Chapter 6

Example Problems

This section presents several example problems that illustrate the contents of input data and computed results files for several typical applications of HEC-6. Detailed descriptions of the input data records can be found in the Input Description (Appendix A), and are not duplicated here. These example problems are not meant to provide engineering application guidance for use of HEC-6; such guidance can be found in Gee (1984), USACE (1989) and HEC (1992). These examples are provided only to illustrate the type and sequence of data needed to model various situations. They encompass a range of situations from fixed-bed backwater computation to simulation of the movement of sediment in a dendritic network of streams.

Although derived from an actual engineering application, the example problems have been altered for illustration purposes. Therefore, the values of the parameters used in these problems are not based on field data and should not necessarily be used in an actual project.

Figure 6-1 shows a schematic of the river system that was the basis for these example problems. Each example builds upon the previous examples, therefore, only the additional or changed data is described for each successive problem.

Several options are available that allow some data to be defined in more than one way. For example, the depth of the bed sediment control volume can be defined explicitly on the HD record or expressed in terms of the elevation of the model bottom on the H record; since only one H or HD record is required for each cross section, either record can be used at a given cross section. Each analyst should select the appropriate options for their particular application. The selection should be based on the physical circumstances, study objectives, data availability and ease of use of the selected option.

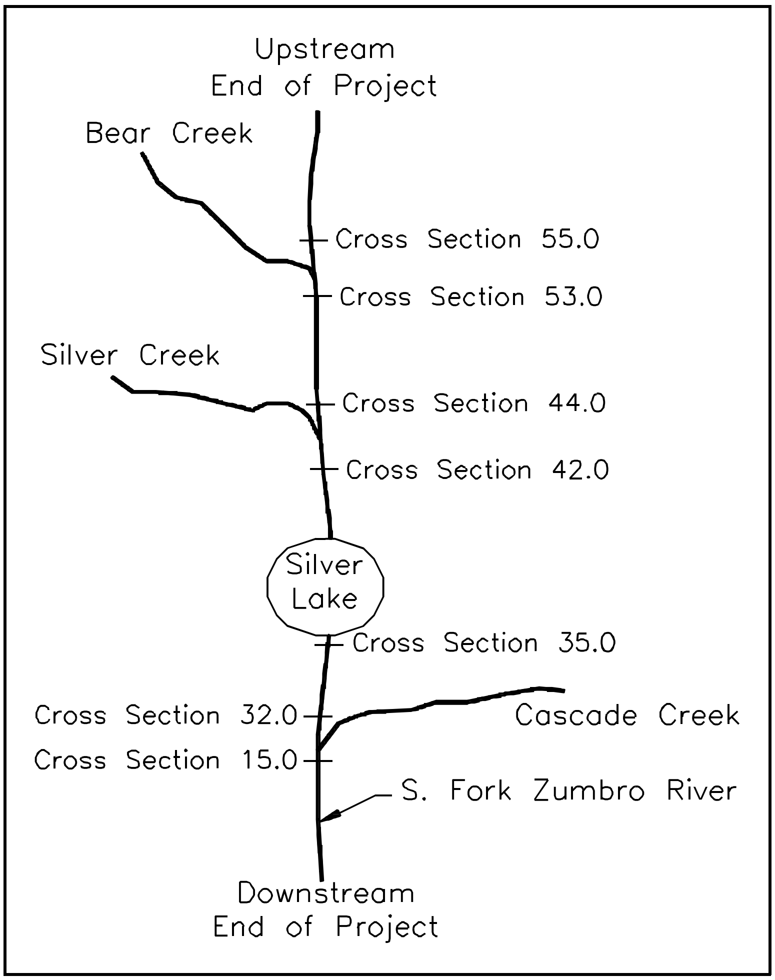

Figure 6-1
Schematic of Example River System

6.1 Example Problem 1 - Fixed-Bed Application

When initially preparing geometric data and calibrating energy loss coefficients, it is often worthwhile to use HEC-6 as a fixed-bed (backwater) model.

6.1.1 Input Data

The data for Example Problem 1, shown in Table 6-1a, is designed to operate HEC-6 as a fixed-bed model. Note that this data is quite similar to HEC-2 data, although some data records (such as QT and X5) have different parameters for HEC-6. These differences are noted in the Input Description (Appendix A). HEC-6 data begins with three title records, T1, T2, and T3. These are followed by bed roughness data (NC) and the geometry for each cross section, beginning with the X1 record. GR records define the cross section's geometry as a series of elevation and station points. The HD records delineate the movable portion of the bed of each cross section; though irrelevant for fixed bed operation of HEC-6, an HD record must follow the GR data for every cross section in the data file.

In general, HEC-6 data records are position dependent. The cross sections are entered from downstream to upstream. The QT records locate inflow/outflow points and tributary junctions. NC records note changes in bed roughness. Comment records, however, are not position dependent; they can be placed anywhere in the data. Comment records are indicated by a blank ID in field 0 (i.e., the first two characters or columns of the record are blank). Comment records can be used throughout a data file to document unusual attributes or conditions in the model.

Duplicate or repeat cross sections are often used to provide extra computational nodes for improving the accuracy of integration of the energy loss equation (HEC, 1986). As indicated by the comment records, Section No. 33.3 is a *duplicate* of Section No. 33.0. This was accomplished by *copying* the data records for Section No. 33.0 and changing the section ID number and reach lengths. In this case, Section No. 33.3 also differs from Section No. 33.0 by width and elevation adjustments. Width and elevation modifications can be made to any cross section in a manner similar to the HEC-2 procedure. A *repeat* section is defined by an X1record with the number of station points (Field 2) equal to zero (see Section 53.1 in Example Problem 5); this is an indicator to HEC-6 that the geometry of the previous section should be re-used for this section. The repeat section option was instituted early in HEC-6's development due to the limitations of file editors and keypunch machines, however, with today's more sophisticated file editors (like COED), it is recommended that duplicated sections be used instead. Care must be taken to assure that duplicate or repeat cross sections have sediment transport characteristics that embody the theory of "reach representative" cross sections (Thomas, 1982).

The distinguishing characteristic of an HEC-6 fixed boundary simulation data file is that there are no sediment data. The geometric data is followed by the flow data which begins with a $HYD record. The flow data for this example contains a rating curve ($RATING and RC records), and flow information (Q, Q, T, and W records). The temperature (T) and duration (W) data, while necessary in the data file, play no role in fixed-bed computations. Example Problem 1 thus is a "multiple profile" run with two flow profiles being computed through a single project reach.

Table 6-1a
Example Problem 1 - Input
Fixed Bed

```
T1      EXAMPLE PROBLEM NO 1.  FIXED-BED APPLICATION.  BASIC GEOMETRY.
T2      3 LOCAL INFLOWS WITH A RATING CURVE AT THE DOWNSTREAM BOUNDARY.
T3      SOUTH FORK, ZUMBRO RIVER   ** Example Problem 1 **
NC    .1      .1     .04      .1      .3
X1   1.0      31  10077.  10275.      0.      0.      0.
GR 1004.   9915.   978.4  10002.   956.0  10060.   959.2  10077.   959.3  10081.
GR 950.0  10092.  948.48  10108.   946.6  10138.   944.7  10158.   955.2  10225.
GR 956.2  10243.   958.9  10250.   959.8  10275.   959.8  10300.   959.9  10325.
GR 958.8  10350.   957.4  10400.   970.0  10700.   966.0  10960.   970.0  11060.
GR 968.0  11085.   968.0  11240.   970.0  11365.   970.0  11500.   970.0  11615.
GR 962.0  11665.   962.0  12400.   976.0  12550.   980.0  12670.   982.0  12730.
GR 984.0  12735.
HD   1.0
X1  15.0      27  10665.  10850.   3560.   3030.   3280.
GR 992.0   9570.   982.0  10110.   976.0  10300.   976.0  10490.   966.0  10610.
GR 964.7  10665.   956.0  10673.   953.0  10693.   954.0  10703.   955.6  10723.
GR 958.6  10750.   959.3  10800.   957.0  10822.   957.3  10825.   961.5  10850.
GR 962.0  10852.   964.0  10970.   966.0  11015.   961.0  11090.   962.0  11150.
GR 970.0  11190.   972.0  11310.   980.0  11410.   984.0  11570.   990.0  11770.
GR 990.0  11865.  1000.0  12150.
HD  15.0
  Model Cascade Creek as a local inflow.
QT
X1  32.0      29  10057.  10271.   3630.   3060.   4240.
GR 998.0   9080.   982.0   9250.   982.0   9510.   980.0   9600.  980.01   9925.
GR979.48  10000.   978.5  10057.   968.6  10075.  959.82  10087.   956.5  10097.
GR 956.8  10117.   957.8  10137.   959.4  10157.   959.6  10177.  959.82  10196.
GR 966.5  10225.   971.2  10250.   978.5  10271.   978.5  10300.   978.6  10350.
GR978.91  10370.  978.96  10387.   980.0  10610.   982.0  10745.   982.0  11145.
GR 984.0  11150.   992.0  11240.  1000.0  11330.   1008.  11425.
HD  32.0
X1  33.0      21   1850.   2150.   3130.   3250.   3320.
GR1000.0    980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.   3170.
HD  33.0
   NOTE:      Section 33.3 is a duplicate of Section  33.0.
   Section 33.0 is a good representative cross section for a long reach.  A
   duplicate is used here to break up the long reach into two smaller reaches.
X1  33.3      21   1850.   2150.   1550.   1750.   1750.     .95    1.49
GR 1000.    980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.   984.4   1850.   979.1   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.   3170.
HD  33.3
X1  35.0      22   9894.  10245.   1050.   1050.   1050.
GR 984.0   9035.   980.0   9070.   978.0   9135.   980.0   9185.   982.0   9270.
GR 980.0   9465.   981.7   9595.   983.7   9745.   984.7   9894.   963.4  9894.1
GR 963.3   9954.   967.1   9974.   967.4  10004.   968.2  10044.   967.6  10054.
GR 973.4  10115.   977.4  10120.   983.7  10155.   984.0  10245.   982.0  10695.
GR 982.0  10895.  1004.0  11085.
HD  35.0
   Silver Lake occupies this reach
NC   .06     .06    .045
X1  42.0      32   9880.  10130.   5370.   5000.   5210.
GR 996.0   7130.   998.0   7310.   998.0   7930.   992.0   8205.   990.0   8495.
GR 988.0   8780.   986.0   8990.   985.7   9570.  986.45   9707.  989.44   9857.
GR 990.0   9880.   969.8   9881.   969.8   9941.   985.8   9941.   985.8   9943.
GR 969.8   9943.   969.8  10001.   986.7  10001.   986.7  10003.   969.8  10003.
GR 969.8  10067.   985.8  10067.   985.8  10069.   969.8  10069.   969.8  10129.
GR 989.9  10130.   989.5  10180.   988.6  10230.   987.6  10280.   985.2  10430.
GR 986.8  11720.   989.9  12310.
HD  42.0
   Model Silver Creek as a local inflow.
QT
X1  44.0      28   9845.  10127.   3200.   3800.   3500.
GR 1002.   8035.   992.0   8150.   990.0   8305.   990.0   8735.   988.0   8835.
GR 996.0   9285.  1017.6   9425.   990.0   9505.   986.0   9650.   984.1   9788.
GR 980.6   9845.   970.9   9868.   972.2   9898.   970.5   9968.   967.5   9998.
GR 968.9  10028.   967.4  10058.   967.1  10078.   971.9  10118.   976.8  10127.
GR 977.8  10150.   976.9  10193.   982.0  10206.   981.2  10300.   979.2  10325.
GR 983.1  10400.   999.8  10450.  1002.4  10464.
HD  44.0
```

```
X1  53.0      22  10000.  10136.   3366.   2832.   2942.
GR 1004.   7550.  1000.0   7760.   998.0   8440.   996.0   8640.   996.0   8780.
GR 994.0   8940.   986.0   9245.   986.3   9555.   986.3   9825.   983.8   9900.
GR 982.8  10000.   978.2  10011.   974.0  10041.   972.2  10071.   972.6  10101.
GR 978.2  10121.   988.7  10136.   989.3  10154.   999.2  10200.  1000.1  10320.
GR 1002.  10470.  1004.0  10700.
HD  53.0
   model Bear Creek as a local inflow
QT
X1  55.0      18   9931.  10062.   2275.   3430.   2770.
GR 1004.   7592.  1000.0   7947.   996.0   8627.   990.0   9052.   986.0   9337.
GR 984.3   9737.   984.7   9837.   985.5   9910.   987.2   9931.   978.1   9955.
GR 974.8   9975.   974.2  10005.   972.9  10035.   973.2  10045.   983.8  10062.
GR 985.8  10187.   986.0  10307.   990.0  10497.
HD  55.0
X1  58.0      22   9912.  10015.   1098.   1012.   1462.
GR 1006.   8542.  1004.0   8952.  1000.0   9702.   997.2   9812.   996.3   9912.
GR 976.2   9944.   975.4   9974.   978.2   9991.   990.4  10015.   988.3  10062.
GR 988.8  10065.   988.3  10065.   989.3  10169.   990.0  10172.   992.0  10242.
GR 992.0  10492.   988.0  10642.   986.7  10852.   988.0  11022.   986.0  11097.
GR 986.0  11137.   988.0  11192.
HD  58.0
EJ
$HYD
$RATING
RC            40    2000       0       0   950.0   955.1   958.0   960.0   962.0
RC         963.6   965.1   966.2   967.0   967.7   968.3   968.9   969.4   969.8
RC         970.2   970.6   971.0   971.4   971.8   972.1   972.4   972.7   972.9
RC         973.1   973.3   973.5   973.7   973.8   973.9   974.0   974.1   974.2
RC         974.3   974.4   974.5   974.6   974.7   974.8   974.9   975.0
Q   A   PROFILE 1 = AVERAGE ANNUAL DISCHARGE
Q  1250.    150.     78.    340.
T
W     1.
Q   A   PROFILE 2 = BANK FULL FLOW
Q  2500.    300.    150.    650.
W     1.
$$END
```

6.1.2 Output

The output from Example Problem 1 is shown in Table 6-1b. Various levels of output detail are available to the user. These are controlled by several input data items (see Chapter 4); the output produced by these options will be described as encountered in the problems. The terminology for output is; default, A-level, B-level, etc., each succeeding level providing increasing detail. The default HEC-6 output provides the minimum level of information.

HEC-6 first gives information regarding program version and date, and the date and time of the run. The input and output file names are placed in the output file for the user's future reference. Information regarding the geometric data follows.

In Example Problem 1, the default (minimum) geometric output is presented. Additional information can be obtained via switches on the T1 record (see Appendix A). Each cross section is labelled by its identification number from the X1 record. We suggest that river mile be used to identify cross sections. The "DEPTH of the Bed..." is based on information from the HD record. Information regarding cross section adjustment is echoed as well as the locations of local inflow points and changes to the energy loss coefficients.

Following the geometric data output, profiles (or time steps) 1 and 2 produced A-level output for the hydraulic, or backwater, computations. This output is triggered by an A in column 5 of the Q record which causes the discharge, water surface elevation, energy grade line elevation, velocity head, alpha, top width, average bed elevation, and average velocity in each subsection for each cross section to be written to the output file. The discharge value represents the subtraction of local inflows as the backwater computation proceeds upstream. Local flow data should be checked to assure that the main river discharge never becomes negative. The average bed elevation (AVG BED) is the water surface elevation minus the effective depth (see Section 2.2.3.6). Subsection 1 is the left overbank, 2 the channel, and

3 the right overbank. This hydraulic information is very useful when first assembling geometric data; once the data are verified and the loss coefficients are calibrated, the A-level hydraulic output may be suppressed.

Table 6-1b
Example Problem 1 - Output
Fixed Bed

```
***************************************************     **********************************
*  SCOUR AND DEPOSITION IN RIVERS AND RESERVOIRS  *     *  U.S. ARMY CORPS OF ENGINEERS   *
*       Version: 4.1.00 -  AUGUST 1993            *     *  HYDROLOGIC ENGINEERING CENTER  *
*  INPUT FILE:  EXAMPLE1.DAT                      *     *  609 SECOND STREET              *
*  OUTPUT FILE: EXAMPLE1.OUT                      *     *  DAVIS, CALIFORNIA 95616-4687   *
*  RUN DATE: 30 AUG 93    RUN TIME: 10:27:58      *     *  (916) 756-1104                 *
***************************************************     **********************************

                       X     X  XXXXXXX   XXXXX          XXXXX
                       X     X  X        X     X        X     X
                       X     X  X        X              X
                       XXXXXXX  XXXX     X       XXXXX  XXXXXX
                       X     X  X        X              X     X
                       X     X  X        X     X        X     X
                       X     X  XXXXXXX   XXXXX          XXXXX

         ***********************************************************************
         *  MAXIMUM LIMITS FOR THIS VERSION ARE:                              *
         *       10  Stream Segments (Main Stem + Tributaries)                 *
         *      150  Cross Sections                                            *
         *      100  Elevation/Station Points per Cross Section                *
         *       20  Grain Sizes                                               *
         *       10  Control Points                                            *
         ***********************************************************************

T1      EXAMPLE PROBLEM NO 1.  FIXED-BED APPLICATION.  BASIC GEOMETRY.
T2      3 LOCAL INFLOWS WITH A RATING CURVE AT THE DOWNSTREAM BOUNDARY.
T3      SOUTH FORK, ZUMBRO RIVER   ** Example Problem 1 **

N values...  Left   Channel   Right    Contraction    Expansion
           0.1000   0.0400   0.1000       1.1000     0.7000

SECTION NO.     1.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    15.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

LOCAL INFLOW POINT  1 occurs upstream from Section No.      15.000

SECTION NO.    32.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    33.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    33.300
...Adjust Section WIDTH to  95.00% of original.
...Adjust Section ELEVATIONS by    1.490 ft.
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    35.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

N values...  Left   Channel   Right    Contraction    Expansion
           0.0600   0.0450   0.0600       1.1000     0.7000

SECTION NO.    42.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

LOCAL INFLOW POINT  2 occurs upstream from Section No.      42.000

SECTION NO.    44.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    53.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

LOCAL INFLOW POINT  3 occurs upstream from Section No.      53.000

SECTION NO.    55.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    58.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

NO. OF CROSS SECTIONS IN STREAM SEGMENT= 11
NO. OF INPUT DATA MESSAGES =   0

TOTAL NO. OF CROSS SECTIONS IN THE NETWORK =  11
TOTAL NO. OF STREAM SEGMENTS IN THE NETWORK=   1
END OF GEOMETRIC DATA
```

```
=================================================================================================================

$HYD
FIXED-BED MODEL

-------------------------------------------------------------------------------------------
$RATING

Downstream Boundary Condition - Rating Curve
  Elevation      Stage     Discharge |  Elevation      Stage     Discharge
 ------------------------------------|----------------------------------
    950.000     950.000        0.000 |    972.400     972.400    40000.000
    955.100     955.100     2000.000 |    972.700     972.700    42000.000
    958.000     958.000     4000.000 |    972.900     972.900    44000.000
    960.000     960.000     6000.000 |    973.100     973.100    46000.000
    962.000     962.000     8000.000 |    973.300     973.300    48000.000
    963.600     963.600    10000.000 |    973.500     973.500    50000.000
    965.100     965.100    12000.000 |    973.700     973.700    52000.000
    966.200     966.200    14000.000 |    973.800     973.800    54000.000
    967.000     967.000    16000.000 |    973.900     973.900    56000.000
    967.700     967.700    18000.000 |    974.000     974.000    58000.000
    968.300     968.300    20000.000 |    974.100     974.100    60000.000
    968.900     968.900    22000.000 |    974.200     974.200    62000.000
    969.400     969.400    24000.000 |    974.300     974.300    64000.000
    969.800     969.800    26000.000 |    974.400     974.400    66000.000
    970.200     970.200    28000.000 |    974.500     974.500    68000.000
    970.600     970.600    30000.000 |    974.600     974.600    70000.000
    971.000     971.000    32000.000 |    974.700     974.700    72000.000
    971.400     971.400    34000.000 |    974.800     974.800    74000.000
    971.800     971.800    36000.000 |    974.900     974.900    76000.000
    972.100     972.100    38000.000 |    975.000     975.000    78000.000

===========================================================================================
TIME STEP #       1
Q   A   PROFILE 1 = AVERAGE ANNUAL DISCHARGE

EXAMPLE PROBLEM NO 1.  FIXED-BED APPLICATION.  BASIC GEOMETRY.
ACCUMULATED TIME (yrs)..........      0.000

--- Downstream Boundary Condition Data for STREAM SEGMENT NO.  1 at Control Point #  1 ---
                            DISCHARGE   TEMPERATURE  WATER SURFACE
                              (cfs)       (deg F)        (ft)
                              1250.000       0.00        953.188

****  DISCHARGE    WATER    ENERGY  VELOCITY   ALPHA     TOP      AVG       AVG VEL (by subsection)
        (CFS)     SURFACE    LINE     HEAD              WIDTH     BED        1        2        3

SECTION NO.      1.000
****   1250.000   953.188   953.251   0.063    1.000   123.928   948.191   0.000   2.019   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     15.000
****   1250.000   957.150   958.285   1.135    1.000    67.126   954.971   0.000   8.546   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  1 is upstream of Section No.      15.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)       (deg F)
            Local Inflow:      150.000       0.00
                   Total:     1100.000       0.00

SECTION NO.     32.000
****   1100.000   963.529   963.580   0.051    1.000   130.197   958.863   0.000   1.811   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     33.000
****   1100.000   964.565   964.599   0.034    1.000   219.876   961.193   0.000   1.484   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     33.300
****   1100.000   965.348   965.405   0.057    1.000   205.246   962.559   0.000   1.922   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     35.000
****   1100.000   966.613   966.986   0.373    1.000    77.367   963.711   0.000   4.898   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     42.000
****   1100.000   972.961   972.994   0.032    1.000   242.312   969.815   0.000   1.443   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  2 is upstream of Section No.      42.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)       (deg F)
            Local Inflow:       78.000       0.00
                   Total:     1022.000       0.00

SECTION NO.     44.000
****   1022.000   973.803   973.819   0.015    1.000   260.206   969.857   0.000   0.995   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     53.000
****   1022.000   975.218   975.804   0.586    1.000    78.162   973.089   0.000   6.141   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
```

```
--- LOCAL INFLOW POINT #  3 is upstream of Section No.      53.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)       (deg F)
            Local Inflow:      340.000        0.00
                   Total:      682.000        0.00

SECTION NO.     55.000
****    682.000   978.823   978.863   0.040    1.000   101.072   974.641   0.000   1.614   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     58.000
****    682.000   979.887   980.091   0.204    1.000    56.154   976.536   0.000   3.625   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

==========================================================================================
TIME STEP #       2
Q   A   PROFILE 2 = BANK FULL FLOW

EXAMPLE PROBLEM NO 1.  FIXED-BED APPLICATION.  BASIC GEOMETRY.
ACCUMULATED TIME (yrs)..........      0.003

--- Downstream Boundary Condition Data for STREAM SEGMENT NO.  1 at Control Point #  1 ---
                            DISCHARGE   TEMPERATURE  WATER SURFACE
                              (cfs)       (deg F)       (ft)
                             2500.000       0.00        955.825

****  DISCHARGE    WATER    ENERGY  VELOCITY   ALPHA     TOP      AVG       AVG VEL (by subsection)
        (CFS)     SURFACE    LINE     HEAD              WIDTH     BED        1       2       3

SECTION NO.      1.000
****   2500.000   955.825   955.927   0.102    1.000   151.140   949.377   0.000   2.565   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     15.000
****   2500.000   959.673   960.191   0.518    1.000   169.528   957.119   0.000   5.774   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  1 is upstream of Section No.      15.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)       (deg F)
            Local Inflow:      300.000        0.00
                   Total:     2200.000        0.00

SECTION NO.     32.000
****   2200.000   965.362   965.465   0.103    1.000   140.643   959.281   0.000   2.572   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     33.000
****   2200.000   966.551   966.604   0.053    1.000   232.014   961.404   0.000   1.842   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     33.300
****   2200.000   967.192   967.273   0.082    1.000   215.861   962.746   0.000   2.292   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     35.000
****   2200.000   968.416   968.811   0.395    1.000   168.513   965.827   0.000   5.043   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     42.000
****   2200.000   974.977   975.025   0.048    1.000   242.514   969.809   0.000   1.755   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  2 is upstream of Section No.      42.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)       (deg F)
            Local Inflow:      150.000        0.00
                   Total:     2050.000        0.00

SECTION NO.     44.000
****   2050.000   975.775   975.802   0.027    1.000   268.762   969.954   0.000   1.310   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     53.000
****   2050.000   977.052   977.665   0.613    1.000    97.657   973.710   0.000   6.281   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  3 is upstream of Section No.      53.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)       (deg F)
            Local Inflow:      650.000        0.00
                   Total:     1400.000        0.00

SECTION NO.     55.000
****   1400.000   980.715   980.794   0.080    1.000   108.982   975.039   0.000   2.264   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     58.000
****   1400.000   981.937   982.255   0.318    1.000    63.384   977.053   0.000   4.522   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

------------------------------------------------------------------------------------------
$$END

       0   DATA ERRORS DETECTED.

TOTAL NO. OF TIME STEPS READ =         2
TOTAL NO. OF WS PROFILES =             2
ITERATIONS IN EXNER EQ =               0

COMPUTATIONS COMPLETED
RUN TIME =  0 HOURS,  0 MINUTES &  0.00 SECONDS
```

6.2 Example Problem 2 - Hydraulic and Geometric Options

This problem builds on Example Problem 1; it is also a fixed-bed run and illustrates some of the more frequently used options for describing certain geometric and hydraulic conditions. The input file for Example Problem 2 is shown in Table 6-2a. Input items that differ from Example Problem 1 are discussed in Sections 6.2.1 through 6.2.5. Output is described in Sections 6.2.6 through 6.2.7.

