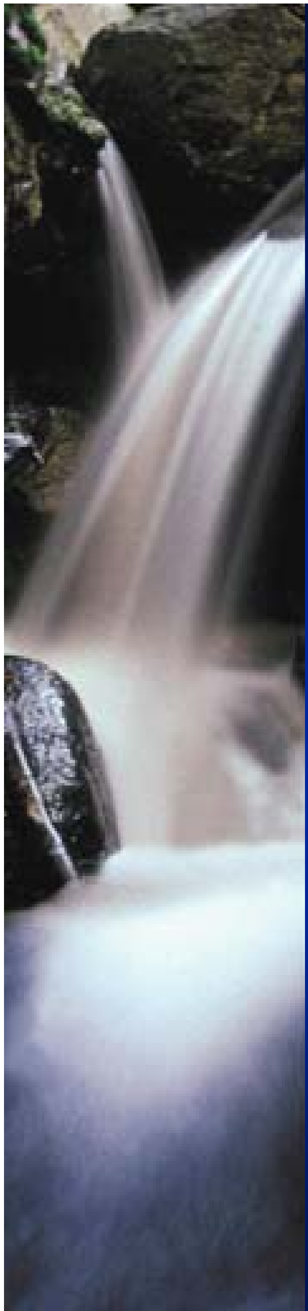
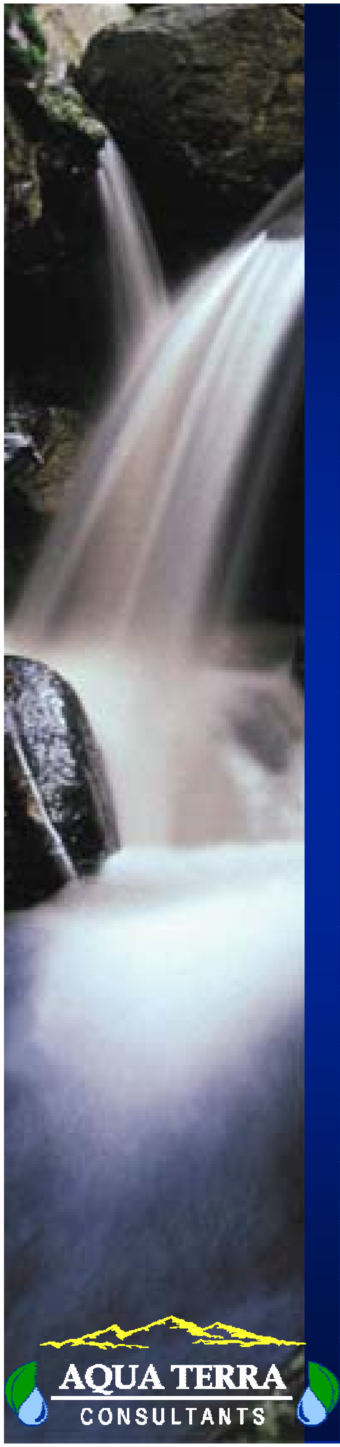
LECTURE #6

CHANNEL ROUTING IN HSPF



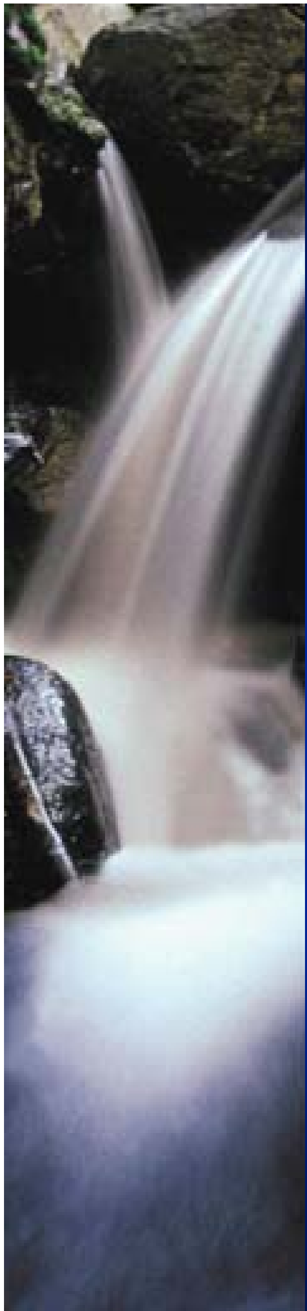
LEARNING OBJECTIVES

- Develop a familiarity with organization and linkages in RCHRES
- Learn the key processes simulated and parameters used in flow routing simulation



