO 935 J=1,NTOUT
      DO 930 KPP=1,80
  930 CHRP(KPP)=BLNKP
      PBP= BDPT(I,J)
      POP= DOSAT - DOPT(I,J)
      CALL PLTPOS(IPLT1,ISCALE,POP,IPOP)
      IF(IPOP.LE.0)GO TO 941
      CHRP(IPBP)= PLTBP
  941 CALL PLOTDO(IPLT1,ISCALE,POP,IPOP)
      IF(IPOP.LE.0)GO TO 942
      CHRP(IPOP)= PLTOP
  942 IF(IPOP.NE.IPOP)GO TO 931
      CHRP(IPOP)= PLTCP
      CHRP(IPOP-1)= PLTBP
      CHRP(IPOP+1)= PLTOP
C
C***********PRINT AND/OR PLOT COMPUTED VALUES
  931 IF(IPLT1.EQ.0)WRITE(KWRT,7100)TIMP(I,J),PBP,POP,CHRP
 7100 FORMAT(' ',4X,F5.2,10X,F5.2,2X,F5.2,18X,'I',80A1)
      IF(IPLT1.NE.0)WRITE(KWRT,7105)CHRP
 7105 FORMAT(' I',80A1)
C
C***********DETERMINE PLOTTING POSITIONS - OBSERVED VALUES
      PBOP= BODPT(I,J)
      POOP=RDOIPT(I,J)
      DO 932 KPP= 1,80
  932 CHRP(KPP)= BLNKP
      CALL PLTPOS(IPLT1,ISCALE,PBOP,IPBOPS)
      CHRP(IPBOPS)= PLTOBP
      IF(IPLT1.EQ.0)WRITE(KWRT,7150)CHRP
 7150 FORMAT('+',50X,80A1)
      IF(IPLT1.NE.0)WRITE(KWRT,7155)CHRP
 7155 FORMAT('+I',80A1)
      DO 933 KPP=1,80
  933 CHRP(KPP)= BLNKP
      CALL PLOTDO(IPLT1,ISCALE,POOP,IPOOPS)
      CHRP(IPOOPS)= PLTOOP
C
C***********PRINT AND/OR PLOT OBSERVED VALUES
      IF(IPLT1.EQ.0)WRITE(KWRT,7200)PBOP,POOP,CHRP
 7200 FORMAT('+',34X,F5.2,2X,F5.2,4X,80A1/50X,'I')
      IF(IPLT1.NE.0)WRITE(KWRT,7205)CHRP
 7205 FORMAT('+I',80A1/)
  935 CONTINUE
      CALL DOAXIS(IPLT1,ISCALE,KWRT)
  940 CONTINUE
      RETURN
      END
/*
//GO.FT10F001 DD DSN=&&KLIP01,DISP=(OLD,DELETE),UNIT=SYSRES
//
```

Table D3.1 Minimum Error Calibration - Data Listing

```
L.001 //AR#CALX JOB 333,CLASS=D
L.002 /*JOBPARM     P=ULK4,R=73
L.003 /*ROUTE  PRINT HOLD
L.004 /*SETUP DISK=PXC003
L.005 // EXEC MPSX370,TIME,GO=5
L.006 //COMP.SYSIN DD *
L.007         PROGRAM
L.008         INITIALZ
L.009         TITLE('KLTP R CALIBRATION RUN 101  24/01/80')
L.010         MOVE(XDATA,'CALIDATA')
L.011         MOVE(XPBNAME,'GODCAL')
L.012         CONVERT
L.013         SETUP
L.014         MOVE(XOBJ,'ERSUM')
L.015         MOVE(XRHS,'RHS')
L.016         OPTIMIZE
L.017         SOLUTION
L.018         EXIT
L.019         PEND
L.020 //GO.SYSIN DD *
L.021 NAME          CALIDATA FREE
L.022 ROWS
L.023  N  ERSUM
L.024  E  QL102
L.025  E  QL103
L.026  E  QL104
L.027  E  QL105
L.028  E  QL106
L.029  E  QL107
L.030  E  QL108
L.031  E  QL109
L.032  E  QL110
L.033  E  QL111
L.034  E  QL112
L.035  E  QL113
L.036  E  QL114
L.037  E  QL115
L.038  E  QL116
L.039  E  QL117
L.040  E  QL118
L.041  E  QL119
L.042  E  QL120
L.043  E  QL121
L.044  E  QL122
L.045  E  QL123
L.046  E  QL124
L.047  E  QL202
L.048  E  QL203
L.049  E  QL204
L.050  E  QL205
L.051  E  QL206
L.052  E  QL207
L.053  E  QL208
L.054  E  QL209
L.055  E  QL210
L.056  E  QL211
L.057  E  QL212
L.058  E  QL213
L.059  E  QL214
L.060  E  QL215
L.061  E  QL216
L.062  E  QL217
L.063  E  QL218
L.064  E  QL219
L.065  E  QL220
L.066  E  QL221
L.067  E  QL222
L.068  E  QL223
L.069  E  QL224
L.070  E  QL302
L.071  E  QL303
L.072  E  QL304
L.073  E  QL305
L.074  E  QL306
L.075  E  QL307
L.076  E  QL308
L.077  E  QL309
L.078  E  QL310
L.079  E  QL311
L.080  E  QL312
L.081  E  QL313
L.082  E  QL314
L.083  E  QL315
L.084  E  QL316
L.085  E  QL317
L.086  E  QL318
L.087  E  QL319
L.088  E  QL320
L.089  E  QL321
L.090  E  QL322
L.091  E  QL323
L.092  E  QL324
L.093  E  RL101
L.094  E  RL102
L.095  E  RL103
