LECTURE #5b

PWATER REFINEMENTS FOR WETLANDS HYDROLOGY

‘NORMAL’ PWATER HYDROLOGIC ASSUMPTIONS

- 'Normal' gravitational-driven watershed hydrology exists
- Surface runoff is driven by ground surface slope; evaporation from surface detention is not significant
- Groundwater level is deep; it does not interact with surface runoff, infiltration, or the unsaturated zone
- Entire active groundwater storage provides baseflow; deep inactive groundwater is not represented
- Unsaturated zone is modeled with two storages - upper zone, lower zone - with 'nominal' capacities but no maximum limits
- Interflow represents a subsurface path to the stream; interflow storage has no maximum

OBJECTIVES OF PWATER REFINEMENTS FOR WETLANDS HYDROLOGY

- **Track dynamic variation in groundwater level (i.e., rising/falling water table)**
- **Model interaction between groundwater storage, soil (unsaturated zone) storages, and infiltration/runoff processes**
- **Accommodate ponded conditions on the land surface**
- **Allow evaporation from ponded surface storage and surface runoff**
- **Allow additional options for surface runoff when not gravity driven, i.e. function of surface storage, water level differences, etc.**
- **Perform refinements with minimal changes to existing PWATER routines**
- **Allow for smooth transition between 'normal' hydrologic conditions and 'water table influence' effects**

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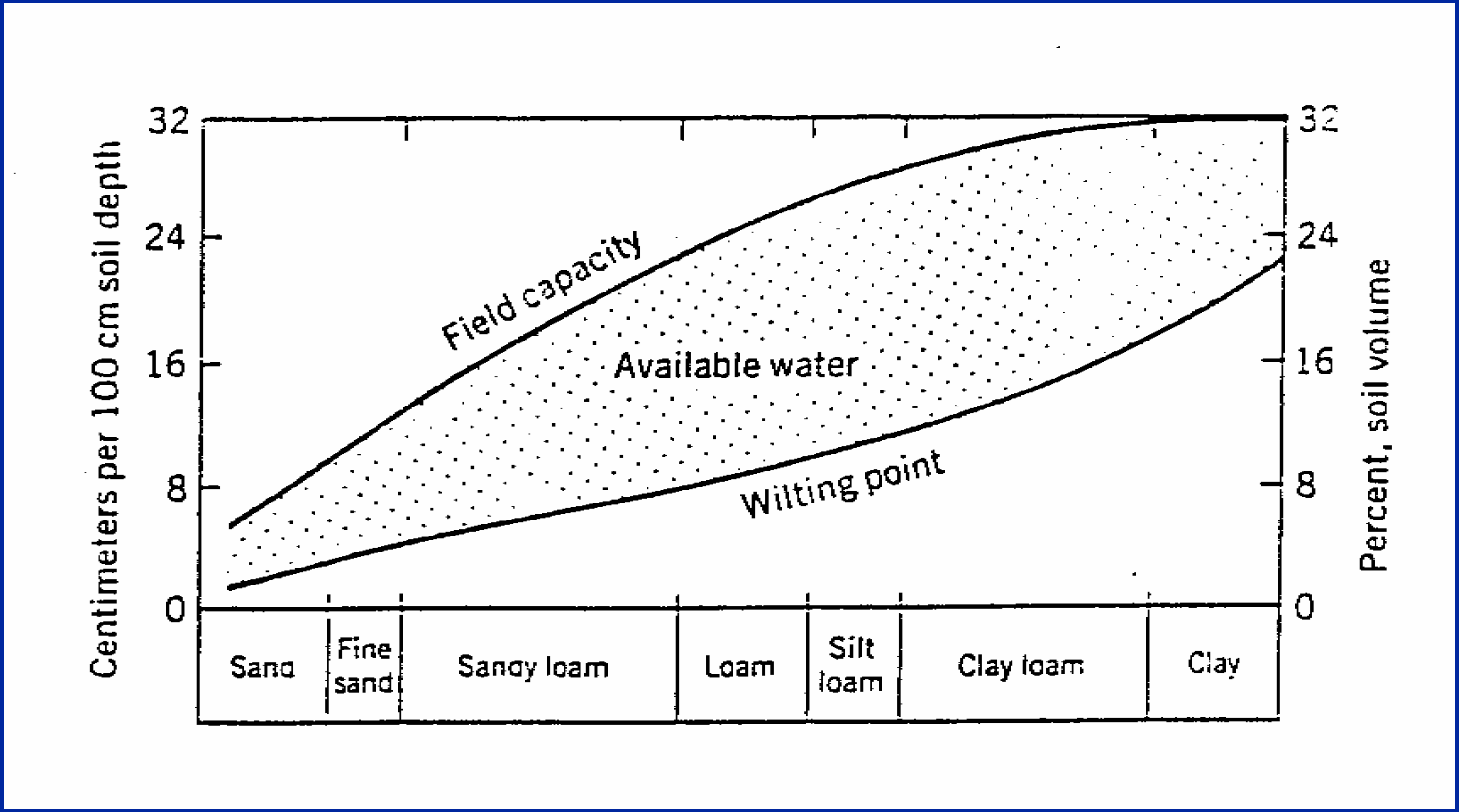
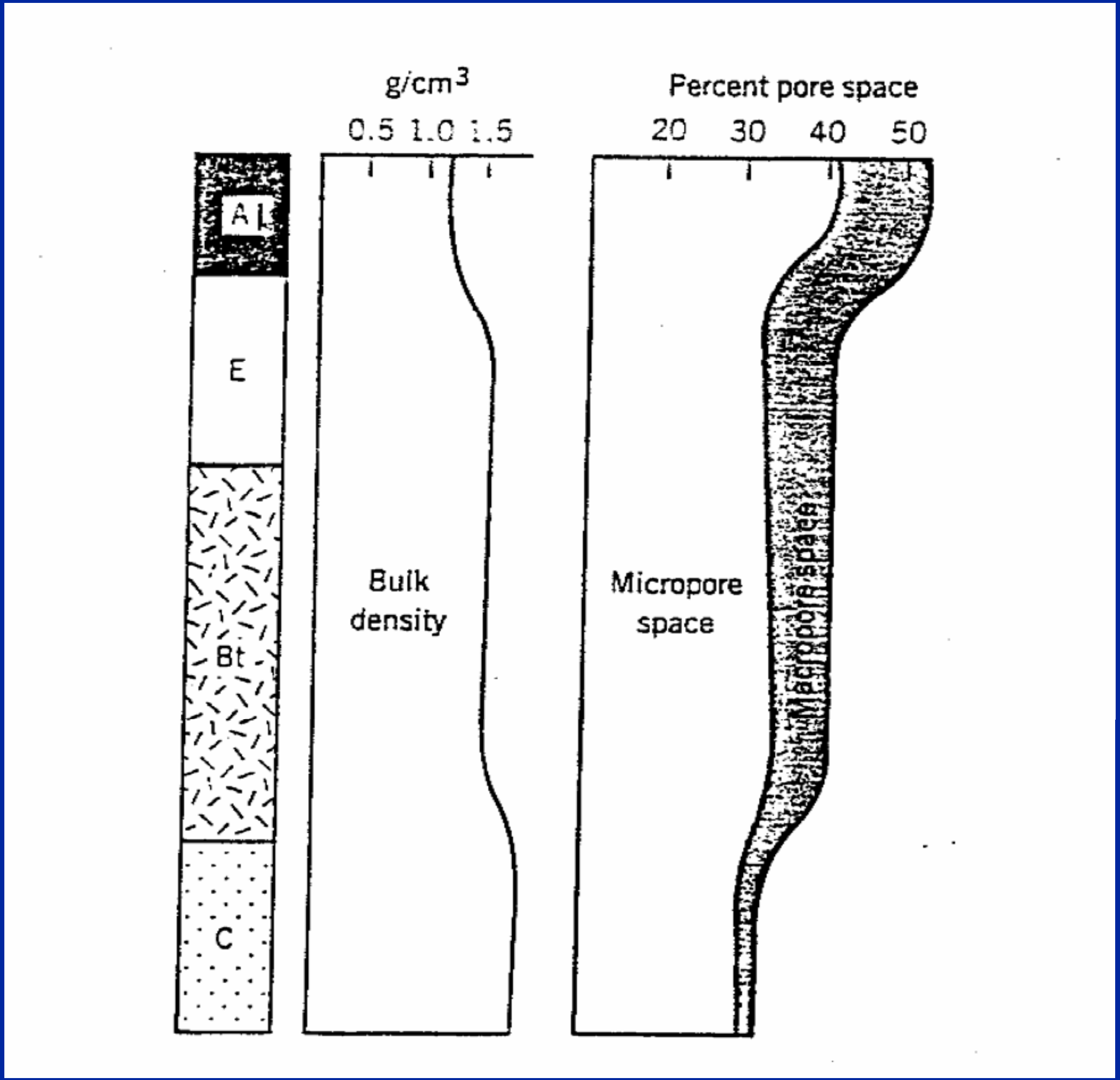
FIELD CAPACITY, WILTING POINT AND AVAILABLE WATER



