USER'S GUIDE

STEP-BACKWATER
AND
FLOODWAY ANALYSES

COMPUTER PROGRAM J635 *

BY

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SURFACE WATER BRANCH

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Supplement to --

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SURFACE WATER BRANCH TECHNICAL MEMORANDUM NO. 78.02

Subject: COMPUTATIONS--Errors in Step-Backwater and Floodway Analyses Computer Program J635

An extensively modified version of computer program E431 has been in limited use for several months to test it for bugs. Its primary purpose is to compute water-surface profiles in the upstream direction for certain situations which program E431 would abort, and for profiles in the downstream direction when supercritical and(or) critical conditions exist.

Distribution of provisional instruction manuals has been limited to several Districts who, with extensive field applications, are providing valuable information as to obvious programing errors and other problems in computed results. Additional copies of the provisional manuals, and(or) some instruction in use of the program, have been given participants at two recent seminars in Denver: Step-Backwater and Floodway Analyses, July 11-15, 1977, and Hydraulic Analyses Seminar, Sept. 19-30, 1977.

Several bugs have already been brought to our attention. We hope to have them corrected soon, before general distribution of user instructions is made. In the meantime, those persons who have been working with J635 should be aware of the following known problems so that they may interpret their computed results accordingly.

VSA Option.--The computer appears to ignore the designated left SA limit on upstream runs. VHD could be used, instead. Be certain, however, that the normal profile is high enough to be overbanks; otherwise, such floodway option designations would not be possible, anyway.

Tabulation of Water-Surface Elevation Differences between Selected Profiles.--In the comparison between a normal and a floodway profile, there is a problem when the NOE option has been used for floodway profile cross sections. Although the computed water-surface elevations are correct, the listed "actual" surcharges could be in error for NOE cross sections. The computer apparently bases "actual" surcharge values on the normal elevation of the last cross section for which the NOE option was used. The error is in the listed surcharge values, and not in the computed normal and floodway elevations.

INTRODUCTION

An extensively modified version of computer program E431 is now available. This modified step-backwater and floodway analyses program has been assigned a new program number, J635. Eventually, J635 will be placed on the WRD system library and be executable with a cataloged procedure. However, for an undefined period of time, J635 will be stored on SYS1.LOADLIB to permit easier revision to the program if and when extensive field applications indicate that changes are required.

Major advantages of using J635 (rather than E431) may be summarized as follows:

1. J635 can be used to compute water-surface profiles in the downstream direction when supercritical and (or) critical conditions are encountered.

2. J635 will provide printout of additional information, such as:
   (a) Comparative tabulation of floodway versus normal profile results (automatic).
   (b) Tabulation of velocity distribution in cross sections (optional).
   (c) Tabulation of water-surface elevation differences between selected profiles (optional).

3. J635 will provide continuous water-surface profile computations in the upstream direction in certain situations for which E431 will abort the computations.

This provisional documentation is designed to supplement the final version of the E431 User's Manual (Shearman, 1976) which was recently (March 1977) printed. User's Manual page numbers referred to in this supplement are page numbers of that final report. Every effort was made to develop J635 in such a manner that it would be fully compatible with E431 instructions. However, some of the additional flexibility and capability programmed into J635 makes it necessary to revise some of the information presented in the E431 User's Manual. Of course, J635 also requires a rather substantial amount of new information so that the user may successfully execute the added features.

REVISIONS TO E431 INSTRUCTIONS

There are three significant differences in the procedure used to balance the energy equation in a subreach when computing in the upstream direction with J635 relative to that procedure used in E431 (E431 User's Manual, p. 7-8). These three differences are:

1. J635 does not consider the value of h_o when making the initial assumption for WSU in a subreach. The initial assumption for WSU is always equal to WSD-0.5Δh.

2. For the situation where both stepping increments (0.5Δh and 0.25Δh) fail to yield a satisfactory elevation for WSU between the initially assumed WSU and GMAX, J635 will make the third attempt to find a satisfactory answer using the range of elevation between the critical water-surface elevation (whereas E431 uses GMIN + 0.50Δh) and GMAX. A message (see table 11/SUPP.) is printed to alert the user that this course of action has been taken. J635 computes the critical water-surface elevation (WSC) for the specified discharge using the minimum energy (water-surface elevation plus velocity head) concept.

3. When using E431, profile computations are aborted at the first cross section at which all attempts fail to yield an acceptable water-surface elevation for WSU. J635, on the other hand, will assign the critical water-surface elevation (WSU=WSC) at all such troublesome cross sections and proceed with the profile computations in the next upstream subreach. Assuming that a sufficient number of cross sections at proper locations are coded, this procedure will yield correct water-surface profiles for any subreach(es) in which critical or subcritical flow occurs. Since only the critical water-surface elevation is printed for any cross-section at which supercritical flow occurs, a combination of water-surface profiles computed in both the upstream and downstream directions is usually required to adequately determine such a profile in its entirety. Instructions needed to use J635 for computing profiles in the downstream direction are explained later in this supplementary documentation.

When NPR is coded incorrectly (E431 User's Manual, p. 20), J635 may compute more profiles than will E431. J635 will attempt profile computations for each and every greater-than-zero discharge coded in consecutive fields of the #4 CARD(S).

J635 contains two major improvements pertaining to the initial water-surface elevations coded on the #2 CARD(S) when computing profiles in the upstream direction.

1. E431 does not compare the index Froude number, FRDN, and the Froude number test value, FN, at the most downstream cross section. This comparison is made in J635 and a message (see table 11/SUPP.) is printed if FRDN > FN. If FRDN is a fair indicator of supercritical flow for that cross section, then the profile computations using that initial water-surface elevation are invalid and corrective action should be taken by the user.

2. E431 will abort profile computations for any initial water-surface elevation coded on the #2 CARD(S) which is less than GMIN at the most downstream cross section. However, J635 will compute the critical water-surface elevation (WSC) for the corresponding discharge and use WSC as the starting

elevation for that profile computation. Thus, the user has the option of intentionally coding a value less than GMIN (or leaving the field blank) on the #2 CARD(S) so that J635 will compute the profile corresponding to a critical flow condition at the most downstream cross section.

J635 also requires that starting elevations for floodway analyses be assigned in a manner much different than described in the E431 User's Manual (p. 83). E431 will add the specified surcharge to the elevation coded on the #2 CARD to obtain the starting elevation. However, J635 uses whatever elevation is coded on the #2 CARD without any adjustment as the starting elevation. Thus, in figure 55 (E431 User's Manual, p. 91) the second elevation on the #2 CARD would be coded as 21229 for J635 to obtain results equivalent to E431 results. Also, as described above, any starting elevation less than GMIN will result in a floodway analysis based on a critical flow condition at the most downstream cross section.

An input data deck which successfully runs using E431 (with possibly some minor revisions to accommodate the above differences) will also run successfully on J635. It is possible that output results will vary somewhat, especially for reaches in which flow is (or borders on) critical. Also, results may differ somewhat for the subcritical segments of reaches in which supercritical flow occurs. J635 will provide a continuous upstream computation since it assumes a critical water-surface elevation at all troublesome cross sections. Such a reach must be computed in segments using E431, with manually computed critical water-surface elevations used as the starting elevation for each subcritical segment. A critical water-surface elevation computed using the QC values printed on the cross-section properties can be quite different from that obtained using the minimum energy concept for many types of cross sections. Thus, a significant difference in segmented subcritical profiles could result.

BALANCING THE ENERGY EQUATION WHEN COMPUTING IN THE DOWNSTREAM DIRECTION

The procedure used to balance the energy equation in a subreach is very similar whether computing profiles in the upstream (E431 User's Manual, pp. 7-8) or the downstream direction. When computing in the downstream direction, an iterative procedure is required to determine a water-surface elevation, WSD, at the downstream cross section that results in the absolute value of ACC (computed by equation 2-4) being less than or equal to the user-specified tolerance, TOL. Of course, the applicable elevation range that must be investigated at each cross section when computing downstream is between channel bottom and the critical water surface elevation, WSC. Also, due to numerical instability problems that may occur for certain situations, eddy loss computations and assumptions in J635 have been programmed to give the user additional control over the coefficients used to compute eddy losses in each subreach. Details for user-specification of these coefficients are presented in a following section entitled ADDITIONAL INSTRUCTIONS FOR J635. The assumption that 0.5 feet is a suitable Δh for the balancing process unless a lesser value is specified on CARD #1 remains the same. Of course, there is no need for a Froude number check when attempting to compute a critical and (or) super-critical profile in the downstream direction.

The initial assumption for WSD is equal to the critical water-surface elevation, WSC. Successively lower values of WSD are assumed in increments of $0.5\Delta h$. The minimum water-surface elevation that is considered in any cross section is equal to GMIN plus 0.2 feet. As in E431, ACC for each assumed elevation is tested for TOL acceptability and for each pair of successive assumptions a change in the algebraic sign of ACC will trigger an attempt to converge upon an acceptable elevation by the method of false position.

If the above process fails to yield an acceptable answer between WSC and GMIN + 0.2 feet, it is assumed that the stepping increment was too large, thereby allowing an ACC sign change to be missed. Therefore, the stepping increment is reduced to $0.25\Delta h$ and the same elevation range (WSC through GMIN + 0.2 feet) is re-examined for an acceptable WSD.

When both stepping increments fail to yield an acceptable WSD, subsequent action depends upon whether or not the user has coded a value for the coefficient to be used to compute eddy loss due to expansion in the subreach. When this expansion coefficient <u>is not coded</u>, the assumption is initially made that there will be zero expansion loss in the subreach. However, when both stepping increments fail to yield an acceptable WSD, it is possible that changing this assumption could yield an answer. Thus, a default value of 0.5 is used for the expansion coefficient and the $0.25\Delta h$ stepping increment is used again for a third and final attempt to find an acceptable WSD between WSC and GMIN + 0.2 feet. If either a positive value or a negative value is coded for the expansion coefficient, no third attempt is made to find an acceptable WSD (see section entitled ADDITIONAL INSTRUCTIONS FOR J635 for complete discussion of coding these coefficients).

Any time that all attempts fail to yield an acceptable WSD, J635 will assume critical flow occurs at the downstream cross section. Therefore, WSD is set equal to WSC and profile computations will be attempted for the next downstream subreach.

COMPUTATIONS AT BRIDGE SITES WHEN COMPUTING IN THE DOWNSTREAM DIRECTION

√ J635 has been programmed to compute water-surface profiles in the downstream direction in the vicinity of bridges using input data identical to that coded for E431. However, as discussed in subsequent paragraphs, the methodology may fail to yield satisfactory results for certain flow situations. Special coding of bridge situations may therefore be required for downstream computations.

When using normally coded bridge situation data, the approach cross section is considered to be no different from a regular cross section. Once an acceptable WSD has been computed for the approach cross section (or assumed equal to WSC), profile computations will be attempted for the subreach defined by the approach cross section and the bridge-opening cross section. These profile computations are performed in the same manner as for any normal subreach with the exception that if a pier cross section is coded, the pier area will be subtracted from the gross area of the bridge opening and the resultant net area of the bridge opening used in the computations.

