

Toward solute transport modeling framework through an Integrated hydrogeological model

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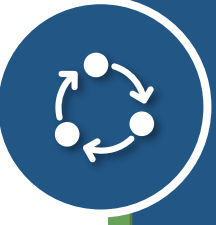
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PRESENTATION STRUCTURE



INTRODUCTION



CONCEPTUAL MODEL SCHEMATIC



MATHEMATICAL FORMULATION



MODIFICATION OF CODES



ONGOING WORK

Introduction:

Statement of the Problem, Purpose, and Approach

Statement of the Problem

- Managing groundwater salinity is a priority in the Central Valley
- SGMA calls out water quality as one of the undesirable results
- IWFM and MODFLOW do not have direct functionality for simulating the salinity across all processes

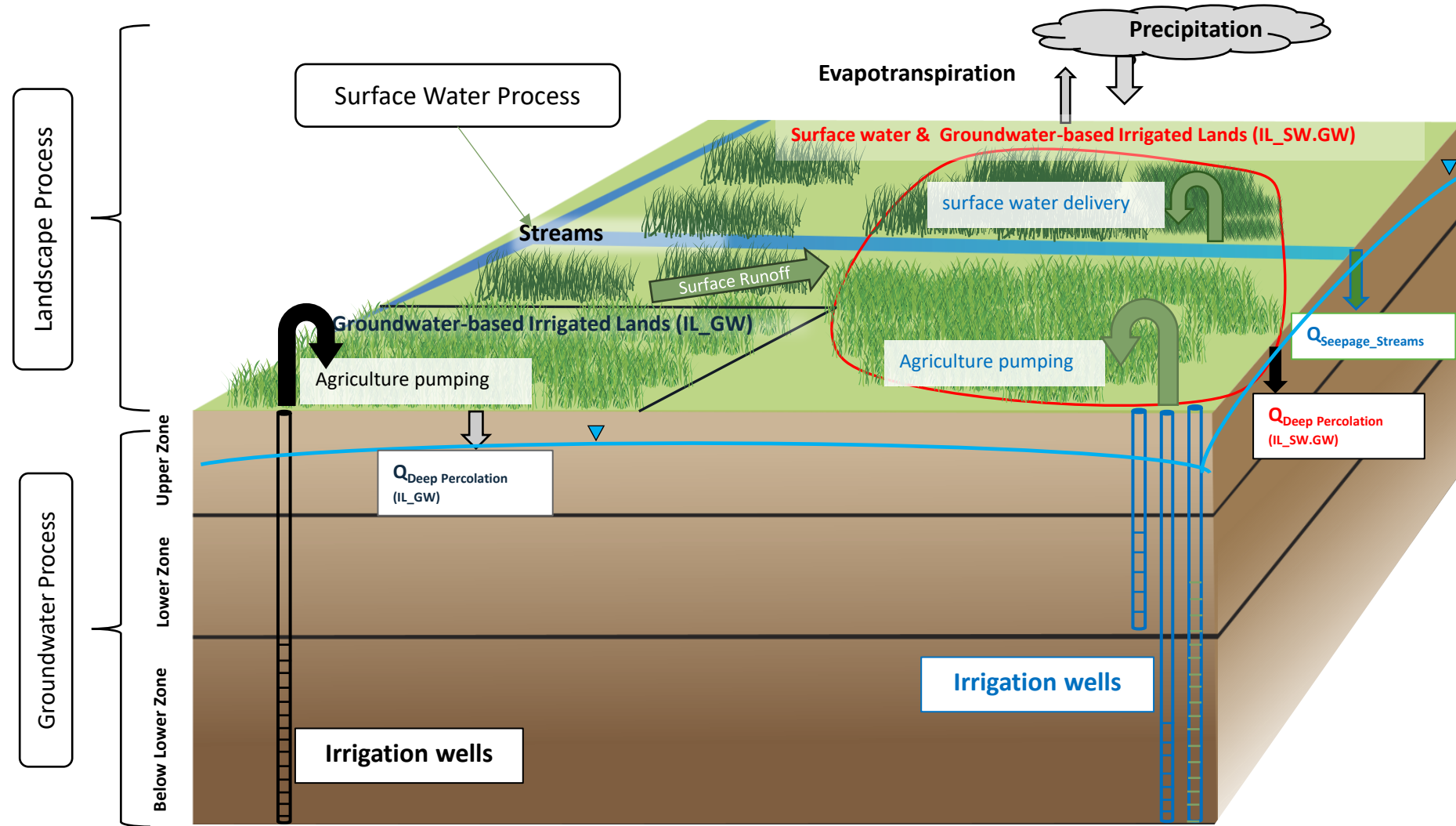
Purpose

Provide a framework of salinity fate and transport via **landscape**, **surface water**, and **groundwater** processes in a dynamic integration concept by considering the primary transport flow paths

