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CITY OF PHOENIX
BR-78043.03

DESIGN COMPUTATIONS FOR THE 35TH AVENUE BRIDGE OVER THE SALT RIVER

HYDRAULIC ANALYSIS

INTERNATIONAL ENGINEERING COMPANY, INC.
MAY 1982

A105.801

II. HYDRAULIC STUDIES

Studies of bridge hydraulic effects covered both analyses of the changes in flow levels and velocities, and analyses of scour effects. A total of six different bridge configurations were investigated for both hydraulic and scour effects, with the result that a 500-foot bridge was recommended as the first-phase structure.

The results of the hydraulic analyses for the initial bridge configuration indicated an adverse scour condition due to the proximity of piers to abutments. Cumulative pier and abutment scour was indicated to be in the range of 60-70 feet. In response to suggestions of the City Engineering staff, relationships were investigated between relative bridge locations within the channel and scour depths. The findings indicated that scour depths were not significantly influenced by location and that scour problems were primarily due to encroachment of bridge abutments into the channel. It was then recommended that the City consider construction of a longer first-phase bridge, both to ameliorate scour problems and to improve long-term stability of the river channel in the reaches above and below the bridge.

Following the recommendation to consider a longer bridge, four additional configurations were analyzed. These included a bridge with three 125-foot spans, with both vertical and sloping abutments, and a bridge with four 125-foot spans, again with both vertical and sloping abutments. The results of those configuration studies showed that vertical abutments were both costly and were susceptible to extreme scour depths. The four-span (500-foot) bridge with sloping riprap abutments was then indicated to be the most preferable alternative, and was subsequently endorsed by the City Engineering staff. Analyses pertinent to the 500-foot bridge follow.

The condition which imposes the extreme hydraulic loading on the bridge is defined as that which occurs immediately prior to failure of the approach. That condition is reached at a discharge of approximately 100,000 cfs, when the depth of flow is about 15 feet and the velocity (before enlargement of the section by scour) is around 20 fps. The two primary design parameters related to hydraulic conditions are depth of scour and hydrodynamic forces on the structure.

Scour depths for the 500-foot bridge have been calculated by methods in the DOT-FHWA manual on hydraulic design and by methods developed by Laursen for the Arizona DOT, as shown in the following calculations.

~~Case III 500' Bridge, Q = 105,000 cfs~~

Data from HEC-2 analyses:

Sta	CWSEL	ELMIN	DEPTH	TOPWID	V_{CH}
14	1026	1011	14.5	406	19.7
15	1031	1011	20.0	1320	8.7
16	1032	1009	23.0	2410	4.0
17	1032	1010	22.3	1986	5.7
18	1032	1010	22.0	1296	8.6

On station 18, use top width = 650 - from topo

General scour from Lacey, with F = 14.08 for $d_{50} = 64$

$$q_{14} = \frac{105\,000}{(490+340)/2} = 253 \rightarrow d_s = 14.7$$

$$q_{18} = \frac{105\,000}{(650+450)/2} = 191 \rightarrow d_s = 12.4$$

$$\Delta d = \underline{\underline{2.3}} \text{ ft.} \leftarrow \Delta d$$

General scour from Laursen's long contraction analogy

Width ratio = $W_{18}/W_{14} = 650/490 = 1.33$

$Fr_{18} = 0.32 \rightarrow$ From p 39 Laursen

$d_s/y_0 = 0.22 \rightarrow d_s = 0.22 \times 22 = \underline{\underline{4.8'}} \leftarrow d_s$

Local Scour

Abutments - Normally, no scour would result for the planned case, since use of guide banks is contemplated. However, contingency planning should consider possible effects of lack of channel maintenance. In that case, an encroachment length of one-half the contraction amount on each side could be assumed.

Abutment scour - DOT method

Approach emb. length $= \frac{650-490}{2} = 80$

$y_s/y_1 = 1.1\,(80/22)^{0.4}\,(0.32)^{0.33}$

$= 1.84 \times 0.69 \times 22 = \underline{27.8}$ ← y_s

Abutment scour - Laursen

$l = 80$; $l/y_0 = 80/22 = 3.64$

$d_s = 0.8 \times 2.8 \times 22 = \underline{49.3}$ ← d_s

Caisson scour - DOT method

$y_s/y_1 = 2.0\,(6/22)^{0.65}\,(0.32)^{0.43}$ 14/22 4' on each side

$y_s = 2\,(0.43)(0.61)(22) = 11.6$ ~~16~~ 20.1

$y_{s_{max}} = 1.3 \times 11.6 = \underline{15.1}$ ← y_s ~~16~~ 26.0 max

Caisson scour - Laursen

$y_0/b = 22/6 = 3.67$

$d_s = 0.9 \times 2.1 \times 6 = \underline{11.3}$ ←

The results of the scour analyses are as follows:

Type of Scour	Method of Analysis: DOT Manual	Method of Analysis: Laursen
General	2.4'	4.8'
Local		
Abutment	27.8'	49.3'
Caisson (6'Ø)	15.1' 26.1 26.1	11.3'
Total Scour		
Abutment	30.2'	54.1'
Caisson (6'Ø)	28.5 17.5' 16.1'	

