Types of Models

- Once you know what the question is (GOAL), you can choose or design your model
- Helpful to be aware that there are different types of models - and to be able to identify the kind of model you need to provide the information you need!
- Always start with a conceptual model!

Types of Models: WHAT's in the BOX

Conceptual.....Mathematical

Static……Dynamic :*TIME*

Lumped.....Spatially Distributed: *SPACE*

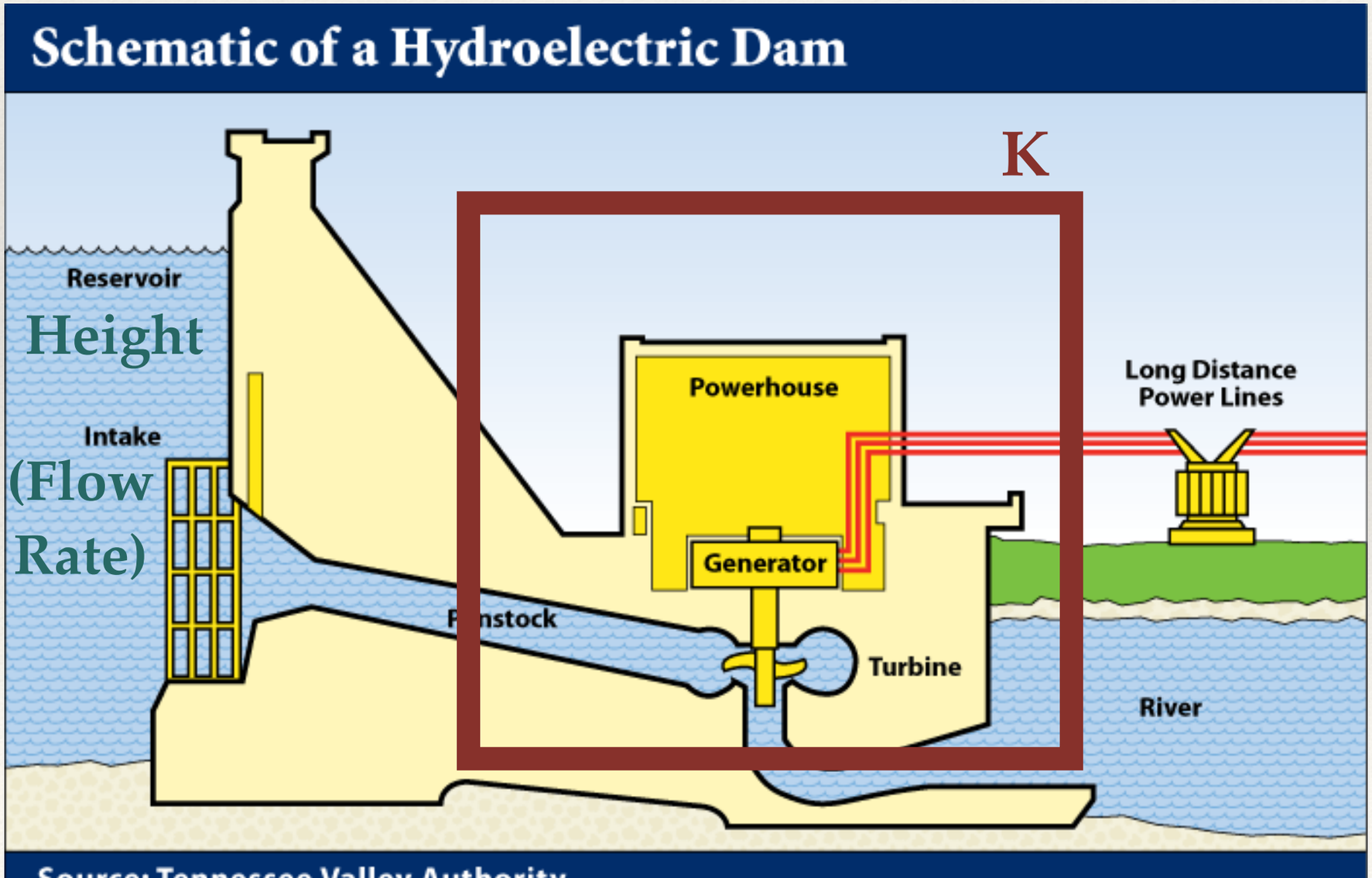
Stochastic.....Deterministic

Abstract……Physically/Process Based

but biggest differences may often be the degree specific processes/parameters are accounted for

Types of models: Example

- Input: Reservoir height and flow rate
- Output: Instantaneous power generation (W/s)
- Parameter: Reservoir Efficiency
- Conceptual model



Types of models: Example

- Input: Reservoir height and flow rate
- Output: Instantaneous power generation (W/s)
- Parameters: $K_{Efficiency}$, ϱ (density of water), g (acceleration due to gravity)

$P = \varrho * h * r * g * K_{Efficiency};$

P is Power in watts, ϱ is the density of water (~1000 kg/m3), h is height in meters, r is flow rate in cubic meters per second, g is acceleration due to gravity of 9.8 m/s2, $K_{Efficiency}$ is a coefficient of efficiency ranging from 0 to 1.