Approach

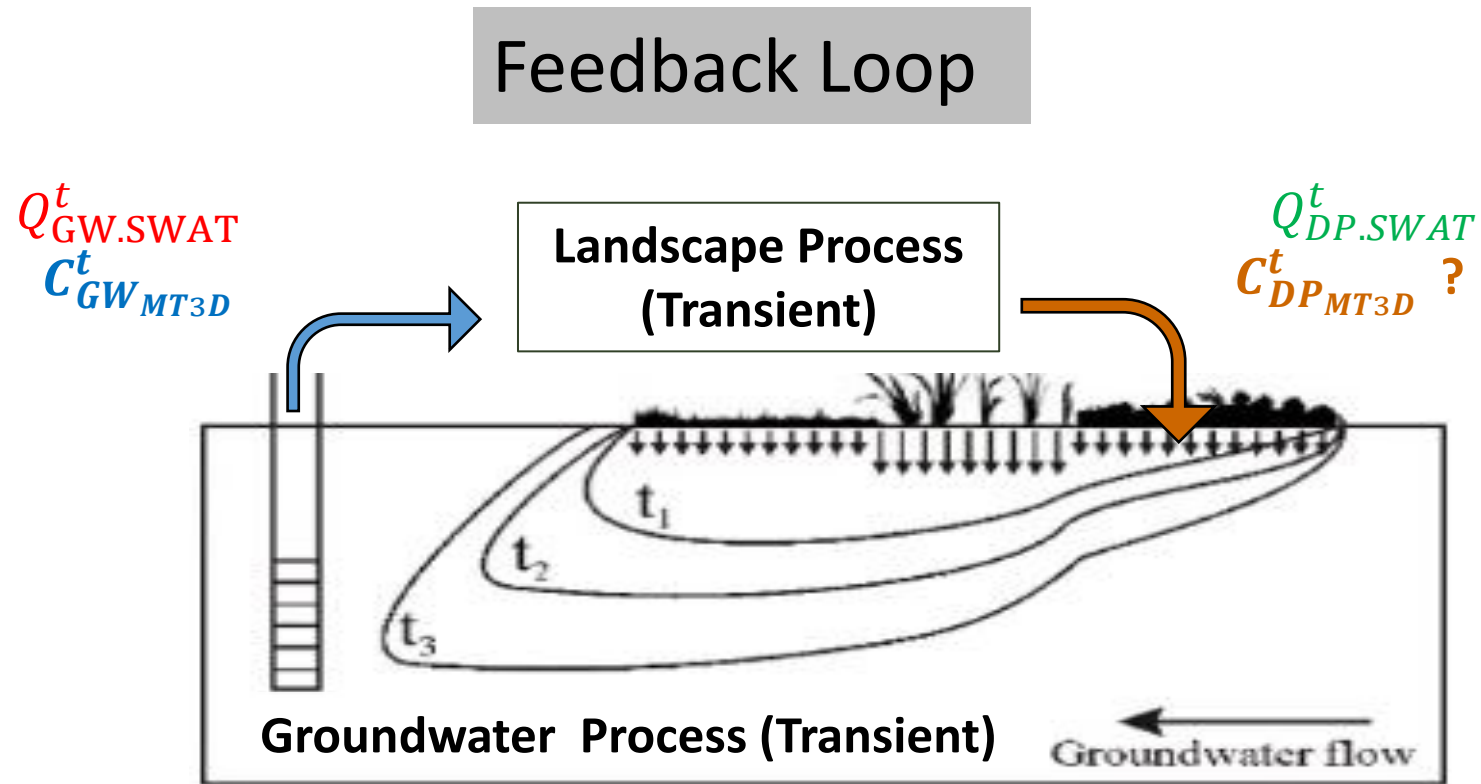
1. Write the salinity mass-conservation equation
2. Modify MF-OWHM and MT3D-USGS to include these linkages between **these transport flow paths** at the process level
 - a) Standalone Code
 - b) Link SWAT with USGS Platforms (MF-OWHM and MT3D-USGS)
3. Application to real world problem