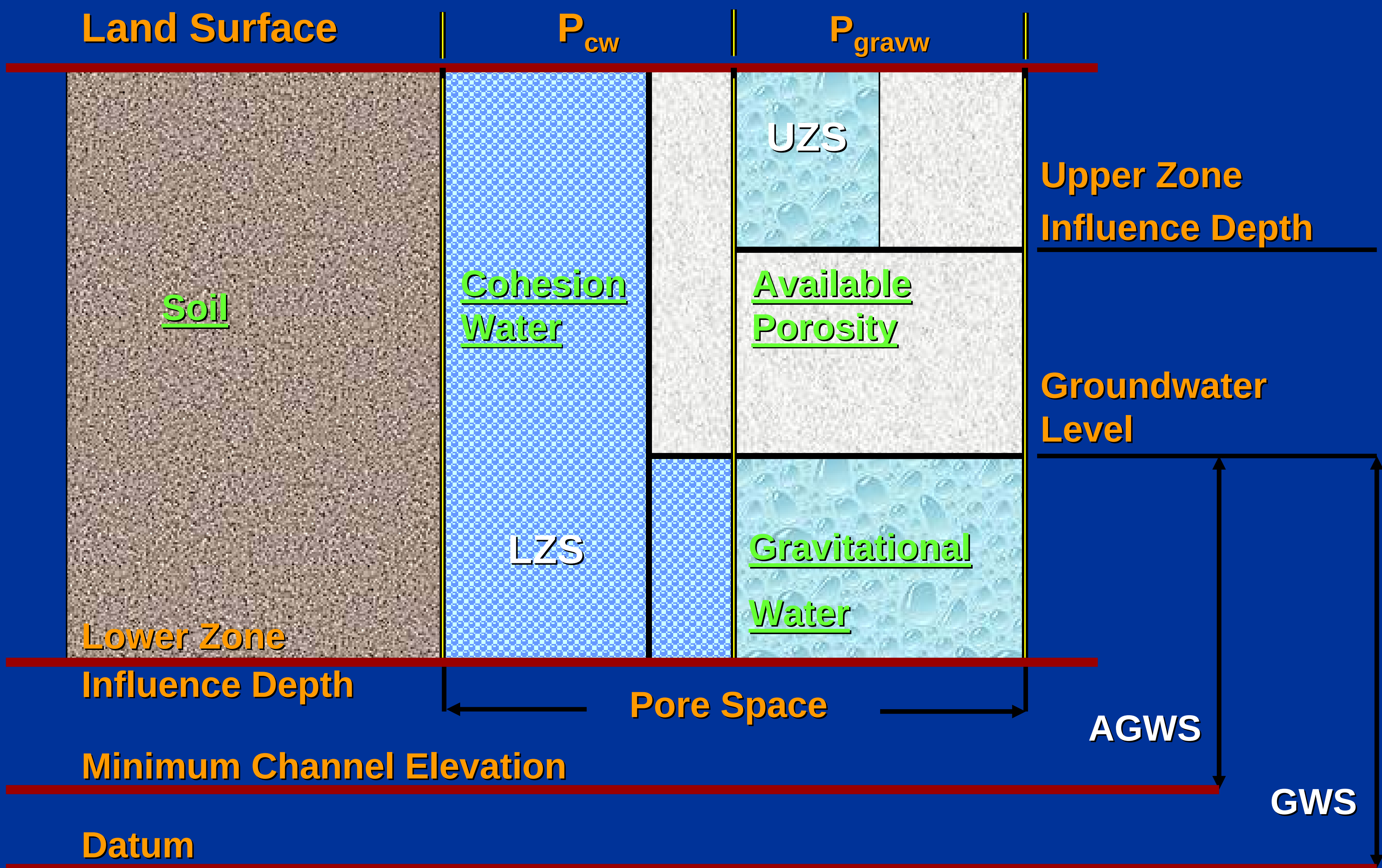
Soil texture and available water holding capacity of soils.

