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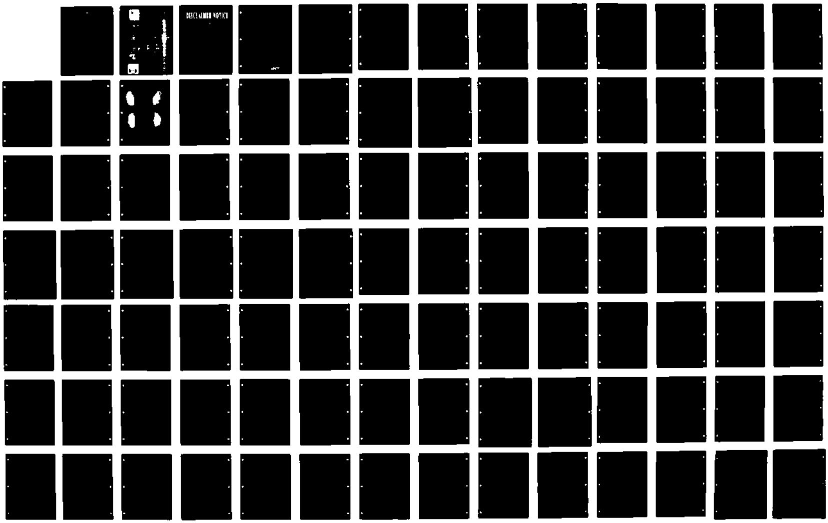

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ENVIRONMENTAL AND WATER QUALITY OPERATIONAL STUDIES

US Army Corps of Engineers

INSTRUCTION REPORT E-87-[illegible]

SELECT: A NUMERI[illegible] ONE-DIMENSIONAL MOD[illegible] [illegible]OR SELECTIVE WITHDRA[illegible]

Jack E. Davis, Jeffery P. Ho[illegible]
Michael L. Schneider, Steven C. [illegible]ms

Hydraulics Laboratory

DEPARTMENT OF THE AR[illegible]
Waterways Experiment Station, Corp[illegible] [illegible]ngineers
PO Box 631, Vicksburg, Mississipp[illegible] [illegible]0-0631

March 1987

Final Report

Approved For Public Release; Distribution [illegible]

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Washington, DC 20314-1000

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Instruction Report E-87-2
July 1992

SELECT: A NUMERICAL, ONE-DIMENSIONAL MODEL FOR SELECTIVE WITHDRAWAL

Final Report
Instruction Report E-87-2
March 1987

Instructions for Updating the SELECT Program and Its Documentation

1. Several improvements have been made and small errors corrected since the 1987 release of Version (Ver.) 1.0 of the SELECT program and documentation. The latest form of the program including these changes has been labelled Ver. 1.3. Ver. 1.1 and 1.2 were interim working versions of the program and therefore were not released or documented.

2. Documentation for Ver. 1.0 is found in the US Army Engineer Waterways Experiment Station Instruction Report E-87-2, entitled "SELECT: A Numerical One-Dimensional Model for Selective Withdrawal." To update this SELECT manual and make it current with the new program, you must

   a. Replace pages 13-14, 35-40, 71-72, and 89-94 in the main text with the corresponding pages in this enclosure.

   b. Replace Appendices A through E with their updated counterparts enclosed.

3. To update the program, a wholesale substitution should be made. That is, SELECT.FOR should be replaced with SELECT13.FOR, and SELECT.EXE with SELECT13.EXE. Input data files used with Ver. 1.0 should be compatible with Ver. 1.3 with one exception. Version 1.3 no longer expects to find the FILES command line in the input. The file assignments have been established as unit 05 for input and unit 06 for output. Removing the FILES command line from the Ver. 1.0 input files will make them usable with Ver. 1.3.

4. The programming errors corrected since Ver. 1.0 will not produce significantly different results for most SELECT applications. If an application you are running yields notably different answers with Ver. 1.3 than with Ver. 1.0, please contact us. A more detailed listing of the changes is given as comment within the code and appears on page 1 of Appendix E of the enclosure.

5. If placed in the manual, these pages can serve as an indication that the manual has been updated and when and how it was done. Any questions or comments regarding this update should be directed to either Mr. Stacy E. Howington (601-634-2939) or Mr. Steven C. Wilhelms (601-634-2475).

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This report was developed to aid users of the program SELECT. It provides guidance on how to construct an input file and how to interpret the output file. It also overviews the concepts behind the program and the internal methodology of its execution. Examples of input and output are also provided.

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PREFACE

Development of this report was sponsored by the Office, Chief of Engineers (OCE), US Army, as a part of the Environmental and Water Quality Operational Studies (EWQOS) Program, Work Unit IIIA.4 (CWIS Work Unit 31604), entitled "Techniques to Meet Environmental Quality Objectives for Reservoir Releases." The OCE Technical Monitors of the EWQOS Program were Mr. Earl E. Eiker, Dr. John Bushman, and Mr. James L. Gottesman. Program Manager of EWQOS was Dr. J. L. Mahloch.

This report was prepared by the Hydraulics Laboratory (HL), US Army Engineer Waterways Experiment Station (WES), under the general supervision of Mr. F. A. Herrmann, Jr., Chief of the HL; Mr. H. B. Simmons, former Chief of the HL; and Mr. John L. Grace, Jr., Chief of the Hydraulic Structures Division; and under the direct supervision of Mr. Jeffery P. Holland, Chief of the Reservoir Water Quality Branch. The report was written by Messrs. Jack E. Davis, Jeffery P. Holland, Michael L. Schneider, and Steven C. Wilhelms. Messrs. Terry Reeves and James A. Daub contributed in the preparation of the variable lists and Appendix A. The report was prepared for publication by Ms. Jessica S. Ruff of the WES Information Products Division of the Information Technology Laboratory.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

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CONTENTS

SELECT: A NUMERICAL, ONE-DIMENSIONAL MODEL FOR SELECTIVE WITHDRAWAL

PART I: INTRODUCTION

Background

1. As a result of increased public awareness and state and Federal legislation, Corps of Engineers (CE) water resources projects are being operated with an emphasis on water quality considerations. The use of a reservoir outlet works incorporating fixed or multilevel selective withdrawal structures is a primary method for the control of reservoir release quality. These structures release water from specified strata in a density-stratified reservoir, thereby allowing, through blending of flows or direct release, greater control of water quality. Two general conditions must be met to ensure that a given structure has the ability to selectively withdraw reservoir waters. First, if the structure exists, the outlets must be at appropriate elevations and have sufficient capacity such that particular outlets can be operated to withdraw water of a desired quality. If the structure is proposed, the number, locations, and capacities of outlets should be determined as part of the design procedure to ensure that the required level of release water can be maintained. Second, for efficient operation of an existing structure or optimal design of a proposed structure, the operator or designer must have the capability to describe the zone of withdrawal formed by a discharge through a selective withdrawal outlet for a given outlet geometry, location, and discharge. Additionally, proper hydraulic performance of such structures acts as a constraint for any solution.

2. Research at the US Army Engineer Waterways Experiment Station (WES) has provided extensive technology with which to assist the operator or designer in addressing the conditions listed above. Through laboratory experimentation, Bohan and Grace (1969) and Grace (1971)

described the withdrawal zone formed by releases from a density-stratified reservoir through ports (orifice flow) and over weirs (i.e., spillway flow, thermal berms). An outgrowth of this initial research was the development of the one-dimensional computer program SELECT, which computes the withdrawal zone formed by a given release through or over a specified outlet structure for a known reservoir density stratification. The program also computes the quality characteristics of the release for user-specified parameters (temperature, dissolved oxygen, etc.) treated as conservative substances. Additional work, which includes Dortch and Holland (1984), describes a numerical procedure that systematically evaluates the optimal number and locations of selective withdrawal intakes required to meet a specified release quality objective. Holland (1984) also overviews the steps that must be followed in the design of selective withdrawal structures.

3. Recent research efforts, building on the work of Bohan and Grace (1973) and many other researchers, have resulted in more-generalized techniques for the description of the withdrawal zone formed by a reservoir release through a port acting as a point sink. Smith et al. (1987) document these techniques. Subsequently, the results of these and other research efforts have been incorporated into an update of the SELECT program.

Purpose and Scope

4. The purpose of this report is to document the updated version of the SELECT program for field office use. This will be done by describing the computational methodologies and the sequence of operations in SELECT (Part II), the operations used in the subprograms (Part III), and the assumptions and limitations inherent to the code (Part IV). Definitions of the data required as input are provided in Part V. Additional information presented in the report includes a description of the input format (Appendix A), input file and output examples (Appendixes B and C), error codes (Appendix D), and program code (Appendix E).

PART II: AN OVERVIEW OF SELECT AND ITS USE

Program Purpose

5. The SELECT program is a one-dimensional numerical model that predicts the vertical extent and distribution of withdrawal from a reservoir of known density and quality distribution for a given discharge from a specified location. Using this prediction for the withdrawal zone, SELECT computes the quality of the release for user-specified parameters (such as temperature, dissolved oxygen (DO), turbidity, iron) treated as conservative substances. The release constituents are considered conservative through the selective withdrawal structure because the detention time in the structure is short compared with the time required for the constituents to physically or chemically change. For example, there would be no time for the water temperature to change significantly nor would there be time for iron to oxidize significantly. SELECT will predict, however, the improvement in DO that would occur due either to natural reaeration, as flow passes through gated-conduit outlet works, or to turbine venting.

6. It is important for the user to realize the purpose of SELECT. SELECT was developed based on the philosophy that the field office users require a tool to compute the withdrawal and release quality characteristics of a structure for given values of density stratification, outlet geometry, and discharge. SELECT is that tool. SELECT is not a water quality or thermal simulation model. It does not consider all the hydrodynamic and biochemical processes ongoing in a reservoir. Its purpose is to compute withdrawal and release quality characteristics.

7. Many times the computation of reservoir release characteristics is, within itself, sufficient to provide insight into the solutions to the posed problems. For example, the day-to-day operation of a multilevel outlet works or the initial design of a thermal berm could be performed with SELECT.

Conceptual Methodology

8. SELECT accomplishes its assigned tasks, subject to various assumptions and limitations, by first dividing the reservoir pool into a user-specified number of layers of equal thickness. (The user should first note the program assumptions and limitations outlined in Part IV.) The layers are assumed in the code to be longitudinally and laterally homogeneous in quality. The effects of density stratification are assumed to act only in the vertical dimension on the release from the project. The velocities induced by the release are also assumed to vary only in the vertical direction, in keeping with the one-dimensional assumption of the program.

9. SELECT computes the limits of withdrawal (defined as the vertical locations in the pool beyond which there is no contribution to the total release), the vertical distribution of withdrawal between those limits, the point of maximum withdrawal, and the outflow quality characteristics. To do this, SELECT first computes a normalized velocity profile for the region within the withdrawal zone of each port or weir. This profile is normalized in the sense that the individual point velocities are divided by the maximum profile velocity and subsequently scaled such that their integration over the profile would yield the discharge producing them.

10. The purpose of computing the normalized velocity profile is not to provide a prediction of actual velocities in the reservoir; rather, the normalized velocity profile is used to generate the reservoir withdrawal profile as a final product. The individual withdrawal profiles from each outlet are then summed, yielding a total withdrawal profile with corresponding withdrawal limits. With the total withdrawal profile known, the release quality can be determined by weighting the quality contribution of each layer with respect to the ratio of the layer discharge to the total discharge.

11. The user should also be alerted to the phrase "theoretical limit of withdrawal" used in this report. This phrase is used to denote a withdrawal condition for which the potential to withdraw flow from

much higher or lower in the pool would have existed had the withdrawal zone not been truncated by the physical boundaries of the reservoir, e.g., the water surface or bottom, respectively. The theoretical limit stands in contrast to the physical limit taken to be the water surface or bottom.

12. A final concept must be formalized prior to use of the model. SELECT uses the concept of "withdrawal angle" to incorporate the effects of many local topographical conditions upon port withdrawal zone formation. In plan view, the withdrawal angle can be thought of as the angle the outlet works structure makes with the local topography. The plan views in Figures 1a and 1b show effective withdrawal angles of π (180 deg) and $\pi/2$ (90 deg), respectively. These conditions typify the most common means of withdrawal through an outlet tower in the middle of a dam face and at the edge of a dam face near a wall.

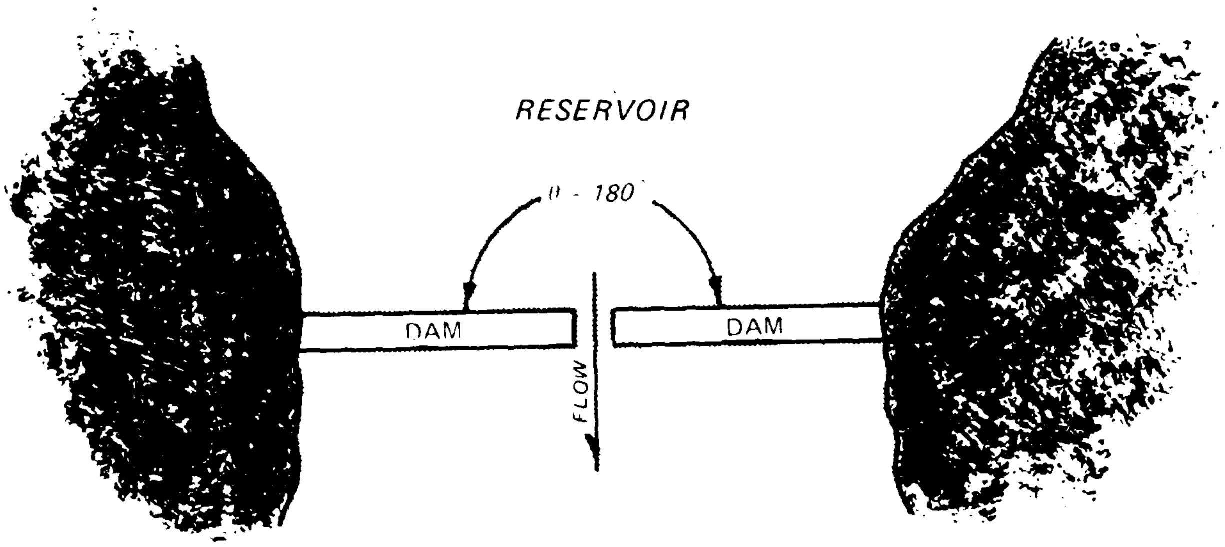
13. SELECT incorporates the concepts described above in a set of transcendental equations that must be iteratively solved to obtain the withdrawal zone characteristics.

Overview of Program Execution

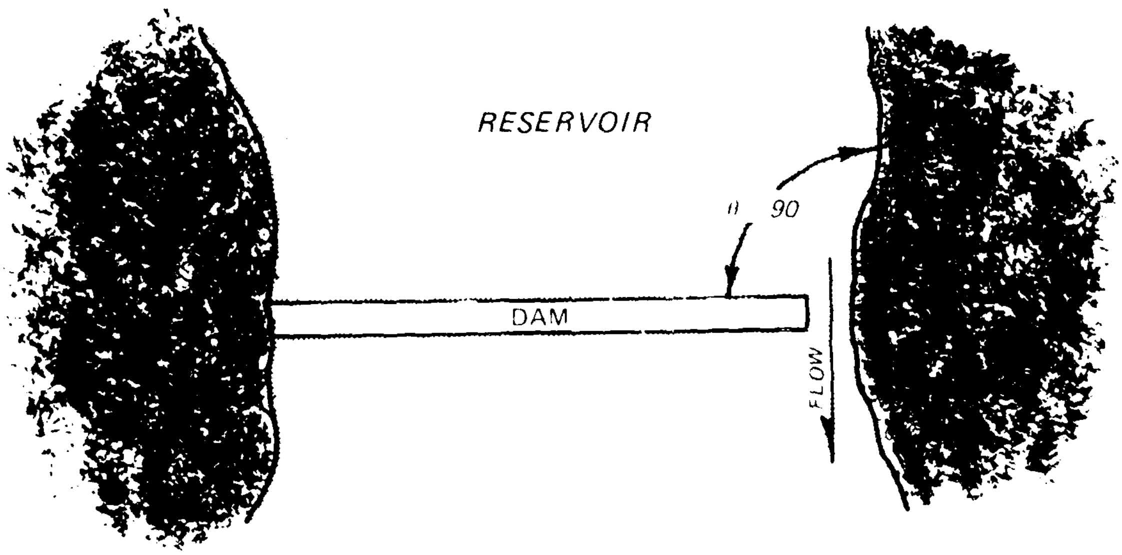
14. The following paragraphs outline the sequence of operations that SELECT executes to determine the withdrawal limits and release water quality. Figure 2 is a flowchart that depicts this sequence. The branches at decision points in the flowchart are labeled T and F for true or false. Figure 3 gives the program call sequence from each subprogram.

15. SELECT's main program orders the sequence in which the subprograms are executed. Subroutine XREAD is called first by the main program to read information from the input file concerning program control parameters such as the number of data sets in the input file. XREAD is then called again to read information about the impoundment, the outlets, and the vertical distribution of all water quality parameters being modeled.

16. After each water quality parameter distribution is entered,



a. Withdrawal angle, 180 deg



b. Withdrawal angle, 90 deg

Figure 1. Plan view of reservoirs showing 180- and 90-deg withdrawal angles (θ)

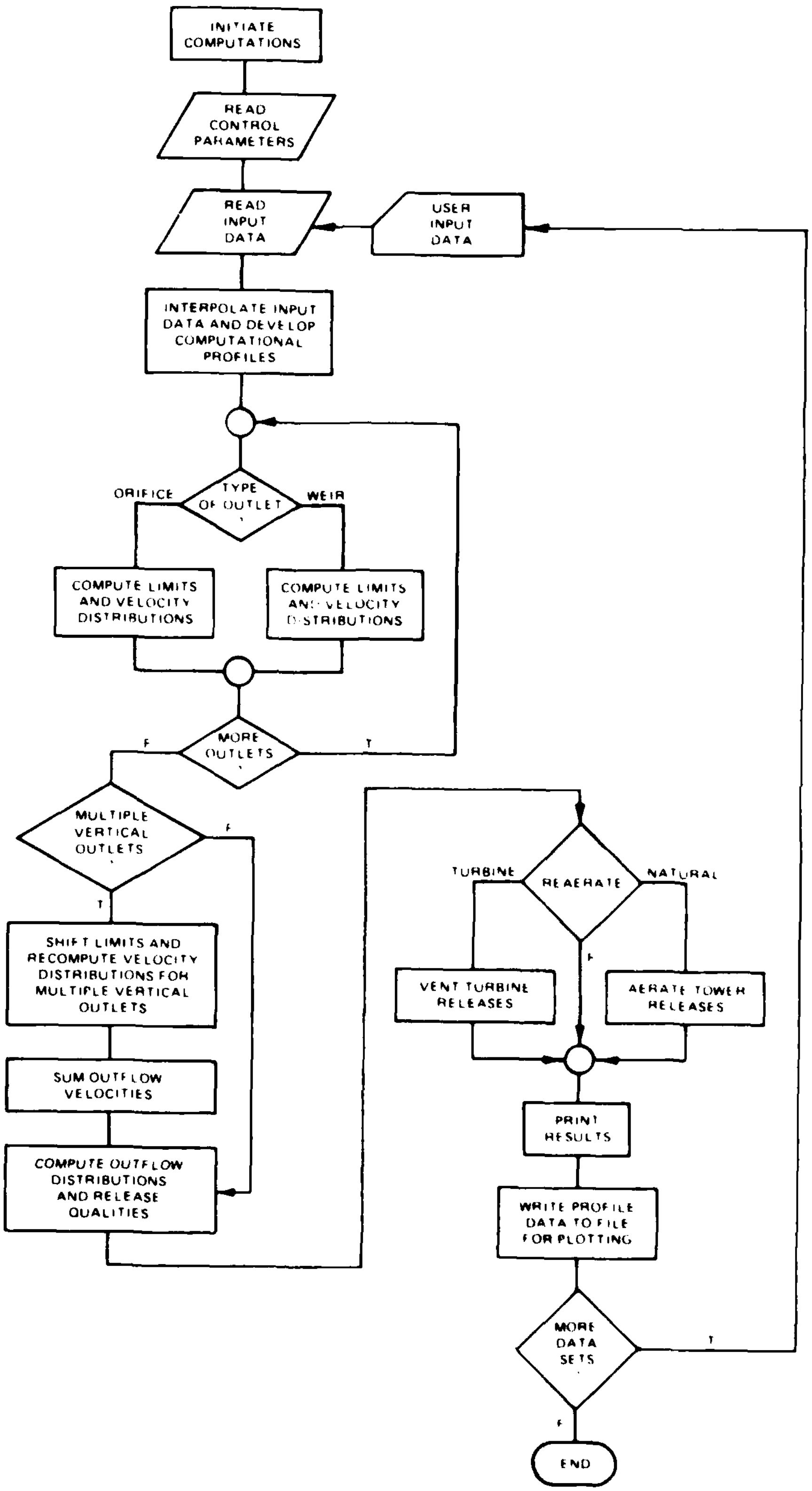


Figure 2. SELECT flowchart

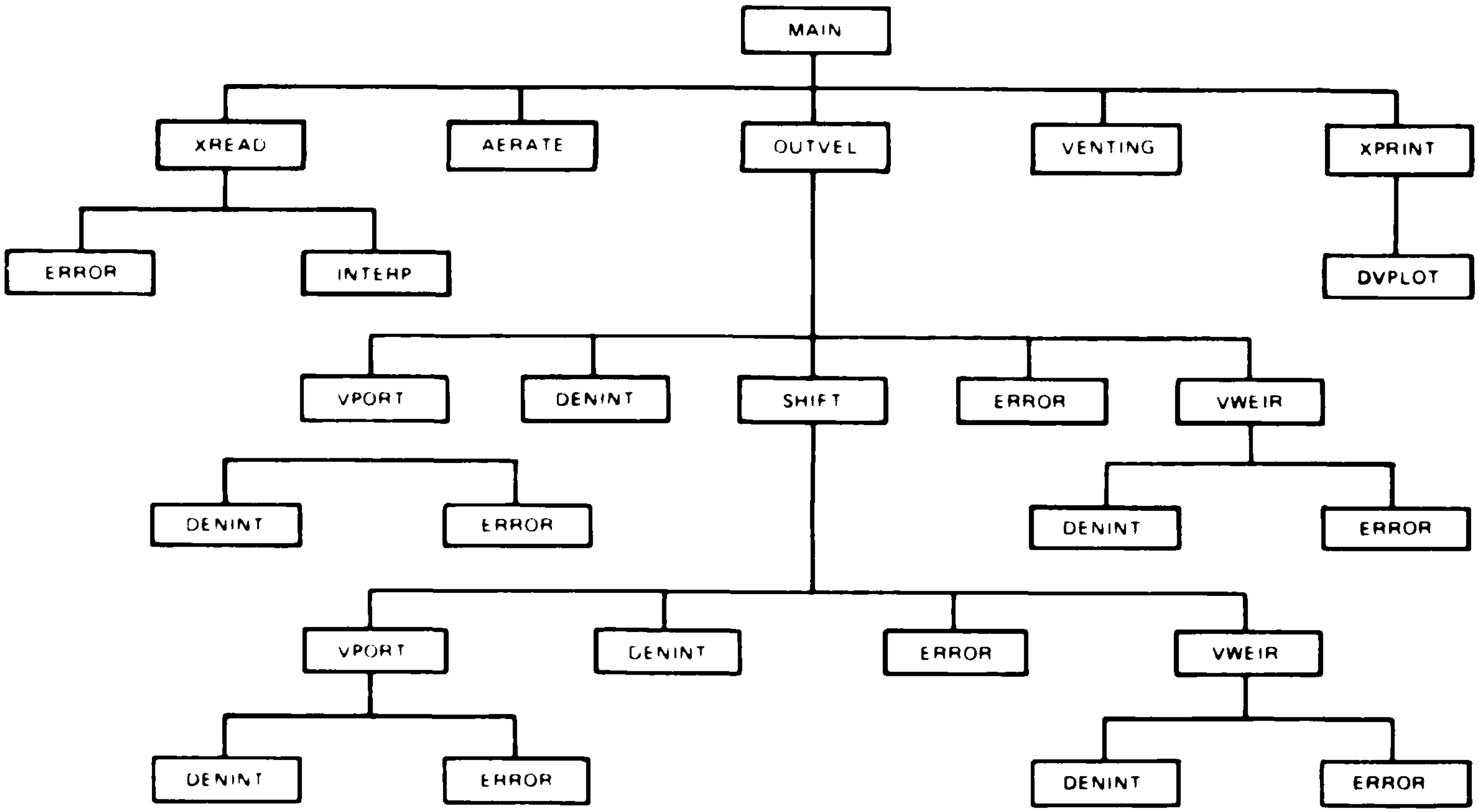


Figure 3. The branched system illustrates the call sequence from each subprogram

subroutine INTERP interpolates between input parameter values at their respective elevations to produce values at the center lines of evenly spaced and vertically distributed horizontal layers (see subroutine INTERP description for greater detail on horizontal layers). Vertical distributions for each parameter are thus created for computational purposes. SELECT bases all of its calculations on these distributions.

17. Subroutine OUTVEL is the next to be called in SELECT's execution. OUTVEL is a subprogram that carries out the organizational duties of the computational portion of the program. Based on whether a weir or a port is being modeled, OUTVEL calls subroutine VWEIR or VPORT, respectively, which are the main computational subroutines in SELECT. VWEIR and VPORT generate the withdrawal zone limits and compute the discharges or flow rates from each computational layer within the withdrawal zone. Program control is then moved back to OUTVEL where all of the withdrawal zone discharges for each outlet modeled in VPORT and VWEIR are summed. The subroutine then normalizes the withdrawal distribution, effectively creating the total normalized velocity distribution. OUTVEL then determines the total release water quality parameter values by summing the contributions of each layer for each parameter modeled. To compute these release values, OUTVEL assumes that each parameter acts as a conservative constituent during the withdrawal process, since detention time in the structure during the release is small compared with the time required for the constituents to change physically or chemically.

18. If withdrawal zones from different outlets overlap vertically, OUTVEL calls subroutine SHIFT to adjust the withdrawal zone limits and outflow profiles from each overlapping zone before the zones are summed as previously stated.

19. If adjustments to the DO content of the release flow are desired based on aeration of the release by the outlet structure (due to turbine venting or natural structural reaeration processes, as described in paragraphs 5-7), the adjustments are performed just prior to outputting the final results.

20. The results are output by subroutines XPRINT and [illegible]. A plot of the normalized velocity and density distribution is generated by

DVPLOT, and a tabular listing of profile data such as DO, normalized velocity, withdrawal, temperature, and other quality constituents is generated by XPRINT along with information about the outlet characteristics and withdrawal zone limits. Details of each of these subprograms are given in Part III.

Available Assistance

21. Assistance in understanding, setting up, or executing the SELECT program or in analyzing its results is available to CE Field Operating Agency users. Copies of the SELECT code are available for use on most mainframes, minicomputers, workstations, and personal computers. Thus far, the program has been executed on Control Data Corporation and CRAY mainframes; Digital Equipment Corporation (DEC) VAX minicomputers and workstations; and IBM, DEC, and Dell personal computers.

PART III: PROGRAM DESCRIPTION

22. The following sections give detailed descriptions of the equations and logic in SELECT and its subprograms. A written description of each subprogram is given along with a flowchart diagramming the operational sequence of the subprogram. Note that throughout the report, T and F signify true and false at decision points in the given flowcharts. Listings of the variables in each subprogram and their definitions are also given.

Main Program

23. The main program of SELECT is very small, with the bulk of the program being found in the functions and subroutines. The main program basically orders the calling sequence of the subprograms to perform input operations, calculations, and output operations (Figure 4). Table 1 lists the variables used in the main program.

24. The main program also performs other tasks that are very important to the operation of SELECT. The first is the generation of a density profile based on a user-input temperature profile. Generally, the user does not have density profile information on the impoundment being modeled but does have temperature data. SELECT will use an input temperature profile to generate densities for each discrete layer. The equation used to convert temperature to density is

$$\rho_I = 1 - \frac{\left(T_I - 3.9863\right)^2}{508,929.2} * \frac{\left(T_I + 288.9414\right)}{\left(T_I + 68.12963\right)} \qquad (1)$$

where

ρ_I = density in grams per cubic centimeter for layer I

T_I = temperature in degrees Centigrade for layer I

I = index designating a specified layer

The main program also checks the stability of the density profile that was given or generated. The profile is stable if the density never decreases with increasing depth. If the profile is found unstable, the program will terminate execution and issue an error message.

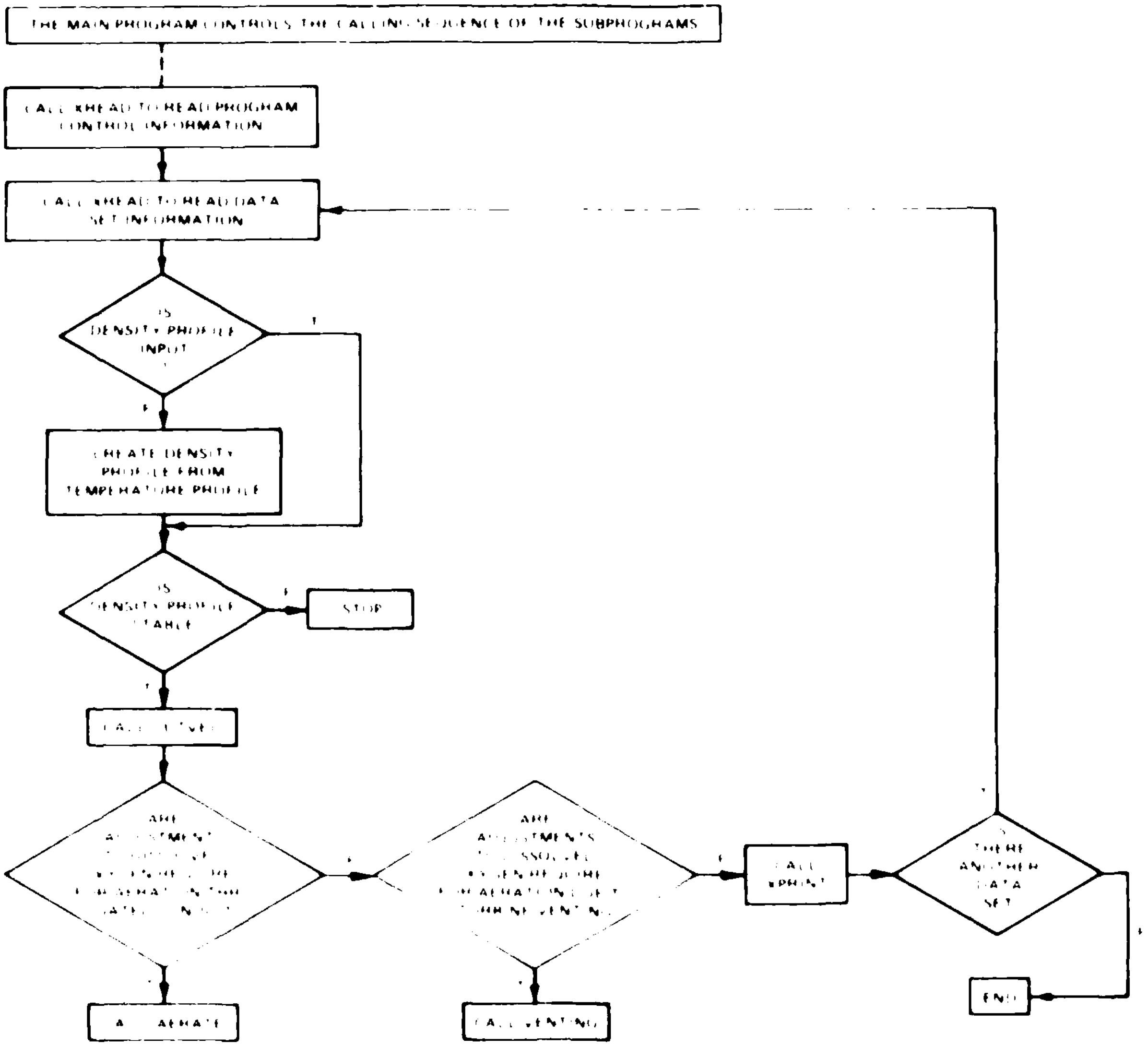


Figure 4. Main program flowchart

Table 1

Main Program Variables

Variable	Definition
C1	Constant = -3.9863 ; used in determining density correspondence to a particular temperature
C2	Constant = 508,929.2 ; used same as C1
C3	Constant = 288.9414 ; used same as C1
C4	Constant = 68.12963 ; used same as C1
DEN(J)	Density of layer J, g/ml
ISURF	Total number of layers in a profile
KFILE	Output file code
NSETS	Number of data sets in the input file
QAERA	Logical variable; true, consider DO uptake due to aeration through a gated structure outlet works; false, do not consider aeration
QCENT	Logical variable; true, temperatures are in degrees Centigrade; false, Fahrenheit
QDEN	Logical variable; true, density profile is input; false, develop density profile from temperature
QVENT	Logical variable; true, consider DO uptake due to turbine venting; false, do not consider uptake
TEMP(J)	Temperature of layer J, degrees Fahrenheit or Centigrade

DENINT

Description

25. Function DENINT determines the density at any elevation. The user-input density profile (or temperature profile which SELECT converts to a density profile) is interpolated by subroutine INTERP to give densities at each layer center line. When the density at some arbitrary elevation is desired, DENINT uses the layer center-line densities above and below the given elevation and linearly interpolates to determine the density at the given elevation. Figure 5 shows a schematic of the algorithm flowchart, and Table 2 lists the variables used in DENINT.

26. The interpolation equation is

$$\Gamma_A = \Gamma_{I+1} - \left(\frac{d}{D}\right)\left(\Gamma_{I+1} - \Gamma_I\right) \tag{2}$$

where

Γ_A = density at the given elevation of point A

Γ_{I+1} = density at the elevation of the layer I+1 center line immediately above point A

d = distance between the elevation of point A and the elevation of the layer center line immediately above

D = distance between the layer center lines immediately above and immediately below point A

Γ_I = density at the elevation of the layer I center line immediately below point A

A schematic defining these variables is shown in Figure 6.

Special considerations

27. If point A lies within 0.01 percent of the layer thickness of a center line, the density at the elevation of point A is assigned the value of the density at the layer center line.

28. When a density value is desired for an elevation that is above the impoundment surface or below the impoundment bottom, linear extrapolation is used (the need for such a calculation is explained in the section on subroutine VPORT). For an elevation above the surface, SELECT uses the change in density and difference in elevation between

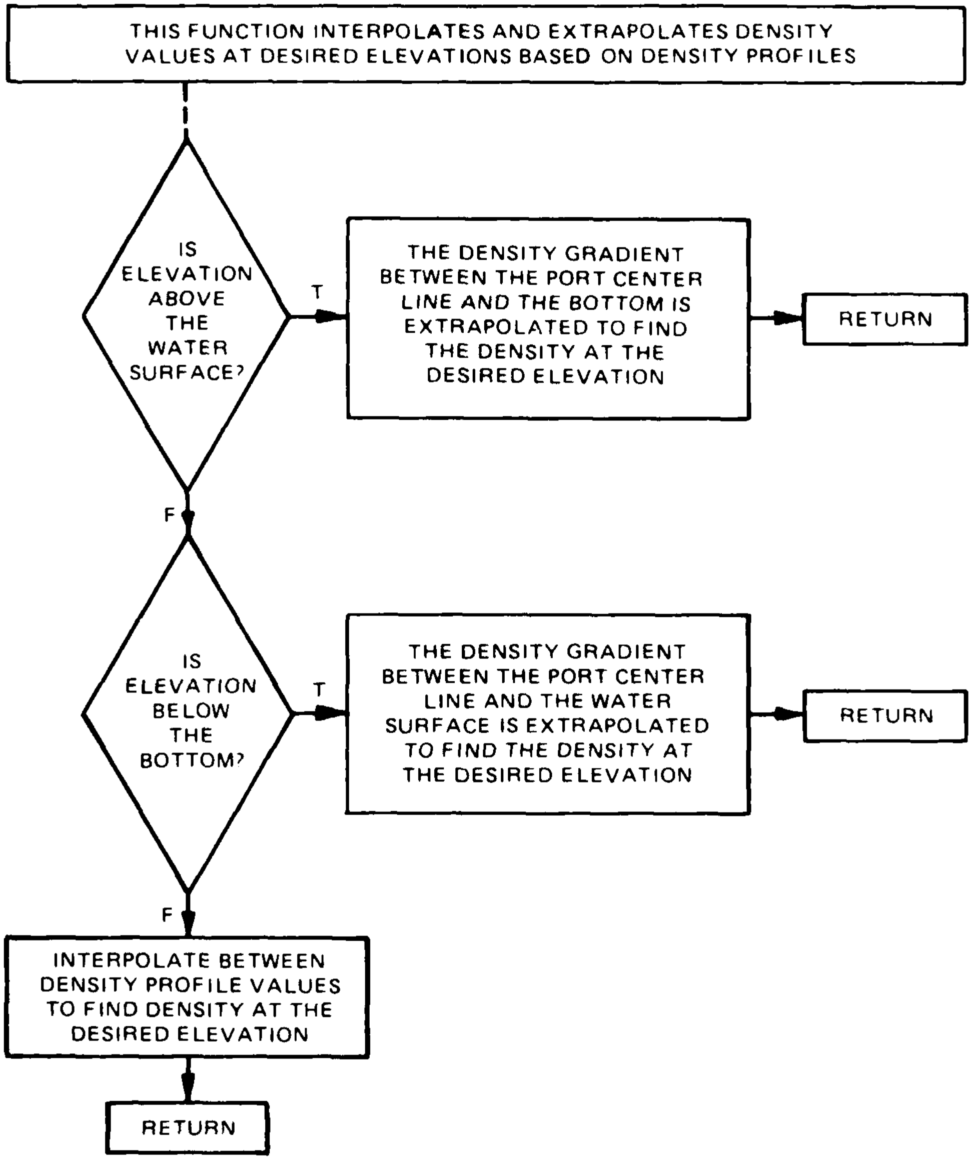


Figure 5. Flowchart for function DENINT

Table 2

DENINT Variables

Variable	Definition
DELZ	Layer thickness
DEN(J)	Density of layer J, g/cm^3
DEN(IJ)	Density of upper interpolation layer, g/cm^3
DEN(JK)	Density of lower interpolation layer, g/cm^3
DENPRT	Density at the port center line
DEPTH	Depth of pool
DGRD	The density gradient used to determine artificial densities outside the pool boundaries
DGRDB	The density gradient from port to bottom; slope equals the density difference over the vertical distance between the port center line and the bottom
DGRDT	The density gradient from port to surface; slope equals the density difference over the vertical distance between the port center line and the surface
DIFF	Absolute difference between locations at which density is to bedetermined and nearest layer midpoint
ELMID	Location of midpoint of the layer containing the location at which density is to be determined
ELTOP	Elevation of midpoint of upper interpolation layer
HGTPRT	Height above bottom of port center line
IJ	Subscript of upper interpolation layer
IJK	0 or 1; used to define interpolation layers
ISURF	Subscript of surface layer
JK	Subscript of lower interpolation layers
LAYER	Layer containing the location at which density is to be determined

(Continued)

Table 2 (Concluded)

Variable	Definition
LAYER1	Assigned the layer number value for layer calculated that lies outside the pool
NUMD	Total number of density values input for the density profile
OLDPRT	Assigned the value of HGTPRT
QEXTR	Logical variable; true when elevation of point is outside of pool; false when elevation of point is inside pool or at boundaries
SIGN	Equals 1, interpolation location is below midpoint of its layer; equals -1, interpolation location is above midpoint of its layer
SLOPE	Change in density between two interpolation layers divided by the vertical distance between the layers
SMALL	Essentially 0, used in check for constant density condition
X	Height above bottom at which density is desired
Y	Assigned the value of X for temporary storage

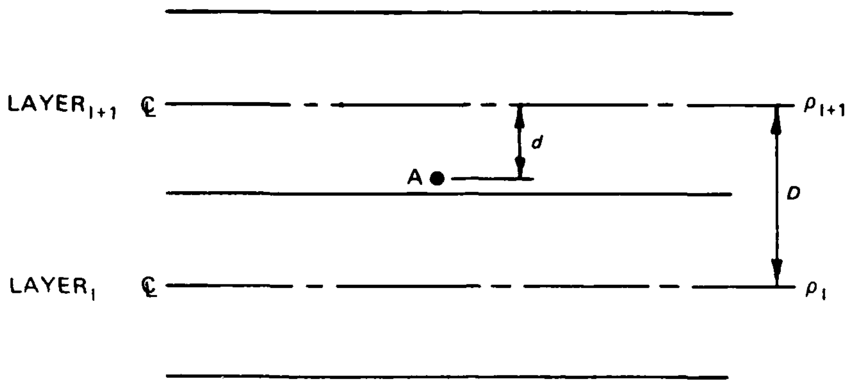


Figure 6. Schematic used to find density at arbitrary elevation A

the port center line and surface to extrapolate the required density value (Figure 7). For an elevation below the bottom, SELECT uses the change in density and difference in elevation between the port center line and the impoundment bottom elevation (Figure 8) to extrapolate the needed density. In actuality, a density value outside the pool is artificial and is necessary only for computations in subroutines VPORT, VWEIR, and SHIFT.

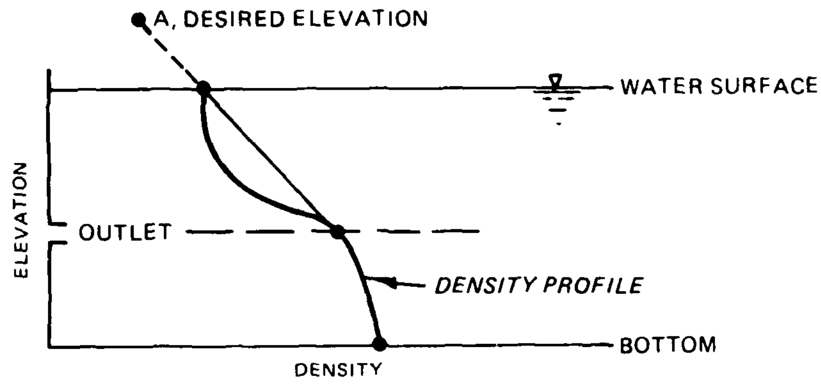


Figure 7. Diagram shows extrapolation of density gradient to determine density at an elevation above the surface

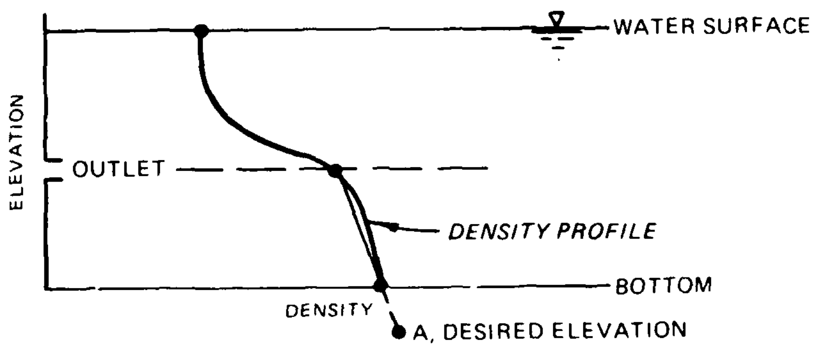


Figure 8. Diagram shows extrapolation of density gradient to determine density at an elevation below the bottom

INTERP

Description

29. Subroutine INTERP generates computational profiles based on user-input data profiles for all parameters to be modeled. INTERP uses linear interpolation of input profile values to determine a value for the center line of each computational layer. The necessity for profile values at the computational layer center lines is for numerical convenience and output organization only. For example, when the density at some arbitrary elevation is desired, the program determines which computational layer the elevation resides in and finds the layer center lines immediately above and below the elevation desired. It then interpolates between the two center-line density values to find the density at the desired elevation. Without the computational layer center-line values, the program would have to scan and compare every input data point elevation with the desired elevation until it found the data values immediately above and below the desired elevation, which is significantly less efficient. Since many of the algorithms in SELECT use profile information and are repeated many times, the use of computational layers is a timesaving necessity.