CONCEPTUAL MODEL SCHEMATIC



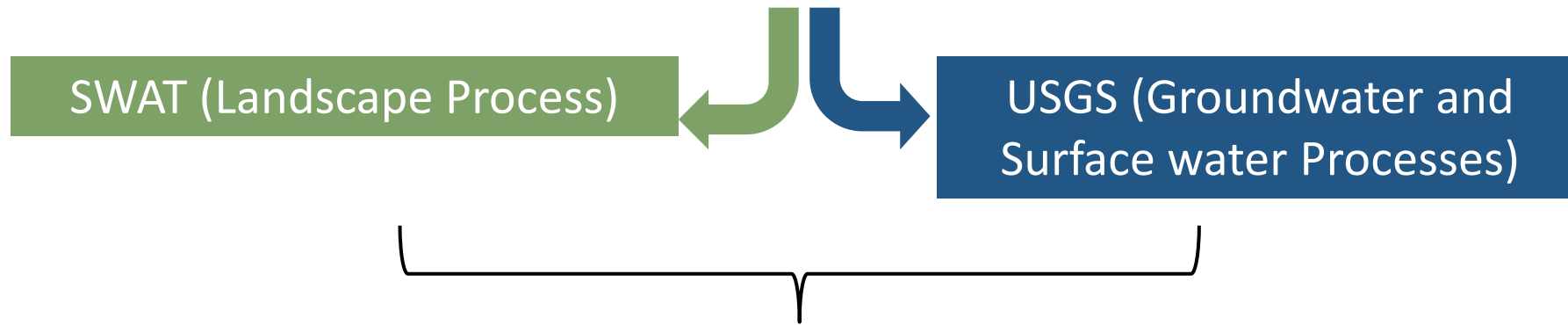
CONCEPTUAL MODEL SCHEMATIC

How the salinity concentration of groundwater pumping influences the salinity concentration of deep percolation?



MATHEMATICAL FORMULATION: Link SWAT with USGS Platforms

The conceptual solute transport model is guided by



- This work presents an initial approach based on modifying MF-OWHM and MT3D-USGS
- Customized version of MF-OWHM and MT3D-USGS platforms

MATHEMATICAL FORMULATION: Link SWAT with USGS Platforms

SWAT Conceptual Model

- Explicit Landscape System

P : Precipitation

SW : Delivery from surface water infrastructure

Q_{GW-ag} : Groundwater pumping delivery out of groundwater system via agricultural well

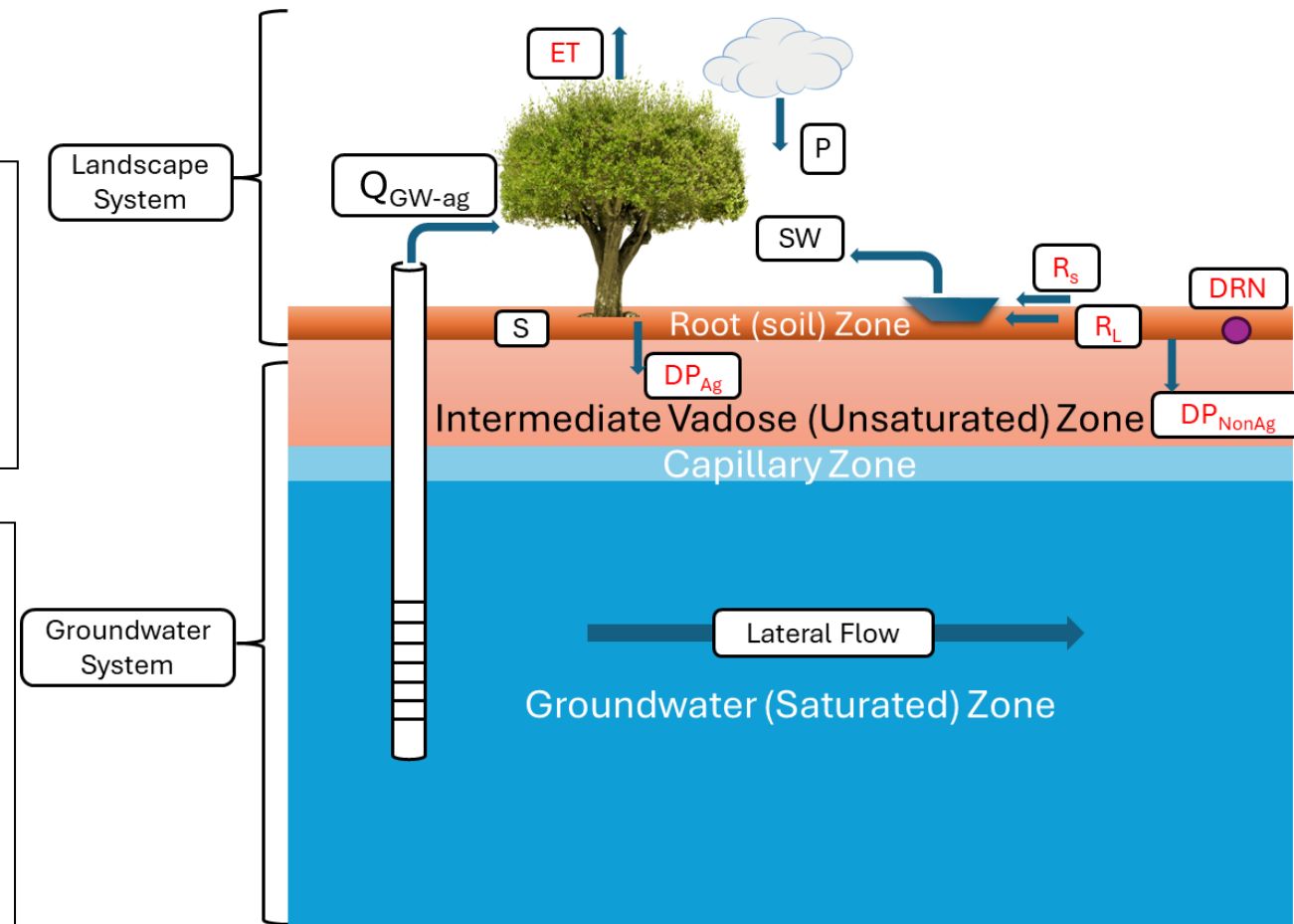
R_s : Overland runoff (= Inefficient Losses from irrigation + Inefficient Losses from Precipitation)