SOIL POROSITY CONCEPTS

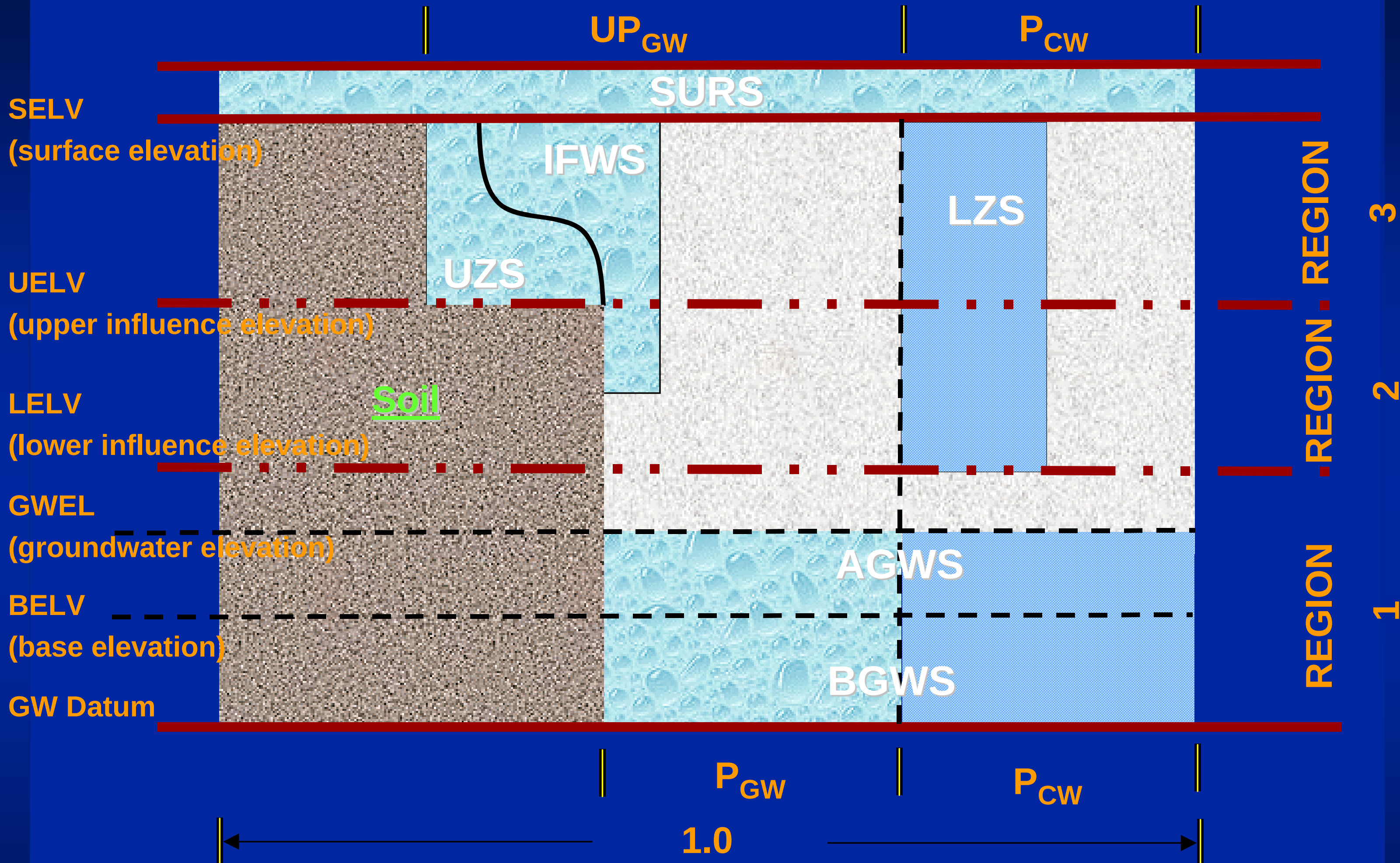


Bulk density and pore space for Miami loam with A, E, Bt and C horizons.

SOIL PROFILE CONCEPTS FOR HIGH WATER TABLE VERSION OF PWATER



SOIL MOISTURE STORAGE CONCEPTS AND MODEL ALGORITHIMS



AVAILABLE PORE SPACE

REGION 3: $\left(1 - \frac{LZS}{2.5\ LZSN}\right) PCW + \left(1 - \frac{UZS + IFWS}{4\ UZSN + IFWSC}\right) UPGW$

REGION 2: $\left(1 - \frac{LZS}{2.5\ LZSN}\right) PCW + PGW$ (if IFWS is low)