30. The use of computational layer center-line values may be less accurate than direct use of the actual data points since it results in interpolation between interpolated values; however, the errors incurred by this technique are not significant. Figure 9 is the computational flowchart of INTERP; Table 3 displays the variables used in INTERP.

Special considerations

31. Layer center-line elevations that lie in the pool above the highest input data point elevation are assigned the value of that highest data point. Layer center-line elevations that lie in the pool below the lowest input data point elevation are assigned the value of that lowest input data point.

32. If a layer center-line elevation lies within 0.01 percent of the layer thickness of a data point, the center line will be assigned the value of that data point.

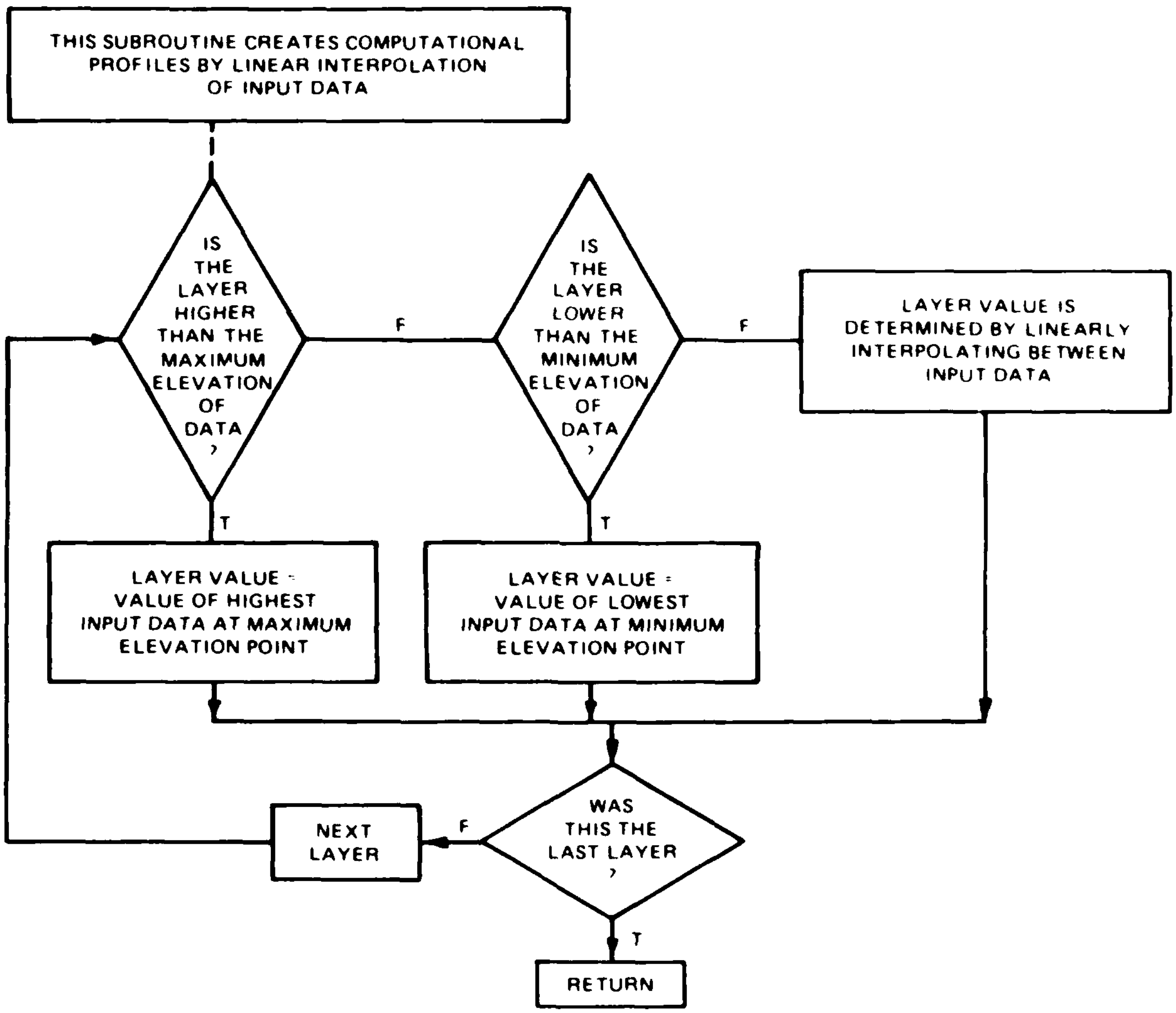


Figure 9. Flowchart of subroutine INTERP

Table 3

INTERP Variables

Variable	Definition
DIFF1	Absolute difference in elevations of present layer midpoint and nearest profile point below it
DIFF2	Absolute difference in elevations of present layer and the nearest profile point above it
DM(I)	Working storage used in resequencing heights into bottom-to-top order
ISURF	Total number of layers
J	Subscript of layer midpoint just above bottom of profile
K	Subscript of layer midpoint just below top of profile
L	Temporarily assigned layer values
NUMV	Number of input profile data points
NV	Number of input profile readings + 1; used in resequencing input profiles into bottom-to-top order
PM(I)	Working storage used in resequencing quality parameter values into bottom or top order
PQUAL(I)	Quality parameter value at midpoint of each layer after profile development in appropriate units
PVALUE(I)	Quality parameter values input as a profile in appropriate units
SIGN1	Variable that keeps track of present lower profile point's position in relation to present layer midpoint
SIGN2	Variable that keeps track of present higher profile point's position in relation to present layer midpoint
SMALL	Essentially zero; check for equality of two values
Y(I)	Height above bottom of the midpoint of each layer
YV(I)	Height above bottom of each input profile parameter

33. If neither of the above cases is true, the program interpolates to find the layer center-line values using the equation

$$q_I = \Delta q * \frac{d}{D} + q_1 \qquad (3)$$

where

q_I = parameter value at the layer I center line

$\Delta q = q_2 - q_1$ = difference between parameter input

q_2 = parameter value of the input data immediately above the layer I center line

q_1 = parameter value of the input data point immediately below the layer I center line

d = elevation difference between the layer I center line and the lower input data point

D = elevation difference between the input data points immediately above and below the layer I center line

A schematic representation of this computation is given in Figure 10.

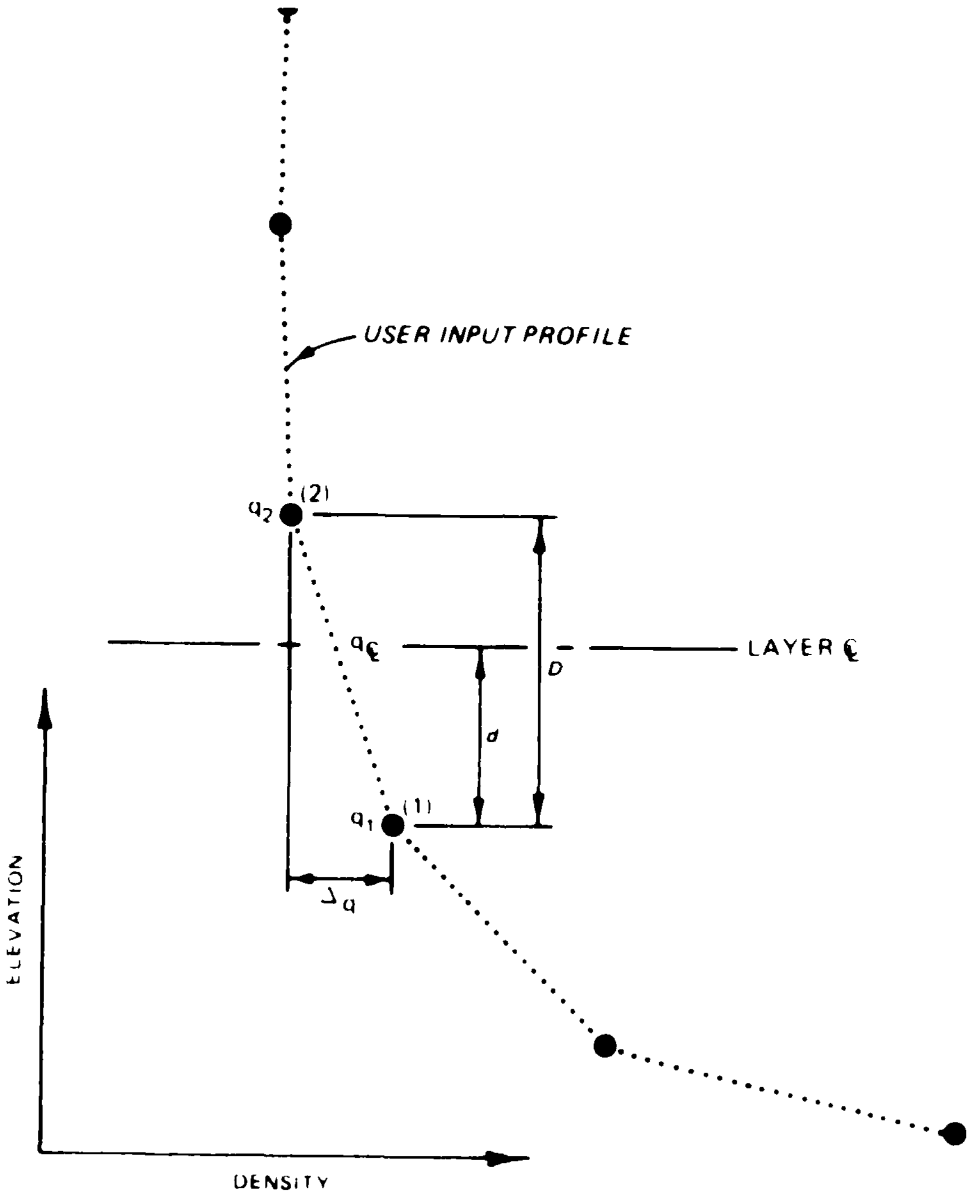


Figure 10. Schematic representation for Equation 3

OUTVEL

34. Subroutine OUTVEL controls the calling sequence of subroutines VWEIR, VPORT, and SHIFT. Based on the information returned from those subroutines, OUTVEL produces a total withdrawal profile and a total normalized velocity profile. OUTVEL also calculates the outflow density, temperature, and water quality concentrations as specified by the user. Figure 11 shows the algorithm flowchart. Table 4 lists descriptions of the subroutine variables.

Withdrawal profile computation

35. The withdrawal profile computed by VPORT or VWEIR is the profile for a port or weir, respectively. The profile values are given at the center-line elevations of the computational layers. When several outlets are modeled, each outlet generates an individual profile that contributes to the total withdrawal from each layer. The total withdrawal profile is found by summing the outflow values assigned to each layer resulting from flow through each outlet (Figure 12). Before this summation is carried out, however, subroutine SHIFT is executed to adjust the withdrawal limits of overlapping withdrawal zones, such as those shown in Figure 12. This accounts for reductions in shear resistance in the overlapping region, and the withdrawal profiles are adjusted accordingly.

Normalized velocity profile computation outflow parameters

36. The total normalized velocity distribution is developed from the total withdrawal distribution. The withdrawal from each layer is divided by the maximum layer withdrawal in the withdrawal zone. Thus, the layer of maximum discharge is assigned a normalized velocity of 1.0 and all others will have a velocity less than 1.0.

Outflow parameters

37. The outflow parameter values (density, temperature, and water qualities) are determined by a flow-weighted averaging technique using the equation

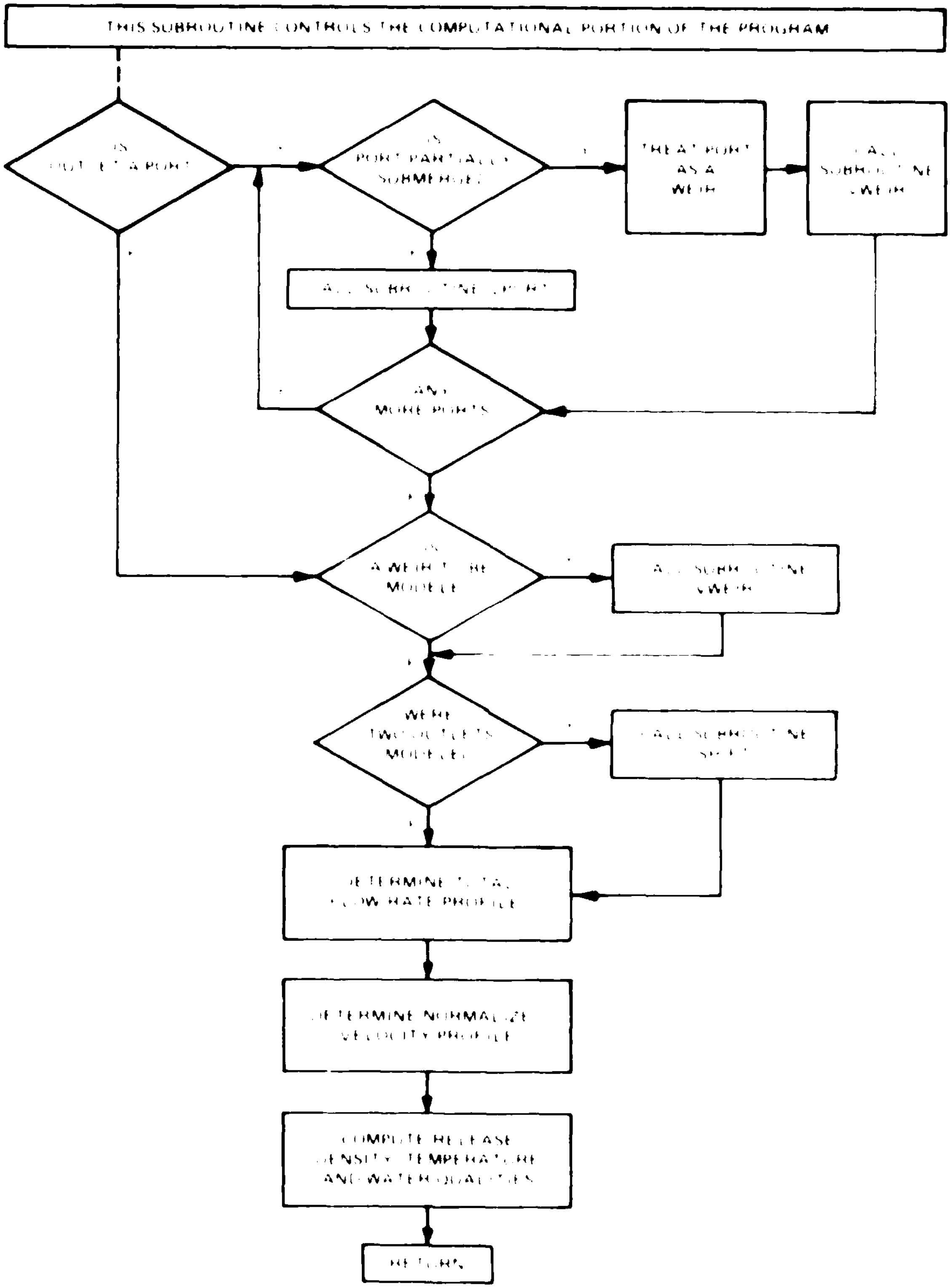


Figure 11. Flowchart for subroutine [illegible]

Table 4

OUIVEL Variables

Variable	Definition
CREST	Weir crest height above bottom
DEN(I)	Density of layer I, g/cm^3
DENOUT	Release density
DENPRT	Density at port center line
DEPTH	Depth of pool
[illegible]	Depth of water between the top of the port and water surface; used in empirical determination of partial port submergence
[illegible]	Flow through the outlet
[illegible]	Release flow rate through ith port
[illegible]	Assigned value of [illegible](K) locally
[illegible]	[illegible] of layer I that is filled with water
[illegible]	Height above bottom of lower withdrawal limit
[illegible]	Height above bottom of the port center line
[illegible]	Height above bottom of upper withdrawal limit
[illegible]	Total number of layers
[illegible]	[illegible] of weir crest
[illegible]	[illegible] lower withdrawal limit for outlet K is [illegible]
[illegible]	[illegible] lower withdrawal limit for [illegible] outlet is [illegible]
[illegible]	[illegible] upper withdrawal limit for [illegible] K is [illegible]
[illegible]	[illegible]

[illegible]

Table 4 (Continued)

Variable	Definition
NPORTS	Number of selective withdrawal ports
NQUAL	Number of quality parameters input
PHDIM(K)	Horizontal dimension of port K
PHGT(K)	Height above bottom of port K center line
PVDIM(K)	Vertical dimension of port K
QALOUT(N)	Average release concentration of N^{th} water quality parameter, appropriate units
QPORT	Logical variable; true, ports are present as outlet devices; false, no ports
QPWEIR	Logical variable; true when a port is considered "partially submerged" and therefore modeled as a weir; false when the above is false
QSUB	Logical variable; true when weir is submerged; false when weir is not submerged
QTEMP	Logical variable; true for temperature profile input; false for no temperature profile
QUAL(J,I)	Value of the J^{th} quality parameter for layer I
QWEIR	Logical variable; true when a weir is present as an outlet device; false when there is no weir
SUMDF	Sum over layers of the product of withdrawal flow and density
SUMOUT	Total flow rate through all outlets
SUMQF	Sum over layers of the product of withdrawal flow and quality
SUMTF	Sum over layers of the product of withdrawal flow and temperature
TEMOUT	Average temperature of outflow, degrees Fahrenheit or Centigrade

(Continued)

(Sheet 2 of 3)

Table 4 (Concluded)

Variable	Definition
TEMP(K)	Temperature value at layer K, degrees Fahrenheit or Centigrade
TOPLIM	Layer of pool where upper withdrawal limit for a given outlet is located
V(I)	Velocity profile value at layer I for flow through one given outlet
VDIM	Assigned value of PVDIM(K) locally
VEL(I)	Total velocity profile value of layer I for all outlets
VHL	Empirical value in the determination of partial submergence of a port
VMAX	Maximum normalized velocity equal to 1.0
VS(I,K)	Velocity profile value of layer I for the K^{th} outlet
VW	Empirical value used in the determination of partial submergence of a port
WANGLE	Assigned the value WTHETA(K) locally
WRHGT	Weir crest height above bottom
WRLNG	Weir length
WTHDRW(I)	Withdrawal flow rate from layer I
WTHETA(K)	Withdrawal angle for port K
ZDN(K)	Height above bottom of the lower withdrawal limit of outlet K
ZUP(K)	Height above bottom of the upper withdrawal limit of outlet K

(Sheet 3 of 3)

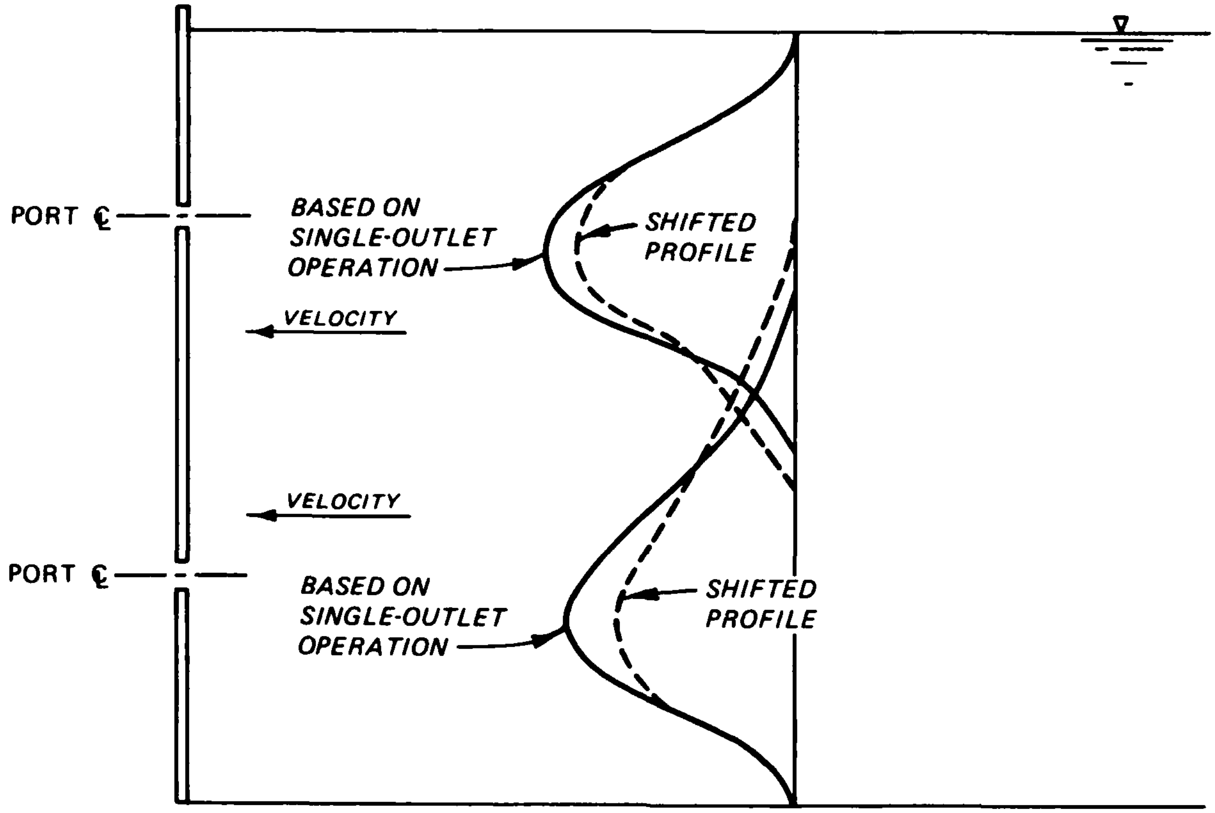


Figure 12. Schematic representation of overlapping withdrawal zones. The profiles are shifted (dashed lines) to better approximate actual profile

$$C_{TOT} = \frac{\sum(C_I * q_I)}{\Sigma q_I} \qquad (4)$$

where

C_{TOT} = total outflow value or concentration

C_I = value or concentration of parameter for layer I

q_I = withdrawal from layer I

The concentrations or values of parameters in each layer are multiplied by the relative contribution of total flow from that layer and divided by the total flow rate from all outlets. Then, these flow-weighted parameter values for each layer are summed, yielding the total outflow parameter value. The outflow parameter calculations are performed for density, temperature, and quality constituents.

38. Subroutine VPORT is the primary computational subprogram called by SELECT when port devices are modeled. VPORT determines the withdrawal zone limits and the associated flow rate profiles for a given port based on input data. The reader is reminded that subroutine OUTVEL performs tasks for the total release; VPORT performs its computations for only a single port per call. Figure 13 shows the computational flowchart for subroutine VPORT. Table 5 lists descriptions of the variables used by VPORT.

39. The following description of VPORT is presented in four parts: the determination of the withdrawal zone limits; the calculation of normalized velocities in the withdrawal zone; the generation of the profile; and the "point sink" calculation to verify that a point sink assumption is valid for the port being analyzed.

Withdrawal zone limits

40. The calculation of withdrawal zone limits is based on densimetric Froude number formulations developed by Bohan and Grace (1973) and Smith et al. (1987). The Bohan and Grace equation (modified for the withdrawal angle concept derived by Smith et al.) is used in three cases. One case is for no interference of the withdrawal zone with a boundary; the second is for simultaneous surface and bottom interference of the withdrawal zone; and the third is for determining the theoretical limit of a limit that experiences interference, while the other limit is free of interference.

41. The Smith et al. (1987) equation is used to find the limit that is free of interference when the other limit experiences interference. Boundary interference is defined to exist when the surface or bottom boundaries of the impoundment lie within the theoretical limits of the withdrawal zone, e.g., the limit cannot form freely within the pool because the impoundment surface or bottom interferes. The determination of limits is the same for no interference and for interference with both boundaries. The difference in the two conditions is not important for the calculation of the limits, but is important in

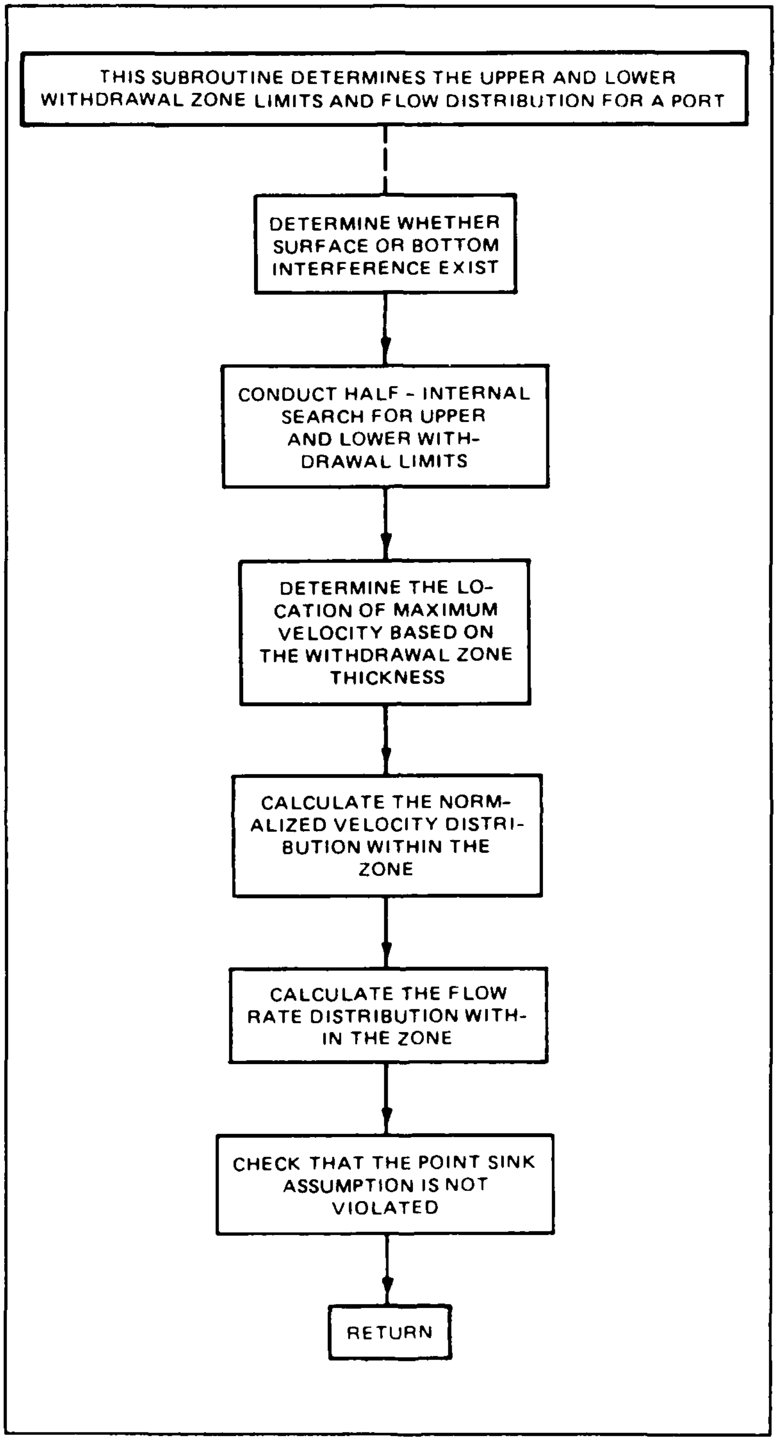


Figure 13. Flowchart for subroutine VPORT

Table 5

VPORT Variables

Variable	Definition
BONLIM	Assigned the value of zero for bottom interference or DEPTH for surface interference
C2	Assigned the value of WANGLE/Π
DELDEN	Density difference from layer of maximum velocity to local elevation, g/cm^3
DELZ	Layer thickness
DEN(I)	Density of layer I, g/cm^3
DENBOT	Density at the bottom of the impoundment
DENDIF	Density difference between fluid at layer of maximum velocity and a particular withdrawal limit, g/cm^3
DENLIM	Assigned value of DENUPP for surface interference or DENBOT for bottom interference
DENLOW	Density at lower withdrawal limit, g/cm^3
DENPRT	Density at port center line, g/cm^3
DENTOP	Density at upper withdrawal limit, g/cm^3
DENUPP	Density at surface of the impoundment
DEPTH	Depth of pool
DRBLIM	Density difference between fluid at the port center line and fluid at the port bottom
DRPBOT	Density difference between fluid at the port center line and the port invert
DRPTOP	Density difference between fluid at the port center line and the port top
DRTLIM	Density difference between fluid at the port center line and fluid at the port top
DVMAX	Density at location of maximum velocity, g/cm^3
F1	Value of withdrawal limit function QBNG(X) evaluated at X1

(Continued)

(Sheet 1 of 4)

Table 5 (Continued)

Variable	Definition
F2	Same as F1 evaluated at X2
F3	Same as F1 evaluated at X3
FLORAT	Flow rate through a port
G	Gravitational acceleration
H1	Value of function QSMITH(X) evaluated at X1
H2	Same as H1 evaluated at X2
H3	Same as H1 evaluated at X3
HGT(I)	Percentage of layer I that is filled with water
HGTLOW	Distance between pool bottom and lower withdrawal limit
HGTPRT	Distance between pool bottom and port center line
HGTTOP	Distance between pool bottom and upper withdrawal limit
ISURF	Total number of layers
LOWLIM	Layer of lower withdrawal limit
LVMAX	Layer of maximum velocity
MAX	Number of search iterations allowed to determine withdrawal limits
PHIFRAC	Fraction of flow within the truncated portion of the theoretical withdrawal zone
PI	Assigned the value of $\Pi = 3.14159$
PRTBOT	Height of the invert of port
PRTTOP	Height of the upper edge of port
QBLIM	Logical variable; true for bottom withdrawal interference; false for no interference from bottom
QSHIFT	Logical variable; true when VPORT is called from SHIFT; false when call is not from SHIFT

(Continued)

(Sheet 2 of 4)

Table 5 (Continued)

Variable	Definition
QSINK1	Logical variable; true when point sink description is adequate for determination of lower withdrawal limit; false when the above is not true
QSINK2	Same as QSINK1, except check is for the upper withdrawal limit
QTLIM	Logical variable; true for surface withdrawal interference; false for no interference from surface
RATIO	Ratio of the product of distance and density difference between the point of maximum velocity and a local point to the product of distance and density difference between the point of maximum velocity and a given limit
SINK1	Empirical value used in determination of validity of point sink description for calculations of lower withdrawal limit
SINK2	Same as SINK1, except now pertaining to upper withdrawal limit
SMALL	Essentially zero; check for approximate equality between two values
SUBR	Subroutine name
SUM	Sum over layers in the withdrawal zone of the velocity values for each layer
TINY	Essentially zero; used in value comparisons
TOPLIM	Layer of upper limit
TRUNCZ	For surface interference, it is the distance between the port center line and the surface; for bottom interference, it is the distance between the bottom and the port center line
V(I)	Normalized velocity profile value at layer I for a given port
VDIM	Assigned as value of PVDIM(K) locally
VDIM2	One-half the vertical dimension of the port; VDIM/2.0
VD2	Equals VDIM2 or, if upper edge of port is above the pool surface, the distance between the surface and the port center line
VM	Scaling factor

(Continued)

(Sheet 3 of 4)

Table 5 (Concluded)

Variable	Definition
VMAX	Maximum velocity in the normalized velocity profile; assigned as 1.0
WANGLE	Withdrawal angle; equals WTHETA(K) from subroutine OUTVEL
X1	Elevation of a search limit
X2	A second limit search elevation
X3	A third limit search elevation
X4	A fourth limit search elevation
XDUMY	Assigned 0.0; used in ERROR () argument list
XDUMY1	Same as XDUMY
XDUMY2	Same as XDUMY
XDUMY3	Same as XDUMY
XVMAX	Location of maximum velocity relative to the bottom
XXX	Used in label assignment statement
Y	Distance from elevation of maximum velocity to local elevation
YVMAX	Location of maximum velocity referenced to lower withdrawal limit
ZLOW	Distance between port center line and lower withdrawal limit
ZONE	Distance from lower withdrawal limit to upper withdrawal limit
ZONED	When surface or bottom interference exists (but not both), it equals the distance between the boundary of interference and the opposing withdrawal limit
ZTOP	Distance between port center line and upper limit

(Sheet 4 of 4)

the calculation of the velocities within the withdrawal zone.

42. The Bohan and Grace equation, modified to include the withdrawal angle, is

$$\frac{Q}{Z^3 N} = \frac{\theta}{\Pi} \tag{5}$$

where

$$N = \frac{\Delta\rho}{\rho}\frac{g}{Z} \tag{6}$$

Q = flow rate

Z = distance between the port center line and the upper or lower withdrawal limit

θ = angle of withdrawal, in radians

Π = 3.14159 radians

$\Delta\rho$ = difference between the density at the upper or lower limit and the density at the port center line

ρ = density at the port center line

g = acceleration due to gravity

Figure 14 shows a schematic definition of these variables. Equation 5 is transcendental and cannot be solved directly since $\Delta\rho$ is a function of Z for the computation of N (Equation 6). Therefore, an iterative technique is needed to solve the equation for Z. Since Equation 5 and the Smith et al. (1987) equation, which follows, are transcendental and solved through iteration, a description of the iterative solution algorithm is withheld until after the Smith et al. equation is presented.

43. Smith et al. (1987) developed an equation that is an analytical extension of Equation 5 and is used to locate the limit that is free of interference when the other limit experiences boundary interference (Figure 15). The equation is

$$\frac{Q'}{D'^3 N} = \frac{0.125\phi}{\chi^3}\frac{\theta}{\Pi} \tag{7}$$

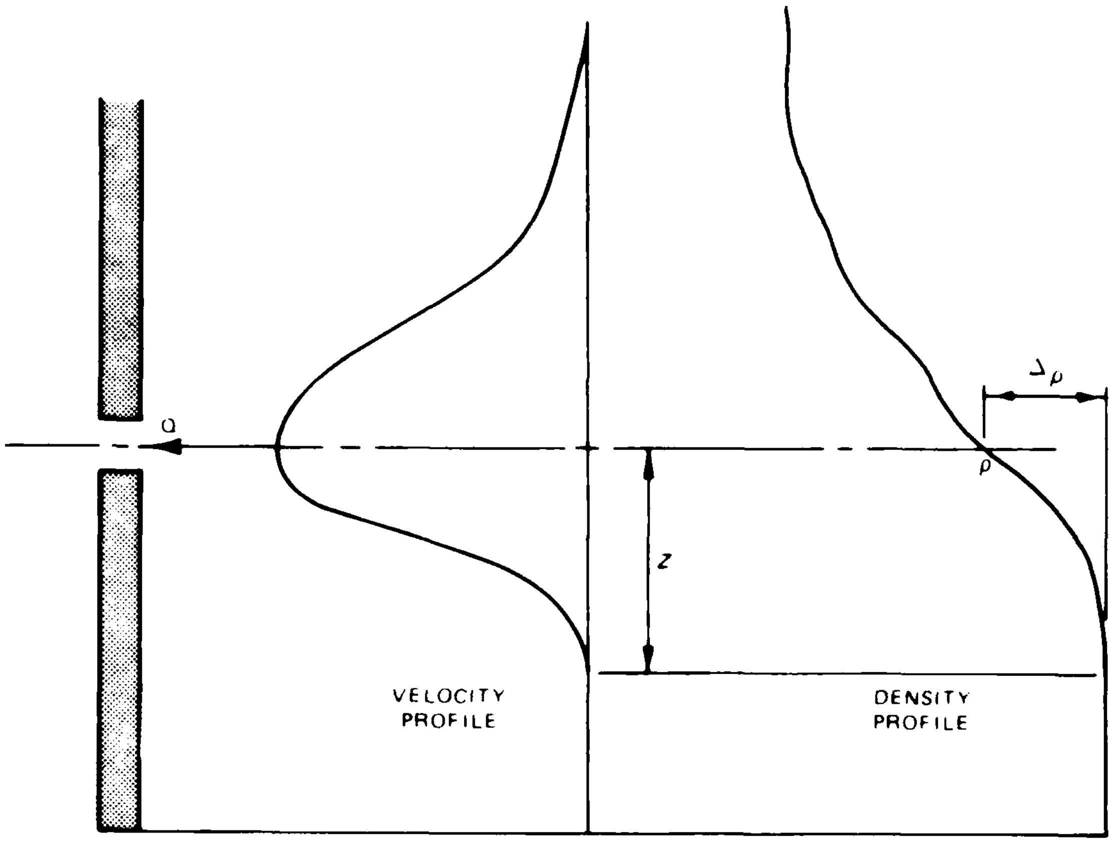


Figure 14. Variable definition schematic

where

$$\Phi = \frac{1}{2}\left[1 + \frac{1}{\pi}\sin\left(\frac{b/D'}{1 - b/D'}\pi\right) + \frac{b/D'}{1 - b/D'}\right] \tag{8}$$

$$X = \frac{1}{2}\left[1 + \frac{b/D'}{1 - b/D'}\right] \tag{9}$$

where

Q' = discharge flow rate from the withdrawal zone

D' = distance between free withdrawal limit and boundary of interference

b = distance between port center line and boundary of interference

A schematic representation of this computation is given in Figure 15. Equation 7 is iteratively solved for D' . With D' known, the

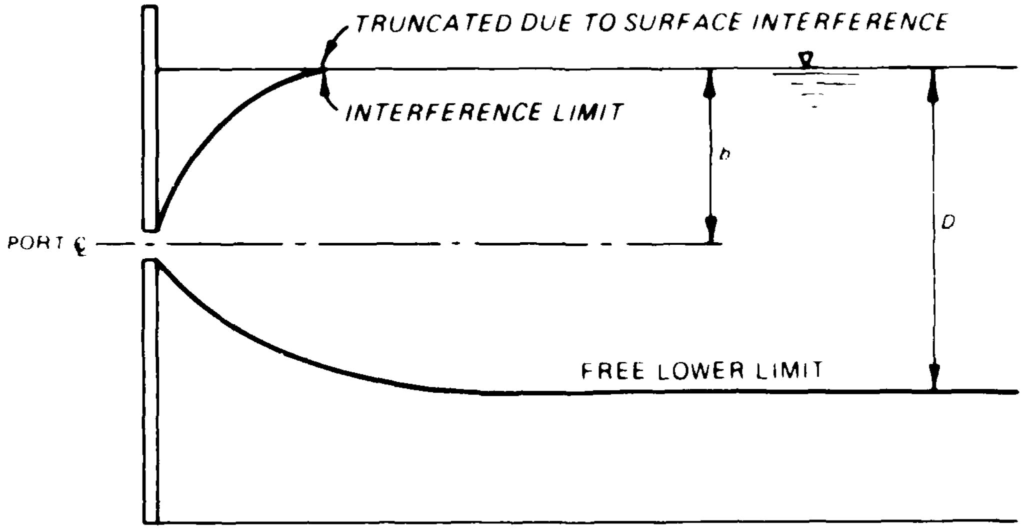


Figure 15. Schematic of a withdrawal zone with surface interference

location of the free limit (a distance D' from the limit of interference) is computed.

44. As mentioned earlier, Equations 5 and 7 are transcendental and therefore require an iterative solution. A half-interval search algorithm is used in SELECT and is discussed in the following paragraphs.

Half-interval search

45. Equations 5 and 7 are rearranged to give

$$Q - Z^3 N \frac{\theta}{\pi} = 0 \qquad (10)$$

$$Q' - (D'^3 N) \left[\frac{1 + \sin \frac{b/D'}{1 - b/D'} \pi + \frac{b/D'}{1 - b/D'}}{\left(1 + \frac{b/D'}{1 - b/D'}\right)^3} \right] \frac{\theta}{2\pi} = 0 \qquad (11)$$

These equations are then used to iteratively solve for Z (Equation 10) and D' (Equation 11). Note that if, during the iteration process, an appropriate Z or D' is chosen and substituted into Equation 10 or 11, respectively, the above equalities become true and the assumed Z or D' would be considered the solution to the equation. If a smaller or larger value is chosen, the left-hand side (LHS) of the equalities will be positive or negative, respectively. By systematically evaluating the magnitude and the sign of the LHS for various values of Z or D' , convergence to the solution can be achieved.

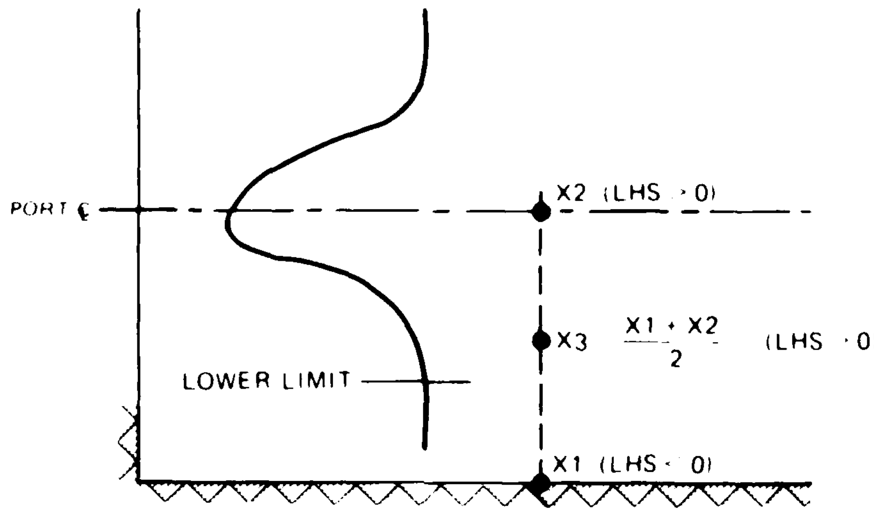
46. For the sake of illustration, the following description of the search for a lower limit in a withdrawal zone free of interference is given. We are solving Equation 10. Note that the half-interval search determines one limit at a time.

a. To begin the iteration process, two points are located: one point is assumed to lie above the limit (usually the outlet center-line elevation X2 = 0.0 since X2 is measured from the port center line downward); the other point is below the limit (a distance X1 below the port center line, usually at the bottom). Figure 16a illustrates this step.

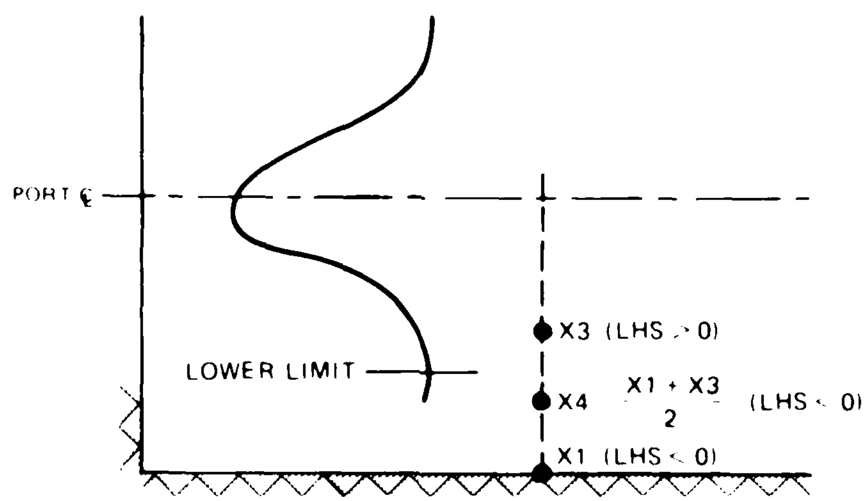
b. A third point (X3) is determined that is halfway between X1 and X2 , hence, the half-interval search technique. Point X3 is assumed to be the withdrawal limit, and its Z value and corresponding density difference are substituted into Equation 10. If the LHS is zero or within a tolerable deviation from zero (10 percent of the layer thickness), X3 is taken as the actual limit. If the LHS of Equation 10 is negative, then X3 is below the actual limit. If the LHS is positive, X3 is above the actual limit.

c. If X3 is not the solution after the first iteration is complete, then X3 replaces the limit (X1 or X2) that lies on the same side of the limit as it does. Thus, a new search region, which is the half of the original search region containing the solution, will be subjected to the same search technique. A new midpoint (X4) is found halfway between X3 and the remaining point (X1 or X2), at a quarter-point of the original search region. In this example, X4 is located on the opposite side of the limit from X3 (Figure 16b). It should be noted that X4 does not always reside on the opposite side of the limit from X3 .

d. The new point, X4, is assumed to be the withdrawal limit, and its Z value and corresponding density difference are substituted into Equation 10. The process described in c repeats itself until successive estimates for Z (X3 and X4) are found that lie within a tolerable distance from each other (10 percent of the layer thickness). The X3 or X4 value is then assigned as the actual limit.



a. Initial estimate of lower limit (X3)



b. Second estimate of lower limit (X4)

Figure 16. Illustration of search for lower withdrawal limit

e. If the search does not converge within 10 iterations, an error message is output and program execution is terminated.