R_L : Lateral flow from root zone

DP : Deep percolation into a groundwater system

DRN : Recycled water delivery from Drain infrastructure

S : Change in storage of root zone

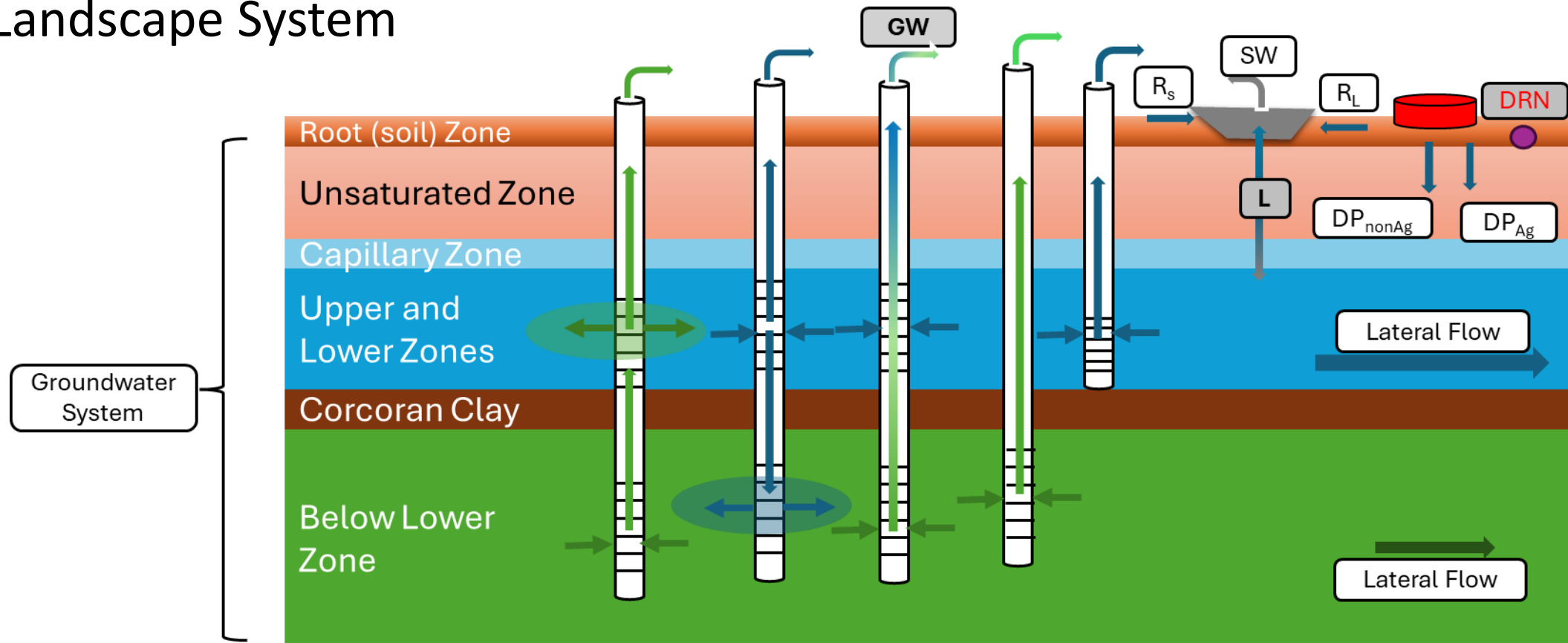


MATHEMATICAL FORMULATION: Link SWAT with USGS Platforms

MODFLOW/MT3D-USGS Conceptual Model

MODFLOW/MT3D-USGS Components/Process :