Once the value for WSD is computed (or assumed equal to WSC) for the bridge-opening cross section, profile computations are performed for the zero-length subreach defined by the bridge-opening and exit cross sections (DISTANCE is equal for these cross sections). Initially, it is assumed that the water-surface elevation at the exit cross section is equal to the final water-surface elevation determined for the bridge-opening cross section. This is equivalent to balancing the energy equation for this zero-length subreach with zero friction loss and a 100 percent expansion loss. This initially assumed elevation will be accepted if it is less than or equal to the computed value of WSC for the exit cross section. Otherwise, the value of WSC computed for the exit cross section will be used as the water surface elevation at the exit cross section. In either case, profile computations then proceed to the next subreach downstream from the exit cross section.

The following list (not necessarily all-inclusive) indicates situations for which the above procedure would (or could) fail to produce an adequate solution without special coding of a bridge situation for downstream computations.

1. J635 is not programmed to compute weir flow over embankments when computing profiles in the downstream direction (embankment cross sections are simply ignored).

2. Drastic variation of conveyance between the approach and bridge-opening cross sections may cause incorrect evaluation of friction losses.

3. Eddy loss computations may not be correct if default values are relied upon.

Therefore, it may be necessary to consider one or more of the following special coding techniques.

1. Recoding a bridge situation as a series of regular cross sections with a composite cross section of the embankment and bridge opening cross sections to account for embankment overflow.

2. Recoding a bridge situation as a series of regular cross sections with additional sections more closely spaced to minimize friction loss computation errors.

3. Specify value(s) of expansion and (or) contraction coefficients to allow a more correct evaluation of eddy losses for very large expansions and (or) contractions.

ADDITIONAL INSTRUCTIONS FOR J635

The major differences in input data between E431 and J635 involve the #7 CARD and the #8 CARD. J635 requires coding of both a #7 and a #8 CARD whenever the user desires one or more of the following:

1. Profile(s) for encroached conditions.
2. Profile(s) computed in the downstream direction.
3. Tabulation(s) of cross-sectional velocity distribution.
4. Tabulation(s) of water-surface elevation differences between selected profiles.

Table 16 (E431 User's Manual, p. 83) may be made valid for J635 by adding the following information:

1. The #7 CARD is also used to select the direction of computation for each profile (see table 16a/SUPP.).

2. The #8 CARD is also used to select the added optional features (see table 16b/SUPP.).

Table 16a/SUPP.—Applicable codes on the #7 CARD.

Coded Value	Profile type and direction of computation
0	Normal profile, upstream computation.
1	Floodway profile, upstream computation.
2	Normal profile, downstream computation.
3	Floodway profile, downstream computation.

Table 16b/SUPP.--Applicable codes on the #8 CARD.

Coded Value	Source of normal water-surface elevations and (or) added feature selection. Normal Profile	Floodway Profile
0	Not applicable.	Normal water-surface elevations from memory.
1	Not applicable.	Normal water-surface elevations from #9 CARD(S).
2 see footnote 1/	Tabulate differences in water-surface elevations between this profile and the last normal profile for which the elevations are in memory.	Not applicable.
3	Not applicable.	Profile computed using previously modified cross sections.
5	Tabulate cross-sectional velocity distribution for all cross sections for this profile.	Same as 0 with tabulation of velocity distribution added.
6	Not applicable.	Same as 1 with tabulation of velocity distribution added.
7 see footnote 1/	Same as 2 with tabulation of velocity distribution added.	Not applicable.
8	Not applicable.	Same as 3 with tabulation of velocity distribution added.

1/ Do not use codes 2 or 7 for the first profile of a job, regardless of whether it is a normal run or a floodway run.

Two data fields have been added to the #3 CARD (for TYPE equal to 0, 1, or 5) to give the user the option of selecting the coefficients used to compute the eddy loss in a subreach. E431 computes eddy loss using either 0.5 (when VHU > VHD) or 0.0 (when VHU < VHD) for k_e (E431 User's Manual, fig. 2, p. 4). In J635, k_e has been replaced with two separate coefficients which are used to compute eddy loss. A contraction coefficient, CK, is used when VHU < VHD and an expansion coefficient, EK, is used when VHU > VHD. The user may code either one or both of these coefficients for any exit, regular or approach cross section. J635 applies the appropriate coefficient in computing the eddy loss for the subreach downstream from the cross section for which the coefficients are coded. CK and EK are coded to the nearest tenth in columns 74-75 and 77-78, respectively (implied decimal between the specified columns). Reasonable values for these coefficients range from 0.1 to 0.5 for CK and from 0.1 to 1.0 for EK, with higher values used for more sudden and (or) larger contractions (expansions). When the fields are left blank (or coded zero), J635 will use default values of 0.0 for CK and 0.5 for EK. A negative value must be coded (for example, code -1 in columns 74 and 75) for EK if the user wishes an expansion coefficient of zero to be used in a subreach.

At this time, it is not possible to present any rigid (or even semi-rigid) guidelines for proper selection of CK and EK. Until additional experience is gained through further testing and actual field applications of program J635, it is only appropriate to make a few educated guesses and tentative remarks about potential applications of this coefficient-selection option. However, it is quite certain that successful application of this option requires experience and good judgment. If used otherwise, erroneous profile computations will most certainly be obtained.

Widespread application of this option in upstream computations is probably unwarranted. The default values should provide adequate and reasonable results for most subreaches if cross sections are properly spaced. Of course, when it can be justified, the user should not hesitate to override the default value(s) by coding value(s) of appropriate magnitude to CK and (or) EK. Frequently, however, the need to code CK and (or) EK will not be apparent until after results obtained using the default values are examined.

An idealized test case for downstream computations revealed that automatic application of an expansion coefficient resulted in mathematically valid but hydraulically invalid results for WSD for certain supercritical flow situations. Such incorrect results were higher than the correct result and subsequently yielded a WSD value at the next downstream cross section which was too low. The problen then perpetuated itself downstream, yielding results which were alternately too high and too low for the entire reach. Therein lies the reason for programming J635 such that an expansion coefficient is not applied in downstream computations (except as a last resort) unless the user overrides the default value. It is probably advisable to first analyze any reach using the default option (except for obvious contracting or expanding subreaches). Examination of the output from such analyses reveal whether or not expansion losses should have been (but were not) computed for any of the subreaches. If such a problem is revealed, the reach should be rerun with appropriate coefficients coded for the troublesome subreaches.

The subreach defined by the bridge-opening and approach cross sections is a good example of where the default option may need to be overridden for downstream computations. If the flow is greatly contracted by the bridge opening, CK should be coded on the #3 CARD of the approach cross section to permit J635 to better evaluate the energy balance in that subreach. Similarly, when a bridge situation is coded as a series of more closely spaced regular cross sections for downstream computations, it is probably advisable to code CK for the subreach upstream from the bridge opening and EK for the subreach downstream from the bridge opening.

Initial water-surface elevations coded on the #2 CARD(S) for downstream computations are, of course, applicable to the most upstream cross section. If the value coded on the #2 CARD (a blank field is equivalent to coding a zero elevation) is less than the minimum ground elevation (GMIN) in the most upstream cross section, J635 will use the computed WSC value for that cross-section as the initial water-surface elevation. If the specified starting elevation is higher than WSC, J635 will print a warning message. If the difference is significant, the user should take corrective action since it is incorrect to compute in the downstream direction starting with a subcritical water-surface elevation.

J635 MESSAGES

The only significant differences between E431 messages and J635 messages are in the error and warning messages pertaining to profile computations. Table 11/SUPP. illustrates the new and revised messages that might be printed by J635. E431 messages PN-1 and PN-7 are not programmed into J635. Except for minor changes in symbols and (or) wording, messages PN-2, PN-3, PN-6, PN-8 through PN-10, and PN-33 are directly equivalent for both programs. The following paragraphs explain the remaining messages of table 11/SUPP. with frequent reference to table 12 (E431 User's Manual, pp. 55-57).

PN-1.1 is printed if the elevation obtained from CARD #2 is less than GMIN of the initial cross section. J635 simply uses the computed WSC as the starting elevation for the profile computation.

PN-1.2 is printed during upstream computations when the elevation obtained from CARD #2 results in FRDN > FN at the most downstream cross section. The user should take corrective action if that starting elevation is actually supercritical since it is incorrect to compute in the upstream direction starting with a supercritical water-surface elevation.

Table 11/SUPP.--Partial summary of J635 profile computation messages.

Message Number	E431 Equiv-alent	PROFILE COMPUTATION MESSAGE			
		SECID	ERROR(WARNING) MESSAGE	INTERMEDIATE RESULTS(IF ANY)	ACTION TAKEN
PN- 1.1		_____	WS TOO LOW		ASSUMED WS = WSC
PN- 1.2		_____	FRDN FAILURE	WS = ____.__ & FR = ____.__	ALERTED USER
PN- 1.3		_____	WS TOO HIGH		ALERTED USER
PN- 1.4		_____	WS TOO LOW		USED WSMIN = WSC
PN- 2	PN- 2	_____	TOL FAILURE BETWEEN	WS = ____.__ & WS = ____.__	USED HIGHER WS
PN- 2.1		_____	TOL FAILURE BETWEEN	WS = ____.__ & WS = ____.__	USED LOWER WS
PN- 3	PN- 3	_____	WS NOT FOUND BETWEEN	WS = ____.__ & WS = ____.__	USED DEL = 0.25
PN- 4	PN- 4	_____	WS NOT FOUND BETWEEN	WS = ____.__ & WS = ____.__	USED WSMIN = WSC
PN- 4.1		_____	WS NOT FOUND BETWEEN	WS = ____.__ & WS = ____.__	USED EK = 0.5
PN- 5	PN- 5	_____	WS NOT FOUND		ASSUMED WS = WSC
PN- 6	PN- 6	_____	FRDN FAILURE	WS = ____.__ & FR = ____.__	USED HIGHER WS
PN- 7.1		_____	WS TOO HIGH		ASSUMED WS = WSC
PN- 7.2		_____	SUPERCRITICAL WS		COMPUTED WSA
PN- 8	PN- 8	_____	LEFT BANK EXTENDED		ALERTED USER
PN- 9	PN- 9	_____	RIGHT BANK EXTENDED		ALERTED USER
PN-10	PN-10	_____	KU/KD < 0.7 OR > 1.4		ALERTED USER
PN-33	PN-33	_____	FW DATA FLUSHED		ABORTED PROFILE

PN-1.3 is printed when the elevation obtained from CARD #2 is higher than WSC at the most upstream cross section. The user should take corrective action if that starting elevation is actually subcritical since it is incorrect to compute in the downstream direction starting with a subcritical water-surface elevation.

PN-1.4 is printed during upstream computations if the initial assumption of WSU = WSD-0.5Δh results in a value of WSU < GMIN. WSC replaces WSD-0.5Δh as the initial assumption for WSU. Subsequent results may be fine, but this could frequently be a good indicator that closer spacing of cross sections is necessary.