RCHRES STRUCTURE CHART

- **RCHRES** – Simulate a reach or mixed reservoir
  - **HYDR** – Simulate hydraulic behavior
  - ADCALC – Simulate transport behavior of constituent
  - CONS – Simulate conservative constituents
  - HTRCH – Simulate heat exchange and water temperature
  - SEDTRN – Simulate inorganic sediment
  - GQUAL – Simulate general quality constituent
  - RQUAL – Simulate biochemical transformations of chemicals
    - OXRX – Simulate DO and BOD reactions
    - NUTRX – Simulate inorganic nitrogen and phosphorus
    - PLANK – Simulate phytoplankton
    - PHCARB – Simulate pH and inorganic carbon



STREAM HYDRAULICS (HYDR)

- **Assumptions**
  - Completely mixed reach (single layer)
  - Unidirectional flow
  - Flow routing by kinematic wave or storage-routing method; conservation of momentum is not considered
- **Requires function table (FTable) for depth-volume-discharge relationship for each reach.**
- **Precipitation and evaporation are considered**
- **Calculates outflow, depth, volume, surface area, and other variables (velocity, cross-sectional area, bed shear stress)**

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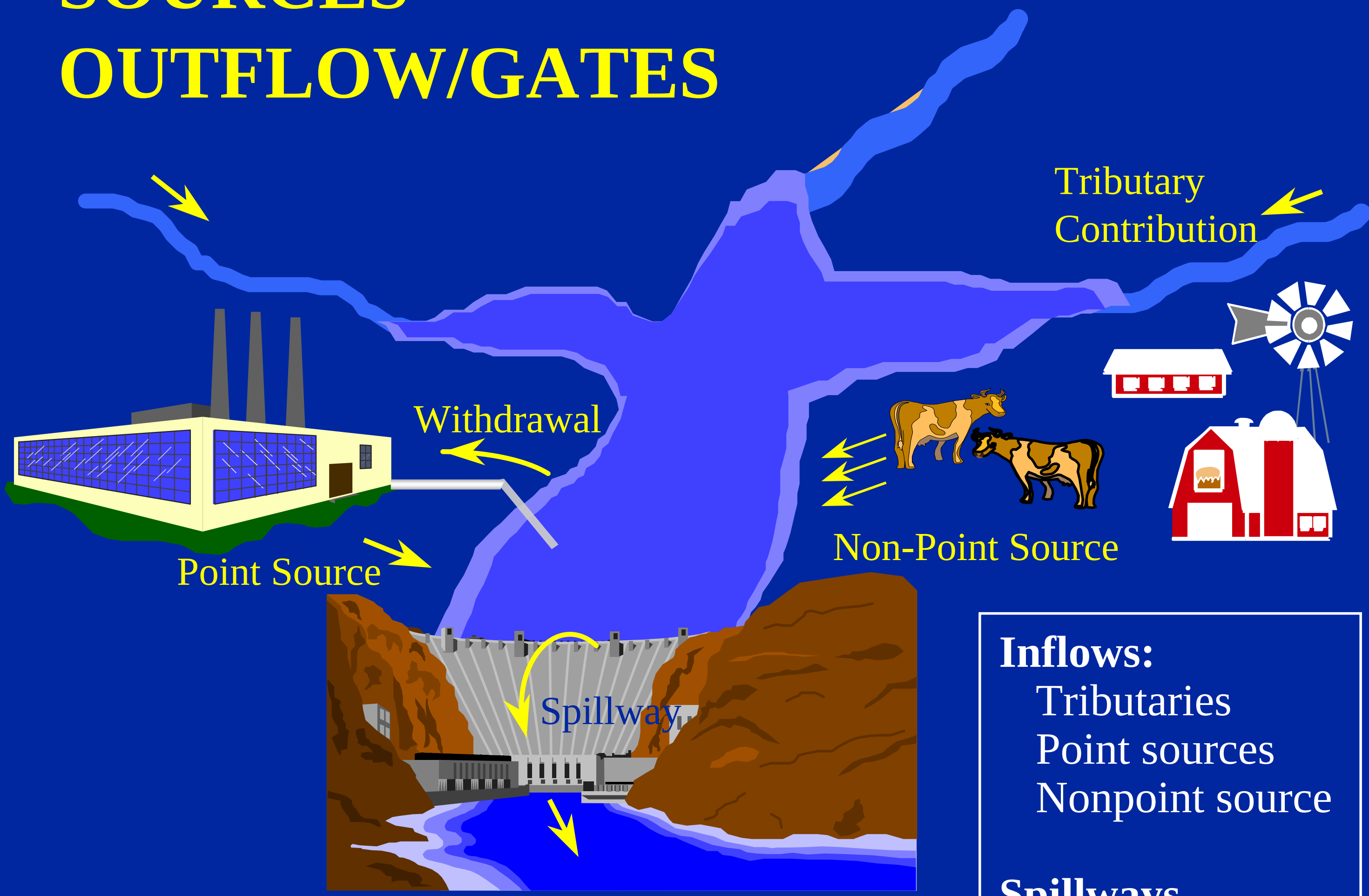
FLOW AND CONSTITUENT SOURCES OUTFLOW/GATES



