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Groundwater in the West (Summer Conference,  
June 16-18)

2004

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### SLIDES: Groundwater-Surface Water Interactions

Thomas Maddock, III

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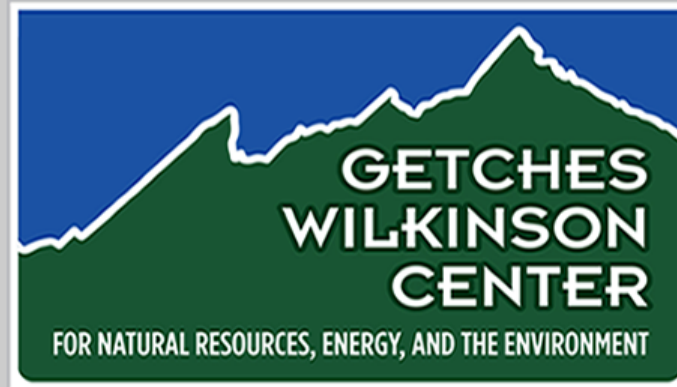
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# **Groundwater - Surface Water Interactions**

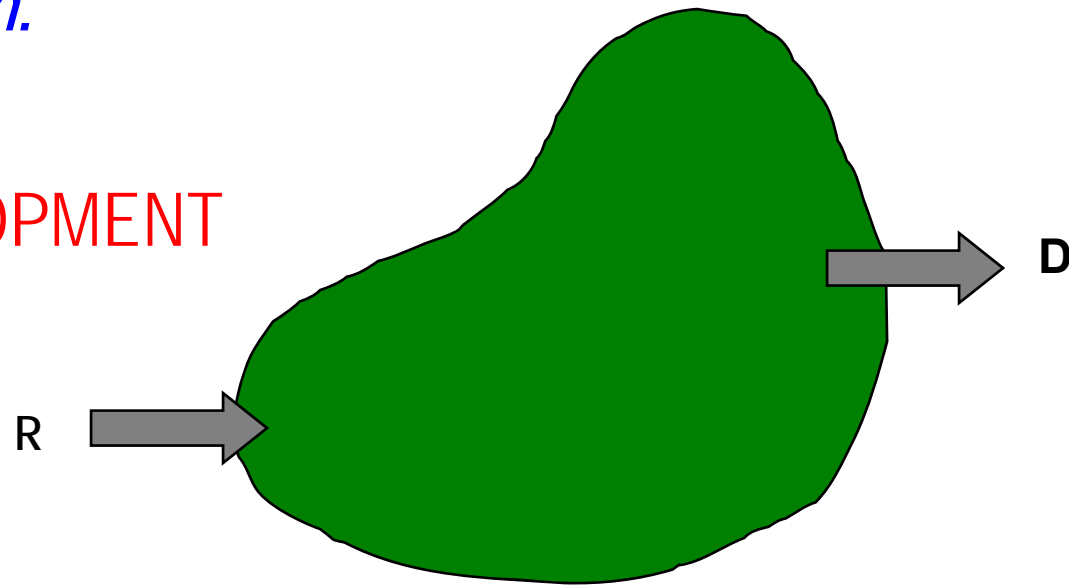
*Thomas Maddock III  
Department of Hydrology  
University of Arizona*

# WHAT IS CAPTURE

# CONCEPT OF CAPTURE

*“Under natural conditions...previous to the development of wells, aquifers are in a state of approximate dynamic equilibrium.”*