6.2.1 Manning's *n* Vs. Elevation

Some situations are better modeled by varying *n* values vertically rather than horizontally; this is done in Example Problem 2 at Section No. 15.0 by using NV records (see Appendix A for details). The *n* vs. elevation functions derived for Section No. 15.0 are shown graphically in Figure 6-2. These functions will be used at all subsequent (upstream) cross sections until another NV or NC record is found. Elevations on NV records are constant for all subsequent cross sections, therefore, as the computation proceeds upstream they may become too low. In this example, the NC record at Section No. 32.0 returns the computations to an *n* vs. subsection function. The NV record can also be used to vary *n* with discharge.

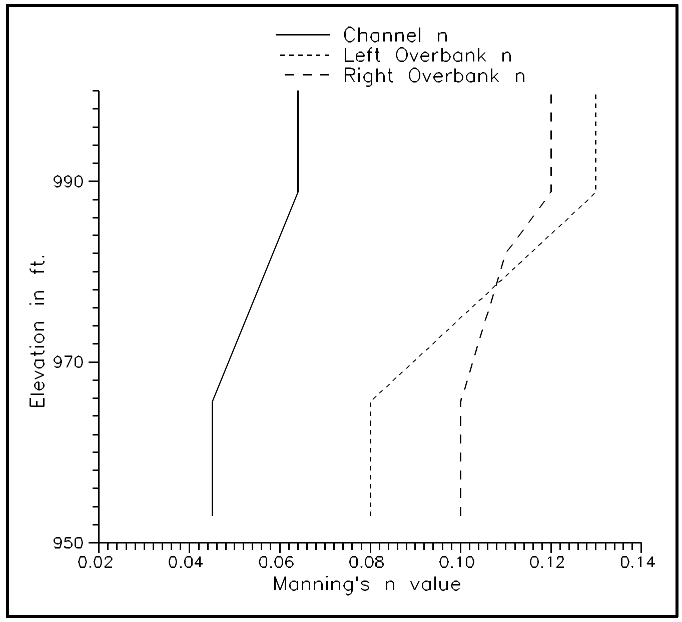

Figure 6-2
Manning's *n* vs. Elevation, Section No. 15

6.2.2 Internal Boundary Conditions

Study reaches will occasionally contain hydraulic controls, such as weirs and gated structures, where the step backwater solution is not appropriate. The effects of such structures can be simulated using X5 and R data to define an Internal Boundary Condition (IBC). In Example Problem 2, Section No. 33.0 is immediately upstream of a gated spillway that can arbitrarily control the upstream water surface elevation. Also, Section No. 35.0 is at the upstream face of an erosion control weir which maintains a fixed water surface elevation of 974 ft at that section during low flow conditions.

An internal boundary condition breaks the project reach into two smaller subreaches, creating a new upstream boundary and a new downstream boundary at that break point. The new upstream boundary is the cross section downstream of the internal boundary condition; the new downstream boundary is the cross section containing the X5 record defining the internal boundary condition.

Some modifications to the reach geometry are needed when an internal boundary condition is added to the model. Because Section No. 32.0 is representative of the reach downstream of the spillway at Section No. 33.0, Section No. 32.1, a duplicate of Section No. 32.0, was added at the downstream face of the spillway. This new cross section was assigned downstream reach lengths equal to those originally defined for Section No. 33.0 and the reach lengths of Section No. 33.0 were set to 0.0. The "2" in Field 4 of the X5 record for Section No. 33.0 causes the water surface elevation for that cross section to be read from Field 2 of the R record in the flow data. Thus, for this example, the specified water surface elevation at Section No. 33.0 will be 966 ft for the first discharge and 978 ft for the second. The larger of this water surface elevation or that computed by the step backwater is used.

Similarly, Section No. 33.9, a duplicate of Section No. 33.3, was added downstream of Section No. 35.0; its reach lengths are those originally set for Section No. 35.0 and the reach lengths for Section No. 35.0 were also set to 0.0. The X5 record entered with this cross section indicates that the minimum water surface elevation and head loss at this point are 974 ft and 0.5 ft, respectively.

6.2.3 Ineffective Flow Area

A portion of Section No. 15.0 is deemed to be ineffective; that is, it carries no flow. This is described with the X3 record, which allows easy modification of existing cross section data to reflect encroachments. In this case, the left encroachment starts at the intersection of the left bank at elevation 961 ft and extends at that elevation to station 10,700 ft. The right encroachment starts at station 11,000 ft and extends at elevation 970 ft to the right bank. This is implemented in HEC-6 by raising the GR points within an encroachment to the encroachment elevation.

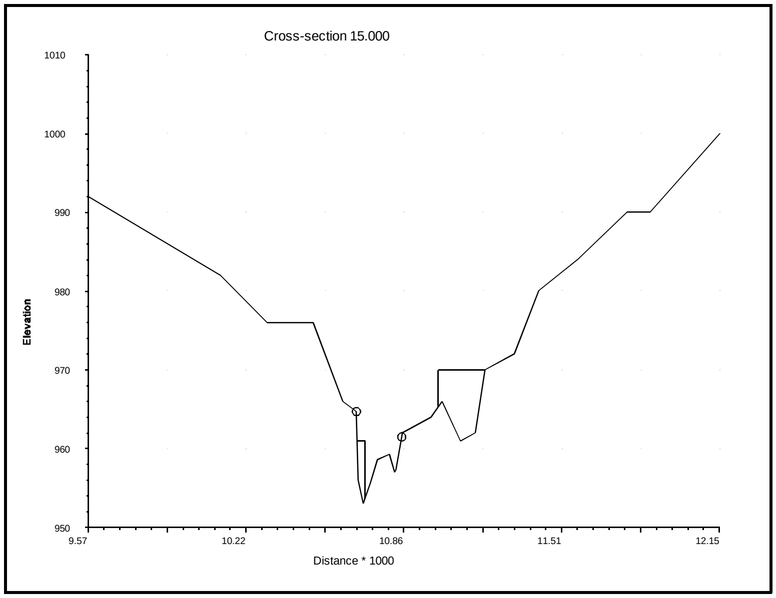

Figure 6-3
Cross Section 15.0 with encroachments

Another commonly used Ineffective Flow option is available to restrain flow within the channel until the water surface is above the bank elevation. This option is used in Section No. 33.9 and 35.0 to model the natural levees in that reach.

Table 6-2a
Example Problem 2 - Input
Hydraulic Options

```
T1      EXAMPLE PROBLEM NO 2.  HYDRAULIC AND GEOMETRIC OPTIONS.
T2      3 LOCAL INFLOWS, USE OF R RECORDS.
T3      SOUTH FORK, ZUMBRO RIVER     ** Example Problem 2 **
NC    .1      .1     .04      .1      .3
X1   1.0      31  10077.  10275.      0.       0.       0.
GR 1004.   9915.   978.4  10002.   956.0  10060.   959.2  10077.   959.3  10081.
GR 950.0  10092.  948.48  10108.   946.6  10138.   944.7  10158.   955.2  10225.
GR 956.2  10243.   958.9  10250.   959.8  10275.   959.8  10300.   959.9  10325.
GR 958.8  10350.   957.4  10400.   970.0  10700.   966.0  10960.   970.0  11060.
GR 968.0  11085.   968.0  11240.   970.0  11365.   970.0  11500.   970.0  11615.
GR 962.0  11665.   962.0  12400.   976.0  12550.   980.0  12670.   982.0  12730.
GR 984.0  12735.
HD   1.0
NV    22    .045   965.6    .064   988.8
NV    12     .08   965.6     .13   988.8
NV    33      .1   965.6     .11   982.0     .12   988.8
X1  15.0      27  10665.  10850.   3560.   3030.   3280.
X3                        10700.   961.0  11000.   970.0
GR 992.0   9570.   982.0  10110.   976.0  10300.   976.0  10490.   966.0  10610.
GR 964.7  10665.   956.0  10673.   953.0  10693.   954.0  10703.   955.6  10723.
GR 958.6  10750.   959.3  10800.   957.0  10822.   957.3  10825.   961.5  10850.
GR 962.0  10852.   964.0  10970.   966.0  11015.   961.0  11090.   962.0  11150.
GR 970.0  11190.   972.0  11310.   980.0  11410.   984.0  11570.   990.0  11770.
GR 990.0  11865.  1000.0  12150.
```

```
HD  15.0
   Model Cascade Creek as a local inflow.
QT
NC    .1       .1      .05
X1  32.0       29  10057.  10271.   3630.   3060.   4240.
GR 998.0    9080.   982.0   9250.   982.0   9510.   980.0   9600.  980.01   9925.
GR979.48   10000.   978.5  10057.   968.6  10075.  959.82  10087.   956.5  10097.
GR 956.8   10117.   957.8  10137.   959.4  10157.   959.6  10177.  959.82  10196.
GR 966.5   10225.   971.2  10250.   978.5  10271.   978.5  10300.   978.6  10350.
GR978.91   10370.  978.96  10387.   980.0  10610.   982.0  10745.   982.0  11145.
GR 984.0   11150.   992.0  11240.  1000.0  11330.   1008.  11425.
HD  32.0
  Section 32.1 is a duplicate of Sec 32.0 which is representative of the reach
  downstream of the spillway at Sec 33.0.  Sec 32.1 is a new upstream boundary.
X1  32.1       29  10057.  10271.   3130.   3250.   3320.
X3    10
GR 998.0    9080.   982.0   9250.   982.0   9510.   980.0   9600.  980.01   9925.
GR979.48   10000.   978.5  10057.   968.6  10075.  959.82  10087.   956.5  10097.
GR 956.8   10117.   957.8  10137.   959.4  10157.   959.6  10177.  959.82  10196.
GR 966.5   10225.   971.2  10250.   978.5  10271.   978.5  10300.   978.6  10350.
GR978.91   10370.  978.96  10387.   980.0  10610.   982.0  10745.   982.0  11145.
GR 984.0   11150.   992.0  11240.  1000.0  11330.   1008.  11425.
HD  32.1
  A spillway is located here.
X1  33.0       21   1850.   2150.       0       0       0
X5                               2
XL                  250.
GR 1000.     980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0    1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0    1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0   2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.    3170.
HD  33.0
  NOTE:       Section 33.3 is a duplicate of Section  33.0.
   Section 33.0 is a good representative cross section for a long reach.  A
   duplicate is used here to break up the long reach into two smaller reaches.
X1  33.3       21   1850.   2150.   1550.   1750.   1750.     .95    1.49
XL                  250.
GR 1000.     980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0    1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0    1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0   2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.    3170.
HD  33.3
  Section 33.9 is a duplicate of Section 33.3.  It is placed at the downstream
  face of the weir being defined at Section 35.0 and is a new upstream boundary.
X1  33.9       21   1850.   2150.   1050.   1050.   1050.     .95    1.65
X3    10
GR 1000.     980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0    1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0    1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0   2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.    3170.
HD  33.9
  A weir is located here.
X1  35.0       22   9894.  10245.       0       0       0
X3    10
X5           974.     0.5
GR 984.0    9035.   980.0   9070.   978.0   9135.   980.0   9185.   982.0   9270.
GR 980.0    9465.   981.7   9595.   983.7   9745.   984.7   9894.   963.4  9894.1
GR 963.3    9954.   967.1   9974.   967.4  10004.   968.2  10044.   967.6  10054.
GR 973.4   10115.   977.4  10120.   983.7  10155.   984.0  10245.   982.0  10695.
GR 982.0   10895.  1004.0  11085.
HD  35.0
NC   .06      .06    .045
X1  42.0       32   9880.  10130.   5370.   5000.   5210.
GR 996.0    7130.   998.0   7310.   998.0   7930.   992.0   8205.   990.0   8495.
GR 988.0    8780.   986.0   8990.   985.7   9570.  986.45   9707.  989.44   9857.
GR 990.0    9880.   969.8   9881.   969.8   9941.   985.8   9941.   985.8   9943.
GR 969.8    9943.   969.8  10001.   986.7  10001.   986.7  10003.   969.8  10003.
GR 969.8   10067.   985.8  10067.   985.8  10069.   969.8  10069.   969.8  10129.
GR 989.9   10130.   989.5  10180.   988.6  10230.   987.6  10280.   985.2  10430.
GR 986.8   11720.   989.9  12310.
HD  42.0
   Model Silver Creek as a local inflow.
QT
X1  44.0       28   9845.  10127.   3200.   3800.   3500.
XL                          9850.  10200.
GR 1002.    8035.   992.0   8150.   990.0   8305.   990.0   8735.   988.0   8835.
GR 996.0    9285.  1017.6   9425.   990.0   9505.   986.0   9650.   984.1   9788.
GR 980.6    9845.   970.9   9868.   972.2   9898.   970.5   9968.   967.5   9998.
GR 968.9   10028.   967.4  10058.   967.1  10078.   971.9  10118.   976.8  10127.
GR 977.8   10150.   976.9  10193.   982.0  10206.   981.2  10300.   979.2  10325.
GR 983.1   10400.   999.8  10450.  1002.4  10464.
```

```
HD  44.0
X1  53.0      22  10000.  10136.   3366.   2832.   2942.
GR 1004.   7550.  1000.0   7760.   998.0   8440.   996.0   8640.   996.0   8780.
GR 994.0   8940.   986.0   9245.   986.3   9555.   986.3   9825.   983.8   9900.
GR 982.8  10000.   978.2  10011.   974.0  10041.   972.2  10071.   972.6  10101.
GR 978.2  10121.   988.7  10136.   989.3  10154.   999.2  10200.  1000.1  10320.
GR 1002.  10470.  1004.0  10700.
HD  53.0
   model Bear Creek as a local inflow.
QT
X1  55.0      18   9931.  10062.   2275.   3430.   2770.
GR 1004.   7592.  1000.0   7947.   996.0   8627.   990.0   9052.   986.0   9337.
GR 984.3   9737.   984.7   9837.   985.5   9910.   987.2   9931.   978.1   9955.
GR 974.8   9975.   974.2  10005.   972.9  10035.   973.2  10045.   983.8  10062.
GR 985.8  10187.   986.0  10307.   990.0  10497.
HD  55.0
X1  58.0      22  9912.0 10015.0   1098.   1012.   1462.
GR 1006.   8542.  1004.0   8952.  1000.0   9702.   997.2   9812.   996.3   9912.
GR 976.2   9944.   975.4   9974.   978.2   9991.   990.4  10015.   988.3  10062.
GR 988.8  10065.   988.3  10065.   989.3  10169.   990.0  10172.   992.0  10242.
GR 992.0  10492.   988.0  10642.   986.7  10852.   988.0  11022.   986.0  11097.
GR 986.0  11137.   988.0  11192.
HD  58.0
EJ
$HYD
Q   A   PROFILE 1 = AVERAGE ANNUAL DISCHARGE
Q  1250.    150.     78.    340.
R   960.    966.
T    60.     60.     60.     60.
W     5.
Q   B   PROFILE 2 = FLOOD EVENT  (0.5% CHANCE FLOOD)
Q 10000.   1200.    600.   2600.
R   973.    978.
W     1.
$$END
```

6.2.4 Conveyance Limits

Ineffective flow areas can also be specified with XL data. In Example Problem 2, Section No. 33.0 has non-conveying areas centered about the channel on both sides, leaving a conveyance width of 250 ft. Since Section No. 33.3 is a duplicate of Section No. 33.0, the conveyance limit is duplicated at this section. At Section No. 44.0, conveyance limits have been specified at stations 9,850 and 10,200, leaving a conveyance width of 350 ft (not centered about the channel). The difference between the ineffective flow area option and the conveyance limits option is that deposition may occur in wetted areas outside the conveyance limits, but not in ineffective flow areas. Although both methods may yield the same hydraulic conditions, sediment deposition may differ. Refer to Sections 3.2.7 for more details.

6.2.5 Downstream Boundary Water Surface Elevation

In Example Problem 1, the downstream boundary water surface elevation was computed for each flow by interpolation within a rating curve provided by the user. Alternately, when the downstream water surface elevation is independent of discharge, as with a reservoir pool elevation, the boundary condition can be specified as a time series of water surface elevations (i.e. a stage hydrograph). This is illustrated by the R records in the input data for Example Problem 2. For this problem the starting water surface elevation at the downstream boundary is 960 ft for the first discharge and 973 ft for the second.

6.2.6 A-Level Hydraulic Output

A-level hydraulic output was produced for the first flow profile (time step) of Example Problem 2. This output, shown in Table 6-2b, is quite similar to that of Example Problem 1. Note that the water surface elevation at Section No. 33.0 of 966 ft reflects the elevation specified on the R record.

A-level hydraulic output is a subset of B-level hydraulic output. It can, therefore, be seen that at time step 2, the 974 ft minimum pool elevation for Section No. 35.0 (as specified on the X5 record) was submerged by tailwater and, therefore, a head loss of 0.5 ft was added to the tailwater elevation of 978.675 ft resulting in a computed water surface elevation of 979.175 ft.

The large discharge for time step 2 produced a sufficiently high water surface profile that the flow at Sections 33.0 and 44.0 is bounded by the conveyance limits. This can be seen in the column labeled "TOP WIDTH" where the values are 250 ft and 350 ft respectively for these cross sections.

6.2.7 B-Level Hydraulic Output

B-level hydraulic output was produced for the second flow profile of Example Problem 2. This output is more detailed than the A-level output produced by the first profile. It may be used to check the effective geometry of each cross section as well as the computed value of most of the hydraulic parameters used in the backwater calculations. For example, to check the operation of the *n* vs. elevation function at Section No. 15.0, refer to the table "REACH PROPERTIES BY STRIP". The *n* values used for the left overbank, channel, and right overbank are 0.0963, 0.0512, and 0.1046, respectively. These are interpolated from the input NV table for a computed water surface elevation of 973.158 ft. Also, note that the GR data shown for Section No. 15.0 reflect the X3 encroachment. Elevations on the left side are kept above 961 ft to station 10,700. The same is seen on the right side as elevations are kept at 970 ft after station 11,000 until the original ground line is encountered.