Inflows:
- Tributaries
- Point sources
- Nonpoint source

Spillways

Withdrawal

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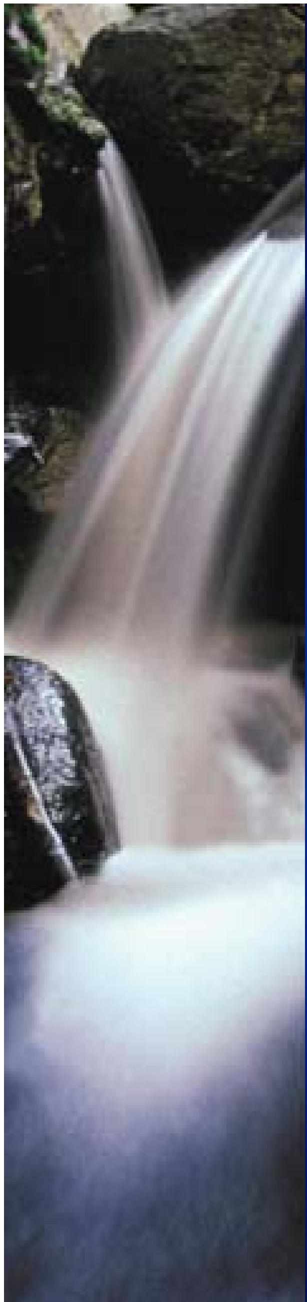
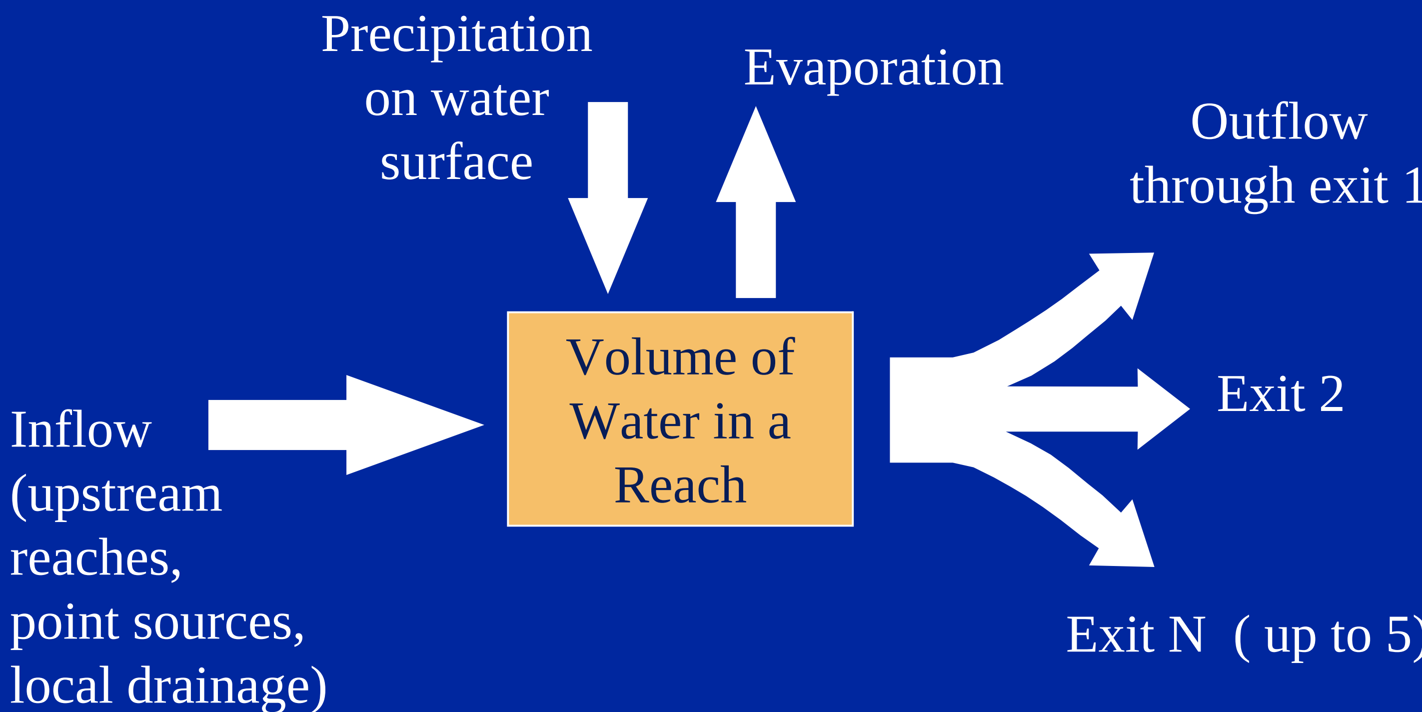
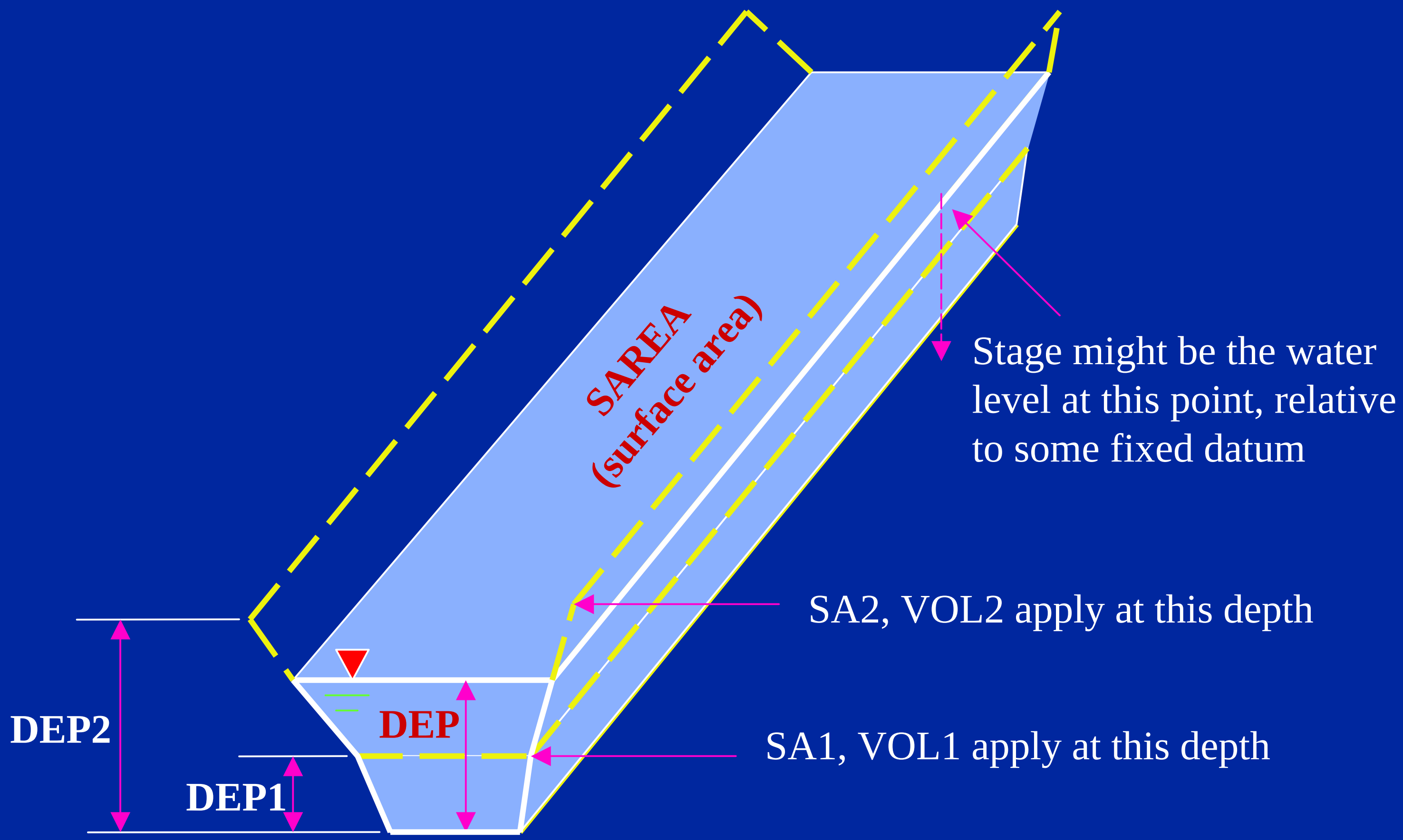
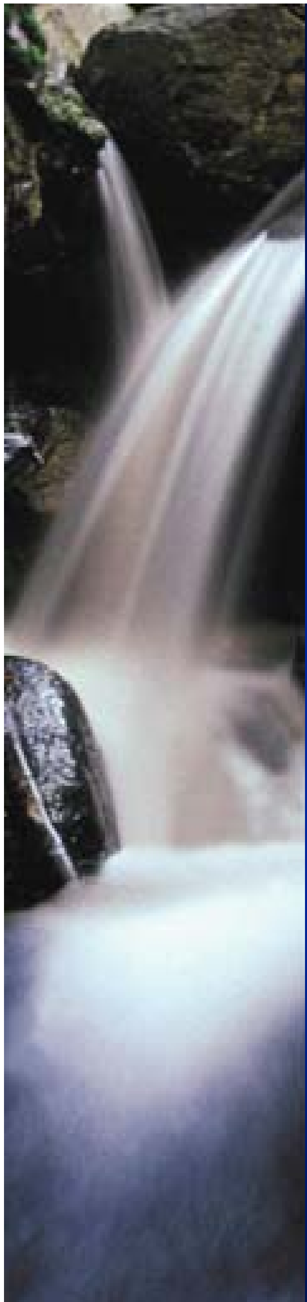