PN-2.1 is the downstream computation equivalent to PN-2 which is printed for upstream computations.

PN-4 of J635 is identical with PN-4 of E431 except that the minimum water-surface elevation that will be used is WSC rather than GMIN + 0.5Δh.

PN-4.1 is printed during downstream computations if both the 0.5Δh and 0.25Δh stepping increments fail to yield an acceptable WSD when using EK = 0.0 in the energy balance computations for a subreach. A third and final attempt to find an acceptable WSD is made using EK = 0.5.

PN-5 is printed for either computational direction when all attempts to balance the energy equation in a subreach have failed. J635 is programmed to assign WSC to the troublesome cross section and proceed to the next subreach to continue the profile computations.

PN-7.1 is printed during downstream computations when the computed water-surface elevation in the bridge-opening cross section (which is subsequently assumed to exist at the exit cross section) is greater than the computed WSC of the exit cross section. In such a case, it is necessary to assume the WSC value computed for the exit cross section is applicable at the exit cross section so that profile computations may proceed to the next downstream subreach.

PN-7.2 is printed during downstream computations for any cross section at which the final water-surface elevation is supercritical (that is, when WSD < WSC). J635 computes the alternate water-surface elevation, WSA, which is the subcritical water-surface elevation having the same energy (elevation plus velocity head) as does the supercritical WSD. All WSA values for the reach are subsequently printed in a table following the profile printout.

J635 OUTPUT AND APPLICATIONS

This section presents several examples of (1) the additional output that may be obtained using J635 and (2) some of the potential applications of J635 that are not possible with E431. Illustrations in this documentation are labeled and referred to as "exhibits" rather than "figures" to eliminate possible confusion that might arise when references are made to the illustrations in the E431 User's Manual.

The SIMPLE REACH EXAMPLE (E431 User's Manual, fig. 34, p. 65) is used to illustrate (1) tabulation of cross-sectional velocity distribution and (2) tabulation of water-surface elevation differences between selected profiles. Assume that the 4,000 and 6,600 cfs respectively represent the 100- and 500-year discharges. Further assume that the user (1) anticipates that subsequent floodway analyses may create (or intensify) high-velocity problems for the 100-year discharge and (2) wishes to know the elevation difference between the 100- and 500-year flood profiles at each cross section. Since these special features are desired, a #7 CARD and a #8 CARD must be added to the data deck shown in figure 34. The #7 CARD is coded with a 0 (zero) in columns 42 and 44 since both analyses are to be normal profiles computed in the upstream direction. The #8 CARD is coded with a 5 (five) in column 42 and a 2 (two) in column 44. The #7 and #8 CARDS are placed after the last #6 CARD in the data deck, just as they are when using E431.

The 5 in column 42 of the #8 CARD will cause the velocity distribution in each cross section for 4,000 cfs to be printed as partially shown in exhibit 1. Subarea velocities are computed using the assumption that discharge distribution is directly proportional to conveyance distribution in the subareas. Also printed are total area, total conveyance, and the distribution of area and conveyance (as a ratio to the total). If NSA exceeds 10, the results for subareas 11 through NSA are printed in an additional tier of three lines for that cross section. The velocity-distribution printout follows the profile printout.

The 2 in column 44 of the #8 CARD will cause J635 to subtract the water-surface elevations stored in memory (which in this case are those computed for 4,000 cfs) from the water-surface elevations computed for 6,600 cfs. A tabulation of these water-surface elevation differences is printed as shown in exhibit 2. This tabulation appears in the output following the profile printout. If a 7 were coded in column 44 of the #8 CARD, the profile printout would be followed by the velocity-distribution printout for 6,600 cfs, which in turn would be followed by the printout of water-surface elevation differences.

The SIMPLE FLOODWAY EXAMPLE (E431 User's Manual, pp. 90-91) is used to illustrate a floodway analysis using J635. As mentioned previously, the second entry on the #2 CARD must be coded as 21229 (rather than 21179) because J635 does not add the specified surcharge to the starting elevation coded on CARD #2. Exhibit 4 illustrates the comparative tabulation of the floodway profile results (shown in exhibit 3) and the normal profile results (E431 User's Manual, fig. 36, p. 67).

Exhibit 4 does not illustrate all of the possible codes that may be printed in the comparative tabulation. In the FW OPTION column, the remaining FW OPTION codes (VSA, VHD, HOR, and NOE) will be printed when

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 *** PAGE COUNT=    8,DATE= 2/25/77

VELOCITY DISTRIBUTION FOR:  SIMPLE REACH EXAMPLE ------- J635 CODING
PAGE  1 OF  1, PROFILE NUMBER  1,   UPSTREAM COMPUTATIONS

SECID       TOTAL    DISTRIBUTION BY SUBAREAS

ONE     V             1.86   6.53   1.86
        A        875  0.21   0.58   0.21
        K      56560  0.09   0.83   0.09

TWO     V             1.86   6.53   1.86
        A        875  0.21   0.58   0.21
        K      56560  0.09   0.83   0.09

THREE   V             1.86   6.53   1.86
        A        875  0.21   0.58   0.21
        K      56560  0.09   0.83   0.09
```

NOTE: Output for last three cross sections is not shown.

Exhibit 1.--Example of velocity-distribution summary.

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 *** PAGE COUNT=   10,DATE= 2/25/77

COMPARISON OF PROFILES FOR: SIMPLE REACH EXAMPLE ------- J635 CODING
     THE "DELTA WS" VALUES ARE COMPUTED BY SUBTRACTING THE ELEVATIONS OF THE
     BASE PROFILE (PROFILE NUMBER  1,   UPSTREAM COMPUTATIONS) FROM THE ELEV-
     ATIONS OF THIS PROFILE (PROFILE NUMBER  2,   UPSTREAM COMPUTATIONS).

   SECID     ONE       TWO       THREE     FOUR      FIVE      SIX
DELTA WS      1.75      1.75      1.75      1.75      1.75      1.75
```

Exhibit 2.--Example of tabulation of water-surface elevation differences between selected profiles.

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USGS STEP-BACKWATER PROGRAM - VERSION 77.055 *** PAGE COUNT=   12,DATE= 2/25/77

WATER-SURFACE PROFILE FOR:  SIMPLE FLOODWAY EXAMPLE ---- J635 CODING
PAGE  1 OF  1, PROFILE NUMBER  2,   UPSTREAM COMPUTATIONS
*** FLOODWAY ANALYSIS *** 0.50' SURCHARGE
===============================================================================
SECID AT DISTANCE/ LENGTH/DISCHARGE/  AREA  /CONVEYANCE/ ALPHA/  LEW  /  REW
  WS ELEV /    HV  /    HF  /    HE  /     EG  /      V  /    FN  /   ACC   *ID*
===============================================================================
ONE    AT    1000 /     0 /  4000. /   655. /   56623. / 1.19 /   99. /  205.
   212.29 /   0.69 /                      /  212.98 /   6.11 /   0.46/          *IS*
-------------------------------------------------------------------------------
TWO    AT    2000 /  1000 /  4000. /   655. /   56623. / 1.19 /   99. /  205.
   217.29 /   0.69 /  4.99 /   0.0  /  217.98 /   6.11 /   0.46 / 0.010  *XS*
-------------------------------------------------------------------------------
THREE AT     3000 /  1000 /  4000. /   655. /   56623. / 1.19 /   99. /  205.
   222.29 /   0.69 /  4.99 /   0.0  /  222.98 /   6.11 /   0.46 / 0.010  *XS*
-------------------------------------------------------------------------------
FOUR   AT    4000 /  1000 /  4000. /   655. /   56623. / 1.19 /   99. /  205.
   227.29 /   0.69 /  4.99 /   0.0  /  227.98 /   6.11 /   0.46 / 0.010  *XS*
-------------------------------------------------------------------------------
FIVE   AT    5000 /  1000 /  4000. /   655. /   56623. / 1.19 /   99. /  205.
   232.29 /   0.69 /  4.99 /   0.0  /  232.98 /   6.11 /   0.46 / 0.010  *XS*
-------------------------------------------------------------------------------
SIX    AT    6000 /  1000 /  4000. /   655. /   56623. / 1.19 /   99. /  205.
   237.29 /   0.69 /  4.99 /   0.0  /  237.98 /   6.11 /   0.46 / 0.010  *XS*
-------------------------------------------------------------------------------

                         END OF THIS PROFILE
```

Exhibit 3.--Floodway profile printout for SIMPLE FLOODWAY EXAMPLE.

USGS STEP-BACKWATER PROGRAM - VERSION 77.055 *** PAGE COUNT= 13, DATE= 2/25/77

SUMMARY OF ENCROACHMENTS FOR: SIMPLE FLOODWAY EXAMPLE ---- J635 CODING
RESULTS OF THE FLOODWAY ANALYSIS ENTITLED 0.50' SURCHARGE (PROFILE NUMBER 2, UPSTREAM COMPUTATIONS) ARE COMPARED TO THE RESULTS OF THE BASE PROFILE (PROFILE NUMBER 1, UPSTREAM COMPUTATIONS). PAGE 1 OF 1

SECID	CARD 3 SEQUENCE	TYPE	FW OPTION	ENCROACHMENT LEFT	ENCROACHMENT RIGHT	SURCHARGE IDEAL	SURCHARGE ACTUAL	CHANNEL WIDTH NATURAL	CHANNEL WIDTH FLOODWAY
ONE	1003	1	VER	YES	YES	0.50	0.50	236	106
TWO	2003	0	VER	YES	YES	0.50	0.50	236	106
THREE	3003	0	VER	YES	YES	0.50	0.50	236	106
FOUR	4003	0	VER	YES	YES	0.50	0.50	236	106
FIVE	5003	0	VER	YES	YES	0.50	0.50	236	106
SIX	6003	0	VER	YES	YES	0.50	0.50	236	106

Exhibit 4.--Comparative tabulation of floodway versus normal profile results.

appropriate. Also, the code N.A. (meaning "not applicable") will be printed for cross sections coded with TYPE = 2, 3, or 4. In the ENCROACHMENT columns there may also be printed the following codes: (1) NO, indicating no encroachment; (2) CONS, indicating that the encroachment was limited by the specified constraint; and (3) N.A., as defined above. In the SURCHARGE columns and the CHANNEL WIDTH columns asterisks are printed when numbers are not applicable (for example, surcharge or width for an embankment cross section).

Exhibit 5 illustrates the input data deck for computing a supercritical profile in a reach having the same shape (see figure 28) as the preceding examples. In this reach, however, the slope changes from 0.005 between sections NINE and TEN to 0.025 between sections TEN and ELEVEN. A normal profile is desired for 4,000 cfs (see CARD #4) for which the water-surface elevation is known to be 299.70 (see CARD #2) at section ELEVEN. Since a supercritical profile must be computed in the downstream direction, a 2 (two) is coded in column 42 of the #7 CARD. A 0 (zero) is coded in column 42 of the #8 CARD since no special features are desired.

Exhibit 6 is the printout of the resultant supercritical profile. The profile computations are successful from sections ELEVEN through section TEN but (as would be expected) are unsuccessful in the mild-sloped subreach between sections TEN and NINE. Therefore, J635 assigns the critical water-surface elevation at section NINE and prints asterisks for HE, HF, and ACC since no meaningful values exist for these parameters when WSC is assumed. Exhibit 7 shows the printouts of (1) the profile computations messages (which actually precede the profile printout) and (2) the summaries of the computed WSC and WSA values. The potential value(s) of the WSC and WSA summaries are discussed later.

Exhibit 8 is a printout of the input data deck for another reach of the same channel. This example is intended to represent a typical reach having a supercritical segment bounded by subcritical segments. Channel slope varies as follows: (1) 0.005 between sections FIVE and SIX, (2) 0.025 between sections SIX and SEVEN, and (3) 0.005 between sections SEVEN and NINE. Two normal profiles are desired for the 4,000 cfs discharge (see CARD #4). The first profile is to be computed in the upstream direction and the second is to be computed in the downstream direction. Therefore, the first elevation on CARD #2 (231.79) represents the known water-surface elevation (subcritical) at section FIVE to be used as the starting water-surface elevation for the upstream computations. The second elevation on CARD #2 (-99.99, which is obviously less than GMIN) indicates that the computed WSC value at section NINE is to be used as the starting water-surface elevation for the downstream computations. The #7 CARD is coded with a 0 (zero) and a 2 (two) in columns 42 and 44 to indicate the upstream and downstream computational directions, respectively. Zeroes are coded in columns 42 and 44 of the 48 CARD since no special features are desired. Printouts of the profiles, profile computation messages, and WSC and WSA summaries are shown in exhibits 9 through 12. An analysis of the results can be used to illustrate potential