Table 6-2b
Example Problem 2
Hydraulic Output

```
***************************************************     **********************************
*  SCOUR AND DEPOSITION IN RIVERS AND RESERVOIRS  *     *  U.S. ARMY CORPS OF ENGINEERS   *
*       Version: 4.1.00 -  AUGUST 1993            *     *  HYDROLOGIC ENGINEERING CENTER  *
*  INPUT FILE:  EXAMPLE2.DAT                      *     *  609 SECOND STREET              *
*  OUTPUT FILE: EXAMPLE2.OUT                      *     *  DAVIS, CALIFORNIA 95616-4687   *
*  RUN DATE: 30 AUG 93    RUN TIME: 10:28:02      *     *  (916) 756-1104                 *
***************************************************     **********************************

                       X     X  XXXXXXX   XXXXX           XXXXX
                       X     X  X        X     X         X     X
                       X     X  X        X               X
                       XXXXXXX  XXXX     X        XXXXX  XXXXXX
                       X     X  X        X               X     X
                       X     X  X        X     X         X     X
                       X     X  XXXXXXX   XXXXX           XXXXX

         **********************************************************************
         *  MAXIMUM LIMITS FOR THIS VERSION ARE:                              *
         *       10  Stream Segments (Main Stem + Tributaries)                *
         *      150  Cross Sections                                           *
         *      100  Elevation/Station Points per Cross Section               *
         *       20  Grain Sizes                                              *
         *       10  Control Points                                           *
         **********************************************************************

T1      EXAMPLE PROBLEM NO 2.  HYDRAULIC AND GEOMETRIC OPTIONS.
T2      3 LOCAL INFLOWS, USE OF R RECORDS.
T3      SOUTH FORK, ZUMBRO RIVER     ** Example Problem 2 **

N values...  Left   Channel   Right    Contraction    Expansion
           0.1000   0.0400   0.1000       1.1000     0.7000

SECTION NO.     1.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.
```

```
N-Values vs. Elevation Table
       Channel           Left Overbank        Right Overbank
  0.0450     966.      0.0800     966.      0.1000     966.
  0.0640     989.      0.1300     989.      0.1100     982.
  0.0000       0.      0.0000       0.      0.1200     989.

SECTION NO.    15.000
...Left Encroachment defined at station 10700.000 at elevation   961.000
...Right Encroachment defined at station 11000.000 at elevation   970.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

LOCAL INFLOW POINT  1 occurs upstream from Section No.      15.000

N values...  Left   Channel   Right    Contraction    Expansion
           0.1000   0.0500   0.1000       1.1000     0.7000

SECTION NO.    32.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    32.100
...Ineffective Flow Area - Method 1 - Left Overbank  Right Overbank
          Natural Levees at Station      10057.000      10271.000
              Ineffective Elevation        978.500        978.500
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    33.000
...Internal Boundary Condition
   Water Surface Elevation will be read from R-RECORD, Field  2
   Head Loss =    0.000
...Limit CONVEYANCE to  250.000 ft. centered about midpoint of channel.
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    33.300
...Adjust Section WIDTH to  95.00% of original.
...Adjust Section ELEVATIONS by    1.490 ft.
...Limit CONVEYANCE to  250.000 ft. centered about midpoint of channel.
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    33.900
...Adjust Section WIDTH to  95.00% of original.
...Adjust Section ELEVATIONS by    1.650 ft.
...Ineffective Flow Area - Method 1 - Left Overbank  Right Overbank
          Natural Levees at Station       1757.500       2042.500
              Ineffective Elevation        986.060        986.150
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    35.000
...Internal Boundary Condition
   Water Surface Elevation =  974.000
   Head Loss =    0.500
...Ineffective Flow Area - Method 1 - Left Overbank  Right Overbank
          Natural Levees at Station       9894.000      10245.000
              Ineffective Elevation        984.700        984.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

N values...  Left   Channel   Right    Contraction    Expansion
           0.0600   0.0450   0.0600       1.1000     0.7000

SECTION NO.    42.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

LOCAL INFLOW POINT  2 occurs upstream from Section No.      42.000

SECTION NO.    44.000
...Limit CONVEYANCE between stations    9850.000 and   10200.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    53.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

LOCAL INFLOW POINT  3 occurs upstream from Section No.      53.000

SECTION NO.    55.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    58.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

NO. OF CROSS SECTIONS IN STREAM SEGMENT= 13
NO. OF INPUT DATA MESSAGES =   0

TOTAL NO. OF CROSS SECTIONS IN THE NETWORK =  13
TOTAL NO. OF STREAM SEGMENTS IN THE NETWORK=   1
END OF GEOMETRIC DATA

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$HYD
FIXED-BED MODEL

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TIME STEP #       1
Q   A   PROFILE 1 = AVERAGE ANNUAL DISCHARGE

EXAMPLE PROBLEM NO 2.  HYDRAULIC AND GEOMETRIC OPTIONS.
ACCUMULATED TIME (yrs)..........      0.000

--- Downstream Boundary Condition Data for STREAM SEGMENT NO.  1 at Control Point #  1 ---
                            DISCHARGE   TEMPERATURE  WATER SURFACE
                              (cfs)      (deg F)       (ft)
                             1250.000       60.00       960.000

****  DISCHARGE    WATER    ENERGY  VELOCITY   ALPHA     TOP      AVG       AVG VEL (by subsection)
        (CFS)     SURFACE    LINE     HEAD              WIDTH     BED        1       2       3

SECTION NO.      1.000
****   1250.000   960.000   960.008   0.008    1.266   412.262   951.520   0.120   0.731   0.075
                                                FLOW DISTRIBUTION (%) =    0.589  98.210   1.201
SECTION NO.     15.000
****   1250.000   960.343   960.518   0.174    1.000   143.121   957.736   0.000   3.350   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  1 is upstream of Section No.      15.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)      (deg F)
            Local Inflow:      150.000       60.00
                   Total:     1100.000       60.00

SECTION NO.     32.000
****   1100.000   964.111   964.151   0.041    1.000   133.277   959.020   0.000   1.621   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     32.100
****   1100.000   965.009   965.038   0.029    1.000   138.576   959.202   0.000   1.367   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     33.000
...Internal Boundary Condition - Water Surface =    966.000
                                     Head Loss =      0.000
****   1100.000   966.000   966.016   0.016    1.000   228.689   961.331   0.000   1.030   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     33.300
****   1100.000   966.410   966.441   0.031    1.000   210.966   962.711   0.000   1.410   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     33.900
****   1100.000   966.792   966.820   0.027    1.000   212.251   962.893   0.000   1.329   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     35.000
...Internal Boundary Condition - Water Surface =    974.000
                                     Head Loss =      0.500
****   1100.000   974.000   974.008   0.008    1.000   221.700   967.056   0.000   0.715   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     42.000
****   1100.000   974.356   974.371   0.016    1.000   242.451   969.819   0.000   1.000   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  2 is upstream of Section No.      42.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)      (deg F)
            Local Inflow:       78.000       60.00
                   Total:     1022.000       60.00

SECTION NO.     44.000
****   1022.000   974.697   974.707   0.010    1.000   264.095   969.892   0.000   0.805   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     53.000
****   1022.000   975.359   975.884   0.525    1.000    79.436   973.146   0.000   5.813   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  3 is upstream of Section No.      53.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)      (deg F)
            Local Inflow:      340.000       60.00
                   Total:      682.000       60.00

SECTION NO.     55.000
****    682.000   978.831   978.872   0.042    1.000   100.844   974.694   0.000   1.635   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     58.000
****    682.000   979.918   980.119   0.201    1.000    56.248   976.547   0.000   3.596   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

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TIME STEP #       2
Q   BB  PROFILE 2 = FLOOD EVENT  (0.5% CHANCE FLOOD)

EXAMPLE PROBLEM NO 2.  HYDRAULIC AND GEOMETRIC OPTIONS.
ACCUMULATED TIME (yrs)..........      0.014

--- Downstream Boundary Condition Data for STREAM SEGMENT NO.  1 at Control Point #  1 ---
                            DISCHARGE   TEMPERATURE  WATER SURFACE
                              (cfs)      (deg F)       (ft)
                            10000.000       60.00       973.000
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****  DISCHARGE    WATER    ENERGY  VELOCITY   ALPHA     TOP      AVG       AVG VEL (by subsection)
        (CFS)     SURFACE    LINE     HEAD              WIDTH     BED        1       2       3

SECTION NO.      1.000

 Cross Section Geometry (STA,ELEV)
   9915.000  1004.000  10002.000   978.400  10060.000   956.000  10077.000   959.200  10081.000   959.300
  10092.000   950.000  10108.000   948.480  10138.000   946.600  10158.000   944.700  10225.000   955.200
  10243.000   956.200  10250.000   958.900  10275.000   959.800  10300.000   959.800  10325.000   959.900
  10350.000   958.800  10400.000   957.400  10700.000   970.000  10960.000   966.000  11060.000   970.000
  11085.000   968.000  11240.000   968.000  11365.000   970.000  11500.000   970.000  11615.000   970.000
  11665.000   962.000  12400.000   962.000  12550.000   976.000  12670.000   980.000  12730.000   982.000
  12735.000   984.000

****  10000.000   973.000   973.013   0.013    4.272  2501.875   951.520   0.301   1.243   0.258
                                                FLOW DISTRIBUTION (%) =    1.914  52.875  45.211

     REACH PROPERTIES BY STRIP          1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE    43459.641 1200769.591 1026719.286
                          AREA       635.95     4252.96    17543.21
                    HYD RADIUS       9.8620     20.9515      7.8160
  REACH...         Manning's N       0.1000      0.0400      0.1000
                       SQRT(L)       0.0000      0.0000      0.0000
  D/S SECTION...          AREA         0.00        0.00        0.00
                    HYD RADIUS        0.000       0.000       0.000

SECTION NO.     15.000

 Cross Section Geometry (STA,ELEV)
   9570.000   992.000  10110.000   982.000  10300.000   976.000  10490.000   976.000  10610.000   966.000
  10665.000   964.700  10673.000   961.000  10693.000   961.000  10699.999   961.000  10700.000   953.700
  10703.000   954.000  10723.000   955.600  10750.000   958.600  10800.000   959.300  10822.000   957.000
  10825.000   957.300  10850.000   961.500  10852.000   962.000  10970.000   964.000  11000.000   965.333
  11000.001   970.000  11015.000   970.000  11090.000   970.000  11150.000   970.000  11190.000   970.000
  11310.000   972.000  11410.000   980.000  11570.000   984.000  11770.000   990.000  11865.000   990.000
  12150.000  1000.000

****  10000.000   973.158   973.259   0.102    2.191   800.329   958.554   0.795   2.878   0.700
                                                FLOW DISTRIBUTION (%) =    5.853  77.741  16.406

     REACH PROPERTIES BY STRIP          1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE    34197.889  454198.571   95851.669
                          AREA       736.62     2701.62     2342.75
                    HYD RADIUS       5.2173     13.9368      4.8880
  REACH...         Manning's N       0.0963      0.0512      0.1046
                       SQRT(L)      59.6657     57.2713     55.0454
  D/S SECTION...          AREA       635.95     4252.96    17543.21
                    HYD RADIUS        9.862      20.951       7.816


--- LOCAL INFLOW POINT #  1 is upstream of Section No.      15.000 ---
                              DISCHARGE   TEMPERATURE
                                (cfs)       (deg F)
            Local Inflow:     1200.000       60.00
                   Total:     8800.000       60.00

SECTION NO.     32.000

 Cross Section Geometry (STA,ELEV)
   9080.000   998.000   9250.000   982.000   9510.000   982.000   9600.000   980.000   9925.000   980.010
  10000.000   979.480  10057.000   978.500  10075.000   968.600  10087.000   959.820  10097.000   956.500
  10117.000   956.800  10137.000   957.800  10157.000   959.400  10177.000   959.600  10196.000   959.820
  10225.000   966.500  10250.000   971.200  10271.000   978.500  10300.000   978.500  10350.000   978.600
  10370.000   978.910  10387.000   978.960  10610.000   980.000  10745.000   982.000  11145.000   982.000
  11150.000   984.000  11240.000   992.000  11330.000  1000.000  11425.000  1008.000

****   8800.000   974.581   974.786   0.205    1.000   195.704   962.193   0.000   3.630   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

     REACH PROPERTIES BY STRIP          1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE        0.000  377076.318       0.000
                          AREA         0.00     2424.45        0.00
                    HYD RADIUS       0.0000     11.9716      0.0000
  REACH...         Manning's N       0.1000      0.0500      0.1000
                       SQRT(L)      60.2495     65.1153     55.3173
  D/S SECTION...          AREA       736.62     2701.62     2342.75
                    HYD RADIUS        5.217      13.937       4.888

SECTION NO.     32.100

 Cross Section Geometry (STA,ELEV)
   9080.000   998.000   9250.000   982.000   9510.000   982.000   9600.000   980.000   9925.000   980.010
  10000.000   979.480  10057.000   978.500  10075.000   968.600  10087.000   959.820  10097.000   956.500
  10117.000   956.800  10137.000   957.800  10157.000   959.400  10177.000   959.600  10196.000   959.820
  10225.000   966.500  10250.000   971.200  10271.000   978.500  10300.000   978.500  10350.000   978.600
  10370.000   978.910  10387.000   978.960  10610.000   980.000  10745.000   982.000  11145.000   982.000
  11150.000   984.000  11240.000   992.000  11330.000  1000.000  11425.000  1008.000

****   8800.000   976.143   976.304   0.161    1.000   202.931   962.684   0.000   3.222   0.000
                                                FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
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     REACH PROPERTIES BY STRIP        1          2          3
                INEFF FLOW  EL     978.500  -99999.000    978.500
  U/S SECTION...    CONVEYANCE       0.000  448358.998      0.000
                          AREA        0.00    2731.27        0.00
                    HYD RADIUS      0.0000    12.9813      0.0000
  REACH...         Manning's N      0.1000     0.0500      0.1000
                       SQRT(L)     55.9464    57.6194     57.0088
  D/S SECTION...          AREA        0.00    2424.45        0.00
                    HYD RADIUS       0.000     11.972       0.000

SECTION NO.     33.000
...Internal Boundary Condition - Water Surface =    978.000
                                     Head Loss =      0.000

 Cross Section Geometry (STA,ELEV)
    980.000  1000.000    1060.000   990.000    1150.000   980.000    1180.000   982.000    1215.000   982.000
   1260.000   980.000    1300.000   982.000    1350.000   982.000    1420.000   980.000    1540.000   980.000
   1730.000   982.000    1830.000   982.000    1850.000   984.410    1851.000   979.190    1875.000   970.424
   1900.800   961.000    2099.200   961.000    2125.000   968.771    2149.000   976.000    2150.000   984.500
   2800.000   982.000    3100.000   990.000    3170.000  1000.000

****   8800.000   978.000   978.074   0.074    1.000   250.000   961.887   0.000   2.185   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

     REACH PROPERTIES BY STRIP        1          2          3
                INEFF FLOW  EL  -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE       0.000  758052.954      0.000
                          AREA        0.00    4028.19        0.00
                    HYD RADIUS      0.0000    15.9335      0.0000
  REACH...         Manning's N      0.1000     0.0500      0.1000
                       SQRT(L)      0.0000     0.0000      0.0000
  D/S SECTION...          AREA        0.00    2731.27        0.00
                    HYD RADIUS       0.000     12.981       0.000

SECTION NO.     33.300

 Cross Section Geometry (STA,ELEV)
    931.000  1001.490    1007.000   991.490    1092.500   981.490    1121.000   983.490    1154.250   983.490
   1197.000   981.490    1235.000   983.490    1282.500   983.490    1349.000   981.490    1463.000   981.490
   1643.500   983.490    1738.500   983.490    1757.500   985.900    1758.450   980.680    1781.250   971.914
   1805.760   962.490    1994.240   962.490    2018.750   970.261    2041.550   977.490    2042.500   985.990
   2660.000   983.490    2945.000   991.490    3011.500  1001.490

****   8800.000   978.266   978.363   0.096    1.000   237.500   963.377   0.000   2.488   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

     REACH PROPERTIES BY STRIP        1          2          3
                INEFF FLOW  EL  -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE       0.000  630880.219      0.000
                          AREA        0.00    3536.31        0.00
                    HYD RADIUS      0.0000    14.7069      0.0000
  REACH...         Manning's N      0.1000     0.0500      0.1000
                       SQRT(L)     39.3700    41.8330     41.8330
  D/S SECTION...          AREA        0.00    4028.19        0.00
                    HYD RADIUS       0.000     15.934       0.000

SECTION NO.     33.900

 Cross Section Geometry (STA,ELEV)
    931.000  1001.650    1007.000   991.650    1092.500   981.650    1121.000   983.650    1154.250   983.650
   1197.000   981.650    1235.000   983.650    1282.500   983.650    1349.000   981.650    1463.000   981.650
   1643.500   983.650    1738.500   983.650    1757.500   986.060    1758.450   980.840    1805.760   962.650
   1994.240   962.650    2041.550   977.650    2042.500   986.150    2660.000   983.650    2945.000   991.650
   3011.500  1001.650

****   8800.000   978.486   978.574   0.088    1.000   277.066   965.114   0.000   2.375   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

     REACH PROPERTIES BY STRIP        1          2          3
                INEFF FLOW  EL     986.060  -99999.000    986.150
  U/S SECTION...    CONVEYANCE       0.000  611504.940      0.000
                          AREA        0.00    3704.84        0.00
                    HYD RADIUS      0.0000    13.0880      0.0000
  REACH...         Manning's N      0.1000     0.0500      0.1000
                       SQRT(L)     32.4037    32.4037     32.4037
  D/S SECTION...          AREA        0.00    3536.31        0.00
                    HYD RADIUS       0.000     14.707       0.000

SECTION NO.     35.000
...Internal Boundary Condition - Water Surface =    974.000
                                     Head Loss =      0.500

 Cross Section Geometry (STA,ELEV)
   9035.000   984.000    9070.000   980.000    9135.000   978.000    9185.000   980.000    9270.000   982.000
   9465.000   980.000    9595.000   981.700    9745.000   983.700    9894.000   984.700    9894.100   963.400
   9954.000   963.300    9974.000   967.100   10004.000   967.400   10044.000   968.200   10054.000   967.600
  10115.000   973.400   10120.000   977.400   10155.000   983.700   10245.000   984.000   10695.000   982.000
  10895.000   982.000   11085.000  1004.000

****   8800.000   978.986   979.155   0.169    1.000   234.784   967.632   0.000   3.301   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

     REACH PROPERTIES BY STRIP        1          2          3
                INEFF FLOW  EL     984.700  -99999.000    984.000
  U/S SECTION...    CONVEYANCE       0.000  381293.994      0.000
                          AREA        0.00    2665.83        0.00
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                  HYD RADIUS       0.0000     10.5576      0.0000
  REACH...       Manning's N       0.1000      0.0500      0.1000
                      SQRT(L)      0.0000      0.0000      0.0000
  D/S SECTION...        AREA         0.00     3704.84        0.00
                  HYD RADIUS        0.000      13.088       0.000

SECTION NO.     42.000

 Cross Section Geometry (STA,ELEV)
   7130.000  996.000   7310.000  998.000   7930.000  998.000   8205.000  992.000   8495.000  990.000
   8780.000  988.000   8990.000  986.000   9570.000  985.700   9707.000  986.450   9857.000  989.440
   9880.000  990.000   9881.000  969.800   9941.000  969.800   9941.000  985.800   9943.000  985.800
   9943.000  969.800  10001.000  969.800  10001.000  986.700  10003.000  986.700  10003.000  969.800
  10067.000  969.800  10067.000  985.800  10069.000  985.800  10069.000  969.800  10129.000  969.800
  10130.000  989.900  10180.000  989.500  10230.000  988.600  10280.000  987.600  10430.000  985.200
  11720.000  986.800  12310.000  989.900

****   8800.000   981.452   981.603   0.151    1.000   243.155   969.845   0.000   3.118   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

     REACH PROPERTIES BY STRIP          1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE        0.000  385783.789       0.000
                        AREA         0.00     2822.24        0.00
                  HYD RADIUS       0.0000      8.4220      0.0000
  REACH...       Manning's N       0.0600      0.0450      0.0600
                      SQRT(L)     73.2803     72.1803     70.7107
  D/S SECTION...        AREA         0.00     2665.83        0.00
                  HYD RADIUS        0.000      10.558       0.000


--- LOCAL INFLOW POINT #  2 is upstream of Section No.      42.000 ---
                              DISCHARGE   TEMPERATURE
                                (cfs)      (deg F)
            Local Inflow:       600.000       60.00
                   Total:      8200.000       60.00

SECTION NO.     44.000

 Cross Section Geometry (STA,ELEV)
   8035.000 1002.000   8150.000  992.000   8305.000  990.000   8735.000  990.000   8835.000  988.000
   9285.000  996.000   9425.000 1017.600   9505.000  990.000   9650.000  986.000   9788.000  984.100
   9845.000  980.600   9850.000  978.491   9868.000  970.900   9898.000  972.200   9968.000  970.500
   9998.000  967.500  10028.000  968.900  10058.000  967.400  10078.000  967.100  10118.000  971.900
  10127.000  976.800  10150.000  977.800  10193.000  976.900  10200.000  979.646  10206.000  982.000
  10300.000  981.200  10325.000  979.200  10400.000  983.100  10450.000  999.800  10464.000 1002.400

****   8200.000   982.491   982.571   0.079    1.085   350.000   970.182   0.000   2.301   0.958
                                                 FLOW DISTRIBUTION (%) =    0.000  95.679   4.321

     REACH PROPERTIES BY STRIP          1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE        0.000  595477.263   26895.576
                        AREA         0.00     3409.65      369.93
                  HYD RADIUS       0.0000     12.1625      5.0296
  REACH...       Manning's N       0.0600      0.0450      0.0600
                      SQRT(L)     56.5685     59.1608     61.6441
  D/S SECTION...        AREA         0.00     2822.24        0.00
                  HYD RADIUS        0.000       8.422       0.000

SECTION NO.     53.000

 Cross Section Geometry (STA,ELEV)
   7550.000 1004.000   7760.000 1000.000   8440.000  998.000   8640.000  996.000   8780.000  996.000
   8940.000  994.000   9245.000  986.000   9555.000  986.300   9825.000  986.300   9900.000  983.800
  10000.000  982.800  10011.000  978.200  10041.000  974.000  10071.000  972.200  10101.000  972.600
  10121.000  978.200  10136.000  988.700  10154.000  989.300  10200.000  999.200  10320.000 1000.100
  10470.000 1002.000  10700.000 1004.000

****   8200.000   983.479   984.372   0.893    1.037   196.098   975.086   0.681   7.586   0.000
                                                 FLOW DISTRIBUTION (%) =    0.190  99.810   0.000

     REACH PROPERTIES BY STRIP          1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE      274.155  144394.365       0.000
                        AREA        22.82     1078.93        0.00
                  HYD RADIUS       0.3378      8.1588      0.0000
  REACH...       Manning's N       0.0600      0.0450      0.0600
                      SQRT(L)     58.0172     54.2402     53.2165
  D/S SECTION...        AREA         0.00     3409.65      369.93
                  HYD RADIUS        0.000      12.163       5.030


--- LOCAL INFLOW POINT #  3 is upstream of Section No.      53.000 ---
                              DISCHARGE   TEMPERATURE
                                (cfs)      (deg F)
            Local Inflow:      2600.000       60.00
                   Total:      5600.000       60.00

SECTION NO.     55.000

 Cross Section Geometry (STA,ELEV)
   7592.000 1004.000   7947.000 1000.000   8627.000  996.000   9052.000  990.000   9337.000  986.000
   9737.000  984.300   9837.000  984.700   9910.000  985.500   9931.000  987.200   9955.000  978.100
   9975.000  974.800  10005.000  974.200  10035.000  972.900  10045.000  973.200  10062.000  983.800
  10187.000  985.800  10307.000  986.000  10497.000  990.000
```

```
****   5600.000   986.704   986.858   0.155    2.280  1047.266   976.369   0.750   3.454   0.649
                                                FLOW DISTRIBUTION (%) =   13.274  82.684   4.042

     REACH PROPERTIES BY STRIP         1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE    32889.590  204875.028   10016.492
                          AREA       990.96     1340.52      348.55
                    HYD RADIUS       1.5513      9.9567      1.2499
  REACH...         Manning's N       0.0600      0.0450      0.0600
                       SQRT(L)      47.6970     52.6308     58.5662
  D/S SECTION...          AREA        22.82     1078.93        0.00
                    HYD RADIUS        0.338       8.159       0.000

SECTION NO.     58.000

 Cross Section Geometry (STA,ELEV)
   8542.000  1006.000    8952.000  1004.000    9702.000  1000.000    9812.000   997.200    9912.000   996.300
   9944.000   976.200    9974.000   975.400    9991.000   978.200   10015.000   990.400   10062.000   988.300
  10065.000   988.800   10065.000   988.300   10169.000   989.300   10172.000   990.000   10242.000   992.000
  10492.000   992.000   10642.000   988.000   10852.000   986.700   11022.000   988.000   11097.000   986.000
  11137.000   986.000   11192.000   988.000

****   5600.000   987.850   988.551   0.701    1.806   576.704   978.997   0.000   6.959   1.060
                                                FLOW DISTRIBUTION (%) =    0.000  92.947   7.053

     REACH PROPERTIES BY STRIP         1           2           3
                INEFF FLOW  EL   -99999.000  -99999.000  -99999.000
  U/S SECTION...    CONVEYANCE        0.000  101054.470    7668.432
                          AREA         0.00      747.99      372.73
                    HYD RADIUS       0.0000      8.2752      0.7571
  REACH...         Manning's N       0.0600      0.0450      0.0600
                       SQRT(L)      33.1361     38.2361     31.8119
  D/S SECTION...          AREA       990.96     1340.52      348.55
                    HYD RADIUS        1.551       9.957       1.250


------------------------------------------------------------------------------------------
$$END

       0   DATA ERRORS DETECTED.

TOTAL NO. OF TIME STEPS READ =         2
TOTAL NO. OF WS PROFILES =             2
ITERATIONS IN EXNER EQ =               0

COMPUTATIONS COMPLETED
RUN TIME =  0 HOURS,  0 MINUTES &  1.00 SECONDS
```

6.3 Example Problem 3 - Movable Bed

The following example demonstrates how to add sediment data to the previously developed file. Existence of sediment data within the input file causes HEC-6 to compute sediment transport rates and modify the cross section geometry as described in Section 2.3. Sediment related data consists of the delineation of the movable bed, characteristics and gradation of sediment within the bed, and inflowing/outflowing sediment loads and gradations. The sediment data is inserted between the EJ record of the geometry data and the $HYD record of the flow data. Table 6-3a shows the input data developed for Example Problem 3.

6.3.1 Movable Bed Limits

Information delineating the movable bed have been added to the HD record of each cross section. For example, at Section No. 1.0, the movable bed limits have been defined at stations 10,081 and 10,250. The "fixed" GR points are those outside of the movable bed stations; that is, should a limit of the movable bed coincide with a GR point, that point is movable and the next point outward is fixed.

The vertical limit (initial depth) of the movable portion of the cross section must also be defined. Data describing the location of this bedrock is entered in Field 2 of the HD record for each cross section. In Example Problem 3, it was determined that the reach represented by Section No. 58.0 had bedrock 3.4 ft below the thalweg. Section No. 33.0 through Section No. 42.1 have either concrete or bedrock at the thalweg.

6.3.2 Sediment Title Records

Five title records (T4-T8) are required at the beginning of the sediment data; these records are available for user documentation of the sediment data.

6.3.3 Sediment Transport Control Parameters

Parameters governing the computation of sediment transport rates and selection of grain sizes are entered on the I records. For Example Problem 3, the number of times that the bed material gradation is to be re-calculated within a time step is set to 5 on the I1 record (see Section 2.3.1.4). Default values for the other parameters on this record will be used. Only sands and gravels are analyzed in Example Problem 3. Since there are no clays or silts in either the bed or the inflowing load, there are no I2 or I3 records. Ten sand and gravel sizes are being analyzed as seen by the 1 in Field 3 and 10 in Field 4 of the I4 record. The transport computation method chosen is that of Yang (4 in Field 2 of the I4 record). Default values for the other parameters were selected, by not providing data. It is important to remember that the range of grain sizes selected on the I records must encompass the entire range of sizes found in both the bed material and inflowing load, even though some of those sizes may be missing in either the bed or inflowing materials.

The "most stable" weighting scheme for the hydraulic parameters has been selected via the I5 record (see Section 2.2.4).

6.3.4 Inflowing Sediment Loads

The inflowing sediment load at the upstream end of the main river is described with a table of sediment load vs. water discharge by grain size. This table is entered using LQ, LT, and LF records. The LQ record contains the water discharges and the LT record contains the corresponding total inflowing sediment loads. The entire range of discharges in the hydrograph being simulated must be spanned by these data. For Example Problem 3, the range of water discharges in the load table is from 1 to 90,000 cfs and the related inflowing sediment loads vary from 0.011 to 400,000 tons/day. The distribution of grain sizes is described by the LF records which contain the fraction of the total load comprised of any particular grain size. These data are entered from fine to coarse and must correspond to the size ranges selected with the I2 to I4 data.

There are three local inflows of water and sediment in this problem; their locations are defined by the QT records in the geometric data. The tables of sediment load vs. local inflow are on LQL, LTL, and LFL records, analogous to the main river inflowing load data. The local flow load tables are entered in the same sequence as the geometric data; that is, downstream to upstream.