FLOW DIAGRAM FOR HYDR SECTION OF RCHRES



CHANNEL GEOMETRY



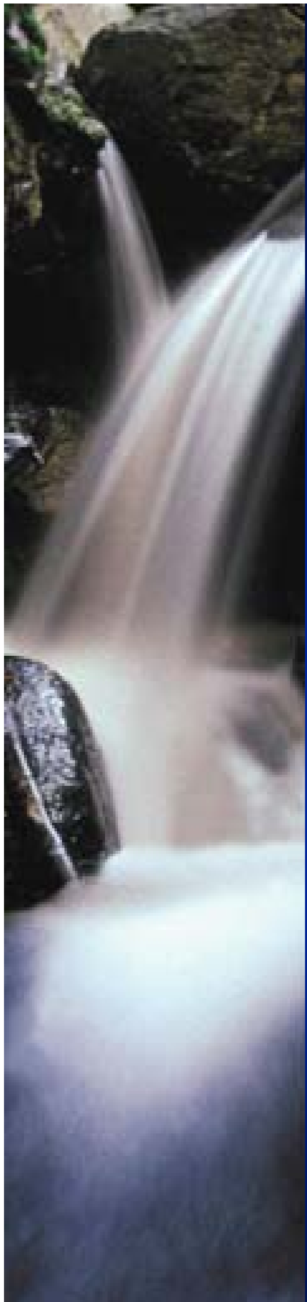


FTABLES

VARIABLE	DEFINITION
NROWS	Number of rows in the FTABLE. There must be at least one.
NCOL	Number of columns in the FTABLE. NCOLS must be between 3 and 8. NROWS*NCOLS must not exceed 500.
DEPTH	Depth of reach (meters or feet). The depth must not decease as the row number increases.
SURFACE AREA	Surface area of the reach (hectares or acres).
VOLUME	Volume of reach ($10^6 m^3$ or acre-feet). The volume must not decrease as the row number increases.
DISCHARGE	Discharge from reach (m^3/sec or ft^3/sec). There may be up to five discharge columns.

EXAMPLE

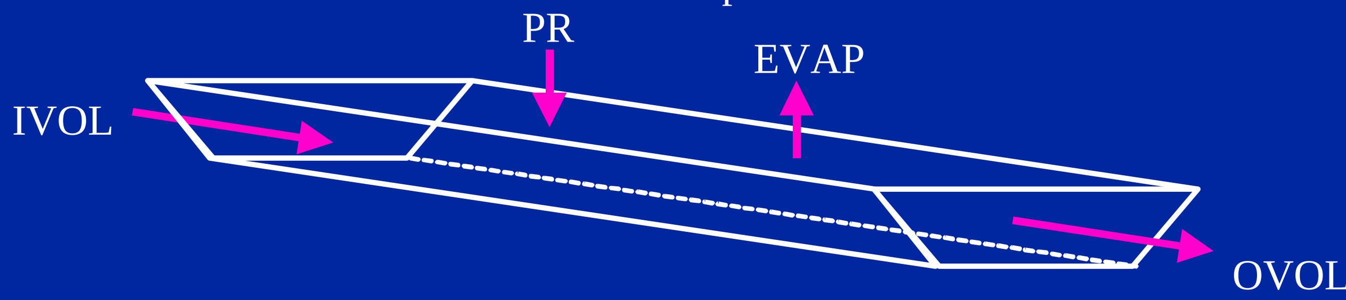
```
 FTABLE     103
ROWS COLS ***
   3    5
    DEPTH      AREA    VOLUME  outflow1  outflow2 ***
     (FT)   (ACRES)   (AC-FT)     (CFS)     (CFS) ***
      0.0       0.0       0.0       0.0       0.0
      5.0      10.0      25.0      20.5      10.2
     20.0     120.0    1000.0     995.0     200.1
 END FTABLE 103
```



FLOW ROUTING EQUATIONS - CONTINUITY

VOLE = VOLS + sum IVOL - sum OVOL + PR - EVAP

VOLE = volume at end of time step
VOLS = volume at start of time step
OVOL = outflow volume
IVOL = inflow volume
PR = volume of precipitation
EVAP = volume of evaporation