This is a static (one point in time), deterministic, lumped (one place) model; its more or less physically based

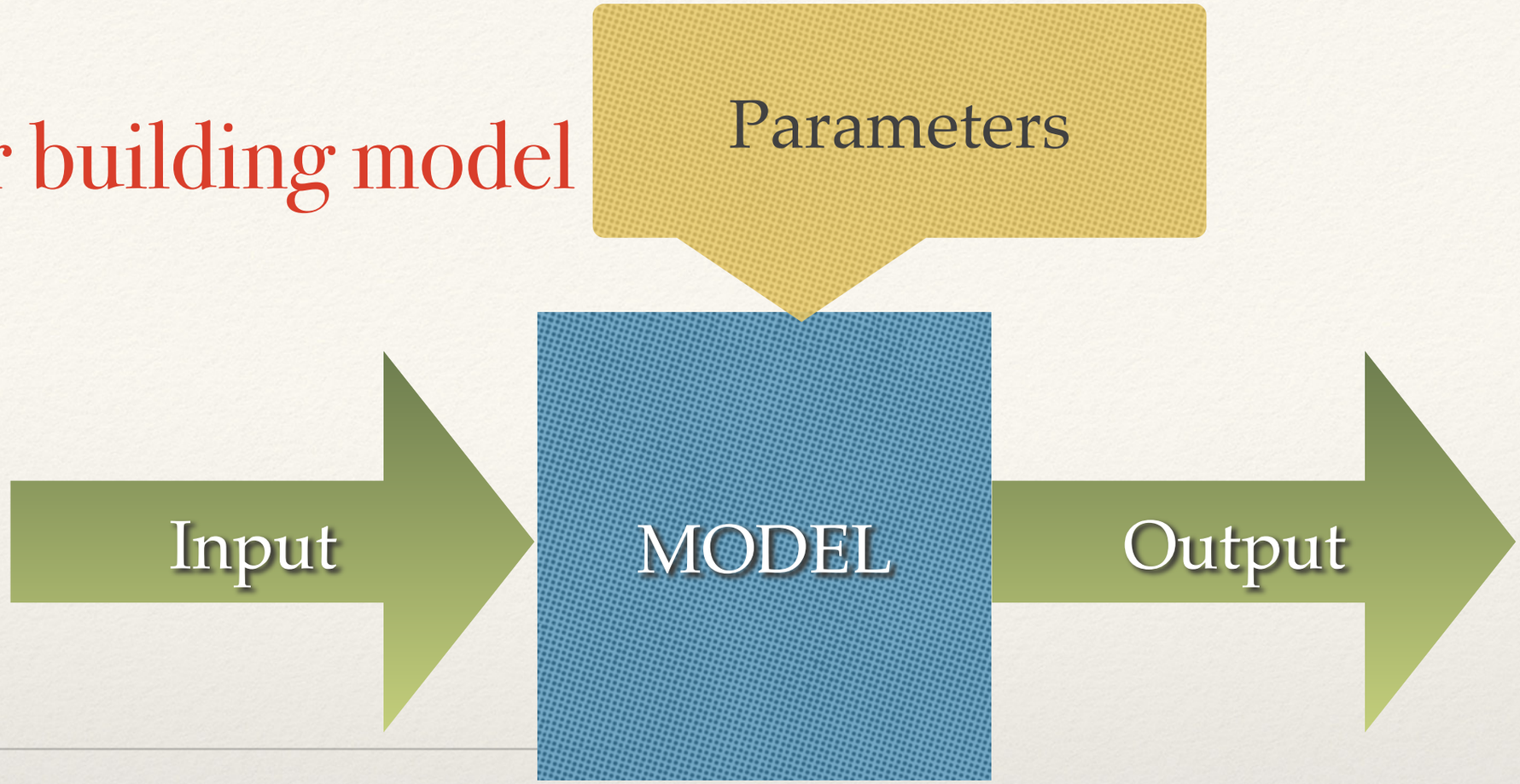
Types of models: Example

- If we expand the model to compute power production over a year, where inputs were streamflow into the reservoir - *Dynamic Model*
- If we expand to model power production from all the reservoirs in California, accounting for spatial patterns of snowmelt inputs and upstream-downstream relationships - *Spatially Distributed Model*
- If we modified the model to estimate the probability distribution of power production, given a probability distribution of reservoir levels - *Stochastic Model*