REGION 1: $PCW + PGW$

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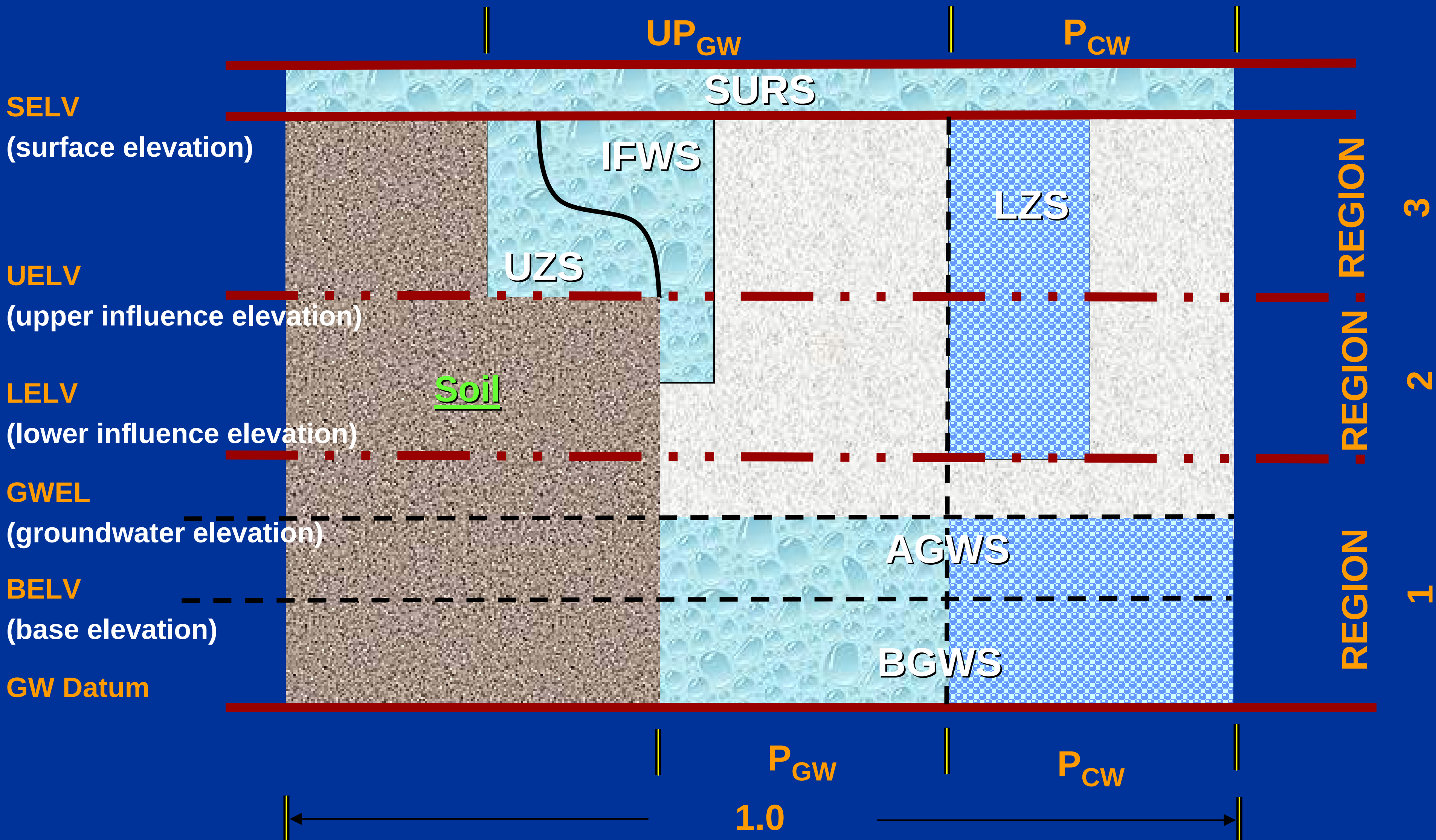
SOIL MOISTURE STORAGE CONCEPTS AND MODEL ALGORITHIMS



INFLUENCE LEVELS

Lower Influence level -Water surface elevation above which groundwater affects lower zone behavior and processes

$$LELV = SELV - (2.5*LZSN)/PCW$$

where: LELV = lower zone influence level [in]
SELV = mean surface elevation (relative to some datum) [in]
LZSN = lower zone nominal storage [in]
PCW = porosity in micropores

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Upper influence level - Water surface elevation above which groundwater affects upper zone behavior and processes

$$UELV = SELV - (4*UZSN + IFWSC)/UPGW$$

where: UELV = upper zone and interflow influence level [in]
SELV = mean surface elevation [in]
UZSN = upper zone nominal storage [in].
IFWSC = interflow storage capacity [in]
UPGW = porosity in macropores in upper soil layer [-]
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GROUNDWATER STORAGES AND ELEVATIONS

Region 1: GWEL < LELV

TGWS = AGWS + BGWS
GWEL = TGWS/(PCW + PGW)

Region 2: UELV > GWEL > LELV

LLGWS = LELV*(PCW + PGW)
GWEL = LELV + (TGWS-LLGWS)/PGW

Region 3: SELV > GWEL > UELV

ULGWS = LLGWS + (UELV - LELV)*PGW
GWEL = UELV + (UZS + IFWS + (TGWS - ULGWS))/PGW

Above Region 3: Surface Ponding

Water Surface Elevation = GWEL + SURS

GROUNDWATER EVAPOTRANSPIRATION

<u>Region 1:</u> **GWEL < LELV**

'Normal' operation of ET algorithms, except ET at potential rate from Surface Detention Storage (SURS)

<u>Region 2:</u> **UELV > GWEL > LELV**

AGWET = REMPET*[AGWETP + (1.0 – AGWETP)*(GWEL-LELV)/(SELV-LELV)]

where: AGWET = evapotranspiration from groundwater [in]
REMPET = remaining potential evapotranspiration [in]
AGWETP = fraction of REMPET from active groundwater, input parameter [-]
GWEL = groundwater elevation [in]
SELV = surface elevation [in]

AGWET cannot exceed the groundwater storage above LELV:

AGWET = MIN[AGWET, (TGWS-LLGWS)]

<u>Region 3:</u> **SELV > GWEL > UELV**

ET at potential rate from UZS (normal operation) and added to AGWET

<u>Above Region 3:</u> **Surface Ponding**

ET at potential rate from SURS

SURFACE RUNOFF OPTIONS

RTOPFG = 1:

'Normal' gravity and slope driven overland flow routing

RTOPFG = 2: **Power function of Surface Storage**

SURO = (1-SRRC*DELT60)*SURSSREXP**

where: SURO = Surface Outflow [in/interval]
SURS = Surface Detention Storage [in]
SRRC = Hourly recession constant
DELT60 = Hours per interval
SREXP = Exponent in surface runoff equation

RTOPFG = 3: **General FTABLE Option**

```
FTABLE        1
ROWS COLS    ***
        5        2
   Depth   Outflow   ***
   (in)      (/hr)  ***
   ----     -------     ***
        0.0      0.00
   2.0      0.01
   4.0      0.02
   6.0      0.03
   8.0      0.04
END FTABLE   1
```