Table 6-3a
Example Problem 3 - Input
Movable Bed

```
T1      EXAMPLE PROBLEM NO 3.  MOVABLE BED
T2      3 LOCAL INFLOWS
T3      SOUTH FORK, ZUMBRO RIVER     ** Example Problem 3 **
NC    .1      .1     .04      .1      .3
X1   1.0      31  10077.  10275.      0.      0.      0.
GR 1004.   9915.   978.4  10002.   956.0  10060.  959.20  10077.   959.3  10081.
GR 950.0  10092.  948.48  10108.   946.6  10138.  944.70  10158.   955.2  10225.
GR 956.2  10243.   958.9  10250.   959.8  10275.  959.80  10300.   959.9  10325.
GR 958.8  10350.   957.4  10400.   970.0  10700.  966.00  10960.   970.0  11060.
GR 968.0  11085.   968.0  11240.   970.0  11365.  970.00  11500.   970.0  11615.
GR 962.0  11665.   962.0  12400.   976.0  12550.  980.00  12670.   982.0  12730.
GR 984.0  12735.
HD   1.0     10. 10081.0  10250.
NV    22    .045   965.6    .064   988.8
NV    12     .08   965.6     .13   988.8
NV    33      .1   965.6     .11   982.0     .12   988.8
X1  15.0      27 10665.0  10850.   3560.   3030.   3280.
X3                        10700.   961.0  11000.   970.0
GR 992.0   9570.   982.0  10110.   976.0  10300.  976.00  10490.   966.0  10610.
GR 964.7  10665.   956.0  10673.   953.0  10693.  954.00  10703.   955.6  10723.
GR 958.6  10750.   959.3  10800.   957.0  10822.  957.30  10825.   961.5  10850.
GR 962.0  10852.   964.0  10970.   966.0  11015.  961.00  11090.   962.0  11150.
GR 970.0  11190.   972.0  11310.   980.0  11410.  984.00  11570.   990.0  11770.
GR 990.0  11865.  1000.0  12150.
HD  15.0     10. 10673.0  10852.
   Cascade Creek - local inflow
QT
NC    .1      .1     .05
X1  32.0      29 10057.0  10271.   3630.   3060.   4240.
GR 998.0   9080.   982.0   9250.   982.0   9510.  980.00   9600.  980.01   9925.
GR979.48  10000.   978.5  10057.   968.6  10075.  959.82  10087.   956.5  10097.
GR 956.8  10117.   957.8  10137.   959.4  10157.  959.60  10177.  959.82  10196.
GR 966.5  10225.   971.2  10250.   978.5  10271.  978.50  10300.   978.6  10350.
GR978.91  10370.  978.96  10387.   980.0  10610.  982.00  10745.   982.0  11145.
GR 984.0  11150.   992.0  11240.  1000.0  11330.  1008.0  11425.
HD  32.0     10.  10075.  10275.
  Section 32.1 is a duplicate of Sec 32.0, needed to model IBC at Sec 33.0
X1  32.1      29 10057.0  10271.   3130.   3250.   3320.
X3    10
GR 998.0   9080.   982.0   9250.   982.0   9510.  980.00   9600.  980.01   9925.
GR979.48  10000.   978.5  10057.   968.6  10075.  959.82  10087.   956.5  10097.
GR 956.8  10117.   957.8  10137.   959.4  10157.  959.60  10177.  959.82  10196.
GR 966.5  10225.   971.2  10250.   978.5  10271.  978.50  10300.   978.6  10350.
GR978.91  10370.  978.96  10387.   980.0  10610.  982.00  10745.   982.0  11145.
GR 984.0  11150.   992.0  11240.  1000.0  11330.  1008.0  11425.
HD  32.1     10.  10075.  10275.
  A spillway is located here.
X1  33.0      21   1850.   2150.       0       0       0
X5                             2
XL                  250.
```

```
GR 1000.    980.   990.0   1060.   980.0   1150.  982.00   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.  980.00   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.  982.00   2800.   990.0   3100.
GR 1000.   3170.
HD  33.0      0.   1851.   2149.
   NOTE:      Section 33.3 is a duplicate of Section  33.0.
   Section 33.0 is a good representative cross section for a long reach.  A
   duplicate is used here to break up the long reach into two smaller reaches.
X1  33.3      21   1850.   2150.   1550.   1750.    1750     .95    1.49
XL                  250.
GR 1000.    980.   990.0   1060.   980.0   1150.  982.00   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.  980.00   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.  982.00   2800.   990.0   3100.
GR 1000.   3170.
HD  33.3      0.   1851.   2149.
  Section 33.9 is a duplicate of Sec 33.3, needed to model IBC at Sec 35.0
X1  33.9      21   1850.   2150.   1050.   1050.   1050.     .95    1.65
X3    10
GR 1000.    980.   990.0   1060.   980.0   1150.  982.00   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.  980.00   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.  982.00   2800.   990.0   3100.
GR 1000.   3170.
HD  33.9      0.   1851.   2149.
  A weir is located here.
X1  35.0      22   9894.  10245.       0       0       0
X3    10
X5          974.     0.5
GR 984.0   9035.   980.0   9070.   978.0   9135.  980.00   9185.   982.0   9270.
GR 980.0   9465.   981.7   9595.   983.7   9745.  984.70   9894.   963.4  9894.1
GR 963.3   9954.   967.1   9974.   967.4  10004.  968.20  10044.   967.6  10054.
GR 973.4  10115.   977.4  10120.   983.7  10155.  984.00  10245.   982.0  10695.
GR 982.0  10895.  1004.0  11085.
HD  35.0      0.   9954.  10155.
   - - -  Silver Lake  - - -
NC   .06     .06    .045
X1  42.0      32   9880.  10130.   5370.   5000.   5210.
GR 996.0   7130.   998.0   7310.   998.0   7930.  992.00   8205.   990.0   8495.
GR 988.0   8780.   986.0   8990.   985.7   9570.  986.45   9707.  989.44   9857.
GR 990.0   9880.   969.8   9881.   969.8   9941.  985.80   9941.   985.8   9943.
GR 969.8   9943.   969.8  10001.   986.7  10001.  986.70  10003.   969.8  10003.
GR 969.8  10067.   985.8  10067.   985.8  10069.  969.80  10069.   969.8  10129.
GR 989.9  10130.   989.5  10180.   988.6  10230.  987.60  10280.   985.2  10430.
GR 986.8  11720.   989.9  12310.
HD  42.0      0.   9881.  10021.
   Silver Creek - local inflow
QT
X1  44.0      28   9845.  10127.   3200.   3800.   3500.
XL                         9850.  10200.
GR 1002.   8035.   992.0   8150.   990.0   8305.  990.00   8735.   988.0   8835.
GR 996.0   9285.  1017.6   9425.   990.0   9505.  986.00   9650.   984.1   9788.
GR 980.6   9845.   970.9   9868.   972.2   9898.  970.50   9968.   967.5   9998.
GR 968.9  10028.   967.4  10058.   967.1  10078.  971.90  10118.   976.8  10127.
GR 977.8  10150.   976.9  10193.   982.0  10206.  981.20  10300.   979.2  10325.
GR 983.1  10400.   999.8  10450.  1002.4  10464.
HD  44.0      1.   9868.  10193.
X1  53.0      22  10000.  10136.   3366.   2832.   2942.
GR 1004.   7550.  1000.0   7760.   998.0   8440.  996.00   8640.   996.0   8780.
GR 994.0   8940.   986.0   9245.   986.3   9555.  986.30   9825.   983.8   9900.
GR 982.8  10000.   978.2  10011.   974.0  10041.  972.20  10071.   972.6  10101.
GR 978.2  10121.   988.7  10136.   989.3  10154.  999.20  10200.  1000.1  10320.
GR 1002.  10470.  1004.0  10700.
HD  53.0     10.  10000.  10136.
   Bear Creek - local inflow
QT
X1  55.0      18   9931.  10062.   2275.   3430.   2770.
GR 1004.   7592.  1000.0   7947.   996.0   8627.  990.00   9052.   986.0   9337.
GR 984.3   9737.   984.7   9837.   985.5   9910.  987.20   9931.   978.1   9955.
GR 974.8   9975.   974.2  10005.   972.9  10035.  973.20  10045.   983.8  10062.
GR 985.8  10187.   986.0  10307.   990.0  10497.
HD  55.0     10.   9931.  10062.
X1  58.0      22   9912.  10015.   1098.   1012.   1462.
GR 1006.   8542.  1004.0   8952.  1000.0   9702.  997.20   9812.   996.3   9912.
GR 976.2   9944.   975.4   9974.   978.2   9991.  990.40  10015.   988.3  10062.
GR 988.8  10065.   988.3  10065.   989.3  10169.  990.00  10172.   992.0  10242.
GR 992.0  10492.   988.0  10642.   986.7  10852.  988.00  11022.   986.0  11097.
GR 986.0  11137.   988.0  11192.
HD  58.0     3.4   9912.  10015.
EJ
T4      South Fork, Zumbro River - Stream Segment 1     ** Example Problem 3 **
T5      LOAD CURVE FROM GAGE DATA.
T6      BED GRADATIONS FROM FIELD SAMPLES.
```

```
T7      Use Full Range of Sands and Gravels
T8      SEDIMENT TRANSPORT BY Yang's STREAM POWER [ref ASCE JOURNAL (YANG 1971)]
I1             5
I4  SAND       4       1      10
I5            .5      .5     .25      .5     .25       0     1.0
LQ             1      50    1000    5800   90000
LT TOTAL   .0110     1.5     320   4500.  400000
LF   VFS    .119    .119    .498    .511    .582
LF    FS    .328    .328    .331    .306    .280
LF    MS    .553    .553    .156    .154    .110
LF    CS    .000    .000    .011    .016    .020
LF   VCS    .000    .000    .004    .008    .005
LF   VFG    .000    .000    .000    .004    .002
LF    FG    .000    .000    .000    .001    .001
LF    MG    .000    .000    .000    .000    .000
LF    CG    .000    .000    .000    .000    .000
LF   VCG      .0      .0    .000    .000    .000
PF EXAMP     1.0     1.0    32.0    16.0    96.5     8.0    95.0     4.0    91.0
PFC  2.0    85.0     1.0    73.0      .5    37.0     .25     8.0    .125     1.0
PFC.0625     0.0
PF EXAMP    32.0     1.0    64.0    32.0    99.5    16.0    99.0     8.0    98.5
PFC  4.0    96.0     2.0    93.5     1.0    83.0     .50    45.5    .250     8.0
PFC .125     1.0   .0625     0.0
PF EXAMP    58.0     1.0    64.0    32.0    97.0    16.0    94.0     8.0    94.0
PFC  4.0    90.0     2.0    79.0     1.0    56.0     .50     4.0    .125     0.0
$LOCAL
  LOAD TABLE - CASCADE CREEK - A LOCAL INFLOW
LQL            1     100    1000   10000
LTLTOTAL   .0040      10     500   30000
LFL  VFS    .664    .664    .015    .198
LFL   FS    .207    .207    .245    .181
LFL   MS    .086    .086    .605    .107
LFL   CS    .031    .031    .052    .098
LFL  VCS    .008    .008    .039    .127
LFL  VFG   .0030   .0030   .0200   .1160
LFL   FG   .0010   .0010   .0110   .0910
LFL   MG   .0000   .0000   .0110   .0530
LFL   CG   .0000   .0000   .0000   .0220
LFL  VCG   .0000   .0000   .0000   .0060
  LOAD TABLE - SILVER CREEK - A LOCAL INFLOW
LQL            1     100    1000   10000
LTLTOTAL   .0040      10     500   30000
LFL  VFS    .664    .664    .015    .198
LFL   FS    .207    .207    .245    .181
LFL   MS    .086    .086    .605    .107
LFL   CS    .031    .031    .052    .098
LFL  VCS    .008    .008    .039    .127
LFL  VFG   .0030   .0030   .0200   .1160
LFL   FG   .0010   .0010   .0110   .0910
LFL   MG   .0000   .0000   .0110   .0530
LFL   CG   .0000   .0000   .0000   .0220
LFL  VCG   .0000   .0000   .0000   .0060
  LOAD TABLE - BEAR CREEK - A LOCAL INFLOW
LQL           1.    100.    500.   1000.  30000.
LTLTOTAL   .0020    30.0    500.    1200   22500
LFL  VFS    .201    .201    .078    .078    .137
LFL   FS    .342    .342    .172    .175    .218
LFL   MS    .451    .451    .454    .601    .476
LFL   CS    .001    .001    .197    .142    .158
LFL  VCS    .000    .000    .000    .003    .008
LFL  VFG   .0000   .0000   .0000   .0000   .0020
LFL   FG   .0000    .000   .0000   .0000   .0010
LFL   MG   .0000    .000   .0000   .0000   .0000
LFL   CG   .0000    .000   .0000   .0000   .0000
LFL  VCG   .0000    .000   .0000   .0000   .0000
$HYD
Q    A     FLOW 1 = BASE FLOW 0F 750 CFS
Q   750.     61.     29.    128.
R   956.    962.
T    65.     72.     70.     67.
W     2.
Q    B     FLOW 2 = 50 DAYS AT BANK FULL DISCHARGE
Q  2500.    300.    150.    650.
R   965.    970.
W    50.
$PRT
CP             1
PS          15.0    32.0    32.1
END
Q   AC     FLOW 3 = NEAR BANK FULL DISCHARGE
Q  1250.    150.     78.    340.
R   960.    966.
W     1.
$PRT   A
```

```
Q    B     FLOW 4 = BASE FLOW OF 750 CFS
Q   750.     61.     29.    128.
R   957.    963.
W     1.
$$END
```

6.3.5 Bed Material Gradation

The *initial* gradation of material in the bed sediment control volume is described with PF (percent finer) and PFC (percent finer continuation) records. In Example Problem 3, this data has only been provided at Sections 1.0, 32.0, and 58.0 as noted in Field 2 of the PF records. The selection of which, and how many, cross sections at which to provide this data depends on study objectives, field data, etc. For intermediate cross sections HEC-6 will linearly interpolate the bed material gradation. Note that the points in the gradation tables need not coincide with the size classes selected for computation. See Appendix A for specific details of these data records.

6.3.6 Flow Data

The flow data input structure is similar to that shown in the previous examples. One of the differences, however, is the selection of A-, B- and C-level output for sediment computations on the Q records. Also, the hydrologic data are extremely important to the results of a movable bed simulation. Particular care must be taken when selecting the period of record or hypothetical event to be simulated and time step sizes to be used. Water temperature may also be important in some instances. See Gee (1984) and HEC (1992) for information regarding preparation of flow data.

6.3.7 Output of Sediment Model

Table 6-3b shows the output file for Example Problem 3. The geometric data output, similar to that produced by Example Problem 2, is followed by sediment data. At this point, no hydraulic or sediment transport computations have been performed. Rather, the input data have been read and manipulated in preparation for the computations which begin when the flow data are read. The sediment title records are echoed followed by the information on the I records. Next is the inflowing sediment load table from stream segment 1; the sediment loads are in scientific notation because of the wide range of possible values. Note that a very small value is used instead of zero because log-log interpolation is used within these data tables.

The table headed "REACH GEOMETRY FOR STREAM SEGMENT 1" depicts the status of the bed sediment control volume at the beginning of the simulation, as described by the input data. Note that the movable bed widths are not necessarily the same as given in the HD data. For example, at Section No. 1.0, the movable bed limits are specified at stations 10,081 and 10,250 which coincide with existing points in the GR data, therefore, these points are part of the movable bed. The movable bed width used for computations extends halfway to the next, fixed, GR points (at stations 10,077 and 10,275).

$$\text{Movable Bed Width} \quad \frac{10275\ \ 10250}{2} \quad \frac{10081\ \ 10077}{2}$$

$$183.5\ \text{ft}$$

The table headed "BED MATERIAL GRADATION" contains the information from the PF and PFC records. That data has been converted from percent finer values to bed fractions per grain size and computed for each cross section. This table allows for checking of the interpolation at each grain size boundary as well as at each cross section.

The next section contains the load tables for the local inflows, these are similar to the table for the main river.

The last table produced by the sediment data is titled "Bed Sediment Control Volumes." The "control volume" is the volume of bed sediment used at each cross section for the sediment transport computations. Generally, this control volume is defined as the depth of the bed times the width times the length. The length used equals one-half the sum of the channel reach lengths upstream and downstream of the cross section. However, if a cross section is an upstream or downstream boundary, then the upstream or downstream reach length, respectively, is zero. As previously noted, an X5 record creates an internal boundary condition within the model, effectively creating a downstream boundary at the X5's cross section and an upstream boundary at the preceding cross section. In locating the new boundaries at these two cross sections, the reach length between them should be zero. For this reason, care should be taken when locating cross sections at internal boundary conditions.

6.3.8 Output of Hydraulic and Sediment Transport Computations

All output that follows the sediment data is produced by the hydraulic and sediment transport computations. By default, HEC-6 will produce no output from these computations unless an output flag is set for either (or both) the hydraulic or sedimentation computations. A-level sediment output was generated for the first time step of this example. This output is limited to "TABLE SA-1", which shows cumulative (since the beginning of the simulation) trap efficiency information. The "ENTRY POINT" is any cross section in the model at which something special occurs; "something special" includes upstream and downstream boundaries, local inflow and tributary junction points (QT), and internal boundary conditions (X5). Note that trap efficiency is computed at each downstream boundary. "TABLE SA-1" for the last time step shows that after 54 days, 13.29 acre-ft of sands and gravels had entered the model at Section No. 58.0; with 16.15 and 0.36 acre-ft entering at local inflows, the total inflowing sediment load to Section No. 35.0 is 29.81 acre-ft. The total load leaving Section No. 35.0 is 5.52 acre-ft, yielding a trap efficiency of 81% for that part of the model reach.

B-level sediment output was requested for the second and fourth time steps. This output begins with information regarding flow changes as the sediment computations proceed from upstream to downstream. Next is the A-level trap efficiency table. This information is followed by "TABLE SB-1", which shows the instantaneous ("snap shot") sediment inflows and outflows by grain size for the entire model. The "SEDIMENT INFLOW" enters the model at the upstream boundary (Section No. 58.0) and the "SEDIMENT OUTFLOW" leaves the model at the downstream boundary (Section No. 1.0). The last table produced by B-level output is "TABLE SB-2: STATUS OF THE BED..." which contains both cumulative and instantaneous information. The BED CHANGE is cumulative from time zero, while the rest of the data are for this time step, only. For example, the "REACH GEOMETRY" table produced after processing the sediment input data shows that the thalweg (minimum elevation GR point within the channel) at Section No. 1.0 was initially 944.70 ft. After a simulation time of 54 days, TABLE SB-2 for time step 4 shows that there was a computed bed change of 1.22 ft at Section No. 1.0, resulting in a thalweg elevation of 945.92 ft.

6.3.9 Detailed Sediment Output

Additional information regarding the sedimentation computations can be obtained with C-level output. Although this output was originally designed for use by HEC-6 developers, some of the information may be of use for project applications.

The Selective Printout option ($PRT) was used to limit output to Sections 15.0, 32.0 and 32.1 for time step 3. A-level hydraulics output for these cross sections begins the output for this time step. This is followed by C-level sediment output; first, the relevant flow information is listed for the Upstream boundary, then the fall velocity of each grain size is calculated based on the inflowing water temperature. Next is the detailed output for each of the selected cross sections. Because a local inflow enters the stream segment upstream of Section No. 15.0, local flow data and a new trap efficiency table precedes the detailed output for Section No. 15.0. The new fall velocity table is included because the particle fall velocities change due to the change in water temperature caused by the local inflow.

The detailed output for each cross section begins with the "HYDRAULIC PARAMETERS" table. This table contains the flow velocity (VEL), energy slope (SLO), effective depth (EFD), effective width (EFW), Manning's *n* (N-VALUE), average shear stress, € (TAU), the grain shear velocity, U_Q (USTARM), and the Froude number. See Vanoni (1975) for definitions of these hydraulic variables.

At this point, it should be noted that the velocity listed in the A-level hydraulics output table may not be equal to the velocity listed in the "HYDRAULIC PARAMETERS" table in the detailed sediment output. For example, at Section No. 15.0, the velocity calculated by the hydraulics computations is 1.637 ft/sec, but due to the weighting factors entered on the I5 record, the weighted velocity at the current cross section that is used in the sedimentation computations is calculated as follows:

$$\begin{aligned} \textit{Weighted}\ \text{VEL} \quad & \text{XID} \quad \text{VEL}\ \textit{at Downstream Section} \\ & \quad \text{XIN} \quad \text{VEL}\ \textit{at Current Section} \\ & \quad\quad \text{XIU} \quad \text{VEL}\ \textit{at Upstream Section} \\ & 0.25\,(1.371) \quad 0.5\,(1.637) \quad 0.25\,(3.048) \\ & 1.923 \end{aligned}$$

Listed in the "BED SEDIMENT CONTROL VOLUME COMPUTATIONS" table is a new surface area of the bed sediment control volume. The K-PORTION is that area of the control volume bounded by the conveyance limits. The S-PORTION is the area of the control volume outside the conveyance limits; this will be greater than zero only when the movable bed limits extend beyond the conveyance limits.

The "GRADATION OF ACTIVE PLUS INACTIVE DEPOSITS" table shows the gradation of the bed material at this cross section at this time. The first column is the contents of the bed by grain size, as fractions of the total bed. For example, at Section No. 15.0, 1% of the bed is very fine sand, 7% is fine sand, etc. These size classes were specified on the I records. The column is the same data as percent finer for each grain size; e.g., 99.1% of the bed material is smaller than coarse gravel.

At the start of the simulation, the bed sediment was 10 ft deep at Section No. 15.0 (HD data). The detailed output for this cross section shows that by the end of time step 3, 9.64 ft of sands and gravels remain in the inactive layer and 0.17 ft are in the active layer. This indicates a loss of 0.19 ft from the bed which corresponds to the 0.19 ft of erosion shown in TABLE SB-2 for this cross section.

Table 6-3b
Example Problem 3 - Output
Movable Bed

```
***************************************************     **********************************
*  SCOUR AND DEPOSITION IN RIVERS AND RESERVOIRS  *     *  U.S. ARMY CORPS OF ENGINEERS   *
*       Version: 4.1.00 -  AUGUST 1993            *     *  HYDROLOGIC ENGINEERING CENTER  *
*  INPUT FILE:  EXAMPLE3.DAT                      *     *  609 SECOND STREET              *
*  OUTPUT FILE: EXAMPLE3.OUT                      *     *  DAVIS, CALIFORNIA 95616-4687   *
*  RUN DATE: 01 SEP 93    RUN TIME: 10:29:27      *     *  (916) 756-1104                 *
***************************************************     **********************************

                       X     X  XXXXXXX   XXXXX           XXXXX
                       X     X  X       X     X         X     X
                       X     X  X       X               X
                       XXXXXXX  XXXX    X        XXXXX  XXXXXX
                       X     X  X       X               X     X
                       X     X  X       X     X         X     X
                       X     X  XXXXXXX   XXXXX           XXXXX

         **********************************************************************
         *  MAXIMUM LIMITS FOR THIS VERSION ARE:                              *
         *       10  Stream Segments (Main Stem + Tributaries)                *
         *      150  Cross Sections                                           *
         *      100  Elevation/Station Points per Cross Section               *
         *       20  Grain Sizes                                              *
         *       10  Control Points                                           *
         **********************************************************************

T1      EXAMPLE PROBLEM NO 3.  MOVABLE BED
T2      3 LOCAL INFLOWS
T3      SOUTH FORK, ZUMBRO RIVER     ** Example Problem 3 **

N values...  Left   Channel   Right    Contraction    Expansion
           0.1000   0.0400   0.1000       1.1000     0.7000

SECTION NO.     1.000
...DEPTH of the Bed Sediment Control Volume =   10.00 ft.

N-Values vs. Elevation Table
       Channel           Left Overbank        Right Overbank
  0.0450     966.       0.0800     966.       0.1000     966.
  0.0640     989.       0.1300     989.       0.1100     982.
  0.0000       0.       0.0000       0.       0.1200     989.

SECTION NO.    15.000
...Left Encroachment defined at station 10700.000 at elevation   961.000
...Right Encroachment defined at station 11000.000 at elevation   970.000
...DEPTH of the Bed Sediment Control Volume =   10.00 ft.

LOCAL INFLOW POINT  1 occurs upstream from Section No.      15.000

N values...  Left   Channel   Right    Contraction    Expansion
           0.1000   0.0500   0.1000       1.1000     0.7000

SECTION NO.    32.000
...DEPTH of the Bed Sediment Control Volume =   10.00 ft.

SECTION NO.    32.100
...Ineffective Flow Area - Method 1 - Left Overbank  Right Overbank
          Natural Levees at Station      10057.000      10271.000
              Ineffective Elevation        978.500        978.500
...DEPTH of the Bed Sediment Control Volume =   10.00 ft.

SECTION NO.    33.000
...Internal Boundary Condition
   Water Surface Elevation will be read from R-RECORD, Field  2
   Head Loss =    0.000
...Limit CONVEYANCE to  250.000 ft. centered about midpoint of channel.
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    33.300
...Adjust Section WIDTH to  95.00% of original.
...Adjust Section ELEVATIONS by    1.490 ft.
...Limit CONVEYANCE to  250.000 ft. centered about midpoint of channel.
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    33.900
...Adjust Section WIDTH to  95.00% of original.
...Adjust Section ELEVATIONS by    1.650 ft.
...Ineffective Flow Area - Method 1 - Left Overbank  Right Overbank
          Natural Levees at Station       1757.500       2042.500
              Ineffective Elevation        986.060        986.150
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

SECTION NO.    35.000
...Internal Boundary Condition
   Water Surface Elevation =  974.000
   Head Loss =    0.500
```

```
...Ineffective Flow Area - Method 1 - Left Overbank  Right Overbank
          Natural Levees at Station       9894.000      10245.000
              Ineffective Elevation        984.700        984.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

N values...  Left   Channel   Right    Contraction    Expansion
           0.0600   0.0450   0.0600       1.1000     0.7000

SECTION NO.    42.000
...DEPTH of the Bed Sediment Control Volume =    0.00 ft.

LOCAL INFLOW POINT  2 occurs upstream from Section No.      42.000

SECTION NO.    44.000
...Limit CONVEYANCE between stations    9850.000 and   10200.000
...DEPTH of the Bed Sediment Control Volume =    1.00 ft.

SECTION NO.    53.000
...DEPTH of the Bed Sediment Control Volume =   10.00 ft.

LOCAL INFLOW POINT  3 occurs upstream from Section No.      53.000

SECTION NO.    55.000
...DEPTH of the Bed Sediment Control Volume =   10.00 ft.

SECTION NO.    58.000
...DEPTH of the Bed Sediment Control Volume =    3.40 ft.

NO. OF CROSS SECTIONS IN STREAM SEGMENT= 13
NO. OF INPUT DATA MESSAGES =   0

TOTAL NO. OF CROSS SECTIONS IN THE NETWORK =  13
TOTAL NO. OF STREAM SEGMENTS IN THE NETWORK=   1
END OF GEOMETRIC DATA

==============================================================================================================

T4      South Fork, Zumbro River - Stream Segment 1     ** Example Problem 3 **
T5      LOAD CURVE FROM GAGE DATA.
T6      BED GRADATIONS FROM FIELD SAMPLES.
T7      Use Full Range of Sands and Gravels
T8      SEDIMENT TRANSPORT BY Yang's STREAM POWER [ref ASCE JOURNAL (YANG 1971)]

        EXAMPLE PROBLEM NO 3.  MOVABLE BED
        3 LOCAL INFLOWS
        SOUTH FORK, ZUMBRO RIVER     ** Example Problem 3 **

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
SEDIMENT PROPERTIES AND PARAMETERS

       SPI     IBG    MNQ      SPGF      ACGR     NFALL    IBSHER
I1      5.       0       1     1.000    32.174        2        1
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 SANDS - BOULDERS ARE PRESENT

       MTC     IASA    LASA     SPGS       GSF      BSAE       PSI     UWDLB
I4      4        1      10     2.650     0.667     0.500    30.000    93.000

USING TRANSPORT CAPACITY RELATIONSHIP #  4, YANG

GRAIN SIZES UTILIZED (mean diameter - mm)
----------------------------------------------------------------------
    VERY FINE SAND....    0.088  |  VERY FINE GRAVEL..    2.828
    FINE SAND.........    0.177  |  FINE GRAVEL.......    5.657
    MEDIUM SAND.......    0.354  |  MEDIUM GRAVEL.....   11.314
    COARSE SAND.......    0.707  |  COARSE GRAVEL.....   22.627
    VERY COARSE SAND..    1.414  |  VERY COARSE GRAVEL   45.255

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
COEFFICIENTS FOR COMPUTATION SCHEME WERE SPECIFIED
        DBI      DBN      XID      XIN      XIU      UBI      UBN      JSL
I5    0.500    0.500    0.250    0.500    0.250    0.000    1.000        1
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -


SEDIMENT LOAD TABLE FOR STREAM SEGMENT #   1
          LOAD BY GRAIN SIZE CLASS (tons/day)
---------------------------------------------------------------------------
LQ       | 1.00000    | 50.0000    | 1000.00    | 5800.00    | 90000.0    |
          ------------ ------------ ------------ ------------ ------------
LF   VFS |0.130900E-02|0.178500    | 159.360    | 2299.50    | 232800.    |
LF    FS |0.360800E-02|0.492000    | 105.920    | 1377.00    | 112000.    |
LF    MS |0.608300E-02|0.829500    | 49.9200    | 693.000    | 44000.0    |
LF    CS |0.100000E-19|0.100000E-19| 3.52000    | 72.0000    | 8000.00    |
LF   VCS |0.100000E-19|0.100000E-19| 1.28000    | 36.0000    | 2000.00    |
LF   VFG |0.100000E-19|0.100000E-19|0.100000E-19| 18.0000    | 800.000    |
LF    FG |0.100000E-19|0.100000E-19|0.100000E-19| 4.50000    | 400.000    |
LF    MG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
LF    CG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
LF   VCG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
          ------------ ------------ ------------ ------------ ------------
   TOTAL |0.110000E-01| 1.50000    | 320.000    | 4500.00    | 400000.    |
---------------------------------------------------------------------------
```