Under initial conditions which would exist in the channel upstream and downstream from the bridge, no abutment scour would develop. The abutment scour depths which were calculated were based upon the possibility of upstream channel migration. If the initial hydraulic approach conditions in the upstream channel were maintained, no abutment scour would develop since water would not have to flow around abutments. However, since the channel is braided, some allowance should be made for changes in alignment. The depths calculated by the DOT method would be appropriate in this case. In addition to the calculated scour, a rather arbitrary allowance of 20 feet was made to try to account for effects of gravel mining near the bridge. While gravel mining effects are largely unknown, an additional scour allowance of around 20 feet would insure the integrity of the structure during passage of one major event - after which some grade control measures could be installed if further scour during subsequent events were possible. From this discussion, it is apparent that the occurrence of scour is conditional upon other changes

it would occur at beginning of dike

to the streambed. A likely minimum depth of scour is around ~~18~~ 29 feet - and it is possible that such a depth would not be exceeded during the life of the structure. It is prudent, however, to allow for morphological changes to the stream plan and profile which would bring about a maximum scour depth of around 50 feet in the area of the abutments. Scour which would occur at the abutment foundations would be of a horizontal type, due to the eddy with a vertical axis that forms in the separation zone on the downstream side of the abutments. It is possible that abutment foundations could be exposed by the downstream eddy, but depth of scour would generally be limited to streambed elevation due to limitations in sediment transport capacity. The recommended design elevations to reflect maximum expected scour are therefore as follows:

Compare this to valid

Location:	Abutment Foundation	Abutment Toe	Caisson
Elevation:	990 − 5 = 985	960	~~970~~ 1010 − 29 − 20 = 961

930 tip elev
31' is this enough?

Riprap protection of abutments has been designed by consideration of critical shear, as developed in the DOT manual. For abutment slopes of lv:3h, a riprap angle of repose of 42°, a depth of flow of 15 feet, a velocity of 20 fps, riprap specific gravity of 2.65, and a riprap maximum size of three feet, the factor of safety against riprap failure is 1.48. The riprap must also have a uniform grain size distribution, with a median grain size of 18 inches and a minimum grain size of four inches.

The riprap calculations follow.

Riprap analysis

Riprap sizing is based upon Section 6.A1.0 of the DOT Manual covering hydraulic considerations.

$$S.F = \frac{\cos\theta \tan\phi}{\eta' \tan\phi + \sin\theta \cos\beta}$$

where θ = slope angle = 18.43° 1:3

ϕ = angle of repose = 42°

$$\beta = \tan^{-1}\left\{\frac{\cos\lambda}{\frac{2\sin\theta}{\eta\tan\phi} + \sin\lambda}\right\} = \frac{1}{\left[\frac{0.6323}{0.4036}\right]} = 32.55^{\circ}$$

$$\eta = \frac{2\tau_0}{(S_s-1)\gamma D} = \frac{2\gamma R S_0}{(S_s-1)\gamma D} = 0.4412 \quad .8824$$

representative size rock 18"

for $D = 3.0$, $S_s = 2.65$, $R = 20$ & $S_0 = 0.0052$

$$\eta' = \eta\left[\frac{1+\sin(\lambda+\beta)}{2}\right] = \frac{1.538}{2}\eta = 0.3447 \quad .6894$$

Then, the factor of safety for rock riprap of 3.0-foot diameter on 1:3 side slopes is:

$$S.F. = \frac{\cos(18.43)\tan(42)}{0.3447\tan(42) + \sin(18.43)\cos(32.55)}$$

$$= \frac{(0.9487)(0.9004)}{0.3104 + (0.3161)(0.8429)} = 1.48 \quad 0.96$$

HYDRAULICS APPENDIX

Results of HEC-2

Analysis for Extreme

Design Conditions

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*****************************************
 HEC2 RELEASE DATED NOV 76 UPDATED APRI 1980
 ERROR CORR -  01,02,03,04
 MODIFICATION -  50,51,52,53,54
*****************************************

T1      35TH AVE BRIDGE STUDY-JOB NO. 2415 NOVEMBER 81
T2      FLOW OF 105000 CFS      6 FT PIERS
T3      105000 CFS SLOPE ABUT. 4-125 FT SPANS
```

– Extreme hydraulic condition prior to approach failure

J1	ICHECK	INQ	NINV	IDIP	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	5.	0.	0.	0.000000	0.00	0.0	0.	1019.100	0.000

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	-1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

33.000	39.000	43.000	1.000	42.000	8.000	17.000	4.000	3.000	26.000
0.000	33.000	43.000	1.000	3.000	26.000	39.000	21.000	22.000	33.000
5.000	53.000	54.000	0.000	33.000	13.000	14.000	15.000	55.000	26.000
56.000	7.000	1.000	3.000	10.000	11.000	12.000	0.000	0.000	0.000

NC	.030	.050	.030	.100	.300	0.000	0.000	0.000	0.000	0.000
QT	2.000	47000.000	55000.000	75000.000	105000.000	150000.000	200000.000	0.000	0.000	0.000

X1	4.000	97.000	351.000	1339.400	580.000	640.000	580.000	0.000	0.000	0.000
X3	0.000	0.000	0.000	0.000	0.000	0.000	1022.200	0.000	0.000	0.000
GR	1025.700	133.400	1026.500	167.200	1025.700	186.800	1025.600	214.700	1025.500	245.000
GR	1025.800	254.100	1024.900	265.200	1025.000	273.200	1025.400	301.000	1025.000	331.400
GR	1025.000	351.000	1024.900	358.600	1013.800	373.100	1010.500	389.600	1009.700	410.600
GR	1008.400	451.500	1006.500	496.400	1005.100	521.700	1005.000	533.900	1007.400	544.900
GR	1010.400	562.300	1011.700	580.400	1012.000	603.700	1011.800	623.900	1013.600	637.800
GR	1014.800	674.700	1015.400	712.500	1015.000	746.900	1014.700	774.700	1014.500	802.300
GR	1015.700	829.800	1015.000	842.300	1016.800	857.600	1016.500	883.000	1016.000	916.400
GR	1017.600	940.000	1019.300	957.300	1019.900	993.100	1019.600	1041.400	1019.400	1068.100
GR	1019.100	1127.100	1019.100	1175.700	1019.300	1239.600	1018.800	1272.300	1018.300	1287.900
GR	1018.300	1302.700	1019.500	1311.500	1020.300	1318.400	1020.300	1328.200	1020.900	1354.100
GR	1020.300	1386.700	1018.800	1418.600	1018.300	1437.800	1016.200	1443.100	1016.600	1467.400
GR	1016.100	1525.600	1016.200	1550.900	1016.300	1555.100	1016.700	1581.300	1017.300	1596.900
GR	1018.100	1608.700	1021.500	1615.900	1022.300	1619.600	1020.900	1628.500	1022.200	1633.500
GR	1018.100	1646.000	1018.000	1666.500	1016.500	1692.300	1016.300	1712.200	1017.500	1728.700
GR	1018.500	1751.400	1016.800	1769.800	1016.400	1779.500	1016.400	1786.000	1018.400	1794.300