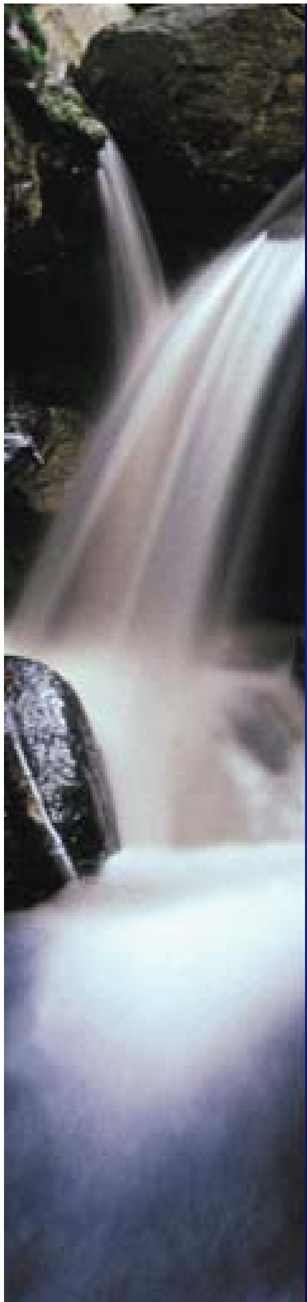


let OVOL = Δt(KS * OS + (1.0 - KS) * OE)

KS = weighting factor (0.0 - 0.5)
OS = outflow at start of time step
OE = outflow at end of time step

unknown → VOLE; unknown → OE

then VOLE = (VOLS + sum IVOL + PR -EVAP) - Δt {KS * OS + (1 - KS) * OE}

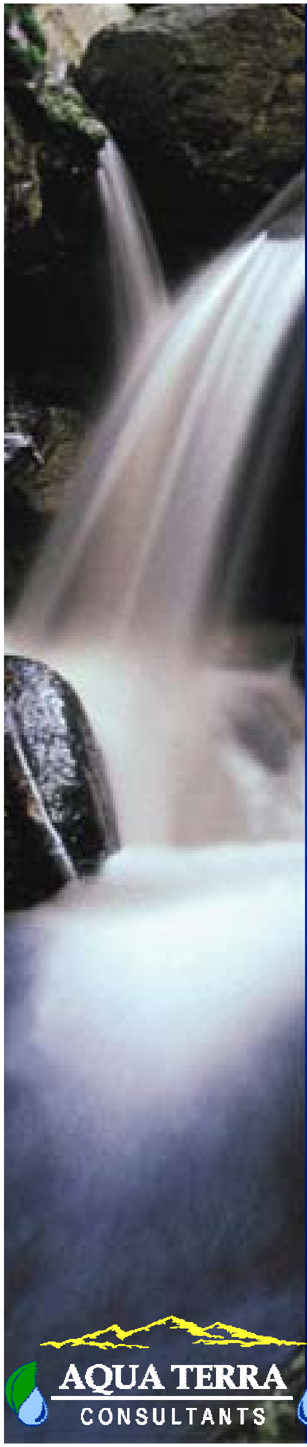


OUTFLOW FROM REACHES

- **User needs to specify each outflow as one of the following:**
  - Case 1. Outflow = f(storage volume)
    - *Open channels and unregulated reservoirs*
  - Case 2. Outflow = f(time)
    - *Reservoir withdrawal for irrigation or water supply, and wastewater discharge*
  - Case 3. Outflow = f(storage volume, time)
    - *Both unregulated outflow and a withdrawal*

OUTFLOW FROM REACHES (CONT.)

- Case 4. Outflow = Min[f(storage volume,time)]
  - *Irrigation demand is a function of time (season), but pump capacity is limited by water level*
- Case 5. Outflow = Max[f(storage volume,time)]
  - *If the reservoir level is high, emergency spillway used, else seasonal release schedule for low flow*



FLOW ROUTING EQUATIONS - OUTFLOW DEMANDS

OE = f(VOLE)

open channels and unregulated reservoirs
use rating table (FTABLE in HSPF)

OE = f(time)

diversions into or out of a channel or reservoir
such reservoir withdrawal for irrigation or waste water treatment plant discharge (time series on WDM file)

OE = f(VOLE) + f(time)

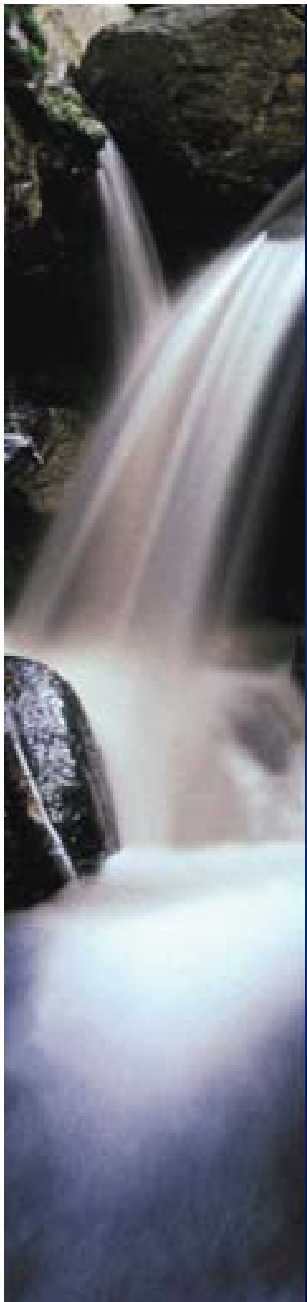
both unregulated outflow and a diversion