STEPS: Modeling for Problem Solving in ES

1. **Clearly define your goal (question you want to answer, hypothesis you want to test, prediction you want to make) - as precisely as possible**
2. **Develop a conceptual model - draw it!**
3. Design or Select your model
4. Implement the model
5. Evaluate the model and quantify uncertainty
6. Apply the model to the goal
7. Communicate model results

Steps for building model



1. Design conceptual model
2. Translate conceptual model into a mathematical representation
3. Choose programming language
4. Define inputs (data type, units)
5. Define output (data type, units)
6. Define model structure
7. Write model
8. Document the model (meta data)
9. Test model

Conceptual models: What is the box

- *Inputs and Outputs*
  - what
  - temporal resolution, extent
  - spatial resolution, extent
- *System boundaries*
  - determine what is I/O and what is internal

Conceptual models: Whats in the box

- *variables*
  - lego bricks
  - state, fluxes in a process model
  - pieces that make up inside our world/box
- *intermediate products*
  - I/O to different steps in a process

Conceptual models: Whats in the box

- *Relationships variables*
  - causal (warm temp increases mosquito growth)
  - feedback (soil water influences plant growth influences soil water)
- *Process*
  - sequential steps (prioritization of habitat quality)

Conceptual models: Composing

- Differentiate between inputs/outputs, variables (states vs products), intermediate products, relationships
- Relationships are often lines with arrows
- Use shape and color to differentiate I/O, variables …
- Vary level of abstraction (sometimes you start with variables that are submodes in themselves)

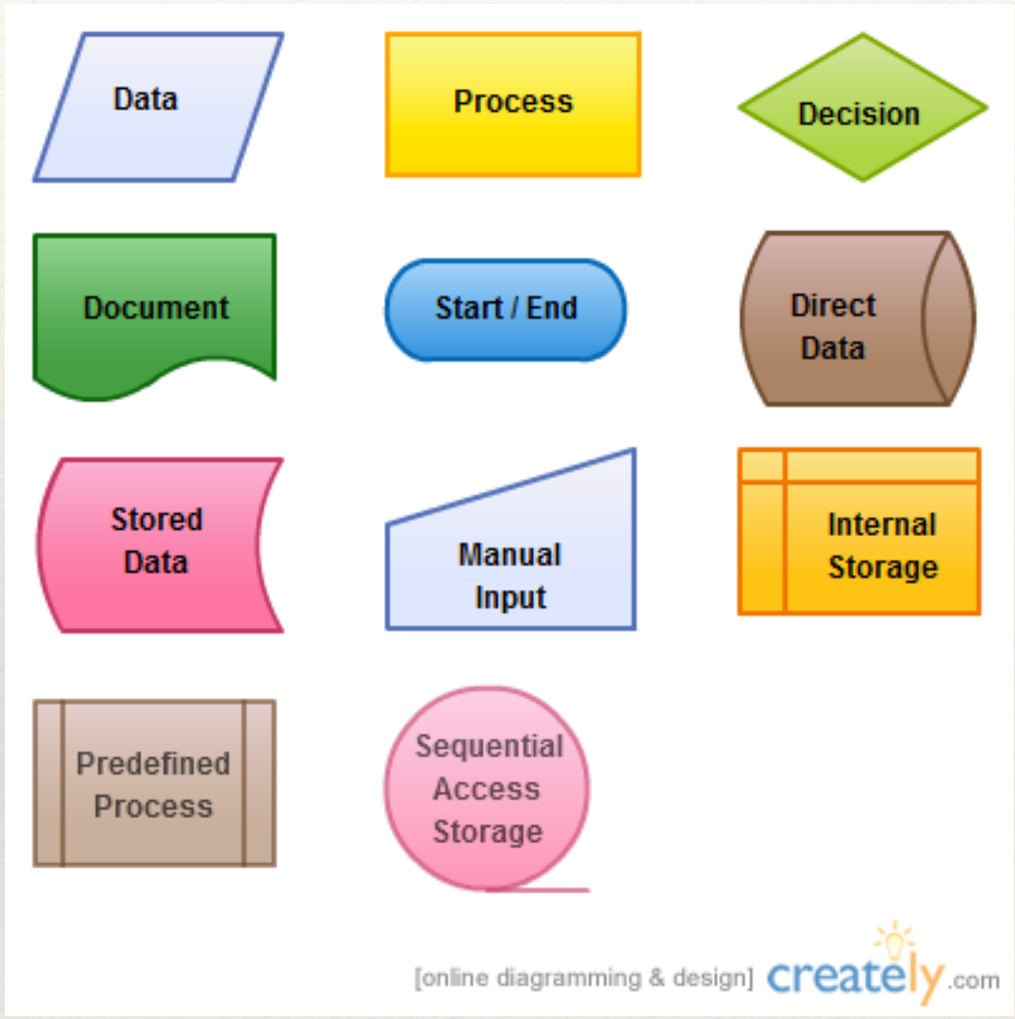
Conceptual models: Composing

- Pictorial representation of how you think about your system, whats included - will tell you really quickly if your model is appropriate for answering specific Qs