REACH GEOMETRY FOR STREAM SEGMENT 1

CROSS SECTION NO.	REACH LENGTH (ft)	MOVABLE BED WIDTH	INITIAL BED-ELEVATIONS LEFT SIDE (ft)	THALWEG (ft)	RIGHT SIDE (ft)	ACCUMULATED CHANNEL DISTANCE FROM DOWNSTREAM (ft)	(miles)
	0.000						
1.000		183.500	959.300	944.700	958.900	0.000	0.000
	3280.000						
15.000		242.000	961.000	953.700	962.000	3280.000	0.621
	4240.000						
32.000		219.500	968.600	956.500	978.500	7520.000	1.424
	3320.000						
32.100		219.500	968.600	956.500	978.500	10840.000	2.053
	0.000						
33.000		299.000	979.190	961.000	976.000	10840.000	2.053
	1750.000						
33.300		284.050	980.680	962.490	977.490	12590.000	2.384
	1050.000						
33.900		284.050	980.840	962.650	977.650	13640.000	2.583
	0.000						
35.000		275.950	963.300	963.300	983.700	13640.000	2.583
	5210.000						
42.000		154.500	969.800	969.800	969.800	18850.000	3.570
	3500.000						
44.000		337.500	970.900	967.100	976.900	22350.000	4.233
	2942.000						
53.000		195.000	982.800	972.200	988.700	25292.000	4.790
	2770.000						
55.000		204.000	987.200	972.900	983.800	28062.000	5.315
	1462.000						
58.000		176.500	996.300	975.400	990.400	29524.000	5.592