47. The following points should also be noted:

a. When one limit experiences interference and the other does not, Equation 11 is used rather than Equation 10 in the search algorithm and the number of iterations allowed is increased from 10 to 20.

b. Although boundary interference may physically constrain a limit to the given boundary, a theoretical value for that limit is determined assuming no interference. This allows the computation of the normalized velocity profile based upon the theoretical extent of the limits, thereby expressing the velocity at the boundary in terms of its theoretical potential. The zone is truncated at the boundary, and all velocity values outside the boundary are omitted (Figure 17) in subsequent computations.

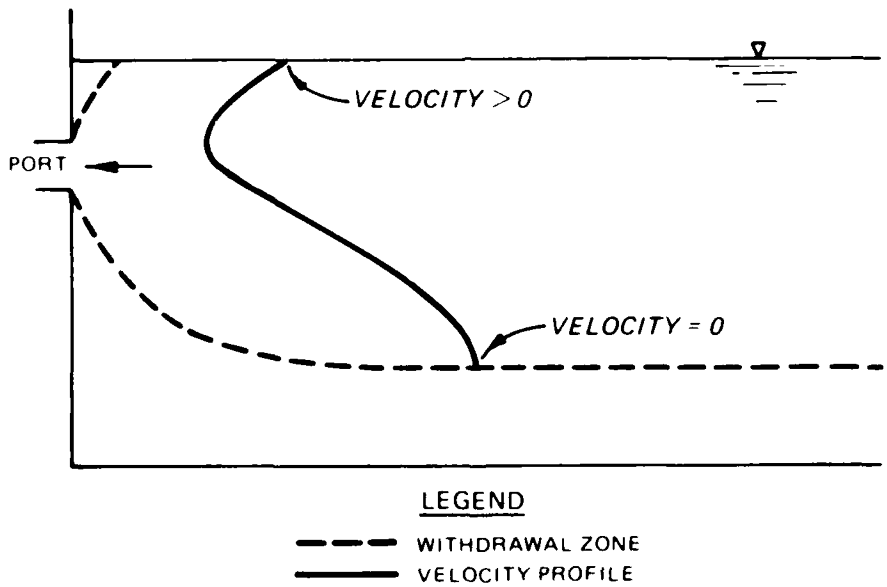


Figure 17. Velocities calculated above the water surface are truncated from velocity profile

Velocity profile computation

48. The velocity profile computations are based on the vertical location of the maximum velocity in the withdrawal zone. The location of maximum velocity is given by the equation (Bohan and Grace 1973)

$$Y_L = H * \sin \left(1.57 \frac{Z_L}{H}\right)^2 \qquad (12)$$

where

Y_L = distance from lower limit to elevation of maximum velocity

H = vertical distance between the upper and lower withdrawal limits

Z_L = vertical distance between the outlet center line and the lower limit

Since the elevation of the lower limit is known, the elevation (and the layer) of maximum velocity can be determined. With the location of the layer of maximum velocity known, the velocity distribution can be determined.

49. Bohan and Grace (1973) found that Equations 13 and 14 described the vertical velocity distribution for withdrawal zones experiencing boundary interference and for zones free of interference, respectively.

$$\frac{V}{V_{MAX}} = 1 - \left(\frac{y}{Y} \frac{\Delta\rho}{\Delta\rho_{MAX}}\right)^2 \qquad (13)$$

$$\frac{V}{V_{MAX}} = \left(1 - \frac{y}{Y} \frac{\Delta\rho}{\Delta\rho_{MAX}}\right)^2 \qquad (14)$$

where

V = velocity value within a given layer of the withdrawal zone

V_{MAX} = maximum layer velocity value in the withdrawal zone

y = vertical distance from the elevation of maximum velocity to that of the given layer

Y = vertical distance between the elevation of maximum velocity and that of the upper or lower limit as appropriate

$\Delta\rho$ = difference in density between that at the elevation of maximum velocity and that at the given layer

$\Delta\rho_{MAX}$ = difference in density between that at the elevation of maximum velocity and that at the elevation of the upper or lower limit as appropriate

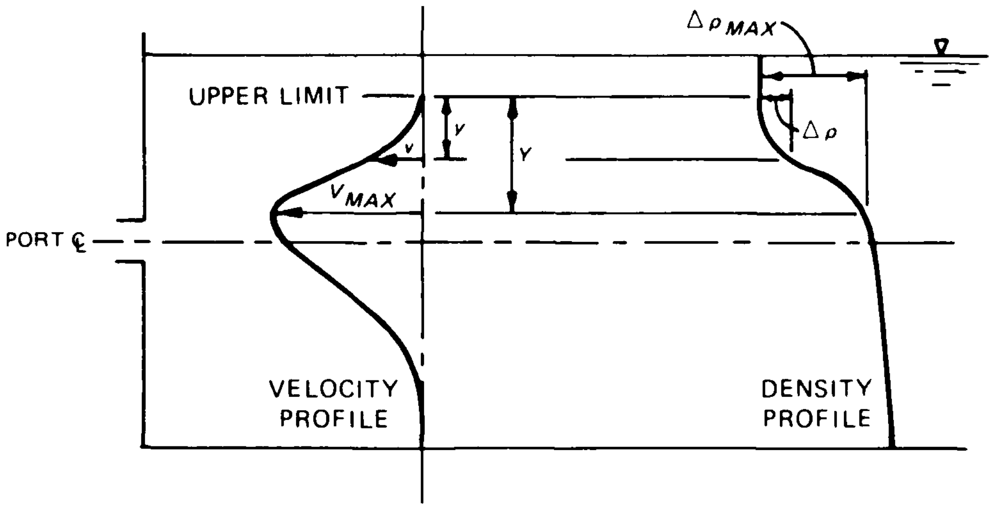


Figure 18. Schematic definition of variables for Equations 13 and 14

A definition sketch for these variables is given in Figure 18. Inspection of Equations 13 or 14 reveals that the product $(y/Y)(\Delta\rho/\Delta\rho_{MAX})$ has a maximum value of 1.0. Therefore, the maximum value of the right-hand side of this equation is 0.0. Since these velocity values will ultimately be scaled to provide a withdrawal profile (shown later), the assignment of V_{MAX} acts only to change the constant used for scaling these profiles. In order to develop the normalized velocity distribution (velocities with values between 0 and 1), V_{MAX} is assigned in VPORT to be 1.0. Thus, the V computed in Equations 13 and 14 is also a normalized velocity. The computation of velocity for each layer is then a straightforward calculation since the variables y, Y, $\Delta\rho_{MAX}$, and $\Delta\rho$ are known for each layer. The computation of the entire velocity profile is accomplished by individual operations for each portion of the withdrawal zone above and below the elevation of the point of maximum velocity.

Special considerations

50. The maximum velocity (1.0) will be assigned to all withdrawal layers above or below the elevation of maximum velocity if the layer densities do not vary from the density at the elevation of maximum velocity, i.e., $\Delta\rho = 0$.

Conversion of
velocities to flow rates

51. Once the normalized velocity distribution is determined for a port, the withdrawal profile, i.e., a flow rate, is calculated for each layer based on the total flow rate through the port. The equation used to compute the withdrawal profile is

$$q_I = \frac{V_I}{\Sigma V_I} Q_T \tag{15}$$

where

q_I = withdrawal from the I^{th} layer

V_I = normalized velocity at the I^{th} layer

Q_T = total flow rate through a port

Point sink assumption

52. One of the basic assumptions in the theory underlying SELECT is that ports may be considered point sinks, i.e., port dimensions are insignificant compared to withdrawal zone thickness. To ensure that the outlet configuration is consistent with the point sink assumptions, the program performs empirically based calculations (see next paragraph) to assess whether the point sink assumption is violated. If the assumption has been violated, a warning statement is issued in the output alerting the user to the violation of the assumption. Should the user receive such a statement, more extensive modeling may be required.

53. Using the illustration in Figure 19 to aid in the description of the variables, the following inequalities are defined to ascertain the applicability of the point sink assumption:

$$\frac{(\Delta\rho_L * Z_L)}{(\Delta\rho_B * h)} > 3.0 \tag{16}$$

$$\frac{(\Delta\rho_U * Z_U)}{(\Delta\rho_T * h)} > 3.0 \tag{17}$$

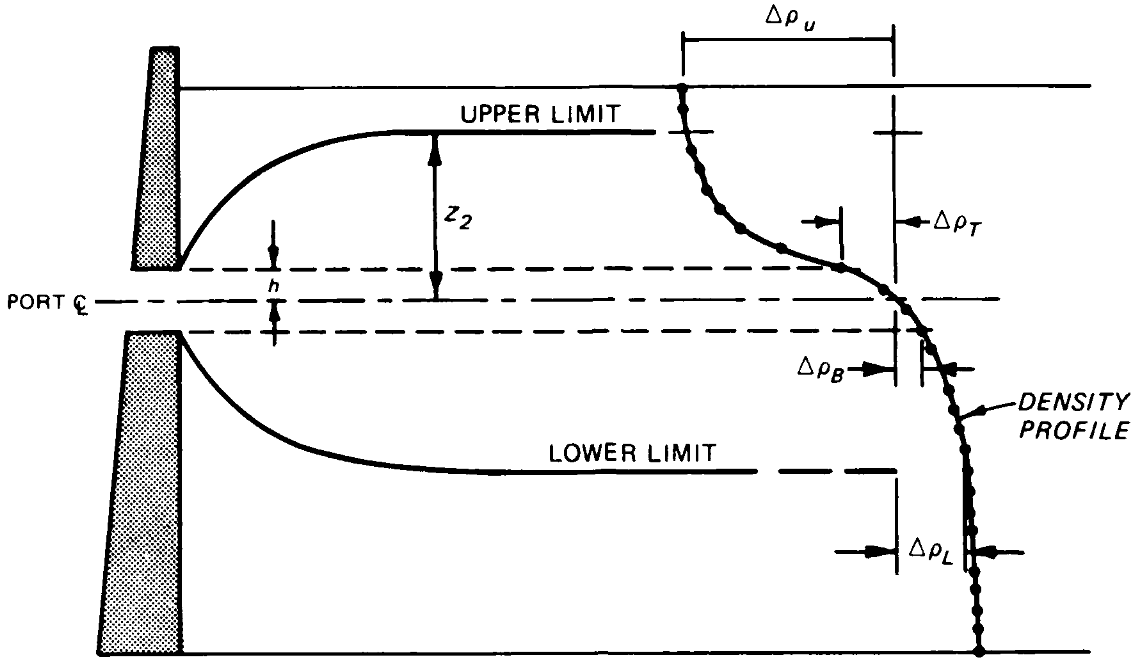


Figure 19. Definition sketch of variables for point sink assumptions

where

$\Delta\rho_L$ = density difference between the port center line and the predicted lower limit

Z_L = distance from the port center line to the lower limit

$\Delta\rho_B$ = density difference between the port center line and the invert of the port

h = one-half the vertical dimension of the port

$\Delta\rho_U$ = density difference between the port center line and the predicted upper limit

Z_u = distance from the port center line and the upper limit

$\Delta\rho_T$ = density difference between the port center line and the top of the port

When Equation 16 is true, a point sink description of withdrawal through the port is not applicable for determining the lower limit. When it is false, a point sink description is valid. When Equation 17 is true, a point sink description of withdrawal through the port is not valid for the upper limit. When it is false, a point sink description is valid.

54. Subroutine VWEIR is the computational subprogram called by OUTVEL when an outlet is modeled as a weir. VWEIR determines the withdrawal zone limits and associated profile for withdrawal over a weir under the assumption that the weir crest is above the thermocline. If this assumption is violated, SELECT may produce erroneous output. It should be noted that the impoundment surface is taken as the upper limit for any type of weir modeled. Also, if the bottom interferes with the lower limit, the bottom is taken as the lower limit.

55. The equation used in VWEIR to calculate the withdrawal zone limit is based on studies and analysis performed by Grace (1971) and additional analytical and empirical development at the WES. Subroutine VWEIR incorporates a formulation based on the densimetric Froude number F_D to describe weir withdrawal such that

$$F_D = \frac{\bar{V} H_w}{\sqrt{\frac{\Delta\rho}{\rho} g (Z + H_w)^3}} = C - D \frac{H_w}{(Z + H_w)} \qquad (18)$$

where

$\bar{V}$ = average velocity in the withdrawal zone

H_w = head above the weir crest elevation

$\Delta\rho$ = difference in density of fluid at the weir crest and the lower limit

ρ = density at the weir crest elevation

g = acceleration due to gravity

Z = distance between the crest elevation and the lower withdrawal limit

$C = 0.54$ and $D = 0$ for $\frac{Z + H_w}{H_w} \geq 2.0$

$C = 0.78$ and $D = 0.70$ for $\frac{Z + H_w}{H_w} < 2.0$

56. Rearranging Equation 18 yields

$$0 = \bar{V} - C \frac{(Z + H_w)}{H_w} \sqrt{\frac{\Delta\rho}{\rho} g(Z + H_w)} + D \sqrt{\frac{\Delta\rho}{\rho} g(Z + H_w)} \qquad (19)$$

With Equation 19, it is possible to solve for the withdrawal limit Z by iteration. The half-interval search, outlined in VPORT, is used in a similar manner in VWEIR except that Equation 19 is used as the iterative equation. Figure 20 shows the computational flowchart of VWEIR. Table 6 lists descriptions of the variables used in subroutine VWEIR.

Velocity profile

57. The calculation of a normalized velocity profile for a weir is based on the equations developed by Bohan and Grace (1973). Two conditions influence which equation governs the description of the profile: (a) whether the portion above or below the elevation of maximum velocity is being described, and (b) whether the weir is free or submerged. The following listing accounts for the conditions under which the equations are used.

58. Submerged weir. The location of the point of maximum velocity is computed exactly as it is for an orifice, as described in paragraph 51 of the subroutine VPORT description. The portion of the profile above the elevation of maximum velocity is described by

$$\frac{V_2}{V_{MAX}} = 1 - \left(\frac{y_2 \Delta\rho_2}{Y_2 \Delta\rho_{2m}}\right)^2 \qquad (20)$$

where

V_2 = layer velocity in the zone of withdrawal at a distance y_2 above the elevation of maximum velocity

V_{MAX} = maximum layer velocity in the withdrawal zone, equals 1.0 for normalized distribution (see discussion of V_{MAX} in section on VPORT)

y_2 = vertical distance from the elevation of maximum velocity to that of the corresponding layer velocity V_2

$\Delta\rho_2$ = density difference of fluid between the elevations of the maximum velocity and the corresponding layer velocity V_2

Y_2 = vertical distance from the elevation of the maximum velocity to the upper limit of the zone of withdrawal

$\Delta\rho_{2m}$ = density difference of fluid between the elevation of the maximum velocity and the elevation of the upper limit

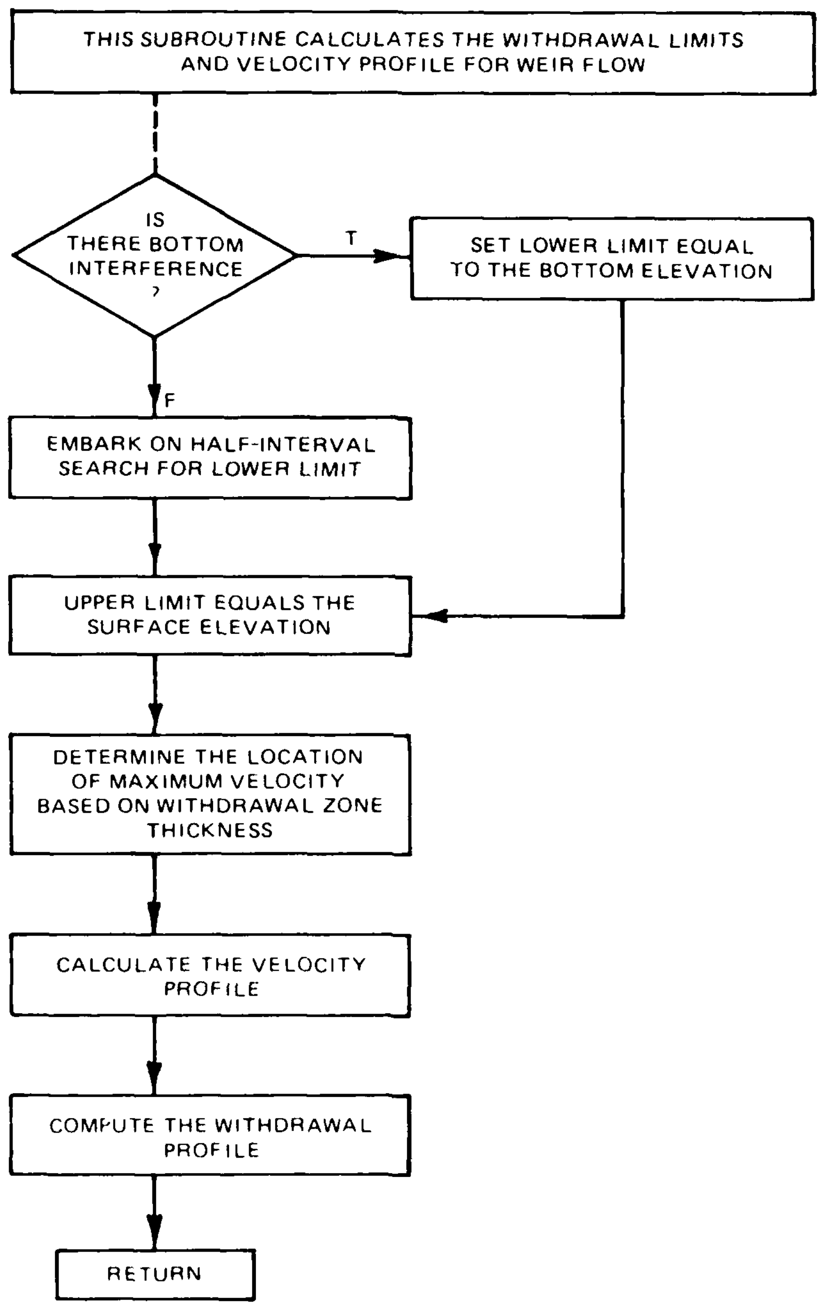


Figure 20. Flowchart for subroutine VWEIR

Table 6

VWEIR Variables

Variable	Definition
A	Coefficient used in determining the velocity profile exponent as a function of the discharge coefficient
AVGVEL	Average velocity over weir
B	Coefficient used in determining the velocity profile exponent as a function of discharge coefficient
C	Coefficient used in the FWEIR(X) function; has values of 0.54 or 0.78
COEF	Weir discharge coefficient
CREST	Weir crest height above bottom
D	Second coefficient used as C; possible values are 0.0 to 0.70
DELDEN	Density difference between fluid at layer of maximum velocity and fluid at a local elevation
DELZ	Layer thickness
DEN(I)	Density of layer I, g/cm^3
DENDIF	Density difference between fluid at layer of maximum velocity and fluid at a withdrawal limit, g/cm^3
DENLOW	Density at lower withdrawal limit, g/cm^3
DENTOP	Density at upper withdrawal limit, g/cm^3
DEPTH	Depth of pool
DVMAX	Density at location of maximum velocity, g/cm^3
EXPNT	Exponent for velocity profile equation for free weir flow
F1	Value of withdrawal limit function FWEIR(X) evaluated at X1
F2	Same as F1 evaluated at X2
F3	Same as F1 evaluated at X3

(Continued)

(Sheet 1 of 4)

Table 6 (Continued)

Variable	Definition
FLORAT	Flow rate over weir
G	Gravitational acceleration
HEAD	Head above weir crest
HGT(I)	Percentage of layer I that is filled with water
HGTLOW	Height above bottom of lower limit
HGTTOP	Height above bottom of upper limit
ISURF	Total number of layers
ITMAX	Number of search iterations allowed to determine withdrawal limits
LENGTH	Length of weir crest
LOWLIM	Layer of lower limit
LVMAX	Layer of maximum velocity
P	Exponent for velocity profile function
Q1	Logical variable; true for positive withdrawal limit function; false for negative
Q2	Logical variable; true for positive withdrawal limit function; false for negative
QZ	Logical variable; true when the vertical distance between the crest and the lower unit is less than the head above the crest, i.e., $Z_o/H_w < 1$; false, when the above is not true
QBLIM	Logical variable; true for bottom withdrawal interference; false for no interference from bottom
QSHIFT	Logical variable; true when VWEIR is called from SHIFT; false when not called from SHIFT
QSUB	Logical variable; true when the weir is submerged; false when not submerged

(Continued)

(Sheet 2 of 4)

Table 6 (Continued)

Variable	Definition
QTLIM	Logical variable; true for surface withdrawal interference; false for no interference from surface
QZ	Logical variable; true when the vertical distance between the crest and the lower limit is less than the head above
RATIO	Ratio of the product of distance and density difference between the point of maximum velocity and a local point to the product of the distance and density difference between the point of maximum velocity and a given limit
SMALL	Essentially zero; check for approximate equality of two values
SUM	Sum over layers of the velocities for each layer
SUBR	Subroutine name
TOPLIM	Upper withdrawal limit
V(I)	Normalized velocity profile for weir
VM	Scaling term equal to FLORAT/SUM
VMAX	Maximum velocity in the normalized velocity profile, 1.0
WRDEN	Density at weir crest, g/cm^3
X1	Elevation of an initial search limit
X2	Elevation of a second search limit
X3	Elevation of a third search limit
X4	Elevation of a fourth search limit
XCHECK	Local variable for the value of $Z + H_w/H_w$
XDUMY	Assigned 0.0; used in ERROR () argument list
XDUMY1	Same as XDUMY
XDUMY2	Same as XDUMY

(Continued)

(Sheet 3 of 4)

Table 6 (Concluded)

Variable	Definition
XDUMY3	Same as XDUMY
XVMAX	Distance from bottom to elevation of maximum velocity
Y	Distance from location of maximum velocity to local elevation
YLOW	Distance from location of maximum velocity to lower withdrawal limit
YTOP	Distance from location of maximum velocity to upper withdrawal limit
YVMAX	Location of maximum velocity referenced to lower withdrawal limit
ZLOW	Difference between crest elevation and lower withdrawal limit
ZONE	Distance from lower withdrawal limit to upper withdrawal limit

(Sheet 4 of 4)

59. A description of the portion of the profile below the elevation of maximum velocity for a submerged weir is given by

a. Without bottom interference

$$\frac{V_1}{V_{MAX}} = \left(1 - \frac{y_1 \Delta\rho_1}{Y_1 \Delta\rho_{1m}}\right)^3 \qquad (21)$$

b. With bottom interference

$$\frac{V_1}{V_{MAX}} = 1 - \left(\frac{y_1 \Delta\rho_1}{Y_1 \Delta\rho_{1m}}\right)^2 \qquad (22)$$

where

V_1 = layer velocity in the zone of withdrawal at a distance y_1 below the elevation of maximum velocity

V_{MAX} = maximum layer velocity in the withdrawal zone; taken as 1.0 for normalized distribution (see V_{MAX} discussion in section on VPORT)

y_1 = vertical distance from the elevation of maximum velocity to that of the corresponding layer velocity V_1

$\Delta\rho_1$ = density difference of fluid between the elevations of the maximum velocity and the corresponding layer velocity V_1

Y_1 = vertical distance from the elevation of the maximum velocity to the lower limit of the zone of withdrawal

$\Delta\rho_{1m}$ = density difference of fluid between the elevations of the maximum velocity and the elevation of the lower limit

60. Free weir. A description of the portion of the profile below the elevation of maximum velocity is given by

$$\frac{V_1}{V_{MAX}} = 1 - \left(\frac{y_1 \Delta\rho_1}{Y_1 \Delta\rho_{1m}}\right)^P \qquad (23)$$

where the exponent P varies with the user's choice of a weir coefficient COEF such that for

$|COEF - 3.00| < 0.1 , \quad P = 1.5$

$|COEF - 3.33| < 0.1 , \quad P = 0.5$

$|COEF - 4.10| < 0.1 , \quad P = 0.2$

where | | denotes the absolute value of the expression. If none of the above is true, $P = 4.35 - (1.04)COEF$.

61. The velocity for each layer is found directly since all variables y_i , Y_i , $\Delta\rho_{im}$, and $\Delta\rho_i$ (i = 1 or 2) are known for each layer in the withdrawal zone.

Special considerations

62. The maximum normalized velocity (1.0) is assigned for each withdrawal layer above and below the elevation of maximum velocity if the layer's density does not vary from the density at the elevation of maximum velocity, i.e., $\Delta\rho_i = 0$.

Conversion of velocities to flow rates

63. Once the normalized velocity profile is determined for the weir, the withdrawal profile is calculated based on the total flow rate over the weir. The flow value for each layer is scaled to sum to the magnitude of the total outflow over the weir. Equation 15 (in the VPORT section) is used to calculate the layer withdrawals based on the normalized velocities.

SHIFT

Description

64. Subroutine SHIFT adjusts the limits of withdrawal zones that overlap vertically when mulltilevel outlets are operated. The adjustment is necessary to correct the difference between the simple superposition of the predicted withdrawal zones for each outlet and the actual zone as observed during testing (see Figure 21). It is believed

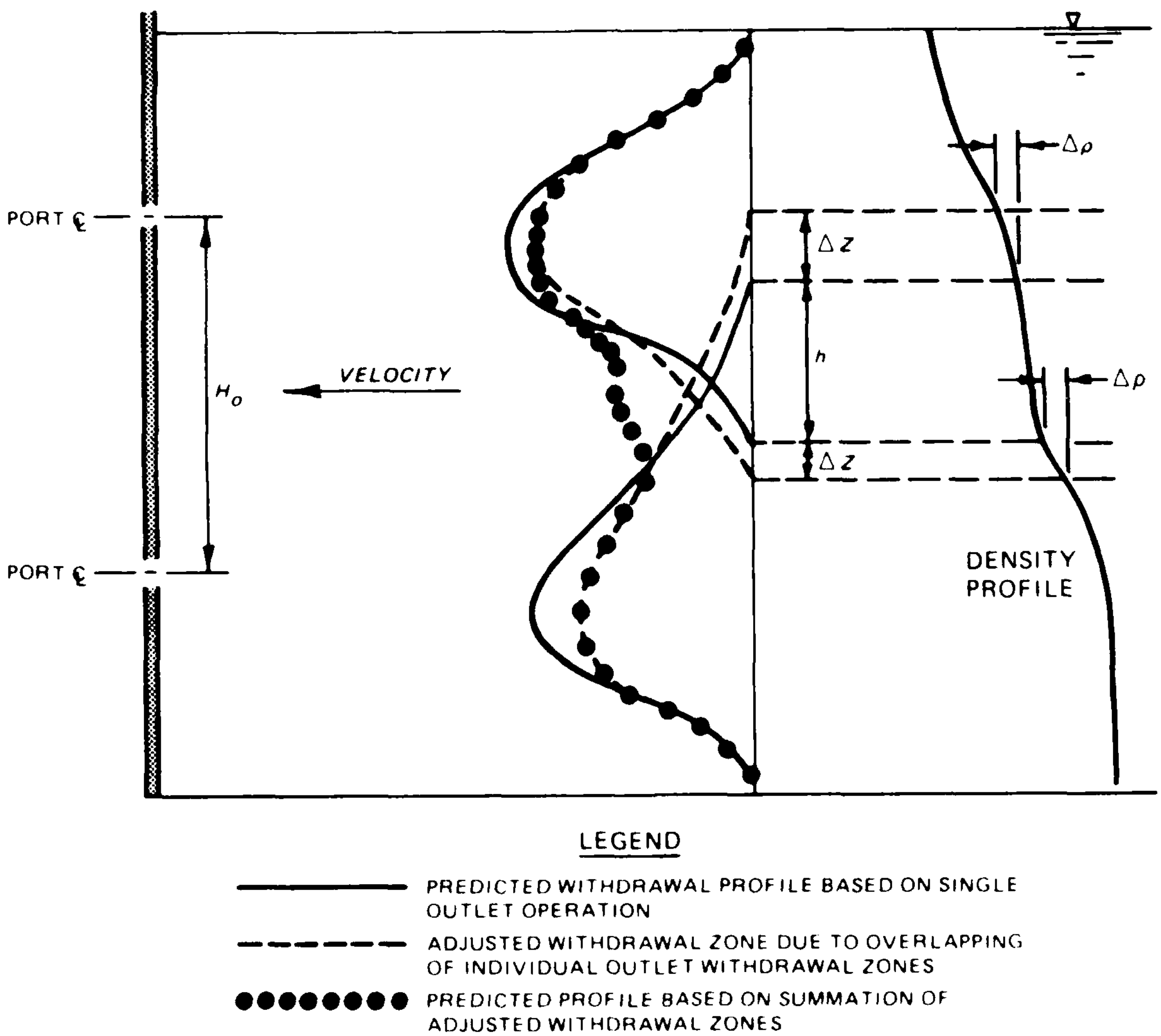


Figure 21. Schematic diagram of differences between initially calculated theoretical withdrawal zones and shifted withdrawal zones

that the difference exists because the fluid motion in one withdrawal zone tends to help the fluid movement in the other zone overcome the shear resistance forces in the region of overlap. Since the predicted velocity profile for each individual outlet does not take into account this apparent reduction in shear resistance, the superposition of the individually predicted profiles will not account for it either.

65. Bohan and Gloriod (1972) found that the discrepancy between the simple superposition of withdrawal zones and the actual zone was relatively consistent in laboratory testing. They concluded that the limits of the overlapping zones could be systematically adjusted to increase the zone thickness, thereby modifying the velocity distribution to produce individual withdrawal zones whose superposition closely approximated the actual zone. Bohan and Gloriod determined that the adjustment was a function of the amount of overlap of the two individual zones, the vertical spacing between the outlets, the density distribution of the impoundment, and the average velocity of each withdrawal zone in the region of overlap. The equation developed and used in SHIFT is

$$\frac{V_h}{\sqrt{\frac{\Delta\rho}{\rho} g\Delta z}} = 0.70 \left(\frac{h}{H_o}\right)^{1.25} \tag{24}$$

where

V_h = average velocity in the region of overlap of the upper or lower withdrawal zones as appropriate

$\Delta\rho$ = density difference between the old limit and the shifted limit

ρ = density at the original limit

g = acceleration due to gravity

Δz = vertical shift of the withdrawal limit

h = vertical distance of overlap

H_o = vertical distance between ports

66. Rearranging, Equation 24 becomes

$$V_h - 0.7 \left(\frac{h}{H_o}\right)^{1.25} \sqrt{\frac{\Delta\rho}{\rho} g\Delta z} = 0 \tag{25}$$

The vertical shift Δz can be found by iteration. The iterative algorithm used is similar to the half-interval search described in the VPORT section. A flowchart of the SHIFT subroutine is shown in Figure 22. Table 7 describes the variables used in this algorithm.

Special considerations

67. If the surface interferes with the new shifted limit and the density at the surface is within 1×10^{-7} of density at the port, the shifted limit is assigned to the surface elevation. Also, if the bottom interferes with the new shifted limit and the density at the bottom is within 1×10^{-7} of the density at the port, the bottom is assigned as the limit. Thus, the upper limit of the lower port's withdrawal zone may experience surface interference and the lower limit of the upper port's withdrawal zone may experience bottom interference.

68. After the new limits are found for each withdrawal zone, SHIFT calls VPORT or VWEIR to recompute the flow rate profile for each zone based on the new limits and then transfers program control back to subroutine OUTVEL.

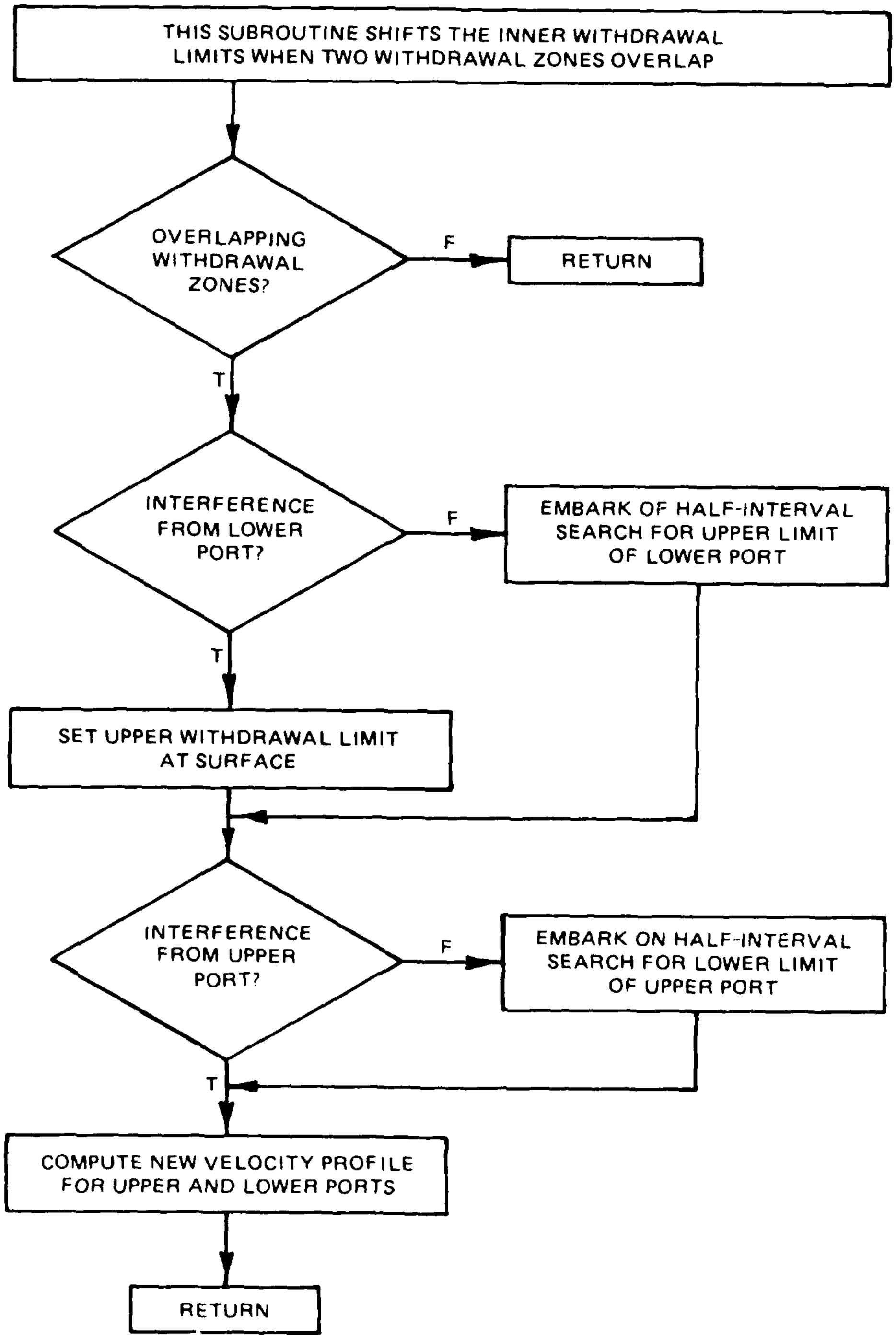


Figure 22. Flowchart for subroutine SHIFT

Table 7

SHIFT Variables

Variable	Definition
CREST	Weir crest height above bottom
DELZ	Layer thickness
DEN(I)	Density of layer I, g/cm^3
DENS1	Density at elevation of lower withdrawal limit for the outlet K + 1, g/cm^3
DENS2	Density at elevation of upper withdrawal limit for the outlet K, g/cm^3 (note: the elevation of port K is below that of port K + 1)
DEPTH	Depth of pool
F1	Value of withdrawal limit shift function FSHIFT (VH, X, D, ZL) evaluated at X1
F2	Same as F1 evaluated at X2
F3	Same as F1 evaluated at X3
FLORAT	Flow rate through one port or over a weir
FLOW(K)	Flow rate through port K
G	Gravitational acceleration
H	Distance between upper withdrawal limit of outlet K and lower withdrawal limit of outlet K + 1
HGT(I)	Percentage of layer I that is filled with water
HGTLOW	Height above bottom of lower withdrawal limit
HGTPRT	Height above bottom of center line of port
HGTTOP	Height above bottom of upper withdrawal limit
HO	Distance between vertical location of outlets K and K + 1
HTEST	Computed value used in withdrawal limit shift function

(Continued)

(Sheet 1 of 4)

Table 7 (Continued)

Variable	Definition
ISURF	Total number of layers
KFILE	File code; KFILE = 06 is output file
L1	Layer containing lower withdrawal limit of outlet K + 1
L2	Layer containing upper withdrawal limit of outlet K
LAY	Number of layers between L1 and L2
LENGTH	Length of weir crest
LLOW(K)	Layer of pool at which lower withdrawal limit for outlet K is located
LOWLIM	Layer of lower limit
LTOP(K)	Layer of pool at which upper withdrawal limit for outlet K is located
MAX	Number of search iterations allowed to determine withdrawal limits
NOUTS	Number of selective withdrawal outlets
PHGT(K)	Height above bottom of port K center line
Q1	Logical variable; true for positive value for withdrawal limit function FSHIFT (VH, X1, D, ZL); false, negative
Q2	Same as Q1 for FSHIFT evaluated at X2
QBLIM	Logical variable; true for bottom withdrawal interference; false for no interference from bottom
QPRINT	Logical variable; initially true, assigned false after print statement is executed; no other reassignment
QSBLIM	Logical variable; true when bottom withdrawal interference occurs after shifting limits; false when no such interference from bottom occurs
QSHIFT	Logical variable; true when VPORT or VWEIR is called; false when return back to SHIFT

(Continued)

(Sheet 2 of 4)

Table 7 (Continued)

Variable	Definition
QSTLIM	Logical variable; true when top withdrawal interference occurs after shifting limits; false when no such top interference occurs
QTLIM	Logical variable; true for surface withdrawal interference; false for no surface interference
QWEIR	Logical variable; true when a weir exists as an outlet device; false when there is no weir
SMALL	Essentially zero; used in value comparisons
SUBR	Subroutine name
TINY	Essentially zero; used in value comparisons
TOPLIM	Layer of upper limit
V(I)	Velocity profile value of layer I for an outlet
VH1	Average outflow of the outlet K in the zone of overlap of the K and K + 1 outlets
VH2	Average outflow of outlet K + 1 in the zone of overlap of the K and K + 1 outlets
VS(I,K)	Velocity profile value of layer I for the K outlet
WRFLOW	Discharge over weir
WRHGT	Weir crest height above bottom
WRLNG	Weir length
X1	Elevation of an initial search limit
X2	Elevation of a second search limit
X3	Elevation of a third search limit
X4	Elevation of a fourth search limit
XDUMY	Assigned 0.0; used in ERROR () argument list

(Continued)

(Sheet 3 of 4)

Table 7 (Concluded)

Variable	Definition
XDUMY1	Same as XDUMY
XDUMY2	Same as XDUMY
XDUMY3	Same as XDUMY
XXX	Used in label assignment statement
ZDN(K)	Height above bottom of the lower withdrawal limit for outlet K
ZL1	Height above the bottom of the lower withdrawal limit for the K + 1 outlet
ZL2	Height above bottom of the upper withdrawal limit for the K outlet
ZUP(K)	Height above bottom of the upper withdrawal limit for outlet K

(Sheet 4 of 4)

XPRINT

69. Subroutine XPRINT controls the output of all tabular information regarding elevations, depths, densities, normalized velocities, flow rates, temperatures, and water quality parameters. Each computational layer has characteristic values for all of the above categories, and subroutine XPRINT prints these parameter values for the layers at user-specified intervals such as at every layer or every third layer. XPRINT also summarizes input information, port center-line elevations, dimensions, crest elevation, crest length, and flow rate. A flowchart showing the organization of XPRINT is displayed in Figure 23. Table 8 lists descriptions of the variables used in XPRINT.