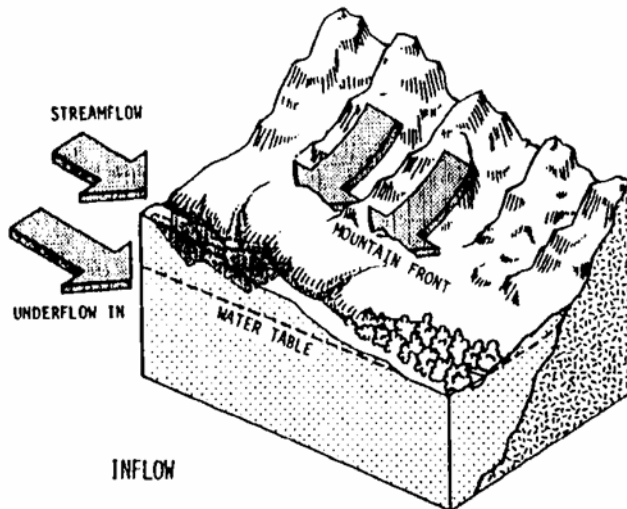
PRE-DEVELOPMENT



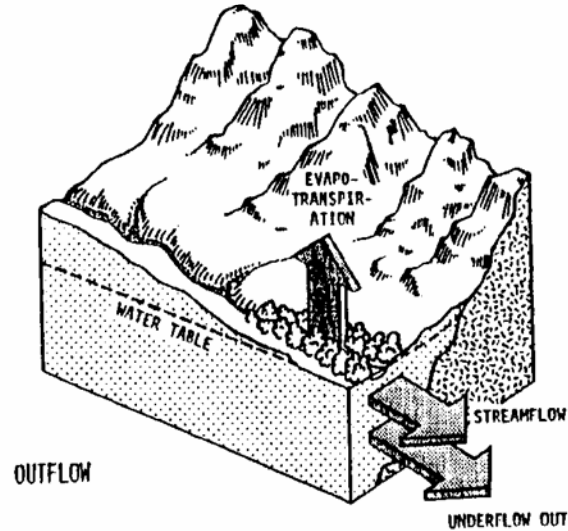
Average recharge R = Average discharge D  
Capture

# CONCEPT OF CAPTURE

## Pre-development Recharge and Discharge



**Recharge:**  
Losing stream  
Underflow in  
Mountain front recharge

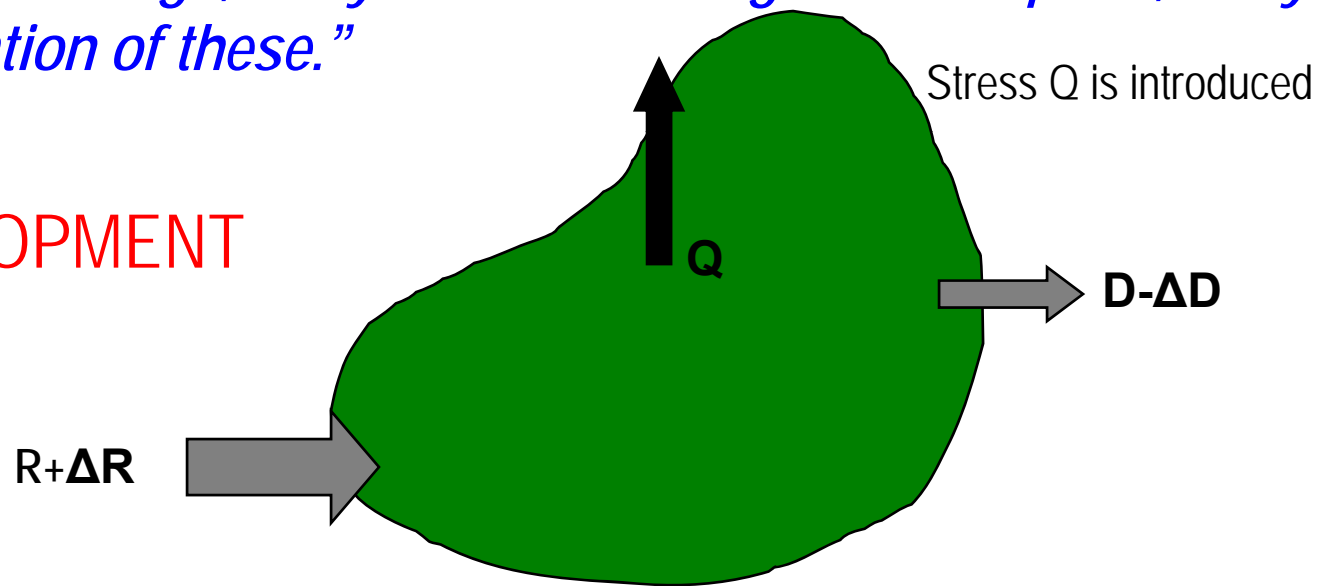


**Discharge:**  
Gaining stream  
Underflow out  
Evapotranspiration

# CONCEPT OF CAPTURE

*“Discharge by wells is thus a new discharge superimposed upon a previously stable system, and it must be balanced by an increase in recharge of the aquifer, or a decrease in the old natural discharge, or by a loss of storage in the aquifer, or by a combination of these.”*