```
          1         2         3         4         5         6         7         8
....5....0....5....0....5....0....5....0....5....0....5....0....5....0....5....0

1  9001 MILD-TO-STEEP SLOPE EXAMPLE ------- J635 CODING    7  1 01 99 12
2  9002  29970
3  9003 NINE  1  10  3  267     9000 99 99
4  9004   4000
5  9010         0  1  2750    50  1  2700  110  2  2680  115  2  2660  130  2  2650
5  9011       170  2  2650   185  2  2660  190  3  2680  250  3  2700  300  3  2750
6  9020  0  1 100 100   0  1 055 055   0  1 100 100
3 10003 TEN    0  10  3  272    10000 99 99
5 10010         0  1  2800    50  1  2750  110  2  2730  115  2  2710  130  2  2700
5 10011       170  2  2700   185  2  2710  190  3  2730  250  3  2750  300  3  2800
6 10020  0  1 100 100   0  1 055 055   0  1 100 100
3 10203 TEN.2 0  10  3  277    10200 99 99
5 10210         0  1  2850    50  1  2800  110  2  2780  115  2  2760  130  2  2750
5 10211       170  2  2750   185  2  2760  190  3  2780  250  3  2800  300  3  2850
6 10220  0  1 100 100   0  1 055 055   0  1 100 100
3 10403 TEN.4 0  10  3  282    10400 99 99
5 10410         0  1  2900    50  1  2850  110  2  2830  115  2  2810  130  2  2800
5 10411       170  2  2800   185  2  2810  190  3  2830  250  3  2850  300  3  2900
6 10420  0  1 100 100   0  1 055 055   0  1 100 100
3 10603 TEN.6 0  10  3  287    10600 99 99
5 10610         0  1  2950    50  1  2900  110  2  2880  115  2  2860  130  2  2850
5 10611       170  2  2850   185  2  2860  190  3  2880  250  3  2900  300  3  2950
6 10620  0  1 100 100   0  1 055 055   0  1 100 100
3 10803 TEN.8 0  10  3  292    10800 99 99
5 10810         0  1  3000    50  1  2950  110  2  2930  115  2  2910  130  2  2900
5 10811       170  2  2900   185  2  2910  190  3  2930  250  3  2950  300  3  3000
6 10820  0  1 100 100   0  1 055 055   0  1 100 100
3 11003 ELEVN 0  10  3  297    11000 99 99
5 11010         0  1  3050    50  1  3000  110  2  2980  115  2  2960  130  2  2950
5 11011       170  2  2950   185  2  2960  190  3  2980  250  3  3000  300  3  3050
6 11020  0  1 100 100   0  1 055 055   0  1 100 100
7 77007                                    2
8 88008                                    0
```

Exhibit 5.--Input data for downstream computation of a supercritical profile.

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 ### PAGE COUNT=     7,DATE= 3/16/77

WATER-SURFACE PROFILE FOR:  MILD-TO-STEEP SLOPE EXAMPLE ------- J635 CODING
PAGE  1 OF  1, PROFILE NUMBER  1, DOWNSTREAM COMPUTATIONS
=================================================================================
SECID AT DISTANCE/ LENGTH/DISCHARGE/  AREA  /CONVEYANCE/ ALPHA/  LEW  /  REW
  WS ELEV /    HV  /    HF  /    HE  /    EG  /     V  /    FN  /   ACC    *ID*
=================================================================================
ELEVN AT   11000 /      0 /  4000. /   428. /  25276. / 1.37 /   59. /  241.
   299.70 /   1.86 /                 /  301.56 /   9.35 /   1.26/           *IS*
---------------------------------------------------------------------------------
TEN.8 AT   10800 /   -200 /  4000. /   429. /  25345. / 1.37 /   59. /  241.
   294.71 /   1.86 /   5.00 /    0.0 /  296.56 /   9.33 /   1.26 /  0.006   *XS*
---------------------------------------------------------------------------------
TEN.6 AT   10600 /   -200 /  4000. /   428. /  25282. / 1.37 /   59. /  241.
   289.70 /   1.86 /   4.99 /    0.0 /  291.56 /   9.35 /   1.26 /  0.005   *XS*
---------------------------------------------------------------------------------
TEN.4 AT   10400 /   -200 /  4000. /   429. /  25339. / 1.37 /   59. /  241.
   284.71 /   1.86 /   5.00 /    0.0 /  286.56 /   9.33 /   1.26 /  0.005   *XS*
---------------------------------------------------------------------------------
TEN.2 AT   10200 /   -200 /  4000. /   428. /  25284. / 1.37 /   59. /  241.
   279.70 /   1.86 /   4.99 /    0.0 /  281.56 /   9.35 /   1.26 /  0.004   *XS*
---------------------------------------------------------------------------------
TEN   AT   10000 /   -200 /  4000. /   429. /  25337. / 1.37 /   59. /  241.
   274.71 /   1.86 /   5.00 /    0.0 /  276.56 /   9.33 /   1.26 /  0.005   *XS*
---------------------------------------------------------------------------------
NINE  AT    9000 /  -1000 /  4000. /   471. /  27950. / 1.44 /   52. /  248.
   269.93 /   1.61 /******* /******* /  271.54 /   8.49 /   1.16 /*******  *XS*
---------------------------------------------------------------------------------

                           END OF THIS PROFILE
```

Exhibit 6.--Profile printout for data of exhibit 5.

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 ### PAGE COUNT=    6,DATE= 3/16/77

PAGE  1 OF PROFILE NOTES FOR: MILD-TO-STEEP SLOPE EXAMPLE ------- J635 CODING
     PROFILE NUMBER  1, DOWNSTREAM COMPUTATIONS

SECID; ERROR(WARNING) MESSAGE; INTERMEDIATE RESULTS(IF ANY); ACTION TAKEN

ELEVN; SUPERCRITICAL WS      ;                                COMPUTED WSA
TEN.8; SUPERCRITICAL WS      ;                                COMPUTED WSA
TEN.6; SUPERCRITICAL WS      ;                                COMPUTED WSA
TEN.4; SUPERCRITICAL WS      ;                                COMPUTED WSA
TEN.2; SUPERCRITICAL WS      ;                                COMPUTED WSA
TEN  ; SUPERCRITICAL WS      ;                                COMPUTED WSA
NINE ; WS NOT FOUND BETWEEN  ; WS =  269.93  & WS =  265.20; USED DEL = 0.25
NINE ; WS NOT FOUND BETWEEN  ; WS =  269.93  & WS =  265.20; USED EK = 0.5
NINE ; WS NOT FOUND          ;                                ASSUMED WS = WSC


USGS STEP-BACKWATER PROGRAM - VERSION 77.055 ### PAGE COUNT=    8,DATE= 3/16/77

COMPUTED WSC VALUES FOR: MILD-TO-STEEP SLOPE EXAMPLE ------- J635 CODING
     PROFILE NUMBER  1, DOWNSTREAM COMPUTATIONS

   SECID   NINE     TEN      TEN.2    TEN.4    TEN.6    TEN.8    ELEVN
     WSC   269.93   274.93   279.93   284.93   289.93   294.93   299.93

COMPUTED WSA VALUES FOR: MILD-TO-STEEP SLOPE EXAMPLE ------- J635 CODING
     PROFILE NUMBER  1, DOWNSTREAM COMPUTATIONS

   SECID   TEN      TEN.2    TEN.4    TEN.6    TEN.8    ELEVN
     WSA   275.22   280.23   285.22   290.23   295.22   300.23
```

Exhibit 7.--Profile message, WSC and WSA printouts associated with the profile of exhibit 6.