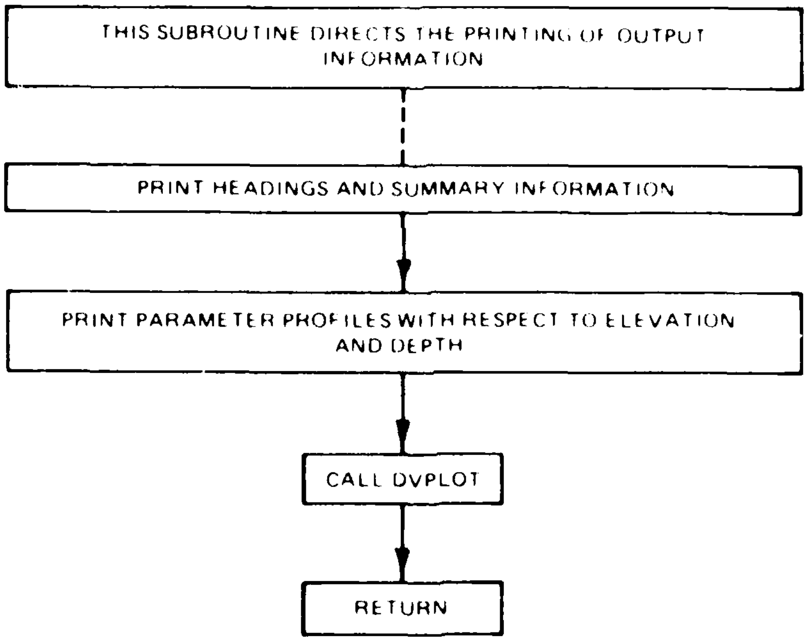


Figure 23. Flowchart for subroutine XPRINT

Table 8

XPRINT Variables

Variable	Definition
AWLBOT	Assigned result of intrinsic function AMAX1(X,Y); X = 0.0 , Y = ZDN(1) = lowest withdrawal limit
AWLUPP	Assigned result of intrinsic function AMIN1(X,Y); X = depth of pool, Y = ZUP (NOUTS) = uppermost withdrawal limit
AZDNEL	The elevation of AWLBOT, i.e., the elevation of the bottom or the lowest limit, whichever is highest
AZUPEL	The elevation of AWLUPP, i.e., the elevation of the surface or the uppermost withdrawal limit, whichever is lowest
BOTTOM	Elevation of bottom of pool
DEEP	Depth from surface to midpoint of layer
DELZ	Layer thickness
DEN(K)	Density of layer K
DENOUT	Average density of outflow, g/cm^3
DEPTH	Depth of pool
DIST	Units of length used
ELEV	Elevation of midpoint of a layer
FLOW(L)	Flow rate through port L
G	Gravitational acceleration
HEADING(K)	Data set title; up to 80 characters in length
INTER	Interval between layers to be printed in output
ISURF	Total number of layers
KFILE	File code for output; KFILE = 06
NAMEQ(K,J)	Name of the J^{th} water quality parameter
NOUTS	Total number of selective withdrawal outlets
NPORTS	Number of selective withdrawal ports
NQUAL	Number of quality parameters input
PELEV	Elevation of a port center line
PHGT(L)	Height above bottom of port L center line

(Continued)

(Sheet 1 of 3)

Table 8 (Continued)

Variable	Definition
PVDIM(K)	The vertical dimension of port K
QALOUT(I)	Average release concentration of the I^{th} water quality parameter
QCENT	Logical variable; true for temperatures in degrees Centigrade; false for temperatures in degrees Fahrenheit
QMETR	Logical variable; true when units are metric (SI); false when units are English (non-SI)
QPLOT	Logical variable; true if line printer plot of density and total velocity profiles is desired; false if not desired
QPORT	Logical variable; true if ports are present as outlets; false if no ports
QPWEIR	Logical variable; true if a port is considered "partially submerged" and therefore modeled as a weir; false otherwise
QSINK1	Logical variable; true when point sink description of port is adequate for calculation of lower withdrawal limit; false when otherwise (see point sink discussion in section on subroutine VPORT)
QSINK2	Same as QSINK1, except now pertaining to upper withdrawal limit
QTEMP	Logical variable; true for temperature profile input; false for no input temperature profile
QUAL(J,K)	K^{th} quality parameter value for layer J
QWEIR	Logical variable; true when a weir is included as an outlet device; false when there is no weir
SUMOUT	Total outflow through all outlets
SURFACE	Elevation of pool surface
TEMOUT	Average temperature of outflow, degrees Fahrenheit or Centigrade
TEMP(K)	Temperature of layer K, degrees Fahrenheit or Centigrade
TITLE(I)	Title of input file; up to 80 characters in length
VEL(K)	Total release velocity profile value of layer K
WELE	Elevation of weir crest

(Continued)

(Sheet 2 of 3)

Table 8 (Concluded)

Variable	Definition
WRFLOW	Flow rate over weir
WRHGT	Weir crest height above bottom
WRLNG	Weir length
WTHDRW(K)	Withdrawal flow rate for layer K
WTHETA(K)	Withdrawal angle for port K
XFEET	Equal to feet
XMETERS	Equal to meters
Y(K)	Height of midpoint of layer K above the bottom
ZDN(I)	Height above bottom of the lower withdrawal limit of outlet I
ZDNEL	Elevation of the lower withdrawal limit for the bottom outlet
ZUP(I)	Height above bottom of the upper limit of outlet I
ZUPEL	Elevation of upper withdrawal limit for the top outlet

(Sheet 3 of 3)

DVPLOT

70. Subroutine DVPLOT generates a line printer plot of elevation (and depth) versus density and velocity. This subroutine is called from subroutine XPRINT. Figure 24 and Table 9 show the algorithm flowchart for DVPLOT and a list of variable descriptions, respectively.

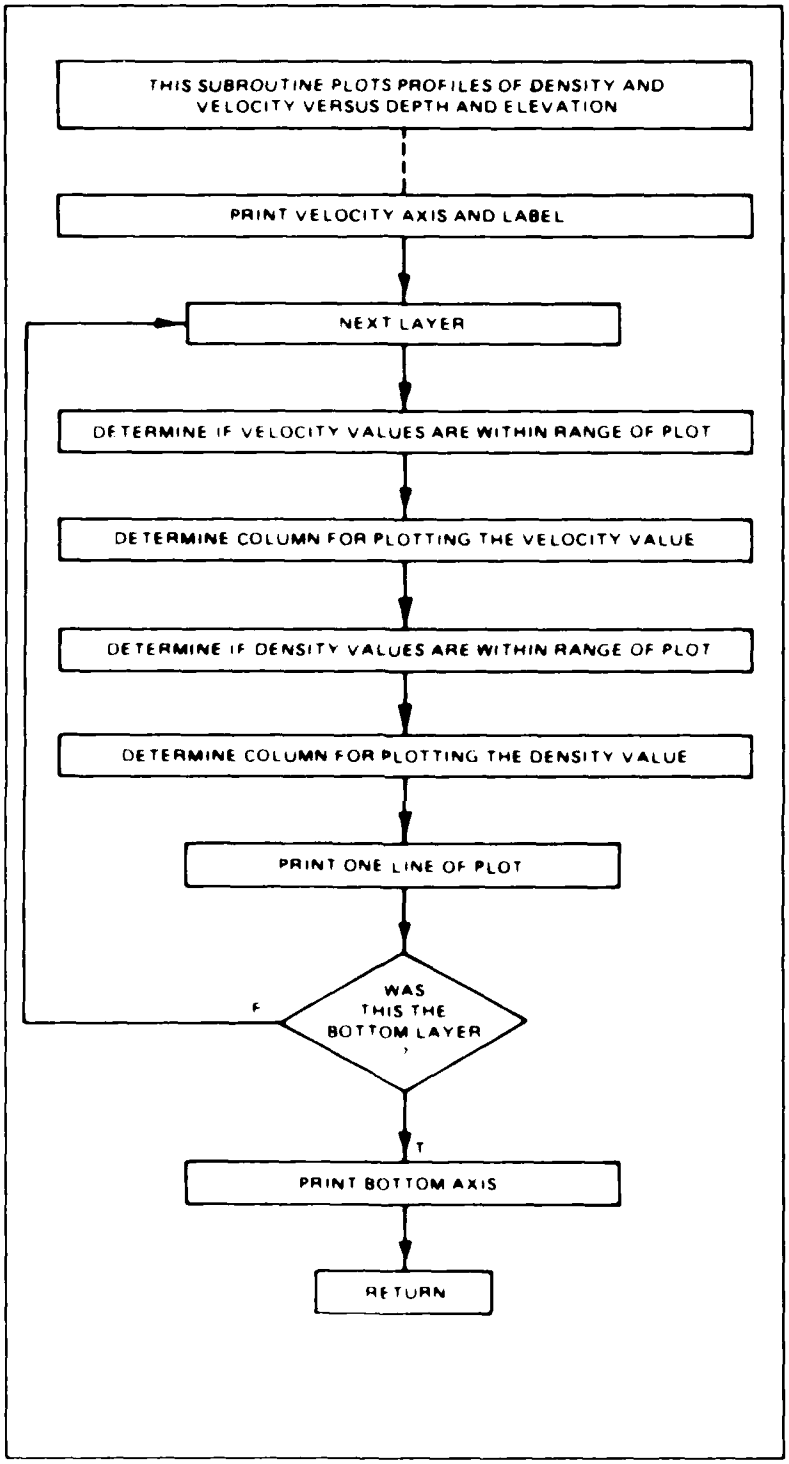


Figure 24. Flowchart for subroutine DVPLOT

Table 9

DVPLOT Variables

Variable	Definition
BLANK	Assigned value of 1H for FORMAT statements
BOTTOM	Elevation of pool bottom
CHANGE	Assigned value of 200; used to increment values along velocity axis of plot
CHANGE2	Assigned value of DENDIF; used to increment values along density axis of plot
COLUMN(K)	Assigned value of variable BLANK or V; K = 100. There are 100 COLUMN values for each line printed. V is assigned to columns where a velocity greater than zero exists; used for plot marks
COLUMN2(K)	Same as COLUMN(K), except it is used for densities and symbol is D instead of V
D	Assigned value of 1HD in data statement; used as plot mark for density
DDIF	Difference between the maximum and minimum densities in the profile when the minimum value is truncated after the third decimal place
DEEP	Used in loop; it begins at zero and is incrementally increased by a layer thickness. Each increment is printed on the vertical axis, thereby listing depth from surface to bottom
[illegible]	User-defined layer thickness
DEN(I)	The density of layer I
DENDIF	Difference between maximum and minimum densities on density axis
DMAX	The maximum density on the density axis of plot, assigned to be 1.00300 g/cm^3
DMIN	The minimum density on the density axis of plot, assigned to be 0.99300 g/cm^3
DN	Temporary assignment of DEN(I)
DSPACE	Value is incremented by CHANGE2 and [illegible] density axis of plot producing the density scale
DUM	Used to truncate DMIN after the third decimal place

(Continued)

Table 9 (Continued)

Variable	Definition
ELEV	Used to print elevations of layers; first value is the elevation of the surface and following values are incrementally reduced by DELZ
FIRST	Assigned the value of variable BLANK or PEGGED; PEGGED is assigned when the density or velocity is less than or equal to zero. The value of FIRST is printed in the first column of the line being plotted
IJK	The column number in which the variable V or D is placed for variable array COLUMN and COLUMN2, respectively
ISURF	Number of layers
KFILE	Output file code
LAST	Assigned the value of variable BLANK or PEGGED; PEGGED is assigned when the velocity or density exceeds VELMAX or DMAX, respectively. LAST is printed in last column of plot
PEGGED	Assigned value of 1H*
PLUS	Assigned value of 2H+
QRANGE	Logical variable; true when velocity value for layer lies between the minimum and maximum velocity value on the plot scale or when the layer density lies between the minimum and maximum density value on the plot scale; false when the above are not true
V	Assigned the value 1HV; used as plot mark for velocity
VEL(I)	Total release velocity profile value of the Ith layer for all outlets combined
VELMAX	Assigned value of 2.0
VL	Assigned the value of VEL(I)
VMAX	Maximum velocity in the velocity profile
VSPACE	Value is incremented by value of CHANGE, and new value is marked on velocity axis producing the velocity scale

<u>ERROR</u>

71. Subroutine ERROR prints error messages and terminates program execution when one of the internal program checks (see Appendix D) has been failed. ERROR receives through its argument list an error number, the name of the subroutine in which the error occurred, the value of the variable CHECK (when applicable), and the values that were expected for CHECK (when applicable). The subroutine then prints the error number, the name of the subroutine-of-the-occurrence, and a brief statement as to the nature of the error, and terminates execution of the program. A flowchart of the subroutine is given in Figure 25, and a listing of variables used in subroutine ERROR is given in Table 10.

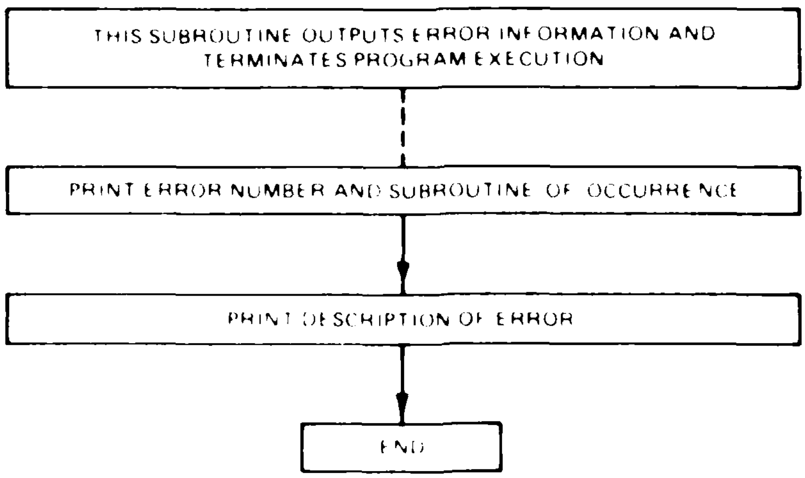


Figure 25. Flowchart for subroutine ERROR

Table 10

ERROR Variables

Variable	Definition
CHK	In subroutine argument list; carries the value of the string which is in error. This is used only when a string is checked in the program for correspondence with an expected string
ERR	In subroutine argument list; carries the value of the error code number
KFILE	Output file code
SUBR	In subroutine argument list; carries the name of the subroutine in which the error occurred
XCHK1	In subroutine argument list; carries the value of the string expected in the corresponding program check. If the program check was not a string comparison, value is zero
XCHK2	In subroutine argument list; when program check has more than one possible expected string, XCHK2 carries the value of one of the strings expected in the program check. If no strings or one string was expected in program check, value is assigned zero
XCHK3	Same as XCHK2, except that it is used when three possible values were expected in the program check. If zero, one, or two possible strings were expected, value is zero

72. Subroutine XREAD transfers information from the input file into working storage. The input file contains program control parameters, outlet characteristics, and reservoir profile data. As the input data are read, they are checked to ensure that the user has observed proper order and format. A general flowchart of the subroutine is shown in Figure 26. Table 11 lists descriptions of the variables used in the subroutine.

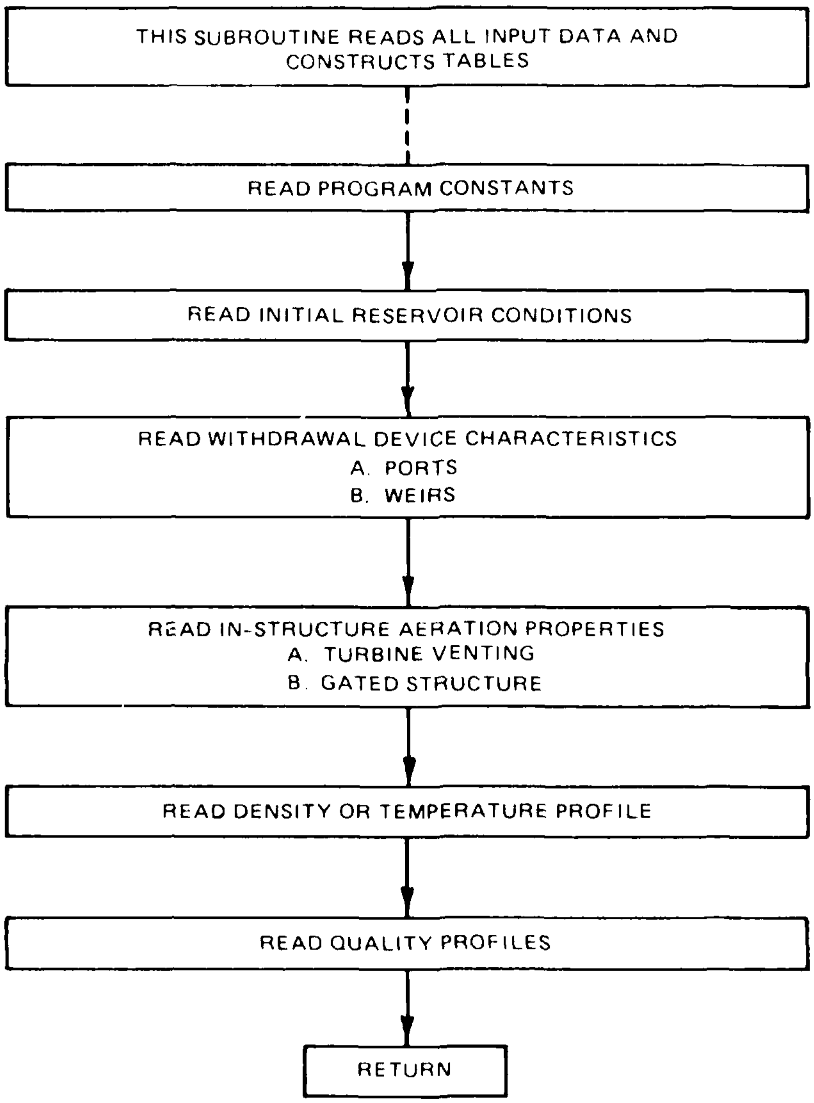


Figure 26. Flowchart for subroutine XREAD

Table 11

XREAD Variables

Variable	Definition
BOTTOM	Elevation of bottom of pool
CHECK	Assigned as first four characters encountered on a line in the user input data file
CHECK1	Same function as CHECK
CHECK2	Same function as CHECK
COEF	Discharge coefficient for free weir flow
DELZ	Layer thickness
DEN(M)	Density of layer M, g/cm^3
DEPTH	Depth of pool
DUMMY(I)	Line of input from data file for echo print of input
DUMQUAL(K)	Working storage assigned to qualities during interpolation of a complete computational profile, appropriate units
DUMYQ(K)	Working storage assigned to height of qualities above bottom during interpolation of a complete completion profile
FLODUM(K)	Working storage assigned to port flow during ordering of ports from bottom to top
FLOW(K)	Release flow rate through the K^{th} port
G	Gravitational acceleration
HDUM	Working storage for port horizontal dimension
HEADING(I)	Title of data set; up to 80 characters in length
HGT(I)	Percentage of layer I that is filled with water
HGTDUM(I)	Working storage assigned as port height above bottom; used during reordering of ports from bottom to top
IFILE	File code for input data file; equals 05
INTER	Interval of layers to be printed in output
ISURF	Total number of layers in a profile
JFILE	File code for auxiliary use; value should usually be specified by user as 00
KFILE	File code for output data file; equals 06
NAMEQ(J,I)	Name of the I^{th} water quality parameter

(Continued)

(Sheet 1 of 4)

Table 11 (Continued)

Variable	Definition
MFILE	Temporarily assigned IFILE or JFILE value; used in echo-print operation
NP	Number of ports + 1; used during ordering of ports from top to bottom
NPORTS	Number of selective withdrawal ports not including a weir
NQUAL	Number of water quality parameters
NSETS	Number of data sets in the input file
NUMD	Total number of density values in density profile
NUMQ(I)	Total number of quality values in the I^{th} quality parameter profile
NUMT	Total number of temperature values in temperature profile
PHDIM(K)	Horizontal dimension of port K
PHGT(K)	Height above bottom of the K^{th} port center line
PVDIM(K)	Vertical dimension of port K
QAERA	Logical variable; true, consider DO uptake due to aeration through a gated structure outlet works; false, do not consider aeration
QCENT	Logical variable; true, temperatures are in degrees Centigrade; false, Fahrenheit
QDEN	Logical variable; true when density is input; if false, program develops density profile
QECHO	Logical variable; true for echo print of input data file; false for no echo print
QFIRST	Logical variable; true, XREAD has been called once by the main program; false, XREAD has not been called by the main program
QMETR	Logical variable; true when units are metric (SI); otherwise, false and units are English (non-SI)
QPLOT	Logical variable; true if line printer plot of density and total velocity profiles is desired; false if not desired
QPORT	Logical variable; true when ports are present as outlet devices; false if there are no ports
QQUAL	Logical variable; true if quality profiles will be entered; false if quality profiles will not be entered

(Continued)

(Sheet 2 of 4)

Table 11 (Continued)

Variable	Definition
QSUB	Logical variable; true for a submerged weir; false for a free weir
QTAB1	Logical variable; true when profile data are input as one table; false when two tables are used: one for vertical locations and one for corresponding profile parameter values (see input description, Part V)
QTEMP	Logical variable; true when temperature profile is input; false otherwise
QTWFUN	Logical variable; true when a tailwater elevation function will be used; false when not used
QUAL(I,M)	M^{th} value for the I^{th} quality parameter, appropriate units
QWEIR	Logical variable; true when a weir is included as an outlet device; false otherwise
SUBR	Subroutine name
SURFACE	Elevation of pool surface
TABTYP	When equal to 1, profile data will be input as one table; when equal to 2, data will be input as two tables (see input description, Part V)
TEMP(M)	Temperature value of layer M, degrees Centigrade or Fahrenheit
TITLE(I)	Identification title for input file; up to 80 characters in length
TWEL	Value of tailwater elevation
UNITS	When equal to CENT, temperature is specified in degrees Centigrade; when equal to FAHR, Fahrenheit degrees
VDIMDM(I)	Temporarily assigned value of PVDIM(K); used in port reordering algorithm
VDUM	Working storage for port vertical dimension
WRFLOW	Outflow quantity over weir
WRHGT	Weir crest height above bottom
WRLNG	Weir length
WRTYPE	Equal to SUBM for a submerged weir; equal to FREE for a free weir
WTHETA(K)	Withdrawal angle for port K

(Continued)

(Sheet 3 of 4)

Table 11 (Concluded)

Variable	Definition
Y(I)	Height above bottom of the midpoint of layer I
YD(M)	Elevation, height above bottom or depth below surface of the M^{th} density profile value
YQ(M)	Elevation, height above bottom or depth below surface of the M^{th} quality profile value
YT(M)	Elevation, height above bottom or depth below surface of the M^{th} temperature profile value

All of the following variables are used to check for input errors and are assigned a character value equal to the four characters that follow the X.

XANGL	XDENS	XFILE	XINTE	XPORT	XSURF	XWEIR
XBOTT	XDEPT	XFLOW	XLENG	XPRIN	XTABL	
XCENT	XELEV	XFREE	XMETR	XQUAL	XTEMP	
XCOEF	XENGL	XHDIM	XNUMB	XSTOP	XTHIC	
XDATA	XFAHR	XHEIG	XPLOT	XSUBM	XVDIM	

(Sheet 4 of 4)

Echo print

73. XREAD has an "echo-print" feature that is optional to the user (option commands are discussed in Part IV). The echo-print feature prints the entire input file to the output, thus allowing the user to see the input and output together. This feature, along with the error checks (given in Appendix D), provide the user with the capability to diagnose error problems in input.

Computational layers

74. XREAD develops the computational layers used in program calculations. The number of computational layers is determined by dividing the impoundment depth by the user-specified layer thickness.

AERATE

75. Subroutine AERATE accounts for the reaeration (DO uptake) of release water during flow through a gated-conduit outlet works. The subroutine determines the upstream oxygen deficit based on the flow-weighted average of DO in the release (calculated in subroutine OUTVEL). AERATE computes the downstream deficit based on the "energy dissipation" model outlined by Wilhelms and Smith (1981) and subsequently calculates the release DO concentration. Figure 27 shows the flowchart for subroutine AERATE. Table 12 lists descriptions of the subroutine variables.

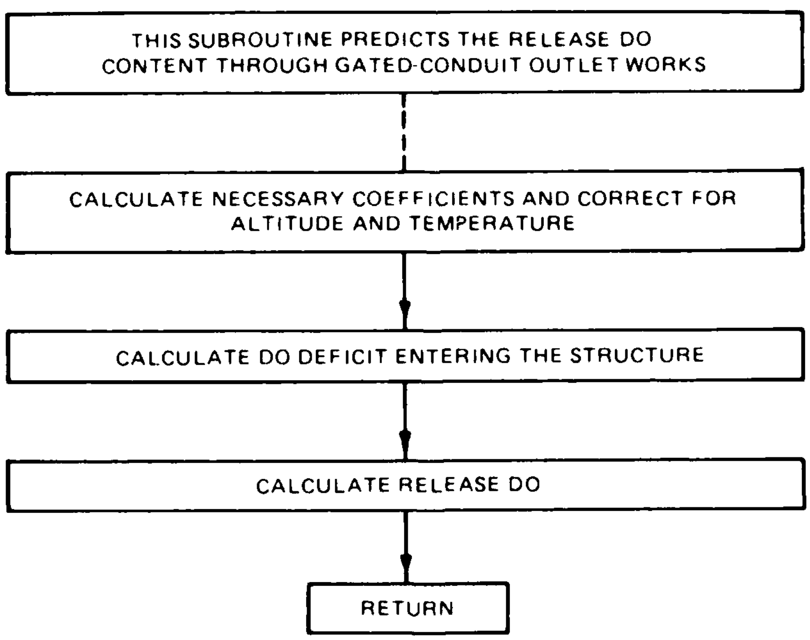


Figure 27. Flowchart for subroutine AERATE

Table 12

AERATE Variables

Variable	Definition
ALT	The elevation of the pool bottom
BOTTOM	The elevation of the pool bottom
C	Temperature-adjusted escape coefficient for oxygen
CSAT	Oxygen saturation concentration adjusted for altitude
C20	Equals 0.045 if English (non-SI) units are used; 0.1476 if metric (SI) units are used
DELH	Elevation difference between the pool surface and the tailwater surface
DEPTH	Depth of the pool
DF	DO deficit exiting structure
DI	DO deficit entering structure
QAERA	Logical variable; true, consider DO uptake due to aeration through a gated-structure outlet works; false, do not consider uptake
QALOUT(1)	The outflow DO concentration (weighted average) that is adjusted by subrouting AERATE
QMETR	Logical variable; true when metric (SI) units are used; false when English (non-SI) units are used
TEMOUT	Outflow temperature (weighted average)
TWEL	Elevation of tailwater

VENTING

76. Subroutine VENTING accounts for the DO uptake by release water if venting techniques are applied to turbine releases. VENTING is based on WES and Tennessee Valley Authority studies of Francis turbines which have shown that a maximum of 30-percent reduction of the initial (penstock) deficit is reasonable with turbine venting. Therefore, VENTING adjusts the flow-weighted average of DO in the release (as calculated in subroutine OUTVEL), to reflect a 30-percent reduction in the deficit. The results predicted by VENTING should be considered as a maximum DO uptake that can be achieved with venting. The reader is referred to Wilhelms (1984) and Wilhelms, Schneider, and Howington (1987) for additional details. Figure 28 is a flowchart of subroutine VENTING; descriptions of the subroutine variables are given in Table 13.

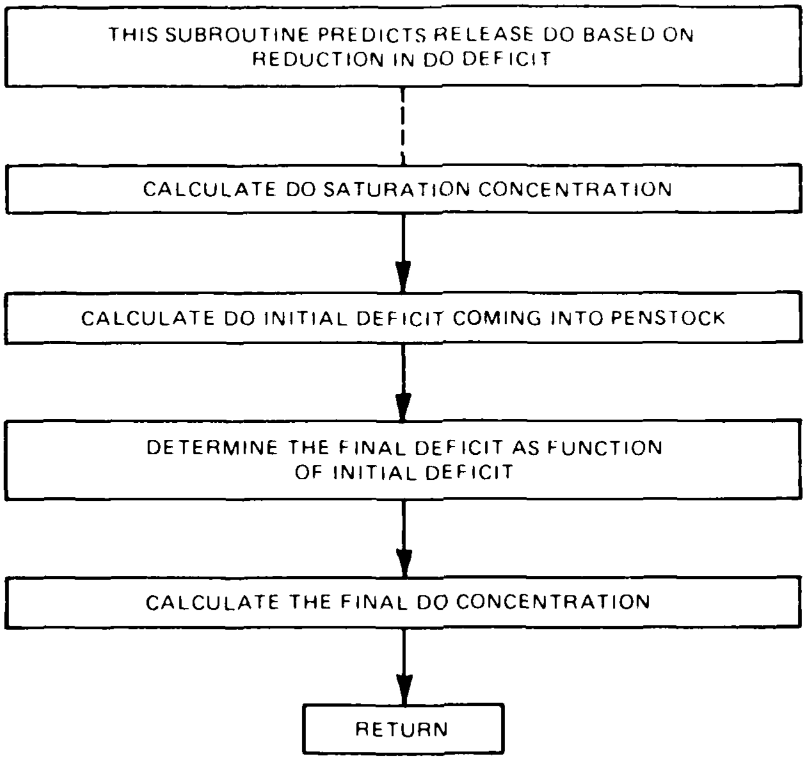


Figure 28. Flowchart for subroutine VENTING

Table 13

VENTING Variables

Variable	Definition
ALT	Elevation of the pool bottom
BOTTOM	Elevation of the pool bottom
CSAT	Oxygen saturation concentration adjusted for altitude
DF	DO deficit of release water from structure
DI	DO deficit of water entering structure
QALOUT(1)	The flow-weighted average of the outflow DO concentration which is adjusted by subroutine VENTING
TEMOUT	The flow-weighted average of the outflow temperature

PART IV: ASSUMPTIONS AND LIMITATIONS

77. In general, if the outlet and approach characteristics are simple, the results produced by SELECT will be accurate. However, if the characteristics are not of a simple nature, the assumptions inherent in the equations and theory of SELECT may be violated. The user should be aware of these assumptions and how they limit the accuracy of results. Thus, a listing of these assumptions is provided below. Violating these assumptions in a misapplication of the SELECT code will result in erroneous predictions. In some cases, more sophisticated modeling tools, such as multidimensional mathematical and physical models, may have to be employed to gain adequate results. In other cases, manipulation of the SELECT code itself might be possible. These solutions, however, must be considered on a site-specific basis. The user is encouraged to consult WES if any of the assumptions listed below are violated. Also included in the listing is a brief description of the limitation and effect of the assumption on SELECT predictions.

Geometry of Ports

78. Bohan and Grace (1969,1973) assumed that orifice geometries had no effect on the withdrawal zone. The dimensions of the orifice were small in comparison to the withdrawal zone thickness, e.g., point sink assumption. If this assumption is violated, SELECT will warn the user with an output statement but will continue to output results as if the assumption were valid.

Impoundment Width

79. The width of the impoundment in the region approaching the outlet works is assumed to be greater than the thickness of the withdrawal zone. Widths that are too narrow will cause lateral constrictions in the development of the withdrawal zone which will cause the extent of the withdrawal zone to increase beyond that predicted by

SELECT. Thus, if SELECT is run when this assumption is not valid, the calculated zone thickness may be less than the actual zone thickness.

Approach Path

80. The approach toward the outlet works is assumed free of obstruction. For example, a ridge at the bottom of the impoundment a short distance upstream from the outlet works could interfere with formation of the withdrawal zone. In such a case, the ridge may control withdrawal for one discharge with the outlet controlling for other discharges.

Approach Curvature

81. The approach toward the outlet works is assumed relatively straight. When the approach being modeled is curved, the withdrawal zone prediction may not be accurate.

Multiple Horizontal Ports

82. Use of SELECT in the past has shown that site-specific judgments need to be made concerning the modeling of multiple horizontal ports. The characteristics of withdrawal due to release through multiple horizontal ports remains largely undocumented. To illustrate, assume the existence of two ports that each withdraw as a point sink. It can be envisioned that, if the ports are far enough apart, the withdrawal zone of one port will not influence the withdrawal zone of the other. If the same ports are very near to each other, a withdrawal zone could be very closely approximated by the point sink equations by assuming that there is a single port with a flow rate equal to the combined magnitudes of the individual flow rates. The problems arise in the transition between ports that are hydrodynamically far apart or close together, because one port will affect the withdrawal characteristics of the others to some degree.

Weir Crest Above Thermocline

83. The equations used in the calculation of withdrawal limits for flow over a weir assume that the weir crest is above the thermocline. If this assumption is violated, the results from the program may be erroneous.

Hydraulic Integrity

84. SELECT assumes that it is hydraulically possible to proportion flows between multiple ports as input by the user. SELECT makes no check, for example, to ensure that multiple ports in the same wet well are not used. SELECT users should be aware of their responsibility to input operational scenarios which are viable for water quality control.

Simultaneous Port-Weir Operation

85. A port and a weir can be operated simultaneously only if each is releasing flow under its own control. For example, a spillway (weir) could be operated simultaneously with a water quality intake (port). Prediction of the withdrawal zone formed by a cofferdam (weir) directly in front of an outlet works is beyond the scope of SELECT. Such an operation would require more sophisticated modeling.

PART V: INPUT DATA

Descriptions

86. The following descriptions are presented to define the data that are needed as input for SELECT. All are listed in the order as they should appear in an input file. Formal descriptions of the input formats are given in Appendix A; example input files are given in Appendix B.

a. TITLE - user-specified label to identify the global input file. The title should not exceed 80 characters in length (including spaces, numbers, and punctuation).

b. DATA SETS - each must contain a heading, all port and weir information, and all necessary and desired parameter profiles. The ability to model several data sets in one execution saves the user time. That is, if the user intends to analyze several data sets, they can all be run in one program loading rather than several.

c. PRINT INPUT - tells the program that the user desires an echo print (a copy of the input file) along with the output.

d. HEADING - similar to TITLE except that it labels a single data set in an input file. Each data set in an input file must have a heading. The heading may be up to 80 characters in length (including spaces, numbers, and punctuation).

e. METRIC OR ENGLISH - indicates which system of units to be used.

English (non-SI) Units	Metric (SI) Units
feet, seconds	meters, seconds

Note: Densities are assumed to be in grams per cubic [illegible] ter. The program default is English (non-SI) units.

f. TABLES - the program accepts two different formats [illegible] listings of any type of profile information. [illegible] is chosen, that format must be used for all tab[illegible] data set.

(1) Format 1 - indicated by following the [illegible] input line by the number 1. Thi[illegible] the user wishes to enter profile [illegible] elevation and the associated [illegible]

(2) Format 2 - indicated by [illegible] input line by any number [illegible] program that the user [illegible] ing way the elevat[illegible] line until all [illegible] parameter value[illegible] until all [illegible]

AD-A181 125 ENVIRONMENTAL AND WATER QUALITY OPERATIONAL STUDIES SELECT: A NUMERICAL O..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA.. 2/3

UNCLASSIFIED J E DAVIS ET AL. MAR 87 WES/IR/E-87-2 F/G 20/4 NL

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c. PRINT INPUT - tells the program that the user desires an echo print (a copy of the input file) along with the output.

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e. METRIC OR ENGLISH - indicates which system of units to be used.

English (non-SI) Units	Metric (SI) Units
feet, seconds	meters, seconds

Note: Densities are assumed to be in grams per cubic centimeter. The program default is English (non-SI) units.

f. TABLES - the program accepts two different formats for table listings of any type of profile information. Whichever format is chosen, that format must be used for all tables in a single data set.

(1) Format 1 - indicated by following the word TABLES on the input line by the number 1. This tells the program that the user wishes to enter profile data as one value of elevation and the associated parameter value per line.

(2) Format 2 - indicated by following the word TABLES on the input line by any number other than 1. This tells the program that the user wishes to enter data in the following way the elevations will be listed eight values per line until all elevations are entered; then the associated parameter values will be listed eight values per line until all parameter values are entered. The positions of

the parameter values on a line must match the line positions of the associated elevations.

g. THICKNESS - indicates the user-desired thickness of each computational layer. It is suggested that the thickness not exceed 5 ft (or 1.5 m) in order to preserve definition of the input profiles. The computational layer has parameter values assigned to it, such as velocity, density, temperature, and water quality. Since the parameter value is taken as constant throughout the layer, any variation in the actual parameter value inside the layer is neglected. Thus, in order to prevent any gross errors from occurring due to the differences between the actual and discretized profiles, a layer thickness of no more than 5 ft should be used. The layer thickness limit may vary from project to project.

h. INTERVAL - determines how often computational layer parameter values are to be output--every layer, every other layer, etc. An interval of "1" will output values for every layer. An interval of "2" will output values for every second layer, and so on. An interval of "0" will not be accepted by the program.

i. SURFACE - the value of the surface elevation. This must be input as an elevation above the user-defined datum.

j. BOTTOM - the value of the bottom elevation. This must be input as an elevation above the user-defined datum.

k. PORTS - identifies the number of operating ports to be modeled by the program in a single data set. The number of operating ports is limited to five by the program dimensions. Multiple ports operating at the same elevation and within close lateral proximity should be combined into a single port for input. Otherwise, the extreme withdrawal zone interaction will likely result in underprediction of the withdrawal zone thickness by the program.

l. VDIM - the value of the vertical dimension of the port. If more than one port is being modeled, the vertical dimensions for all of the ports must be listed on one line. They may be listed from the bottom port to the top port, or vice versa.

m. HDIM - the value of the horizontal dimension of the port. If more than one port is modeled, the horizontal dimensions of all the ports must be listed on one line. They may be listed from the bottom port to the top port, or vice versa; however, the ordering must match the ordering of VDIM.

n. PORT ELEVATION - the vertical port positions in the impoundment may be given as elevation above a user-defined datum, as depth below the surface, or as height above the bottom. Elevation (or depth or height) values for multiple ports must be listed on one line. The ordering may be from the bottom port to the top port, or vice versa. Again, however, the ordering must match the ordering used for VDIM.

o. FLOW - the value of the flow rate through a port or over a weir. If multiple ports are modeled, the flow rates for all the ports must be listed on one line. The ordering of the values may be from the top port to the bottom port, or vice versa. This ordering must also match the ordering of VDIM.

p. WITHDRAWAL ANGLE - the effective angle of withdrawal in the horizontal plane of the port. The withdrawal angles for all ports must be entered on one line and may be ordered from bottom port to top port, or vice versa. The ordering must match that of VDIM.

q. WEIR - indicates that a weir is to be modeled by the program.

r. WEIR TYPE - indicates whether the weir is a free weir (discharge unaffected by downstream pool) or a submerged weir (discharge affected by downstream pool).

s. COEFFICIENT - the weir coefficient to be used if the weir is not considered submerged.

t. WEIR LENGTH - the length of the crest of the weir.

u. WEIR CREST ELEVATION - the elevation above the user-defined datum, depth below the surface, or height above the bottom of the weir crest.

v. TURBINE VENTING - indicates that the improvement in DO content due to turbine aeration should be taken into account. The improvement is based on a 30 percent decrease in the penstock DO deficit. A DO water quality profile must be part of the input file if this command is used.

w. GATED STRUCTURE - indicates that the change in DO content due to aeration through gated-conduit structures should be taken into account. The amount of change is approximated based on results of Wilhelms and Smith (1981). A DO water quality profile must be part of the input file if this command is used.

x. TAILWATER ELEVATION - indicates that the tailwater elevation is entered. The tailwater elevation must be used only if the GATED STRUCTURE command is used.

y. TAILWATER FUNCTION - often the tailwater cannot be given directly but is a function of the discharge. In that case, a function subprogram must be written and appended to the SELECT code. This command may be used only if the GATED STRUCTURE command is used. For assistance with this input, the user should contact personnel of the Reservoir Water Quality Branch of the WES Hydraulics Laboratory.

Profile Formats

87. Input profile formats for a single data set must match the format specified on the "TABLES" card.

a. DENSITY - density profile is necessary for the operation of SELECT. If a density profile is not available, a temperature profile must be input from which the program can generate densities.

b. OTHER PARAMETERS - water quality parameter profiles are necessary if release water quality predictions are desired. If the GATED STRUCTURE or TURBINE VENTING input commands are used, a DO profile must be the first water quality profile listed after the density and/or temperature profiles. If a density profile is input to define reservoir stratification (to account for suspended or dissolved solids) and release temperature is of interest, the temperature profile may be input as a water quality parameter. Up to four other water quality parameter profiles may be entered.

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APPENDIX A: INPUT FORMAT DESCRIPTION

Notes on Input Format

1. CARD refers to card image input if disc files or magnetic tapes are used as input devices.

2. The format code following the CARD number is the format by which the input line of data will be read. The input must match the fields of the appropriate format.

3. Following the CARD-FORMAT line is the list of variables used to store the input data. They are listed in the order by which they are entered. Following each variable name is the expected input for the first word(s) of the input line. When several expected input phrases are listed, only one is chosen.

4. Each time more than one card is required to input profile values, the remaining input cards will need to be renumbered to reflect the extra cards used. For example, when profile data are to be entered as one elevation value and one parameter value per line, such as CARD #24 when TABTYP = 1 , more than one profile data card will be required to define the profile. If, as a simple case, it is assumed four profile data input cards will be necessary, they would be numbered CARD #24, CARD #25, CARD #26, and CARD #27. The remaining input cards should be resequenced beginning with CARD #28.

5. Be sure that all input data units are consistent with the system of units specified on CARD #05. The exception to this is the units for density, which should always be entered as grams per cubic centimeter.

6. There must be a STOP statement at the end of each data set.

SELECT Program-Input Format Description

CARD #01 FORMAT (20A4)
1. TITLE - An arbitrary title not to exceed 80 characters in length

CARD #02 FORMAT (A4, 6X, 14I5)
1. CHECK - "DATA"
2. NSETS - Number of data sets in input file

CARD #03 FORMAT (20A4)
1. CHECK - A) "PRINT INPUT" - Echo print input
B) "(ANYTHING ELSE)" - No echo print

CARD #04 FORMAT (20A4)
1. HEADING - An arbitrary descriptive heading for the simulation, not to exceed 80 characters in length

CARD #05 FORMAT (20A4)
1. CHECK - A) "METRIC" - Input and output are in Metric (SI) units
B) "ENGLISH" - Input and output are in English (non-SI) units

CARD #06 FORMAT (A4, 6X, 14I5)
1. CHECK - "TABLES"
2. TABTYP - A) "1" - Program reads profile input data in a table of one value of elevation, depth below the surface, or height above the bottom, and a corresponding value of density, temperature, or quality per line.

B) "(ANY OTHER NUMBER)" - Program reads profile data as a table of all the values (eight per line) of elevation, depth below the surface, or height above the bottom followed by a table of all the values of the corresponding density, temperature, or quality.

CARD #07 FORMAT (A4, 6X (7F10.0))
1. CHECK - "THICKNESS"
2. DELZ - Thickness of each computational layer (feet or meters)

CARD #08 FORMAT (A4, 6X, 14I5)
1. CHECK - "INTERVAL"
2. INTER - The interval used to select layer information for printout

CARD #09 FORMAT (A4, 6X (7F10.0))
1. CHECK - "SURFACE"
2. SURFACE - Elevation of the water surface (feet or meters)

CARD #10 FORMAT (A4, 6X (7F10.0))
1. CHECK - "BOTTOM"
2. BOTTOM - Elevation of the lake bottom (feet or meters)

CARD #11 FORMAT (A4, 6X, 14I5)
1. CHECK - A) "PORT"
B) "WEIR"
2. NPORTS - Number of ports (not applicable if weir only)

If "WEIR" was specified on Card #11, go to Card #18; otherwise continue.

CARD #12 FORMAT (A4, 6X (7F10.0))
1. CHECK - "VDIM"
2. (PVDIM(K), K=1, NPORTS) - Vertical dimensions of the ports (feet or meters)

CARD #13 FORMAT (A4, 6X (7F10.0))
1. CHECK - "HDIM"
2. (PHDIM(K), K=1, NPORTS) - Horizontal dimensions of the ports (feet or meters)

CARD #14 FORMAT (A4, 6X (7F10.0))
1. CHECK - A) "ELEVATION"
B) "DEPTH"
C) "HEIGHT"
2. (PHGT(K), K=1, NPORTS) - Center-line elevation, depth or height of the ports (feet or meters)

CARD #15 FORMAT (A4, 6X (7F10.0))
1. CHECK - "FLOW"
2. (FLOW(K), K=1, NPORTS) - Flow through each of the ports (cubic feet per second or cubic meters per second)

CARD #16 FORMAT (A4, 6X (7F10.0))
1. CHECK - "ANGLE"
2. (WTHETA(K), K=1, NPORTS) - The withdrawal angle for each port (radians)

If "PORTS" was specified on Card #11 and a weir is to be modeled also, used CARDS #17, #18, and #19; otherwise omit them.

CARD #17 FORMAT (A4, 6X, 14I5)
1. CHECK - "WEIR"

CARD #18 FORMAT (A4, 6X, 14I5)
1. CHECK - A) "FREE"
B) "SUBMERGED"

If "SUBMERGED" was specified on Card #18, omit Card #19; otherwise continue.