OE = MIN [f(VOLE), f(time)]

irrigation demand is a function of time(season), but pump capacity limited by water level

OE = MAX [f(VOLE), f(time)]

if reservoir level is high, emergency spillway used, else seasonal release schedule for low flow



DISCHARGE OPTION

ODFVFG - volume component (each exit)

- 0 - exit is not f(vol)
- > 0 - use column in FTABLE
- < 0 - absolute value is index in COLIND input timeseries (which is obtained from WDM file)

ODGTFG - time component (each exit)

- 0 - exit is not f(time)
- > 0 - index in OUTDGT input timeseries (which is obtained from WDM file)

FUNCT - combination rule (each exit)

- 1 - min(f(vol), f(time))
- 2 - max(f(vol), f(time))
- 3 - f(vol) + f(time)

DISCHARGE EXAMPLES

```
HYDR-PARM1
    #     # VC A1 A2 A3  ODFVFG      ODGTFG      FUNCT
            FG FG FG FG    1  2        1  2        1  2
    1        0  1          4           0
    2        0  1         -1           0
    3        0  1          4  5        1           1
END HYDR-PARM1
```

Reach 1 - Simple stream reach with constant stage-discharge relationship

```
FTABLE    1
     Depth      Area    Volume    Disch1    Disch2 ***
      (ft)    (acres)  (ac-ft)    (cfs)     (cfs) ***
       0.0       0.0       0.0       0.0       0.0
       3.0       1.0       2.0       5.0       3.0
      10.0      10.0      50.0      25.0      18.0
END FTABLE    1
```

No time series required.

Reach 2 - Stream reach with seasonally variable stage-discharge relationship

Same FTABLE as above.

COLIND(1) specifies discharge column(s)
For example: 4.0 4.1 4.2 4.5 5.0 4.9 4.8 4.6 ...

Reach 3 - Reservoir with gate and spillway

```
FTABLE    3
     Depth      Area    Volume    Disch1    Disch2 ***
      (ft)    (acres)   (ac-ft)    (cfs)     (cfs) ***
       0.0       0.0       0.0       0.0       0.0
      20.0      50.0     500.0     100.0       0.0
      40.0     500.0    7000.0     300.0      10.0
      50.0     900.0   12000.0     350.0     200.0
END FTABLE    3
```

OUTDGT(1) specifies the outflow demand
For example: 75.0 80.0 100.0 120.0 90.0 85.0 ...

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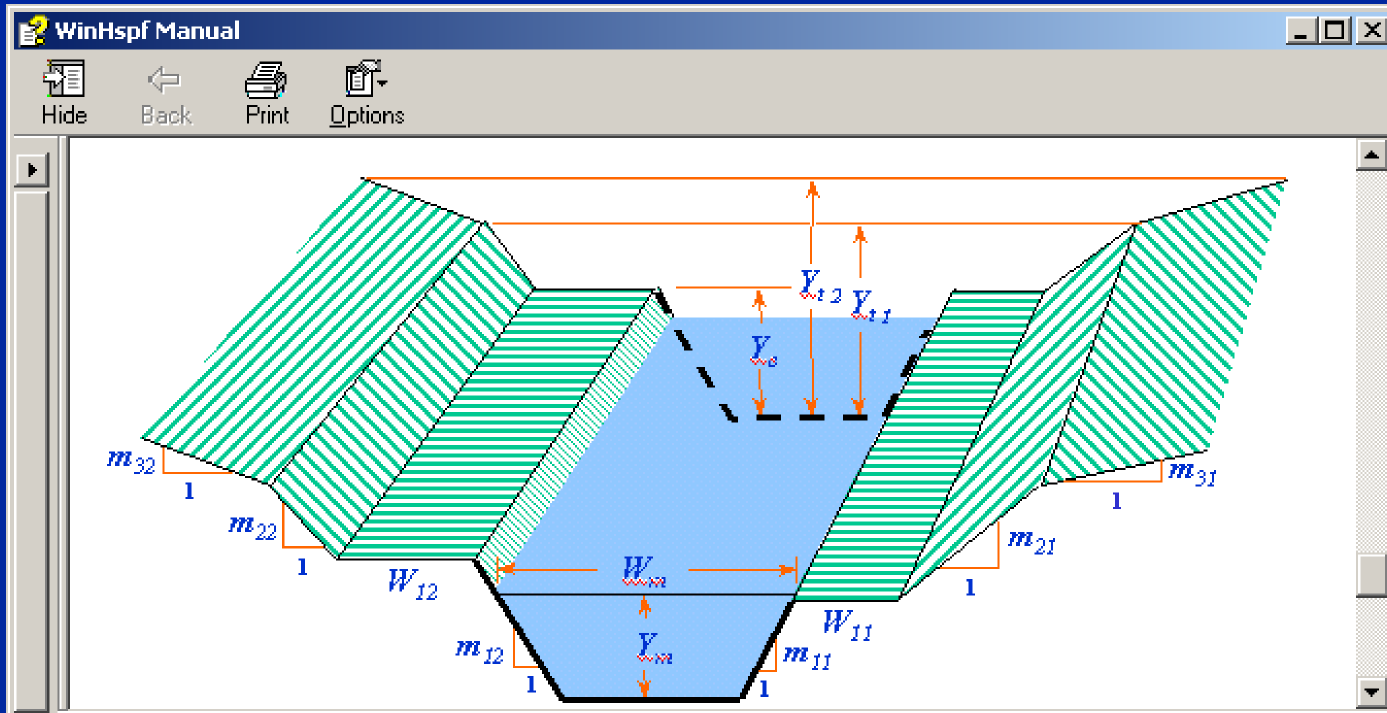
WinHSPF FTABLE GENERATION