BED MATERIAL GRADATION

SECNO	SAE	DMAX (ft)	DXPI (ft)	XPI	TOTAL BED	BED MATERIAL FRACTIONS per grain size					
1.000	1.000	0.105	0.105	1.000	1.000	VF SAND	0.010	VC SAND	0.120	M GRVL	0.015
						F SAND	0.070	VF GRVL	0.060	C GRVL	0.035
						M SAND	0.290	F GRVL	0.040	VC GRVL	0.000
						C SAND	0.360				
15.000	1.000	0.151	0.151	1.000	1.000	VF SAND	0.010	VC SAND	0.113	M GRVL	0.011
						F SAND	0.070	VF GRVL	0.045	C GRVL	0.022
						M SAND	0.327	F GRVL	0.033	VC GRVL	0.002
						C SAND	0.367				
32.000	1.000	0.210	0.210	1.000	1.000	VF SAND	0.010	VC SAND	0.105	M GRVL	0.005
						F SAND	0.070	VF GRVL	0.025	C GRVL	0.005
						M SAND	0.375	F GRVL	0.025	VC GRVL	0.005
						C SAND	0.375				
32.100	1.000	0.210	0.210	1.000	1.000	VF SAND	0.008	VC SAND	0.124	M GRVL	0.004
						F SAND	0.062	VF GRVL	0.038	C GRVL	0.009
						M SAND	0.321	F GRVL	0.027	VC GRVL	0.009
						C SAND	0.397				
33.000	1.000	0.210	0.210	1.000	1.000	VF SAND	0.008	VC SAND	0.124	M GRVL	0.004
						F SAND	0.062	VF GRVL	0.038	C GRVL	0.009
						M SAND	0.321	F GRVL	0.027	VC GRVL	0.009
						C SAND	0.397				
33.300	1.000	0.210	0.210	1.000	1.000	VF SAND	0.008	VC SAND	0.134	M GRVL	0.004
						F SAND	0.058	VF GRVL	0.045	C GRVL	0.011
						M SAND	0.293	F GRVL	0.028	VC GRVL	0.011
						C SAND	0.408				
33.900	1.000	0.210	0.210	1.000	1.000	VF SAND	0.007	VC SAND	0.140	M GRVL	0.004
						F SAND	0.056	VF GRVL	0.049	C GRVL	0.012
						M SAND	0.276	F GRVL	0.029	VC GRVL	0.012
						C SAND	0.415				
35.000	1.000	0.210	0.210	1.000	1.000	VF SAND	0.007	VC SAND	0.140	M GRVL	0.004
						F SAND	0.056	VF GRVL	0.049	C GRVL	0.012
						M SAND	0.276	F GRVL	0.029	VC GRVL	0.012
						C SAND	0.415				
42.000	1.000	0.210	0.210	1.000	1.000	VF SAND	0.005	VC SAND	0.169	M GRVL	0.002
						F SAND	0.044	VF GRVL	0.069	C GRVL	0.018
						M SAND	0.192	F GRVL	0.033	VC GRVL	0.018
						C SAND	0.450				
44.000	1.000	0.210	0.210	1.000	1.000	VF SAND	0.003	VC SAND	0.189	M GRVL	0.002
						F SAND	0.036	VF GRVL	0.082	C GRVL	0.022
						M SAND	0.136	F GRVL	0.035	VC GRVL	0.022
						C SAND	0.473				
53.000	1.000	0.210	0.210	1.000	1.000	VF SAND	0.002	VC SAND	0.206	M GRVL	0.001
						F SAND	0.030	VF GRVL	0.094	C GRVL	0.025
						M SAND	0.088	F GRVL	0.037	VC GRVL	0.025
						C SAND	0.492				

```
    55.000  1.000  0.210  0.210  1.000  1.000 | VF SAND  0.001 | VC SAND  0.222 | M  GRVL  0.000 |
                                              | F  SAND  0.023 | VF GRVL  0.104 | C  GRVL  0.028 |
                                              | M  SAND  0.044 | F  GRVL  0.039 | VC GRVL  0.028 |
                                              | C  SAND  0.510 |

    58.000  1.000  0.210  0.210  1.000  1.000 | VF SAND  0.000 | VC SAND  0.230 | M  GRVL  0.000 |
                                              | F  SAND  0.020 | VF GRVL  0.110 | C  GRVL  0.030 |
                                              | M  SAND  0.020 | F  GRVL  0.040 | VC GRVL  0.030 |
                                              | C  SAND  0.520 |

..LOCAL INFLOW DATA...
SEDIMENT LOAD TABLE FOR STREAM SEGMENT #   1
                 AT LOCAL INFLOW POINT #   1
          LOAD BY GRAIN SIZE CLASS (tons/day)
---------------------------------------------------------------
LQL      | 1.00000    | 100.000    | 1000.00    | 10000.0    |
          ------------ ------------ ------------ ------------
LFL  VFS |0.265600E-02| 6.64000    | 7.50000    | 5940.00    |
LFL   FS |0.828000E-03| 2.07000    | 122.500    | 5430.00    |
LFL   MS |0.344000E-03|0.860000    | 302.500    | 3210.00    |
LFL   CS |0.124000E-03|0.310000    | 26.0000    | 2940.00    |
LFL  VCS |0.320000E-04|0.800000E-01| 19.5000    | 3810.00    |
LFL  VFG |0.120000E-04|0.300000E-01| 10.0000    | 3480.00    |
LFL   FG |0.400000E-05|0.100000E-01| 5.50000    | 2730.00    |
LFL   MG |0.100000E-19|0.100000E-19| 5.50000    | 1590.00    |
LFL   CG |0.100000E-19|0.100000E-19|0.100000E-19| 660.000    |
LFL  VCG |0.100000E-19|0.100000E-19|0.100000E-19| 180.000    |
          ------------ ------------ ------------ ------------
   TOTAL |0.400000E-02| 10.0000    | 499.000    | 29970.0    |
---------------------------------------------------------------

SEDIMENT LOAD TABLE FOR STREAM SEGMENT #   1
                 AT LOCAL INFLOW POINT #   2
          LOAD BY GRAIN SIZE CLASS (tons/day)
---------------------------------------------------------------
LQL      | 1.00000    | 100.000    | 1000.00    | 10000.0    |
          ------------ ------------ ------------ ------------
LFL  VFS |0.265600E-02| 6.64000    | 7.50000    | 5940.00    |
LFL   FS |0.828000E-03| 2.07000    | 122.500    | 5430.00    |
LFL   MS |0.344000E-03|0.860000    | 302.500    | 3210.00    |
LFL   CS |0.124000E-03|0.310000    | 26.0000    | 2940.00    |
LFL  VCS |0.320000E-04|0.800000E-01| 19.5000    | 3810.00    |
LFL  VFG |0.120000E-04|0.300000E-01| 10.0000    | 3480.00    |
LFL   FG |0.400000E-05|0.100000E-01| 5.50000    | 2730.00    |
LFL   MG |0.100000E-19|0.100000E-19| 5.50000    | 1590.00    |
LFL   CG |0.100000E-19|0.100000E-19|0.100000E-19| 660.000    |
LFL  VCG |0.100000E-19|0.100000E-19|0.100000E-19| 180.000    |
          ------------ ------------ ------------ ------------
   TOTAL |0.400000E-02| 10.0000    | 499.000    | 29970.0    |
---------------------------------------------------------------

SEDIMENT LOAD TABLE FOR STREAM SEGMENT #   1
                 AT LOCAL INFLOW POINT #   3
          LOAD BY GRAIN SIZE CLASS (tons/day)
----------------------------------------------------------------------------
LQL      | 1.00000    | 100.000    | 500.000    | 1000.00    | 30000.0    |
          ------------ ------------ ------------ ------------ ------------
LFL  VFS |0.402000E-03| 6.03000    | 39.0000    | 93.6000    | 3082.50    |
LFL   FS |0.684000E-03| 10.2600    | 86.0000    | 210.000    | 4905.00    |
LFL   MS |0.902000E-03| 13.5300    | 227.000    | 721.200    | 10710.0    |
LFL   CS |0.200000E-05|0.300000E-01| 98.5000    | 170.400    | 3555.00    |
LFL  VCS |0.100000E-19|0.100000E-19|0.100000E-19| 3.60000    | 180.000    |
LFL  VFG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19| 45.0000    |
LFL   FG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19| 22.5000    |
LFL   MG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
LFL   CG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
LFL  VCG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
          ------------ ------------ ------------ ------------ ------------
   TOTAL |0.199000E-02| 29.8500    | 450.500    | 1198.80    | 22500.0    |
----------------------------------------------------------------------------

BED SEDIMENT CONTROL VOLUMES

STREAM SEGMENT #  1: EXAMPLE PROBLEM NO 3.  MOVABLE BED
|  SECTION  |  LENGTH   |   WIDTH    |  DEPTH   |        V O L U M E         |
|  NUMBER   |   (ft)    |    (ft)    |   (ft)   |   (cu.ft)    |   (cu.yd)   |
-------------------------------------------------------------------------------
|     1.000 |  1640.000 |    203.000 |   10.000 |0.332920E+07 | 123304.     |
|    15.000 |  3760.000 |    229.266 |   10.000 |0.862040E+07 | 319274.     |
|    32.000 |  3780.000 |    223.706 |   10.000 |0.845610E+07 | 313189.     |
|    32.100 |  1660.000 |    219.500 |   10.000 |0.364370E+07 | 134952.     |
|    33.000 |   875.000 |    294.017 |    0.000 |0.000000     |0.000000     |
|    33.300 |  1400.000 |    287.165 |    0.000 |0.000000     |0.000000     |
|    33.900 |   525.000 |    284.050 |    0.000 |0.000000     |0.000000     |
|    35.000 |  2605.000 |    235.467 |    0.000 |0.000000     |0.000000     |
|    42.000 |  4355.000 |    203.228 |    0.000 |0.000000     |0.000000     |
|    44.000 |  3221.000 |    282.665 |    1.000 | 910465.     | 33720.9     |
|    53.000 |  2856.000 |    220.920 |   10.000 |0.630947E+07 | 233684.     |
|    55.000 |  2116.000 |    198.870 |   10.000 |0.420808E+07 | 155855.     |
|    58.000 |   731.000 |    185.667 |    3.400 | 461456.     | 17091.0     |

NO. OF INPUT DATA MESSAGES=    0
END OF SEDIMENT DATA
==========================================================================================
```

```
$HYD
BEGIN COMPUTATIONS.

==========================================================================================
TIME STEP #       1
Q    A     FLOW 1 = BASE FLOW 0F 750 CFS

TABLE SA-1. TRAP EFFICIENCY ON STREAM SEGMENT #  1
            EXAMPLE PROBLEM NO 3.  MOVABLE BED
            ACCUMULATED AC-FT ENTERING AND LEAVING THIS STREAM SEGMENT
******************************************************
    TIME       ENTRY *            SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
    2.00      58.000 *      0.09                    *
              53.000 *      0.04                    *
              42.000 *      0.00                    *
   TOTAL=     35.000 *      0.14      0.00      1.00 *
******************************************************
    TIME       ENTRY *            SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
    2.00      35.000 *      0.00                    *
   TOTAL=     33.000 *      0.00      0.00      0.49 *
******************************************************
    TIME       ENTRY *            SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
    2.00      33.000 *      0.00                    *
              15.000 *      0.00                    *
   TOTAL=      1.000 *      0.00      0.02     -3.36 *
******************************************************

==========================================================================================
TIME STEP #       2
Q    B     FLOW 2 = 50 DAYS AT BANK FULL DISCHARGE

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
EXAMPLE PROBLEM NO 3.  MOVABLE BED
       ACCUMULATED TIME (yrs)....       0.142
       FLOW DURATION (days)......      50.000

UPSTREAM BOUNDARY CONDITIONS
----------------------------------------------------------------------
Stream Segment # 1      |   DISCHARGE    | SEDIMENT LOAD | TEMPERATURE
Section No.     58.000 |     (cfs)      |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
                INFLOW |       1400.00 |        529.98 |       62.04

Upstream of SECTION NO.     53.000 is...
LOCAL INFLOW POINT # 3 |   DISCHARGE    | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)      |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |       1400.00 |        529.98 |       62.04
      LOCAL     INFLOW |        650.00 |        647.71 |       67.00
----------------------------------------------------------------------
                 TOTAL |       2050.00 |       1177.69 |       63.61

Upstream of SECTION NO.     42.000 is...
LOCAL INFLOW POINT # 2 |   DISCHARGE    | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)      |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |       2050.00 |       1177.69 |       63.61
      LOCAL     INFLOW |        150.00 |         14.45 |       70.00
----------------------------------------------------------------------
                 TOTAL |       2200.00 |       1192.13 |       64.05

Upstream of SECTION NO.     15.000 is...
LOCAL INFLOW POINT # 1 |   DISCHARGE    | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)      |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |       2200.00 |       1192.13 |       64.05
      LOCAL     INFLOW |        300.00 |         40.00 |       72.00
----------------------------------------------------------------------
                 TOTAL |       2500.00 |       1232.13 |       65.00

TABLE SA-1. TRAP EFFICIENCY ON STREAM SEGMENT #  1
            EXAMPLE PROBLEM NO 3.  MOVABLE BED
            ACCUMULATED AC-FT ENTERING AND LEAVING THIS STREAM SEGMENT
******************************************************
    TIME       ENTRY *            SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   52.00      58.000 *     13.17                    *
              53.000 *     16.03                    *
              42.000 *      0.36                    *
   TOTAL=     35.000 *     29.56      5.51      0.81 *
******************************************************
    TIME       ENTRY *            SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   52.00      35.000 *      5.51                    *
   TOTAL=     33.000 *      5.51      1.47      0.73 *
******************************************************
    TIME       ENTRY *            SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   52.00      33.000 *      1.47                    *
              15.000 *      0.99                    *
   TOTAL=      1.000 *      2.46      0.07      0.97 *
******************************************************
```

```
TABLE SB-1:  SEDIMENT LOAD PASSING THE  BOUNDARIES OF STREAM SEGMENT #  1
--------------------------------------------------------------------------------
  SEDIMENT INFLOW at the Upstream Boundary:
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....        265.63  |  VERY FINE GRAVEL..          0.00
    FINE SAND.........        173.06  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......         82.59  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......          6.27  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          2.42  |  VERY COARSE GRAVEL          0.00
                       -------------                   -------------
                                                 TOTAL =        529.98
  SEDIMENT OUTFLOW from the Downstream Boundary
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....          0.24  |  VERY FINE GRAVEL..          0.00
    FINE SAND.........          0.27  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......          0.72  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......          0.59  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          0.13  |  VERY COARSE GRAVEL          0.00
                       -------------                   -------------
                                                 TOTAL =          1.94

TABLE SB-2:  STATUS OF THE BED PROFILE AT TIME =    52.000 DAYS
--------------------------------------------------------------------------------
  SECTION   BED CHANGE   WS ELEV   THALWEG        Q      TRANSPORT RATE (tons/day)
  NUMBER       (ft)       (ft)      (ft)       (cfs)        SAND
     58.000      -0.60    981.86    974.80      1400.        557.
     55.000       0.10    980.67    973.00      1400.        525.
     53.000       0.40    977.12    972.60      2050.       1044.
     44.000       0.08    975.90    967.18      2050.       1014.
     42.000       0.92    975.15    970.72      2200.        300.
     35.000       0.17    974.00    963.47      2200.        223.
     33.900       0.57    970.36    963.22      2200.        160.
     33.300       0.12    970.19    962.61      2200.        124.
     33.000       0.33    970.00    961.33      2200.         59.
     32.100      -0.19    967.63    956.31      2200.        105.
     32.000      -0.13    966.55    956.37      2200.        157.
     15.000      -0.19    965.13    953.51      2500.        232.
      1.000       1.03    965.00    945.73      2500.          2.

------------------------------------------------------------------------------------------
$PRT
...Selective Printout Option
     - Print at the following cross sections
CP           1
PS          15.0    32.0    32.1
END

==========================================================================================
TIME STEP #       3
Q   AC     FLOW 3 = NEAR BANK FULL DISCHARGE

EXAMPLE PROBLEM NO 3.  MOVABLE BED
ACCUMULATED TIME (yrs)..........      0.142

--- Downstream Boundary Condition Data for STREAM SEGMENT NO.  1 at Control Point #  1 ---
                            DISCHARGE   TEMPERATURE  WATER SURFACE
                              (cfs)      (deg F)       (ft)
                              1250.000       65.00       960.000

****  DISCHARGE    WATER    ENERGY  VELOCITY   ALPHA     TOP      AVG       AVG VEL (by subsection)
        (CFS)     SURFACE    LINE     HEAD              WIDTH     BED        1       2       3

SECTION NO.     15.000
****   1250.000   960.477   960.622   0.144    1.000   144.463   957.639   0.000   3.048   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

--- LOCAL INFLOW POINT #  1 is upstream of Section No.      15.000 ---
                            DISCHARGE   TEMPERATURE
                              (cfs)      (deg F)
            Local Inflow:      150.000       72.00
                   Total:     1100.000       64.05

SECTION NO.     32.000
****   1100.000   963.899   963.941   0.042    1.000   132.795   958.838   0.000   1.637   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000
SECTION NO.     32.100
****   1100.000   964.813   964.842   0.029    1.000   138.333   959.013   0.000   1.371   0.000
                                                 FLOW DISTRIBUTION (%) =    0.000 100.000   0.000

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
EXAMPLE PROBLEM NO 3.  MOVABLE BED
       ACCUMULATED TIME (yrs)....      0.145
       FLOW DURATION (days)......      1.000

UPSTREAM BOUNDARY CONDITIONS
----------------------------------------------------------------------
Stream Segment # 1      |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
Section No.     58.000 |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
                INFLOW |        682.00 |        149.81 |       61.89
```

```
  SEDIMENT INFLOW at SECTION NO.     58.000
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....         66.90  |  VERY FINE GRAVEL..         0.00
    FINE SAND.........         53.32  |  FINE GRAVEL.......         0.00
    MEDIUM SAND.......         29.58  |  MEDIUM GRAVEL.....         0.00
    COARSE SAND.......          0.01  |  COARSE GRAVEL.....         0.00
    VERY COARSE SAND..          0.00  |  VERY COARSE GRAVEL         0.00
                       -------------                     -------------
                                                TOTAL =       149.81

    FALL VELOCITIES - Method 2
              DIAMETER   VELOCITY       REY. NO.          CD
    ------------------------------------------------------------
    VF SAND   0.000290  0.1860300E-01  0.4558130       59.31192
    F  SAND   0.000580  0.5765145E-01   2.825166       12.35143
    M  SAND   0.001160  0.1327884       13.01437       4.656360
    C  SAND   0.002320  0.2803304       54.94943       2.089569
    VC SAND   0.004640  0.4807405       188.4667       1.421041
    VF GRVL   0.009280  0.7191215       563.8404       1.270145
    F  GRVL   0.018559   1.039704       1630.395       1.215254
    M  GRVL   0.037118   1.472894       4619.401       1.211086
    C  GRVL   0.074237   2.082985       13065.61       1.211086
    VC GRVL   0.148474   2.945788       36955.21       1.211086

*****************************************************************************************
                TRACE OUTPUT FOR SECTION NO.     32.100
           -------------------------------------------------------

HYDRAULIC PARAMETERS:
      VEL      SLO        EFD       EFW     N-VALUE     TAU      USTARM    FROUDE NO.
     1.371  0.000271      6.763   118.634    0.0500   0.11467   0.24306     0.093

BED SEDIMENT CONTROL VOLUME COMPUTATIONS:
NEW SURFACE AREA (SQ FT):     TOTAL        K-PORTION      S-PORTION
                          214970.00      214970.00           0.00

GRADATION OF ACTIVE PLUS INACTIVE DEPOSITS
BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER             BED FRACTION  PERCENT FINER
                       VF SAND      0.012074      1.207441      VF GRVL      0.038537     94.998190
                       F  SAND      0.062093      7.416711      F  GRVL      0.027800     97.778156
                       M  SAND      0.319568     39.373478      M  GRVL      0.004329     98.211069
                       C  SAND      0.394570     78.830455      C  GRVL      0.008945     99.105534
                       VC SAND      0.123140     91.144443      VC GRVL      0.008945     99.999998

SAND
** ARMOR LAYER **
STABILITY COEFFICIENT=     0.81992
MIN.GRAIN DIAM       =    0.001943
BED SURFACE EXPOSED  =     0.28365

        INACTIVE LAYER      ACTIVE LAYER
         %       DEPTH      %      DEPTH
 CLAY   0.0000    0.00     0.0000   0.00
 SILT   0.0000    0.00     0.0000   0.00
 SAND   1.0000    9.76     1.0000   0.05
TOTAL   1.0000    9.76     1.0000   0.05

       AVG. UNIT              AVG. UNIT
         WEIGHT                 WEIGHT
        0.046500               0.046500

    COMPOSITE UNIT WT OF ACTIVE LAYER   (t/cf)=       0.046500
    COMPOSITE UNIT WT OF INACTIVE LAYER (t/cf)=       0.046500
    DEPTH OF SURFACE LAYER (ft)           DSL=            0.1
    WEIGHT IN SURFACE LAYER (tons)       WTSL=          833.0
    DEPTH OF NEW ACTIVE LAYER (ft)        DSE=         0.0008
    WEIGHT IN NEW ACTIVE LAYER(tons)    WTMXAL=           7.6
    WEIGHT IN OLD ACTIVE LAYER(tons)      WAL=          497.7
    USEABLE WEIGHT, OLD INACTIVE LAYER    WIL=        97534.4
    SURFACE AREA OF DEPOSIT (sq ft)      SABK= 0.21497000E+06

** INACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER             BED FRACTION  PERCENT FINER
                       VF SAND      0.008485      0.848488      VF GRVL      0.038120     95.056453
                       F  SAND      0.062410      7.089446      F  GRVL      0.027476     97.804037
                       M  SAND      0.321199     39.209296      M  GRVL      0.004279     98.231907
                       C  SAND      0.396583     78.867631      C  GRVL      0.008840     99.115953
                       VC SAND      0.123768     91.244461      VC GRVL      0.008840     99.999998
** ACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER             BED FRACTION  PERCENT FINER
                       VF SAND      0.715456     71.545615      VF GRVL      0.120357     83.581306
                       F  SAND      0.000000     71.545615      F  GRVL      0.091254     92.706690
                       M  SAND      0.000000     71.545615      M  GRVL      0.014211     94.127749
                       C  SAND      0.000000     71.545615      C  GRVL      0.029361     97.063875
                       VC SAND      0.000000     71.545615      VC GRVL      0.029361    100.000000

C FINES, COEF(CFFML), MX POTENTIAL= 0.000000E+00 0.100000E+01 0.237600E+07
POTENTIAL TRANSPORT (tons/day):  VF SAND 0.560062E+03  VF GRVL 0.100000E-06
                                 F  SAND 0.199470E+03  F  GRVL 0.100000E-06
                                 M  SAND 0.125719E+03  M  GRVL 0.100000E-06
                                 C  SAND 0.947155E+02  C  GRVL 0.100000E-06
                                 VC SAND 0.765651E+02  VC GRVL 0.100000E-06
```

```
  SEDIMENT OUTFLOW FROM SECTION NO.     32.100
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....        148.98  |  VERY FINE GRAVEL..          0.00
    FINE SAND.........          9.07  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......         23.59  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......         21.05  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          5.30  |  VERY COARSE GRAVEL          0.00

*****************************************************************************************
                  TRACE OUTPUT FOR SECTION NO.     32.000
           -------------------------------------------------------
HYDRAULIC PARAMETERS:
      VEL      SLO       EFD       EFW     N-VALUE     TAU      USTARM    FROUDE NO.
     1.923  0.000527     5.733   110.118    0.0500   0.18875   0.31184     0.142

BED SEDIMENT CONTROL VOLUME COMPUTATIONS:
NEW SURFACE AREA (SQ FT):     TOTAL        K-PORTION      S-PORTION
                           495163.69      495163.69          0.00

GRADATION OF ACTIVE PLUS INACTIVE DEPOSITS
BED MATERIAL PER GRAIN SIZE:   BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.011063      1.106303     VF GRVL      0.025317     95.945944
                       F  SAND      0.070203      8.126581     F  GRVL      0.025337     98.479681
                       M  SAND      0.374483     45.574892     M  GRVL      0.005068     98.986453
                       C  SAND      0.373745     82.949358     C  GRVL      0.005068     99.493225
                       VC SAND      0.104649     93.414209     VC GRVL      0.005068     99.999998

SAND
** ARMOR LAYER **
STABILITY COEFFICIENT=     0.76487
MIN.GRAIN DIAM       =    0.003170
BED SURFACE EXPOSED  =     1.00000

        INACTIVE LAYER      ACTIVE LAYER
          %      DEPTH      %      DEPTH
 CLAY   0.0000    0.00     0.0000    0.00
 SILT   0.0000    0.00     0.0000    0.00
 SAND   1.0000    9.84     1.0000    0.03
TOTAL   1.0000    9.84     1.0000    0.03

       AVG. UNIT              AVG. UNIT
         WEIGHT                 WEIGHT
        0.046500               0.046500

    COMPOSITE UNIT WT OF ACTIVE LAYER   (t/cf)=       0.046500
    COMPOSITE UNIT WT OF INACTIVE LAYER (t/cf)=       0.046500
    DEPTH OF SURFACE LAYER (ft)            DSL=            0.1
    WEIGHT IN SURFACE LAYER (tons)        WTSL=         1918.8
    DEPTH OF NEW ACTIVE LAYER (ft)         DSE=         0.0042
    WEIGHT IN NEW ACTIVE LAYER(tons)    WTMXAL=           97.6
    WEIGHT IN OLD ACTIVE LAYER(tons)       WAL=          635.8
    USEABLE WEIGHT, OLD INACTIVE LAYER     WIL=       226538.3
    SURFACE AREA OF DEPOSIT (sq ft)       SABK= 0.49516369E+06

** INACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:   BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.009994      0.999449     VF GRVL      0.025198     95.968320
                       F  SAND      0.069961      7.995595     F  GRVL      0.025198     98.488119
                       M  SAND      0.374794     45.474949     M  GRVL      0.005040     98.992078
                       C  SAND      0.374794     82.954303     C  GRVL      0.005040     99.496038
                       VC SAND      0.104942     93.448522     VC GRVL      0.005040     99.999998
** ACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:   BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.391813     39.181331     VF GRVL      0.067850     87.972420
                       F  SAND      0.156193     54.800582     F  GRVL      0.075005     95.472886
                       M  SAND      0.263868     81.187410     M  GRVL      0.015090     96.981924
                       C  SAND      0.000000     81.187410     C  GRVL      0.015090     98.490962
                       VC SAND      0.000000     81.187410     VC GRVL      0.015090    100.000000

C FINES, COEF(CFFML), MX POTENTIAL= 0.000000E+00 0.100000E+01 0.237600E+07
POTENTIAL TRANSPORT (tons/day):  VF SAND 0.279192E+04  VF GRVL 0.108066E+01
                                 F  SAND 0.906230E+03  F  GRVL 0.100000E-06
                                 M  SAND 0.533420E+03  M  GRVL 0.100000E-06
                                 C  SAND 0.403607E+03  C  GRVL 0.100000E-06
                                 VC SAND 0.382254E+03  VC GRVL 0.100000E-06

  SEDIMENT OUTFLOW FROM SECTION NO.     32.000
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....        256.66  |  VERY FINE GRAVEL..          0.04
    FINE SAND.........         78.38  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......        185.55  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......        116.49  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..         30.96  |  VERY COARSE GRAVEL          0.00

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Upstream of SECTION NO.     15.000 is...
LOCAL INFLOW POINT # 1 |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |      1100.00 |        362.61 |        64.05
      LOCAL     INFLOW |       150.00 |         14.45 |        72.00
----------------------------------------------------------------------
                 TOTAL |      1250.00 |        377.06 |        65.00
```

```
  SEDIMENT LOAD FROM LOCAL INFLOW:
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....          6.78  |  VERY FINE GRAVEL..         0.08
    FINE SAND.........          4.25  |  FINE GRAVEL.......         0.03
    MEDIUM SAND.......          2.41  |  MEDIUM GRAVEL.....         0.00
    COARSE SAND.......          0.68  |  COARSE GRAVEL.....         0.00
    VERY COARSE SAND..          0.21  |  VERY COARSE GRAVEL         0.00
                       -------------                       -------------
                                                TOTAL =        14.45

    FALL VELOCITIES - Method 2
              DIAMETER   VELOCITY       REY. NO.          CD
    ------------------------------------------------------------
    VF SAND   0.000290  0.1931441E-01  0.4941259       55.02308
    F  SAND   0.000580  0.5916114E-01   3.027072       11.72910
    M  SAND   0.001160  0.1355164       13.86779       4.470784
    C  SAND   0.002320  0.2833008       57.98200       2.045980
    VC SAND   0.004640  0.4824925       197.4999       1.410740
    VF GRVL   0.009280  0.7200893       589.5120       1.266733
    F  GRVL   0.018559   1.040325       1703.352       1.213806
    M  GRVL   0.037118   1.472894       4823.231       1.211086
    C  GRVL   0.074237   2.082985       13642.13       1.211086
    VC GRVL   0.148474   2.945788       38585.85       1.211086

*******************************************************************************************
                  TRACE OUTPUT FOR SECTION NO.     15.000
           -------------------------------------------------------
HYDRAULIC PARAMETERS:
      VEL      SLO        EFD        EFW     N-VALUE     TAU      USTARM    FROUDE NO.
     2.137  0.000485      6.241    112.022    0.0450   0.18889   0.31196     0.151

BED SEDIMENT CONTROL VOLUME COMPUTATIONS:
NEW SURFACE AREA (SQ FT):     TOTAL        K-PORTION      S-PORTION
                            543327.92      543327.92           0.00

GRADATION OF ACTIVE PLUS INACTIVE DEPOSITS
BED MATERIAL PER GRAIN SIZE:   BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.010618      1.061792      VF GRVL      0.045645     93.051050
                       F  SAND      0.070017      8.063516      F  GRVL      0.034096     96.460669
                       M  SAND      0.325449     40.608371      M  GRVL      0.010834     97.544118
                       C  SAND      0.365690     77.177345      C  GRVL      0.022336     99.777722
                       VC SAND      0.113092     88.486534      VC GRVL      0.002223     99.999998

SAND
** ARMOR LAYER **
STABILITY COEFFICIENT=     0.78731
MIN.GRAIN DIAM       =    0.002878
BED SURFACE EXPOSED  =     0.00000

        INACTIVE LAYER      ACTIVE LAYER
         %       DEPTH      %       DEPTH
 CLAY   0.0000    0.00     0.0000    0.00
 SILT   0.0000    0.00     0.0000    0.00
 SAND   1.0000    9.64     1.0000    0.17
TOTAL   1.0000    9.64     1.0000    0.17

       AVG. UNIT              AVG. UNIT
        WEIGHT                 WEIGHT
        0.046500               0.046500

    COMPOSITE UNIT WT OF ACTIVE LAYER   (t/cf)=       0.046500
    COMPOSITE UNIT WT OF INACTIVE LAYER (t/cf)=       0.046500
    DEPTH OF SURFACE LAYER (ft)            DSL=            0.1
    WEIGHT IN SURFACE LAYER (tons)        WTSL=         2105.4
    DEPTH OF NEW ACTIVE LAYER (ft)         DSE=         0.0000
    WEIGHT IN NEW ACTIVE LAYER(tons)    WTMXAL=            0.0
    WEIGHT IN OLD ACTIVE LAYER(tons)       WAL=         4252.7
    USEABLE WEIGHT, OLD INACTIVE LAYER     WIL=       243631.1
    SURFACE AREA OF DEPOSIT (sq ft)       SABK= 0.54332792E+06

** INACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:   BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.010000      1.000000      VF GRVL      0.044734     93.180849
                       F  SAND      0.070000      8.000000      F  GRVL      0.033457     96.526594
                       M  SAND      0.327074     40.707446      M  GRVL      0.010638     97.590423
                       C  SAND      0.366543     77.361700      C  GRVL      0.021915     99.781913
                       VC SAND      0.113457     88.707445      VC GRVL      0.002181     99.999998
** ACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:   BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.046017      4.601728      VF GRVL      0.097841     85.615105
                       F  SAND      0.071005     11.702227      F  GRVL      0.070689     92.683996
                       M  SAND      0.232303     34.932536      M  GRVL      0.022074     94.891357
                       C  SAND      0.316834     66.615964      C  GRVL      0.046463     99.537628
                       VC SAND      0.092150     75.831001      VC GRVL      0.004624    100.000000

C FINES, COEF(CFFML), MX POTENTIAL= 0.000000E+00 0.100000E+01 0.270000E+07
POTENTIAL TRANSPORT (tons/day):  VF SAND 0.326022E+04  VF GRVL 0.230126E+01
                                 F  SAND 0.107158E+04  F  GRVL 0.328571E-03
                                 M  SAND 0.638850E+03  M  GRVL 0.100000E-06
                                 C  SAND 0.495316E+03  C  GRVL 0.100000E-06
                                 VC SAND 0.491224E+03  VC GRVL 0.100000E-06
```

```
  SEDIMENT OUTFLOW FROM SECTION NO.     15.000
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ---------------------------------------------------------------------------
    VERY FINE SAND....        138.47  |  VERY FINE GRAVEL..         0.18
    FINE SAND.........         75.72  |  FINE GRAVEL.......         0.00
    MEDIUM SAND.......        168.18  |  MEDIUM GRAVEL.....         0.00
    COARSE SAND.......        162.61  |  COARSE GRAVEL.....         0.00
    VERY COARSE SAND..         47.90  |  VERY COARSE GRAVEL         0.00


TABLE SA-1. TRAP EFFICIENCY ON STREAM SEGMENT #  1
            EXAMPLE PROBLEM NO 3.  MOVABLE BED
            ACCUMULATED AC-FT ENTERING AND LEAVING THIS STREAM SEGMENT
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *   INFLOW   OUTFLOW  TRAP EFF *
   53.00      58.000 *     13.25                     *
              53.000 *     16.13                     *
              42.000 *      0.36                     *
   TOTAL=     35.000 *     29.74      5.52      0.81 *
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *   INFLOW   OUTFLOW  TRAP EFF *
   53.00      35.000 *      5.52                     *
   TOTAL=     33.000 *      5.52      1.54      0.72 *
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *   INFLOW   OUTFLOW  TRAP EFF *
   53.00      33.000 *      1.54                     *
              15.000 *      1.00                     *
   TOTAL=      1.000 *      2.54      0.07      0.97 *
******************************************************

TABLE SB-1:  SEDIMENT LOAD PASSING THE  BOUNDARIES OF STREAM SEGMENT #  1
-------------------------------------------------------------------------------
  SEDIMENT INFLOW at the Upstream Boundary:
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ---------------------------------------------------------------------------
    VERY FINE SAND....         66.90  |  VERY FINE GRAVEL..         0.00
    FINE SAND.........         53.32  |  FINE GRAVEL.......         0.00
    MEDIUM SAND.......         29.58  |  MEDIUM GRAVEL.....         0.00
    COARSE SAND.......          0.01  |  COARSE GRAVEL.....         0.00
    VERY COARSE SAND..          0.00  |  VERY COARSE GRAVEL         0.00
                        -------------                        -------------
                                                 TOTAL =       149.81
  SEDIMENT OUTFLOW from the Downstream Boundary
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ---------------------------------------------------------------------------
    VERY FINE SAND....          2.05  |  VERY FINE GRAVEL..         0.00
    FINE SAND.........          1.13  |  FINE GRAVEL.......         0.00
    MEDIUM SAND.......          2.94  |  MEDIUM GRAVEL.....         0.00
    COARSE SAND.......          2.79  |  COARSE GRAVEL.....         0.00
    VERY COARSE SAND..          1.08  |  VERY COARSE GRAVEL         0.00
                        -------------                        -------------
                                                 TOTAL =         9.99

TABLE SB-2:  STATUS OF THE BED PROFILE AT TIME =    53.000 DAYS
-------------------------------------------------------------------------------
  SECTION   BED CHANGE   WS ELEV   THALWEG        Q      TRANSPORT RATE (tons/day)
  NUMBER       (ft)       (ft)      (ft)        (cfs)       SAND
     58.000      -0.83    979.94    974.57        682.        818.
     55.000       0.04    979.11    972.94        682.       1476.
     53.000       0.25    975.42    972.45       1022.       4056.
     44.000       0.19    974.82    967.29       1022.        560.
     42.000       0.94    974.43    970.74       1100.         15.
     35.000       0.17    974.00    963.47       1100.          6.
     33.900       0.48    966.96    963.13       1100.        528.
     33.300       0.13    966.48    962.62       1100.        442.
     33.000       0.36    966.00    961.36       1100.        156.
     32.100      -0.20    964.81    956.30       1100.        208.
     32.000      -0.15    963.90    956.35       1100.        668.
     15.000      -0.19    960.48    953.51       1250.        593.
      1.000       1.07    960.00    945.77       1250.         10.

Accumulated Water Discharge from day zero (sfd)
     MAIN
  127750.00

---------------------------------------------------------------------------------------
$PRT   A
...Selective Printout Option
   A - Print at all cross sections

=======================================================================================
TIME STEP #       4
Q    B     FLOW 4 = BASE FLOW OF 750 CFS

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
EXAMPLE PROBLEM NO 3.  MOVABLE BED
       ACCUMULATED TIME (yrs)....      0.148
       FLOW DURATION (days)......      1.000
```

```
UPSTREAM BOUNDARY CONDITIONS
----------------------------------------------------------------------
Stream Segment # 1      |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
Section No.     58.000 |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
                INFLOW |        532.00 |         93.30 |       63.44

Upstream of SECTION NO.     53.000 is...
LOCAL INFLOW POINT # 3 |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |        532.00 |         93.30 |       63.44
      LOCAL     INFLOW |        128.00 |         43.20 |       67.00
----------------------------------------------------------------------
                 TOTAL |        660.00 |        136.50 |       64.13

Upstream of SECTION NO.     42.000 is...
LOCAL INFLOW POINT # 2 |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |        660.00 |        136.50 |       64.13
      LOCAL     INFLOW |         29.00 |          1.22 |       70.00
----------------------------------------------------------------------
                 TOTAL |        689.00 |        137.72 |       64.38

Upstream of SECTION NO.     15.000 is...
LOCAL INFLOW POINT # 1 |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |        689.00 |        137.72 |       64.38
      LOCAL     INFLOW |         61.00 |          4.32 |       72.00
----------------------------------------------------------------------
                 TOTAL |        750.00 |        142.04 |       65.00

TABLE SA-1. TRAP EFFICIENCY ON STREAM SEGMENT #  1
            EXAMPLE PROBLEM NO 3.  MOVABLE BED
            ACCUMULATED AC-FT ENTERING AND LEAVING THIS STREAM SEGMENT
******************************************************
    TIME       ENTRY *          SAND               *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   54.00      58.000 *     13.29                    *
              53.000 *     16.15                    *
              42.000 *      0.36                    *
   TOTAL=     35.000 *     29.81      5.52     0.81 *
******************************************************
    TIME       ENTRY *          SAND               *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   54.00      35.000 *      5.52                    *
   TOTAL=     33.000 *      5.52      2.04     0.63 *
******************************************************
    TIME       ENTRY *          SAND               *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   54.00      33.000 *      2.04                    *
              15.000 *      1.00                    *
   TOTAL=      1.000 *      3.04      0.08     0.97 *
******************************************************

TABLE SB-1:  SEDIMENT LOAD PASSING THE  BOUNDARIES OF STREAM SEGMENT #  1
--------------------------------------------------------------------------------
  SEDIMENT INFLOW at the Upstream Boundary:
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ----------------------------------------------------------------------------
    VERY FINE SAND....         38.08  | VERY FINE GRAVEL..          0.00
    FINE SAND.........         34.16  | FINE GRAVEL.......          0.00
    MEDIUM SAND.......         21.06  | MEDIUM GRAVEL.....          0.00
    COARSE SAND.......          0.00  | COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          0.00  | VERY COARSE GRAVEL          0.00
                        -------------                    -------------
                                                 TOTAL =        93.30
  SEDIMENT OUTFLOW from the Downstream Boundary
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ----------------------------------------------------------------------------
    VERY FINE SAND....          6.28  | VERY FINE GRAVEL..          0.15
    FINE SAND.........          2.82  | FINE GRAVEL.......          0.19
    MEDIUM SAND.......          6.67  | MEDIUM GRAVEL.....          0.07
    COARSE SAND.......          6.38  | COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          2.69  | VERY COARSE GRAVEL          0.00
                        -------------                    -------------
                                                 TOTAL =        25.24

TABLE SB-2:  STATUS OF THE BED PROFILE AT TIME =    54.000 DAYS
--------------------------------------------------------------------------------
  SECTION   BED CHANGE   WS ELEV   THALWEG        Q      TRANSPORT RATE (tons/day)
  NUMBER       (ft)       (ft)      (ft)        (cfs)        SAND
     58.000      -0.94    979.24    974.46        532.        415.
     55.000       0.00    978.47    972.90        532.        833.
     53.000       0.23    974.73    972.43        660.       1274.
     44.000       0.22    974.40    967.32        660.        138.
     42.000       0.94    974.18    970.74        689.          1.
     35.000       0.17    974.00    963.47        689.          0.
     33.900       0.40    965.77    963.05        689.        433.
     33.300       0.11    965.05    962.60        689.        713.
     33.000       0.33    963.74    961.33        689.       1000.
```

```
     32.100      -0.10    963.74    956.40        689.         49.
     32.000      -0.18    963.13    956.32        689.        694.
     15.000      -0.24    957.66    953.46        750.       1530.
      1.000       1.22    957.00    945.92        750.         25.

------------------------------------------------------------------------------------------
$$END

       0   DATA ERRORS DETECTED.

TOTAL NO. OF TIME STEPS READ =         4
TOTAL NO. OF WS PROFILES =             4
ITERATIONS IN EXNER EQ =             260

COMPUTATIONS COMPLETED
RUN TIME =  0 HOURS,  0 MINUTES &  2.00 SECONDS
```

6.4 Example Problem 4 - Some Sediment Options

Several options are available in HEC-6 to control sedimentation. Among these are dredging, transmissive boundary conditions, an alternate bed roughness computation method, and the opportunity to enter a new sediment load table or rating curve at any point in the hydrograph. In any study, selection and use of any of these options must be based on sound engineering analysis. Example Problem 4 illustrates how to use these options.

The data for this example problem (shown in Table 6-4a) also shows the use of output control to select output at specified cross sections ($PRT and PN) and request cumulative volumes of sediment passing each cross section ($VOL). Table 6-4b shows the simulation output for this example; since the output produced by the geometry and sediment input data does not differ from that of Example Problem 3, it has been omitted from Table 6-4b.

6.4.1 Dredging

Frequent dredging occurs in the reach bounded by Sections 35.0 and 44.0. The geometric data for the cross sections in this reach were modified via the HD record to identify the dredged channel template. The dredging option is activated by a $DREDGE record in the flow data and will be performed at the start of each time step until deactivated by a $NODREDGE record.

The default output produced by the dredging option is limited to the quantity of material removed from the bed and is only given for those cross sections at which material was removed. The output for Example Problem 4 (Table 6-4b), shows that the dredging algorithm was initiated before time step 2 and terminated after time step 3. The table labelled "TONS OF SEDIMENT DREDGED FROM THIS REACH" indicates that prior to time step 3, 13568.3 tons of material was dredged from Sections 42.0 and 44.0.