CARD #19 FORMAT (A4, 6X (7F10.0))
1. CHECK - "COEF"
2. COEF - Coefficient of discharge for free weir flow. These coefficients should be 3.0, 3.33, or 4.10.

```
CARD #20  FORMAT (A4, 6X (7F10.0))
          1.  CHECK - "LENGTH"
          2.  WRLNG - Length of the weir crest (feet or meters)

CARD #21  FORMAT (A4, 6X (7F10.0))
          1.  CHECK - A) "ELEVATION"
                      B) "DEPTH"
                      C) "HEIGHT"
          2.  WRHGT - Elevation, depth, or height of the weir crest
                      (feet per second or meters per second)

CARD #22  FORMAT (A4, 6X (7F10.0))
          1.  CHECK - "FLOW"
          2.  WRFLOW - Flow over the weir (cubic feet per second or
              cubic meters per second)

Optional CARD FORMAT (20A4)
          1.  CHECK - A) "TURBINE VENTING" - If turbine venting is to be
                                             modeled
                      B) "GATED STRUCTURE" - If aeration due to gated conduit
                                             is to be modeled

      If "GATED STRUCTURE" is entered, so must the following optional card.

Optional CARD FORMAT (A4, 6X, A4 6X, (6F10.0))
          1.  CHECK1 - "TAILWATER"
          2.  CHECK2 - A) "ELEVATION" - If tailwater elevation
                       B) "FUNCTION" - If tailwater function
          3.  TWEL - Value of the tailwater elevation

CARD #23  FORMAT (A4, 6X, A4, 6X, 12I5)
          1.  CHECK1 - "NUMBER OF"
          2.  CHECK2 - A) "DENSITIES"
                       B) "TEMPS"
          3.  NUMD - A) Number of density values in profile, or
                     B) Number of temperature values in profile

      If "TEMPS" was specified on Card #23, go to Card #29; otherwise
      continue.

      If TABTYP EQ. 1 (Card #06)

CARD #24  FORMAT (A4, 6X, A4)
          1.  CHECK1 - A) "ELEVATION"
                       B) "DEPTH"
                       C) "HEIGHT"
          2.  CHECK2 - "DENSITIES

CARD #25  FORMAT (2F10.0)
          1.  (YD(M), DEN(M), M-1, NUMD) - Values of elevation, depth, or
              height (feet or meters) and the corresponding values of density
              (grams per cubic centimeter)
```

CARD #26 and #27 not used

An adequate number of cards containing the profile elevation and density values using the above format are required at this point. The remaining input cards should be renumbered to continue in sequence.

If TABTYP. NE. 1 (Card #06)

CARD #24 FORMAT (20A4)
CHECK - A) "ELEVATION"
B) "DEPTH"
C) "HEIGHT"

CARD #25 FORMAT (8F10.0)
1. (YD(M), M=1, NUMD) - Values of elevation, depth, or height corresponding with density values to be input (feet or meters)

An adequate number of cards containing profile elevation values using the above format are required at this point. The remaining input cards should be renumbered to continue in sequence.

CARD #26 FORMAT (A4, 6X, 14I5)
1. CHECK - "DENSITY"

CARD #27 FORMAT (8F10.0)
1. (DEN(M), M=1, NUMD) - Values of density corresponding to the data on Card #25 (grams per cubic centimeters)

An adequate number of cards containing profile density values using the above format are required at this point. The remaining input cards should be renumbered to continue in this sequence.

CARD #28 FORMAT (A4, 16X, 12I5)
1. CHECK - A) "NUMBER OF TEMPS"
B) "QUALITIES"
C) "STOP" - Read sequence stops
2. NUMT - Number of temperature if "NUMBER OF TEMPS" is entered

If "STOP" was specified on Card #28, go to last line of this description (page A8).

If "QUALITIES" was specified on Card #28, go to Card #35.

If "NUMBER OF TEMPS" was specified on Card #28, continue.

CARD #29 FORMAT (A4, 16X, A4)
1. CHECK - A) "TEMPERATURE DEGREES"
2. UNITS - A) "FAHRENHEIT"
B) "CENTIGRADE"

If TABTYP EQ. 1 (Card #06)

CARD #30 FORMAT (A4, 6X, A4)
1. CHECK1 - A) "ELEVATION"
B) "DEPTH"
C) "HEIGHT"
2. CHECK2 - "TEMPERATURE"

CARD #31 FORMAT (2F10.0)
1. (YT(M), TEMP(M), M=1, NUMT) - Values of elevation, depth, or height (feet or meters) and the corresponding values of temperature (units specified on Card #29)

CARD #32 and #33 not used

An adequate number of cards containing the profile elevation and temperature values using the above format are required at this point. The remaining input cards should be renumbered to continue in this sequence.

If TABTYP NE. 1 (Card #06)

CARD #30 FORMAT (20A4)
1. CHECK - A) "ELEVATION"
B) "DEPTH"
C) "HEIGHT"

CARD #31 FORMAT (8F10.0)
1. (TY(M), M=1, NUMT) - Values of elevation, depth, or height corresponding with temperature values to be input (feet or meters)

An adequate number of cards containing profile elevations using the above format are required at this point. The remaining input cards should be renumbered to continue in sequence.

CARD #32 FORMAT (20A4)
1. CHECK - "TEMPERATURE"

CARD #33 FORMAT (8F10.0)
1. (TEMP(M), M=1, NUMT) - Values of temperature corresponding to the data on Card #31 (units specified on Card #30)

An adequate number of cards containing profile temperatures using the above format are required at this point. The remaining input cards should be renumbered to continue in sequence.

CARD #34 FORMAT (A4, 6X, 14I5)
1. CHECK - A) "QUALITIES"
B) "STOP" - Read sequence stops
2. NQUAL - Number of quality parameters

If STOP was specified on CARD #34, go to last line of this description (page A8). If QUALITIES was specified on CARD #34, continue.

CARD #35 FORMAT (A4, 6X, 5A4, I5)

1. CHECK - "NUMBER OF"
2. (NAME(NM, I) NM-1,5) - Name of the I^{th} quality parameter (not to exceed 20 characters)
3. NUMQ(I) - Number of quality(I) values

If TABTYP EQ. 1 (Card #06)

CARD #36 FORMAT (A4, 6X, A4)

1. CHECK - A) "ELEVATION"
   B) "DEPTH"
   C) "HEIGHT"

CARD #37 FORMAT (2F10.0)

1. (YQ(I,M), QUAL(I,M), M-1, NUMQ(I)) - Values of elevation, depth, or height (feet or meters) and the corresponding values of the I^{th} quality parameter (appropriate units)

CARDS #38 and #39 not used

An adequate number of cards containing the profile elevation and quality values using the above format are required at this point. The remaining input cards should be renumbered to continue in sequence.

If TABTYP NE. 1 (Card #06)

CARD #36 FORMAT (20A4)

1. CHECK - A) "ELEVATION
   B) "DEPTH"
   C) "HEIGHT"

CARD #37 FORMAT (8F10.0)

1. (YQ(I,M) M-1, NUMQ(I)) - Values of elevation, depth, or height corresponding with the I^{th} quality parameter values to be input (feet or meters)

An adequate number of cards containing the profile elevations using the above format are required at this point. The remaining input cards should be renumbered to continue in sequence.

CARD #38 FORMAT (20A4)

1. CHECK - Name of the I^{th} quality parameter

CARD #39 FORMAT (8F10.0)

1. (QUAL(I,M), M-1, NUMQ(I)) - Values of the I^{th} quality parameter corresponding to the data on Card #37 (appropriate units)

An adequate number of cards containing the profile qualities using the above format are required at this point. The remaining input card should be renumbered to continue in sequence.

If there are more water quality profiles, repeat CARDS #36-39 for each additional water quality parameter.

CARD #40 FORMAT (20A4)

1. CHECK - "STOP" - Stops read sequence

If there are more data sets, repeat CARDS #04-40 for each additional data set.

APPENDIX B: INPUT EXAMPLES

1. The following are examples of simple input files. They are presented to help clarify the structure of an input file.

2. The impoundment being modeled has a pool that is 100 ft deep, with the elevation of the bottom taken as zero or datum.

Example File 1

3. Example File 1 models a single 5- by 5-ft port whose center line is located 20 ft below the pool surface. The port has a withdrawal angle of 180 deg (3.14 rad) and releases a flow rate of 100 cfs.

4. The density profile needed to run SELECT will be generated by the program using the given temperature profile. The only water quality parameter modeled is temperature.

5. For the computations, the pool will be divided into layers 3 ft thick each. The printout interval for layer information will be at every layer (INTERVAL = 01).

```
ANONYMOUS LAKE EXAMPLE
DATA SETS     01
PRINT INPUT
EXAMPLE FOR INPUT/OUTPUT USING PORT
ENGLISH
TABLE         01
THICKNESS         3.0
INTERVAL      01
SURFACE         100.0
BOTTOM            0.0
PORT           1
VDIM              5.0
HDIM              5.0
DEPTH            20.0
FLOW            100.0
ANGLE            3.14
NUMBER OF TEMP          12
TEMPERATURE DEGREES CENTIGRADE
HEIGHT     TEMP
      97.6       28.9
      90.0       28.2
      80.0       27.0
      69.8       26.0
      65.0       24.9
      60.0       23.0
      57.6       20.0
      53.9       18.5
      50.0       17.5
      40.0       16.7
      31.2       15.9
      20.0       15.0
STOP
```

Example File 2

6. Example File 2 models the same thing as Example File 1 with a few variations. One variation is that another port vertically separated from the first port is to be modeled. The two ports are considered to be operating simultaneously and independently. The second port is located 50 ft below the pool surface and has the same dimensions and withdrawal characteristics as the first port.

7. The presence of the dissolved oxygen (DO) profile following the temperature profile indicates that the user wishes to know the release DO concentration as well as temperature. The calculation of release DO will include DO uptake due to gated-conduit reaeration because the GATED STRUCTURE command is present following the port information in the input file.

```
ANONYMOUS LAKE EXAMPLE
DATA SETS    01
PRINT INPUT
EXAMPLE FOR INPUT/OUTPUT USING PORT
ENGLISH
TABLE        01
THICKNESS       3.0
INTERVAL     01
SURFACE       100.0
BOTTOM          0.0
PORT          2
VDIM            5.0      5.0
HDIM            5.0      5.0
DEPTH          50.0     20.0
FLOW          100.0    100.0
ANGLE           3.14     3.14
GATED STRUCTURE
TAILWATER ELEVATION      15.9
NUMBER OF TEMP          12
TEMPERATURE DEGREES CENTIGRADE
HEIGHT     TEMP
      97.6        28.9
      90.0        28.2
      80.0        27.0
      69.8        26.0
      65.0        24.9
      60.0        23.0
      57.6        20.0
      53.9        18.5
      50.0        17.5
      40.8        16.7
      31.2        15.9
      20.0        15.0
QUALITIES     1
NUMBER OF DISSOLVED OXYGEN       13
HEIGHT     DISSOLVED OXYGEN
      95.6        3.2
      90.2        3.2
      84.9        3.1
      78.7        3.0
      73.4        2.1
      69.5        1.8
      61.0        1.3
      58.4        0.5
      50.3        0.3
      40.6        0.2
      30.0        0.2
      21.7        0.1
      15.4        0.0
STOP
```

Example File 3

8. Example File 3 models a weir. The weir is the submerged type with its crest 65 ft off the bottom. It is 100 ft in length and has a total flow rate of 200 cfs over its crest.

9. The input file dictates that the pool should be divided into layers that are 3 ft thick and that the output data be given at every layer (INTERVAL = 01). As in Example File 2, the temperature and DO concentration of the release are desired. There is no option for DO calculations based on reaeration through the outlet works for weir flow.

```
ANONYMOUS LAKE EXAMPLE
DATA SETS    01
PRINT INPUT
EXAMPLE FOR INPUT/OUTPUT USING WEIR
ENGLISH
TABLE        01
THICKNESS        3.0
INTERVAL     01
SURFACE        100.0
BOTTOM           0.0
WEIR
SUBMERGED
LENGTH         100.
HEIGHT          65.0
FLOW           200.0
NUMBER OF TEMP          12
TEMPERATURE DEGREES CENTIGRADE
HEIGHT     TEMP
      97.6       28.9
      90.0       28.2
      80.0       27.0
      69.8       26.0
      65.0       24.9
      60.0       23.0
      57.6       20.0
      53.9       18.5
      50.0       17.5
      40.0       16.7
      31.2       15.9
      20.0       15.0
QUALITIES    1
NUMBER OF DISSOLVED OXYGEN       13
HEIGHT     DISSOLVED OXYGEN
      95.6        3.2
      90.2        3.2
      84.9        3.1
      78.7        3.0
      73.4        2.1
      69.5        1.8
      61.0        1.3
      58.4        0.5
      50.3        0.3
      40.6        0.2
      30.0        0.2
      21.7        0.1
      15.4        0.0
STOP
```

Example File 4

10. Example File 4 is an input file made up of Example Files 1 and 3. In other words, it is one input file containing two data sets. It is important to realize that this data file format will not cause the program to model the port and the weir simultaneously; rather, it will model the port only and produce output. Then it will model the weir only and produce output.

11. This technique of appending data sets saves time in loading and reloading the program for consecutive runs.

```
ANONYMOUS LAKE EXAMPLE
DATA SETS     02
PRINT INPUT
EXAMPLE FOR INPUT/OUTPUT USING PORT
ENGLISH
TABLE         01
THICKNESS        3 0
INTERVAL      01
SURFACE        100 0
BOTTOM           0 0
PORT           1
VDIM             5 0
HDIM             5 0
DEPTH           20 0
FLOW           100 0
ANGLE            3 14
NUMBER OF TEMP          12
TEMPERATURE DEGREES CENTIGRADE
HEIGHT     TEMP
         97 6       28 9
         90 0       28 2
         80 0       27 0
         69 8       26 0
         65 0       24 9
         60 0       23 0
         57 6       20 0
         53 9       18 5
         50 0       17 5
         40 0       16 7
         31 2       15 9
         20 0       15 0
STOP
EXAMPLE FOR INPUT/OUTPUT USING WEIR
ENGLISH
TABLE         01
THICKNESS        3 0
INTERVAL      01
SURFACE        100 0
BOTTOM           0 0
WEIR
SUBMERGED
LENGTH          100
HEIGHT          65 0
FLOW            100 0
NUMBER OF TEMP          12
TEMPERATURE DEGREES CENTIGRADE
HEIGHT     TEMP
         97 6       28 9
         90 0       28 2
         80 0       27 0
         69 8       26 0
         65 0       24 9
         60 0       23 0
         57 6       20 0
         53 9       18 5
         50 0       17 5
         40 0       16 7
         31 2       15 9
         20 0       15 0
QUALITIES      1
NUMBER OF DISSOLVED OXYGEN        13
HEIGHT     DISSOLVED OXYGEN
         95 6        3 2
         90 2        3 2
         84 9        3 1
         78 7        3 0
         73 4        2 1
         69 5        1 8
         61 0        1 3
         58 4        0 5
         50 3        0 3
         40 6        0 2
         30 0        0 2
         21 7        0 1
         15 4        0 0
STOP
```

APPENDIX C: OUTPUT EXAMPLE

1. This appendix presents SELECT output for the fourth example input file in Appendix B. This output is divided as follows:

   a. Listing of the input file. In this example, the PRINT INPUT command was included in the input file. If the command is omitted from the input file, no listing of the input file is given.

   b. Summary of the output results. The summary includes the title of the input file, the title of the data set to which the results pertain, the units used for computations, each outlet's dimensions and flow rate, the total flow rate from all outlets, the locations of the upper and lower withdrawal limits, and the total outflow concentration of all water quality parameters modeled.

   c. Tabular listing of flow rates, velocities, and water quality parameter concentrations, given at layer center-line elevations. The interval between the layers at which information is given depends on the INTERVAL command listed in the input file. An interval of "1" will list layer information at every layer, an interval of "2" will list layer information at every other layer, and so on.

   d. Line-printer plot of the velocity and density profile. The data points on the plot coincide with the data in each of the layers. All layers are included in this plot.

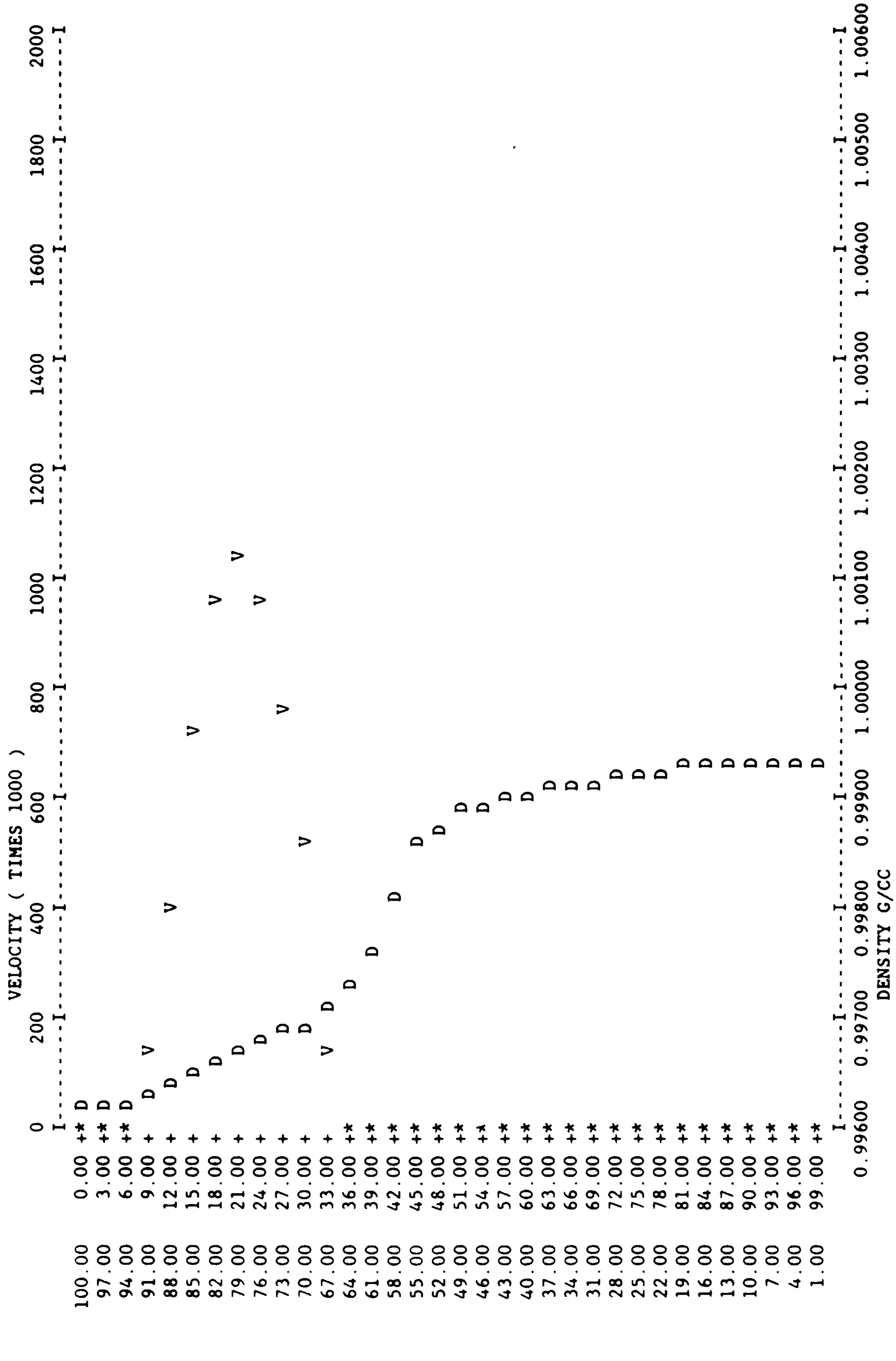
2. If the user chooses to use multiple data sets in one input file, as in this example, the results from each data set will be listed individually and output one after the other in the results.

```
1000        ***ANONYMOUS LAKE EXAMPLE
1010        ***DATA SETS     02
1020        ***PRINT INPUT
1030        ***EXAMPLE FOR INPUT/OUTPUT USING PORT
1040        ***ENGLISH
1050        ***TABLE         01
1060        ***THICKNESS         3.0
1070        ***INTERVAL      01
1080        ***SURFACE         100.0
1090        ***BOTTOM            0.0
1100        ***PORT           1
1110        ***VDIM              5.0
1120        ***HDIM              5.0
1130        ***DEPTH            20.0
1140        ***FLOW            100.0
1150        ***ANGLE            3.14
1160        ***NUMBER OF TEMP          12
1170        ***TEMPERATURE DEGREES CENTIGRADE
1180        ***HEIGHT    TEMP
1190        ***       97.6      28.9
1200        ***       90.0      28.2
1210        ***       80.0      27.0
1220        ***       69.8      26.0
1230        ***       65.0      24.9
1240        ***       60.0      23.0
1250        ***       57.6      20.0
1260        ***       53.9      18.5
1270        ***       50.0      17.5
1280        ***       40.8      16.7
1290        ***       31.2      15.9
1300        ***       20.0      15.0
1310        ***STOP
1320        ***EXAMPLE FOR INPUT/OUTPUT USING WEIR
1330        ***ENGLISH
1340        ***TABLE         01
1350        ***THICKNESS         3.0
1360        ***INTERVAL      01
1370        ***SURFACE         100.0
```

```
1380    ***BOTTOM            0.0
1390    ***WEIR
1400    ***SUBMERGED
1410    ***LENGTH          100.
1420    ***HEIGHT          65.0
1430    ***FLOW            100.0
1440    ***NUMBER OF TEMP          12
1450    ***TEMPERATURE DEGREES CENTIGRADE
1460    ***HEIGHT    TEMP
1470    ***         97.6        28.9
1480    ***         90.0        28.2
1490    ***         80.0        27.0
1500    ***         69.8        26.0
1510    ***         65.0        24.9
1520    ***         60.0        23.0
1530    ***         57.6        20.0
1540    ***         53.9        18.5
1550    ***         50.0        17.5
1560    ***         40.8        16.7
1570    ***         31.2        15.9
1580    ***         20.0        15.0
1590    ***QUALTITIES    1
1600    ***NUMBER OF DISSOLVED OXYGEN        13
1610    ***HEIGHT    DISSOLVED OXYGEN
1620    ***         95.6         3.2
1630    ***         90.2         3.2
1640    ***         84.9         3.1
1650    ***         78.7         3.0
1660    ***         73.4         2.1
1670    ***         69.5         1.8
1680    ***         61.0         1.3
1690    ***         58.4         0.5
1700    ***         50.3         0.3
1710    ***         40.6         0.2
1720    ***         30.0         0.2
1730    ***         21.7         0.1
1740    ***         15.4         0.0
1750    ***STOP
```

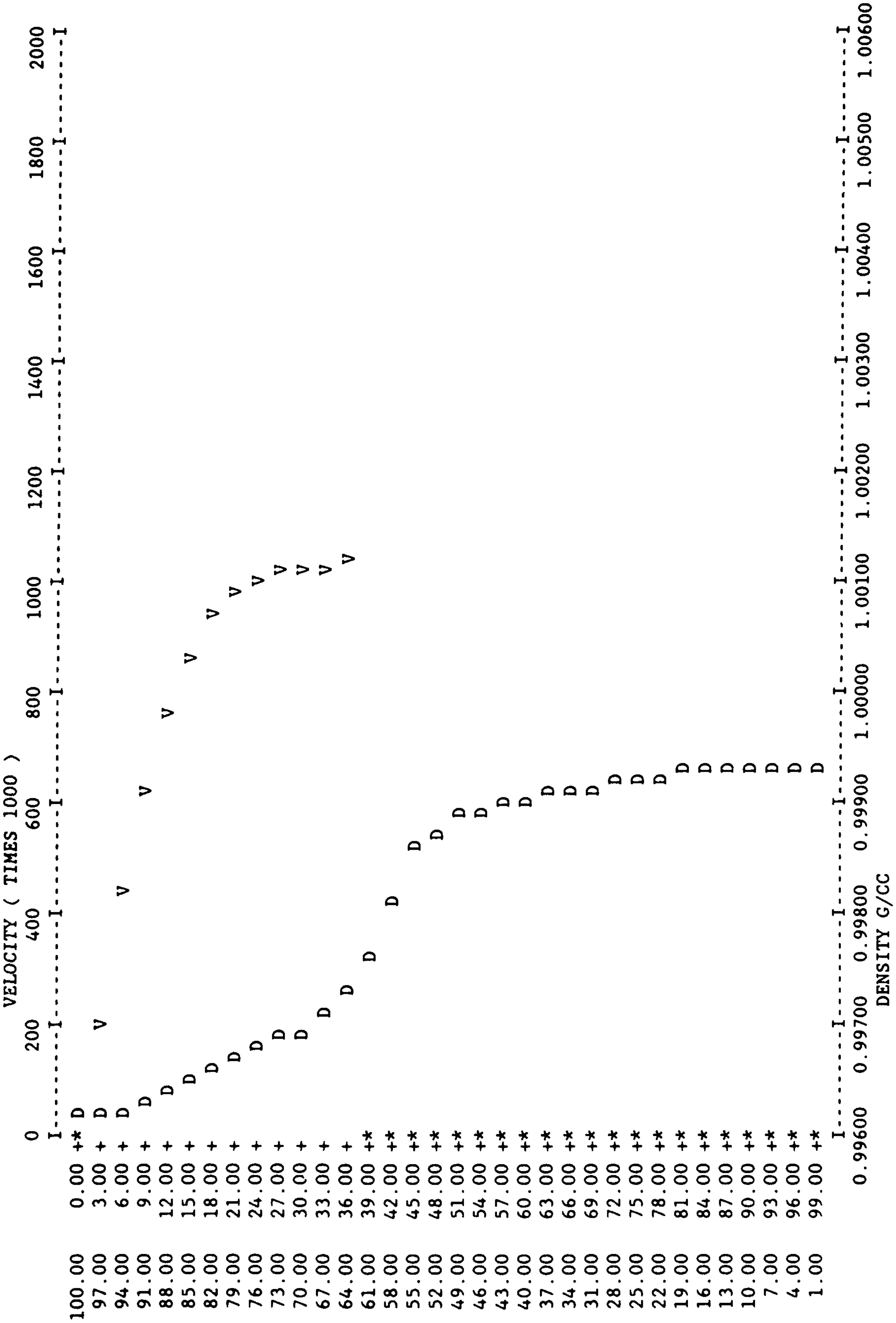
```
ANONYMOUS LAKE EXAMPLE


EXAMPLE FOR INPUT/OUTPUT USING PORT


      UNITS ARE IN FEET

      PORT ELEVATION     80.000
      PORT VERTICAL DIMENSION       5.000
      DISCHARGE, VOLUME FLOW PER SEC.     100.0000
      WITHDRAWAL ANGLE, RAD  3.1400


      TOTAL DISCHARGE, VOLUME PER SEC     100.0000

      LOWER WITHDRAWAL LIMIT ( ACTUAL ) HEIGHT ABOVE BOTTOM          65.781    ELEVATION     65.781
      LOWER WITHDRAWAL LIMIT ( THEORETICAL ) HEIGHT ABOVE BOTTOM     65.781    ELEVATION     65.781
      UPPER WITHDRAWAL LIMIT ( ACTUAL ) HEIGHT ABOVE BOTTOM          94.531    ELEVATION     94.531
      UPPER WITHDRAWAL LIMIT ( THEORETICAL ) HEIGHT ABOVE BOTTOM     94.531    ELEVATION     94.531
      OUTFLOW DENSITY  0.99655  G/CC
      OUTFLOW TEMPERATURE   26.96
```

ELEVATION	DEPTH	DENSITY	NORM. VEL.	FLOW	TEMPERATURE
99.500	0.50	0.99600	0.0000	0.0000	28.90
97.500	2.50	0.99601	0.0000	0.0000	28.89
94.500	5.50	0.99609	0.0000	0.0000	28.61
91.500	8.50	0.99617	0.1022	1.9055	28.34
88.500	11.50	0.99626	0.3755	7.0034	28.02
85.500	14.50	0.99636	0.6951	12.9650	27.66
82.500	17.50	0.99646	0.9260	17.2724	27.30
79.500	20.50	0.99656	1.0000	18.6533	26.95
76.500	23.50	0.99664	0.9259	17.2719	26.66
73.500	26.50	0.99672	0.7398	13.7991	26.36
70.500	29.50	0.99680	0.4823	8.9959	26.07
67.500	32.50	0.99695	0.1144	2.1336	25.47
64.500	35.50	0.99715	0.0000	0.0000	24.71
61.500	38.50	0.99743	0.0000	0.0000	23.57
58.500	41.50	0.99799	0.0000	0.0000	21.13
55.500	44.50	0.99841	0.0000	0.0000	19.15
52.500	47.50	0.99860	0.0000	0.0000	18.14
49.500	50.50	0.99872	0.0000	0.0000	17.46
46.500	53.50	0.99877	0.0000	0.0000	17.20
43.500	56.50	0.99882	0.0000	0.0000	16.93
40.500	59.50	0.99886	0.0000	0.0000	16.68
37.500	62.50	0.99890	0.0000	0.0000	16.43
34.500	65.50	0.99894	0.0000	0.0000	16.17
31.500	68.50	0.99898	0.0000	0.0000	15.92
28.500	71.50	0.99902	0.0000	0.0000	15.68
25.500	74.50	0.99906	0.0000	0.0000	15.44
22.500	77.50	0.99910	0.0000	0.0000	15.20
19.500	80.50	0.99913	0.0000	0.0000	15.00
16.500	83.50	0.99913	0.0000	0.0000	15.00
13.500	86.50	0.99913	0.0000	0.0000	15.00
10.500	89.50	0.99913	0.0000	0.0000	15.00
7.500	92.50	0.99913	0.0000	0.0000	15.00
4.500	95.50	0.99913	0.0000	0.0000	15.00
1.500	98.50	0.99913	0.0000	0.0000	15.00

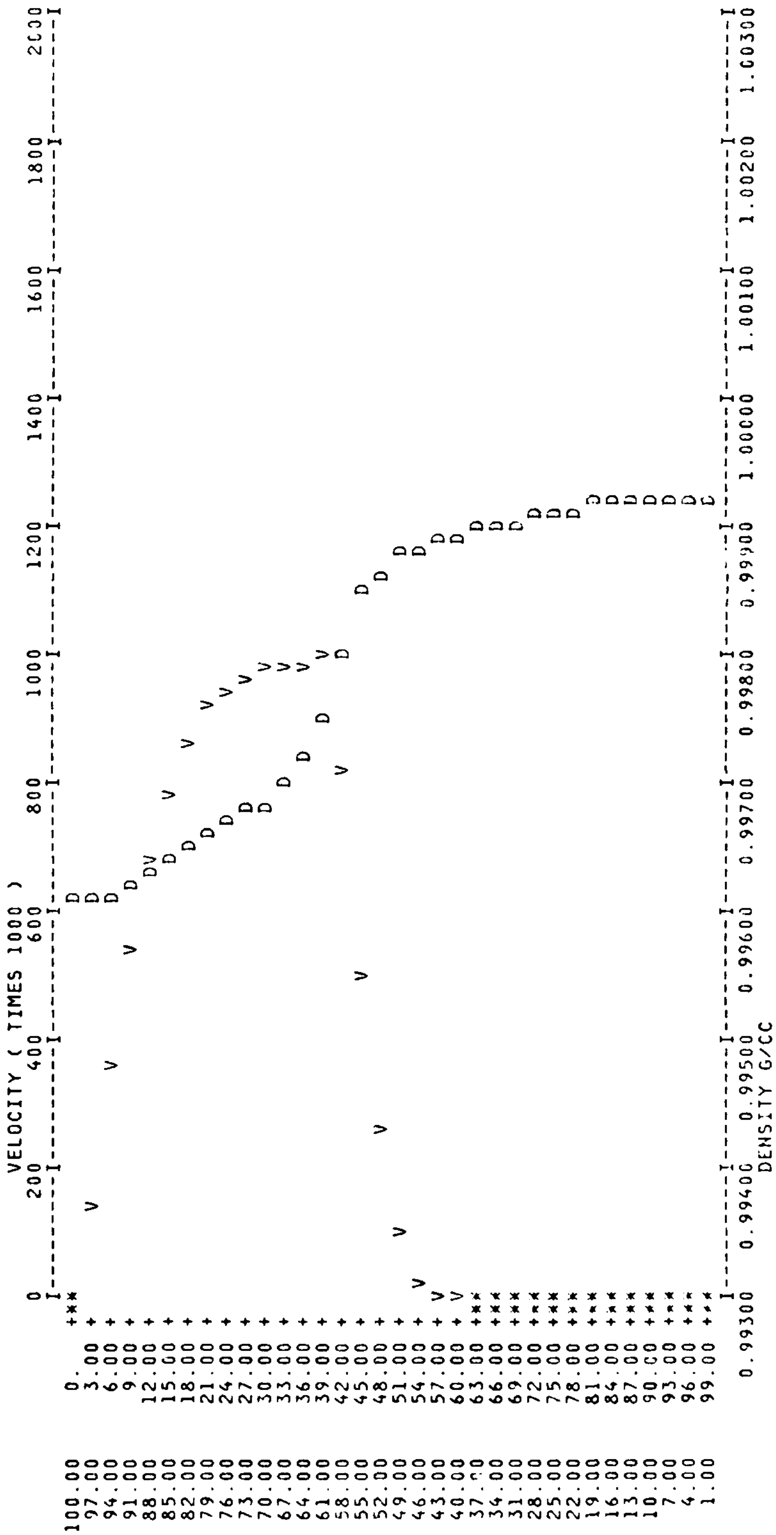

VELOCITY (TIMES 1000)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
DENSITY G/CC
0.99600
0.99700
0.99800
0.99900
1.00000
1.00100
1.00200
1.00300
1.00400
1.00500
1.00600

```
ANONYMOUS LAKE EXAMPLE


EXAMPLE FOR INPUT/OUTPUT USING WEIR

     UNITS ARE IN FEET

     WEIR CREST ELEVATION     65.000
     WEIR LENGHT     100.000
     DISCHARGE, VOLUME FLOW PER SEC.      100.0000


     TOTAL DISCHARGE, VOLUME PER SEC      100.0000

     LOWER WITHDRAWAL LIMIT ( ACTUAL ) HEIGHT ABOVE BOTTOM          64.238    ELEVATION     64.238
     LOWER WITHDRAWAL LIMIT ( THEORETICAL ) HEIGHT ABOVE BOTTOM     64.238    ELEVATION     64.238
     UPPER WITHDRAWAL LIMIT ( ACTUAL ) HEIGHT ABOVE BOTTOM         100.000    ELEVATION    100.000
     UPPER WITHDRAWAL LIMIT ( THEORETICAL ) HEIGHT ABOVE BOTTOM    100.000    ELEVATION    100.000
     OUTFLOW DENSITY  0.99661  G/CC
     OUTFLOW TEMPERATURE   26.74
     OUTFLOW CONCENTRATION OF DISSOLVED OXYGEN        2.51
```

ELEVATION	DEPTH	DENSITY	NORM. VEL.	FLOW	TEMPERATURE	DISSOLVED OX
99.500	0.50	0.99600	0.0000	0.0000	28.90	3.20
97.500	2.50	0.99601	0.1636	1.7156	28.89	3.20
94.500	5.50	0.99609	0.4010	4.2055	28.61	3.20
91.500	8.50	0.99617	0.5837	6.1209	28.34	3.20
88.500	11.50	0.99626	0.7280	7.6343	28.02	3.17
85.500	14.50	0.99636	0.8356	8.7634	27.66	3.11
82.500	17.50	0.99646	0.9074	9.5159	27.30	3.06
79.500	20.50	0.99656	0.9520	9.9836	26.95	3.01
76.500	23.50	0.99664	0.9768	10.2439	26.66	2.63
73.500	26.50	0.99672	0.9906	10.3881	26.36	2.12
70.500	29.50	0.99680	0.9971	10.4571	26.07	1.88
67.500	32.50	0.99695	0.9998	10.4847	25.47	1.68
64.500	35.50	0.99715	1.0000	10.4872	24.71	1.51
61.500	38.50	0.99743	0.0000	0.0000	23.57	1.33
58.500	41.50	0.99799	0.0000	0.0000	21.13	0.53
55.500	44.50	0.99841	0.0000	0.0000	19.15	0.43
52.500	47.50	0.99860	0.0000	0.0000	18.14	0.35
49.500	50.50	0.99872	0.0000	0.0000	17.46	0.29
46.500	53.50	0.99877	0.0000	0.0000	17.20	0.26
43.500	56.50	0.99882	0.0000	0.0000	16.93	0.23
40.500	59.50	0.99886	0.0000	0.0000	16.68	0.20
37.500	62.50	0.99890	0.0000	0.0000	16.43	0.20
34.500	65.50	0.99894	0.0000	0.0000	16.17	0.20
31.500	68.50	0.99898	0.0000	0.0000	15.92	0.20
28.500	71.50	0.99902	0.0000	0.0000	15.68	0.18
25.500	74.50	0.99906	0.0000	0.0000	15.44	0.15
22.500	77.50	0.99910	0.0000	0.0000	15.20	0.11
19.500	80.50	0.99913	0.0000	0.0000	15.00	0.07
16.500	83.50	0.99913	0.0000	0.0000	15.00	0.02
13.500	86.50	0.99913	0.0000	0.0000	15.00	0.00
10.500	89.50	0.99913	0.0000	0.0000	15.00	0.00
7.500	92.50	0.99913	0.0000	0.0000	15.00	0.00
4.500	95.50	0.99913	0.0000	0.0000	15.00	0.00
1.500	98.50	0.99913	0.0000	0.0000	15.00	0.00


VELOCITY (TIMES 1000)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
DENSITY G/CC
0.99600
0.99700
0.99800
0.99900
1.00000
1.00100
1.00200
1.00300
1.00400
1.00500
1.00600
100.00
97.00
94.00
91.00
88.00
85.00
82.00
79.00
76.00
73.00
70.00
67.00
64.00
61.00
58.00
55.00
52.00
49.00
46.00
43.00
40.00
37.00
34.00
31.00
28.00
25.00
22.00
19.00
16.00
13.00
10.00
7.00
4.00
1.00
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
30.00
33.00
36.00
39.00
42.00
45.00
48.00
51.00
54.00
57.00
60.00
63.00
66.00
69.00
72.00
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00
99.00

BLANK


VELOCITY (TIMES 1000)
0 200 400 600 800 1000 1200 1400 1600 1800 2000
DENSITY G/CC
0.99300 0.99400 0.99500 0.99600 0.99700 0.99800 0.99900 1.00000 1.00100 1.00200 1.00300

APPENDIX D: ERROR CODES

1. SELECT has various internal checks that test for errors in the input file data and format, and for errors in some of the program's internal computations. When a check is failed, the program prints an appropriate error message and terminates program execution.

2. The error message contains an error number, a subroutine name, and a statement regarding the type of error. With this information, the line at which the error occurred (and the cause) can often be easily determined by the user through the use of the program code. It is suggested that the user locate the subroutine in which the error occurred and then scan the CALL ERROR () statements therein for the error number. (The error number is the first number in the ERROR argument list.) The appropriate CALL ERROR () statement should be near the line(s) of code in which the failure occurred. NOTE: Most errors (error numbers 1010-1380 excluding 1080 and 1345) are due to input file format problems. If the user determines that the error is in the input file, check for missing lines, misplaced lines, misspelled words, etc., in the input file.