```
1  5001 MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING      9  2 01 99 12
2  5002  23179   -9999
3  5003 FIVE   1   10   3   227      5000 99 99
4  5004    4000      4000
5  5010          0   1   2350     50   1   2300   110   2   2280   115   2   2260   130   2   2250
5  5011        170   2   2250    185   2   2260   190   3   2280   250   3   2300   300   3   2350
6  5020   0   1 100 100   0   1 055 055   0   1 100 100
3  6003 SIX      0   10   3   232      6000 99 99
5  6010          0   1   2400     50   1   2350   110   2   2330   115   2   2310   130   2   2300
5  6011        170   2   2300    185   2   2310   190   3   2330   250   3   2350   300   3   2400
6  6020   0   1 100 100   0   1 055 055   0   1 100 100
3  6203 SIX.2 0   10   3   237      6200 99 99
5  6210          0   1   2450     50   1   2400   110   2   2380   115   2   2360   130   2   2350
5  6211        170   2   2350    185   2   2360   190   3   2380   250   3   2400   300   3   2450
6  6220   0   1 100 100   0   1 055 055   0   1 100 100
3  6403 SIX.4 0   10   3   242      6400 99 99
5  6410          0   1   2500     50   1   2450   110   2   2430   115   2   2410   130   2   2400
5  6411        170   2   2400    185   2   2410   190   3   2430   250   3   2450   300   3   2500
6  6420   0   1 100 100   0   1 055 055   0   1 100 100
3  6603 SIX.6 0   10   3   247      6600 99 99
5  6610          0   1   2550     50   1   2500   110   2   2480   115   2   2460   130   2   2450
5  6611        170   2   2450    185   2   2460   190   3   2480   250   3   2500   300   3   2550
6  6620   0   1 100 100   0   1 055 055   0   1 100 100
3  6803 SIX.8 0   10   3   252      6800 99 99
5  6810          0   1   2600     50   1   2550   110   2   2530   115   2   2510   130   2   2500
5  6811        170   2   2500    185   2   2510   190   3   2530   250   3   2550   300   3   2600
6  6820   0   1 100 100   0   1 055 055   0   1 100 100
3  7003 SEVEN 0   10   3   257      7000 99 99
5  7010          0   1   2650     50   1   2600   110   2   2580   115   2   2560   130   2   2550
5  7011        170   2   2550    185   2   2560   190   3   2580   250   3   2600   300   3   2650
6  7020   0   1 100 100   0   1 055 055   0   1 100 100
3  8003 EIGHT 0   10   3   262      8000 99 99
5  8010          0   1   2700     50   1   2650   110   2   2630   115   2   2610   130   2   2600
5  8011        170   2   2600    185   2   2610   190   3   2630   250   3   2650   300   3   2700
6  8020   0   1 100 100   0   1 055 055   0   1 100 100
3  9003 NINE   0   10   3   267      9000 99 99
5  9010          0   1   2750     50   1   2700   110   2   2680   115   2   2660   130   2   2650
5  9011        170   2   2650    185   2   2660   190   3   2680   250   3   2700   300   3   2750
6  9020   0   1 100 100   0   1 055 055   0   1 100 100
7 77007                                        0 2
8 88008                                        0 0
```

Exhibit 8.--Input data for a reach having a supercritical segment bounded by subcritical segments.

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 ### PAGE COUNT=    7,DATE= 3/16/77

WATER-SURFACE PROFILE FOR:  MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING
PAGE  1 OF  1, PROFILE NUMBER  1,    UPSTREAM COMPUTATIONS
===============================================================================
SECID AT DISTANCE/ LENGTH/DISCHARGE/  AREA  /CONVEYANCE/ ALPHA/  LEW  /  REW
  WS ELEV /    HV  /    HF  /    HE  /     EG  /      V  /    FN  /   ACC   #ID#
===============================================================================
FIVE  AT    5000 /     0 /    4000. /   875. /   56560. / 1.72 /   32. /  268.
   231.79 /   0.56 /                      /  232.35 /   4.57 /   0.46/          #IS#
-------------------------------------------------------------------------------
SIX   AT    6000 /  1000 /    4000. /   875. /   56560. / 1.72 /   32. /  268.
   236.79 /   0.56 /   5.00 /    0.0  /  237.35 /   4.57 /   0.46 / -0.001  #XS#
-------------------------------------------------------------------------------
SIX.2 AT    6200 /   200 /    4000. /   470. /   27869. / 1.44 /   52. /  248.
   239.92 /   1.62 /######## /######## /  241.54 /   8.51 /   0.87 /########  #XS#
-------------------------------------------------------------------------------
SIX.4 AT    6400 /   200 /    4000. /   470. /   27869. / 1.44 /   52. /  248.
   244.92 /   1.62 /######## /######## /  246.54 /   8.51 /   0.87 /########  #XS#
-------------------------------------------------------------------------------
SIX.6 AT    6600 /   200 /    4000. /   470. /   27869. / 1.44 /   52. /  248.
   249.92 /   1.62 /######## /######## /  251.54 /   8.51 /   0.87 /########  #XS#
-------------------------------------------------------------------------------
SIX.8 AT    6800 /   200 /    4000. /   470. /   27869. / 1.44 /   52. /  248.
   254.92 /   1.62 /######## /######## /  256.54 /   8.51 /   0.87 /########  #XS#
-------------------------------------------------------------------------------
SEVEN AT    7000 /   200 /    4000. /   471. /   27950. / 1.44 /   52. /  248.
   259.93 /   1.61 /######## /######## /  261.54 /   8.49 /   0.87 /########  #XS#
-------------------------------------------------------------------------------
EIGHT AT    8000 /  1000 /    4000. /  1203. /   83348. / 1.80 /   19. /  281.
   268.11 /   0.31 /   6.87 /    0.0  /  268.42 /   3.33 /   0.32 /  0.004  #XS#
-------------------------------------------------------------------------------
NINE  AT    9000 /  1000 /    4000. /   827. /   52858. / 1.70 /   34. /  266.
   271.58 /   0.62 /   3.63 /   0.15 /  272.20 /   4.84 /   0.49 /  0.001  #XS#
-------------------------------------------------------------------------------

                         END OF THIS PROFILE
```

Exhibit 9.--Profile printout for upstream computations for data of exhibit 8.

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 ### PAGE COUNT=    6,DATE= 3/16/77

PAGE  1 OF PROFILE NOTES FOR: MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING
     PROFILE NUMBER  1,    UPSTREAM COMPUTATIONS

SECID; ERROR(WARNING) MESSAGE; INTERMEDIATE RESULTS(IF ANY); ACTION TAKEN

SIX.2; FRDN FAILURE             ; WS =  238.84  & FR =     1.40; USED HIGHER WS
SIX.2; WS NOT FOUND BETWEEN     ; WS =  236.54  & WS =   245.00; USED DEL = 0.25
SIX.2; WS NOT FOUND BETWEEN     ; WS =  236.54  & WS =   245.00; USED WSMIN = WSC
SIX.2; WS NOT FOUND             ;                                ASSUMED WS = WSC
SIX.4; WS TOO LOW               ;                                USED WSMIN = WSC
SIX.4; WS NOT FOUND BETWEEN     ; WS =  244.92  & WS =   250.00; USED DEL = 0.25
SIX.4; WS NOT FOUND             ;                                ASSUMED WS = WSC
SIX.6; WS TOO LOW               ;                                USED WSMIN = WSC
SIX.6; WS NOT FOUND BETWEEN     ; WS =  249.92  & WS =   255.00; USED DEL = 0.25
SIX.6; WS NOT FOUND             ;                                ASSUMED WS = WSC
SIX.8; WS TOO LOW               ;                                USED WSMIN = WSC
SIX.8; WS NOT FOUND BETWEEN     ; WS =  254.92  & WS =   260.00; USED DEL = 0.25
SIX.8; WS NOT FOUND             ;                                ASSUMED WS = WSC
SEVEN; WS TOO LOW               ;                                USED WSMIN = WSC
SEVEN; WS NOT FOUND BETWEEN     ; WS =  259.93  & WS =   265.00; USED DEL = 0.25
SEVEN; WS NOT FOUND             ;                                ASSUMED WS = WSC
EIGHT; WS TOO LOW               ;                                USED WSMIN = WSC
EIGHT; KU/KD < 0.7 OR > 1.4     ;                                ALERTED USER
NINE ; KU/KD < 0.7 OR > 1.4     ;                                ALERTED USER


USGS STEP-BACKWATER PROGRAM - VERSION 77.055 ### PAGE COUNT=    8,DATE= 3/16/77


COMPUTED WSC VALUES FOR: MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING
     PROFILE NUMBER  1,    UPSTREAM COMPUTATIONS

   SECID   SIX.2    SIX.4    SIX.6    SIX.8    SEVEN    EIGHT
     WSC   239.92   244.92   249.92   254.92   259.93   264.93
```

Exhibit 10.--Profile message and WSC printouts associated with profile of exhibit 9.

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 ### PAGE COUNT=   10,DATE= 3/16/77

WATER-SURFACE PROFILE FOR:  MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING
PAGE  1 OF  1, PROFILE NUMBER  2, DOWNSTREAM COMPUTATIONS
===============================================================================
SECID AT DISTANCE/ LENGTH/DISCHARGE/  AREA  /CONVEYANCE/ ALPHA/  LEW  /  REW
  WS ELEV /    HV  /    HF  /    HE  /     EG  /      V  /    FN  /  ACC   *ID*
===============================================================================
NINE  AT    9000 /       0 /   4000. /   471. /  27950. / 1.44 /   52. /  248.
   269.93 /   1.61 /                   /  271.54 /   8.49 /   1.16/          *IS*
-------------------------------------------------------------------------------
EIGHT AT    8000 / -1000 /   4000. /   471. /  27950. / 1.44 /   52. /  248.
   264.93 /   1.61 /####### /####### /  266.54 /   8.49 /   1.16 /#######  *XS*
-------------------------------------------------------------------------------
SEVEN AT    7000 / -1000 /   4000. /   471. /  27950. / 1.44 /   52. /  248.
   259.93 /   1.61 /####### /####### /  261.54 /   8.49 /   1.16 /#######  *XS*
-------------------------------------------------------------------------------
SIX.8 AT    6800 /  -200 /   4000. /   394. /  23209. / 1.31 /   65. /  235.
   254.51 /   2.10 /   4.93 /    0.0  /  256.61 /  10.14 /   1.35 / 0.001  *XS*
-------------------------------------------------------------------------------
SIX.6 AT    6600 /  -200 /   4000. /   459. /  27227. / 1.42 /   54. /  246.
   249.87 /   1.68 /   5.06 /    0.0  /  251.54 /   8.71 /   1.18 / 0.001  *XS*
-------------------------------------------------------------------------------
SIX.4 AT    6400 /  -200 /   4000. /   403. /  23745. / 1.33 /   63. /  237.
   244.56 /   2.03 /   4.95 /    0.0  /  246.59 /   9.93 /   1.32 / 0.001  *XS*
-------------------------------------------------------------------------------
SIX.2 AT    6200 /  -200 /   4000. /   451. /  26708. / 1.41 /   55. /  245.
   239.82 /   1.72 /   5.05 /    0.0  /  241.55 /   8.87 /   1.20 / 0.001  *XS*
-------------------------------------------------------------------------------
SIX   AT    6000 /  -200 /   4000. /   409. /  24146. / 1.34 /   62. /  238.
   234.60 /   1.99 /   4.96 /    0.0  /  236.58 /   9.77 /   1.31 / 0.001  *XS*
-------------------------------------------------------------------------------
FIVE  AT    5000 / -1000 /   4000. /   470. /  27869. / 1.44 /   52. /  248.
   229.92 /   1.62 /####### /####### /  231.54 /   8.51 /   1.16 /#######  *XS*
-------------------------------------------------------------------------------

                         END OF THIS PROFILE
```