```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


CCHV=    .100 CEHV=    .300
*SECNO 4.000

3265 DIVIDED FLOW

3280 CROSS SECTION       4.00 EXTENDED       4.40 FEET

     4.00     22.80  1019.10  1018.38  1019.10  1022.02     2.92      0.00      0.00  1025.00
   105000.       0.    32161.   72839.       0.    4489.    4619.        0.        0.  1020.60
      0.00     0.00     7.17    15.77     .030     .030     .030     0.000    996.30   365.18
  .003102      580.     580.     640.        0       12        0      0.00   1507.33  2304.30

*SECNO 5.000

3265 DIVIDED FLOW

3280 CROSS SECTION       5.00 EXTENDED       1.62 FEET

3301 HV CHANGED MORE THAN HVINS

     5.00     19.42  1022.72     0.00     0.00  1023.22      .50      .95      .24  1023.90
   105000.     1468.    59021.   44511.     449.   11022.    7310.     234.      33.  1024.20
      .04      3.37     5.36     6.39     .030     .030     .030     .034  1003.30   193.30
  .000743      800.     800.     640.        2        0        0      0.00  2397.32  2610.50

*SECNO 6.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

     6.00     12.41  1023.21     0.00     0.00  1024.31     1.10      .91      .18  1025.50
   105000.     1886.    52901.   50113.     385.    7314.    5213.     516.      73.  1026.10
      .05      6.16     7.23     9.61     .030     .030     .030     .031  1010.80   170.37
  .002105      730.     730.     840.        3        0        0      0.00  2058.98  2382.52
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SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       LEFT/RIGHT
TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
SLOPE     XLOBL     XLCH      XLOBR     ITPIAL    IDC       ICONT     CORAR     TOPWID    ENDST

*SECNO 7.000

3265 DIVIDED FLOW

     7.00     11.61  1024.61      0.00      0.00  1025.91      1.30      1.54       .06  1023.40
   105000.     2324.  102676.        0.      412.     11148.        0.      711.      101.  1029.40
      .08      5.64      9.21      0.00      .030      .030      .030      .030   1013.00   233.59
  .002284      442.      665.      836.         2         0         0      0.00   1579.24  1949.29

*SECNO 8.000

3265 DIVIDED FLOW

     8.00     13.08  1025.28      0.00      0.00  1026.46      1.19       .55       .01  1026.50
   105000.     2535.  102465.        0.      455.     11632.        0.      781.      110.  1030.20
      .09      5.57      9.21      0.00      .030      .030      .030      .030   1012.20   199.73
  .001935      260.      260.      347.         2         0         0      0.00   1562.49  1931.70

*SECNO 9.000
     9.00     13.83  1025.93      0.00      0.00  1027.06      1.13       .59       .01  1025.20
   105000.     2483.  102511.        0.      561.     11390.        0.      871.      122.  1031.80
      .10      4.44      8.62      0.00      .030      .030      .030      .030   1012.10   303.27
  .001776      295.      320.      175.         2         0         0      0.00   1635.79  1939.06

*SECNO 10.000
    10.00     14.79  1026.23      0.00      0.00  1027.71      1.43       .56       .09  1025.60
   105000.     3059.  101941.        0.      576.     10526.        0.      943.      132.  1032.30
      .11      5.31      9.69      0.00      .030      .030      .030      .030   1011.50   335.13
  .002501      320.      265.      220.         2         0         0      0.00   1579.55  1914.68

*SECNO 11.000

3265 DIVIDED FLOW

    11.00     15.47  1026.97      0.00      0.00  1028.44      1.47       .72       .01  1028.70
   105000.     3121.  101879.        0.      574.     10377.        0.     1017.      143.  1031.30
      .12      5.85      9.83      0.00      .030      .030      .030      .030   1011.50   430.77
  .002462      335.      290.      260.         2         0         0      0.00   1497.45  1976.08
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         OLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA      LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 12.000
    12.00     15.18   1027.53      0.00      0.00   1029.26      1.68       .75       .06   1026.20
  105000.     4535.   100465.        0.      839.     9492.        0.     1086.      152.   1031.40
      .12      5.40     10.58      0.00      .030      .030      .030      .030   1012.40    499.95
  .002849      275.      285.      290.         2         0         0      0.00   1517.19   2017.14

*SECNO 13.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

    13.00     15.31   1026.31      0.00      0.00   1030.98      4.67       .82       .90   1040.00
  105000.      530.   104470.        0.      163.     6006.        0.     1134.      158.   1040.00
      .13      3.25     17.39      0.00      .030      .030      .030      .030   1011.00    710.39
  .003852      250.      250.      255.         3         0         0      0.00    598.20   1943.93