Error Number	Subroutine of Occurrence	Input Format Card	Explanation
1010	XREAD	02	"DATA" was expected as first four characters of input line.
1020	XREAD	05	"METR" or "ENGL" was expected as first four characters of input line.
1030	XREAD	06	"TABL" was expected as first four characters of input line.
1040	XREAD	07	"THIC" was expected as first four characters of input line.
1050	XREAD	08	"INTE" was expected as first four characters of input line.
1060	XREAD	09	"SURF" was expected as first four characters of input line
1070	XREAD	10	"BOTT" was expected as first four characters of input line.
1080	XREAD	07	The number of computational layers dimensioned in the model has been exceeded. Probable solution is to increase the desired thickness of each layer.
1100	XREAD	11	"WEIR" or "PORT" was expected as first four characters of input line.
1110	XREAD	12	"VDIM" was expected as first four characters of input line
1120	XREAD	13	"HDIM" was expected as first four characters of input line

(Continued)

Error Number	Subroutine of Occurrence	Input Format Card	Explanation
1130	XREAD	14	"DEPT" or "ELEV" or "HEIG" was expected as first four characters of input line.
1140	XREAD	15	"FLOW" was expected as first four characters of input line
1150	XREAD	16	"ANGL" was expected as first four characters of input line
1160	XREAD	17	"SUBM" or "FREE" was expected as first four characters of input line.
1170	XREAD	18	"COEF" was expected as first four characters of input line
1180	XREAD	19	"LENG" was expected as first four characters of input line
1200	XREAD	20	"DEPTH" or "ELEV" or "HEIG" was expected as first four characters of input line.
1210	XREAD	21	"FLOW" was expected as first four characters of input line
1215	XREAD	22	"TAIL" was expected as first four characters of input line
1220	XREAD	22	"NUMB" was expected as first four characters of input line
1225	XREAD	22	"TEMP" or "DENS" was expected as first four characters of the second alphanumeric format field

(Continued)

Error Number	Subroutine of Occurrence	Input Format Card	Explanation
1230	XREAD	23	"DEPT" or "ELEV" or "HEIG" was expected as first four characters of input line TABTYP not equal to 1
1240	XREAD	25	"DENS" was expected as first four characters of input line TABTYP not equal to 1
1250	XREAD	23	"DEPT" or "ELEV" or "HEIG" was expected as first four characters of input line TABTYP not equal to 1
1260	XREAD	23	"DENS" was expected as first four characters of the second alphanumeric format field TABTYP not equal to 1
1270	XREAD	27	"NUMB" or "QUAL" or "STOP" was expected as first four characters of input line
1280	XREAD	28	"TEMP" or "STOP" was expected as first four characters of input line
1290	XREAD	28	"FAHR" or "CENT" was expected as first four characters of the second alphanumeric format field
1300	XREAD	29	"DEPT" or "ELEV" or "HEIG" was expected as first four characters of input line TABTYP not equal to 1
1310	XREAD	31	"TEMP" was expected as first four characters of input line TABTYP not equal to 1
1320	XREAD	29	"DEPT" or "ELEV" or "HEIG" was expected as first four characters of input line TABTYP equal to 1

(Continued)

Error Number	Subroutine of Occurrence	Input Format Card	Explanation
1330	XREAD	29	"TEMP" was expected as first four characters of the second alphanumeric format field TABTYP equal to 1
1340	XREAD	33	"QUAL" or "STOP" was expected as first four characters of input line
1345	XREAD	--	Dissolved oxygen must be the first quality profile listed if aeration techniques are modeled
1350	XREAD	34	"NUMB" was expected as first four characters of input line
1360	XREAD	35	"DEPT" or "ELEV" or "HEIG" was expected as first four characters of input line TABTYP not equal to 1
1370	XREAD	35	"DEPT" or "ELEV" or "HELG" was expected as first four characters of input line TABTYP equal to 1
1380	XREAD	39	"STOP" was expected as first four characters of input line
1400	OUTVEL	15	Flow rate entered for a port was less than or equal to zero Flow rates must be greater than zero
1410	OUTVEL	14	Center line height of port exceeded depth of water
1420	VPORT	21	Flow rate for weir found to be less than or equal to zero Flow rate must be greater than zero

(Continued)

Error Number	Subroutine of Occurrence	Input Format Card	Explanation
1500	VPORT	--	Convergence on the upper or lower withdrawal limit has not been reached
1510	VPORT	--	Same as error number 1500
1520	VPORT	--	Elevation of maximum velocity in withdrawal profile was found to be above the water surface or below the bottom
1600	VWEIR	--	Internal computation check failure. Function FWEIR(X) must be positive at the crest elevation and negative at the bottom to allow convergence on the lower limit
1610	VWEIR	--	Convergence on the lower withdrawal limit has not been reached
1800	SHIFT		Number of iterations internally programmed for convergence on shifted limit is not sufficient

APPENDIX E   PROGRAM LISTING

```
      PROGRAM SELECT
****************************************************************
*                                                              *
*       P R O G R A M   S E L E C T                            *
*                                                              *
****************************************************************
*
* *****************      *****************     *****************
* * VERSION 1.3   *      * VERSION 1.3   *     * VERSION 1.3   *
* *****************      *****************     *****************
*
*
*     VERSION 1.0
*
*     COMPUTES THE LIMITS OF THE ZONE OF WITHDRAWAL
*     AND THE DISTRIBUTION OF FLOW WITHIN THAT ZONE.  THE
*     PROGRAM ALSO COMPUTES THE OUTFLOW DENSITY AND QUALITY FROM
*     INPUT DENSITY AND QUALITY PROFILES.  VERSION 1.0 IS SUPPORTED
*     BY THE WES EWQOS INSTRUCTION REPORT #E-87-2, "SELECT:  A
*     NUMERICAL MODEL FOR SELECTIVE WITHDRAWAL" BY
*     JACK E. DAVIS ET AL.
*
*
*     VERSION 1.1        FEBRUARY 18, 1988
*
*     THE INPUT AND OUTPUT FILE CODES WERE HARDWIRED IN PROGRAM.
*     THE INPUT FILE IS 05 AND MUST BE CALLED SELECT.IN AND THE
*     OUTPUT FILE IS 06 AND MUST BE CALLED SELECT.OUT
*
*
*     VERSION 1.2        JULY 20, 1990
*
*     CORRECTED AN ERROR IN ROUTINE DENINT.  THE ROUTINE CAN NO
*     LONGER SEARCH FOR DENSITIES OUTSIDE THE POOL WHEN A WEIR
*     IS BEING MODELED.
*
*
*     VERSION 1.3        JANUARY 6, 1992
*
*     MADE SUPERFICIAL CHANGES TO THE CODE APPEARANCE TO IMPROVE
*     READABILITY.  ALSO MADE INCONSEQUENTIAL CHANGES TO THE OUTPUT
*     ROUTINE TO MAKE OUTPUT FILE MORE PC PRINTER COMPATIBLE.  THE
*     SUBROUTINES WERE REORDERED TO APPEAR ALPHABETICALLY.  FUNCTION
*     NAMES IN VPORT WERE CHANGED TO MATCH THE VARIABLE NAMES IN THE
*     DOCUMENTATION.
*
*     AN ERROR IN CONVERTING FAHRENHEIT TO CENTIGRADE WAS CORRECTED.
*     DENINT WAS CORRECTED TO ACCOMMODATE POINT SINKS AT THE
*     RESERVOIR BOTTOM.  THE SMITH ET AL. FORMULATION WAS
```

MAIN

```
*     CORRECTED TO COMPUTE THE DENSITY GRADIENT FROM THE PORT
*     CENTER LINE TO THE FREE LIMIT, RATHER THAN FROM THE BOUNDARY
*     OF INTERFERENCE.  FOR ONE BOUNDARY OF INTERFERENCE, THE
*     BOHAN AND GRACE CALCULATION OF THE THEORETICAL LIMIT NOW
*     CORRECTLY USES A FRACTION MULTIPLIER FOR THE AMOUNT OF FLOW
*     IN THE TRUNCATED WITHDRAWAL ZONE.  THE PORT ORDERING
*     ROUTINE IN XREAD WAS CORRECTED TO INCLUDE FLOW AND ANGLE.
*     (HOWINGTON)
*
         COMMON / AA / QMETR, NSETS, G, HEADING (18), TITLE (18)
         COMMON / BB / IFILE, KFILE
         COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
         COMMON / DD / WTHETA (5), WANGLE
         COMMON / EE / NPORTS, QPORT, QWEIR, QPLOT, QPWEIR
         COMMON / FF / PVDIM (5), PHGT (5), FLOW (5), PHDIM (5)
         COMMON / GG / COEF, QSUB, QQUAL
         COMMON / HH / WRLNG, WRHGT, WRFLOW
         COMMON / II / NUMD, DEN (100), YD (100), QDEN, DENPRT
         COMMON / JJ / NUMT, QCENT, TEMP (100), YT (100), QTEMP
         COMMON / KK / NQUAL, NUMQ (4), NAMEQ (5,4),
     &                 QUAL (4,100), YQ (4,100)
         COMMON / LL / ISURF, HGT(100), DEPTH, Y (100)
         COMMON / MM / SUMOUT, VEL(100), FLORAT
         COMMON / NN / HGTPRT, VDIM, QTLIM, QBLIM, QSINK1,
     &                 QSINK2, QSHIFT
         COMMON / OO / LENGTH, CREST, HDIM
         COMMON / PP / LOWLIM, TOPLIM, HGTLOW, HGTTOP, V (100), VM
         COMMON / QQ / VS (100, 6), NOUTS
         COMMON / RR / ZUP (6), ZDN (6), LTOP (6), LLOW (6)
         COMMON / SS / WTHDRW (100), DENOUT, TEMOUT, QALOUT (4)
         COMMON / TT / QVENT, QAERA, QTWFUN, TWEL
*
         LOGICAL QDEN, QCENT
         LOGICAL QVENT, QAERA
*
         DATA C1, C2 / -3.9863, 508929.2 /
         DATA C3, C4 / 288.9414, 68.12963 /
*
*  ... DENSITIES FROM TEMPERATURES ....
*
         DENFUN ( X ) = 1. - ( X + C1 ) ** 2 / C2
     &                * ( X + C3 ) / ( X + C4 )
*
*....   FAHRENHEIT TO CENTIGRADE ....
*
         TEMFUN ( T ) = ( 5. / 9. ) * ( T - 32. )
*
*     READ CONTROL INFORMATION ....
*
         IFILE = 5
```

MAIN

```
            KFILE = 6
      *
            OPEN ( 5, FILE = 'SELECT.IN'  , STATUS = 'OLD' )
            OPEN ( 6, FILE = 'SELECT.OUT' , STATUS = 'NEW' )
      *
            CALL XREAD
      *
      *.... INITIATE LOOP FOR THE NUMBER OF DATA SETS ....
      *
            DO 130 I = 1, NSETS
      *
      *.... READ INPUT DATA AND CONSTRUCT COMPLETE DATA TABLES ....
      *
            CALL XREAD
      *
      *.... DEVELOP DENSITY PROFILE IF NOT GIVEN ....
      *
            IF ( QDEN ) GO TO 110
            DO 100 J = 1, ISURF
               IF ( .NOT. QCENT ) TEMP(J) = TEMFUN ( TEMP(J) )
               DEN (J) = DENFUN ( TEMP(J) )
       100  CONTINUE
       110  CONTINUE
      *
      *.... CHECK FOR STABLE DENSITY PROFILE ....
      *
            DO 120 K = 2, ISURF
               IF ( DEN (K - 1) .GE. DEN (K) ) GO TO 120
               WRITE ( KFILE , 500 )
               STOP
       120  CONTINUE
      *
      *.... COMPUTE SELECTIVE WITHDRAWAL LIMITS AND VELOCITIES AND
      *     RESULTANT OUTFLOW DENSITY AND QUALITIES ....
      *
            CALL OUTVEL
      *
      *.... MODIFY OUTFLOW D.O. IF GATED STRUCTURE
      *     AERATION IS USED. ....
      *
            IF ( QAERA ) CALL AERATE
      *
      *.... MODIFY OUTFLOW D.O. IF TURBINE VENTING IS USED ....
      *
            IF ( QVENT ) CALL VENTING
      *
      *.... PRINT RESULTS ....
      *
            CALL XPRINT
       130  CONTINUE
```

MAIN

```
            STOP
      500   FORMAT ( /// 10X, 27HDENSITY PROFILE UNSTABLE - ,
         &                      16HPROGRAM STOPPED )
            END
```

AERATE

```
          SUBROUTINE AERATE
*****************************************************************
*                                                               *
*         S U B R O U T I N E   A E R A T E                     *
*                                                               *
*****************************************************************
*
*.... PREDICTS THE RELEASE D.O. (MG/L) THROUGH GATED CONDUIT OULET
*     WORKS USING THE ENERGY DISSIPATION MODEL OUTLINED IN
*     TR-E-81-5 BY WILHELMS AND SMITH ....
*
          COMMON / AA / QMETR, NSETS, G, HEADING(18), TITLE(18)
          COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
          COMMON / LL / ISURF, HGT(100), DEPTH, Y(100)
          COMMON / MM / SUMOUT, VEL(100), FLORAT
          COMMON / SS / WTHDRW(100), DENOUT, TEMOUT, QALOUT(4)
          COMMON / TT / QVENT, QAERA, QTWFUN, TWEL
*
          LOGICAL QVENT, QAERA, QTWFUN
          LOGICAL QMETR
*
*.... FUNCTIONS FOR CALCULATIONS ADJUSTED ESCAPE COEFFICIENT ....
*
          CT( X ) = C20 * 1.022 ** ( X - 20.0 )
*
*.... DISSOLVED OXYGEN SATURATION ....
*
          DOSAT( X ) = 1 / ( 0.00209 * X + 0.06719 )
*
*.... ALTITUDE CORRECTION FACTOR ....
*
          BARO( X ) = 1.0 - 3.224 E-5 * X
          C20 = 0.045
          IF ( QMETR ) C20 = 0.1476
*
*.... ADJUST ESCAPE COEFFICIENT ....
*
          C = CT( TEMOUT )
*
*.... OXYGEN SATURATION CONCENTRATION ADJUSTED FOR ALTITUDE ....
*
          ALT = BOTTOM
          IF ( QMETR ) ALT = BOTTOM * 3.28
          CSAT = DOSAT( TEMOUT ) * BARO( ALT )
*
*.... DELTA-H THROUGH STRUCTURE ....
*
          DELH = DEPTH + BOTTOM - TWEL
*
*.... DISSOLVED OXYGEN DEFICIT ENTERING STRUCTURE ....
```

AERATE

```
*
          DI = CSAT - QALOUT(1)
*
*.... REAERATE DISCHARGE ....
*
          DF = DI * EXP( - C * DELH )
*
*.... RELEASE DISSOLVED OXYGEN ....
*
         QALOUT(1) = CSAT - DF
         RETURN
         END
```

DENINT

```
      REAL FUNCTION DENINT ( X )
************************************************************************
*                                                                      *
*           R E A L   F U N C T I O N   D E N I N T                    *
*                                                                      *
************************************************************************
*
*.... DETERMINE DENSITY AT ANY LOCATION ....
*
      COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
      COMMON / EE / NPORTS, QPORT, QWEIR, QPLOT, QPWEIR
      COMMON / II / NUMD, DEN(100), YD(100), QDEN, DENPRT
      COMMON / LL / ISURF, HGT(100), DEPTH, Y(100)
      COMMON / NN / HGTPRT, VDIM, QTLIM, QBLIM,
     &              QSINK1, QSINK2, QSHIFT
*
      INTEGER SIGN
*
      LOGICAL QDEN, QTLIM, QBLIM, QSINK1, QSINK2, QSHIFT, QWEIR
*
      DATA SMALL / 1.E - 05 /
*
      LAYER = 1. + X / DELZ
*
*.... IF WEIRS ARE BEING MODELED, CODE ONLY SEARCHES IN THE POOL
*     FOR DENSITIES.  IF PORTS ARE BEING MODELED THE CODE SEARCHES
*     BOTH IN AND OUTSIDE THE POOL FOR DENSITIES ....
*
      IF ( QWEIR ) THEN
         IF ( LAYER .LE. 1 ) THEN
            LAYER = 1
            DENINT = DEN ( LAYER )
            RETURN
         ELSE IF ( LAYER .GT. ISURF ) THEN
            LAYER = ISURF
            DENINT = DEN ( LAYER )
            RETURN
         END IF
      END IF
*
      IF ( X .GE. DEPTH .OR. X .LT. 0.0 ) GO TO 120
*
*.... IF THE LAYER IS OUTSIDE THE POOL, THE DENSITY IS
*     EXTRAPOLATED BASED ON A LINEAR DENSITY GRADIENT EXTENDED
*     FROM THE PORT CENTERLINE TO THE DESIRED BOUNDARY LAYER ....
*
*.... FIND THE DENSITY INSIDE THE POOL ....
*
      ELMID = DELZ * ( FLOAT ( LAYER ) - 0.5 )
      DIFF = ABS ( ELMID - X )
```

DENINT

```
            IF ( DIFF .LT. SMALL ) THEN
               DENINT = DEN ( LAYER )
               RETURN
            ENDIF
*
            IF ( LAYER .EQ. ISURF .AND. X .GE. ELMID ) THEN
               SLOPE = ( DEN ( ISURF - 1 ) - DEN ( ISURF ) )
     &                  / DELZ
               DENINT = DEN ( LAYER ) - DIFF * SLOPE
               RETURN
            ELSEIF ( LAYER .EQ. 1 .AND. X .LE. ELMID ) THEN
               SLOPE = ( DEN ( 1 ) - DEN ( 2 ) ) / DELZ
               DENINT = DEN ( LAYER ) + DIFF * SLOPE
               RETURN
            ENDIF
*
            SIGN = ( ELMID - X ) / ABS ( ELMID - X )
            IJK = - ( SIGN - 1 ) / 2
            IJ = LAYER + IJK
            JK = IJ - 1
            SLOPE = ( DEN ( IJ ) - DEN ( JK ) ) / DELZ
            ELTOP = DELZ * ( FLOAT ( IJ ) - 0.5 )
            DENINT = DEN ( IJ ) - ( ELTOP - X ) * SLOPE
            RETURN
  120       CONTINUE
*
*.... FIND THE DENSITY OUTSIDE THE POOL ....
*
            IF ( HGTPRT .GE. DEPTH - 0.5 * DELZ ) THEN
               DGRDT = ( DEN ( ISURF ) - DEN ( ISURF - 1 ) )
     &                  / DELZ
            ELSE
               DGRDT = ( DEN ( ISURF ) - DENPRT ) / ( DEPTH - HGTPRT )
            ENDIF
*
            IF ( HGTPRT .LE. 0.5 * DELZ ) THEN
               DGRDB = ( DEN ( 1 ) - DEN ( 2 ) ) / DELZ
            ELSE
               DGRDB = ( DEN ( 1 ) - DENPRT ) / HGTPRT
            ENDIF
            IF ( LAYER .GE. ISURF ) DGRD = DGRDT
            IF ( LAYER .LE. 1 ) DGRD = DGRDB
            DENINT = DGRD * ABS ( HGTPRT - X ) + DENPRT
            RETURN
            END
```

DVPLOT

```
      SUBROUTINE DVPLOT
*****************************************************************
*                                                               *
*     S U B R O U T I N E   D V P L O T                         *
*                                                               *
*****************************************************************
*
*.... THIS SUBROUTINE PLOTS PROFILES OF DENSITY AND VELOCITY
*     VERSUS DEPTH ....
*
      COMMON / BB / IFILE, KFILE
      COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
      COMMON / II / NUMD, DEN (100), YD (100), QDEN, DENPRT
      COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
      COMMON / MM / SUMOUT,  VEL (100), FLORAT
*
      CHARACTER*1 T, BLANK, PEGGED, FIRSTD, BOTH, COL1(100),
     *            V, D, LASTV, LASTD, COL2(100), FIRSTV
*
      DIMENSION VSPACE(11), DSPACE(11)
*
      CHARACTER*2 PLUS
      INTEGER VSPACE
      LOGICAL QRANGE, QDEN
*
      DATA PEGGED, BLANK, V, D, PLUS / '*',' ','V','D',' +'/
      DATA VELMAX / 2.0 /
      DATA BOTH / 'B' /
*
      WRITE ( KFILE, 500 )
*
*.... DETERMINE MAXIMUM VELOCITY ....
*
      VMAX = VEL ( 1 )
      DO 100 I = 2, ISURF
         IF ( VEL ( I ) .GT. VMAX ) VMAX = VEL ( I )
 100  CONTINUE
*
*.... DETERMINE VELOCITY AXIS SPACING ....
*
      CHANGE = VELMAX * 100.
      VSPACE ( 1 ) = 0
      DO 110 K = 1 , 10
         VSPACE( K + 1 ) = VSPACE ( K ) + INT ( CHANGE )
 110  CONTINUE
*
*.... DETERMINE MAXIMUM AND MINIMUM DENSITIES FOR AXIS SPACING ....
*
      DMIN = DEN ( 1 )
      DMAX = DEN ( 1 )
```

```
          DO 115 I = 2, ISURF
             DMIN = AMIN1 ( DMIN, DEN ( I ) )
             DMAX = AMAX1 ( DMAX, DEN ( I ) )
  115     CONTINUE
          DUM = DMIN * 1000.
          DMIN = FLOAT ( INT ( DUM ) )  / 1000.
          DDIF = DMAX - DMIN
          DMAX = DMIN + 0.01
          IF ( DDIF .GT. 0.01 ) DMAX = DMIN + 0.02
*
*.... DETERMINE DENSITY AXIS SPACING ....
*
          DENDIF = DMAX - DMIN
          CHANGE2 = DENDIF / 10.
          DSPACE ( 1 ) = DMIN
          DO 120 J = 1, 10
             DSPACE ( J + 1 ) = DSPACE ( J ) + CHANGE2
  120     CONTINUE
*
*.... PRINT VELOCITY AXIS AND LABEL ....
*
          WRITE ( KFILE, 510 )
          WRITE ( KFILE, 520 ) ( VSPACE ( K ), K = 1, 11 )
          WRITE ( KFILE, 530 )
*
*.... BEGIN TO FILL IN COLUMN ARRAY ....
*
          ELEV = BOTTOM + DEPTH + DELZ
          DEEP = - DELZ
          DO 170 I = 1, ISURF
             K = ISURF - I + 1
             DEEP = DEEP + DELZ
             ELEV = ELEV - DELZ
*
*.... BLANK OUT VELOCITY COLUMN ARRAY ....
*
             FIRSTV = BLANK
             LASTV = BLANK
             DO 130 L = 1, 100
                COL1 ( L ) = BLANK
  130        CONTINUE
*
*.... DETERMINE IF VELOCITY VALUES ARE WITHIN RANGE OF PLOT ....
*
             VL = VEL ( K )
             IF ( VL .LE. 0.     ) FIRSTV = PEGGED
             IF ( VL .GT. VELMAX ) LASTV = PEGGED
*
*.... DETERMINE COLUMN FOR PLOTTING EACH VELOCITY COMPONENT ....
*
```

DVPLOT

```
              QRANGE = VL .GT. 0. .AND. VL .LE. VELMAX
              IRANGE = 0
              IF ( QRANGE ) IRANGE = 1
              IF ( .NOT. QRANGE ) GO TO 140
              IJK = INT ( ( VL / VELMAX ) * 100. )
              IJK = IJK + 1
              COL1 ( IJK ) = V
  140         CONTINUE
*
*.... BLANK OUT DENSITY COLUMN ARRAY ....
*
              FIRSTD = BLANK
              LASTD = BLANK
              DO 150 L = 1, 100
                 COL2 ( L ) = BLANK
  150         CONTINUE
*
*.... DETERMINE IF DENSITY VALUES ARE WITHIN RANGE OF PLOT ....
*
              DN = DEN(K)
              IF ( DN .LE. 0.   ) FIRSTD = PEGGED
              IF ( DN .GT. DMAX ) LASTD = PEGGED
*
*.... DETERMINE COLUMN FOR PLOTTING EACH DENSITY COMPONENT ....
*
              QRANGE = DN .GT. 0. .AND. DN .LE. DMAX
              IRANGE = 0
              IF ( QRANGE ) IRANGE = 1
              IF ( .NOT. QRANGE ) GO TO 160
              IJK = INT ( 100. * ( DN - DMIN ) / DENDIF )
              IJK = IJK + 1
              COL2 ( IJK ) = D
  160         CONTINUE
              DO 165 L = 1, 100
                 IF ( COL1 ( L ) .EQ. V ) GO TO 162
                 COL1 ( L ) = COL2 ( L )
                 GO TO 165
  162            CONTINUE
                 IF ( COL2 ( L ) .NE. D ) GO TO 165
                 COL1 ( L ) = BOTH
  165            CONTINUE
*
*.... PRINT ONE LINE OF PLOT ....
*
                 WRITE ( KFILE, 550 ) ELEV  , DEEP , PLUS  , FIRSTV ,
     &                                FIRSTD, COL1 , LASTV , LASTD
  170       CONTINUE
*
*.... PRINT BOTTOM AXIS ....
*
```

```
          WRITE ( KFILE , 530 )
          WRITE ( KFILE , 570 ) ( DSPACE ( J ), J = 1, 11 )
          WRITE ( KFILE , 540 )
*
*.... QUIT
*
          RETURN
*
  500     FORMAT ( 1H1 , /// )
  510     FORMAT ( 30X , 23HVELOCITY ( TIMES 1000 ) )
  520     FORMAT ( 11X , 11I10 )
  530     FORMAT ( 20X , 10 ( 10HI--------- ), 1HI )
  540     FORMAT ( 30X , 12HDENSITY G/CC )
  550     FORMAT ( 1X  , F7.2, 1X, F7.2, A2, 104A1 )
  570     FORMAT ( 11X , 11F10.5 )
          END
```

ERROR

```
      SUBROUTINE ERROR ( ERR, SUBR, CHK, XCHK1, XCHK2, XCHK3 )
*****************************************************************
*                                                               *
*     S U B R O U T I N E   E R R O R                           *
*                                                               *
*****************************************************************
*
*.... THERE ARE TWO TYPES OF ERROR CHECKS - ONE FOR INPUT
*     FORMATTING AND ONE FOR PROGRAM COMPUTATIONS. FOR PROGRAM
*     COMPUTATIONS, ONLY THE ERROR NUMBER AND THE SUBROUTINE-OF-
*     OCCURRANCE NAME ARE PASSED TO THE ERROR SUBROUTINE.  THEN AN
*     APPROPRIATE STATEMENT IS MATCHED WITH THE ERROR NUMBER AND
*     PRINTED.  THE OTHER ARGUMENTS PASSED ARE EQUAL TO ZERO ....
*
*.... FOR FORMAT ERRORS, THE ERROR NUMBER, THE SUBROUTINE-OF-
*     OCCURRANCE NAME, THE STRING IN ERROR, AND THE STRING(S)
*     EXPECTED BY THE PROGRAM ARE PASSED.  UNUSED ARGUMENTS ARE
*     PASSED AS ZERO ....
*
      COMMON / BB / IFILE, KFILE
*
      INTEGER ERR
*
      CHARACTER*4 CHK, XCHK1, XCHK2, XCHK3
      CHARACTER*6 SUBR
*
*.... PRINT ERROR NUMBER AND SUBROUTINE-OF-OCCURRANCE ....
*
      WRITE ( KFILE, 500 ) ERR, SUBR
*
*.... MATCH ERROR CODE WITH PROPER OUTPUT STATEMENT ....
*
*.... ERROR CODES FOR IMPROPER INPUT VALUES ....
*
      IF ( ERR .EQ. 1400 ) WRITE ( KFILE, 510 )
      IF ( ERR .EQ. 1410 ) WRITE ( KFILE, 520 )
      IF ( ERR .EQ. 1420 ) WRITE ( KFILE, 530 )
*
*.... ERROR CODES FOR INTERNAL COMPUTATIONS ....
*
      IF ( ERR .EQ. 2100 .OR. ERR .EQ. 2070 .OR.
     &         ERR .EQ. 2090 .OR. ERR .EQ. 2300 )
     &         WRITE ( KFILE, 540 )
      IF ( ERR .EQ. 2310 ) WRITE ( KFILE, 570 )
      IF ( ERR .EQ. 2320 ) WRITE ( KFILE, 580 )
*
*.... ERROR CODES FOR HALF INTERVAL SEARCH CONVERGENCE ERRORS ....
*
      IF ( ERR .EQ. 2310 ) WRITE ( KFILE, 570 )
      IF ( ERR .EQ. 2080 .OR. ERR .EQ. 2110 )
```

ERROR

```
     &       WRITE ( KFILE, 590 )
           IF ( ERR .EQ. 1080 ) WRITE ( KFILE, 600 )
*
*.... IF THIS SUBROUTINE  USED ONE OF THE ABOVE 'IF' STATEMENTS
*     THEN THE FOLLOWING IF STATEMENT IS USED TO EXIT PROGRAM ....
*
           IF ( XCHK1 .EQ. '0    ' .AND  XCHK2 .EQ. '0    '
     &      .AND. XCHK3 .EQ. '0    ' ) GO TO 100
*
*.... ERROR CODES FOR INPUT FORMAT FAILURE CHECKS ....
*
*.... IF VARIABLE 'CHECK' WAS TESTED FOR ONLY ONE STRING VALUE
*     DURING PROGRAM OPERATION ....
*
           IF ( XCHK2 .EQ. '0    ' .AND. XCHK3 .EQ. '0    ' )
     &       WRITE ( KFILE, 610 ) CHK, XCHK1
*
*.... IF VARIABLE 'CHECK' WAS TESTED FOR ONE OF TWO STRING VALUES
*     DURING PROGRAM OPERATION ....
*
           IF ( XCHK2 .NE. '0    ' .AND. XCHK3 .EQ. '0    ' )
     &       WRITE ( KFILE, 620 ) CHK, XCHK1, XCHK2
*
*.... IF VARIABLE 'CHECK' WAS TESTED FOR ONE OF THREE STRING VALUES
*     DURING PROGRAM OPERATION ....
*
           IF ( XCHK2 .NE. '0    ' .AND. XCHK3 .NE. '0    ' )
     &       WRITE ( KFILE, 630 ) CHK, XCHK1, XCHK2, XCHK3
  100      STOP
*
  500      FORMAT ( /,'ERROR NUMBER ',I4,
     &               ' OCCURRED IN SUBROUTINE' , A6 )
  510      FORMAT (/, 'FLOW RATE FOR A PORT WAS FOUND TO BE', /,
     &             'LESS THAN OR EQUAL TO ZERO.', /, 'ENTERED FLOWRATE',
     &             ' MUST BE GREATER THAN  ZERO.')
  520      FORMAT ( /, 'CENTER LINE OF PORT WAS HIGHER ', /,
     &             'THAN THE WATER SURFACE.')
  530      FORMAT ( /, 'FLOW RATE FOR WEIR MUST BE > THAN ZERO' )
  540      FORMAT ( /,'*** COMPUTATIONAL ERROR IN PROGRAM ' )
  570      FORMAT ( /,'CONVERGENCE IN SUBROUTINE SHIFT FAILED.')
  580      FORMAT ( /, 'IN HALF INTERVAL SEARCH, CONVERGENCE ON THE',
     &               /, 'UPPER OR LOWER WITHDRAWAL LIMIT FAILED')
  590      FORMAT ( /, 'IN HALF INTERVAL SEARCH, CONVERGENCE ON ',/,
     &                 'THE UPPER OR LOWER WITHDRAWAL LIMIT FAILED.')
  600      FORMAT ( /,'NUMBER OF LAYERS DIMENSIONED WAS EXCEEDED')
  610      FORMAT ( /, 'INTERNAL CHECK WAS "',A4, '"', /,
     &               'PROGRAM EXPECTED "', A4,'" AS FIRST FOUR', /,
     &               'CHARACTERS OF INPUT LINE.')
```

ERROR

```
620     FORMAT ( /,'INTERNAL CHECK WAS "', A4, '"', /,
     &              'PROGRAM EXPECTED "', A4, '" OR "', A4, '"', /,
     &              'AS FIRST FOUR CHARACTERS OF INPUT LINE ')
630     FORMAT ( /, 'INTERNAL CHECK WAS "',A4, '"', /,
     &              'PROGRAM EXPECTED "', A4, '" OR "', A4, '"', /,
     &              'OR "', A4, '" AS FIRST FOUR CHARACTERS OF',
     &              ' INPUT LINE ')
        END
```

INTERP

```
      SUBROUTINE INTERP ( PQUAL, YV, NUMV )
*****************************************************************
*                                                               *
*           S U B R O U T I N E   I N T E R P                   *
*                                                               *
*****************************************************************
*
*.... PROGRAM TO DEVELOP COMPLETE DATA TABLES OR PROFILES BY LINEAR
*     INTERPOLATION OF INPUT DATA ....
*
      COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
      COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
*
      DIMENSION PQUAL (100), YV (100), PVALUE (100),
     &               DM (100), PM (100)
*
      INTEGER SIGN1, SIGN2
*
*.... TOLERANCE, 0.01% OF LAYER THICKNESS ....
*
      SMALL = 0.0001 * DELZ
*
*.... IF DATA IS ORDERED FROM TOP TO BOTTOM, IT MUST BE RESEQUENCED
*     FROM BOTTOM TO TOP ....
*
      IF ( YV(1) .LT. YV(2) ) GO TO 120
      NV = NUMV + 1
*
*.... RESEQUENCE ....
*
      DO 100 I = 1, NUMV
         DM(I) = YV(NV - I)
         PM(I) = PQUAL(NV - I)
  100 CONTINUE
      DO 110 I = 1, NUMV
         YV(I) = DM(I)
         PQUAL(I) = PM(I)
  110 CONTINUE
  120 CONTINUE
*
*.... ASSIGN PARAMETER VALUE TO INTERP VARIABLE ....
*
      DO 130 I = 1, NUMV
         PVALUE(I) = PQUAL(I)
  130 CONTINUE
*
*.... START PROFILE DEVELOPMENT ....
*
*.... ANY CENTER LINE ELEVATION BELOW LOWEST PARAMETER POINT
*     IS ASSIGNED THE VALUE OF THAT PARAMETER POINT ....
```

INTERP

```
*
          DO 140 I = 1, ISURF
             IF ( Y(I) .GT. YV(1) ) GO TO 150
             PQUAL(I) = PVALUE(1)
  140     CONTINUE
  150     CONTINUE
          J = I
*
*.... ANY CENTER LINE ELEV. ABOVE HEIGHEST PARAMETER POINT IS
*     ASSIGNED THAT PARAMETER VALUE ....
*
          DO 160 I = 1, ISURF
             L = ISURF + 1 - I
             IF ( Y(L) .LT. YV(NUMV) ) GO TO 170
             PQUAL(L) = PVALUE(NUMV)
  160     CONTINUE
  170     CONTINUE
*
*.... FIRST CENTER LINE BELOW HIGHEST PARAMETER POINT ....
*
          K = L
*
*.... FIRST CENTER LINE ABOVE LOWEST PARAMETER POINT ....
*
          I = J - 1
  180     CONTINUE
          I = I + 1
          IF ( I .GT. K ) GO TO 270
          NMINUS = NUMV - 1
*
*.... LOCATE DATA POINTS ABOVE AND BELOW THE LAYER CENTER LINE ....
*
          DO 230 M = 1, NMINUS
             DIFF1 = ABS ( YV(M) - Y(I) )
             IF ( DIFF1 .LT. SMALL ) GO TO 190
*
*....  IF SIGN1 IS NEGATIVE, FIRST DATA POINT LIES BELOW CENTER
*      LINE IF SIGN1 IS POSITIVE, POINT LIES ABOVE CENTER LINE ....
*
             SIGN1 = ( YV(M) - Y(I) ) / DIFF1 * 1.2
             GO TO 200
  190        CONTINUE
             SIGN1 = 0
  200        CONTINUE
             DIFF2 = ABS ( YV(M+1) - Y(I) )
             IF ( DIFF2 .LT. SMALL ) GO TO 210
*
*.... IF SIGN2 IS NEGATIVE, SECOND DATA POINT LIES BELOW CENTER
*     LINE IF SIGN2 IS POSITIVE, POINT IS ABOVE CENTER LINE ....
*
```

INTERP

```
                SIGN2 = ( YV ( M + 1 ) - Y ( I ) ) / DIFF2 * 1.2
                GO TO 220
 210            CONTINUE
                SIGN2 = 0
 220            CONTINUE
*
*.... IF BOTH DATA POINTS ARE BELOW CENTER LINE, LOOP AGAIN ....
*
                IF ( SIGN1 .EQ. SIGN2 .AND. SIGN1 .EQ. -1 ) GO TO 230
                GO TO 240
 230        CONTINUE
 240        CONTINUE
*
*.... DOES CENTER LINE LIE VERY CLOSE TO DATA POINT ....
*
            IF ( SIGN1 .EQ. 0 ) GO TO 250
            IF ( SIGN2 .EQ. 0 ) GO TO 260
*
*.... INTERPOLATE BETWEEN DATA POINTS FOR VALUE AT CENTER LINE ....
*
            PQUAL(I) = ( ( PVALUE ( M + 1 ) - PVALUE ( M ) )
     &                 * ( Y ( I ) - YV ( M ) ) /
     &                 ( YV ( M + 1 ) - YV ( M ) ) ) + PVALUE ( M )
            GO TO 180
 250        CONTINUE
*
*.... ASSIGN LOWER DATA POINT VALUE TO CENTER LINE ....
*
            PQUAL ( I ) = PVALUE ( M )
            GO TO 180
 260        CONTINUE
*
*.... ASSIGN UPPER DATA POINT VALUE TO CENTER LINE ....
*
            PQUAL ( I ) = PVALUE ( M + 1 )
            GO TO 180
 270        CONTINUE
            RETURN
            END
```

OUTVEL

```
      SUBROUTINE OUTVEL
*****************************************************************
*                                                               *
*      S U B R O U T I N E   O U T V E L                        *
*                                                               *
*****************************************************************
*
*.... THIS IS THE CONTROL MODULE FOR THE COMPUTATION PORTION OF
*     THIS PROGPAM ....
*
      COMMON / DD / WTHETA (5), WANGLE
      COMMON / EE / NPORTS, QPORT, QWEIR, QPLOT, QPWEIR
      COMMON / FF / PVDIM (5), PHGT (5), FLOW (5), PHDIM (5)
      COMMON / GG / COEF, QSUB, QQUAL
      COMMON / HH / WRLNG, WRHGT, WRFLOW
      COMMON / II / NUMD, DEN (100), YD (100), QDEN, DENPRT
      COMMON / JJ / NUMT, QCENT, TEMP(100), YT (100), QTEMP
      COMMON / KK / NQUAL, NUMQ (4), NAMEQ (5,4),
     &              QUAL (4,100), YQ (4,100)
      COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
      COMMON / MM / SUMOUT,  VEL (100), FLORAT
      COMMON / NN / HGTPRT, VDIM, QTLIM, QBLIM, QSINK1,
     &              QSINK2, QSHIFT
      COMMON / OO / LENGTH, CREST, HDIM
      COMMON / PP / LOWLIM, TOPLIM, HGTLOW, HGTTOP, V (100), VM
      COMMON / QQ / VS (100,6), NOUTS
      COMMON / RR / ZUP (6), ZDN (6), LTOP (6), LLOW (6)
      COMMON / SS / WTHDRW (100), DENOUT, TEMOUT, QALOUT (4)
      COMMON / TT / QVENT, QAERA, QTWFUN, TWEL
*
      INTEGER TOPLIM
*
      LOGICAL QPORT, QWEIR, QSUB, QTEMP, QPWEIR
*
      REAL LENGTH
*
      CHARACTER*4 XDUMY, XDUMY1, XDUMY2, XDUMY3, NAMEQ
      CHARACTER*6 SUBR
*
      DATA XDUMY, XDUMY1, XDUMY2, XDUMY3 / 4 * '0   ' /
      DATA SUBR / 'OUTVEL' /
*
      LAYER ( X ) = 1. + X / DELZ
      NOUTS = NPORTS
      IF ( QWEIR ) NOUTS = NOUTS + 1
*
*.... INITIALIZE THE TOTAL OUTFLOW FLOW RATE PROFILE ....
*
      DO 100 I = 1, ISURF
         VEL (I) = 0.0
```

```
 100     CONTINUE
         SUMOUT = 0.0
*
*.... DETERMINE TYPE OF WITHDRAWAL ....
*
         IF ( QPORT ) GO TO 110
         IF ( QWEIR ) GO TO 140
*
*.... SELECTIVE WITHDRAWAL FOR ORIFICE FLOW ....
*
 110     CONTINUE
         DO 130 K = 1, NPORTS
*
*.... VARIABLE ASSIGNMENTS ....
*
            QPWEIR = .FALSE.
            FLORAT= FLOW(K)
            IF ( FLORAT .LE. 0. )
     &           CALL ERROR ( 1400   , SUBR, XDUMY, XDUMY1, XDUMY2,
     &                        XDUMY3 )
            SUMOUT = SUMOUT + FLORAT
            VDIM = PVDIM(K)
            HDIM = PHDIM(K)
            HGTPRT = PHGT(K)
            IF ( HGTPRT .GE. DEPTH )
     &           CALL ERROR ( 1410   , SUBR, XDUMY, XDUMY1, XDUMY2,
     &                        XDUMY3 )
            DENPRT = DENINT ( HGTPRT )
            WANGLE = WTHETA ( K )
*
*.... CHECK FOR PARTIALLY SUBMERGED PORT ....
*
            FLODEP = DEPTH - HGTPRT + VDIM/2.
            IF ( VDIM .LE. FLODEP ) GO TO 115
            VW = FLORAT / ( FLODEP * HDIM )
            VHL = ( VW * FLODEP ** .5 ) / HDIM
            IF ( VHL .GT. 0.5 ) GO TO 115
*
*.... PARTIALLY SUBMERGED PORT - TREAT AS A WEIR ....
*
            QPWEIR = .TRUE.
            QSUB = .TRUE.
            LENGTH = HDIM
            CREST = HGTPRT - VDIM/2.
*
            CALL VWEIR
*
            GO TO 116
 115        CONTINUE
*
```

OUTVEL

```
*.... FULLY SUBMERGED PORT ....
*
            CALL VPORT
*
 116        CONTINUE
*
*.... ASSIGN FLOW RATE PROFILE VALUES CALCULATED IN VPORT
*     OR VWEIR TO AN ARRAY ....
*
            DO 120 I = 1, ISURF
               VS(I,K) = V(I)
 120        CONTINUE
*
*.... ASSIGN WITHDRAWAL LIMIT VALUES TO AN ARRAY ....
*
            ZUP  ( K ) = HGTTOP
            ZDN  ( K ) = HGTLOW
            LTOP ( K ) = TOPLIM
            LLOW ( K ) = LOWLIM
 130     CONTINUE
 140     CONTINUE
         IF ( .NOT. QWEIR ) GO TO 160
*
*.... SELECTIVE WITHDRAWAL FOR WEIR FLOW ....
*
         FLORAT = WRFLOW
         SUMOUT = SUMOUT + FLORAT
         IF ( FLORAT .LE. 0.)
     &        CALL ERROR ( 1420  , SUBR, XDUMY, XDUMY1, XDUMY2,
     &                     XDUMY3 )
         LENGTH = WRLNG
         CREST  = WRHGT
*
*.... DETERMINE WITHDRAWAL LIMITS AND FLOW RATE PROFILES ....
*
         CALL VWEIR
*
*.... ASSIGN FLOW RATE PROFILE VALUES CALCULATED IN VWEIR TO AN
*     ARRAY ....
*
         DO 150 I = 1, ISURF
            VS(I,NOUTS) = V(I)
 150     CONTINUE
*
*.... ASSIGN WITHDRAWAL LIMIT VALUES TO ARRAY ....
*
         ZUP  ( NOUTS ) = HGTTOP
         ZDN  ( NOUTS ) = HGTLOW
         LTOP ( NOUTS ) = TOPLIM
         LLOW ( NOUTS ) = LOWLIM
```

OUTVEL

```
 160     CONTINUE
*
*.... IF MUTIPLE OUTLETS CALL SHIFT ....
*
         IF ( NOUTS .GT. 1 ) CALL SHIFT
*
*.... DETERMINE TOTAL OUTFLOW FLOW RATE DISTRIBUTION ....
*
         DO 180 I = 1, ISURF
         DO 170 J = 1, NOUTS
            VEL ( I ) = VEL ( I ) + VS ( I , J )
 170     CONTINUE
 180     CONTINUE
*
*.... FIND MAXIMUM LAYER FLOW RATE ....
*
         VMAX = VEL ( LOWLIM )
         DO 185 I = 1, ISURF
            VMAX = AMAX1 ( VMAX, VEL ( I ) )
 185     CONTINUE
*
*.... ASSIGN LAYER FLOW RATES TO WTHDRW(I) ....
*
         DO 190 I = 1, ISURF
            WTHDRW ( I ) = VEL ( I ) * HGT ( I )
 190     CONTINUE
         DO 200 I = 1, ISURF
            VEL ( I ) = VEL ( I ) / VMAX
 200     CONTINUE
*
*.... COMPUTE THE RELEASE DENSITY ....
*
         SUMDF = 0.
         DO 210 I = 1, ISURF
            SUMDF = SUMDF + DEN ( I ) * WTHDRW ( I )
 210     CONTINUE
         DENOUT = SUMDF / SUMOUT
*
*.... COMPUTE RELEASE TEMPERATURE ....
*
         IF ( .NOT. QTEMP ) GO TO 230
         SUMTF = 0.
         DO 220 I = 1, ISURF
            SUMTF = SUMTF + TEMP ( I ) * WTHDRW ( I )
 220     CONTINUE
         TEMOUT = SUMTF / SUMOUT
 230     CONTINUE
*
*.... COMPUTE RELEASE QUALITIES ....
*
```

OUTVEL

```
      IF ( NQUAL .EQ. 0 ) GO TO 260
      DO 250 J = 1, NQUAL
         SUMQF = 0.
         DO 240 I = 1, ISURF
            SUMQF = SUMQF + QUAL(J,I) * WTHDRW ( I )
  240    CONTINUE
         QALOUT ( J ) = SUMQF / SUMOUT
  250 CONTINUE
  260 CONTINUE
      RETURN
      END
```

SHIFT

```
        SUBROUTINE SHIFT
*****************************************************************
*                                                               *
*       S U B R O U T I N E   S H I F T                         *
*                                                               *
*****************************************************************
*
*.... THIS SUBROUTINE SHIFTS THE INNER WITHDRAWAL LIMITS WHEN TWO
*     WITHDRAWAL ZONES OVERLAP ....
*
        COMMON / AA / QMETR, NSETS, G, HEADING(18), TITLE(18)
        COMMON / BB / IFILE, KFILE
        COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
        COMMON / EE / NPORTS, QPORT, QWEIR, QPLOT, QPWEIR
        COMMON / FF / PVDIM (5), PHGT (5), FLOW (5), PHDIM (5)
        COMMON / II / NUMD, DEN (100), YD (100), QDEN, DENPRT
        COMMON / HH / WRLNG, WRHGT, WRFLOW
        COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
        COMMON / MM / SUMOUT, VEL(100), FLORAT
        COMMON / NN / HGTPRT, VDIM  , QTLIM, QBLIM, QSINK1,
     &                QSINK2, QSHIFT
        COMMON / OO / LENGTH, CREST, HDIM
        COMMON / PP / LOWLIM, TOPLIM, HGTLOW, HGTTOP, V (100), VM
        COMMON / QQ / VS (100,6), NOUTS
        COMMON / RR / ZUP (6), ZDN (6), LTOP (6), LLOW (6)
*
        LOGICAL QPORT , QWEIR , QSBLIM, QSTLIM, QBLIM,
     &          Q1    , Q2    , QTLIM
        LOGICAL QPRINT, QSINK1, QSINK2, QSHIFT
*
        INTEGER TOPLIM, XXX
*
        CHARACTER*4 XDUMY, XDUMY1, XDUMY2, XDUMY3
        CHARACTER*6 SUBR
*
        DATA MAX                              / 10       /
        DATA TINY                             / 1.E-07   /
        DATA QPRINT                           / .TRUE.   /
        DATA XDUMY, XDUMY1, XDUMY2, XDUMY3 / 4*'0     ' /
        DATA SUBR                             / 'SHIFT'  /
*
*.... LAYER NO. LOCATION OF X ....
*
        LAYER ( X ) = 1. + X / DELZ
        FROUD ( X, D, ZL ) = SQRT ( G * ABS ( 1. -
     &                       DENINT ( X ) / D ) * ABS ( X - ZL ) )
*
*.... BASED ON BOHAN AND GRACE ....
*
        FSHIFT ( VH, X, D, ZL ) = VH - HTEST * FROUD ( X, D, ZL)
```