DEVELOPMENT



The system may respond in three different ways:

increase in recharge  $R \rightarrow R + \Delta R$

decrease in discharge  $D \rightarrow D - \Delta D$

change in aquifer storage  $\Delta S$

Capture

# CONCEPT OF CAPTURE

There is a new equilibrium:

$$(R + \Delta R) - (D - \Delta D) - Q = \frac{\Delta S}{\Delta t}$$

remembering

$$R = D$$

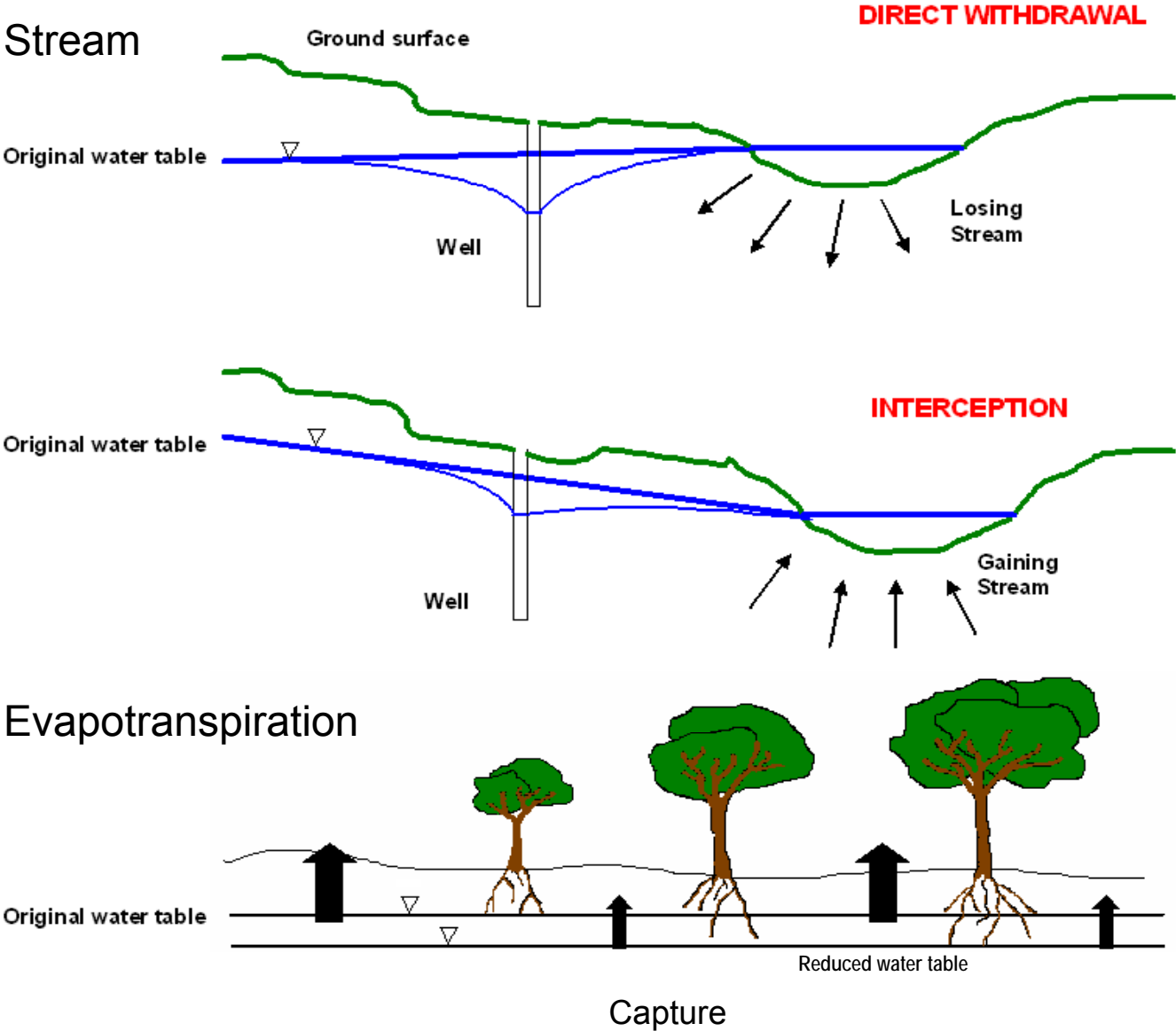
gives

$$\Delta R + \Delta D - Q = \frac{\Delta S}{\Delta t}$$

the term  $\Delta R + \Delta D$  is called capture.



# CONCEPT OF CAPTURE



# HOW DO YOU CALCULATE CAPTURE

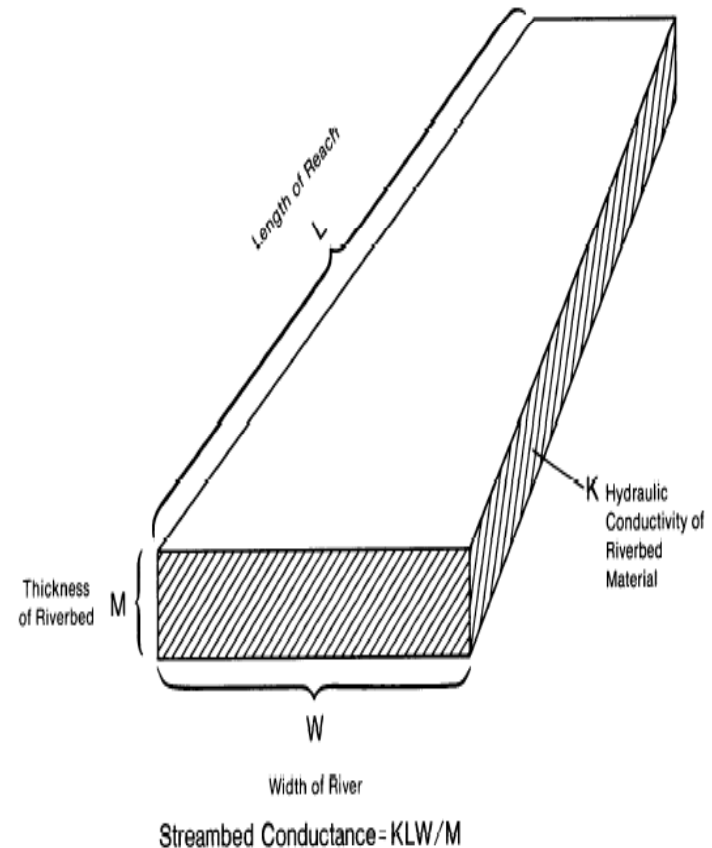
# Capture Is Calculated with Models

- There will be a surface water model and a groundwater model.
- There will be a historical model and a base case model.
- The models will consist of control variables, state variables and parameters.
- There is no capture data values to compare or calibrate with calculated values.

# MODEL CHARACTERISTICS

- Surface water model is one-dimensional
- Groundwater model is distributed parameter (Two or Three Dimensional)
- Interaction between surface and groundwaters if governed by Darcy's law

$$Q = KWL \frac{H_S - H_A}{M}$$



# HISTORICAL MODEL

- Attempts to match historical processes
- Can be calibrated with temporal and spatial data
- Used to demonstrate the viability, accuracy and robustness of the model
- Does not calculate capture.