Import From Cross-Section

Cross-Section Files

Open 1 Save

FTABLE 25

Variable	Description	Value
L	Length (ft)	1
Ym	Mean Depth (ft)	3.5
Wm	Mean Width (ft)	42.5
n	Mannings Roughness Coefficient	0.02
S	Longitudinal Slope	0.0007
m32	Side Slope of Upper Flood Plain Left	0.4
m22	Side Slope of Lower Flood Plain Left	0.4
W12	Zero Slope Flood Plain Width Left (ft)	0.01
m12	Side Slope of Channel Left	0.4
m11	Side Slope of Channel Right	0.4
W11	Zero Slope Flood Plain Width Right (ft)	0.01
m21	Side Slope Lower Flood Plain Right	0.4
m31	Side Slope Upper Flood Plain Right	0.4
Yc	Channel Depth (ft)	5
Yt1	Flood Side Slope Change at Depth (ft)	15
Yt2	Maximum Depth (ft)	16

OK Cancel Help

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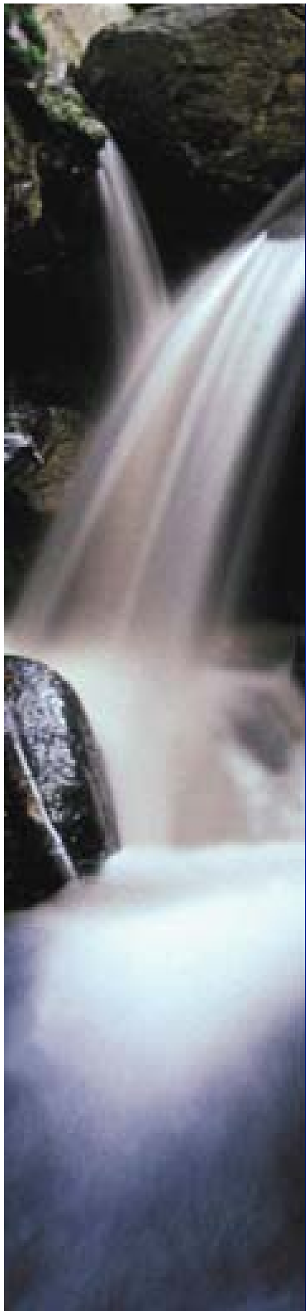
FTABLE DEVELOPMENT

EPA Web-based Toolkit to Support Low Impact Development (LID) and Other Urban Stormwater Modeling Applications

- Channel shape options (natural, rectangular, circular, trapezoidal, triangular, parabolic)
- Free-flowing channels
- Storm sewers
- Storage BMPs
- Infiltration BMPs
- Other models supported (e.g., SWMM, HEC-HMS, TR-20)

http://www.epa.gov/athens/research/modeling/HSPFWebTools/index.htm



CREATING FTABLES FOR RESERVOIRS BASINS TECHNICAL NOTE 1

- Obtain data tables or graphs describing the depth-area and depth-volume relationships from reservoir management agency
- Alternatively, create a bathymetric map of the lake
  - Determine surface area at different depths from planimetry
  - Calculate volume of lake at given depths
- Obtain reservoir release data from reservoir management agency or USGS

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BATHYMETRY WITHIN GIS

Incrementally increase Stage and calculate Surface Area and Volume

Calculate Q using appropriate Weir Equation