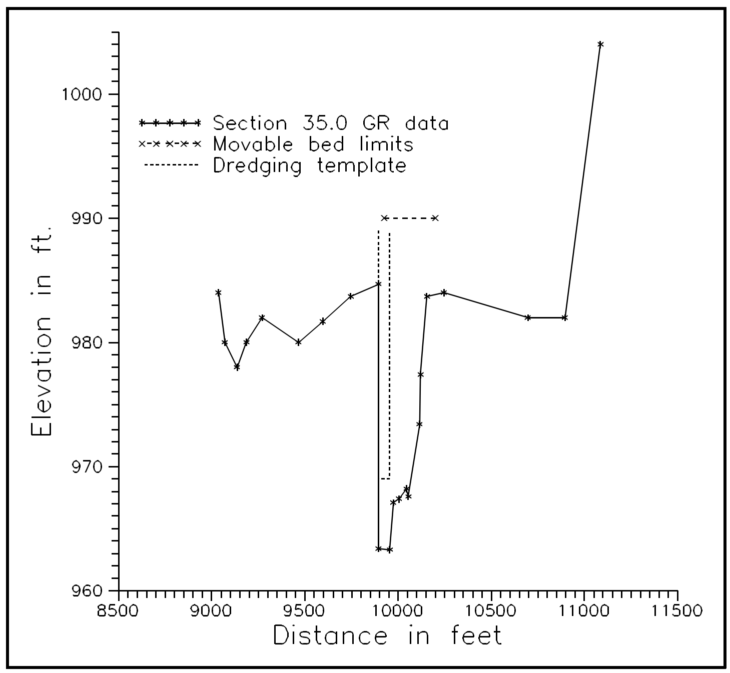

Figure 6-4
Cross Section 35.0, Example Problem 4

Table 6-4a
Example Problem 4 - Input
Sediment Options

```
T1      EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.
T2      3 LOCAL INFLOWS
T3      SOUTH FORK, ZUMBRO RIVER     ** Example Problem 4 **
NC    .1      .1     .04      .1       .3
X1   1.0      31  10077.  10275.      0.       0.       0.
GR 1004.   9915.   978.4  10002.   956.0  10060.   959.2  10077.   959.3  10081.
GR 950.0  10092.  948.48  10108.   946.6  10138.   944.7  10158.   955.2  10225.
GR 956.2  10243.   958.9  10250.   959.8  10275.   959.8  10300.   959.9  10325.
GR 958.8  10350.   957.4  10400.   970.0  10700.   966.0  10960.   970.0  11060.
GR 968.0  11085.   968.0  11240.   970.0  11365.   970.0  11500.   970.0  11615.
GR 962.0  11665.   962.0  12400.   976.0  12550.   980.0  12670.   982.0  12730.
GR 984.0  12735.
HD   1.0     10.  10081.  10250.
```

```
NV    22    .045   965.6    .064   988.8
NV    12     .08   965.6     .13   988.8
NV    33      .1   965.6     .11   982.0     .12   988.8
X1  15.0      27  10665.  10850.   3560.   3030.   3280.
X3                        10700.   961.0  11000.   970.0
GR 992.0   9570.   982.0  10110.   976.0  10300.   976.0  10490.   966.0  10610.
GR 964.7  10665.   956.0  10673.   953.0  10693.   954.0  10703.   955.6  10723.
GR 958.6  10750.   959.3  10800.   957.0  10822.   957.3  10825.   961.5  10850.
GR 962.0  10852.   964.0  10970.   966.0  11015.   961.0  11090.   962.0  11150.
GR 970.0  11190.   972.0  11310.   980.0  11410.   984.0  11570.   990.0  11770.
GR 990.0  11865.  1000.0  12150.
HD  15.0     10.  10673.  10852.
  CASCADE CREEK - Local Inflow
QT
NC    .1      .1     .05
X1  32.0      29 10057.0 10271.0   3630.   3060.   4240.
GR 998.0   9080.   982.0   9250.   982.0   9510.   980.0   9600.  980.01   9925.
GR979.48  10000.   978.5  10057.   968.6  10075.  959.82  10087.   956.5  10097.
GR 956.8  10117.   957.8  10137.   959.4  10157.   959.6  10177.   959.8  10196.
GR 966.5  10225.   971.2  10250.   978.5  10271.   978.5  10300.   978.6  10350.
GR978.91  10370.  978.96  10387.   980.0  10610.   982.0  10745.   982.0  11145.
GR 984.0  11150.   992.0  11240.  1000.0  11330.   1008.  11425.
HD  32.0     10.  10075.  10275.
  Section 32.1 is a duplicate of Sec 32.0 - Needed to model IBC at Sec 33.0
X1  32.1      29 10057.0 10271.0   3130.   3250.   3320.
X3    10
GR 998.0   9080.   982.0   9250.   982.0   9510.   980.0   9600.  980.01   9925.
GR979.48  10000.   978.5  10057.   968.6  10075.  959.82  10087.   956.5  10097.
GR 956.8  10117.   957.8  10137.   959.4  10157.   959.6  10177.   959.8  10196.
GR 966.5  10225.   971.2  10250.   978.5  10271.   978.5  10300.   978.6  10350.
GR978.91  10370.  978.96  10387.   980.0  10610.   982.0  10745.   982.0  11145.
GR 984.0  11150.   992.0  11240.  1000.0  11330.   1008.  11425.
HD  32.1     10.  10075.  10275.
  A spillway is located here.
X1  33.0      21   1850.   2150.       0       0       0
X5                             2
XL                  250.
GR 1000.    980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.   3170.
HD  33.0      0.   1851.   2149.
  Section 33.3 is a duplicate of Section  33.0.
X1  33.3      21   1850.   2150.   1550.   1750.   1750.     .95    1.49
XL                  250.
GR 1000.    980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.   3170.
HD  33.3      0.   1851.   2149.
  Section 33.9 is a duplicate of Sec 33.3 - Needed to model IBC at Sec 35.0
X1  33.9      21   1850.   2150.   1050.   1050.   1050.     .95    1.65
X3    10
GR 1000.    980.   990.0   1060.   980.0   1150.   982.0   1180.   982.0   1215.
GR 980.0   1260.   982.0   1300.   982.0   1350.   980.0   1420.   980.0   1540.
GR 982.0   1730.   982.0   1830.  984.41   1850.  979.19   1851.   961.0  1900.8
GR 961.0  2099.2   976.0   2149.   984.5   2150.   982.0   2800.   990.0   3100.
GR 1000.   3170.
HD  33.9      0.   1851.   2149.
  A weir is located here.
X1  35.0      22   9894.  10245.       0       0       0
X3    10
X5          974.     0.5
GR 984.0   9035.   980.0   9070.   978.0   9135.   980.0   9185.   982.0   9270.
GR 980.0   9465.   981.7   9595.   983.7   9745.   984.7   9894.   963.4  9894.1
GR 963.3   9954.   967.1   9974.   967.4  10004.   968.2  10044.   967.6  10054.
GR 973.4  10115.   977.4  10120.   983.7  10155.   984.0  10245.   982.0  10695.
GR 982.0  10895.  1004.0  11085.
HD  35.0      0.   9954.  10155.           969.0   9894.   9954.             1.0
    - - -  SILVER LAKE  - - -
NC   .06     .06    .045
X1  42.0      32   9880.  10130.   5370.   5000.   5210.
GR 996.0   7130.   998.0   7310.   998.0   7930.   992.0   8205.   990.0   8495.
GR 988.0   8780.   986.0   8990.   985.7   9570.  986.45   9707.  989.44   9857.
GR 990.0   9880.   969.8   9881.   969.8   9941.   985.8   9941.   985.8   9943.
GR 969.8   9943.   969.8  10001.   986.7  10001.   986.7  10003.   969.8  10003.
GR 969.8  10067.   985.8  10067.   985.8  10069.   969.8  10069.   969.8  10129.
GR 989.9  10130.   989.5  10180.   988.6  10230.   987.6  10280.   985.2  10430.
GR 986.8  11720.   989.9  12310.
HD  42.0      0.   9881.  10021.           971.0   9881.   9941.             1.0
  SILVER CREEK - Local Inflow
QT
X1  44.0      28   9845.  10127.   3200.   3800.   3500.
XL                         9850.  10200.
```

```
GR 1002.   8035.   992.0   8150.   990.0   8305.   990.0   8735.   988.0   8835.
GR 996.0   9285.  1017.6   9425.   990.0   9505.   986.0   9650.   984.1   9788.
GR 980.6   9845.   970.9   9868.   972.2   9898.   970.5   9968.   967.5   9998.
GR 968.9  10028.   967.4  10058.   967.1  10078.   971.9  10118.   976.8  10127.
GR 977.8  10150.   976.9  10193.   982.0  10206.   981.2  10300.   979.2  10325.
GR 983.1  10400.   999.8  10450.  1002.4  10464.
HD  44.0      1.   9868.  10193.           971.0   9968.  10028.             1.0
X1  53.0      22  10000.  10136.   3366.   2832.   2942.
GR 1004.   7550.  1000.0   7760.   998.0   8440.   996.0   8640.   996.0   8780.
GR 994.0   8940.   986.0   9245.   986.3   9555.   986.3   9825.   983.8   9900.
GR 982.8  10000.   978.2  10011.   974.0  10041.   972.2  10071.   972.6  10101.
GR 978.2  10121.   988.7  10136.   989.3  10154.   999.2  10200.  1000.1  10320.
GR 1002.  10470.  1004.0  10700.
HD  53.0     10.  10000.  10136.
  BEAR CREEK - Local Inflow
QT
X1  55.0      18   9931.  10062.   2275.   3430.   2770.
GR 1004.   7592.  1000.0   7947.   996.0   8627.   990.0   9052.   986.0   9337.
GR 984.3   9737.   984.7   9837.   985.5   9910.   987.2   9931.   978.1   9955.
GR 974.8   9975.   974.2  10005.   972.9  10035.   973.2  10045.   983.8  10062.
GR 985.8  10187.   986.0  10307.   990.0  10497.
HD  55.0     10.   9931.  10062.
X1  58.0      22   9912.  10015.   1098.   1012.   1462.
GR 1006.   8542.  1004.0   8952.  1000.0   9702.   997.2   9812.   996.3   9912.
GR 976.2   9944.   975.4   9974.   978.2   9991.   990.4  10015.   988.3  10062.
GR 988.8  10065.   988.3  10065.   989.3  10169.   990.0  10172.   992.0  10242.
GR 992.0  10492.   988.0  10642.   986.7  10852.   988.0  11022.   986.0  11097.
GR 986.0  11137.   988.0  11192.
HD  58.0     3.4   9912.  10015.
EJ
T4      South Fork, Zumbro River - Stream Segment 1      ** Example Problem 4 **
T5      LOAD CURVE FROM GAGE DATA.
T6      BED GRADATIONS FROM FIELD SAMPLES.
T7      FULL RANGE OF SANDS AND GRAVELS
T8      SEDIMENT TRANSPORT BY YANG'S STREAM POWER [REF-ASCE JOURNAL (YANG 1971)]
I1             5
I4  SAND       4       1      10
I5            .5      .5     .25      .5     .25       0     1.0
LQ             1      50    1000    5800   90000
LT TOTAL   .0110     1.5     320   4500.  400000
LF   VFS    .119    .119    .498    .511    .582
LF    FS    .328    .328    .331    .306    .280
LF    MS    .553    .553    .156    .154    .110
LF    CS    .000    .000    .011    .016    .020
LF   VCS    .000    .000    .004    .008    .005
LF   VFG    .000    .000    .000    .004    .002
LF    FG    .000    .000    .000    .001    .001
LF    MG    .000    .000    .000    .000    .000
LF    CG    .000    .000    .000    .000    .000
LF   VCG      .0      .0    .000    .000    .000
PF EXAMP     1.0     1.0    32.0    16.0    96.5     8.0    95.0     4.0    91.0
PFC  2.0    85.0     1.0    73.0      .5    37.0     .25     8.0    .125     1.0
PFC.0625     0.0
PF EXAMP    32.0     1.0    64.0    32.0    99.5    16.0    99.0     8.0    98.5
PFC  4.0    96.0     2.0    93.5     1.0    83.0     .50    45.5    .250     8.0
PFC .125     1.0   .0625     0.0
PF EXAMP    58.0     1.0    64.0    32.0    97.0    16.0    94.0     8.0    94.0
PFC  4.0    90.0     2.0    79.0     1.0    56.0     .50     4.0    .125     0.0
$LOCAL
  LOAD TABLE - CASCADE CREEK - A LOCAL INFLOW
LQL            1     100    1000   10000
LTLTOTAL   .0040      10     500   30000
LFL  VFS    .664    .664    .015    .198
LFL   FS    .207    .207    .245    .181
LFL   MS    .086    .086    .605    .107
LFL   CS    .031    .031    .052    .098
LFL  VCS    .008    .008    .039    .127
LFL  VFG   .0030   .0030   .0200   .1160
LFL   FG   .0010   .0010   .0110   .0910
LFL   MG   .0000   .0000   .0110   .0530
LFL   CG   .0000   .0000   .0000   .0220
LFL  VCG   .0000   .0000   .0000   .0060
  LOAD TABLE - SILVER CREEK - A LOCAL INFLOW
LQL            1     100    1000   10000
LTLTOTAL   .0040      10     500   30000
LFL  VFS    .664    .664    .015    .198
LFL   FS    .207    .207    .245    .181
LFL   MS    .086    .086    .605    .107
LFL   CS    .031    .031    .052    .098
LFL  VCS    .008    .008    .039    .127
LFL  VFG   .0030   .0030   .0200   .1160
LFL   FG   .0010   .0010   .0110   .0910
LFL   MG   .0000   .0000   .0110   .0530
LFL   CG   .0000   .0000   .0000   .0220
LFL  VCG   .0000   .0000   .0000   .0060
```

```
  LOAD TABLE - BEAR CREEK - A LOCAL INFLOW
LQL           1.    100.    500.   1000.  30000.
LTLTOTAL   .0020    30.0    500.    1200   22500
LFL  VFS    .201    .201    .078    .078    .137
LFL   FS    .342    .342    .172    .175    .218
LFL   MS    .451    .451    .454    .601    .476
LFL   CS    .001    .001    .197    .142    .158
LFL  VCS    .000    .000    .000    .003    .008
LFL  VFG   .0000   .0000   .0000   .0000   .0020
LFL   FG   .0000    .000   .0000   .0000   .0010
LFL   MG   .0000    .000   .0000   .0000   .0000
LFL   CG   .0000    .000   .0000   .0000   .0000
LFL  VCG   .0000    .000   .0000   .0000   .0000
$HYD
$B            2
$KL
Q    A     FLOW 1 = BASE FLOW 0F 750 CFS
Q   750.     61.     29.    128.
R   956.    962.
T    65.     72.     70.     67.
W     2.
$DREDGE
Q    B     FLOW 2 = 50 DAYS AT BANK FULL DISCHARGE
Q  2500.    300.    150.    650.
R   965.    970.
X            2.5     50.
Q          FLOW 3 = NEAR BANK FULL DISCHARGE
Q  1250.    150.     78.    340.
R   960.    966.
W     1.
$SED
  NEW LOAD TABLE FOR MAIN STEM...
LPOINT        1       0
LQ            1      50    1000    5800   90000
LT TOTAL   .0110     1.5     320   4500.  400000
LF   VFS    .119    .119    .498    .511    .582
LF    FS    .328    .328    .331    .306    .280
LF    MS    .553    .553    .156    .154    .110
LF    CS    .345    .345    .011    .016    .020
LF   VCS    .025    .025    .004    .008    .005
LF   VFG    .005    .005    .000    .004    .002
LF    FG    .000    .000    .000    .001    .001
LF    MG    .000    .000    .000    .000    .000
LF    CG    .000    .000    .000    .000    .000
LF   VCG      .0      .0    .000    .000    .000
  NEW LOAD TABLE FOR SILVER CREEK - A LOCAL INFLOW
LPOINT        1       2
LQL           1     100    1000   10000
LTLTOTAL   .0040      10     500   30000
LFL  VFS    .664    .664    .015    .198
LFL   FS    .207    .207    .245    .181
LFL   MS    .086    .086    .605    .107
LFL   CS    .031    .031    .052    .098
LFL  VCS    .008    .008    .039    .127
LFL  VFG   .0030   .0030   .0200   .1160
LFL   FG   .0010   .0010   .0110   .0910
LFL   MG   .0000   .0000   .0110   .0530
LFL   CG   .0000   .0000   .0000   .0220
LFL  VCG   .0000   .0000   .0000   .0060
END
$RATING
RC           40    2000       0       0   950.0   955.1   958.0   960.0   962.0
RC        963.6   965.1   966.2   967.0   967.7   968.3   968.9   969.4   969.8
RC        970.2   970.6   971.0   971.4   971.8   972.1   972.4   972.7   972.9
RC        973.1   973.3   973.5   973.7   973.8   973.9   974.0   974.1   974.2
RC        974.3   974.4   974.5   974.6   974.7   974.8   974.9   975.0
$PRT
CP            1
PS          1.0    15.0
END
$NODREDGE
Q    C     FLOW 4 = BASE FLOW OF 750 CFS
Q   750.     61.     29.    128.
R   957.    963.
W     1.
$VOL   A
$$END
```

6.4.2 Transmissive Boundary Condition

With the addition of the $B record at the beginning of the hydrologic data, HEC-6 implements a transmissive boundary condition at each downstream boundary. This option causes all inflowing sediment to pass through the affected cross section without interacting with the bed. A caution: this option applies to all downstream boundaries in the model.

As in Example Problems 2 and 3, this example has two internal boundary conditions which effectively divide the model into 3 subreaches, each with its own downstream boundary.

The effect of the transmissive boundary condition on the 3 downstream boundaries can be seen by carefully reviewing the output of Example Problem 4. For instance, looking at TABLE SB-2 for the last time step, Sections 35.0, 33.0, and 1.0 all show that no bed change has occurred after a simulation of 52 days.

6.4.3 Limerinos' Bed Form Roughness Function

The Limerinos function (16) for bed form roughness is used in this example ($KL record). The value of Manning's *n* resulting from this computation can be found in the "HYDRAULIC PARAMETERS" table of the C-level sediment output. For example, the *n* value calculated by the Limerinos equation for the last time step for Section No. 42.1 is 0.0153. Note, this computation overrides the roughness data (NC and NV records) in the geometric data.

6.4.4 Flow Duration Option

The use of X rather than W data to select the time step is also illustrated in this problem. This option allows a long period of constant flow to be subdivided into multiple computational time steps without repeating Q, Q, W data.

In this example, time step 2 represents 20 separate (incremental or computational) time steps each having a duration of 2.5 days. At the end of the last incremental time step, output is produced depicting the state of the river system for the last 2.5 day time step (i.e., instantaneous data such as the sediment load data in TABLE SB-2 are only for the last 2.5 day time step, while cumulative data, such as trap efficiency and bed change, represent changes since the start of the simulation.) Caution, because of this dichotomy, output produced by a time step such as this can be misleading. See Example Problem 7, Section 6.7.2.

6.4.5 Modifying the Sediment Load Tables

Sometimes the inflowing water vs. sediment relationship will change in time due to land use changes or even seasonal variations in vegetation. Such changes, should they be known or predicted, can be described in the flow data by using the $SED option. Example Problem 4 demonstrates the use of this option by changing the inflowing load curve for the main river and one local inflowing load curve prior to the last flow in the hydrograph. Tables echoing this data are shown in the output after time step 3.

6.4.6 Downstream Rating Curve

Prior to the last time step, a rating curve ($RATING) was added to replace the stage hydrograph (R records). Although a rating curve is usually defined prior to the first time step, it can be placed (or replaced) before any time step of the simulation.

6.4.7 Accumulated Sediment Transported

Summary information regarding weight and volume of sediment can be requested via the A-level output option on the $VOL record. A-level output begins with the table labelled "SUMMARY TABLE: MASS AND VOLUME OF SEDIMENT". This table lists cumulative values of sediment transported through and deposited at each cross section since time zero. The difference between the sediment volume entering and leaving a cross section represents the material scoured from or deposited into the control volume associated with that cross section. This value is given under the heading "SEDIMENT DEPOSITED IN REACH IN CUBIC YARDS"; negative values represent scour. Under the heading "TOTAL SEDIMENT per grain size THROUGH EACH CROSS SECTION" are tables listing the total sediment transported through each cross section's control volume since the start of the simulation by grain size. Because the $PRT option was invoked to limit output to Sections 1.0 and 15.0, only tables for these cross sections have been produced.

Table 6-4b
Example Problem 4 - Output
Sediment Options

```
***************************************************     **********************************
*  SCOUR AND DEPOSITION IN RIVERS AND RESERVOIRS  *     *  U.S. ARMY CORPS OF ENGINEERS   *
*       Version: 4.1.00 -  AUGUST 1993            *     *  HYDROLOGIC ENGINEERING CENTER  *
*  INPUT FILE:  example4.DAT                      *     *  609 SECOND STREET              *
*  OUTPUT FILE: example4.OUT                      *     *  DAVIS, CALIFORNIA 95616-4687   *
*  RUN DATE: 31 AUG 93    RUN TIME: 16:06:03      *     *  (916) 756-1104                 *
***************************************************     **********************************

                       X     X  XXXXXXX   XXXXX           XXXXX
                       X     X  X        X     X         X     X
                       X     X  X        X               X
                       XXXXXXX  XXXX     X       XXXXX   XXXXXX
                       X     X  X        X               X     X
                       X     X  X        X     X         X     X
                       X     X  XXXXXXX   XXXXX           XXXXX

         **********************************************************************
         *  MAXIMUM LIMITS FOR THIS VERSION ARE:                              *
         *       10  Stream Segments (Main Stem + Tributaries)                *
         *      150  Cross Sections                                           *
         *      100  Elevation/Station Points per Cross Section               *
         *       20  Grain Sizes                                              *
         *       10  Control Points                                           *
         **********************************************************************
```