# BASE MODEL

- Based on little or no data
- May be fictional or artificial in nature
- May be the result of a negotiation process
- Should be composed of the same physical based parameters as the historical model

Examples: Steady State, Steady Oscillatory, Constrained Process

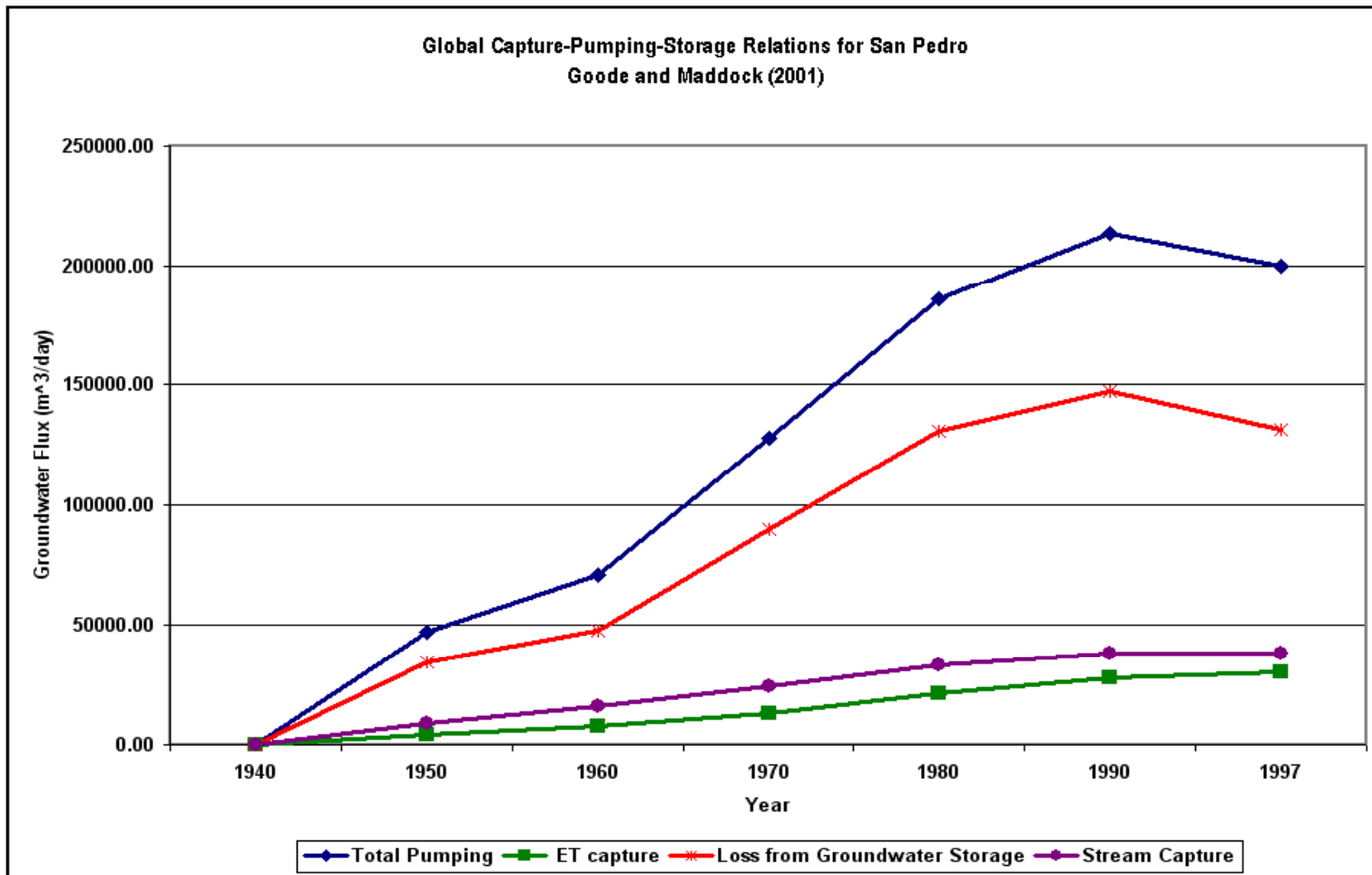
Subtracting the historical streamflows from the base streamflows provides an estimate of surface water capture by groundwater pumping.