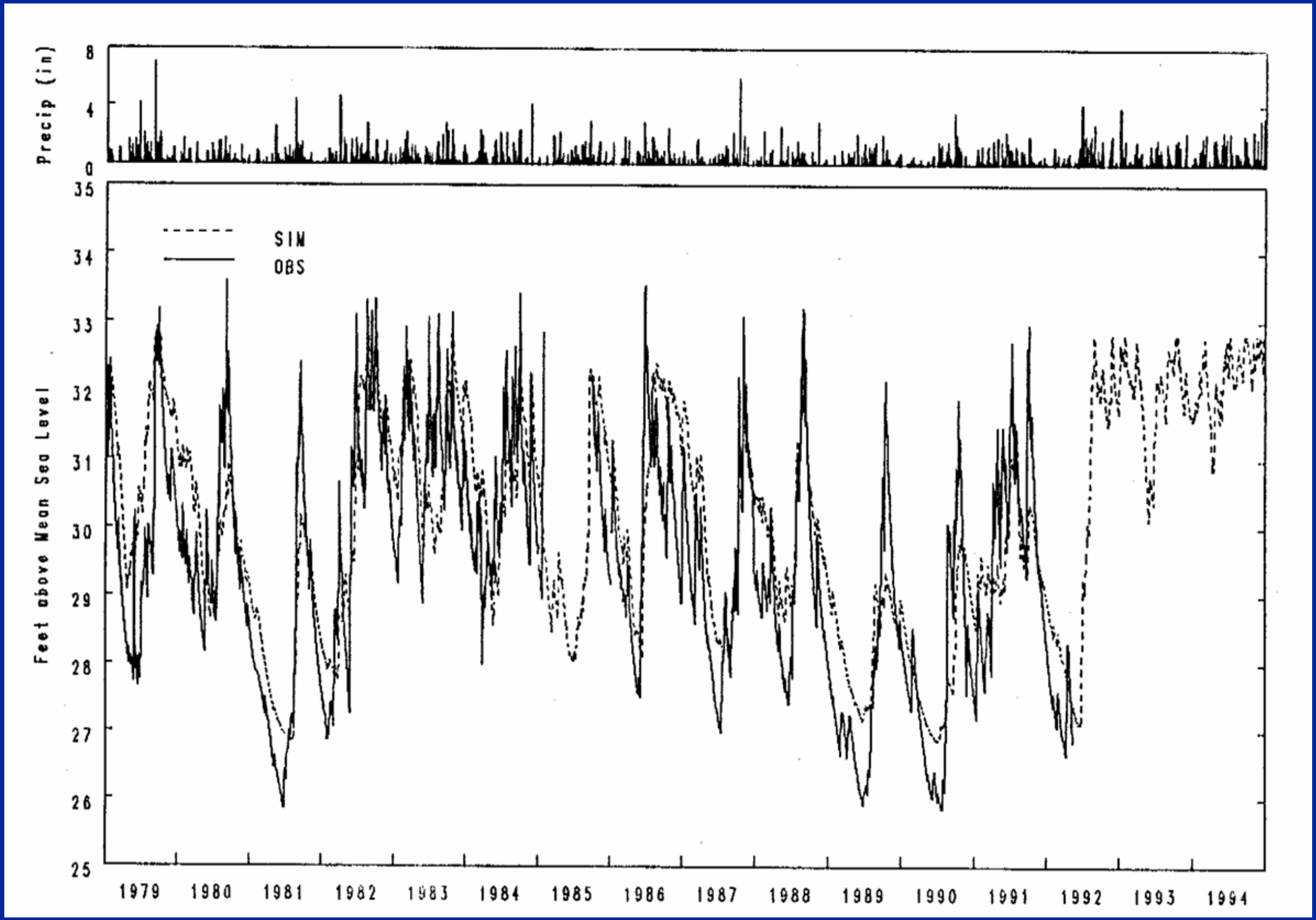
NEW PWATER VARIABLES, PARAMETERS, AND CONSTANTS (#1)

NAME	TYPE	EXPLANATION	COMMENTS
GWEL	Variable	Groundwater elevation (in)	Elevation of the groundwater calculated in each time step.
GWDATM	Parameter	Datum for GWEL (ft) (typically mean sea level in coastal areas)	Total groundwater storage is the storage between GWDATM and the groundwater elevation.
SELV	Constant	Mean surface elevation (in) =MELEV*12-GWDATM (MELEV is a parameter)	The mean elevation is representative for flat areas.
UELV	Constant	Upper Influence Elevation (in) = SELV-(4*UZSN+IFWSC)/UPGW	Elevation above which the groundwater affects upper zone and interflow storage behavior.
LELV	Constant	Lower Influence Elevation (in) = SELV-(2.5*LZSN)/PCW	Elevation above which the groundwater affects lower zone behavior and may affect interflow.
BELV	Parameter	Base elevation for AGWO (in) (corresponds to the bottom elevation of nearby channels)	Groundwater elevation above which there is outflow into the channels. Groundwater below BELV is inactive.
ULGWS	Constant	Total Groundwater storage when the groundwater level is at UELV (in)	Groundwater storage above which groundwater affects upper zone and interflow behavior.
LLGWS	Constant	Total Groundwater storage when the groundwater level is at LELV (in)	Groundwater storage above which groundwater affects lower zone and may affect interflow behavior.

NEW PWATER VARIABLES, PARAMETERS, AND CONSTANTS (#2)

NAME	TYPE	EXPLANATION	COMMENTS
BGWS	Constant	Total Groundwater storage when groundwater level is BELV (in)	Groundwater storage above which there is groundwater outflow.
PCW	Parameter	Cohesion water porosity (-)	Soil pore space in micropores
PGW	Parameter	Gravitational water porosity (-)	Soil pore space in macropores.
UPGW	Parameter	Upper gravitational water porosity (-)	Pore space in macropores in the upper layers of the soil column.
IFWSC	Parameter	Maximum interflow storage (in)	Maximum interflow storage if GWEL>UELV
SRRC	Parameter	Surface Runoff Recession Constant (-)	Used to calculate surface runoff as a function of surface storage only.
SREXP	Parameter	Surface Runoff Exponent (-)	Used to calculate surface runoff as a function of surface storage only.
DELTA	Constant / Parameter	Tolerance level to determine transition between regions (in)	Used to smooth out jumps in gw elevation due to changes in soil region.
LELFAC	Parameter	Factor in equation describing lower zone influence level	Typical value is 2.5.
UELFAC	Parameter	Factor in equation describing the upper influence level	Typical value is 4.0.