*SECNO 14.000

3301 HV CHANGED MORE THAN HVINS

    14.00     14.56   1025.56      0.00      0.00   1031.59      6.03       .20       .41   1040.00
  105000.        0.   105000.        0.        0.     5327.        0.     1140.      159.   1040.00
      .13      0.00     19.71      0.00      .030      .030      .030      .030   1011.00   1566.35
  .005200       50.       45.       45.         3         0         0      0.00    405.82   1972.68

SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS   1022.09 ,NOT   1025.56 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
     1.05      1.50      3.10      0.00    326.00     42.00   10324.00      3.00   1011.00   1011.00

*SECNO 15.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS
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SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA     LEFT/RIGHT
TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

CLASS B LOW FLOW

3420 BRIDGE W.S.=   1026.30 BRIDGE VELOCITY=,     20.80     CALCULATED CHANNEL AREA=,     5048.

 EGPRS      ECLWC       H3       QWEIP      QPR       BAREA   TRAPEZOID      ELLC      ELTRD
                                                                AREA
    0.00   1032.12     0.00        0.   105000.   10324.**********  9999999.009999999.00

   15.00     20.07  1031.07     0.00     0.00  1032.12     1.05      .53     0.00  1030.10
 105000.   20503.   84421.      70.    3540.    9708.      81.    1159.     161.   1030.00
     .13      5.79     8.70      .87     .030     .030     .030     .030  1011.00   741.41
 .000711       75.      95.     110.        0        0        0     0.00  1320.45  2155.79

*SECNO 16.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

   16.00     22.25  1032.05     0.00     0.00  1032.29      .25      .10      .08  1017.30
 105000.   33215.   65123.    6663.    7893.   16293.    2637.    1291.     173.   1025.10
     .13      4.21     4.00     2.53     .030     .030     .030     .030  1009.10    67.29
 .000199      275.     290.     305.        2        0        0     0.00  2410.59  2480.98

*SECNO 17.000

3265 DIVIDED FLOW

   17.00     22.28  1031.98     0.00     0.00  1032.44      .46      .08      .06  1025.30
 105000.    9025.   80176.   15799.    1829.   14022.    3835.    1446.     188.   1032.10
     .17      4.93     5.72     4.10     .030     .030     .030     .030  1009.70   299.81
 .000470      285.     290.     295.        2        0        0     0.00  1986.44  2377.08

*SECNO 18.000

3265 DIVIDED FLOW
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DBB 6-17-82

$\theta = 3:1 = 18.43°$ $V = 20$ $D = 1.5'$

$\phi = \quad = 42°$ $S_s = 2.65$

$\lambda = \quad = 0°$ $S_o = 0.0052$

$$\eta = \frac{21 V S_o}{(S_s - 1) D} = \frac{21(20)(.0052)}{1.65(1.5)} = 0.8824$$

$$\beta = \tan^{-1}\left\{\frac{\cos 0°}{\frac{2 \sin 18.43}{(.8824)\tan 42°} + \sin 0}\right\} = 51.49°$$

$$\eta' = 0.8824\left[\frac{1 + \sin(0 + 51.49°)}{2}\right] = 0.7864$$

$$S.F = \frac{\cos 18.43 \ \tan 42°}{(.7864)\tan 42° + \sin 18.43 \cos 51.49} = 0.94$$

failure

$$\beta = \tan^{-1}\left\{\frac{(.8824)\tan 42°}{2 \sin 18.43°}\right\} = 51.49°$$

$$\eta' = .8824\left\{\frac{1 + \sin 51.49°}{2}\right\} = .7864$$

$SF =$ $= 0.94 < 1 \therefore$ failure.

Ok.

```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

3301 HV CHANGED MORE THAN HVINS

    18.00     22.05   1031.75      0.00      0.00   1032.84      1.10       .21       .19   1038.80
   105000.       0.    95114.     9386.        0.    11031.     1704.     1556.      199.   1035.20
      .18      0.00      8.62      5.30      .030      .030      .030      .030   1009.70    711.69
  .001163      295.      300.      310.         3         0         0      0.00   1296.48   2542.31

*SECNO 19.000

3265 DIVIDED FLOW

    19.00     23.02   1032.12      0.00      0.00   1033.17      1.06       .32       .00   1038.20
   105000.       0.    93932.    11018.        0.    11067.     1913.     1641.      208.   1035.30
      .19      0.00      8.49      5.76      .030      .030      .030      .030   1007.10    701.21
  .001146      375.      330.      285.         2         0         0      0.00   1371.74   2567.09

*SECNO 20.000

3265 DIVIDED FLOW

    20.00     24.38   1032.63      0.00      0.00   1033.49       .81       .30       .02   1027.30
   105000.      426.    96459.     8115.      122.    13012.     1652.     1735.      218.   1035.30
      .20      3.48      7.41      4.91      .030      .030      .030      .030   1007.80    533.04
  .000693      290.      295.      300.         2         0         0      0.00   1535.63   2416.22

*SECNO 21.000

3265 DIVIDED FLOW

    21.00     23.11   1032.91      0.00      0.00   1033.82       .91       .29       .03   1037.00
   105000.       0.    95437.     9513.        0.    12300.     1669.     1335.      228.   1035.50
      .21      0.00      7.83      5.70      .030      .030      .030      .030   1009.80    552.02
  .001063      320.      305.      290.         2         0         0      0.00   1414.80   2430.24

*SECNO 22.000

3265 DIVIDED FLOW
```

```
SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA     LEFT/RIGHT
TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

  22.00    21.31  1033.41     0.00     0.00  1034.08      .67      .24      .02  1033.40
105000.     862.   96497.    7641.     282.   14303.    1788.    1930.     238.   1032.90
    .22     3.06     6.75     4.27     .030     .030     .030     .030  1012.10    117.68
.000745     300.     275.     255.        2        0        0     0.00  1756.80   2345.79

*SECNO 23.000

3265 DIVIDED FLOW

  23.00    19.39  1033.59     0.00     0.00  1034.41      .82      .28      .04  1034.90
105000.       0.   98362.    6638.       0.   13279.    1465.    2046.     251.   1032.70
    .23     0.00     7.41     4.53     .030     .030     .030     .030  1014.20    374.83
.001011     310.     325.     340.        2        0        0     0.00  1747.56   2360.65

*SECNO 24.000

3265 DIVIDED FLOW

3280 CROSS SECTION      24.00 EXTENDED      1.67 FEET

  24.00    20.46  1034.16     0.00     0.00  1034.68      .52      .24      .03  1030.90
105000.    8221.   87342.    9437.    2058.   14376.    2477.    2169.     265.   1028.50
    .25     3.99     6.08     3.81     .030     .030     .030     .030  1013.70      0.00
.000591     300.     320.     310.        2        0        0     0.00  2164.48   2258.35

*SECNO 25.000
  25.00    21.62  1034.52     0.00     0.00  1034.84      .32      .14      .02  1031.20
105000.    9582.   84220.   11193.    2650.   17893.    3081.    2321.     280.   1028.70
    .27     3.62     4.71     3.63     .030     .030     .030     .030  1012.90     33.23
.000326     220.     330.     280.        2        0        0     0.00  2235.11   2268.34
```

