SAC PROGRAM CHANGES AND ADDENDUMS AND ERRATA TO OFR 94-360

by Janice M. Fulford

ABSTRACT

This report documents changes to the Slope Area Computation (SAC) program. The changes documented have been made since the publication of OFR 94-360 and the release of the 1994 version of the program. This report documents the new release of SAC, version 2.0 dated August 30, 2012.

INTRODUCTION

One new feature and a few program corrections have been made to the SAC program since 1994. The new feature allows input data and the output results to be in either meter-second or feet-second units. A new record implements this new feature. Additionally, an output change was made and a program bug corrected. In 2012, SAC was modified to permit communicate with the SACGui program.

NEW FEATURE

The new metric conversion feature permits the SAC program to process data in either meter second or feet second units. A new input record, SI, implements this feature and can be inserted at the beginning of the input data file. Input data can be in either feet, second or meter, second and output results can be specified to be in either feet second or meter second units.

SI record

Purpose: Data units record. This record indicates the input data units and the units for the output results. The record is not required. Omission of the record results in the program assuming that units are in feet, inches, and seconds. If two input files are used (separate approach and culvert files) a SI record should be included in each file unless default, feet, inches, second is desired.

Format:

Column	Format	Contents
1-2	A2	SI
3-10	8X	blanks
11-80	free	SICODE

Definition of variables:

SICODE a single digit code that indicates the units of the unit data and the desired units for the printed results.

0-- input in feet, inches, seconds; output in feet, seconds.
1-- input in meters, centimeters, seconds; output in meters, seconds.
2-- input in feet, inches, seconds; output in meters, seconds.
3-- input in meters, centimeters, seconds; output in meters, seconds.

EXAMPLE OF SI Record Use

The following is an example of using an SI record with example 1 of OFR 94-360, reach with level water surfaces in the cross sections. The input data with the SI record is as follows:

```
T1   EXAMPLE1:  Simple reach data
SI        2
XS   SEC3 1000
GR        -121,98.8 -106.,98.1 -90.,94.4 -85.,90.9 -80.,88.7
GR        -75.,88.7 -70.,89.4 -65.,90.7 -60.,90.9 -54.,91.2 -51.,95.5
GR        0.,97.2 67.,97.6 83.,98.7
N         0.035 0.040 0.030
SA        -106. -51.
HP 4 SEC3 98.75
XS   SEC2 1380
GR        2.,99. 15.,97.7 27.,97.6 33.,91. 38.,89.8 43.,89.8 48.,90.2
GR        53.,90.4 58.,90.5 60.,91.1 68.,95.8 78.,97.8 185.,99.2
GR        234.,99.4
N         0.030 0.037 0.030
SA        27. 78.
HP 4 SEC2 99.20
XS   SEC1 1666.
GR        12.1,99.6 16.,98.9 26.,98.5 30.,93. 32.,90.5 37.,91.2 42.,90.9
GR        47.,91.6 52.,92.2 57.,92.6 62.,93.2 67.,91.7 72.,93. 82.,98.4
GR        255.,99. 265.1,99.9
N         0.030 0.045 0.030
SA        26. 82.
HP 4 SEC1 99.75
```