EXAMPLE GW ELEVATION SIMULATION RESULTS FOR St. LUCIE WATERSHED, FL (#1)



Groundwater elevations at Indiantown Well (1979-1994).

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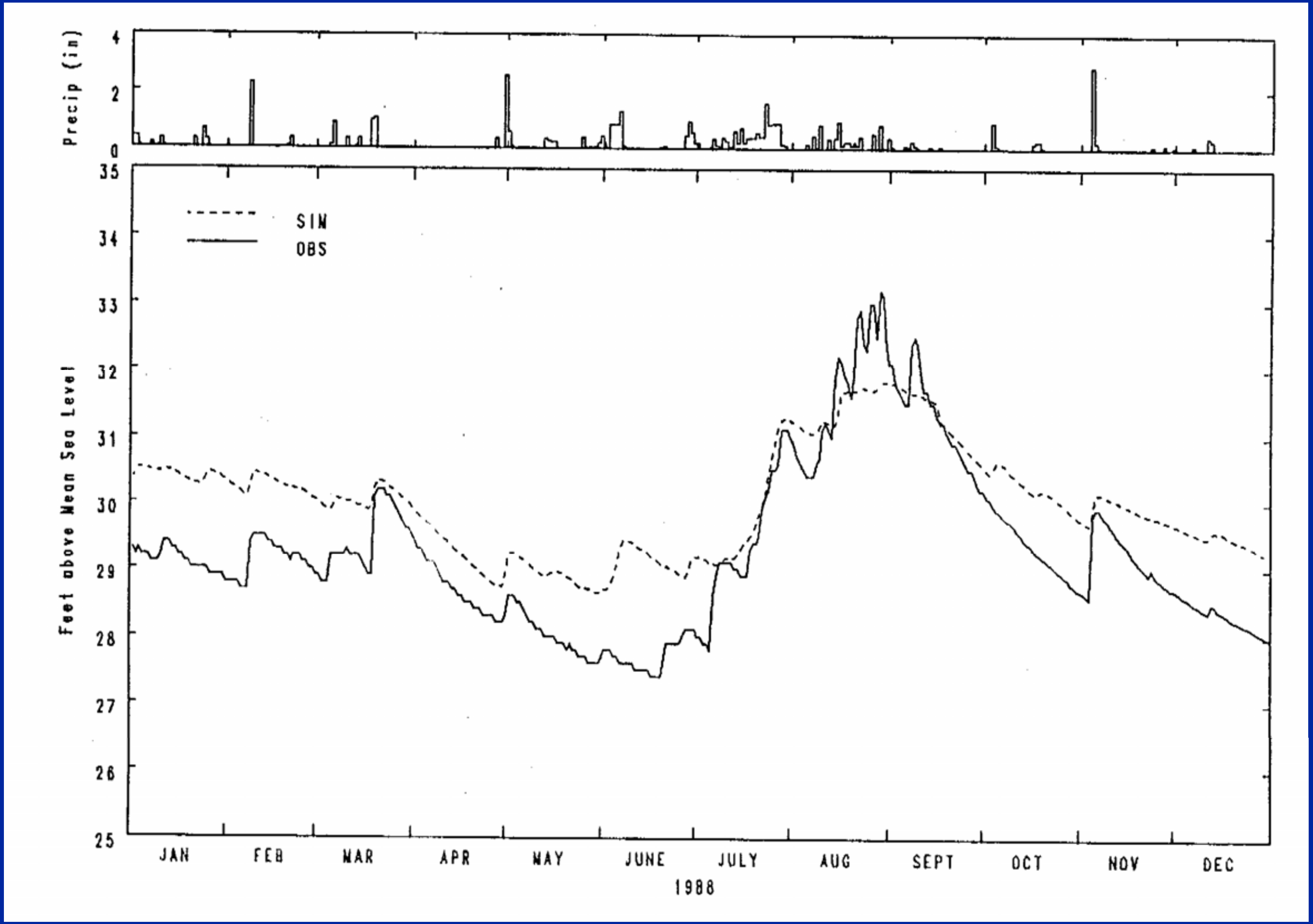
EXAMPLE GW ELEVATION SIMULATION RESULTS FOR St. LUCIE WATERSHED, FL (#2)



Groundwater elevations at Indiantown Well (1988).

CONCLUSIONS

- High water table/wetlands code changes have been successfully implemented into PWATER
- Preliminary testing with prototype model and generic data for South Florida has been successful; model simulates range and variability of groundwater levels
- Preliminary testing with a subset of St. Lucie data shows reasonable reproduction of groundwater levels and variability
- Complete testing within the integrated HSPF/FEQ system on St. Lucie is needed; issues of irrigation applications, pumping, and canal water levels must be addressed