SHIFT

```
      *
      *.... TOLERANCE, 10% OF THE LAYER THICKNESS ....
      *
            SMALL = .10 * DELZ
      *
      *.... INITIALIZE LOGICAL VARIABLE ....
      *
            QSTLIM = .FALSE.
            QSBLIM = .FALSE.
            QBLIM  = .FALSE.
            QTLIM  = .FALSE.
            QSHIFT = .FALSE.
      *
      *.... CHECK FOR OVERLAP OF WITHDRAWAL ZONES. IS LOWER LIMIT OF
      *     UPPER PORT BELOW UPPER LIMIT OF LOWER PORT ....
      *
            NMINUS = NOUTS - 1
            DO 260 K = 1, NMINUS
            H = ZDN ( K + 1 ) - ZUP ( K )
            IF ( H .GE. 0. ) GO TO 260
      *
      *.... SET UP PARAMETERS FOR SHIFTING LIMITS ....
      *
            H  = ABS ( H )
            IF ( QWEIR .AND. K .EQ. NOUTS - 1 ) GO TO 100
            HO = PHGT ( K + 1 ) - PHGT ( K )
            GO TO 110
        100 CONTINUE
      *
      *.... ZONES FROM WEIR AND A PORT OVERLAP ....
      *
            HO    = CREST - PHGT(K)
        110 CONTINUE
            HTEST = .7 * ( H / HO ) ** 1.25
            VH1   = 0.
            VH2   = 0.
      *
      *.... K + 1 IS THE UPPER PORT, K IS THE LOWER PORT ....
      *
            L1 = LLOW ( K + 1 )
            L2 = LTOP ( K     )
      *
      *.... NUMBER OF LAYERS BETWEEN OVERLAPPING LIMITS, INCLUSIVE ...
      *
            LAY = L2 - L1 + 1
            DO 120 I = L1, L2
      *
      *.... DETERMINE AVERAGE VELOCITY IN OVERLAPPING REGION ....
      *
            VH1 = VH1 + VS ( I , K      )
```

SHIFT

```
                  VH2 = VH2 + VS ( I , K + 1 )
      120         CONTINUE
                  VH1 = VH1 / LAY
                  VH2 = VH2 / LAY
      *
      *.... CALCULATE DENSITIES AT LIMITS ....
      *
                  DENS2 = DENINT ( ZUP ( K     ) )
                  DENS1 = DENINT ( ZDN ( K + 1 ) )
      *
      *.... LIMIT VARIABLES REASSIGNED ....
      *
                  ZL2 = ZUP ( K     )
                  ZL1 = ZDN ( K + 1 )
      *
      *.... CHECK FOR INTERFERENCE FROM SURFACE OR BOTTOM ....
      *
                  QSTLIM = FSHIFT ( VH1, DEPTH, DENS2, ZL2 ) .GE. 0.
                  QSBLIM = FSHIFT ( VH2, 0., DENS1, ZL1 ) .GE. 0.
                  IF ( .NOT. QSTLIM ) GO TO 125
      *
      *.... SOLVE FOR THE SHIFTED LIMIT ....
      *
      *.... CHECK FIRST FOR DENSITY DIFFERENCE
      *     BETWEEN THE PORT AND THE SURFACE ....
      *
                  IF ( ABS ( DEN ( ISURF ) - DENINT ( PHGT ( K ) ) ) .GT.
           &                  TINY ) GO TO 125
                  ZUP ( K ) = DEPTH
                  GO TO 175
      125         CONTINUE
      *
      *.... DETERMINE FUNCTION SIGN AT EACH SEARCH LIMIT AND ORIGINAL
      *     UPPER LIMIT OF LOWER PROFILE IF THE FUNCTION SIGN IS
      *     POSITIVE , ASSUMED AMOUNT OF SHIFT IS LESS THAN ACTUAL
      *     AMOUNT OF SHIFT; IF FUNCTION SIGN IS NEGATIVE, ASSUMED AMOUNT
      *     OF SHIFT IS GREATER THAN ACTUAL AMOUNT OF SHIFT ....
      *
                  KOUNT = 0
                  X1 = DEPTH
      130         CONTINUE
                  KOUNT = KOUNT + 1
                  IF ( KOUNT .GE. 5 ) GO TO 135
                  X2 = ZUP ( K )
                  F2 = FSHIFT ( VH1, X2, DENS2, ZL2 )
                  Q2 = F2 .GT. 0.
                  X1 = X1 * 2.0
                  F1 = FSHIFT ( VH1, X1, DENS2, ZL2 )
                  Q1 = F1 .GE. 0.
                  X3 = -2. * SMALL
```

SHIFT

```
      *
      *.... FUNCTION SIGN MUST BE POSITIVE AT THE ORIGINAL LIMIT AND
      *     NEGATIVE AT THE NEW LIMIT, ELSE CHOOSE NEW LIMIT, X1,
      *     2 TIMES GREATER ....
      *
            IF ( Q1 .OR. .NOT. Q2 ) GO TO 130
            ASSIGN 170 TO XXX
            GO TO 140
  135       CONTINUE
      *
      *.... IF THEORETICAL SHIFTED UPPER LIMIT IS NOT FOUND, IT IS
      *     ASSIGNED TO 2 * DEPTH AND NOTED IN THE OUTPUT ....
      *
            IF ( QPRINT ) WRITE ( KFILE, 500 )
            QPRINT= .FALSE.
            WRITE ( KFILE, 505 ) K
            WRITE ( KFILE, 510 )
            X3 = 2 * DEPTH
            GO TO 170
  140       CONTINUE
      *
      *.... INITIATE ITERATION PROCESS ....
      *
            DO 160 I = 1, MAX
      *
      *.... ESTABLISH A THIRD POINT BETWEEN TWO EXISTING POINTS ....
      *
            X4 = X3
            X3 = ( X1 + X2 ) / 2.
      *
      *.... CALCULATE FUNCTION SIGN AT NEW ELEVATION ....
      *
            F3 = FSHIFT ( VH1, X3, DENS2, ZL2 )
      *
      *.... IF NEW POINT IS THE SAME AS THE PREVIOUS POINT, THEN SEARCH
      *     IS COMPLETE ....
      *
            IF ( ABS ( X4 - X3 ) .LT. SMALL ) GO TO XXX, ( 170, 200 )
      *
      *.... USE AS NEW SEARCH LIMITS THE MOST RECENTLY COMPUTED POINT
      *     AND THE REMAINING POINT OF OPPOSITE SIGN ....
      *
            IF ( F1 * F3 .GT. 0. ) GO TO 150
            X2 = X3
            F2 = F3
            GO TO 160
  150       CONTINUE
            X1 = X3
            F1 = F3
  160       CONTINUE
```

SHIFT

```
*
*.... CONVERGENCE HAS NOT BEEN REACHED ....
*
            CALL ERROR ( 1800, SUBR, XDUMY, XDUMY1, XDUMY2, XDUMY3 )
  170       CONTINUE
*
*.... SET UP SHIFTED UPPER LIMIT OF LOWER PROFILE ....
*
            ZUP ( K ) = X3
  175       CONTINUE
            IF ( .NOT. QSBLIM ) GO TO 180
*
*.... CHECK DENSITY STRUCTURE FOR LOWER LIMIT OF UPPER PORT ....
*
            IF ( ABS ( DEN ( 1 ) - DENINT ( PHGT ( K + 1 ) ) )
     &                  .GT. TINY ) GO TO 180
            ZDN( K + 1 ) = 0.
            GO TO 210
  180       CONTINUE
*
*.... DETERMINE FUNCTION SIGN AT SEARCH LIMITS (1) BOTTOM
*     (2) ORIGINAL LOWER LIMIT OF UPPER PROFILE ....
*
            X1 = - DEPTH / 2.
            KOUNT = 0
  185       CONTINUE
            KOUNT = KOUNT + 1
            IF ( KOUNT .GE. 5 ) GO TO 190
            X1 = X1 * 2.0
            F1 = FSHIFT ( VH2, X1, DENS1, ZL1 )
            Q1 = F1 .GE. 0.
            X2 = ZDN(K + 1)
            F2 = FSHIFT ( VH2, X2, DENS1, ZL1 )
            Q2 = F2 .GT. 0.
*
*.... FUNCTION VALUE MUST BE NEGATIVE AT BOTTOM AND POSITIVE AT
*     ORIGINAL LIMIT ....
*
            IF ( Q1 .OR. .NOT. Q2 ) GO TO 185
*
*.... IF LIMIT IS IN POOL, USE PRIOR SEARCH PROCEDURE ....
*
            ASSIGN 200 TO XXX
            GO TO 140
  190       CONTINUE
*
*.... IF LIMIT IS OUTSIDE THE POOL, ASSIGN IT TO DEPTH ....
*
            WRITE ( KFILE, 520 )
            X3 = - DEPTH
```

SHIFT

```
 200     CONTINUE
*
*.... SET SHIFTED LOWER LIMIT OF UPPER PROFILE ....
*
         ZDN ( K + 1 ) = X3
 210     CONTINUE
*
*.... COMPUTE NEW NORMALIZED VELOCITIES AND LAYER FLOW RATES FOR
*     LOWER HALF OF PROFILE ....
*
*.... ASSIGN LIMITS TO VARIABLES ....
*
         HGTLOW = ZDN   ( K      )
         LOWLIM = LAYER ( HGTLOW )
         HGTTOP = ZUP   ( K      )
         TOPLIM = LAYER ( HGTTOP )
         HGTPRT = PHGT  ( K      )
         FLORAT = FLOW  ( K      )
         QBLIM  = ZDN   ( K      ) .LE. 0.
         IF ( QSTLIM ) QTLIM = .TRUE.
*
*.... CALL VPORT TO RECALCULATE VELOCITIES ....
*
         QSHIFT = .TRUE.
         CALL VPORT
*
         QSHIFT   = .FALSE.
         DO 220 I = 1, ISURF
         VS ( I , K ) = V ( I )
 220     CONTINUE
*
*.... COMPUTE NEW NORMALIZED VELOCITIES AND LAYER FLOW RATES FOR
*     THE UPPER HALF OF THE PROFILE ....
*
*.... ASSIGN LIMITS TO VARIABLES ....
*
         HGTLOW = ZDN   ( K + 1  )
         LOWLIM = LAYER ( HGTLOW )
         HGTTOP = ZUP   ( K + 1  )
         TOPLIM = LAYER ( HGTTOP )
         IF ( QWEIR .AND. K .EQ. NOUTS - 1 ) GO TO 230
         HGTPRT = PHGT  ( K + 1  )
         FLORAT = FLOW  ( K + 1  )
         QTLIM  = ZUP   ( K + 1  ) .GE. DEPTH
         IF ( QSBLIM ) QBLIM = .TRUE.
         QSHIFT = .TRUE.
*
*.... CALL VPORT TO RECALCULATE VELOCITIES ....
*
         CALL VPORT
```

SHIFT

```
*
               QSHIFT = .FALSE.
               GO TO 240
  230          CONTINUE
*
*.... ASSIGN WEIR INFO TO VARIABLES ....
*
               CREST  = WRHGT
               LENGTH = WRLNG
               FLORAT = WRFLOW
               QTLIM  = .TRUE.
               IF ( QSBLIM ) QBLIM = .TRUE.
               QSHIFT = .TRUE.
*
*.... CALL VWEIR TO CALCULATE VELOCITIES ....
*
*.... CALL VWEIR ....
*
               QSHIFT = .FALSE.
  240          CONTINUE
               DO 250 I = 1, ISURF
                  VS ( I , K + 1 ) = V ( I )
  250          CONTINUE
  260          CONTINUE
  500          FORMAT ( 1H1 )
  510          FORMAT ( // , 5X, 29H*** THEORITICAL SHIFTED UPPER,
     &                  43H LIMIT NOT FOUND. ASSIGNED TO 2 * DEPTH ***)
  520          FORMAT ( // , 5X, 29H*** THEORETICAL SHIFTED LOWER,
     &                      41H LIMIT NOT FOUND. ASSIGNED TO - DEPTH ***)
  505          FORMAT ( // , 5X, 35H*** LOWER PORT FOR THIS CASE IS NO.,
     &                   I5, 5H  ***)
               RETURN
               END
```

VENTING

```
              SUBROUTINE VENTING
*****************************************************************
*                                                               *
*             S U B R O U T I N E   V E N T I N G               *
*                                                               *
*****************************************************************
*
*....   PREDICTS RESEASE D.O. BASED ON A MAXIMUM 30% REDUCTION
*       IN D.O. DEFICIT ....
*
              COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
              COMMON / SS / WTHDRW (100), DENOUT, TEMOUT, QALOUT (4)
              COMMON / TT / QVENT, QAERA, QTWFUN, TWEL
*
              LOGICAL QVENT, QAERA, QTWFUN
*
*....   D.O. SATURATION ....
*
              DOSAT ( X ) = 1 / ( 0.00209 * X + 0.06719 )
*
*....   ALTITUDE CORRECTION FACTOR ....
*
              BARO( X ) = 1.0 - 3.224 E-5 * X
*
*....   OXYGEN SATURATION CONCENTRATION ADJUSTED FOR ALTITUDE ....
*
              ALT = BOTTOM
              CSAT = DOSAT ( TEMOUT ) * BARO ( ALT )
*
*....   DEFICIT CALCULATIONS; DI = INITIAL DEFICIT,
*       DF = FINAL DEFICIT ....
*
              DI = CSAT - QALOUT ( 1 )
              DF = 0.70 * DI
              QALOUT ( 1 ) = CSAT - DF
              RETURN
              END
```

VPORT

```
      SUBROUTINE VPORT
****************************************************************
*                                                              *
*     S U B R O U T I N E   V P O R T                          *
*                                                              *
****************************************************************
*
*.... CALCULATE WITHDRAWAL LIMITS AND VELOCITY PROFILE FOR
*     AN ORIFICE ....
*
      COMMON / AA / QMETR, NSETS, G, HEADING (18), TITLE (18)
      COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
      COMMON / DD / WTHETA (5), WANGLE
      COMMON / II / NUMD, DEN (100), YD (100), QDEN, DENPRT
      COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
      COMMON / MM / SUMOUT, VEL (100), FLORAT
      COMMON / NN / HGTPRT, VDIM, QTLIM, QBLIM, QSINK1,
   &                QSINK2, QSHIFT
      COMMON / OO / LENGTH, CREST, HDIM
      COMMON / PP / LOWLIM, TOPLIM, HGTLOW, HGTTOP, V (100), VM
*
      LOGICAL  QBLIM, QTLIM, QMETR, QSINK1, QSINK2, QSHIFT
*
      INTEGER XXX , TOPLIM
*
      CHARACTER*4 XDUMY, XDUMY1, XDUMY2, XDUMY3
      CHARACTER*6 SUBR
*
      DATA  MAX, VMAX, TINY             / 10, 1., 1.0E-08 /
      DATA XDUMY, XDUMY1, XDUMY2, XDUMY3 / 4 * '0   '      /
      DATA SUBR                         / 'VPORT'         /
*
*.... FUNCTION STATEMENTS TO SOLVE FOR ORIFICE WITHDRAWAL LIMITS
*     FOR INTERMEDIATE FLOW CONDITIONS ....
*
      LAYER   ( X ) = 1. + X / DELZ
      ZEE     ( X ) = ABS ( HGTPRT - X )
      FROUD   ( X ) = SQRT ( G * ABS ( 1. - DENINT ( X )
   &                  / DENPRT ) )
*
*.... COMPUTE THE DIFFERENCE BETWEEN THE FLOW 'ENERGY' AND THE
*     ENERGY EXPENDED BASED ON BOHAN AND GRACE (1969), MODIFIED
*     TO INCLUDE WITHDRAWAL ANGLE CONCEPTS ....
*
      QBNG    ( X ) = FLORAT / PHIFRAC - C2 * FROUD ( X )
   &                  * ZEE ( X ) ** 2.5
*
*.... FUNCTION STATEMENTS TO SOLVE FOR THE UNBOUNDED WITHDRAWAL
*     LIMIT WHEN THERE IS BOTTOM OR SURFACE INTERFERENCE ....
*
```

VPORT

```
          DPRIME  ( X ) = ABS ( BONLIM - X )
          BDRATIO ( X ) = SMALLB / DPRIME ( X ) /
      &                   ( 1 - SMALLB / DPRIME ( X ) )
          FROUDE  ( X ) = SQRT ( G * ABS ( 1. - DENINT ( X )
      &                   / DENPRT ) / ZEE ( X ) )
          CHI     ( X ) = 1. / 2. * ( 1. + BDRATIO ( X ) )
          PHI     ( X ) = 1. / 2. * ( 1 + 1 / PI
      &                   * SIN ( BDRATIO ( X ) * PI ) +
      &                   BDRATIO ( X ) )
*
*.... COMPUTE THE DIFFERENCE BETWEEN THE FLOW 'ENERGY' AND THE
*     'ENERGY' EXPENDED BASED ON SMITH, ET AL (1985), EQN 36 ....
*
          QSMITH  ( X ) = FLORAT - C2 *  FROUDE ( X ) * PHI ( X )
      &                   / ( 2.0 * CHI ( X ) ) ** 3
      &                   * DPRIME ( X ) ** 3
*
*.... TOLERANCE, 10% OF LAYER THICKNESS ....
*
          SMALL = .10 * DELZ
*
*....  INITIALIZE LOGICAL VARIABLES ....
*
          QSINK1 = .TRUE.
          QSINK2 = .TRUE.
          QSHIFT = .FALSE.
*
*....  SET THE VALUE  OF THE ANGLE OF WITHDRAWAL COEFFICIENT
*      FOR THE BOUNDARY INTERFERENCE EQUATION ....
*
*.... CHECK TO SEE IF ENTERING FROM SUBROUTINE SHIFT ....
*
          IF ( QSHIFT ) GO TO 185
          PI      = 3.14159
          C2      = WANGLE / PI
          PHIFRAC = 1.0
*
*.... CHECK FOR BOUNDARY INTERFERENCE FROM SURFACE OR BOTTOM
*     USING INTERMEDIATE FLOW EQUATION ....
*
          DENBOT = DENINT ( 0.    )
          DENUPP = DENINT ( DEPTH )
          IF ( HGTPRT .GT. 0.0 ) THEN
               QBLIM  = QBNG   ( 0.     ) .GE. 0.
          ELSE
               QBLIM  = .TRUE.
          ENDIF
          QTLIM  = QBNG   ( DEPTH ) .GE. 0.
*
*.... DIRECT COMPUTATIONS BASED ON INTERFERENCE
```

VPORT

```
*     CHARACTERISTICS ....
*
         IF ( QTLIM .AND. QBLIM              ) GO TO 540
         IF ( QTLIM                          ) GO TO 500
         IF ( QBLIM                          ) GO TO 510
         IF ( .NOT. QTLIM .AND. .NOT. QBLIM ) GO TO 540
  500    CONTINUE
*
*....  IF ONLY ONE  BOUNDARY EXPERIENCES INTERFERENCE, FIND THE
*       HEIGHT OF WITHDRAWAL USING SMITH, 1987 ....
*
*.... DETERMINE THE HEIGHT OF THE TRUNCATED PORTION, THE BOUNDARY
*     LIMIT, THE SEARCH INTERVAL LIMITS, AND THE FUNCTION SIGN AT
*     THE SEARCH LIMITS ....
*
*.... SURFACE INTERFERENCE ....
*
         SMALLB = DEPTH - HGTPRT
         DENLIM = DENUPP
         BONLIM = DEPTH
         X1     = 0.
         X2     = DEPTH
         H1     = QSMITH ( X1 )
         GO TO 530
  510    CONTINUE
*
*.... BOTTOM INTERFERENCE ....
*
         SMALLB = HGTPRT
         DENLIM = DENBOT
         BONLIM = 0.
         X1     = 0.
         X2     = DEPTH
         H1     = 1.
  530    CONTINUE
*
*.... FIND THE LIMIT USING A HALF-INTERVAL SEARCH ....
*
*.... INITIALIZE X3 ....
*
         X3 = SMALL
*
*.... BEGIN ITERATION ....
*
         DO 560 I = 1, 2 * MAX
            X4 = X3
*
*.... ESTABLISH A THIRD POINT BETWEEN TWO EXISTING POINTS ....
*
            X3 = ( X1 + X2 ) / 2.0
```

VPORT

```
*
*.... CALCULATE FUNCTION SIGN AT NEW POINT ....
*
            H3 = QSMITH ( X3 )
            ZONED = ABS ( BONLIM - X3 )
*
*.... IF NEW POINT IS SAME AS PREVIOUS POINT (WITHIN TOLERANCE),
*     ITERATION IS COMPLETE ....
*
            IF ( ABS ( X4 - X3 ) .LT. SMALL ) GO TO 570
*
*.... USE AS NEW SEARCH LIMITS THE MOST RECENT POINT AND THE
*     REMAINING POINT OF OPPOSITE FUNCTION SIGN ....
*
            IF ( H1 * H3  .LT. 0. ) GO TO 535
            X1 = X3
            H1 = H3
            GO TO 560
  535       CONTINUE
            X2 = X3
  560     CONTINUE
*
*.... CONVERGENCE WAS NOT REACHED ....
*
          CALL ERROR ( 1500, SUBR, XDUMY, XDUMY1, XDUMY2, XDUMY3 )
  570     CONTINUE
          PHIFRAC = PHI ( X3 )
*
*....  CALCULATE WITHDRAWAL LIMIT ....
*
          IF ( QTLIM .AND. .NOT. QBLIM ) HGTLOW = DEPTH - ZONED
          IF ( QBLIM .AND. .NOT. QTLIM ) HGTTOP = ZONED
  540     CONTINUE
*
*.... USAGE FOR THE BOHAN AND GRACE EQUATION
*     1. NO BOUNDARY INTERFERENCE
*     2. BOTH BOUNDARIES INTERFERE WITH WITHDRAWAL ZONE
*     3. SINGLE BOUNDARY INTERFERENCE.  THEORETICAL LIMIT
*        OF ONE INTERFERED WITH MUST BE DETERMINED
*        (FREE LIMIT IS DETERMINED ABOVE WITH SMITH EQUATION) ....
*
          IF ( QTLIM .AND. .NOT. QBLIM  ) GO TO 150
*
*.... EMBARK ON DETERMINATION OF LOWER WITHDRAWAL LIMIT ....
*
*
*.... IF LOWER LIMIT IS WITHIN THE POOL THEN FIND IT WITH A
*     HALF-INTERVAL SEARCH ....
*
*.... INITIAL SEARCH LIMITS ARE X1 =0 AND X2 = HGTPRT ....
```

VPORT

```
*
            X1 = 0.0
*
*.... IF BOTTOM BOUNDARY INTERFERENCE EXISTS (LOWER LIMIT OUTSIDE
*     POOL), THEN X1 = - DEPTH ....
*
            IF ( QBLIM ) X1 = - DEPTH
            F1 = QBNG ( X1 )
            DENLIM = DENBOT
            X2 = HGTPRT
            X3 = -2. * SMALL
            ASSIGN 140 TO XXX
 110        CONTINUE
*
*.... INITIATE ITERATION PROCESS ....
*
            DO 130 I = 1, MAX
*
*.... ESTABLISH A THIRD POINT BETWEEN THE TWO EXISTING POINTS ....
*
               X4 = X3
               X3 = ( X1 + X2 ) / 2.
*
*.... CALCULATE FUNCTION SIGN AT NEW ELEVATION ....
*
               DENLIM = DENINT ( X3 )
               IF (  DENLIM .EQ. DENPRT ) GO TO XXX
               F3 = QBNG ( X3 )
*
*....  IF NEW POINT IS SAME AS PREVIOUS POINT (WITHIN TOLERANCE)
*      THEN SEARCH IS COMPLETE ....
*
               IF ( ABS ( X4 - X3 ) .LT. SMALL )
     &              GO TO XXX, ( 140, 170 )
*
*.... USE AS NEW SEARCH LIMITS THE MOST RECENTLY COMPUTED POINT AND
*     THE REMAINING POINT OF OPPOSITE SIGN
*
               IF ( F1 * F3 .GT. 0. ) GO TO 120
               X2 = X3
               GO TO 130
 120           CONTINUE
               X1 = X3
               F1 = F3
 130        CONTINUE
*
*.... CONVERGENCE HAS NOT BEEN REACHED ....
*
            CALL ERROR ( 1510, SUBR, XDUMY, XDUMY1, XDUMY2, XDUMY3 )
 140        CONTINUE
```

VPORT

```
*
*.... SET LOWER LIMIT ELEVATION ....
*
            HGTLOW = X3
  150       CONTINUE
            IF ( QBLIM .AND. .NOT. QTLIM ) GO TO 180
*
*.... APPLY SAME PROCEDURE FOR DETERMINING UPPER WITHDRAWAL LIMIT
*     FOR ORIFICE
*
*.... DETERMINE ELEVATION, LAYER AND FUNCTION SIGN AT SEARCH
*     LIMITS.  IF NIETHER LIMIT EXPERIENCES INTERFERENCE THE THE
*     INITIAL SEARCH LIMITS ARE X1 = HGTPRT AND X2 = DEPTH.
*     HOWEVER, IF SURFACE INTERFERENCE EXISTS ( UPPER LIMIT OUTSIDE
*     POOL ), THEN X2 = 2. * DEPTH ....
*
            X1 = HGTPRT
            X2 = DEPTH
            IF ( QTLIM )  X2 = 2 * DEPTH
            F1 = QBNG ( X1 )
*
*.... USE THE PRIOR SEARCH PROCEDURE ....
*
            ASSIGN 170 TO XXX
            DENLIM = DENUPP
            GO TO 110
  170       CONTINUE
            HGTTOP = X3
  180       CONTINUE
*
*.... CALCULATE LOCATION OF MAXIMUM VELOCITY AND THICKNESS OF
*     WITHDRAWAL LIMITS ....
*
  185       CONTINUE
            ZONE = HGTTOP - HGTLOW
            ZTOP = HGTTOP - HGTPRT
            ZLOW = HGTPRT - HGTLOW
*
*.... BASED ON BOHAN AND GRACE
*
            YVMAX = ZONE * ( SIN ( 1.57 * ZLOW / ZONE ) ) ** 2
*            YVMAX = HGTPRT
*
*.... HEIGHT ABOVE BOTTOM.  HARDWIRE TO PREVENT MAX VELOCITY
*     OUTSIDE THE POOL (HOWINGTON 9-25-91) ....
*
            XVMAX = YVMAX + HGTLOW
            IF ( XVMAX .LT. 0.0   ) XVMAX = 0.0
            IF ( XVMAX .GT. DEPTH ) XVMAX = DEPTH
            LVMAX = LAYER ( XVMAX )
```

VPORT

```
*
*.... MAXIMUM VELOCITY OUTSIDE THE POOL ....
*
          IF ( ( XVMAX .LT. 0. ) .OR. ( XVMAX .GT. DEPTH ) )
     &        CALL ERROR ( 1520  , SUBR, XDUMY, XDUMY1, XDUMY2,
     &                             XDUMY3 )
*
*.... ASSIGN DENSITIES AT LIMITS AND MAXIMUM VELOCITY ....
*
          DVMAX  = DENINT ( XVMAX  )
          DENLOW = DENINT ( HGTLOW )
          DENTOP = DENINT ( HGTTOP )
*
*.... WITHDRAWAL LAYER LIMITS ....
*
          IF ( HGTLOW .LT. 0.    ) LOWLIM = LAYER ( 0.     )
          IF ( HGTLOW .GE. 0.    ) LOWLIM = LAYER ( HGTLOW )
          IF ( HGTTOP .GE. DEPTH ) TOPLIM = ISURF
          IF ( HGTTOP .LT. DEPTH ) TOPLIM = LAYER ( HGTTOP )
*
*.... ZERO THE VELOCITY PROFILE FOR THE CURRENT PORT ....
*
          DO 190 I = 1, ISURF
            V ( I ) = 0.
 190      CONTINUE
*
*.... IF LOWER WITHDRAWAL LAYERS ARE OF CONSTANT DENSITY THEN
*     ASSIGN CONSTANT VELOCITY TO EACH LAYER ....
*
          DENDIF = DENLOW - DVMAX
          IF ( DENDIF .GT. 0. ) GO TO 210
          DO 200 I = LOWLIM, LVMAX
            V ( I ) = VMAX
 200      CONTINUE
          GO TO 240
 210      CONTINUE
*
*.... CALCULATE VELOCITY PROFILE FROM LAYER OF MAXIMUM VELOCITY
*     TO LOWER LIMIT ....
*
          IF ( LOWLIM .EQ. LVMAX ) GO TO 240
          DO 230 I = LOWLIM, LVMAX
            Y1 = DELZ * ( LVMAX - I )
            DELDEN = DEN ( I ) - DVMAX
*
*.... BASED ON BOHAN AND GRACE ....
*
            RATIO = Y1 * DELDEN / ( ZLOW * DENDIF )
            RATIO = AMIN1 ( 1., RATIO )
            V(I) = VMAX * ( 1. - RATIO ) ** 2.0
```

VPORT

```
 230      CONTINUE
 240      CONTINUE
*
*.... IF UPPER WITHDRAWAL LAYERS ARE OF CONSTANT DENSITY THEN
*     ASSIGN CONSTANT VELOCITY TO EACH LAYER ....
*
          DENDIF = DVMAX - DENTOP
          IF ( DENDIF .GT. 0. ) GO TO 260
          DO 250 I = LVMAX, TOPLIM
             V ( I ) = VMAX
 250      CONTINUE
          GO TO 290
 260      CONTINUE
*
*.... DETERMINE VELOCITY PROFILE FROM LAYER OF MAXIMUM VELOCITY
*     TO UPPER LIMIT ....
*
          IF ( LVMAX .EQ. TOPLIM ) GO TO 290
          DO 280 I = LVMAX, TOPLIM
             Y1 = DELZ * ( I - LVMAX )
             DELDEN = DVMAX - DEN ( I )
*
*.... BASED ON BOHAN AND GRACE ....
*
             RATIO = Y1 * DELDEN / ( ZTOP * DENDIF )
             RATIO = AMIN1 ( 1., RATIO )
             V(I) = VMAX * ( 1. - RATIO ) ** 2.0
 280      CONTINUE
 290      CONTINUE
*
*.... CONVERT NORMALIZED VELOCITIES TO FLOW RATES, I.E., DETERMINE
*     THE WITHDRAWAL FROM EACH LAYER ....
*
          SUM = 0.0
          DO 310 I = LOWLIM, TOPLIM
             SUM = SUM + V ( I ) *  HGT ( I )
 310      CONTINUE
          VM = FLORAT / SUM
          DO 320 I = LOWLIM, TOPLIM
             V ( I ) = V ( I ) * VM
 320      CONTINUE
*
*.... CHECK FOR POINT SINK DESCRIPTION ....
*
          VDIM2 = VDIM / 2.
          PRTTOP = HGTPRT + VDIM2
          VD2 = VDIM2
          IF ( PRTTOP .GT. DEPTH ) VD2 = DEPTH - HGTPRT
          IF ( PRTTOP .GT. DEPTH ) PRTTOP = DEPTH
          PRTBOT = HGTPRT - VDIM2
```

VPORT

```
              IF ( PRTBOT .LT. 0. .AND. PRTBOT .GT. -.1 ) PRTBOT = 0.
              DRPTOP = DENPRT - DENINT ( PRTTOP )
              DRPBOT = DENINT ( PRTBOT ) - DENPRT
      *
              DRTLIM = DENPRT - DENTOP
              DRBLIM = DENLOW - DENPRT
      *
              IF ( DRPBOT .LT. TINY ) DRPBOT = TINY
              IF ( DRPTOP .LT. TINY ) DRPTOP = TINY
              IF ( DRBLIM .LT. TINY ) DRBLIM = TINY
              IF ( DRTLIM .LT. TINY ) DRTLIM = TINY
              IF ( VDIM2  .LT. TINY ) VDIM2  = TINY
              IF ( VD2    .LT. TINY ) VD2    = TINY
      *
      *.... EMPIRICAL EQUATIONS FOR POINT SINK VERIFICATION
      *
              SINK1  = ( DRBLIM ) * ZLOW / ( DRPBOT * VDIM2 )
              SINK2  = ( DRTLIM ) * ZTOP / ( DRPTOP * VD2 )
              QSINK1 = SINK1 .GT. 3.0
              QSINK2 = SINK2 .GT. 3.0
              RETURN
              END
```

VWEIR

```
      SUBROUTINE VWEIR
***************************************************************
*                                                             *
*      S U B R O U T I N E   V W E I R                        *
*                                                             *
***************************************************************
*
*.... CALCULATE WITHDRAWAL LIMITS AND VELOCITY PROFILE FOR
*     WEIR FLOW ....
*
      COMMON / AA / QMETER, NSETS, G, HEADING(18), TITLE(18)
      COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
      COMMON / DD / WTHETA (5), WANGLE
      COMMON / GG / COEF, QSUB, QQUAL
      COMMON / II / NUMD, DEN (100), YD(100), QDEN, DENPRT
      COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
      COMMON / MM / SUMOUT, VEL (100), FLORAT
      COMMON / NN / HGTPRT, VDIM, QTLIM, QBLIM, QSINK1, QSINK2,
     &              QSHIFT
      COMMON / OO / LENGTH, CREST, HDIM
      COMMON / PP / LOWLIM, TOPLIM, HGTLOW, HGTTOP, V (100), VM
*
      LOGICAL QSUB, QMETER, QSHIFT, QBLIM, QTLIM, Q1, Q2, QZ
*
      REAL LENGTH
      INTEGER TOPLIM
*
      CHARACTER*4 XDUMY, XDUMY1, XDUMY2, XDUMY3
      CHARACTER*6 SUBR
*
      DATA A, B                             / 4.35 , -1.04 /
      DATA VMAX, ITMAX                      / 1.   , 10    /
      DATA XDUMY, XDUMY1, XDUMY2, XDUMY3    / 4 * '0    '  /
      DATA SUBR                             / 'VWEIR'      /
*
      LAYER ( X ) = 1 + X/DELZ
*
*.... FUNCTION STATEMENTS TO SOLVE FOR LOWER WITHDRAWAL LIMITS ....

*
      SIZE   ( X ) = ABS  ( CREST - X )
      RWEIR  ( Z ) = SQRT ( Z + HEAD  ) * ( 1. + Z / HEAD )
      R2WEIR ( Z ) = SQRT ( Z + HEAD  )
*
*.... BASED ON DORTCH AND WILHELMS ....
*
      FWEIR ( X ) = AVGVEL - ( C * RWEIR ( SIZE ( X ) ) *
     &              SQRT ( G * ABS ( 1. - DENINT (X) / WRDEN ))
     &              + D * R2WEIR ( SIZE(X) ) *
     &              SQRT ( G * ABS ( 1. - DENINT(X) / WRDEN ) )
```

VWEIR

```
      *
      *.... TOLERANCE, 10% OF THE LAYER THICKNESS ....
      *
            SMALL = 0.10 * DELZ
      *
      *.... CHECK TO SEE IF ENTERING VWEIR FROM SUBROUTINE SHIFT ....
      *
            IF ( QSHIFT ) GO TO 145
            IF ( QSUB   ) GO TO 85
      *
      *.... CALCULATE EXPONENT FOR USE WITH FREE WEIR ....
      *
            EXPNT = A + B * COEF
            IF ( ABS ( COEF - 3.00 ) .LT. .01 ) EXPNT = 1.5
            IF ( ABS ( COEF - 3.33 ) .LT. .01 ) EXPNT = 0.5
            IF ( ABS ( COEF - 4.10 ) .LT. .01 ) EXPNT = 0.2
       85   CONTINUE
            C = .54
            D = 0.
            QZ = .FALSE.
      *
      *.... CALCULATE AVERAGE VELOCITY OVER THE WEIR IN FT/SEC ....
      *
            VMAX = 1.
            HEAD = DEPTH - CREST
            AVGVEL = FLORAT / ( HEAD * LENGTH )
      *
      *.... CHECK FOR INTERFERENCE FROM BOTTOM. ASSUMED SURFACE
      *     INTERFERENCE ....
      *
        90  CONTINUE
            WRDEN = DENINT ( CREST )
            QBLIM = FWEIR  ( 0.     ) .GE. 0.
            QTLIM = .TRUE.
      *
      *.... EMBARK ON DETERMINATION OF LOWER WITHDRAWAL LIMIT ....
      *
            IF ( .NOT. QBLIM ) GO TO 100
      *
      *.... IF BOTTOM INTERFERENCE EXISTS THEN SET LOWER LIMIT
      *     AT THE BOTTOM ....
      *
            HGTLOW = 0.
            LOWLIM = 1
            GO TO 140
       100  CONTINUE
      *
      *.... IF LOWER LIMIT IS WITHIN THE POOL THEN FIND IT WITH A
      *     HALF-INTERVAL SEARCH ....
      *
```

VWEIR

```
*.... DETERMINE ELEVATION, LAYER, FUNCTION VALUE, AND FUNCTION SIGN
*     AT EACH SEARCH LIMIT X1 POOL BOTTOM AND X2 WEIR CREST ....
*
          X1 = 0.
          F1 = FWEIR ( X1 )
          Q1 = F1 .GT. 0.
          X2 = CREST
          F2 = AVGVEL
          Q2 = F2 .GT. 0.
          X3 = - 2. * SMALL
*
*.... FUNCTION MUST BE POSITIVE AT THE WEIR LEVEL AND NEGATIVE
*     AT THE BOTTOM ....
*
          IF ( Q1 .OR. .NOT. Q2 )
     &         CALL ERROR ( 1600   , SUBR, XDUMY, XDUMY1, XDUMY2,
     &                          XDUMY3 )
*
*.... INITIATE ITERATION PROCESS ....
*
          DO 120 I = 1, ITMAX
*
*.... ESTABLISH A THIRD POINT BETWEEN THE TWO EXISTING POINTS ....
*
          X4 = X3
          X3 = ( X1 + X2 ) / 2
*
*.... CALCULATE FUNCTION SIGN AT NEW ELEVATION ....
*
          F3 = FWEIR ( X3 )
*
*.... IF NEW POINT IS SAME AS PREVIOUS POINT (WITHIN TOLERANCE)
*     THEN SEARCH IS COMPLETE ....
*
          IF ( ABS ( X4 - X3 ) .LT. SMALL ) GO TO 130
*
*.... USE AS NEW SEARCH LIMITS THE MOST RECENTLY COMPUTED POINT
*     AND THE REMAINING POINT OF OPPOSITE SIGN
*
          IF ( F1 * F3 .GT. 0. ) GO TO 110
          X2 = X3
          F2 = F3
          GO TO 120
  110     CONTINUE
          X1 = X3
          F1 = F3
  120     CONTINUE
*
*     CONVERGENCE HAS NOT BEEN REACHED
*
```

VWEIR

```
              CALL ERROR ( 1610, SUBR, XDUMY, XDUMY1, XDUMY2, XDUMY3 )
      130     CONTINUE
*
*.... CHECK FOR ( Z + H ) / H LESS THAN 2.0.  IF TRUE, REASSIGN
*     COEFFICIENTS C AND D AND REPEAT ITERATION PROCESS
*
              IF ( QZ ) GO TO 136
              ZLOW = CREST - X3
              XCHECK = ( ZLOW + HEAD ) / HEAD
              IF ( XCHECK .GE. 2.0 ) GO TO 135
              C  = .78
              D  = .70
              QZ = .TRUE.
              GO TO 90
      135     CONTINUE
      136     CONTINUE
*
*.... SET LOWER LIMIT ELEVATION AND LAYER
*
              HGTLOW = X3
              LOWLIM = LAYER ( X3 )
      140     CONTINUE
*
*.... SET UPPER LIMIT AT SURFACE
*
      145     CONTINUE
              HGTTOP = DEPTH
              TOPLIM = ISURF
*
*.... CALCULATE LOCATION OF MAXIMUM VELOCITY
*
              ZONE = HGTTOP - HGTLOW
              ZLOW = CREST  - HGTLOW
*
*.... IF WEIR IS FREE, MAXIMUM VELOCITY IS AT THE SURFACE
*
              IF ( .NOT. QSUB ) YVMAX = ZONE
*
*     BASED ON BOHAN AND GRACE
*
              IF ( QSUB ) YVMAX = ZONE * SIN ( 1.57 * ZLOW / ZONE ) **2
*
*     COMPUTE THICKNESS OF WITHDRAWAL ZONE
*
*     HEIGHT OF MAX. VELOCITY ABOVE THE BOTTOM
*
              XVMAX = YVMAX + HGTLOW
*
*     LAYER NO. LOCATION OF MAX VELOCITY
*
```

VWEIR

```
            LVMAX - LAYER ( XVMAX )
      *
      *.... DENSITY AT LAYER OF MAX. VELOCITY ....
      *
            DVMAX - DENINT ( XVMAX )
      *
      *.... DETERMINE DISTANCE BETWEEN PORT ELEVATION AND LOWER AND
      *     UPPER LIMITS RESPECTIVELY ....
      *
            YLOW - DELZ * ( LVMAX - LOWLIM )
            YTOP - DELZ * ( TOPLIM - LVMAX )
      *
      *.... DETERMINE DENSITY AT LIMITS ....
      *
            DENLOW - DENINT ( HGTLOW )
            DENTOP - DENINT ( HGTTOP )
      *
      *.... CALCULATE MAXIMUM VELOCITY ....
      *
            VMAX - 1.
      *
      *.... ZERO THE VELOCITY PROFILE ....
      *
            DO 150 I - 1, ISURF
              V ( I ) - 0
        150 CONTINUE
      *
      *.... IF LOWER WITHDRAWAL LAYERS ARE OF CONSTANT DENSITY THEN
      *     ASSIGN CONSTANT VELOCITY TO EACH LAYER
      *
            IF ( LVMAX .EQ. LOWLIM ) GO TO 200
            DENDIF - DENLOW - DVMAX
            IF ( DENDIF .GT. 0  ) GO TO 170
            DO 160 I - LOWLIM, LVMAX
              V ( I ) - VMAX
        160 CONTINUE
            GO TO 200
        170 CONTINUE
      *
      *.... CALCULATE VELOCITY PROFILE FROM LAYER OF MAXIMUM VELOCITY
      *     TO LOWER LIMIT ....
      *
            DO 190 I - LOWLIM, LVMAX
            Y1 - DELZ * ( LVMAX - I )
            DELDEN - DEN ( I ) - DVMAX
            RATIO - Y1 * DELDEN / ( YLOW * DENDIF )
            RATIO - AMIN1 ( 1., RATIO )
            IF ( QBLIM ) GO TO 180
            P - 3.0
      *
```

VWEIR

```
      *.... IF WEIR IS SUBMERGED ....
      *
            IF ( QSUB ) V ( I ) = VMAX * ( 1. - RATIO ) ** P
      *
      *.... IF WEIR IS FREE ....
      *
            IF ( .NOT. QSUB ) V ( I ) = VMAX *
           &                         ( 1. - RATIO ** EXPNT )
            GO TO 190
  180       CONTINUE
      *
      *.... IF BOTTOM INTERFERENCE ....
      *
            V ( I ) = VMAX * ( 1. - RATIO ** 2 )
  190       CONTINUE
  200       CONTINUE
      *
      *.... IF FREE WEIR, GO TO 260 ....
      *
            IF ( .NOT. QSUB ) GO TO 260
      *
      *.... IF UPPER WITHDRAWAL LAYERS ARE OF CONSTANT DENSITY THEN
      *     ASSIGN CONSTANT VELOCITY TO EACH LAYER ....
      *
            IF ( LVMAX .EQ. TOPLIM ) GO TO 260
            DENDIF = DVMAX - DENTOP
            IF ( DENDIF .GT. 0. ) GO TO 220
            DO 210 I = LVMAX, TOPLIM
               V ( I ) = VMAX
  210       CONTINUE
            GO TO 250
  220       CONTINUE
      *
      *.... DETERMINE VELOCITY PROFILE FROM LAYER OF MAXIMUM VELOCITY
      *     TO UPPER LIMIT ....
      *
            DO 240 I = LVMAX, TOPLIM
               Y1      = DELZ * ( I - LVMAX )
               DELDEN  = DVMAX - DEN ( I )
               RATIO   = Y1 * DELDEN / ( YTOP * DENDIF )
               RATIO   = AMIN1 ( 1. , RATIO )
               V ( I ) = VMAX * ( 1. - RATIO ** 2 )
  240       CONTINUE
  250       CONTINUE
  260       CONTINUE
      *
      *.... CONVERT NORMALIZED VELOCITIES TO FLOW RATES, I.E.,
      *     DETERMINE WITHDRAWAL FROM EACH LAYER ....
      *
            SUM = 0.0
```