The output results produced by this input file follow. Note that units are labeled in the output to avoid confusion.

```
SAC -USGS slope-area program Ver 97-01                                  page  0

Echo input data file
Example 1 with feet second input and meter second output
XS   SEC3 1000
GR        -121,98.8 -106.,98.1 -90.,94.4 -85.,90.9 -80.,88.7
GR        -75.,88.7 -70.,89.4 -65.,90.7 -60.,90.9 -54.,91.2 -51.,95.5
GR        0.,97.2 67.,97.6 83.,98.7
N         0.035 0.040 0.030
SA        -106. -51.
HP   SEC3 98.75
XS   SEC2 1380
GR        2.,99. 15.,97.7 27.,97.6 33.,91. 38.,89.8 43.,89.8 48.,90.2
GR        53.,90.4 58.,90.5 60.,91.1 68.,95.8 78.,97.8 185.,99.2
GR        234.,99.4
N         0.030 0.037 0.030
SA        27. 78.
HP   SEC2 99.20
XS   SEC1 1666.
GR        12.1,99.6 16.,98.9 26.,98.5 30.,93. 32.,90.5 37.,91.2 42.,90.9
GR        47.,91.6 52.,92.2 57.,92.6 62.,93.2 67.,91.7 72.,93. 82.,98.4
GR        255.,99. 265.1,99.9
N         0.030 0.045 0.030
SA        26. 82.
HP   SEC1 99.75



SAC -USGS slope-area program Ver 97-01                                  page  1

Example 1 with feet second input and meter second output
EXAMPLE1:  Simple reach data



                          DISCHARGE COMPUTATIONS
                  Reach
            dH,fall  length  Discharge  Spread    HF      CX      RC      RX  ER
              (m)      (m)      (cms)     (%)    (m)
```

```
 SEC1 - SEC2  0.168     87.2       54.5       0  0.1195  1.000  0.403  0.000
 SEC2 - SEC3  0.137    115.8       59.7      26  0.1692  0.876  0.000 -0.378 *

 SEC1 - SEC3  0.305    203.0       56.6       9  0.2815  0.952  0.185 -0.205

Definitions:
  Spread, the percent difference between discharge computed with no expansion
      loss (k=0) and discharge computed with full expansion loss (k=1.0), divided
      by the discharge computed with full expansion loss
  HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge;
      L, reach length; K1, upstream section conveyance;
      K2, downstream section conveyance
  CX, the computed discharge divided by the discharge computed with no expansion
      loss (k=0)
  RC, velocity head change in contracting section divided by friction head
  RX, velocity head change in expanding section divided by friction head
  ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short
      error, 1-negative or 0 fall
  ******, terms that can not be computed because of strong expansion in reach

                              CROSS  SECTION  PROPERTIES
--------------------------------------------------------------------------------
  I.D. SEC3                   Velocity head    0.07m     Discharge       57.cms
   Ref.distance      305.m              Q/K    0.0011        Alpha 1.200

  Sub  Water                  Top   Wetted   Hydraulic   Conveyance
 area surface   n     Area   width perimeter   radius   x 0.001      Vel.    F
  no. el.(m)        (sq. m)   (m)    (m)        (m)      (cms)   %   (mps)
    1  30.099 0.035     0.42    4.25   4.25      0.10      0.003   0. .20  0.21
    2  30.099 0.040    33.41   16.76  18.12      1.84      1.259   2. ***  0.28
    3  30.099 0.030    20.67   40.84  40.88      0.51      0.438   1. .71  0.32
Total   30.10   ---      54.     62.    63.      0.86      1.700   3.  1.0  0.35
--------------------------------------------------------------------------------
Definitions:
  n, Manning's coefficient of roughness    Q/K = discharge/conveyance
  F, Froude number F = Ki*Q/(K*A sqrt(g*(Ai/TWi)); Q, discharge; A, total cross-
      section area; g, acceleration of gravity; Ai, sub-section area; TWi, sub-
      section top width


SAC -USGS slope-area program Ver 97-01                                  page  2

Example 1 with feet second input and meter second output
EXAMPLE1:  Simple reach data



                              CROSS  SECTION  PROPERTIES
--------------------------------------------------------------------------------
  I.D. SEC2                   Velocity head    0.12m     Discharge       57.cms
   Ref.distance      421.m              Q/K    0.0016        Alpha 1.299

  Sub  Water                  Top   Wetted   Hydraulic   Conveyance
 area surface   n     Area   width perimeter   radius   x 0.001      Vel.    F
  no. el.(m)        (sq. m)   (m)    (m)        (m)      (cms)   %   (mps)
    1  30.236 0.030     2.75    7.62   7.70      0.36      0.046   0. .67  0.35
    2  30.236 0.037    31.72   15.54  16.96      1.87      1.305   3. ***  0.36
    3  30.236 0.030     6.96   32.61  32.62      0.21      0.083   0. .47  0.33
Total   30.24   ---      41.     56.    57.      0.72      1.434   3.  1.4  0.51
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
  I.D. SEC1                   Velocity head    0.07m     Discharge       57.cms
   Ref.distance      508.m              Q/K    0.0014        Alpha 1.290

  Sub  Water                  Top   Wetted   Hydraulic   Conveyance
 area surface   n     Area   width perimeter   radius   x 0.001      Vel.    F
  no. el.(m)        (sq. m)   (m)    (m)        (m)      (cms)   %   (mps)
    1  30.404 0.030     1.16    4.24   4.30      0.27      0.016   0. .52  0.32
```

```
    2  30.404 0.045    35.93   17.07  18.88      1.90      1.229   2. ***  0.28
    3  30.404 0.030    17.17   55.30  55.31      0.31      0.263   0. .58  0.33
Total   30.40   ---      54.     77.    78.      0.69      1.509   3.  1.0  0.40
-------------------------------------------------------------------------------
Definitions:
  n, Manning's coefficient of roughness    Q/K = discharge/conveyance
  F, Froude number F = Ki*Q/(K*A sqrt(g*(Ai/TWi)); Q, discharge; A, total cross-
      section area; g, acceleration of gravity; Ai, sub-section area; TWi, sub-
      section top width
```

PROGRAM CHANGES AND CORRECTIONS

The previous version of the SAC program did not correct cross section stationing for skew angles entered on the XS record. This error has been corrected. The stationing for cross sections is adjusted by the cosine of the skew angle entered on the XS record. The section reference distance is not affected by the skew angle. Section reference distances should be determined using the center of the main channel of the reach.

The program did not compute correctly for sections with level water surfaces that were described using the method in the OFR for nonlevel water surfaces. This error has been corrected so that cross sections with level water surfaces described as a nonlevel water surface cross section will be computed correctly.

The program originally used the mean cross sectional velocity to compute the Froude numbers listed in the results for each subarea. The equation used was listed in the output results. The Froude computation has been changed to use an estimated subarea velocity for the subarea Froude numbers. The Froude number is now computed as

$$F = Ki*Q/(K*A \sqrt{g*(Ai/TWi)}),$$

where K is conveyance, A is area, TW is wetted perimeter, g is the acceleration of gravity and Q is discharge. The i indicates the ith subarea of the cross section. The new equation is listed in the output results.

The program did not select the appropriate water-surface elevation for cross sections described by enclosing the figure (Fulford, p21) if a vertical bank existed on the right side of the cross section. This error has been corrected.

SUMMARY

This report documents the changes and new features that have been made since the 1994 version of SAC was released. These changes are included in the most recent release. The new feature allows users to input data in either feet second or meter second and obtain results in either feet second or meter second units. Additionally, a few known program bugs were corrected.

REFERENCES

Dalrymple, Tate, and Benson, M.A., 1967, Measurement of peak discharge by the slope-area method: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chapter A2, 12p.

Fulford, Janice M., 1964, User's guide to SAC, a computer program for computing discharge by slope-area method, U.S. Geological Survey Open File Report 94-360, 31p.