Continuous Simulation Modeling of Stormwater Ponds, Lakes, & Wetlands: THE TECHNOLOGY IS HERE!

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CONTINUOUS SIMULATION MODELING: WHAT IS IT?

- A model which analyzes the day to day hydrology of the system over a long period of time (say 3 to 100 years), taking into account all components of the system's water budget.
- Such a model can predict, on a daily basis, stages, inflows, and discharge rates and volumes (both ground water & surface water).

CONTINUOUS SIMULATION MODELING: WHY IS IT NEEDED?

- **Because of potential water quantity & water quality impacts in volume-sensitive basins, there is a growing concern for regulating cumulative discharge volume from stormwater management systems. This is apart from regulating peak discharge rates.**

- **Useful for predicting predevelopment and postdevelopment wetland hydroperiods.**

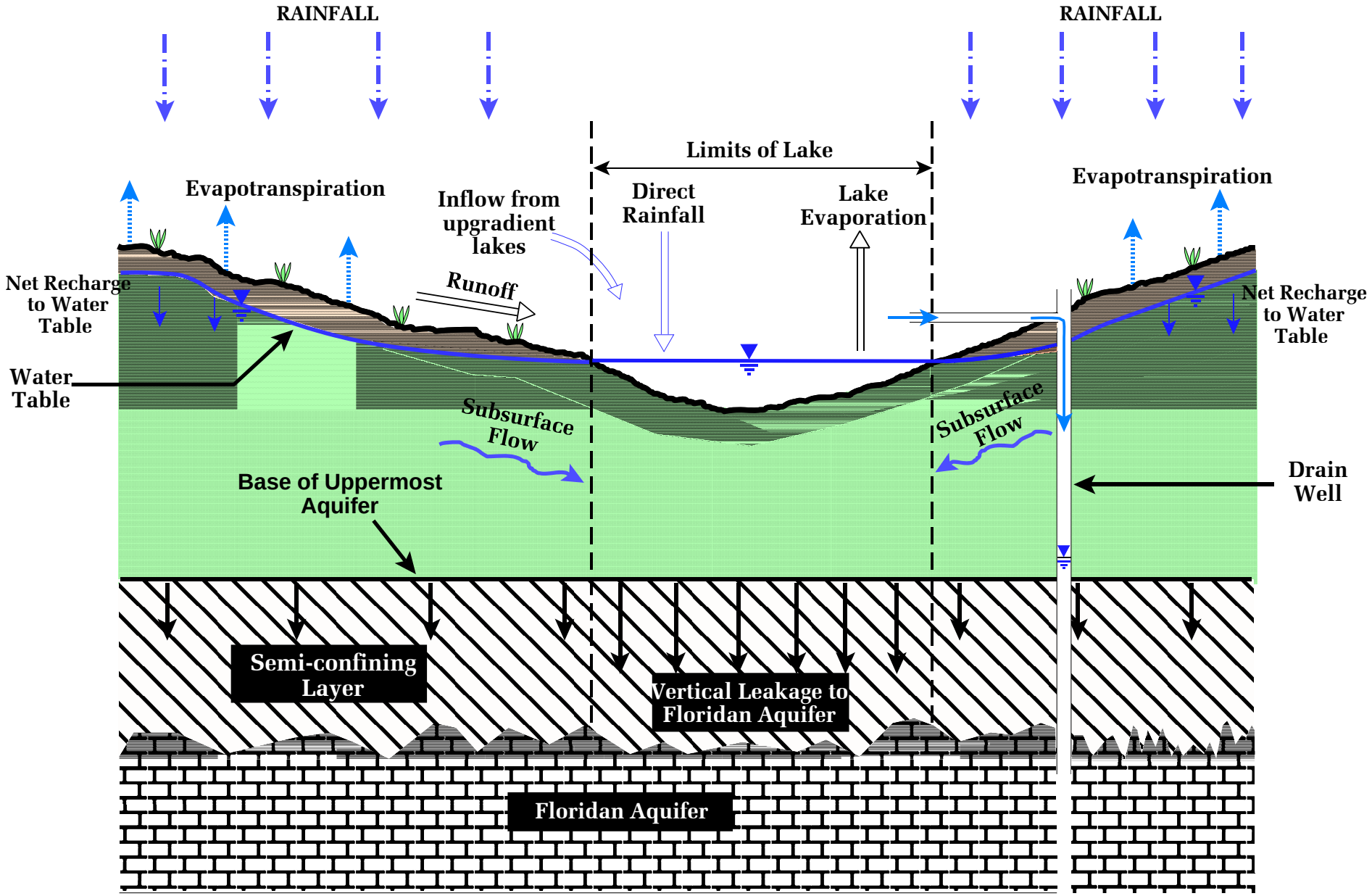
- **In land-locked basins, excess cumulative rainfall over a 2 to 3 year period can result in stages which approach or exceed the 100 year flood elevations. *Is 210 inches of rain in 3 years more critical than 10.6 inches of rain in 24 hours? How about 23 inches in 3 dry season months such as El Nino gave us during Dec 1997 to Feb 1998?* Conventional modeling and current regulatory requirements do not address this type of occurrence which many of us saw first hand in 1994-1996 and late 1997, early 1998.**