- Explicit Groundwater System (Groundwater and Surface water processes)
- Implicit Landscape System



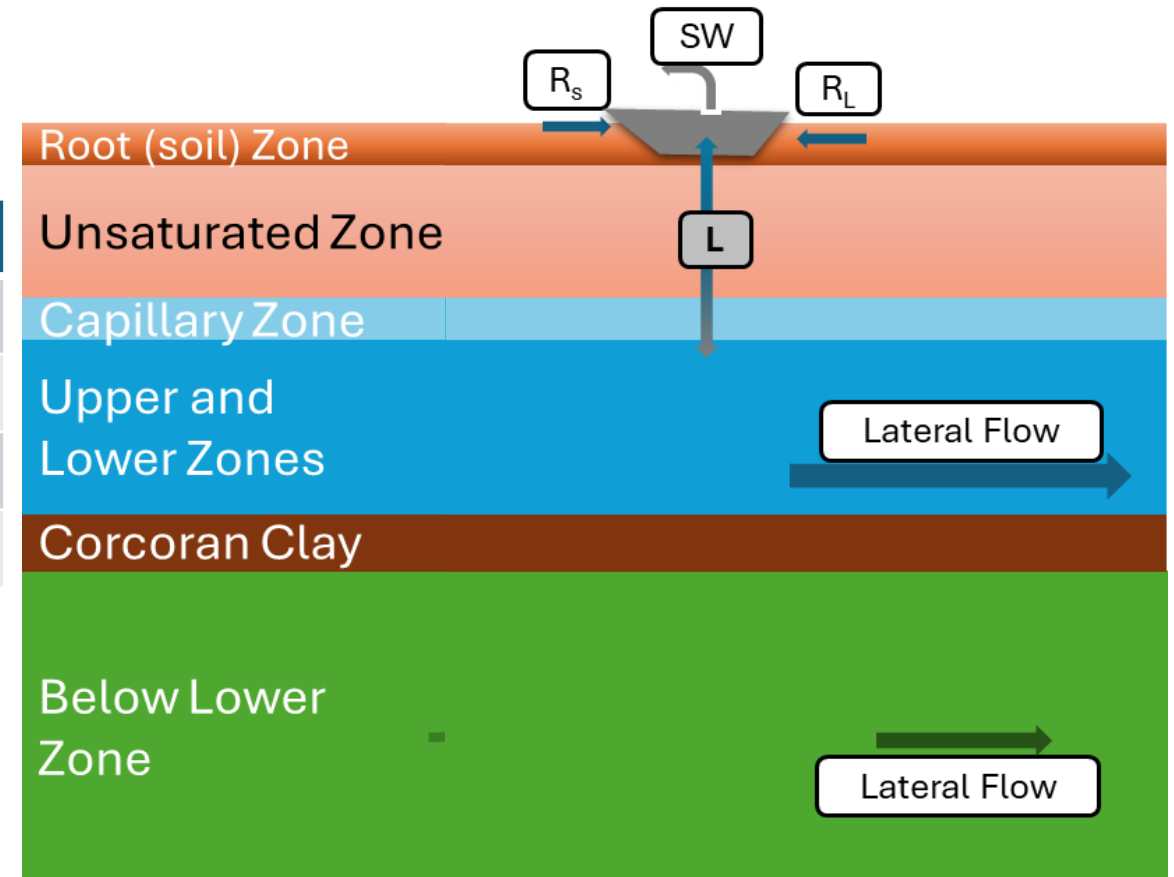
MATHEMATICAL FORMULATION: Link SWAT with USGS Platforms

MODFLOW/MT3D-USGS Conceptual Model

MODFLOW/MT3D-USGS Components/Process :

- Surface water simulation

Budget component	Flow Source	TDS Source
Lateral flow (R_L)	SWAT	SWAT
Surface runoff (R_s)	SWAT	SWAT
SW-GW Interaction (L)	MODFLOW	MT3D-USGS
Flow along stream	MODFLOW	MT3D-USGS