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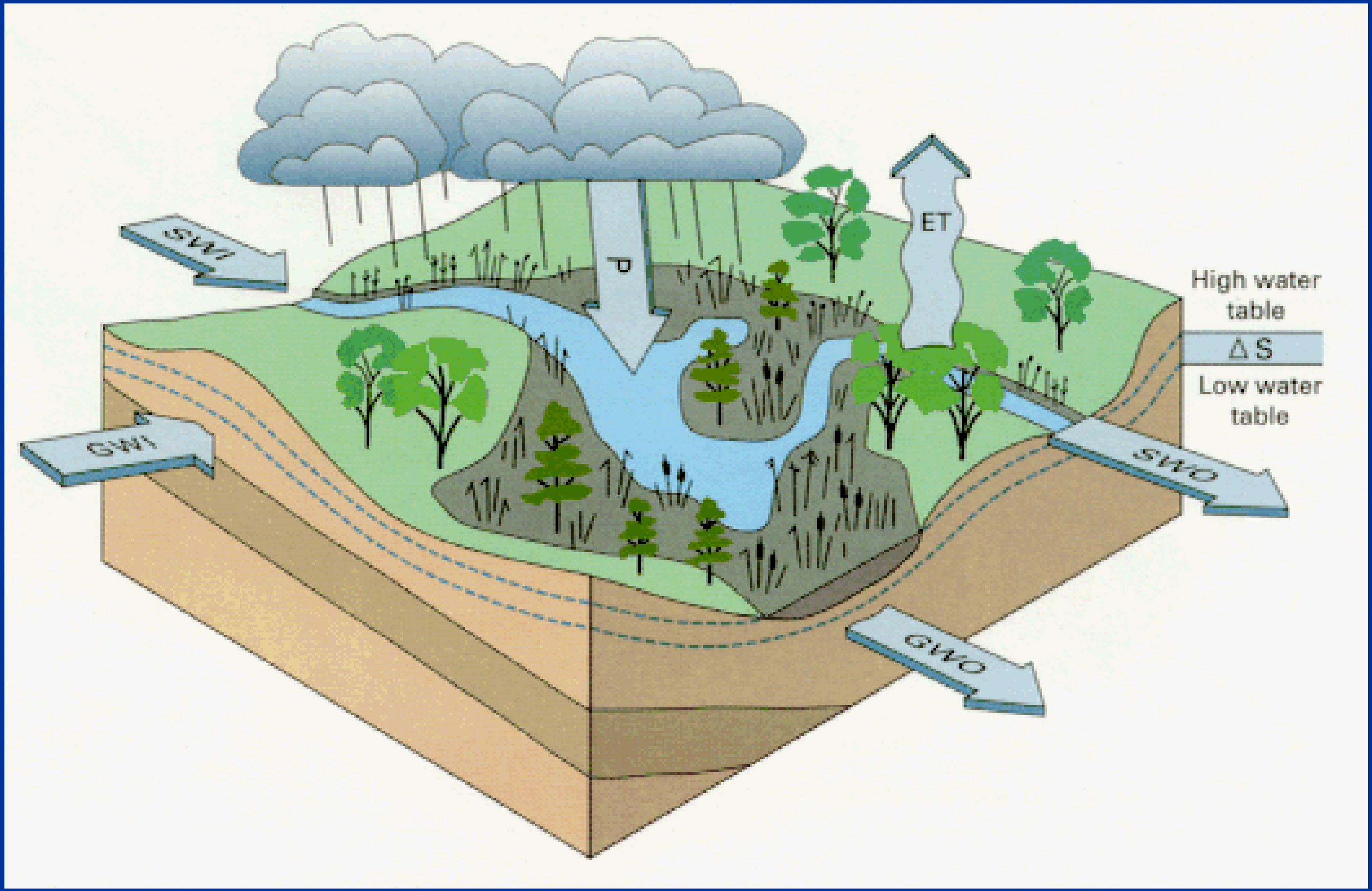
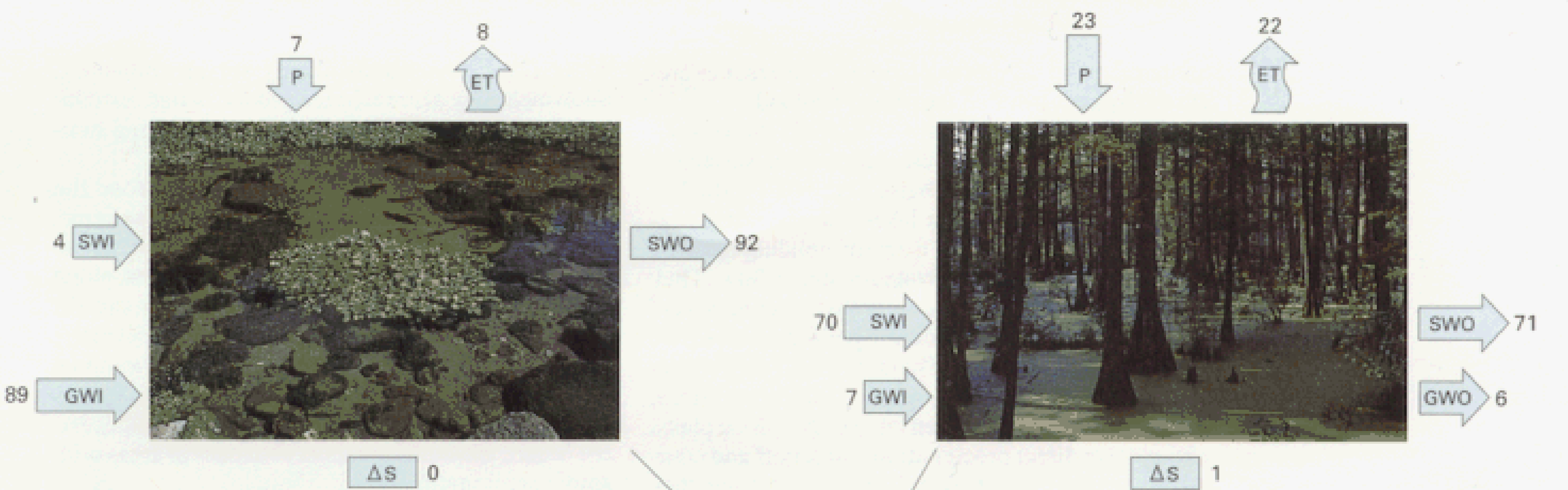
COMPONENTS OF WETLANDS WATER BUDGETS



P = precipitation
SWI = surface-water inflow
SWO = surface-water outflow
GWI = ground-water inflow
GWO = ground-water outflow
ET = evapotranspiration
ΔS = change in storage