CONCEPTUAL MODEL FOR CLOSED BASINS IN CENTRAL FLORIDA

WHAT DOES IT LOOK LIKE?

Let's see.....

CONCEPTUAL MODEL FOR LAND-LOCKED BASINS



CONTINUOUS SIMULATION MODELING: THE METHODOLOGY

- The long-term, continuous simulation model is performed using the PONDS Version 3 computer program (Win95/NT version). This is a MODFLOW-based ground water/surface water interaction model which computes ground water and surface water discharges during and following transient hydraulic loading of a water management pond or lake.
- The first step is to create a long-term, continuous simulation hydrograph and the second step is to route it through the stormwater management pond.
- This methodology has been used successfully on numerous projects in the Central Florida area.

CONTINUOUS SIMULATION MODELING: THE ROUTING MODULE

- Saturated ground water flow is simulated using a modified (recompiled) version of the USGS MODFLOW computer code. The three relevant modifications to MODFLOW are as follows:
  - A new subprogram (written by the author) has been included to model non-linear discharge structures such as unsubmerged weirs, orifices, notches, etc., and
  - Irregular surface area vs. stage relationships are modeled by changing the storage coefficient as a function of the water elevation within the "limits" of the water body.
  - The computer code has been compressed and optimized such that 40,000+ MODFLOW stress periods can be executed in a reasonable computational time.
- Code has been formally approved by the St. Johns River Water Management District (Florida) for routing analyses and it is also used by the Southwest Florida Water Management District (Florida) for permit review purposes.

CONTINUOUS SIMULATION MODELING: THE HYDROGRAPH

- Unlike conventional surface water routing models, the continuous simulation inflow hydrograph includes 3 columns of data:
  - the elapsed time (in hr),
  - the flow rate (in cfs) into the water body (which may be positive or negative), and
  - the recharge rate (in ft/day) to the water table aquifer adjacent to the water body (which may also be positive or negative).
- The first two columns of data in the hydrograph are the same as the conventional surface water routing models but the third column is added to model fluctuation of the water table adjacent to the water body.