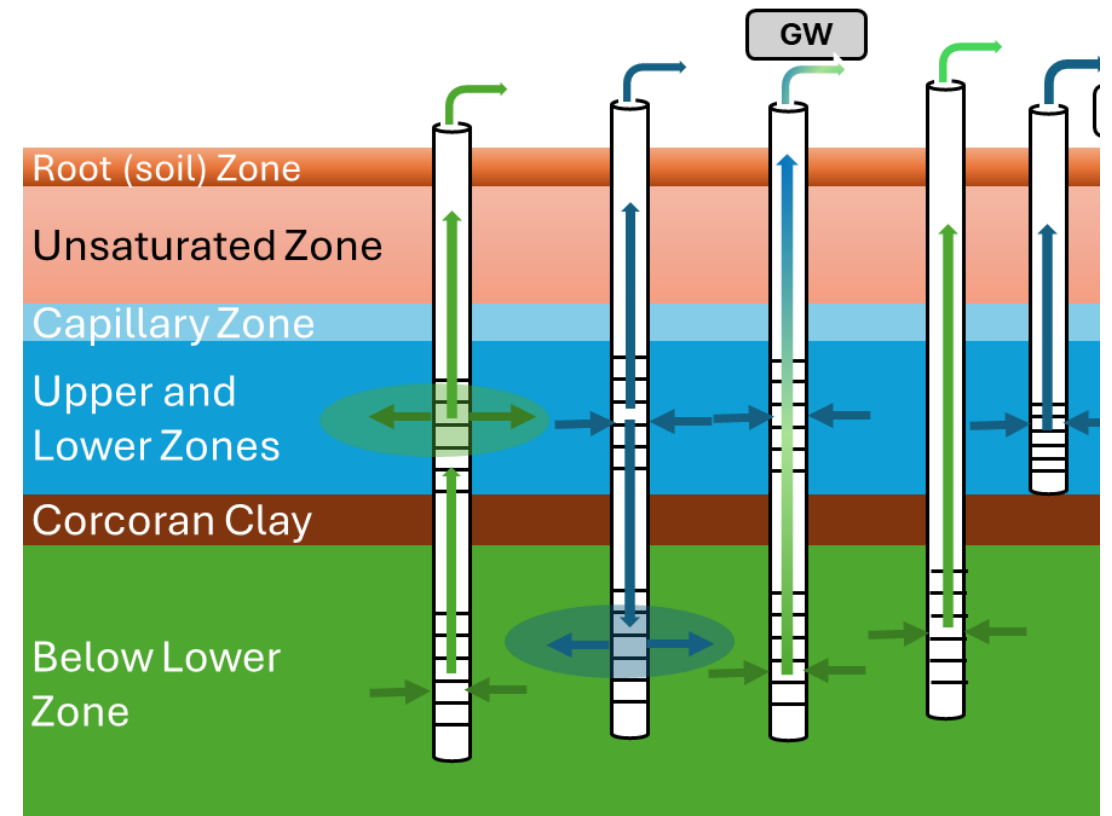
MATHEMATICAL FORMULATION: Link SWAT with USGS Platforms

MODFLOW/MT3D-USGS Conceptual Model

MODFLOW/MT3D-USGS Components/Process :

- Well hydraulics

Budget component	Flow Source	TDS Source
Pumping	SWAT	MT3D-USGS
Borehole	MODFLOW	MT3D-USGS



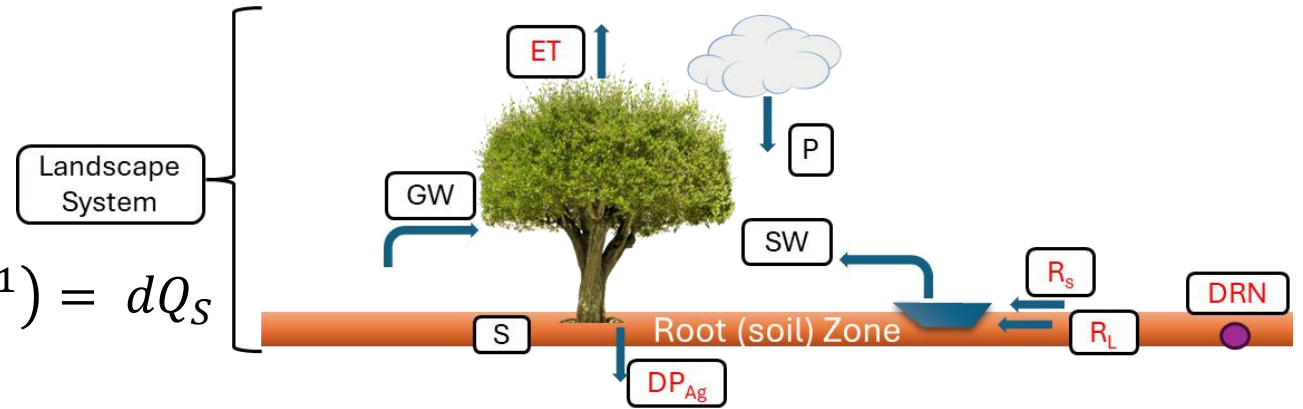
MATHEMATICAL FORMULATION: Link SWAT with USGS Platforms