Exhibit 11.--Profile printout for downstream computations for data of exhibit 8.

```
USGS STEP-BACKWATER PROGRAM - VERSION 77.055 *** PAGE COUNT=    9,DATE= 3/16/77

PAGE   1 OF PROFILE NOTES FOR: MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING
     PROFILE NUMBER  2, DOWNSTREAM COMPUTATIONS

SECID; ERROR(WARNING) MESSAGE; INTERMEDIATE RESULTS(IF ANY); ACTION TAKEN

NINE ; WS TOO LOW              ;                                ASSUMED WS = WSC
EIGHT; WS NOT FOUND BETWEEN    ; WS =  264.93  & WS =  260.20;  USED DEL = 0.25
EIGHT; WS NOT FOUND BETWEEN    ; WS =  264.93  & WS =  260.20;  USED EK = 0.5
EIGHT; WS NOT FOUND            ;                                ASSUMED WS = WSC
SEVEN; WS NOT FOUND BETWEEN    ; WS =  259.93  & WS =  255.20;  USED DEL = 0.25
SEVEN; WS NOT FOUND BETWEEN    ; WS =  259.93  & WS =  255.20;  USED EK = 0.5
SEVEN; WS NOT FOUND            ;                                ASSUMED WS = WSC
SIX.8; SUPERCRITICAL WS        ;                                COMPUTED WSA
SIX.6; SUPERCRITICAL WS        ;                                COMPUTED WSA
SIX.4; SUPERCRITICAL WS        ;                                COMPUTED WSA
SIX.2; SUPERCRITICAL WS        ;                                COMPUTED WSA
SIX  ; SUPERCRITICAL WS        ;                                COMPUTED WSA
FIVE ; WS NOT FOUND BETWEEN    ; WS =  229.92  & WS =  225.20;  USED DEL = 0.25
FIVE ; WS NOT FOUND BETWEEN    ; WS =  229.92  & WS =  225.20;  USED EK = 0.5
FIVE ; WS NOT FOUND            ;                                ASSUMED WS = WSC

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COMPUTED WSC VALUES FOR: MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING
     PROFILE NUMBER  2, DOWNSTREAM COMPUTATIONS

   SECID   FIVE     SIX      SIX.2    SIX.4    SIX.6    SIX.8    SEVEN    EIGHT
     WSC   229.92   234.92   239.92   244.92   249.92   254.92   259.93   264.93

   SECID   NINE
     WSC   269.93

COMPUTED WSA VALUES FOR: MILD-STEEP-MILD SLOPE EXAMPLE ----- J635 CODING
     PROFILE NUMBER  2, DOWNSTREAM COMPUTATIONS

   SECID   SIX      SIX.2    SIX.4    SIX.6    SIX.8
     WSA   235.34   240.09   245.38   249.98   255.44
```

Exhibit 12.--Profile message, WSC, and WSA printouts associated with profile of exhibit 11.

problems that can result from improper cross-section spacing. Exhibit 13 presents a table comparing J635 results to the true profile for this idealized case.

The profile must pass through critical flow at section SEVEN. Upstream from SEVEN the profile must follow an M2 curve from critical depth to a convergence with the normal (subcritical) profile at some point upstream. However, due to the length of the subreach between sections SEVEN and EIGHT, the water-surface elevation computed by J635 for section EIGHT is significantly higher than the true normal water-surface elevation at that point. Subsequent J635 computations yield a water-surface elevation at section NINE which is lower than the true normal water-surface elevation at NINE. Of course, if computations were continued upstream from NINE, this erroneous profile would converge upon the true normal profile (probably in only two or three 1,000-ft subreaches). Correction of this erroneous profile would require additional cross sections, at least between sections SEVEN and EIGHT. At some cross-section spacing greater than 1,000 feet, the problem of erroneous computations would become especially acute as illustrated by exhibit 14a. At the third cross section upstream, the water-surface elevation(s) that would balance the energy equation would be rejected on the basis of the FN test and J635 would assume WSC for that cross section. Therefore, the resultant profile would be a meaningless (useless) succession of critical (at sections 1, 3, 5, and so on) and subcritical (at sections 2, 4, 6, and so on) water-surface elevations.

A similar problem exists in the downstream computations. Downstream from SEVEN the profile computed by J635 "flip-flops" above and below the true normal profile (see exhibit 13). The computed profile should, of course, follow an S2 curve from critical flow at SEVEN to a convergence with the normal (supercritical) profile at some point downstream. Additional cross sections (at least between SEVEN and SIX.8) would provide such a profile. Deviations from the true profile may not be significant in this case and the erroneous profile has almost "self-corrected" itself at section SIX. Again, however, at some cross-section spacing greater than 200 feet the computational error problem would become especially acute as illustrated by exhibit 14b. At the third cross section downstream the water-surface elevation(s) that would balance the energy equation would be higher than the critical water-surface elevation. Since that is a result which is unacceptable (and not even considered) by J635, a value of WSC would be assumed at that cross section. Therefore, the resultant profile would be a meaningless (useless) succession of critical (at sections 11, 13, 15, and so on) and supercritical (at sections 12, 14, 16, and so on) water-surface elevations.

The above two paragraphs should reveal to the user the importance and necessity of utilizing the available WSC information in the evaluation of the computed results. A computed profile should roughly parallel the profile of WSC results, except for the subreaches in which there is a transition from either an above-normal or below-normal water-surface elevation to a normal water-surface elevation.

		Results based on J635 Computations				
	TRUE NORMAL	Upstream Computations		Downstream Computations		ALTER-NATE
SECID	DEPTH	DEPTH	ERROR	DEPTH	ERROR	DEPTH 5/
FIVE	6.79 1/	6.79	0.00	4/	---	---
SIX	6.79 1/ or 4.70 2/	6.79	0.00	4.60	-0.10	5.34
SIX.2	4.70 2/	4/	---	4.82	0.12	5.09
SIX.4	4.70 2/	4/	---	4.56	-0.14	5.38
SIX.6	4.70 2/	4/	---	4.87	+0.17	4.98
SIX.8	4.70 2/	4/	---	4.51	-0.19	5.44
SEVEN	4.93 3/	4.93	0.00	4.93	0.00	---
EIGHT	6.79 1/	8.11	+1.32	4/	---	---
NINE	6.79 1/	6.58	-0.21	4/	---	---

NOTE: All depths expressed as distance above GMIN.

1/ Subcritical depth when computing in the upstream direction.

2/ Supercritical depth when computing in the downstream direction.

3/ Critical depth

4/ J635 defaulted to WSC to continue profile computations

5/ True alternate depth is 5.22

Exhibit 13.--Comparison of J635 computations to actual profile.

In these "transition" subreaches, the computed profile should at least resemble the appropriate theoretical gradually-varied flow profile. That is, the computed profile in such cases should (at a decreasing rate) be either converging towards or diverging from (and never crossing) the WSC profile. Of course, in "real-life" situations it may sometimes be very difficult to distinguish cross-section spacing problems from the inherent problem that normal depth essentially changes at every cross section. However, if the user provides a sufficient number of cross sections to properly define the variations (in channel slope, size, roughness, and so on) in the reach, an erratic (or inconsistent) relationship between the computed profile and the WSC profile may well indicate the need for additional cross sections.

WSC values are easily obtained for the entire reach by simply computing a profile in the downstream direction. At times (for example when supercritical and (or) critical flow situations are encountered in only a minor portion of the reach) this approach may appear to be a waste of money. WSC computations and downstream profile computations through subcritical reaches require many iterative computations and thus cost somewhat more than upstream computations. However, it may well be worth the coins (or bills) since the WSC values can provide an additional, invaluable tool for evaluation of the results.

WSC values are computed only as a last resort when computing in the upstream direction. In fact, the use of WSC is not even considered unless: (1) no water-surface elevation is found between WSD-0.5Δh and GMAX that balances the energy equation, or (2) all water-surface elevations in that range that do balance the energy equation are rejected on the basis of the FN test (see PN-4, table 11/SUPP.). Also, the index Froude number may be less than 1.0 for critical and (or) supercritical flow (see exhibit 9 where the computed Froude number is 0.87 for sections SIX.2 through SEVEN for a water-surface elevation of WSC). Thus, it is possible for J635 to accept a supercritical water-surface elevation in upstream computations because it does balance the energy equation and passes the FN test. The writer has observed a "real-life" situation in which a water-surface elevation which was more than a foot less than WSC was accepted during upstream computations because it passed the TOL and FN tests (FN was 1.2). Such a computed profile is obviously incorrect since upstream computations cannot be made for a sequence of subcritical to supercritical to subcritical flow. Undesirable results of this nature can be prevented by simply coding a sufficiently low value for FN (even less than 1.0). It should also be noted here that the computed Froude number printed for downstream profile computations is different (see exhibit 11) from the index Froude number (see exhibit 9). Equation 3-3 (E431 User's Manual, fig. 3, p. 9) is used to compute the Froude number during downstream computations.

Exhibit 15 illustrates a computed, normal profile for a mild-steep-mild sloped reach. Also shown is an "estimated" profile between sections 6 and 11. This "estimated" profile demonstrates a potential use of the computed WSA values for a supercritical reach. Such an application depends upon: (1) yet-to-be-made policy decisions, and

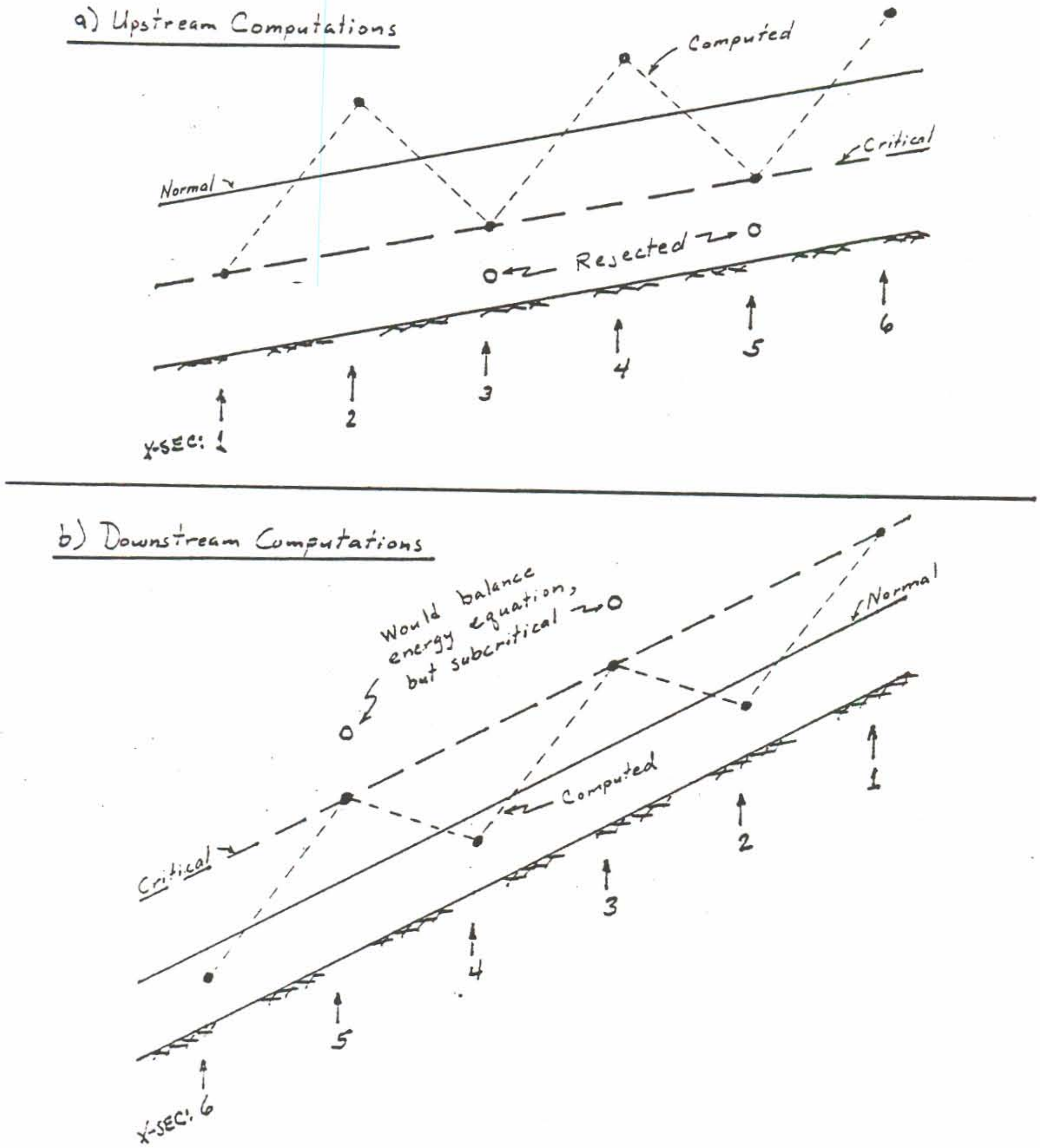

Exhibit 14.--Potential computational problems with too few cross sections.