PROFILE FOR STREAM 105000 CFS SLOPE ABUT. 4

PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

```
ELEVATION   995.     1000.     1005.     1010.     1015.     1020.     1025.     1030.     1035.     1040.
   SECNO    CUMDIS
   4.00      0.  .  I      .         .         .         M.      CW .R  E     L         .         .         .         .
             50.  C  I      .         .         .         M        W. R E     L         .         .         .         .
            100.  C   I     .         .         .         .M       W. R E     L         .         .         .         .
            150.  C    I    .         .         .         . M       W  RE     L         .         .         .         .
            200.  C     I   .         .         .         .  M      W  R E   L.         .         .         .         .
            250.  C      I  .         .         .         .  M      W  R E   L.         .         .         .         .
            300.  C       I .         .         .         .   M     .W  RE   L.         .         .         .         .
            350.  C        I.         .         .         .    M    .W  RE   L.         .         .         .         .
            400.  C         I         .         .         .     M   . W  E   L.         .         .         .         .
            450.  C         I         .         .         .      M  . W  E   L.         .         .         .         .
            500.  C         .I        .         .         .      M  .  W  E  L.         .         .         .         .
            550.  C         . I       .         .         .       M .  W  E L .         .         .         .         .
            600.  C         .  I      .         .         .        M.   W ERL .         .         .         .         .
            650.  C         .   I     .         .         .         M   W ERL .         .         .         .         .
            700.  C         .    I    .         .         .         .M   WERL .         .         .         .         .
            750.  C         .     I   .         .         .         .M   WE L .         .         .         .         .
   5.00     800.  C         .      I  .         .         .         . M  WE L .         .         .         .         .
            850.  C         .       I .         .         .         .  M  WELR.         .         .         .         .
            900.  C         .        I.         .         .         .  M  WELR.         .         .         .         .
            950.  C         .         I         .         .         .  M  WELR.         .         .         .         .
           1000.  C         .         .I        .         .         .   M WE L.         .         .         .         .
           1050.  C         .         . I       .         .         .   M WE LR         .         .         .         .
           1100.  C         .         .  I      .         .         .   M WE LR         .         .         .         .
           1150.  C         .         .   I     .         .         .    MWE LR         .         .         .         .
           1200.  C         .         .    I    .         .         .    MW E L         .         .         .         .
           1250.  C         .         .     I   .         .         .    MW E LP        .         .         .         .
           1300.  C         .         .      I  .         .         .     W E LP        .         .         .         .
           1350.  C         .         .       I .         .         .     W E LP        .         .         .         .
           1400.  C         .         .        I.         .         .     W E L R       .         .         .         .
           1450.  C         .         .         I         .         .     WME .LR       .         .         .         .
           1500.  C         .         .         .I        .         .     WM E.LR       .         .         .         .