# PARAMETERS

- Physically or scientifically based parameters – Actual measurements
- Calibration or Ad Hoc parameters – No measurements (or bounds)
- Calibration of the models' physically based parameters provides a measure of the natural error of the model.
- Calibration or Ad Hoc parameters mask the natural error of the model and may improperly influence the Base Model

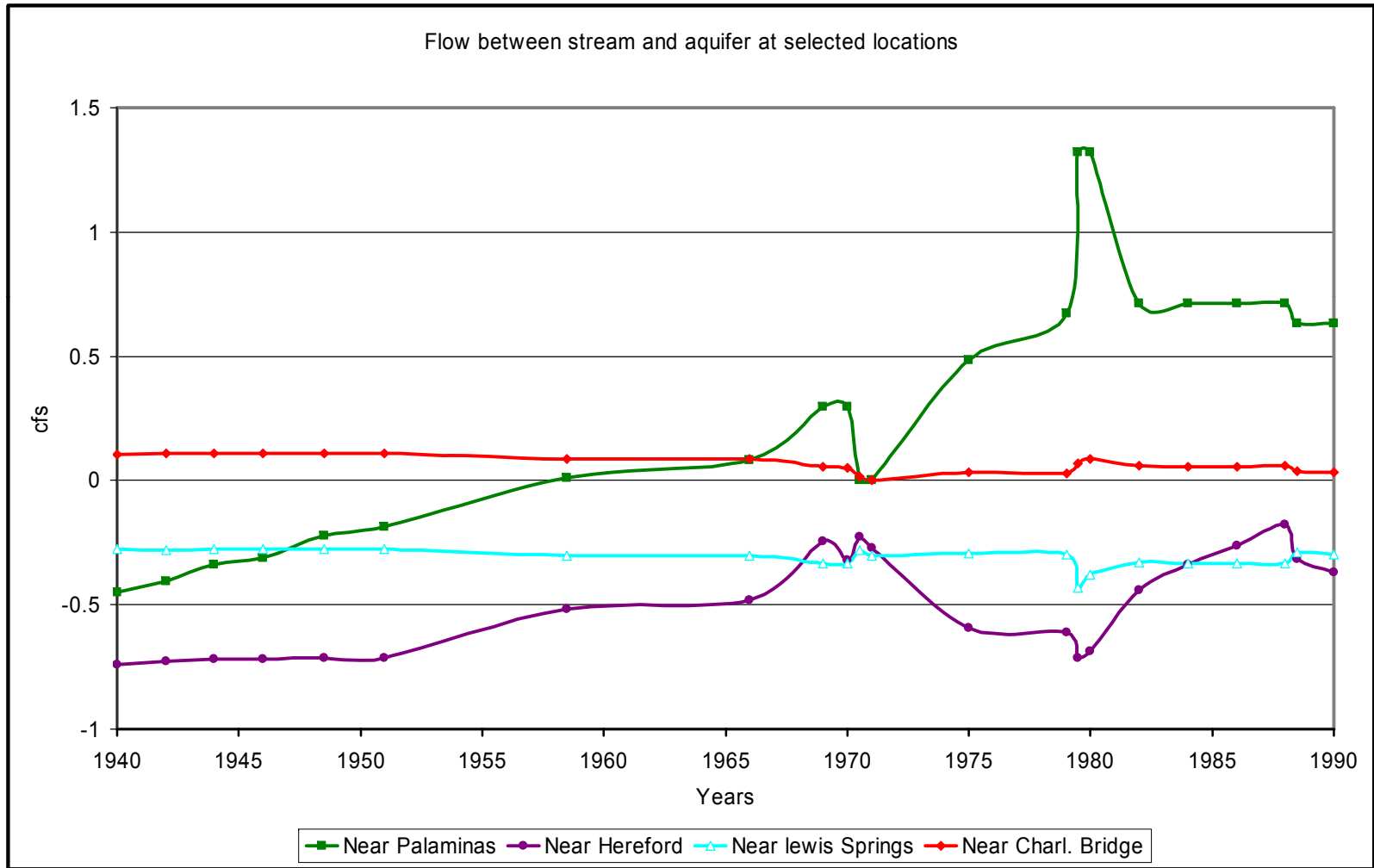


# CONCEPT OF CAPTURE



Capture

# CONCEPT OF CAPTURE



Capture