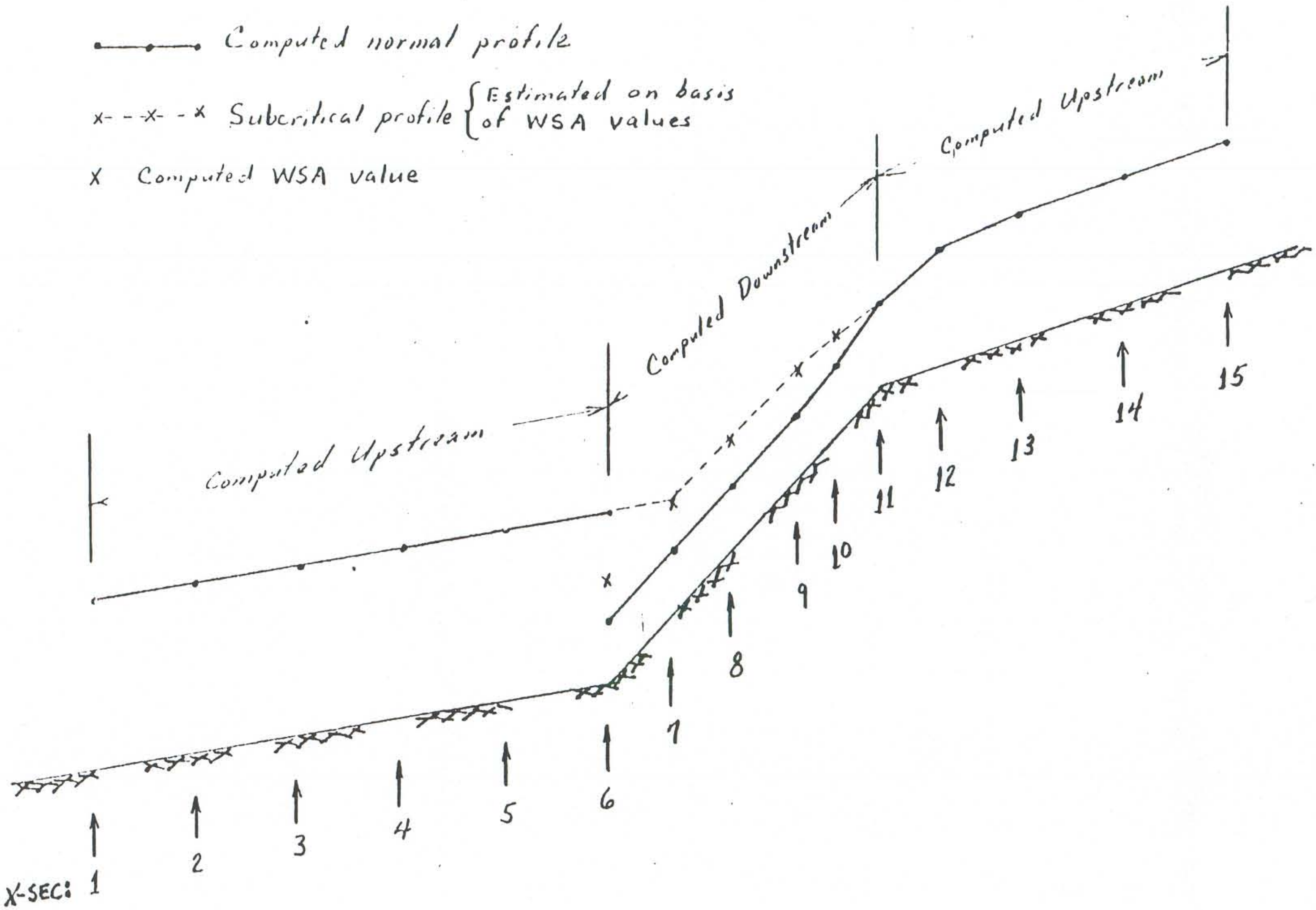

Exhibit 15.--Schematic of a reach having a supercritical segment bounded by subcritical segments.

(2) the assumption that a high probability exists for the occurrence of a hydraulic jump at any point in a supercritical reach (for example, triggered by the lodging of floating debris). Depending upon where a hydraulic jump occurs, flow conditions for all or any portion of the supercritical reach would change from the supercritical regime to the more stable subcritical flow regime. Precise determination of this subcritical flow regime would require computation of sequent water-surface elevations. However, computation of alternate water-surface elevations is significantly easier to program and requires significantly fewer calculations. Thus, for the sake of simplicity, the computed WSA values are assumed to be an adequate estimate of the possible subcritical flow conditions in a supercritical reach. User judgment is required in connecting the computed subcritical segments with the WSA values computed for the supercritical reach. For example, it might be more nearly correct in this example to assume the jump would definitely occur between sections 5 and 6. If so, "estimated" profile would be shown somewhat lower between sections 5 and 6, and perhaps merged into the WSA profile between sections 6 and 7.

Exhibit 15 is also used to demonstrate possible approaches to floodway analyses for a reach within which supercritical flow exists. The first approach presented assumes that no encroachment is to be permitted at those cross sections for which supercritical (sections 6 through 10) or critical (section 11) water-surface elevations have been computed for existing conditions. In this case, upstream computations only are required since the critical and supercritical water-surface elevations will not be changed by the encroachments. Exhibit 16a illustrates one appropriate set of #2, #4, #7, #8, and #9 CARDS which would yield output useful in preparing an FIA report. The #1 CARD would be coded with NPR=5. Notations on the #2 CARD (left to right) represent the desired starting water-surface elevations (at section 1) for the 100-year normal profile, the floodway profile, and the 10-, 50-, and 500-year normal profiles, respectively. Associated notations on the #4 CARD represent the 100-, 100-, 10-, 50-, and 500-year discharges, respectively.

Computed values of water-surface elevation and top width at all cross sections for a normal profile (computed in either direction) are stored in memory as "base profile" data unless the CARD #8 entry for that normal profile is either 2 or 7. A normal profile with a CARD #8 entry of either 2 or 7 is compared to existing "base profile" elevations and the existing "base profile" data is left unchanged. If NORMAL WS elevations are coded on #9 CARDS, those elevations are stored as the "base profile" elevations (but "base profile" top widths are then not available to be printed in the comparative tabulation of floodway profile and normal profile results). "Base profile" data remain unchanged in memory until either: (1) another normal profile without a CARD #8 entry of 2 or 7 is computed, or (2) another set of NORMAL WS elevations is input via #9 CARDS.

Therefore, in this example, the first profile establishes the "base profile" data for the entire analysis. The floodway profile (second profile) utilizes the "base profile" data for: (1) encroaching sections 1-5 and 12-15 in accordance with the VER option for 0.5 foot surcharge, and (2) the comparative tabulation of floodway versus normal profile results. For each of the third through fifth profiles (in addition to a profile printout) the user will obtain a tabulation of water-surface elevation differences between the "base (100-year) profile" elevations and the 10-, 50-, and 500-year profile elevations.

In the above approach there are many "wasted" computations for sections 7 through 10. J635 will assume WS = WSC at each of these cross sections for each profile, but only after many iterations. Also, the water-surface elevation differences for these cross sections are simply differences between the critical profiles which may or may not be useful information. In many instances, significant reduction in cost and output volume may be realized by separating such a reach into a multi-job analysis. Exhibits 16b and 16c illustrate such a separation for this example. Appropriate coding for sections 1-6 is shown in exhibit 16b and for sections 11-15 in exhibit 16c. It should be noted that the altered order of the second through fifth entries on the #2, #4, #7, and #8 CARDS will affect only the order of the output and not the results. Also, note that the #2 CARD for the upstream reach (exhibit 16c) must be coded such that the appropriate WSC value will be used for the starting elevation at section 11.

Exhibit 16d illustrates the #2, #4, #7, and #8 CARDS that could be used to obtain the elevation difference tabulations for the downstream computations (sections 6 through 11). These data could be used with a data deck for either: (1) the entire reach (with "wasted" calculations for sections 1-5 and 12-15), or (2) sections 6-11 only (thus the ??? for SEQUENCE on the #2 and #4 CARDS). The user must separate useful results in the tabulations of water-surface elevation differences for upstream and downstream computations in this type of reach. In "transition" areas (such as in the vicinity of section 5-7), if the user assumes water-surface elevations different from either the computed subcritical or computed supercritical values, the printed elevation differences for such cross sections are useless.

Analysis of the reach of exhibit 15 becomes somewhat more complex if encroachment of sections 6 and (or) 11 is permitted. Modification of section 11 alters the starting critical water-surface elevation (WSC) for the supercritical profile (computed downstream, sections 11 through 6). Modification of section 6 alters both the supercritical and alternate water-surface elevations at section 6 (thereby affecting any assumed transition profile in that vicinity). Such an analysis must therefore include the computation of the profile in the downstream direction for the modified conditions. Exhibit 16e illustrates data coded for the case in which encroachment of sections 6 and 11 is permitted and profiles are to be computed for the entire reach.