   6.00    1550.  C         .         .         . I       .         .     WM E.LR       .         .         .         .
           1600.  C         .         .         . I       .         .      WME.L R      .         .         .         .
           1650.  C         .         .         . I       .         .      W E. LR      .         .         .         .
           1700.  C         .         .         .  I      .         .      W EM L R     .         .         .         .
           1750.  C         .         .         .  I      .         .      W  EM LR     .         .         .         .
           1800.  C         .         .         .  I      .         .      W  E  L R    .         .         .         .
           1850.  C         .         .         .   I     .         .       W E   LR    .         .         .         .
           1900.  C         .         .         .   I     .         .       W E   LMR   .         .         .         .
           1950.  C         .         .         .   I     .         .       W .E  L R   .         .         .         .
           2000.  C         .         .         .    I    .         .       W .E   L R  .         .         .         .
           2050.  C         .         .         .    I    .         .        W.E   L RM .         .         .         .
           2100.  C         .         .         .    I    .         .        W.E    L RM.         .         .         .
           2150.  C         .         .         .     I   .         .        W. E   L R M         .         .         .
   7.00    2200.  C         .         .         .     I   .         .        W. E    L R.M        .         .         .
           2250.  C         .         .         .     I   .         .        W. E   L  R.M        .         .         .
           2300.  C         .         .         .    I    .         .         W E  L   R. M       .         .         .
           2350.  C         .         .         .    I    .         .         W E  L    R M       .         .         .
           2400.  C         .         .         .    I    .         .         W  EL     R  M      .         .         .
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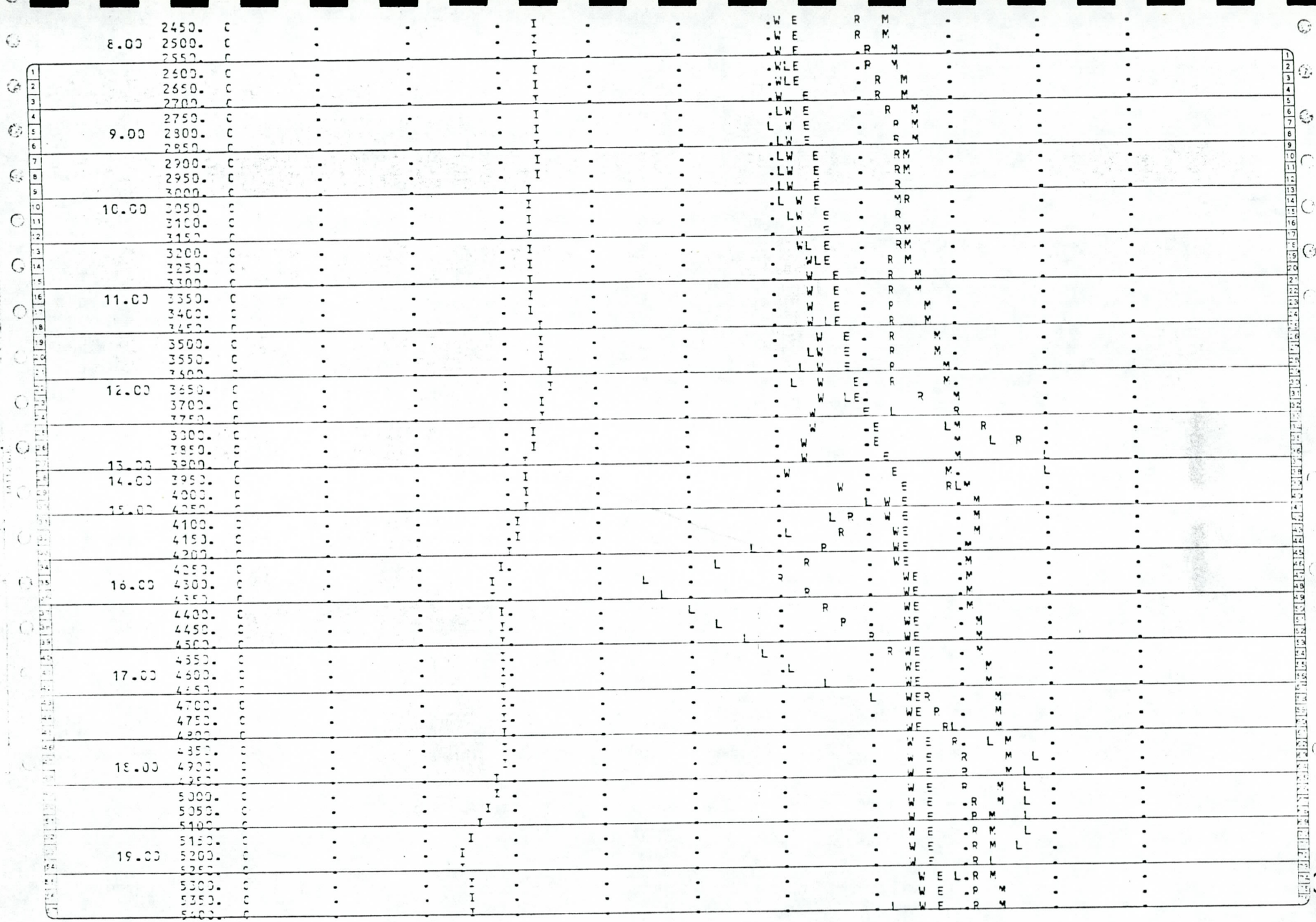

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        5450.  C        .        .   I    .        .        .        .     L .    W E  .P  M    .        .
20.00   5500.  C        .        .    I   .        .        .        .   L   .    W E  .R   M   .        .
        5550.  C        .        .     I  .        .        .        .     L .    W E  .R  M    .        .
        5600.  C        .        .     I  .        .        .        .       .L    WE  .R M      .        .
        5650.  C        .        .      I .        .        .        .       .   L WE  .R M      .        .
        5700.  C        .        .      I .        .        .        .       .     WE  .RM       .        .
        5750.  C        .        .       I.        .        .        .       .     W E .LM       .        .
21.00   5800.  C        .        .        I        .        .        .       .     W E .R  L     .        .
        5850.  C        .        .        I        .        .        .       .     W E RM L      .        .
        5900.  C        .        .        .I       .        .        .       .     W EP.L        .        .
        5950.  C        .        .        . I      .        .        .       .     W E LM        .        .
        6000.  C        .        .        .  I     .        .        .       .      WEL.M        .        .
22.00   6050.  C        .        .        .   I    .        .        .       .     PWE .M        .        .
        6100.  C        .        .        .    I   .        .        .       .     RWE . M       .        .
        6150.  C        .        .        .    I   .        .        .       .     RWE .  M      .        .
        6200.  C        .        .        .     I  .        .        .       .     RWE .  M      .        .