Building Models

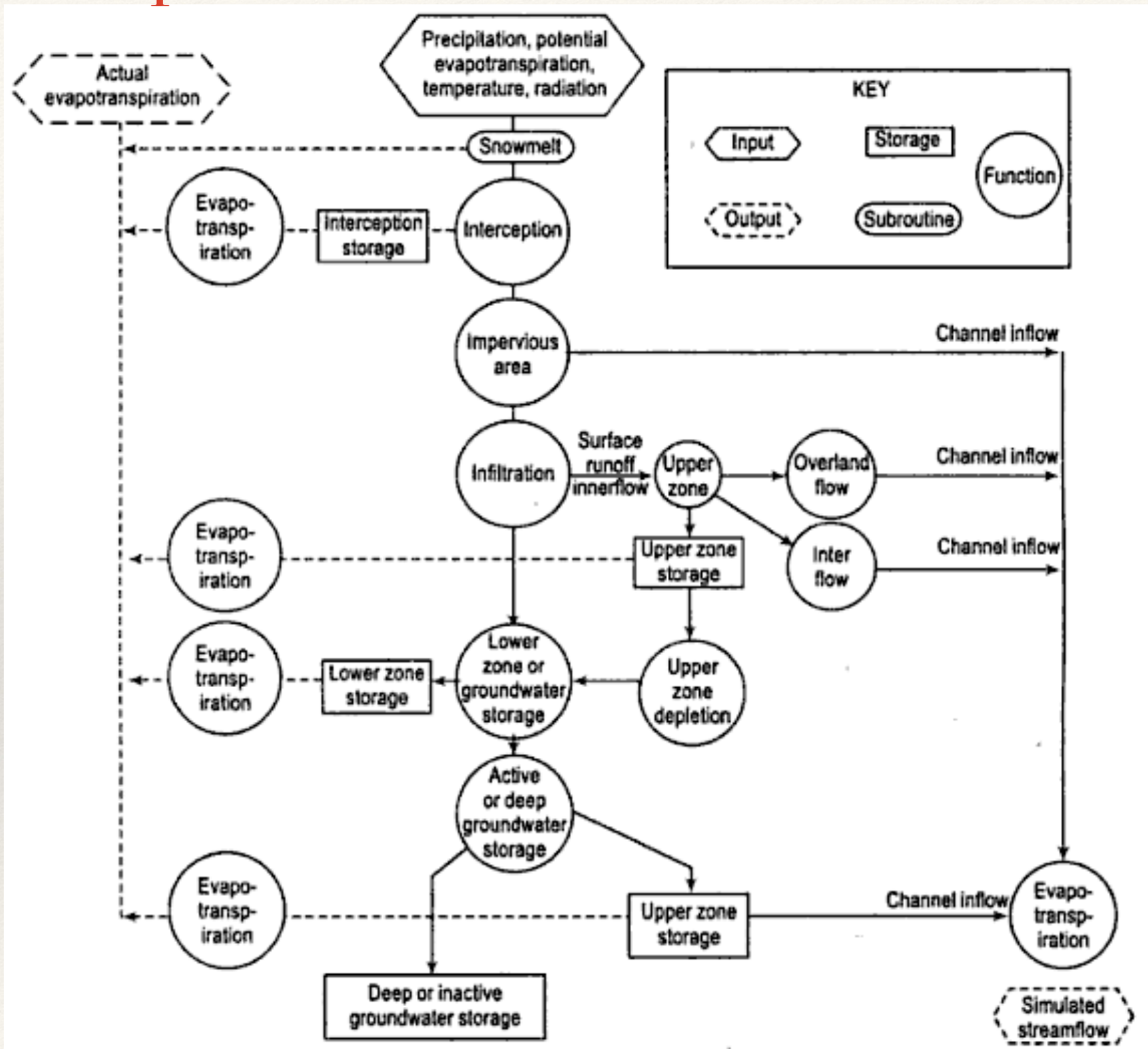
Return to conceptual model; expand to show how you will implement;

Some model designers uses standard symbols for the different



Conceptual Models

- PhD of Norman Crawford under supervision of Ray K Linsley at Stanford University in 1962



Conceptual models: for design of your system