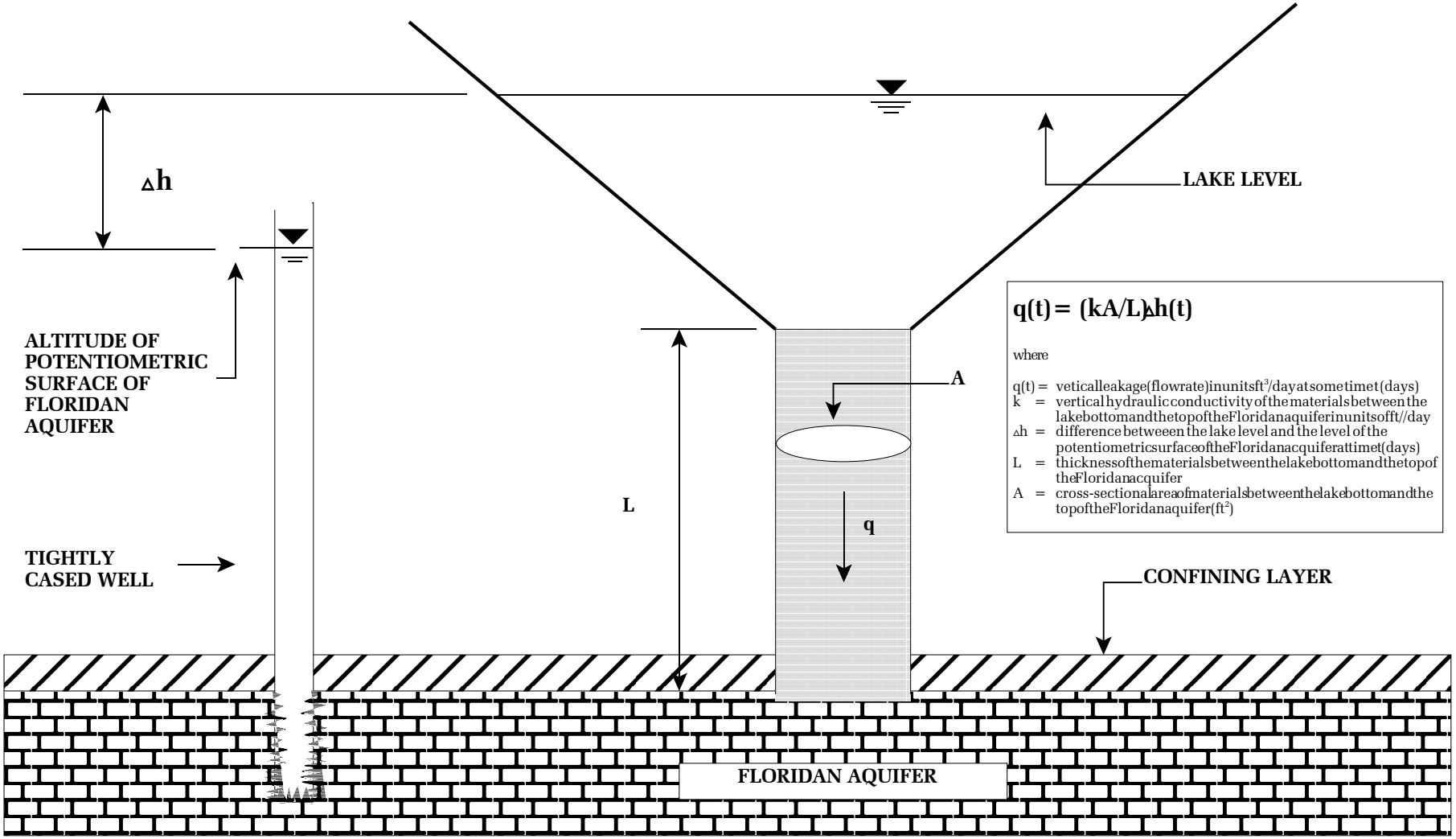
CONTINUOUS SIMULATION MODELING: INPUTS TO GENERATE HYDROGRAPH

- Surface water inflow: Directly Connected Impervious Area (DCIA) (acres), non-DCIA area (acres), CN for non-DCIA area. Note CN is automatically adjusted daily based on antecedent rainfall. Also note that precise definition of DCIA is extremely important when modeling small rainfall events.
- Evaporation loss & rainfall (daily)
- E.T. within non-DCIA area of watershed (daily)
- Artificial recharge within non-DCIA area of watershed

CONTINUOUS SIMULATION MODELING: POND DEFINITION

- Stage-area relationship & perimeter of water body
- Typical parameters for surficial aquifer system: permeability, porosity, and depth of aquifer (from site-specific geotechnical report)
- Overflow discharge structures (up to 3)
- Vertical exchange of water between water body & Floridan aquifer (linear or non-linear relationship established by geotech). Can also be modeled as an equivalent weir or orifice. Let's take a look at what this means .....

MODEL FOR COMPUTING DISCHARGE FROM LAKE OR POND TO FLORIDAN AQUIFER AS AN EQUIVALENT LINEAR WEIR



$$q(t) = (kA/L)\Delta h(t)$$

where

$q(t)$ = veticalleakage(flowrate)inunitsft^3/dayatsometimet(days)
k = verticalhydraulicconductivityofthematerialsbetweenthe lakebottomandthetopoftheFloridanaquiferinunitsofft//day
Δh = differencebetweenthelakelevelandthelevelofthe potentiometricsurfaceoftheFloridanacquiferattimet(days)
L = thicknessofthematerialsbetweenthelakebottomandthetopof theFloridanacquifer
A = cross-sectionalareaofmaterialsbetweenthelakebottomandthe topoftheFloridanaquifer(ft^2)

CONTINUOUS SIMULATION MODELING: EXAMPLES & CASE STUDIES

- The first demonstration is a simple example to compute predevelopment and postdevelopment runoff volume for a small project in the South Florida Water Management District. We are presently using this technique on a study for SFWMD.
- Results of continuous simulation modeling of some land-locked basins or basins with limited discharge capacity, mainly within Central Florida.
- Results of wetland hydroperiod modeling for an enhancement project and a restoration project.