        6250.  C        .        .        .      I .        .        .       .     RW E.   M     .        .
        6300.  C        .        .        .      I .        .        .       .    R W E.   M     .        .
        6350.  C        .        .        .       I .        .        .       .    R W EL    M    .        .
23.00   6400.  C        .        .        .       I .        .        .       .    R W EL    M    .        .
        6450.  C        .        .        .       I .        .        .       .   R  W E.   M     .        .
        6500.  C        .        .        .       I .        .        .       .  R   LWE. M       .        .
        6550.  C        .        .        .       I .        .        .       .R    L WEM         .        .
        6600.  C        .        .        .       I .        .        .       R    L  WE.         .        .
        6650.  C        .        .        .        I .        .        .      R.   L  MWE.         .        .
24.00   6700.  C        .        .        .       I .        .        .     R  . L  M  WE.         .        .
        6750.  C        .        .        .       I .        .        .     R  . L   M WE.         .        .
        6800.  C        .        .        .       I .        .        .     R  . L     ME.         .        .
        6850.  C        .        .        .       I .        .        .     R  . L      WE         .        .
        6900.  C        .        .        .      I  .        .        .     R  . L      WE         .        .
        6950.  C        .        .        .      I  .        .        .     R  . L      WE M       .        .
        7000.  C        .        .        .      I  .        .        .     R  . L      WE  M      .        .
25.00   7050.  C        .        .        .      I  .        .        .     R  . L      WE   M     .        .
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*****************************************
 HEC2 RELEASE DATED NOV 76 UPDATED APRI 1980
 ERROR CORR - 01,02,03,04
 MODIFICATION - 50,51,52,53,54
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

105000 CFS SLOPE ABUT. 4

SUMMARY PRINTOUT

	SECNO	XLCH	Q	CWSEL	ELMIN	DEPTH	K*XNCH	TOPWID	EG	VCH
	4.000	580.00	105000.00	1019.10	996.30	22.80	30.00	1507.33	1022.02	7.17
	5.000	300.00	105000.00	1022.72	1003.30	19.42	30.00	2397.32	1023.22	5.36
	6.000	730.00	105000.00	1023.21	1010.80	12.41	30.00	2058.98	1024.31	7.23
	7.000	665.00	105000.00	1024.61	1013.00	11.61	30.00	1579.24	1025.91	9.21
	8.000	260.00	105000.00	1025.28	1012.20	13.08	30.00	1562.49	1026.46	8.81
	9.000	320.00	105000.00	1025.93	1012.10	13.83	30.00	1635.79	1027.06	8.62
	10.000	265.00	105000.00	1026.28	1011.50	14.78	30.00	1579.55	1027.71	9.69
	11.000	290.00	105000.00	1026.97	1011.50	15.47	30.00	1497.45	1028.44	9.82
	12.000	285.00	105000.00	1027.56	1012.40	15.18	30.00	1517.19	1029.26	10.58
	13.000	250.00	105000.00	1026.31	1011.00	15.31	30.00	598.20	1030.98	17.39
	14.000	45.00	105000.00	1025.56	1011.00	14.56	30.00	405.82	1031.59	19.71
*	15.000	95.00	105000.00	1031.07	1011.00	20.07	30.00	1320.45	1032.12	8.70
	16.000	290.00	105000.00	1032.05	1009.10	22.95	30.00	2410.59	1032.29	4.00
	17.000	290.00	105000.00	1031.98	1009.70	22.28	30.00	1986.44	1032.44	5.72
	18.000	300.00	105000.00	1031.75	1009.70	22.05	30.00	1296.48	1032.84	8.62
	19.000	280.00	105000.00	1032.12	1007.10	25.02	30.00	1371.74	1033.17	8.49
	20.000	295.00	105000.00	1032.68	1007.30	24.88	30.00	1535.63	1033.49	7.41

SECNO	XLCH	Q	CWSEL	ELMIN	DEPTH	K*XNCH	TOPWID	EG	VCH
21.000	305.00	105000.00	1032.91	1009.80	23.11	30.00	1414.80	1033.82	7.83
22.000	275.00	105000.00	1033.41	1012.10	21.31	30.00	1756.80	1034.08	6.75
23.000	325.00	105000.00	1033.59	1014.20	19.39	30.00	1747.56	1034.41	7.41
24.000	320.00	105000.00	1034.16	1013.70	20.46	30.00	2164.48	1034.68	6.08
25.000	330.00	105000.00	1034.52	1012.90	21.62	30.00	2235.11	1034.84	4.71

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105000 CFS SLOPE ABUT. 4