$$P + SWI + GWI = ET + SWO + GWO + \Delta S$$

WATER BUDGETS FOR SELECTED WETLAND TYPES

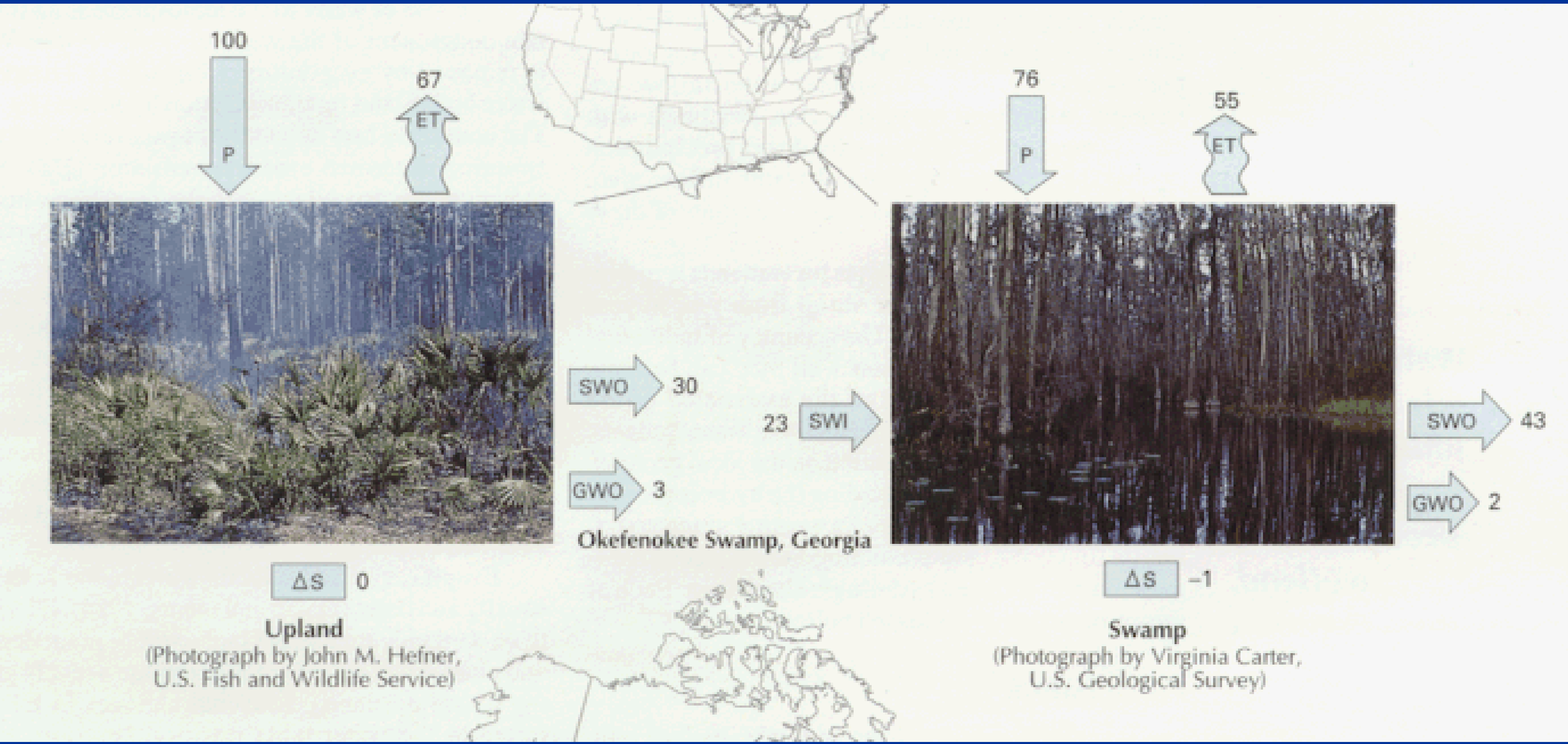


Nevin Wetland, Wisconsin
(Photograph by Richard P. Novitzki, ManTech Environmental Technology, Inc.)

Heron Pond, Alluvial Cypress Swamp, Illinois
(Photograph by William J. Mitsch, Ohio State University)

Components are expressed in percentages.

WATER BUDGETS FOR SELECTED WETLAND TYPES



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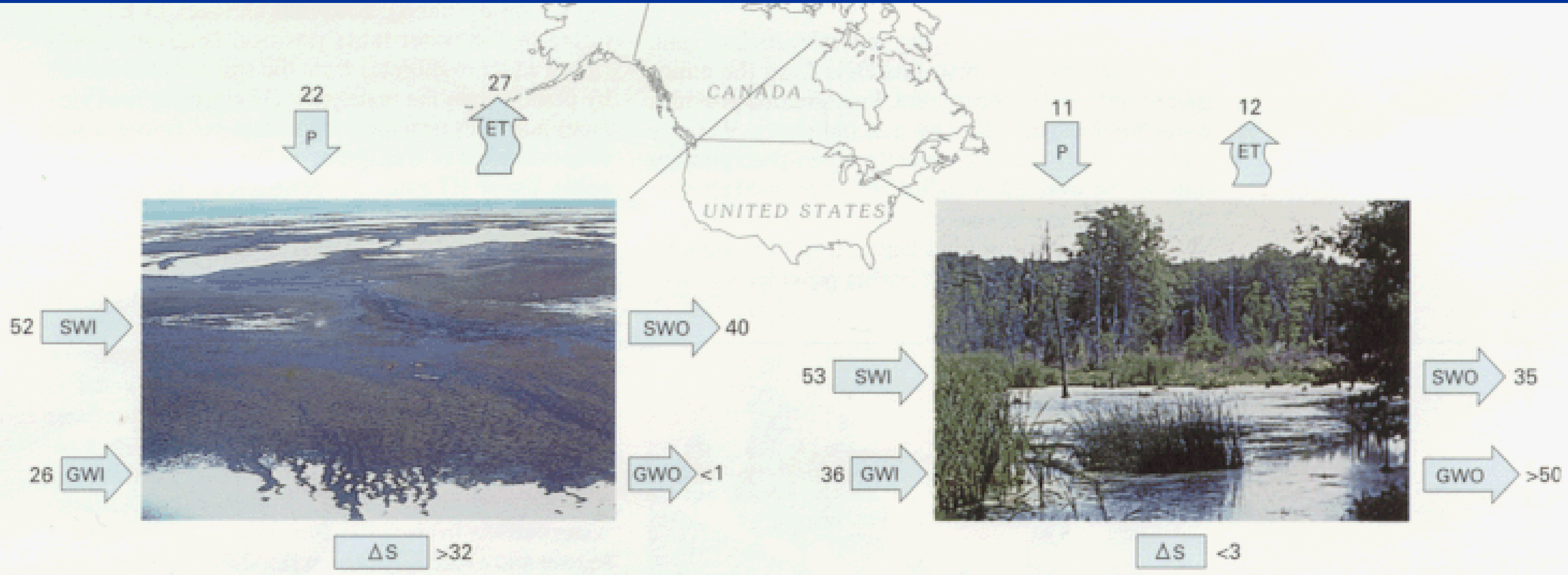
WATER BUDGETS FOR SELECTED WETLAND TYPES



Arctic Fen, west of Baker Lake, Northwest Territories, Canada
(Photograph by Nigel T. Roulet, McGill University, Montreal)

Hidden Valley Marsh, Ontario, Canada
(Photograph by Jim Gehrels, Ontario Ministry of Environmental Energy)

Components are expressed in percentages.