Feedback loop Concept

Approach : Start with mass balance equations (Flow and TDS)

Flow mass balance

$$\left(Q_P + Q_{SW} + Q_{GW} - Q_{RS} - Q_{RL} - Q_{ET} - Q_{DRN} - Q_{DP} \right)^t = (Q_S^t - Q_S^{t-1}) = dQ_S$$



TDS mass balance

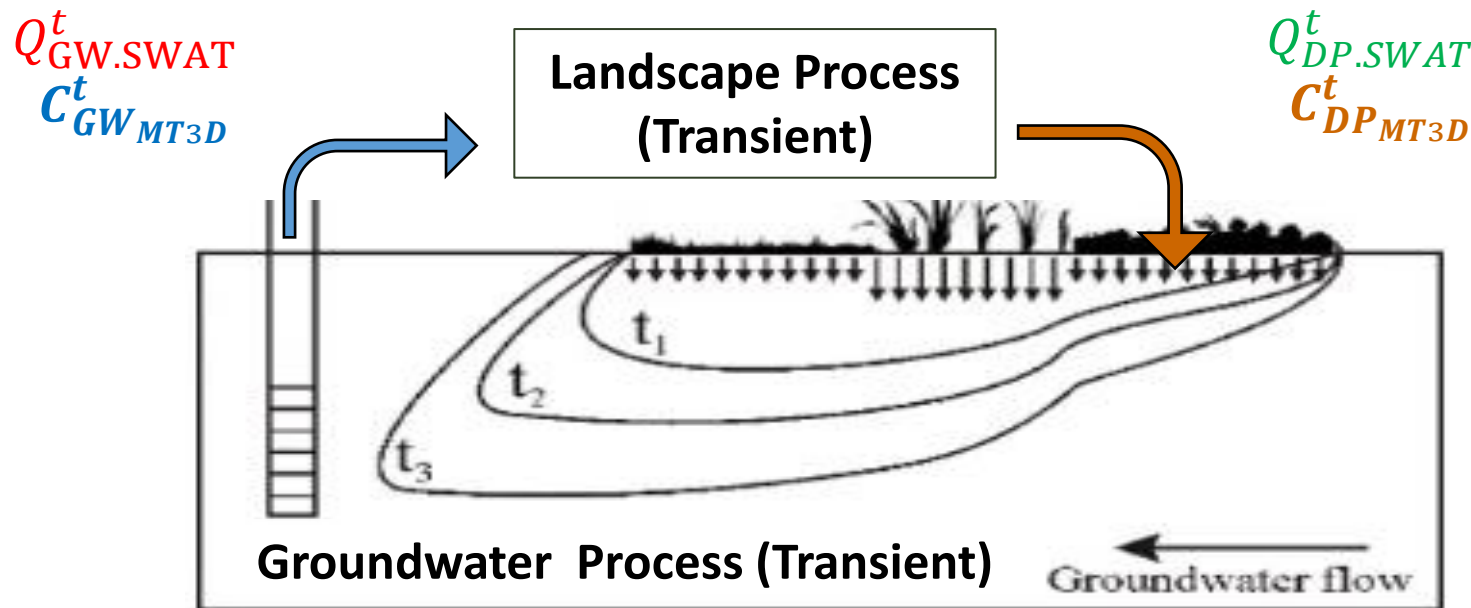
$$(C_P Q_P + C_{SW} Q_{SW} + \mathbf{C_{GW}} Q_{GW} - C_{RS} Q_{RS} - C_{RL} Q_{RL} - C_{ET} Q_{ET} - C_{DRN} Q_{DRN} - \mathbf{C_{DP}} Q_{DP})^t \pm M^t = (C_S^t Q_S^t - C_S^{t-1} Q_S^{t-1}) = dC_S Q_S$$

$$\mathbf{C_{DP_{MT3D}}^t} = \mathbf{b \cdot C_{GW_{MT3D}}^t} + (\mathbf{C_{DP_SWAT}^t} - \mathbf{b \cdot C_{GW_{SWAT}}^t}), \quad b = \left(\frac{(Q_{GW}^t)}{(Q_{DP}^t)} \right)$$