SUMMARY PRINTOUT

SECNO	Q	CWSEL	CRIWS	VCH	XLCH	STCHL	STCHR	K*CHSL	10K*S	SSTA	ENDST
4.000	105000.00	1019.10	1018.38	7.17	580.00	351.00	1839.40	0.00	31.02	366.18	2304.30
5.000	105000.00	1022.72	0.00	5.36	800.00	324.60	1716.40	8.75	7.43	193.30	2610.50
6.000	105000.00	1023.21	0.00	7.23	730.00	410.60	1725.00	10.27	21.05	170.87	2382.52
7.000	105000.00	1024.61	0.00	9.21	665.00	464.00	1960.40	3.31	22.84	238.59	1949.29
8.000	105000.00	1025.28	0.00	8.81	260.00	493.80	1959.30	-3.08	19.35	199.73	1931.70
9.000	105000.00	1025.93	0.00	8.62	320.00	525.60	1956.10	-.31	17.76	303.27	1939.06
10.000	105000.00	1026.28	0.00	9.69	265.00	555.70	1928.30	-2.26	25.01	335.13	1914.68
11.000	105000.00	1026.97	0.00	9.82	290.00	677.60	2006.10	0.00	24.62	430.77	1976.08
12.000	105000.00	1027.58	0.00	10.56	285.00	836.00	2063.50	3.16	28.49	499.95	2017.14
13.000	105000.00	1026.31	0.00	17.39	250.00	1455.00	1985.00	-5.60	38.52	710.89	1943.93
14.000	105000.00	1025.56	0.00	19.71	45.00	1531.00	2016.00	0.00	52.00	1565.85	1972.68
* 15.000	105000.00	1031.07	0.00	8.70	95.00	1438.40	2005.00	0.00	7.11	741.41	2155.79
16.000	105000.00	1032.05	0.00	4.00	290.00	655.40	1845.10	-6.55	1.99	67.29	2480.98
17.000	105000.00	1031.98	0.00	5.72	290.00	494.40	1644.90	2.07	4.70	299.81	2377.08
18.000	105000.00	1031.75	0.00	8.62	300.00	696.60	1787.40	0.00	11.63	711.69	2542.31
19.000	105000.00	1032.12	0.00	8.49	280.00	689.20	1730.60	-9.29	11.46	701.21	2567.09
20.000	105000.00	1032.68	0.00	7.41	295.00	575.60	1734.90	2.37	8.93	538.04	2416.02
21.000	105000.00	1032.91	0.00	7.33	305.00	539.30	1699.40	6.56	10.58	552.02	2430.24
22.000	105000.00	1033.41	0.00	6.75	275.00	306.10	1585.20	8.36	7.45	117.68	2345.79
23.000	105000.00	1033.59	0.00	7.41	325.00	371.70	1671.90	6.46	10.11	374.83	2360.65
24.000	105000.00	1034.16	0.00	6.08	320.00	481.60	1749.40	-1.56	5.91	0.00	2258.35
25.000	105000.00	1034.52	0.00	4.71	330.00	393.00	1871.20	-2.42	3.26	33.23	2263.34

105000 CFS SLOPE ABUT. 4

SUMMARY PRINTOUT

	SECNO	QLOB	QCH	QROB	VLOB	VCH	VROB	VOL	CWSEL	EG	HV	HL	OLOSS
	4.000	0.00	32161.24	72838.76	0.00	7.17	15.77	0.00	1019.10	1022.02	2.92	0.00	0.00
	5.000	1468.44	59020.78	44510.78	3.27	5.36	6.09	234.17	1022.72	1023.22	.50	.95	.24
	6.000	1986.27	52901.43	50112.31	5.16	7.23	9.61	515.54	1023.21	1024.31	1.10	.91	.18
	7.000	2323.57	102676.43	0.00	5.44	9.21	0.00	710.53	1024.61	1025.91	1.30	1.54	.06
	8.000	2534.83	102465.17	0.00	5.57	8.31	0.00	781.10	1025.28	1026.46	1.19	.55	.01
	9.000	2489.01	102510.99	0.00	4.44	8.62	0.00	870.94	1025.93	1027.06	1.13	.59	.01
	10.000	3059.02	101940.98	0.00	5.31	9.69	0.00	943.30	1026.28	1027.71	1.43	.56	.09
	11.000	3121.41	101878.59	0.00	5.85	9.80	0.00	1017.14	1026.97	1028.44	1.47	.72	.01
	12.000	4534.91	100465.09	0.00	5.40	10.58	0.00	1086.47	1027.58	1029.26	1.68	.75	.06
	13.000	529.95	104470.05	0.00	3.25	17.39	0.00	1133.83	1026.31	1030.98	4.67	.82	.90
	14.000	0.00	105000.00	0.00	0.00	19.71	0.00	1139.77	1025.56	1031.59	6.03	.20	.41
*	15.000	20506.34	84421.39	70.28	5.79	8.70	.87	1159.32	1031.07	1032.12	1.05	.53	0.00
	16.000	33214.56	65122.68	6662.77	4.21	4.00	2.53	1291.49	1032.05	1032.29	.25	.10	.08
	17.000	9025.04	80176.19	15798.76	4.93	5.72	4.12	1446.14	1031.98	1032.44	.46	.08	.06
	18.000	0.00	95114.12	9885.38	0.00	8.62	5.80	1558.31	1031.75	1032.84	1.10	.21	.19
	19.000	0.00	93982.47	11017.53	0.00	8.49	5.76	1641.17	1032.12	1033.17	1.06	.32	.00
	20.000	426.66	96458.91	8115.43	3.48	7.41	4.91	1735.38	1032.68	1033.49	.81	.30	.02
	21.000	0.00	95486.69	9513.31	0.00	7.83	5.70	1835.15	1032.91	1033.82	.91	.29	.03
	22.000	862.37	96496.93	7640.70	3.06	6.75	4.27	1929.39	1033.41	1034.08	.67	.24	.02
	23.000	0.00	98362.17	6637.83	0.00	7.41	4.53	2046.48	1033.59	1034.41	.82	.28	.04
	24.000	8220.77	87341.74	9437.49	3.99	6.08	3.81	2169.18	1034.16	1034.68	.52	.24	.03
	25.000	9582.07	84220.27	11197.66	3.60	4.71	3.63	2321.16	1034.52	1034.34	.32	.14	.02

SUMMARY OF ERRORS

CAUTION SECNO= 15.000 PROFILE= 1 HYDRAULIC JUMP D.S.

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