L.096  E  RL104
L.097  E  RL105
L.098  E  RL106
L.099  E  RL107
L.100  E  RL108
L.101  E  RL109
L.102  E  RL110
L.103  E  RL111
L.104  E  RL112
L.105  E  RL113
L.106  E  RL114
L.107  E  RL115
L.108  E  RL116
L.109  E  RL117
L.110  E  RL118
L.111  E  RL119
L.112  E  RL120
L.113  E  RL121
L.114  E  RL122
L.115  E  RL123
L.116  E  RL124
L.117  E  RL201
L.118  E  RL202
L.119  E  RL203
L.120  E  RL204
L.121  E  RL205
L.122  E  RL206
L.123  E  RL207
L.124  E  RL208
L.125  E  RL209
L.126  E  RL210
L.127  E  RL211
L.128  E  RL212
L.129  E  RL213
L.130  E  RL214
L.131  E  RL215
L.132  E  RL216
L.133  E  RL217
L.134  E  RL218
L.135  E  RL219
L.136  E  RL220
L.137  E  RL221
L.138  E  RL222
L.139  E  RL223
L.140  E  RL224
L.141  E  RL301
L.142  E  RL302
L.143  E  RL303
L.144  E  RL304
L.145  E  RL305
L.146  E  RL306
L.147  E  RL307
L.148  E  RL308
L.149  E  RL309
L.150  E  RL310
L.151  E  RL311
L.152  E  RL312
L.153  E  RL313
L.154  E  RL314
L.155  E  RL315
L.156  E  RL316
L.157  E  RL317
L.158  E  RL318
L.159  E  RL319
L.160  E  RL320
```

(Continued)

```
L.161  E  RL321
L.162  E  RL322
L.163  E  RL323
L.164  E  RL324
L.165  E  RL401
L.166  E  RL402
L.167  E  RL403
L.168  E  RL404
L.169  E  RL405
L.170  E  RL406
L.171  E  RL407
L.172  E  RL408
L.173  E  RL409
L.174  E  RL410
L.175  E  RL411
L.176  E  RL412
L.177  E  RL413
L.178  E  RL414
L.179  E  RL415
L.180  E  RL416
L.181  E  RL417
L.182  E  RL418
L.183  E  RL419
L.184  E  RL420
L.185  E  RL421
L.186  E  RL422
L.187  E  RL423
L.188  E  RL424
L.189  E  QC102
L.190  E  QC103
L.191  E  QC104
L.192  E  QC105
L.193  E  QC106
L.194  E  QC107
L.195  E  QC108
L.196  E  QC109
L.197  E  QC110
L.198  E  QC111
L.199  E  QC112
L.200  E  QC113
L.201  E  QC114
L.202  E  QC115
L.203  E  QC116
L.204  E  QC117
L.205  E  QC118
L.206  E  QC119
L.207  E  QC120
L.208  E  QC121
L.209  E  QC122
L.210  E  QC123
L.211  E  QC124
L.212  E  QC202
L.213  E  QC203
L.214  E  QC204
L.215  E  QC205
L.216  E  QC206
L.217  E  QC207
L.218  E  QC208
L.219  E  QC209
L.220  E  QC210
L.221  E  QC211
L.222  E  QC212
L.223  E  QC213
L.224  E  QC214
L.225  E  QC215
L.226  E  QC216
L.227  E  QC217
L.228  E  QC218
L.229  E  QC219
L.230  E  QC220
L.231  E  QC221
L.232  E  QC222
L.233  E  QC223
L.234  E  QC224
L.235  E  QC302
L.236  E  QC303
L.237  E  QC304
L.238  E  QC305
L.239  E  QC306
L.240  E  QC307
L.241  E  QC308
L.242  E  QC309
L.243  E  QC310
L.244  E  QC311
L.245  E  QC312
L.246  E  QC313
L.247  E  QC314
L.248  E  QC315
L.249  E  QC316
L.250  E  QC317
L.251  E  QC318
L.252  E  QC319
L.253  E  QC320
L.254  E  QC321
L.255  E  QC322
L.256  E  QC323
L.257  E  QC324
L.258  E  RC101
L.259  E  RC102
L.260  E  RC103
L.261  E  RC104
L.262  E  RC105
L.263  E  RC106
L.264  E  RC107
L.265  E  RC108
L.266  E  RC109
L.267  E  RC110
L.268  E  RC111
L.269  E  RC112
L.270  E  RC113
L.271  E  RC114
L.272  E  RC115
L.273  E  RC116
L.274  E  RC117
L.275  E  RC118
L.276  E  RC119
L.277  E  RC120
L.278  E  RC121
L.279  E  RC122
L.280  E  RC123
```

(Continued)

```
L.281  E  RC124
L.282  E  RC201
L.283  E  RC202
L.284  E  RC203
L.285  E  RC204
L.286  E  RC205
L.287  E  RC206
L.288  E  RC207
L.289  E  RC208
L.290  E  RC209
L.291  E  RC210
L.292  E  RC211
L.293  E  RC212
L.294  E  RC213
L.295  E  RC214
L.296  E  RC215
L.297  E  RC216
L.298  E  RC217
L.299  E  RC218
L.300  E  RC219