MODIFICATION OF CODES : Link SWAT with USGS Platforms

MT3D-USGS code was modified to include this equation in the framework of Contaminant Treatment Systems (CTS) package

$$C_{DP_{MT3D}}^t = b \cdot C_{GW_{MT3D}}^t + (C_{DP_SWAT}^t - b \cdot C_{GW_{SWAT}}^t), \quad b = \left(\frac{(Q_{GW.SWAT}^t)}{(Q_{DP.SWAT}^t)} \right)$$

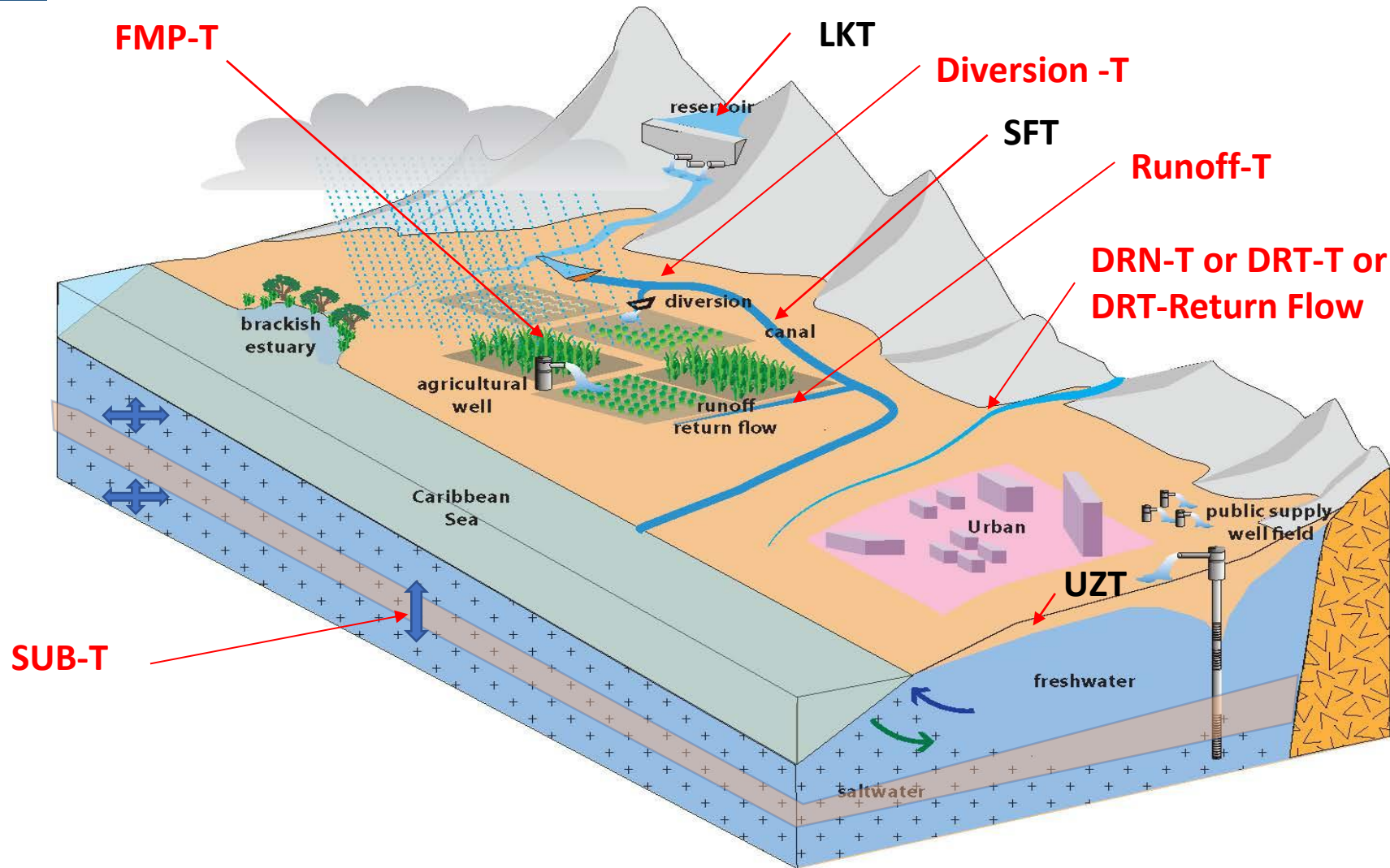


WORK IN PROGRESS:

Standalone Modules of Solute Transport for Landscape Process

[MT3D-OWHM]

MT3D-USGS
(Packages Not
Supported)



WORK IN PROGRESS

Like MF-OWHM Code that simulates water flow in an Integrated Hydrogeological Model Framework, associated solute transport code in the same principal that includes FMP-transport module will be added to MT3D-USGS to work with MF-OWHM.