VWEIR

```
          DO 270 I = LOWLIM, TOPLIM
             SUM = SUM + V ( I ) * HGT ( I )
  270     CONTINUE
          VM = FLORAT / SUM
          DO 280 I = LOWLIM, TOPLIM
             V ( I ) = V ( I ) * VM
  280     CONTINUE
          RETURN
          END
```

XPRINT

```
      SUBROUTINE XPRINT
******************************************************************
*                                                                *
*     S U B R O U T I N E   X P R I N T                          *
*                                                                *
******************************************************************
*
*.... PRINTS OUTPUT INFORMATION ....
*
      COMMON / AA / QMETR, NSETS, G, HEADING (18), TITLE (18)
      COMMON / BB / IFILE, KFILE
      COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
      COMMON / DD / WTHETA (5), WANGLE
      COMMON / EE / NPORTS, QPORT, QWEIR, QPLOT, QPWEIR
      COMMON / FF / PVDIM (5), PHGT (5), FLOW (5), PHDIM (5)
      COMMON / HH / WRLNG, WRHGT, WRFLOW
      COMMON / II / NUMD, DEN (100), YD (100), QDEN, DENPRT
      COMMON / JJ / NUMT, QCENT, TEMP (100), YT (100), QTEMP
      COMMON / KK / NQUAL, NUMQ (4), NAMEQ (5,4),
     &              QUAL (4, 100), YQ (4, 100)
      COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
      COMMON / MM / SUMOUT, VEL (100), FLORAT
      COMMON / NN / HGTPRT, VDIM, QTLIM, QBLIM, QSINK1,
     &              QSINK2, QSHIFT
      COMMON / QQ / VS (100, 6), NOUTS
      COMMON / RR / ZUP (6), ZDN (6), LTOP (6), LLOW (6)
      COMMON / SS / WTHDRW (100), DENOUT, TEMOUT, QALOUT (4)
*
      CHARACTER*4 HEADING, TITLE, NAMEQ
*
      LOGICAL QMETR, QPORT, QWEIR, QCENT, QTEMP, QPLOT
      LOGICAL QSINK1, QSINK2, QPWEIR
*
      CHARACTER*6 XMETERS, DIST
      CHARACTER*4 XFEET
*
      DATA XFEET, XMETERS / 'FEET', 'METERS' /
*
      TEMFUN ( T ) = 9. / 5. * T + 32.
*
*.... PRINT HEADINGS AND SUMMARY INFORMATION ....
*
      WRITE ( KFILE, 510 ) TITLE
      WRITE ( KFILE, 520 ) HEADING
*
*.... UNITS ....
*
      DIST = XFEET
      IF ( QMETR ) DIST = XMETERS
      WRITE ( KFILE, 500 ) DIST
```

XPRINT

```
             IF ( .NOT. QPORT ) GO TO 110
      *
      *.... PORT INFORMATION ....
      *
             DO 100 L = 1, NPORTS
                PELEV = PHGT(L) + BOTTOM
                WRITE ( KFILE, 530 ) PELEV, PVDIM ( L ), FLOW ( L ),
          &                          WTHETA ( L )
  100        CONTINUE
  110        CONTINUE
      *
      *.... WEIR INFORMATION ....
      *
             IF ( QWEIR ) WELE = WRHGT + BOTTOM
             IF ( QWEIR ) WRITE ( KFILE, 540 ) WELE, WRLNG, WRFLOW
      *
      *.... FLOW RATE INFORMATION ....
      *
             WRITE ( KFILE, 550 ) SUMOUT
      *
      *.... WITHDRAWAL LIMIT INFORMATION ....
      *
      *.... THEORETICAL LIMITS ....
      *
             ZUPEL = ZUP ( NOUTS ) + BOTTOM
             ZDNEL = ZDN (     1 ) + BOTTOM
      *
      *.... ACTUAL LIMITS ....
      *
             AWLUPP = AMIN1 ( DEPTH, ZUP ( NOUTS ) )
             AWLBOT = AMAX1 ( 0.0  , ZDN ( 1     ) )
             AZUPEL = AWLUPP + BOTTOM
             AZDNEL = AWLBOT + BOTTOM
             WRITE ( KFILE, 555 ) AWLBOT       , AZDNEL
             WRITE ( KFILE, 560 ) ZDN ( 1     ), ZDNEL
             WRITE ( KFILE, 565 ) AWLUPP       , AZUPEL
             WRITE ( KFILE, 570 ) ZUP ( NOUTS ), ZUPEL
      *
      *.... RELEASE DENSITY ....
      *
             WRITE ( KFILE, 580 ) DENOUT
             IF ( .NOT. QTEMP ) GO TO 120
      *
      *      RELEASE TEMPERATURE ....
      *
             IF ( .NOT. QCENT ) TEMOUT = TEMFUN ( TEMOUT )
             WRITE ( KFILE, 590 ) TEMOUT
             CONTINUE
                NQUAL .EQ. 0 ) GO TO 130
```

XPRINT

```
      *.... RELEASE QUALITY PARAMETER VALUE ....
      *
               WRITE( KFILE, 600 ) ( ( NAMEQ ( NM, J ), NM = 1, 5 ),
           &                               QALOUT ( J ), J = 1, NQUAL )
       130     CONTINUE
      *
      *.... PORT MODELED AS WEIR ....
      *
               IF ( QPWEIR ) WRITE ( KFILE, 607 )
      *
      *.... POINT SINK VERIFICATION INFORMATION ....
      *
               IF ( .NOT. QSINK1 ) WRITE ( KFILE, 605 )
               IF ( .NOT. QSINK2 ) WRITE ( KFILE, 606 )
      *
      *.... PRINT TABULAR INFORMATION ....
      *
                  IF ( .NOT. QTEMP .AND. NQUAL .EQ. 0 ) THEN
                     WRITE ( KFILE, 610 )
                  ELSEIF ( QTEMP .AND. NQUAL .EQ. 0 ) THEN
                     WRITE ( KFILE, 620 )
                  ELSEIF ( .NOT. QTEMP .AND. NQUAL .GT. 0 ) THEN
                     WRITE ( KFILE, 630 ) ( ( NAMEQ ( NM , J ), NM = 1, 3 ),
           &                                   J = 1, NQUAL )
                  ELSE
                     WRITE ( KFILE, 635 ) ( ( NAMEQ ( NM , J ), NM = 1, 3 ),
           &                                   J = 1, NQUAL )
                  ENDIF
      *
               DO 170 I = 1, ISURF, INTER
                  K = ISURF - I + 1
                  ELEV = Y ( K ) + BOTTOM
                  DEEP = SURFACE - ELEV
      *
      *.... ELEVATION, DENSITIES, NORMALIZED VELOCITY, AND
      *     LAYER WITHDRAWAL ....
      *
                  IF ( .NOT. QTEMP .AND. NQUAL .EQ. 0 ) THEN
                     WRITE ( KFILE, 640 ) ELEV, DEEP, DEN ( K ),
           &                 VEL ( K ), WTHDRW ( K )
                  ELSEIF ( QTEMP .AND. NQUAL .EQ. 0 ) THEN
                     IF ( .NOT. QCENT ) TEMP ( K ) = TEMFUN ( TEMP ( K ) )
                     WRITE ( KFILE, 650 ) ELEV, DEEP, DEN ( K ),
           &                 VEL ( K ), WTHDRW ( K ), TEMP ( K )
                  ELSEIF ( .NOT. QTEMP .AND. NQUAL .GT. 0 ) THEN
                     WRITE ( KFILE, 660 ) ELEV, DEEP, DEN ( K ),
           &                 VEL ( K ), WTHDRW ( K ),
           &                 ( QUAL ( J , K ), J = 1, NQUAL )
                  ELSE
                     WRITE ( KFILE, 670 ) ELEV, DEEP, DEN ( K ),
```

XPRINT

```
         &              VEL ( K ), WTHDRW ( K ), TEMP ( K ) ,
         &              ( QUAL ( J , K ), J = 1, NQUAL )
                     ENDIF
  170             CONTINUE
*
*.... PLOT DENSITY AND VELOCITY PROFILES ....
*
                  CALL DVPLOT
*
                  RETURN
  500             FORMAT ( // 20X, 12HUNITS ARE IN, 1X, A6 )
  510             FORMAT ( 1H1 // 8X, 18A4 )
  520             FORMAT ( //// 8X, 18A4 )
  530             FORMAT ( // 20X, 14HPORT ELEVATION, 2X, F9.3 / 20X,
         &             23HPORT VERTICAL DIMENSION, 2X, F10.3 / 20X,
         &             31HDISCHARGE, VOLUME FLOW PER SEC., 2X, F11.4
         &             / 20X, 21HWITHDRAWAL ANGLE, RAD, 2X , F6.4 )
  540             FORMAT ( // 20X, 20HWEIR CREST ELEVATION, 2X, F9.3 /
         &             20X, 11HWEIR LENGHT, 2X, F10.3 / 20X,
         &             31HDISCHARGE, VOLUME FLOW PER SEC., 2X, F11.4 )
  550             FORMAT ( /// 20X, 31HTOTAL DISCHARGE, VOLUME PER SEC,
         &             2X, F11.4 )
  555             FORMAT ( // 20X, 33HLOWER WITHDRAWAL LIMIT ( ACTUAL ),
         &             20H HEIGHT ABOVE BOTTOM, 7X, F9.3, 4X,
         &             9HELEVATION, 2X, F9.3 )
  560             FORMAT ( 20X, 38HLOWER WITHDRAWAL LIMIT ( THEORETICAL ),
         &             20H HEIGHT ABOVE BOTTOM, 2X, F9.3, 4X,
         &             9HELEVATION, 2X, F9.3 )
  565             FORMAT ( 20X, 33HUPPER WITHDRAWAL LIMIT ( ACTUAL ),
         &             20H HEIGHT ABOVE BOTTOM, 7X, F9.3, 4X,
         &             9HELEVATION, 2X, F9.3 )
  570             FORMAT ( 20X, 38HUPPER WITHDRAWAL LIMIT ( THEORETICAL ),
         &             20H HEIGHT ABOVE BOTTOM, 2X, F9.3, 4X,
         &             9HELEVATION, 2X, F9.3 )
  580             FORMAT ( 20X, 15HOUTFLOW DENSITY, 2X, F7.5, 2X, 4HG/CC )
  590             FORMAT ( 20X, 19HOUTFLOW TEMPERATURE, 2X, F6.2 )
  600             FORMAT ( 20X, 24HOUTFLOW CONCENTRATION OF, 1X, 5A4,
         &             2X, F8.2 )
  605             FORMAT ( /, 20X, 10H**********, 5X, 18HWARNING-POINT SINK,
         &             41HDESCRIPTION NOT ADEQUATE FOR LOWER LIMIT, 5X,
         &             10H********** )
  606             FORMAT ( /, 20X, 10H**********, 5X, 18HWARNING-POINT SINK,
         &             41H DESCRIPTION NOT ADEQUATE FOR UPPER LIMIT, 5X,
         &             10H********** )
  607             FORMAT ( /, 20X, 5H*****, 3X, 'PARTIALLY SUBMERGED',
         &             ' PORT RESPONDED AS A WEIR FOR THIS CONDITION',
         &             ' SO VWEIR WAS USED' )
  610             FORMAT ( 1H1 // 2X, 9HELEVATION, 3X, 5HDEPTH, 4X,
         &             7HDENSITY, 3X, 10HNORM. VEL., 4X, 4HFLOW )
  620             FORMAT ( 1H1 // 2X, 9HELEVATION, 3X, 5HDEPTH, 4X,
```

XPRINT

```
     &          7HDENSITY, 3X, 10HNORM. VEL., 4X, 4HFLOW,
     &          13X, 11HTEMPERATURE )
 630      FORMAT ( 1H1 // 2X, 9HELEVATION, 3X, 5HDEPTH, 4X,
     &          7HDENSITY, 3X, 10HNORM. VEL., 4X, 4HFLOW,
     &          24X, 4( 2X, 3A4 ) )
 635      FORMAT ( 1H1 // 2X, 9HELEVATION, 3X, 5HDEPTH, 4X,
     &          7HDENSITY, 3X, 10HNORM. VEL., 4X, 4HFLOW,
     &          13X, 11HTEMPERATURE, 4( 2X, 3A4 ) )
 640      FORMAT ( 2X, F9.3, 4X, F6.2,  4X,   F7.5,
     &          5X, F6.4, 3X, F9.4 )
 650      FORMAT ( 2X, F9.3, 4X, F6.2,  4X,   F7.5,
     &          5X, F6.4, 3X, F9.4, 15X,   F5.2 )
 660      FORMAT ( 2X, F9.3, 4X, F6.2,  4X,   F7.5,
     &          5X, F6.4, 3X, F9.4, 20X, 4F13.2 )
 670      FORMAT ( 2X, F9.3, 4X, F6.2,  4X,   F7.5,
     &          5X, F6.4, 3X, F9.4, 15X,   F5.2, 4F13.2 )
          END
```

XREAD

```
          SUBROUTINE XREAD
*****************************************************************
*                                                               *
*         S U B R O U T I N E   X R E A D                       *
*                                                               *
*****************************************************************
*
*.... THIS SUBROUTINE READS ALL INPUT DATA AND CONSTRUCTS
*     FULL TABLES ....
*
          COMMON / AA / QMETR, NSETS, G, HEADING (18), TITLE (18)
          COMMON / BB / IFILE, KFILE
          COMMON / CC / DELZ, INTER, SURFACE, BOTTOM
          COMMON / DD / WTHETA (5), WANGLE
          COMMON / EE / NPORTS, QPORT, QWEIR, QPLOT, QPWEIR
          COMMON / FF / PVDIM (5), PHGT (5), FLOW (5), PHDIM (5)
          COMMON / GG / COEF, QSUB, QQUAL
          COMMON / HH / WRLNG, WRHGT, WRFLOW
          COMMON / II / NUMD, DEN (100), YD (100), QDEN, DENPRT
          COMMON / JJ / NUMT, QCENT, TEMP (100), YT (100), QTEMP
          COMMON / KK / NQUAL, NUMQ (4), NAMEQ (5,4),
     &                  QUAL (4,100), YQ (4,100)
          COMMON / LL / ISURF, HGT (100), DEPTH, Y (100)
          COMMON / NN / HGTPRT, VDIM, QTLIM, QBLIM, QSINK1,
     &                  QSINK2, QSHIFT
          COMMON / TT / QVENT, QAERA, QTWFUN, TWEL
*
          DIMENSION DUMMY (20)
          DIMENSION DUMQUAL (100), DUMYQ (100)
*
          INTEGER     TABTYP
*
          CHARACTER*4 CHECK, CHECK1, CHECK2,
     &                HEADING, TITLE, NAMEQ,
     &                XDATA, XPRIN, XENGL, XMETR, XELEV, XDEPT,
     &                XHEIG, XTHIC, XINTE, XSURF, XBOTT,
     &                XNUMB, XPORT, XWEIR, XVDIM, XFLOW,
     &                XFREE, XSUBM, XCOEF, XLENG, XDENS, XTEMP,
     &                XQUAL, XFAHR, XCENT, XTABL, XSTOP, XHDIM,
     &                XTURB, XGATE, XFUNC, XTAIL, XDISS,
     &                DUMMY, UNITS, XANGL
          CHARACTER*6 SUBR
*
          LOGICAL QECHO , QMETR, QPORT , QWEIR , QSUB   , QPLOT,
     &            QPWEIR, QDEN , QCENT , QTAB1 , QTEMP , QQUAL
          LOGICAL QVENT , QAERA, QTWFUN, QFIRST, QSINK1, QSINK2
*
          DATA XDATA, XPRIN, XENGL / 'DATA', 'PRIN', 'ENGL' /
          DATA XMETR, XELEV, XDEPT / 'METR', 'ELEV', 'DEPT' /
          DATA XHEIG, XTHIC        / 'HEIG', 'THIC'         /
```

XREAD

```
          DATA XINTE, XSURF, XBOTT / 'INTE', 'SURF', 'BOTT' /
          DATA XNUMB, XPORT, XGATE / 'NUMB', 'PORT', 'GATE' /
          DATA XWEIR, XVDIM, XFLOW / 'WEIR', 'VDIM', 'FLOW' /
          DATA XFREE, XSUBM, XCOEF / 'FREE', 'SUBM', 'COEF' /
          DATA XLENG, XDENS, XTEMP / 'LENG', 'DENS', 'TEMP' /
          DATA XQUAL, XFAHR, XCENT / 'QUAL', 'FAHR', 'CENT' /
          DATA XTABL, XSTOP, XANGL / 'TABL', 'STOP', 'ANGL' /
          DATA XHDIM, XDISS        / 'HDIM', 'DISS'         /
          DATA XTURB, XTAIL, XFUNC / 'TURB', 'TAIL', 'FUNC' /
          DATA QFIRST              / .FALSE.                /
          DATA XDUMY, XDUMY1, XDUMY2, XDUMY3 / 4 * '0   '   /
          DATA SUBR                / 'XREAD'                /
*
*....   PROGRAM CONTROL PARAMETERS ....
*
          IF ( QFIRST ) GO TO 145
          QFIRST = .TRUE.
*
*....   INPUT FILE TITLE ....
*
          READ ( IFILE, 610 ) TITLE
*
*....   NUMBER OF DATA SETS ....
*
          READ ( IFILE, 620 ) CHECK, NSETS
          IF ( CHECK .NE. XDATA )
     &        CALL ERROR ( 1010   , SUBR, CHECK, XDATA , XDUMY2,
     &                     XDUMY3 )
*
*....   ECHO PRINT ....
*
          QECHO = .FALSE.
          READ ( IFILE, 610 ) CHECK
          QECHO = CHECK .EQ. XPRIN
          IF ( .NOT. QECHO ) GO TO 140
          QECHO = .FALSE.
          MFILE = IFILE
          REWIND MFILE
          WRITE ( KFILE, 600 )
*
*....   INITIALIZE LINE NUMBERS.  ECHO PRINT FILE ....
*
          LINE = 1000
  100     CONTINUE
*
*....   PRINT LINE OF INPUT TO OUTPUT WITH EACH LOOP ....
*
          READ ( MFILE, 610, END = 110 ) DUMMY
          WRITE ( KFILE, 630 ) LINE, DUMMY
*
```

XREAD

```
*....  INCREMENT LINE NUMBER ....
*
         LINE = LINE + 10
         GO TO 100
  110    CONTINUE
*
         REWIND MFILE
*
  120    CONTINUE
*
*....  INCREMENT FILE POINTER TO PRIOR INPUT LINE ....
*
         IK = 3
         DO 130 I = 1, IK
            READ ( IFILE, 610 ) DUMMY
  130    CONTINUE
  140    CONTINUE
         RETURN
*
*....  ENTRY POINT TO READ THE INDIVIDUAL DATA SETS ....
*
  145    CONTINUE
*
*....  INITIALIZE VARIABLES ....
*
         QSINK1 = .TRUE.
         QSINK2 = .TRUE.
         QPWEIR = .FALSE.
         QMETR  = .FALSE.
         QPORT  = .FALSE.
         QWEIR  = .FALSE.
         QTEMP  = .FALSE.
         QSUB   = .FALSE.
         QDEN   = .FALSE.
         QCENT  = .FALSE.
         QTAB1  = .FALSE.
         QVENT  = .FALSE.
         QAERA  = .FALSE.
         QTWFUN = .FALSE.
         NPORTS = 0
         NQUAL  = 0
         G      = 32.18
*
*....  DATA SET HEADING ....
*
         READ ( IFILE, 610 ) HEADING
*
*....  METRIC OR ENGLISH UNITS
*
         READ ( IFILE, 610 ) CHECK
```

```
               IF ( CHECK .NE. XMETR .AND.
     &              CHECK .NE. XENGL )
     &              CALL ERROR ( 1020   , SUBR, CHECK, XENGL, XMETR,
     &                                   XDUMY3 )
               QMETR = CHECK .EQ. XMETR
               IF ( QMETR ) G = 9.807
*
*....     FORM OF INPUT TABLES ....
*
               READ ( IFILE, 620 ) CHECK, TABTYP
               IF ( CHECK .NE. XTABL )
     &              CALL ERROR ( 1030   , SUBR, CHECK, XTABL, XDUMY2,
     &                                   XDUMY3 )
               QTAB1 = TABTYP .EQ. 1
*
*....     LAYER THICKNESS ....
*
               READ ( IFILE, 650 ) CHECK, DELZ
               IF ( CHECK .NE. XTHIC )
     &              CALL ERROR ( 1040   , SUBR, CHECK, XTHIC, XDUMY2,
     &                                   XDUMY3 )
*
*....     LAYER INTERVALS FOR WHICH OUTPUT INFO IS DESIRED ....
*
               READ ( IFILE, 620 ) CHECK, INTER
               IF ( CHECK .NE. XINTE )
     &              CALL ERROR ( 1050   , SUBR, CHECK, XINTE, XDUMY2,
     &                                   XDUMY3 )
*
*....     SURFACE ELEVATION ....
*
               READ ( IFILE, 650 ) CHECK, SURFACE
               IF ( CHECK .NE. XSURF )
     &              CALL ERROR ( 1060   , SUBR, CHECK, XSURF, XDUMY2,
     &                                   XDUMY3 )
*
*....     BOTTOM ELEVATION ....
*
               READ ( IFILE, 650 ) CHECK, BOTTOM
               IF ( CHECK .NE. XBOTT )
     &              CALL ERROR ( 1070   , SUBR, CHECK, XBOTT, XDUMY2,
     &                                   XDUMY3 )
*
*....     CONSTRUCT LAYERS ....
*
               DEPTH = SURFACE - BOTTOM
*
*....     CALCULATE NUMBER OF LAYERS ....
*
               ISURF = ( DEPTH / DELZ ) + .999
```

XREAD

```
              IF ( ISURF .GT. 100 )
     &            CALL ERROR ( 1080   , SUBR, XDUMY, XDUMY1, XDUMY2,
     &                         XDUMY3 )
*
*....  PERCENTAGE OF LAYER FILLED WITH WATER ....
*
              DO 150 I = 1, ISURF
                 HGT ( I ) = 1.0
                 Y   ( I ) = ( DELZ * FLOAT ( I ) ) - ( .5 * DELZ )
  150         CONTINUE
              HGT ( ISURF ) = ( DEPTH - ( DELZ * ( ISURF - 1 ) ) )
     &                       / DELZ
*
*....  TOP LAYER MAY NOT BE DELZ THICK ....
*
              Y ( ISURF ) = DEPTH - ( HGT ( ISURF ) * DELZ / 2.0 )
*
*....  DESCRIPTION OF WITHDRAWAL DEVICES ....
*
*....  PORT (AND TOTAL NUMBER THEREOF) OR WEIR ....
*
              READ ( IFILE, 620 ) CHECK, NPORTS
              IF ( CHECK .NE. XPORT .AND.
     &            CHECK .NE. XWEIR )
     &            CALL ERROR ( 1100   , SUBR, CHECK, XWEIR, XPORT,
     &                         XDUMY3 )
*
*....  DETERMINE TYPE OF WITHDRAWAL DEVICE ....
*
              QPORT = CHECK .EQ. XPORT
              QWEIR = CHECK .EQ. XWEIR
              IF ( QPORT ) GO TO 220
              IF ( QWEIR ) GO TO 300
  220         CONTINUE
*
*....  PORT CHARACTERISTICS ....
*
*....  PORT VERTICAL DIMENSIONS ....
*
              READ ( IFILE, 650 ) CHECK, ( PVDIM ( K ), K = 1, NPORTS )
              IF ( CHECK .NE. XVDIM )
     &            CALL ERROR ( 1110   , SUBR, CHECK, XVDIM, XDUMY2,
     &                         XDUMY3 )
*
*....  PORT HORIZONTAL DIMENSIONS ....
*
              READ ( IFILE, 650 ) CHECK, ( PHDIM ( K ), K = 1, NPORTS )
              IF ( CHECK .NE. XHDIM )
     &            CALL ERROR ( 1120   , SUBR, CHECK, XHDIM, XDUMY2,
     &                         XDUMY3 )
```

XREAD

```
      *
      *....  PORT ELEVATIONS ....
      *
               READ ( IFILE, 650 ) CHECK, ( PHGT ( K ), K = 1, NPORTS )
               IF ( CHECK .NE. XELEV .AND. CHECK .NE. XHEIG .AND.
           &         CHECK .NE. XDEPT )
           &         CALL ERROR ( 1130 , SUBR, CHECK, XDEPT, XHEIG,
           &                      XELEV )
      *
      *....  CONVERT ELEVATION TO HEIGHT ABOVE BOTTOM ....
      *
               IF ( CHECK .EQ. XHEIG ) GO TO 260
               IF ( CHECK .EQ. XDEPT ) GO TO 240
      *
      *....  ELEVATION TO HEIGHT ....
      *
               DO 230 K = 1, NPORTS
                  PHGT ( K ) = PHGT ( K ) - BOTTOM
        230    CONTINUE
               GO TO 260
        240    CONTINUE
      *
      *....  DEPTHS TO HEIGHTS ....
      *
               DO 250 K = 1, NPORTS
                  PHGT ( K ) = SURFACE - PHGT ( K ) - BOTTOM
        250    CONTINUE
        260    CONTINUE
      *
      *....  PORT FLOW RATES ....
      *
               READ ( IFILE, 650 ) CHECK, ( FLOW ( K ), K=1, NPORTS )
               IF ( CHECK .NE. XFLOW )
           &         CALL ERROR ( 1140  , SUBR, CHECK, XFLOW, XDUMY2,
           &                      XDUMY3 )
      *
      *....  WITHDRAWAL ANGLE ....
      *
               READ ( IFILE, 650 ) CHECK, ( WTHETA ( K ), K=1, NPORTS )
               IF ( CHECK .NE. XANGL )
           &         CALL ERROR ( 1150  , SUBR, CHECK, XANGL, XDUMY2,
           &                      XDUMY3 )
               IF ( NPORTS .EQ. 1 ) GO TO 290
      *
      *....  ORDER PORTS FROM BOTTOM TO TOP ....
      *
               NP = NPORTS - 1
               DO 280 I = 1, NP
                  K = I + 1
                  DO 270 J = K, NPORTS
```

XREAD

```
                  IF ( PHGT ( I ) .LT. PHGT ( J ) ) GO TO 270
      *
      *....   ASSIGN CHARACTERISTICS OF LOWER SUBSCRIPTED PORTS
      *       TO DUMMY VARIABLES ....
      *
                  HGTDUM  = PHGT   ( I )
                  VDUM    = PVDIM  ( I )
                  HDUM    = PHDIM  ( I )
                  FLOWDUM = FLOW   ( I )
                  ANGDUM  = WTHETA ( I )
      *
      *....   ASSIGN CHARACTERISTICS OF HIGHER SUBSCRIPTED PORTS
      *       TO LOWER SUBSCRIPT ....
      *
                  PHGT   ( I ) = PHGT   ( J )
                  PVDIM  ( I ) = PVDIM  ( J )
                  PHDIM  ( I ) = PHDIM  ( J )
                  FLOW   ( I ) = FLOW   ( J )
                  WTHETA ( I ) = WTHETA ( J )
      *
      *....   ASSIGN DUMMY VARIABLE VALUES TO HIGHER SUBSCRIPTED PORT ....
      *
                  PHGT   ( J ) = HGTDUM
                  PVDIM  ( J ) = VDUM
                  PHDIM  ( J ) = HDUM
                  FLOW   ( J ) = FLOWDUM
                  WTHETA ( J ) = ANGDUM
        270     CONTINUE
        280   CONTINUE
        290   CONTINUE
      *
      *....   CHECK FOR WEIR INPUT ....
      *
              READ ( IFILE, 620 ) CHECK
              QWEIR = CHECK .EQ. XWEIR
              IF ( QWEIR ) GO TO 300
              BACKSPACE IFILE
              GO TO 340
        300   CONTINUE
      *
      *....   WEIR CHARACTERISTICS ....
      *
      *....   SUBMERGED OR FREE ....
      *
              READ ( IFILE, 620 ) CHECK
              IF ( CHECK .NE. XFREE .AND.
     &             CHECK .NE. XSUBM )
     &             CALL ERROR ( 1160   , SUBR, CHECK, XSUBM, XFREE,
     &                          XDUMY3 )
              QSUB = CHECK .EQ. XSUBM
```

```
               IF ( QSUB ) GO TO 310
      *
      *....  FREE WEIR COEFFICIENT ....
      *
               READ ( IFILE, 650 ) CHECK, COEF
               IF ( CHECK .NE. XCOEF )
          &         CALL ERROR ( 1170  , SUBR, CHECK, XCOEF, XDUMY2,
          &                      XDUMY3 )
       310     CONTINUE
      *
      *....  WEIR LENGTH ....
      *
               READ ( IFILE, 650 ) CHECK, WRLNG
               IF ( CHECK .NE. XLENG )
          &         CALL ERROR ( 1180  , SUBR, CHECK, XLENG, XDUMY2,
          &                      XDUMY3 )
      *
      *....  WEIR HEIGHT ....
      *
               READ ( IFILE, 650 ) CHECK, WRHGT
               IF ( CHECK .NE. XELEV .AND. CHECK .NE. XHEIG .AND.
          &         CHECK .NE. XDEPT )
          &         CALL ERROR ( 1200  , SUBR, CHECK, XDEPT, XELEV,
          &                      XHEIG )
      *
      *....  CONVERT DEPTH OR ELEV TO HEIGHT ABOVE BOTTOM ....
      *
               IF ( CHECK .EQ. XHEIG ) GO TO 330
               IF ( CHECK .EQ. XDEPT ) GO TO 320
      *
      *....  ELEVATION TO HEIGHT ....
      *
               WRHGT = WRHGT - BOTTOM
               GO TO 330
       320     CONTINUE
      *
      *....  DEPTH TO HEIGHT ....
      *
               WRHGT = SURFACE - WRHGT - BOTTOM
       330     CONTINUE
      *
      *....  FLOW RATE OVER WEIR ....
      *
               READ ( IFILE, 650 ) CHECK, WRFLOW
               IF ( CHECK .NE. XFLOW )
          &         CALL ERROR ( 1210  , SUBR, CHECK, XFLOW, XDUMY2,
          &                      XDUMY3 )
       340     CONTINUE
      *
      *....  TURBINE VENTING OR CONDUIT AERATION ....
```

XREAD

```
*
        READ( IFILE, 610 ) CHECK
        QVENT = CHECK .EQ. XTURB
        QAERA = CHECK .EQ. XGATE
        IF( .NOT. QVENT .AND. .NOT. QAERA ) BACKSPACE IFILE
*
*....  TAILWATER FUNCTION OR SINGLE ELEVATION.
*      NEEDED WHEN QAERA =.TRUE. ....
*
        IF ( .NOT. QAERA ) GO TO 345
        READ ( IFILE, 635 ) CHECK1, CHECK2, TWEL
        IF ( CHECK1 .NE. XTAIL )
     &      CALL ERROR( 1215  , SUBR, CHECK1, XTAIL, XDUMY2,
     &                  XDUMY3 )
        QTWFUN = CHECK2 .EQ. XFUNC
  345   CONTINUE
*
*....  INFORMATION FOR DENSITY OR TEMP PROFILE INCLUDING
*      NUMBER OF DATA ....
*
        READ ( IFILE, 640 ) CHECK1, CHECK2, NUMD
        IF ( CHECK1 .NE. XNUMB )
     &      CALL ERROR ( 1220  , SUBR, CHECK1, XNUMB, XDUMY2,
     &                   XDUMY3 )
        IF( CHECK2 .NE. XDENS .AND. CHECK2 .NE. XTEMP )
     &      CALL ERROR ( 1225  , SUBR, CHECK2, XDENS, XTEMP,
     &                   XDUMY3 )
*
        QDEN = CHECK2 .EQ. XDENS
        IF ( QDEN ) GO TO 350
        NUMT = NUMD
        GO TO 420
  350   CONTINUE
*
*....  DENSITY ....
*
        IF ( QTAB1 ) GO TO 360
*
*....  ELEVATION AND DENSITY VALUES LISTED IN SEPERATE TABLES ....
*
        READ ( IFILE, 610 ) CHECK
*
*....  ELEVATIONS ....
*
        IF ( CHECK .NE. XELEV .AND. CHECK .NE. XHEIG .AND.
     &      CHECK .NE. XDEPT )
     &      CALL ERROR ( 1230 , SUBR, CHECK, XDEPT, XHEIG,
     &                   XELEV )
        READ ( IFILE, 660 ) ( YD ( M ), M = 1, NUMD )
*
```

```
*....  DENSITIES ....
*
            READ ( IFILE, 620 ) CHECK
            IF ( CHECK .NE. XDENS )
     &          CALL ERROR ( 1240   , SUBR, CHECK, XDENS, XDUMY1,
     &                              XDUMY3 )
            READ ( IFILE, 660 ) ( DEN ( M ), M = 1, NUMD
            GO TO 370
  360       CONTINUE
*
*....  ELEVATION AND DENSITY VALUES LISTED IN ONE TABLE
*
            READ ( IFILE, 670 ) CHECK1, CHECK2
            IF ( CHECK1 .NE. XDEPT .AND. CHECK1 .NE.
     &          .AND. CHECK1 .NE. XELEV )
     &          CALL ERROR ( 1250   , SUBR, CHECK,
     &                              XHEIG )
            IF ( CHECK2 .NE. XDENS )
     &          CALL ERROR ( 1260   , SUBR
     &                              XDUMY3 )
            READ ( IFILE, 680 ) ( YD ( M ), DEN
            CHECK = CHECK1
  370       CONTINUE
*
*....  CONVERT DEPTH OR ELEVATION TO HEIGHT
*
            IF ( CHECK .EQ. XHEIG ) GO TO
            IF ( CHECK .EQ. XDEPT ) GO TO
*
*....  ELEVATION TO HEIGHT
*
            DO 380 M = 1, NUMD
              YD ( M ) = YD ( M )
  380       CONTINUE
            GO TO 410
  390       CONTINUE
*
*....  DEPTH TO HEIGHT
*
            DO 400 M = 1, NUMD
              YD ( M ) =
  400       CONTINUE
  410       CONTINUE
*
*....  GENERATE
*
            CALL INTER
*
*....  CHECK
*      AND
```

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XREAD

```
*
          READ ( IFILE, 700 ) CHECK, NUMT
          IF ( CHECK .NE. XNUMB .AND. CHECK .NE. XQUAL .AND.
     &         CHECK .NE. XSTOP )
     &         CALL ERROR ( 1270  , SUBR, CHECK, XNUMB, XQUAL,
     &                      XSTOP )
          IF ( CHECK .EQ. XSTOP ) RETURN
          IF ( CHECK .EQ. XQUAL ) GO TO 490
*
*.... TEMPERATURE ....
*
  420     CONTINUE
*
*.... FAHRENHEIT OR CENTIGRADE ....
*
          READ ( IFILE, 690 ) CHECK, UNITS
          IF ( CHECK .NE. XTEMP .AND. CHECK .NE. XSTOP )
     &         CALL ERROR ( 1280  , SUBR, CHECK, XTEMP, XSTOP,
     &                      XDUMY3 )
*
          IF ( CHECK .EQ. XSTOP ) RETURN
          IF ( UNITS .NE. XFAHR .AND. UNITS .NE. XCENT )
     &        CALL ERROR ( 1290  , SUBR, UNITS, XFAHR, XCENT,
     &                     XDUMY3 )
*
          QCENT = UNITS .EQ. XCENT
          QTEMP = .TRUE.
          IF ( QTAB1 ) GO TO 430
*
*.... ELEVATION AND TEMPERATURE LISTED IN SEPERATE TABLES ....
*
          READ ( IFILE, 610 ) CHECK
*
*.... ELEVATION TABLE
*
          IF ( CHECK .NE. XELEV .AND. CHECK .NE. XHEIG .AND.
     &         CHECK .NE. XDEPT )
     &         CALL ERROR ( 1300  , SUBR, CHECK, XHEIG, XELEV,
     &                      XDEPT )
          READ ( IFILE, 660 ) ( YT ( M ), M = 1, NUMT )
*
*.... TEMPERATURE TABLE ....
*
          READ ( IFILE, 610 ) CHECK
          IF ( CHECK .NE. XTEMP )
     &         CALL ERROR ( 1310  , SUBR, CHECK, XTEMP, XDUMY2,
     &                      XDUMY3 )
          READ ( IFILE, 660 ) ( TEMP ( M ), M = 1, NUMT )
          GO TO 440
  430     CONTINUE
```

XREAD

```
*
*....  ELEVATION AND TEMP LISTED IN ONE TABLE ....
*
          READ ( IFILE, 670 ) CHECK1, CHECK2
          IF ( CHECK1 .NE. XELEV .AND. CHECK1 .NE. XHEIG
     &        .AND. CHECK1 .NE. XDEPT )
     &         CALL ERROR ( 1320 , SUBR, CHECK1, XDEPT, XELEV,
     &                      XHEIG )
          IF ( CHECK2 .NE. XTEMP )
     &         CALL ERROR ( 1330  , SUBR, CHECK2, XTEMP, XDUMY2,
     &                      XDUMY3 )
          READ ( IFILE, 680 ) ( YT ( M ), TEMP ( M ), M = 1, NUMT )
          CHECK = CHECK1
  440     CONTINUE
*
*....  CONVERT ELEVATION OR DEPTH TO HEIGHT ABOVE BOTTOM ....
*
          IF ( CHECK .EQ. XHEIG ) GO TO 480
          IF ( CHECK .EQ. XDEPT ) GO TO 460
*
*....  ELEVATION TO HEIGHT ....
*
          DO 450 M = 1, NUMT
             YT ( M ) = YT ( M ) - BOTTOM
  450     CONTINUE
*
          GO TO 480
  460     CONTINUE
*
*....  DEPTH TO HEIGHT ....
*
          DO 470 M = 1, NUMT
             YT ( M ) = SURFACE - YT ( M ) - BOTTOM
  470     CONTINUE
  480     CONTINUE
*
*....  GENERATE COMPUTATIONAL PROFILE ....
*
          CALL INTERP ( TEMP, YT, NUMT )
*
          GO TO 500
*
*....  QUALITIES ....
*
  490     CONTINUE
          BACKSPACE IFILE
  500     CONTINUE
*
*....  CHECK FOR QUALITY PROFILE ( AND NUMBER OF DATA)
*      OR A STOP COMMAND ....
```

XREAD

```
*
            READ ( IFILE, 620 ) CHECK, NQUAL
            QQUAL = CHECK .EQ. XQUAL
            IF ( CHECK .NE. XQUAL .AND.
     &           CHECK .NE. XSTOP )
     &           CALL ERROR ( 1340  , SUBR, CHECK, XQUAL, XSTOP,
     &                          XDUMY3 )
            IF ( CHECK .EQ. XSTOP ) RETURN
            DO 590 I = 1, NQUAL
            READ ( IFILE, 710 ) CHECK, ( NAMEQ ( NM, I ),
     &                            NM = 1, 5 ), NUMQ ( I )
            IF ( CHECK .NE. XNUMB )
     &            CALL ERROR ( 1350  , SUBR, CHECK, XNUMB, XDUMY2,
     &                           XDUMY3 )
*
*....   CHECK THAT THE FIRST QUALITY PROFILE IS DISSOLVED OXYGEN
*       WHEN AERATE OR VENTING SUBROUTINES ARE TO BE USED ....
*
            IF( QVENT .OR. QAERA .AND. NAMEQ ( 1 , 1 ) .NE. XDISS )
     &           CALL ERROR ( 1345  , SUBR, XDUMY, XDUMY1, XDUMY2,
     &                          XDUMY3 )
            NUMBER = NUMQ ( I )
            IF ( QTAB1 ) GO TO 510
*
*....   ELEVATION AND QUALITY LISTED IN SEPERATE TABLES ....
*
            READ ( IFILE, 610 ) CHECK
*
*....   ELEVATION TABLE ....
*
            IF ( CHECK .NE. XELEV .AND. CHECK .NE. XHEIG .AND.
     &           CHECK .NE. XDEPT )
     &           CALL ERROR ( 1360, SUBR, CHECK, XDEPT, XHEIG,
     &                          XELEV )
            READ ( IFILE, 660 ) ( YQ ( I , M ), M = 1, NUMBER )
*
*....   QUALITY PARAMETERS ....
*
            READ ( IFILE, 610 ) CHECK
            READ ( IFILE, 660 ) ( QUAL ( I , M ), M = 1, NUMBER )
            GO TO 520
  510       CONTINUE
*
*....   ELEVATION AND QUALITY LISTED IN ONE TABLE ....
*
            READ ( IFILE, 670 ) CHECK
            IF ( CHECK .NE. XELEV .AND. CHECK .NE. XHEIG
     &           .AND. CHECK .NE. XDEPT )
     &           CALL ERROR ( 1370 , SUBR, CHECK, XDEPT, XHEIG,
     &                          XELEV )
```

XREAD

```
            READ ( IFILE, 680 ) ( YQ ( I , M ), QUAL ( I , M ),
     &                             M = 1, NUMBER)

  520       CONTINUE
*
*....   CONVERT ELEVATION OR DEPTH TO HEIGHT ABOVE THE BOTTOM ....
*
            IF ( CHECK .EQ. XHEIG ) GO TO 560
            IF ( CHECK .EQ. XDEPT ) GO TO 540
*
*....   ELEVATION TO HEIGHT ....
*
            DO 530 M = 1, NUMBER
               YQ ( I , M ) = YQ ( I , M ) - BOTTOM
  530       CONTINUE
            GO TO 560
  540       CONTINUE
*
*....   DEPTH TO HEIGHT ....
*
            DO 550 M = 1, NUMBER
               YQ ( I , M ) = SURFACE - YQ ( I , M ) - BOTTOM
  550       CONTINUE
  560       CONTINUE
*
*....   ASSIGN QUALITY VALUES TO DUMMY VARIABLES TO BE PASSED
*       TO ROUTINE INTERP ....
*
            NQ = NUMQ ( I )
            DO 570 K = 1 , NUMBER
               DUMQUAL ( K ) = QUAL ( I , K )
               DUMYQ   ( K ) = YQ   ( I , K )
  570       CONTINUE
*
*....   GENERATE COMPUTATIONAL PROFILE ....
*
            CALL INTERP ( DUMQUAL, DUMYQ, NQ )
*
*....   ASSIGN ROUTINE INTERP OUTPUT TO ARRAY ....
*
            DO 580 K = 1, ISURF
               QUAL ( I , K ) = DUMQUAL ( K )
  580       CONTINUE
  590       CONTINUE
*
*....  STOP COMMAND ....
*
            READ ( IFILE, 610 ) CHECK
            IF ( CHECK .NE. XSTOP )
     &         CALL ERROR ( 1380  , SUBR, CHECK, XSTOP, XDUMY2,
```

XREAD

```
      &                         XDUMY3 )
 600      FORMAT ( 1H1 )
 610      FORMAT ( 20A4 )
 620      FORMAT ( A4, 6X, 14I5 )
 630      FORMAT ( 10X, I6, 7X, 3H***, 20A4 )
 635      FORMAT( A4, 6X, A4,  6X, 6F10.0 )
 640      FORMAT ( A4, 6X, A4, 6X, 12I5 )
 650      FORMAT ( A4, 6X, ( 7F10.0 ) )
 660      FORMAT ( 8F10.0 )
 670      FORMAT ( A4, 6X, A4 )
 680      FORMAT ( 2F10.0 )
 690      FORMAT ( A4, 16X, A4 )
 700      FORMAT ( A4, 16X, 12I5 )
 710      FORMAT ( A4, 6X, 5A4, I5 )
          RETURN
          END
```

END

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DATE:

10-92

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