L.301  E  RC220
L.302  E  RC221
L.303  E  RC222
L.304  E  RC223
L.305  E  RC224
L.306  E  RC301
L.307  E  RC302
L.308  E  RC303
L.309  E  RC304
L.310  E  RC305
L.311  E  RC306
L.312  E  RC307
L.313  E  RC308
L.314  E  RC309
L.315  E  RC310
L.316  E  RC311
L.317  E  RC312
L.318  E  RC313
L.319  E  RC314
L.320  E  RC315
L.321  E  RC316
L.322  E  RC317
L.323  E  RC318
L.324  E  RC319
L.325  E  RC320
L.326  E  RC321
L.327  E  RC322
L.328  E  RC323
L.329  E  RC324
L.330  E  RC401
L.331  E  RC402
L.332  E  RC403
L.333  E  RC404
L.334  E  RC405
L.335  E  RC406
L.336  E  RC407
L.337  E  RC408
L.338  E  RC409
L.339  E  RC410
L.340  E  RC411
L.341  E  RC412
L.342  E  RC413
L.343  E  RC414
L.344  E  RC415
L.345  E  RC416
L.346  E  RC417
L.347  E  RC418
L.348  E  RC419
L.349  E  RC420
L.350  E  RC421
L.351  E  RC422
L.352  E  RC423
L.353  E  RC424
L.354 COLUMNS
L.355        L101      QL102      0.763      RL101      1.
L.356        L102      QL102     -0.237      RL102      1.
L.357        L102      QL103      0.763
L.358        L103      QL103     -0.237      RL103      1.
L.359        L103      QL104      0.763
L.360        L104      QL104     -0.237
L.361        L104      QL105      0.763      RL104      1
L.362        L105      QL105     -0.237      RL105      1.
L.363        L105      QL106      0.763
L.364        L106      QL106     -0.237      RL106      1.
L.365        L106      QL107      0.763
L.366        L107      QL107     -0.237      RL107      1.
L.367        L107      QL108      0.763
L.368        L108      QL108     -0.237      RL108      1.
L.369        L108      QL109      0.763
L.370        L109      QL109     -0.237      RL109      1.
L.371        L109      QL110      0.763
L.372        L110      QL110     -0.237      RL110      1.
L.373        L110      QL111      0.763
L.374        L111      QL111     -0.237      RL111      1.
L.375        L111      QL112      0.763
L.376        L112      QL112     -0.237      RL112      1.
L.377        L112      QL113      0.763
L.378        L113      QL113     -0.237      RL113      1.
L.379        L113      QL114      0.763
L.380        L114      QL114     -0.237      RL114      1.
L.381        L114      QL115      0.763
L.382        L115      QL115     -0.237      RL115      1.
L.383        L115      QL116      0.763
L.384        L116      QL116     -0.237      RL116      1.
L.385        L116      QL117      0.763
L.386        L117      QL117     -0.237      RL117      1.
L.387        L117      QL118      0.763
L.388        L118      QL118     -0.237      RL118      1.
L.389        L118      QL119      0.763
L.390        L119      QL119     -0.237      RL119      1.
L.391        L119      QL120      0.763
L.392        L120      QL120     -0.237      RL120      1.
L.393        L120      QL121      0.763
L.394        L121      QL121     -0.237      RL121      1.
L.395        L121      QL122      0.763
L.396        L122      QL122     -0.237      RL122      1.
L.397        L122      QL123      0.763
L.398        L123      QL123     -0.237      RL123      1.
L.399        L123      QL124      0.763
L.400        L124      QL124     -0.237      RL124      1.
```

Minimum Error Data (Continued)

(Continued)

Minimum Error Calibration (Continued)

(Continued)

· Minimum Error Calibration (Continued)

(Continued)