The output produced during processing of the geometry and sediment data does not differ from that produced for Example Problem 3. It has therefore been omitted from this table. Refer to Table 6-3b.

```
==========================================================================================

$HYD
BEGIN COMPUTATIONS.

------------------------------------------------------------------------------------------
$B           2
...Transmissive Boundary Condition - ON

------------------------------------------------------------------------------------------
$KL
...USING LIMERINOS METHOD TO CALCULATE BED ROUGHNESS.

==========================================================================================
```

```
TIME STEP #       1
Q    A     FLOW 1 = BASE FLOW 0F 750 CFS

TABLE SA-1. TRAP EFFICIENCY ON STREAM SEGMENT #  1
            EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.
            ACCUMULATED AC-FT ENTERING AND LEAVING THIS STREAM SEGMENT
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
    2.00      58.000 *      0.09                     *
              53.000 *      0.04                     *
              42.000 *      0.00                     *
   TOTAL=     35.000 *      0.14      0.00      1.00 *
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
    2.00      35.000 *      0.00                     *
   TOTAL=     33.000 *      0.00      0.00      0.36 *
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
    2.00      33.000 *      0.00                     *
              15.000 *      0.00                     *
   TOTAL=      1.000 *      0.00      2.96   -692.13 *
******************************************************

------------------------------------------------------------------------------------------
$DREDGE
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

STREAM SEGMENT #  1: EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.

SEC NO.     42.000
ELEVATION OF DREDGED CHANNEL INCLUDING    1.00 FEET OF OVER DREDGING=     970.00

==========================================================================================
TIME STEP #       2
Q    B     FLOW 2 = 50 DAYS AT BANK FULL DISCHARGE
COMPUTING FROM TIME=      2.0000 DAYS TO TIME=     52.0000 DAYS IN    20 COMPUTATION STEPS

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.
       ACCUMULATED TIME (yrs)....      0.142
       FLOW DURATION (days)......      2.500

UPSTREAM BOUNDARY CONDITIONS
----------------------------------------------------------------------
Stream Segment # 1      |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
Section No.     58.000  |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
                 INFLOW |       1400.00 |        529.98 |       62.04

Upstream of SECTION NO.     53.000 is...
LOCAL INFLOW POINT # 3  |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                        |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW  |       1400.00 |        529.98 |       62.04
      LOCAL     INFLOW  |        650.00 |        647.71 |       67.00
----------------------------------------------------------------------
                  TOTAL |       2050.00 |       1177.69 |       63.61

Upstream of SECTION NO.     42.000 is...
LOCAL INFLOW POINT # 2  |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                        |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW  |       2050.00 |       1177.69 |       63.61
      LOCAL     INFLOW  |        150.00 |         14.45 |       70.00
----------------------------------------------------------------------
                  TOTAL |       2200.00 |       1192.13 |       64.05

Upstream of SECTION NO.     15.000 is...
LOCAL INFLOW POINT # 1  |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                        |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW  |       2200.00 |       1192.13 |       64.05
      LOCAL     INFLOW  |        300.00 |         40.00 |       72.00
----------------------------------------------------------------------
                  TOTAL |       2500.00 |       1232.13 |       65.00

TABLE SA-1. TRAP EFFICIENCY ON STREAM SEGMENT #  1
            EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.
            ACCUMULATED AC-FT ENTERING AND LEAVING THIS STREAM SEGMENT
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   52.00      58.000 *     13.17                     *
              53.000 *     16.03                     *
              42.000 *      0.36                     *
   TOTAL=     35.000 *     29.56      2.05      0.93 *
******************************************************
    TIME       ENTRY *             SAND              *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   52.00      35.000 *      2.05                     *
   TOTAL=     33.000 *      2.05      0.08      0.96 *
******************************************************
    TIME       ENTRY *             SAND              *
```

```
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   52.00      33.000 *      0.08                     *
              15.000 *      0.99                     *
   TOTAL=      1.000 *      1.07      3.42     -2.21 *
******************************************************

TABLE SB-1:  SEDIMENT LOAD PASSING THE  BOUNDARIES OF STREAM SEGMENT #  1
--------------------------------------------------------------------------------
  SEDIMENT INFLOW at the Upstream Boundary:
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ----------------------------------------------------------------------------
    VERY FINE SAND....        265.63  |  VERY FINE GRAVEL..          0.00
    FINE SAND.........        173.06  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......         82.59  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......          6.27  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          2.42  |  VERY COARSE GRAVEL          0.00
                       -------------                         -------------
                                                TOTAL =        529.98
  SEDIMENT OUTFLOW from the Downstream Boundary
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ----------------------------------------------------------------------------
    VERY FINE SAND....          1.42  |  VERY FINE GRAVEL..          0.03
    FINE SAND.........          1.61  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......          7.44  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......          9.01  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          3.68  |  VERY COARSE GRAVEL          0.00
                       -------------                         -------------
                                                TOTAL =         23.18

TABLE SB-2:  STATUS OF THE BED PROFILE AT TIME =    52.000 DAYS
--------------------------------------------------------------------------------
  SECTION   BED CHANGE   WS ELEV   THALWEG         Q      TRANSPORT RATE (tons/day)
  NUMBER       (ft)       (ft)      (ft)         (cfs)       SAND
     58.000      -2.79    978.33    972.61       1400.        577.
     55.000      -1.24    978.30    971.66       1400.        837.
     53.000      -1.55    976.02    970.65       2050.       1885.
     44.000       0.92    974.67    968.02       2050.       1258.
     42.000       1.75    974.19    971.55       2200.        138.
     35.000       0.00    974.00    963.30       2200.        138.
     33.900       0.69    970.03    963.34       2200.          9.
     33.300       0.01    970.01    962.50       2200.          4.
     33.000       0.00    970.00    961.00       2200.          4.
     32.100      -0.52    965.75    955.98       2200.        107.
     32.000      -0.05    965.23    956.45       2200.        138.
     15.000      -0.18    964.99    953.52       2500.         23.
      1.000       0.00    965.00    944.70       2500.         23.
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

STREAM SEGMENT #  1: EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.

SEC NO.     42.000
ELEVATION OF DREDGED CHANNEL INCLUDING    1.00 FEET OF OVER DREDGING=     970.00

SEC NO.     44.000
ELEVATION OF DREDGED CHANNEL INCLUDING    1.00 FEET OF OVER DREDGING=     970.00
TONS OF SEDIMENT DREDGED FROM THIS REACH=        13568.3 ACCUMULATED FROM DOWNSTREAM END=         13568.
                             CUBIC YARDS=        10807.1                                          10807.
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

STREAM SEGMENT #  1: EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.
------------------------------------------------------------------------------------------
$SED
LPOINT         1       0
SEDIMENT LOAD TABLE FOR STREAM SEGMENT #   1
          LOAD BY GRAIN SIZE CLASS (tons/day)
---------------------------------------------------------------------------
LQ       | 1.00000    | 50.0000    | 1000.00    | 5800.00    | 90000.0    |
          ------------ ------------ ------------ ------------ ------------
LF   VFS |0.130900E-02|0.178500    | 159.360    | 2299.50    | 232800.    |
LF    FS |0.360800E-02|0.492000    | 105.920    | 1377.00    | 112000.    |
LF    MS |0.608300E-02|0.829500    | 49.9200    | 693.000    | 44000.0    |
LF    CS |0.379500E-02|0.517500    | 3.52000    | 72.0000    | 8000.00    |
LF   VCS |0.275000E-03|0.375000E-01| 1.28000    | 36.0000    | 2000.00    |
LF   VFG |0.550000E-04|0.750000E-02|0.100000E-19| 18.0000    | 800.000    |
LF    FG |0.100000E-19|0.100000E-19|0.100000E-19| 4.50000    | 400.000    |
LF    MG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
LF    CG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
LF   VCG |0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|0.100000E-19|
          ------------ ------------ ------------ ------------ ------------
   TOTAL |0.151250E-01| 2.06250    | 320.000    | 4500.00    | 400000.    |
---------------------------------------------------------------------------

LPOINT         1       2
SEDIMENT LOAD TABLE FOR STREAM SEGMENT #   1
                 AT LOCAL INFLOW POINT #   2
          LOAD BY GRAIN SIZE CLASS (tons/day)
--------------------------------------------------------------
LQL      | 1.00000    | 100.000    | 1000.00    | 10000.0    |
          ------------ ------------ ------------ ------------
LFL  VFS |0.265600E-02| 6.64000    | 7.50000    | 5940.00    |
LFL   FS |0.828000E-03| 2.07000    | 122.500    | 5430.00    |
LFL   MS |0.344000E-03|0.860000    | 302.500    | 3210.00    |
LFL   CS |0.124000E-03|0.310000    | 26.0000    | 2940.00    |
LFL  VCS |0.320000E-04|0.800000E-01| 19.5000    | 3810.00    |
LFL  VFG |0.120000E-04|0.300000E-01| 10.0000    | 3480.00    |
LFL   FG |0.400000E-05|0.100000E-01| 5.50000    | 2730.00    |
```

```
LFL   MG |0.100000E-19|0.100000E-19| 5.50000    | 1590.00    |
LFL   CG |0.100000E-19|0.100000E-19|0.100000E-19| 660.000    |
LFL  VCG |0.100000E-19|0.100000E-19|0.100000E-19| 180.000    |
          ------------ ------------ ------------ ------------
   TOTAL |0.400000E-02| 10.0000    | 499.000    | 29970.0    |
--------------------------------------------------------------

-------------------------------------------------------------------------------------------
$RATING

Downstream Boundary Condition - Rating Curve
  Elevation      Stage     Discharge |  Elevation      Stage     Discharge
 ------------------------------------|-------------------------------------
    950.000     950.000        0.000 |    972.400     972.400    40000.000
    955.100     955.100     2000.000 |    972.700     972.700    42000.000
    958.000     958.000     4000.000 |    972.900     972.900    44000.000
    960.000     960.000     6000.000 |    973.100     973.100    46000.000
    962.000     962.000     8000.000 |    973.300     973.300    48000.000
    963.600     963.600    10000.000 |    973.500     973.500    50000.000
    965.100     965.100    12000.000 |    973.700     973.700    52000.000
    966.200     966.200    14000.000 |    973.800     973.800    54000.000
    967.000     967.000    16000.000 |    973.900     973.900    56000.000
    967.700     967.700    18000.000 |    974.000     974.000    58000.000
    968.300     968.300    20000.000 |    974.100     974.100    60000.000
    968.900     968.900    22000.000 |    974.200     974.200    62000.000
    969.400     969.400    24000.000 |    974.300     974.300    64000.000
    969.800     969.800    26000.000 |    974.400     974.400    66000.000
    970.200     970.200    28000.000 |    974.500     974.500    68000.000
    970.600     970.600    30000.000 |    974.600     974.600    70000.000
    971.000     971.000    32000.000 |    974.700     974.700    72000.000
    971.400     971.400    34000.000 |    974.800     974.800    74000.000
    971.800     971.800    36000.000 |    974.900     974.900    76000.000
    972.100     972.100    38000.000 |    975.000     975.000    78000.000

-------------------------------------------------------------------------------------------

$PRT
...Selective Printout Option
    - Print at the following cross sections
CP            1
PS           1.0    15.0
END

-------------------------------------------------------------------------------------------

$NODREDGE


===========================================================================================
TIME STEP #       4
Q    C     FLOW 4 = BASE FLOW OF 750 CFS

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.
       ACCUMULATED TIME (yrs)....      0.148
       FLOW DURATION (days)......      1.000

UPSTREAM BOUNDARY CONDITIONS
----------------------------------------------------------------------
Stream Segment # 1      |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
Section No.     58.000 |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
                INFLOW |        532.00 |         96.26 |       63.44

  SEDIMENT INFLOW at SECTION NO.     58.000
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  ---------------------------------------------------------------------------
    VERY FINE SAND....          38.08  |  VERY FINE GRAVEL..          0.00
    FINE SAND.........          34.16  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......          21.06  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......           2.35  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..           0.61  |  VERY COARSE GRAVEL          0.00
                       -------------                        -------------
                                                  TOTAL =          96.26

    FALL VELOCITIES - Method 2
              DIAMETER   VELOCITY       REY. NO.          CD
    ------------------------------------------------------------
    VF SAND   0.000290  0.1895778E-01  0.4746927       57.11272
    F  SAND   0.000580  0.5840962E-01   2.925091       12.03287
    M  SAND   0.001160  0.1341560      13.43676        4.561910
    C  SAND   0.002320  0.2818261      56.45410        2.067449
    VC SAND   0.004640  0.4816294      192.9560        1.415800
    VF GRVL   0.009280  0.7196122      576.5988        1.268414
    F  GRVL   0.018559   1.040018      1666.653        1.214521
    M  GRVL   0.037118   1.472894      4720.706        1.211086
    C  GRVL   0.074237   2.082985      13352.15        1.211086
    VC GRVL   0.148474   2.945788      37765.65        1.211086

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
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Upstream of SECTION NO.     15.000 is...
LOCAL INFLOW POINT # 1 |   DISCHARGE   | SEDIMENT LOAD | TEMPERATURE
                       |     (cfs)     |  (tons/day)   |   (deg F)
----------------------------------------------------------------------
      MAIN STEM INFLOW |        689.00 |        140.68 |       64.38
      LOCAL     INFLOW |         61.00 |          4.32 |       72.00
----------------------------------------------------------------------
                 TOTAL |        750.00 |        145.00 |       65.00

  SEDIMENT LOAD FROM LOCAL INFLOW:
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....          2.87  |  VERY FINE GRAVEL..         0.01
    FINE SAND.........          0.89  |  FINE GRAVEL.......         0.00
    MEDIUM SAND.......          0.37  |  MEDIUM GRAVEL.....         0.00
    COARSE SAND.......          0.13  |  COARSE GRAVEL.....         0.00
    VERY COARSE SAND..          0.03  |  VERY COARSE GRAVEL         0.00
                       -------------                     -------------
                                             TOTAL =            4.32

    FALL VELOCITIES - Method 2
              DIAMETER   VELOCITY       REY. NO.          CD
    ------------------------------------------------------------
    VF SAND   0.000290  0.1931441E-01  0.4941259       55.02308
    F  SAND   0.000580  0.5916114E-01   3.027072       11.72910
    M  SAND   0.001160  0.1355164      13.86779        4.470784
    C  SAND   0.002320  0.2833008      57.98200        2.045980
    VC SAND   0.004640  0.4824925      197.4999        1.410740
    VF GRVL   0.009280  0.7200893      589.5120        1.266733
    F  GRVL   0.018559   1.040325      1703.352        1.213806
    M  GRVL   0.037118   1.472894      4823.231        1.211086
    C  GRVL   0.074237   2.082985      13642.13        1.211086
    VC GRVL   0.148474   2.945788      38585.85        1.211086


*****************************************************************************************
                  TRACE OUTPUT FOR SECTION NO.     15.000
           -------------------------------------------------------

HYDRAULIC PARAMETERS:
      VEL      SLO        EFD        EFW     N-VALUE     TAU      USTARM    FROUDE NO.
     4.382  0.000558     4.555     72.960    0.0167   0.15863   0.28588     0.362

BED SEDIMENT CONTROL VOLUME COMPUTATIONS:
NEW SURFACE AREA (SQ FT):     TOTAL        K-PORTION      S-PORTION
                             336901.25     336901.25           0.00

GRADATION OF ACTIVE PLUS INACTIVE DEPOSITS
BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.010519      1.051939     VF GRVL      0.045573     93.063185
                       F  SAND      0.068551      7.907044     F  GRVL      0.034049     96.468071
                       M  SAND      0.324948     40.401812     M  GRVL      0.010808     97.548838
                       C  SAND      0.367062     77.107991     C  GRVL      0.022292     99.777989
                       VC SAND      0.113979     88.505902     VC GRVL      0.002220     99.999998

SAND
** ARMOR LAYER **
STABILITY COEFFICIENT=     0.80177
MIN.GRAIN DIAM      =    0.030569
BED SURFACE EXPOSED  =     0.00000

        INACTIVE LAYER      ACTIVE LAYER
         %       DEPTH      %      DEPTH
 CLAY   0.0000    0.00     0.0000   0.00
 SILT   0.0000    0.00     0.0000   0.00
 SAND   1.0000    9.25     1.0000   0.57
TOTAL   1.0000    9.25     1.0000   0.57

       AVG. UNIT              AVG. UNIT
         WEIGHT                 WEIGHT
        0.046500               0.046500

    COMPOSITE UNIT WT OF ACTIVE LAYER   (t/cf)=       0.046500
    COMPOSITE UNIT WT OF INACTIVE LAYER (t/cf)=       0.046500
    DEPTH OF SURFACE LAYER (ft)          DSL=            0.1
    WEIGHT IN SURFACE LAYER (tons)      WTSL=         1305.5
    DEPTH OF NEW ACTIVE LAYER (ft)       DSE=         0.0373
    WEIGHT IN NEW ACTIVE LAYER(tons)   WTMXAL=         584.9
    WEIGHT IN OLD ACTIVE LAYER(tons)      WAL=        8927.8
    USEABLE WEIGHT, OLD INACTIVE LAYER    WIL=      144962.8
    SURFACE AREA OF DEPOSIT (sq ft)      SABK= 0.33690125E+06

** INACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.010000      1.000000     VF GRVL      0.044734     93.180849
                       F  SAND      0.070000      8.000000     F  GRVL      0.033457     96.526593
                       M  SAND      0.327074     40.707446     M  GRVL      0.010638     97.590423
                       C  SAND      0.366543     77.361700     C  GRVL      0.021915     99.781912
                       VC SAND      0.113457     88.707445     VC GRVL      0.002181     99.999998

** ACTIVE LAYER **
BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER              BED FRACTION  PERCENT FINER
                       VF SAND      0.018953      1.895284     VF GRVL      0.059193     91.152666
                       F  SAND      0.045024      6.397700     F  GRVL      0.043652     95.517835
                       M  SAND      0.290415     35.439182     M  GRVL      0.013558     96.873609
```

```
                       C  SAND      0.375493     72.988468      C  GRVL      0.028407     99.714290
                       VC SAND      0.122449     85.233411      VC GRVL      0.002857    100.000000

C FINES, COEF(CFFML), MX POTENTIAL= 0.000000E+00 0.100000E+01 0.162000E+07
POTENTIAL TRANSPORT (tons/day):  VF SAND 0.767631E+04  VF GRVL 0.540007E+02
                                 F  SAND 0.222208E+04  F  GRVL 0.856678E+02
                                 M  SAND 0.120096E+04  M  GRVL 0.924255E+02
                                 C  SAND 0.879011E+03  C  GRVL 0.343755E+01
                                 VC SAND 0.885363E+03  VC GRVL 0.100000E-06

BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER             BED FRACTION  PERCENT FINER
                       VF SAND      0.011944      1.194380      VF GRVL      0.064549     90.362954
                       F  SAND      0.037695      4.963900      F  GRVL      0.047476     95.110553
                       M  SAND      0.276179     32.581777      M  GRVL      0.014690     96.579579
                       C  SAND      0.387609     71.342665      C  GRVL      0.031077     99.687310
                       VC SAND      0.125654     83.908024      VC GRVL      0.003127    100.000000

  SEDIMENT OUTFLOW FROM SECTION NO.     15.000
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....        115.42  |  VERY FINE GRAVEL..          3.19
    FINE SAND.........        101.72  |  FINE GRAVEL.......          3.74
    MEDIUM SAND.......        348.91  |  MEDIUM GRAVEL.....          1.25
    COARSE SAND.......        332.83  |  COARSE GRAVEL.....          0.10
    VERY COARSE SAND..        108.39  |  VERY COARSE GRAVEL          0.00

******************************************************************************************
                  TRACE OUTPUT FOR SECTION NO.      1.000
           -------------------------------------------------------

HYDRAULIC PARAMETERS:
      VEL      SLO        EFD        EFW     N-VALUE     TAU      USTARM    FROUDE NO.
     4.011  0.000004      5.838     83.730    0.0176   0.00159   0.02864     0.293

BED SEDIMENT CONTROL VOLUME COMPUTATIONS:
NEW SURFACE AREA (SQ FT):     TOTAL        K-PORTION      S-PORTION
                            209373.61     209373.61           0.00


TRANSMISSIVE BOUNDARY CONDITION = TYPE     2
BED MATERIAL PER GRAIN SIZE:    BED FRACTION  PERCENT FINER             BED FRACTION  PERCENT FINER
                       VF SAND      0.010000      1.000000      VF GRVL      0.060000     90.999998
                       F  SAND      0.070000      8.000000      F  GRVL      0.040000     94.999998
                       M  SAND      0.290000     36.999999      M  GRVL      0.015000     96.499998
                       C  SAND      0.360000     72.999998      C  GRVL      0.035000     99.999998
                       VC SAND      0.120000     84.999998      VC GRVL      0.000000     99.999998

  SEDIMENT OUTFLOW FROM SECTION NO.      1.000
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....        115.42  |  VERY FINE GRAVEL..          3.19
    FINE SAND.........        101.72  |  FINE GRAVEL.......          3.74
    MEDIUM SAND.......        348.91  |  MEDIUM GRAVEL.....          1.25
    COARSE SAND.......        332.83  |  COARSE GRAVEL.....          0.10
    VERY COARSE SAND..        108.39  |  VERY COARSE GRAVEL          0.00


TABLE SA-1. TRAP EFFICIENCY ON STREAM SEGMENT #  1
            EXAMPLE PROBLEM NO 4.  SOME SEDIMENT OPTIONS.
            ACCUMULATED AC-FT ENTERING AND LEAVING THIS STREAM SEGMENT
******************************************************
    TIME       ENTRY *           SAND               *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   54.00      58.000 *     13.30                    *
              53.000 *     16.15                    *
              42.000 *      0.36                    *
   TOTAL=     35.000 *     29.81      2.05      0.93 *
******************************************************
    TIME       ENTRY *           SAND               *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   54.00      35.000 *      2.05                    *
   TOTAL=     33.000 *      2.05      1.22      0.40 *
******************************************************
    TIME       ENTRY *           SAND               *
    DAYS       POINT *    INFLOW   OUTFLOW  TRAP EFF *
   54.00      33.000 *      1.22                    *
              15.000 *      1.00                    *
   TOTAL=      1.000 *      2.22      4.07     -0.83 *
******************************************************

TABLE SB-1:  SEDIMENT LOAD PASSING THE  BOUNDARIES OF STREAM SEGMENT #  1
--------------------------------------------------------------------------------
  SEDIMENT INFLOW at the Upstream Boundary:
      GRAIN SIZE      LOAD (tons/day) |    GRAIN SIZE      LOAD (tons/day)
  --------------------------------------------------------------------------
    VERY FINE SAND....         38.08  |  VERY FINE GRAVEL..          0.00
    FINE SAND.........         34.16  |  FINE GRAVEL.......          0.00
    MEDIUM SAND.......         21.06  |  MEDIUM GRAVEL.....          0.00
    COARSE SAND.......          2.35  |  COARSE GRAVEL.....          0.00
    VERY COARSE SAND..          0.61  |  VERY COARSE GRAVEL          0.00
                       -------------                   -------------
                                           TOTAL =         96.26
```

SEDIMENT OUTFLOW from the Downstream Boundary

GRAIN SIZE	LOAD (tons/day)	GRAIN SIZE	LOAD (tons/day)
VERY FINE SAND....	115.42	VERY FINE GRAVEL..	3.19
FINE SAND.........	101.72	FINE GRAVEL.......	3.74
MEDIUM SAND.......	348.91	MEDIUM GRAVEL.....	1.25
COARSE SAND.......	332.83	COARSE GRAVEL.....	0.10
VERY COARSE SAND..	108.39	VERY COARSE GRAVEL	0.00
		TOTAL =	1015.54

TABLE SB-2: STATUS OF THE BED PROFILE AT TIME = 54.000 DAYS

SECTION NUMBER	BED CHANGE (ft)	WS ELEV (ft)	THALWEG (ft)	Q (cfs)	TRANSPORT RATE (tons/day) SAND
58.000	-2.93	976.06	972.47	532.	195.
55.000	-1.23	975.95	971.67	532.	193.
53.000	-1.54	974.32	970.66	660.	156.
44.000	0.01	974.07	968.04	660.	7.
42.000	0.00	974.02	970.00	689.	0.
35.000	0.00	974.00	963.30	689.	0.
33.900	0.22	964.63	962.87	689.	2576.
33.300	0.03	963.41	962.52	689.	2295.
33.000	0.00	963.00	961.00	689.	2295.
32.100	-0.31	961.87	956.19	689.	85.
32.000	-0.07	961.21	956.43	689.	241.
15.000	-0.23	957.71	953.47	750.	1016.
1.000	0.00	957.00	944.70	750.	1016.

Accumulated Water Discharge from day zero (sfd)

MAIN
3500.00

$VOL A

STREAM SEGMENT # 1: EXAMPLE PROBLEM NO 4. SOME SEDIMENT OPTIONS.

SUMMARY TABLE: MASS AND VOLUME OF SEDIMENT

SECTION	SEDIMENT THROUGH SECTION (tons) TOTAL	SAND	SILT	CLAY	SEDIMENT DEPOSITED IN REACH in cu. yds TOTAL	CUMULATIVE	SAND	SILT	CLAY
INFLOW	26932.	26932.	0.	0.	21451.				
58.000	34630.	34630.	0.	0.	-6132.	-6132.	-6132.	0.	0.
55.000	47052.	47052.	0.	0.	-9894.	-16025.	-9894.	0.	0.
LOCAL	32721.	32721.	0.	0.	26062.				
53.000	104248.	104248.	0.	0.	-19495.	-35520.	-19495.	0.	0.
44.000	73173.	73173.	0.	0.	24751.	-10769.	24751.	0.	0.
LOCAL	733.	733.	0.	0.	583.				
42.000	4159.	4159.	0.	0.	55553.	44784.	55553.	0.	0.
35.000	4159.	4159.	0.	0.	0.	44784.	0.	0.	0.
33.900	2940.	2940.	0.	0.	971.	45755.	971.	0.	0.
33.300	2475.	2475.	0.	0.	370.	46125.	370.	0.	0.
33.000	2475.	2475.	0.	0.	0.	46125.	0.	0.	0.
32.100	5577.	5577.	0.	0.	-2471.	43655.	-2471.	0.	0.
32.000	7299.	7299.	0.	0.	-1371.	42283.	-1371.	0.	0.
LOCAL	2027.	2027.	0.	0.	1615.				
15.000	8242.	8242.	0.	0.	863.	43147.	863.	0.	0.
1.000	8242.	8242.	0.	0.	0.	43147.	0.	0.	0.

TOTAL SEDIMENT - per grain size - THROUGH EACH CROSS SECTION (tons)

UPSTREAM INFLOW

VF SAND	13463.	VC SAND	122.	C GRVL	0.
F SAND	8809.	VF GRVL	0.	VC GRVL	0.
M SAND	4222.	F GRVL	0.		0.
C SAND	316.				

LOCAL INFLOW

VF SAND	2765.	VC SAND	0.	C GRVL	0.
F SAND	6123.	VF GRVL	0.	VC GRVL	0.
M SAND	17758.	F GRVL	0.		0.
C SAND	6075.				

LOCAL INFLOW

VF SAND	346.	VC SAND	11.	C GRVL	0.
F SAND	214.	VF GRVL	4.	VC GRVL	0.
M SAND	122.	F GRVL	2.		0.
C SAND	34.				

LOCAL INFLOW

VF SAND	367.	VC SAND	55.	C GRVL	0.
F SAND	732.	VF GRVL	24.	VC GRVL	0.
M SAND	709.	F GRVL	10.		0.

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       C  SAND       129.

  SECTION NO.     15.000
       VF SAND       320.   VC SAND       851.   C  GRVL         3.
       F  SAND      1079.   VF GRVL        13.   VC GRVL         0.
       M  SAND      3214.   F  GRVL        14.                   0.
       C  SAND      2742.
  SECTION NO.      1.000
       VF SAND       320.   VC SAND       851.   C  GRVL         3.
       F  SAND      1079.   VF GRVL        13.   VC GRVL         0.
       M  SAND      3214.   F  GRVL        14.                   0.
       C  SAND      2742.

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$$END

      0   DATA ERRORS DETECTED.

TOTAL NO. OF TIME STEPS READ =         4
TOTAL NO. OF WS PROFILES =            23
ITERATIONS IN EXNER EQ =            1150

COMPUTATIONS COMPLETED
RUN TIME =  0 HOURS,  0 MINUTES & 9.00 SECONDS
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