The first (upstream, normal) profile establishes the base profile data. The second (upstream, floodway) profile will produce valid results only for the subcritical segments of the reach. Also, only that portion of the comparative tabulation of floodway versus normal profiles that pertains to the subcritical segments will be useful.

```
         1         2         3         4         5         6
....5....0....5....0....5....0....5....0....5....0....5....0....5

A) ENTIRE REACH, X-SEC'S 1-5 & 12-15 ENCROACHED

PROFILE:  #1       #2      #3      #4      #5

2    102  WS100    WSFW    WS10    WS50    WS500

4    104  Q100     Q100    Q10     Q50     Q500

7   7001                                     0 1 0 0 0
8   8001                                     0 0 2 2 2
9   9001     103 VER 050                   X-SEC'S 1-5
9   9002     603 NOE                       X-SEC'S 6-11
9   9003    1203 VER 050                   X-SEC'S 12-15
9   9004         END                       0.5' SURCHARGE (VER)

*****************************************************************

B) SECTIONS 1-6

PROFILE:  #1       #2      #3      #4      #5

2    102  WS100  --WS10    WS100 -- WS50   WS500

4    104  Q100     Q10     Q100    Q50     Q500

7    701                                     0 0 1 0 0
8    801                                     0 2 0 2 2
9    901     103 VER 050                   X-SEC'S 1-5
9    902     603 NOE                       X-SEC 6
9    903         END                       0.5' SURCHARGE (VER)

*****************************************************************

C) SECTIONS 11-15

PROFILE:  #1       #2      #3      #4      #5

2   1102  -9999    -9999   -9999   -9999   -9999

4   1104  Q100     Q500    Q10     Q50     Q100

7   7001                                     0 0 0 0 1
8   8001                                     0 2 2 2 0
9   9001    1103 NOE                       X-SEC 11
9   9002    1203 VER 050                   X-SEC'S 12-15
9   9003         END                       0.5' SURCHARGE (VER)

         1         2         3         4         5         6
....5....0....5....0....5....0....5....0....5....0....5....0....5
```

Exhibit 16.--Data coding examples for reach of exhibit 15.

```
          1         2         3         4         5         6
....5....0....5....0....5....0....5....0....5....0....5....0....5.

D) PROFILE COMPARISON FOR SECTIONS 6-11

PROFILE:  #1     #2     #3     #4

2   ???  -9999  -9999  -9999  -9999

4   ???  Q100   Q10    Q50    Q500

7  7001                                   2 2 2 2
8  8001                                   0 2 2 2

******************************************************************

E) ENTIRE REACH, X-SEC'S 1-6 & 11-15 ENCROACHED

PROFILE:  #1     #2     #3     #4     #5     #6

2   102  WS100  WSFW   -9999  WS10   WS50   WS500

4   104  Q100   Q100   Q100   Q10    Q50    Q500

7  7001                                   0 1 3 0 0 0
8  8001                                   0 0 3 2 2 2
9  9001   103 VER 050                    X-SEC'S 1-6
9  9002   703 NOE                        X-SEC'S 7-10
9  9003  1103 VER 050                    X-SEC'S 11-15
9  9004       END                        0.5' SURCHARGE (VER)

******************************************************************

F) SUPERCRITICAL REACH, SECTIONS 6 & 11 ENCROACHED

PROFILE:  #1     #2     #3     #4     #5

2   602  -9999  -9999  -9999  -9999  -9999

4   604  Q100   Q100   Q10    Q50    Q500

7  7001                                   2 3 2 2 2
8  8001                                   0 0 2 2 2
9  9001   603 VER 050                    X-SEC 6
9  9002   703 NOE                        X-SEC'S 7-10
9  9003  1103 VER 050                    X-SEC 11
9  9004       END                        0.5' SURCHARGE (VER)

          1         2         3         4         5         6
....5....0....5....0....5....0....5....0....5....0....5....0....5.
```

Exhibit 16.--Continued.

The third (downstream, floodway) profile utilizes the cross sections as modified by the previous floodway analysis and produces a valid critical-supercritical profile for sections 11 through 6 for the modified conditions. The comparative tabulation for this third profile is totally useless since it uses the upstream, normal profile as a basis for comparison. The fourth through sixth profiles provide the elevation difference tabulations for upstream computations. The data of exhibit 16d would provide that tabulation for downstream computations.

Separation of the above analysis into a multi-job analysis would (1) eliminate "wasted" calculations and (2) provide a valid comparison of floodway versus normal results for the downstream computations. These problems (especially the second) are rather insignificant for short reaches. However, for longer reaches the reduction in costs, output volume, and manual computations may make such a separation feasible. Upstream computations would require data identical with exhibits 16b and 16c except that NOE would not be specified for sections 6 and 11. Data required for downstream computations is shown in exhibit 16f. The first (downstream, normal) profile establishes the base profile data. The second (downstream, floodway) profile modifies sections 6 and 11, computes a valid critical-supercritical profile for modified conditions, and produces a valid comparison of modified versus normal results for sections 11 through 6. The third through fifth profiles yield the elevation difference tabulations (rather than a separate job using the data of exhibit 16d).

J635 should not be used for floodway analyses or to obtain final summary tabulations until after all preliminary analyses have been satisfactorily accomplished. Preliminary analyses are always required to determine whether or not the input data are accurate and adequate. Preliminary runs are frequently required to determine starting water-surface elevations. In these runs it is advisable to compute all profiles for the same discharge in succession. Considerable savings can be realized in this manner when critical water-surface elevations are involved because WSC values are retained for use in consecutive profiles if the discharge doesn't change and if the profile type (normal or floodway) is the same.

J635 JOB CONTROL LANGUAGE

Exhibit 17 is a printout of the Job Control Language required to execute program J635. Except for the altered JCL, all of the information pertaining to E431 also pertains to J635 (E431 User's Manual, Appendix, pp. 102-103). Of course, estimates of time and lines may have to be increased for J635 computations.

XII

```
         1         2         3         4         5         6         7         8
....5....0....5....0....5....0....5....0....5....0....5....0....5....0....5....0

//RELAY  PUNCH RE2                                                     RE2 CARD
//USERCODE JOB (ACCOUNTNO,J635,TT,LL),'USERNAME',CLASS=?               JOB CARD
//JOBLIB DD DSN=SYS1.LOADLIB,DISP=SHR                                  JCL  01
//  EXEC  PGM=J635,REGION=160K,TIME=1                                  JCL  02
//FT11F001 DD SPACE=(2852,(99),,CONTIG),DCB=(DSORG=DA),UNIT=SYSDK      JCL  03
//FT12F001 DD SPACE=(2844,(99),,CONTIG),DCB=(DSORG=DA),UNIT=SYSDK      JCL  04
//FT13F001 DD SPACE=(100,(150),,CONTIG),DCB=(DSORG=DA),UNIT=SYSDK      JCL  05
//FT18F001 DD  SPACE=(252,(99),,CONTIG),DCB=(DSORG=DA),UNIT=SYSDK      JCL  06
//FT06F001 DD SYSOUT=A                                                 JCL  07
//FT05F001 DD *                                                        JCL  08
   YOUR J635 INPUT DATA DECK(S)
/*
//

         1         2         3         4         5         6         7         8
....5....0....5....0....5....0....5....0....5....0....5....0....5....0....5....0
```

Exhibit 17.--Job Control Language printout for Program J635.

Form 9-1891A
(May 1974)

BACKWATER ANALYSIS -- E431

#1 Reach I.D.

CARD	SEQUENCE	STREAM IDENTIFICATION	GAGING STATION NO	NXS	NPR	TOL	Δh	FN	
1	3-7	9-48	50-57	58-59	60-61	62-65	66-69	70-72	(7x)

#2 Initial Water Surface

CARD	SEQUENCE	H1 (11)	H2 (12)	H3 (13)	H4 (14)	H5 (15)	H6 (16)	H7 (17)	H8 (18)	H9 (19)	H10 (20)
2	3-7	9-14	16-21	23-28	30-35	37-42	44-49	51-56	58-63	65-70	72-77

#3 Cross Section I.D.

Enter these data when col 15 =
- 0,1,5,9: NSA, h_o, DISTANCE, SAL, SAR
- 2: NSA, h_o, DISTANCE, SKEW, SUBEL, WW ABUT
- 3: PIER
- 4: NSEG, RDWID, SEGL, SEGR, T_1 T_2 T_3 T_4 T_5 T_6 T_7 T_8 T_9 T_{10} QTOL

CARD	SEQUENCE	SEC ID	TYPE	NPTS	Always enter these data																		
3	3-7	9-13	15	17-19	21-22	24-27	29-35	37-38	40-41	43-44	45-50	52	54	56	58	60	62	64	66	68	70	72	(7x)

#4 Discharge Data

CARD	SEQUENCE	Q1 (11)	Q2 (12)	Q3 (13)	Q4 (14)	Q5 (15)	Q6 (16)	Q7 (17)	Q8 (18)	Q9 (19)	Q10 (20)
4	3-7	9-14	16-21	23-28	30-35	37-42	44-49	51-56	58-63	65-70	72-77

#5 Cross Section Geometry

Enter these data when Col 15 of CARD 3 =
- 0,1,2,5,9: Station, SA, Ground Elev.
- 3: Width, Elevation
- 4: Station, SEG, Road Elev.

Always enter these data

CARD	SEQUENCE		Station / Width / Station	SA / SEG	Ground Elev. / Elevation / Road Elev.	Station / Width / Station	SA / SEG	Ground Elev / Elevation / Road Elev	Station / Width / Station	SA / SEG	Ground Elev / Elevation / Road Elev	Station / Width / Station	SA / SEG	Ground Elev / Elevation / Road Elev	Station / Width / Station	SA / SEG	Ground Elev / Elevation / Road Elev
5	3-7	(4x)															
5																	
5																	
5																	
5																	
5																	
5																	
5																	
5																	
5																	
5																	

#6 Cross Section Roughness

CARD	SEQUENCE	SA 1 (6 11 16) b	a	n_1	n_3	SA 2 (7 12 17) b	a	n_1	n_3	SA 3 (8 13 18) b	a	n_1	n_3	SA 4 (9 14 19) b	a	n_1	n_3	SA 5 (10 15 20) b	a	n_1	n_3
6	3-7	9-10	12-13		19-21	23-24			33-35	37-38	40-41	43-45	47-49	51-52	54-55						
6																					
6																					
6																					
6																					

Form 9-1891B
(May 1974)

FLOODWAY ANALYSIS

(THIS FORM IS USED IN CONJUNCTION WITH BACKWATER ANALYSIS FORM 9—1891A)

CARD 7 1 8 | SEQUENCE 3 4 5 6 7

PROFILE TYPE: 0 = NORMAL, 1 = FLOODWAY

NORMAL WS ELEV FROM: 0 = MEMORY, 1 = CARDS

PROFILE FOR H(I) AND Q(I) SPECIFIED ON CARD TYPES 2 AND 4

I = 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80

CARD	SEQUENCE	CARD 3 SEQUENCE	FW OPTION	Y	LEFT STA.	RIGHT STA.	NORMAL WS ELEV	FLOODWAY ID (Enter only on END option card)
1	3–7	9–13	15–17	19–21	23–26	28–31	33–38	40–59

FW OPTIONS

VER — specify Y
— no constraints

VSA — specify Y
— sub-area constraint

VHD — specify Y
— horizontal stationing constraints

HØR — Y not specified
— horizontal stationing of encroachment specified.

NØE — no encroachment

ADD — add Y to Y of previous FW analysis

END — must be last card of the set for each FW analysis.

[0] = ZERO [Ø] = ALPHA O [1] = ONE [I] = ALPHA I [2] = TWO [Z] = ALPHA Z [/] = SLASH [-] = MINUS

LISTED BY________ CHECKED BY________