Thoughts on Recent Groundwater-Model Applications in the Upper San Pedro Basin

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Upper San Pedro Partnership Technical Committee Meeting

December 4, 2012

➢Recent USGS report:

- ➢Open-file Report 2012-1206—Evaluations of Simulations…

http://pubs.usgs.gov/of/2012/1206/

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Purpose of Report

- Provide a general background on effects of groundwater pumping and artificial recharge on streamflow and evapotranspiration
- Comment on applications if the USGS USP groundwater flow model in the following reports:
  - **Lacher, L.J., 2011, Simulated groundwater and surface water conditions in the upper San Pedro Basin, 1902–2105: Tucson, Lacher Hydrologic Consulting, Task 1 Report for December 2010 Contract, 71 p.**
  - **Lacher, L.J., 2012, Simulated near-stream recharge at three sites in the Sierra Vista subbasin, Arizona: Tucson, Lacher Hydrologic Consulting, Task 2-4 Report for December 2010 Contract, 62 p.**

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Scope of Work

- Consultation with Laurel during her modeling phases
- Review of Laurel's draft reports
- Prepare a final written report with overall evaluations of model applications

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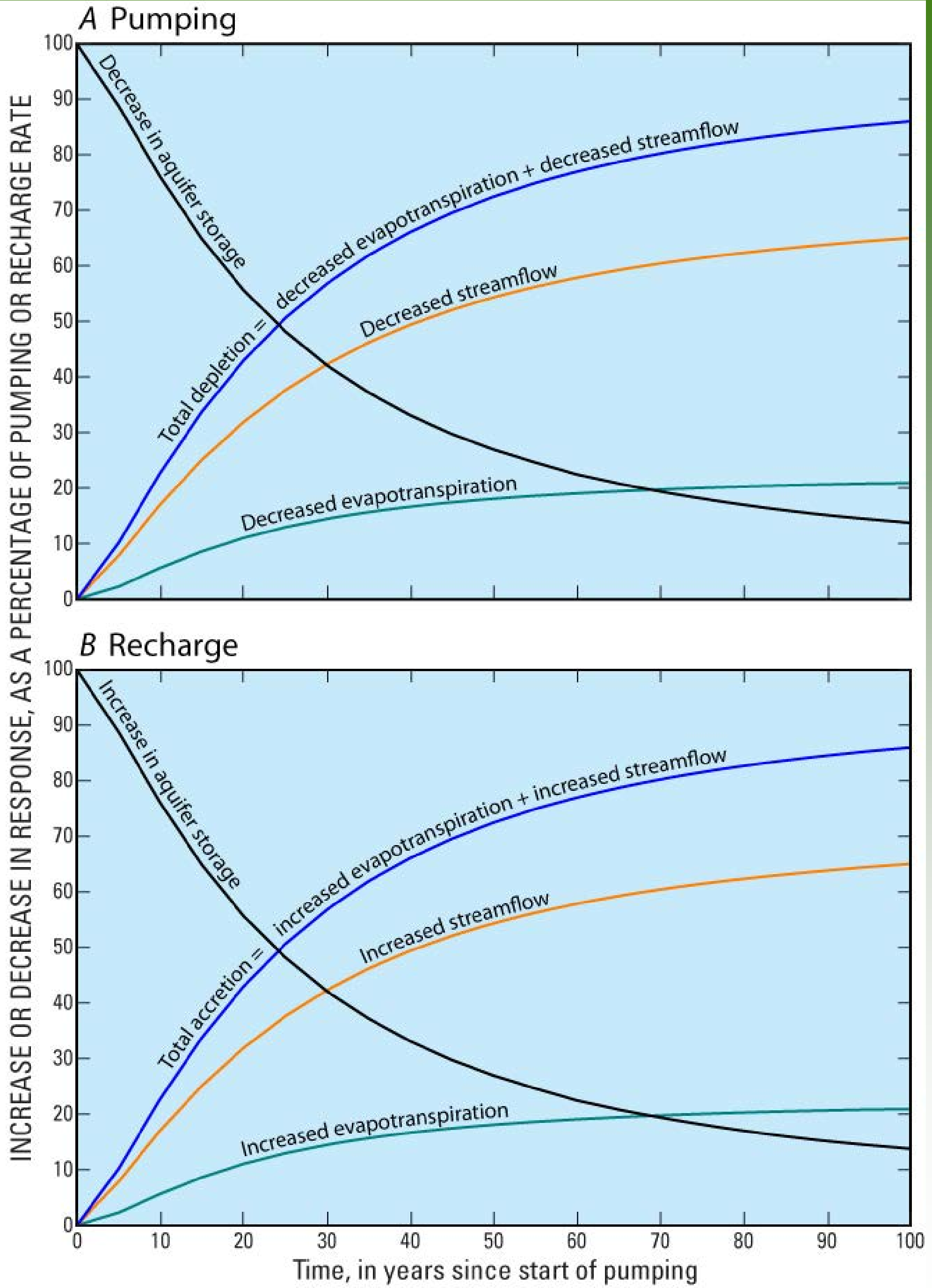

Increases in natural recharge

- ➢Increased groundwater gradients away from surface-water features (such as losing streams)
- ➢Movement of groundwater divides into an adjacent basin
- ➢Lowering of the water table below the land surface to allow infiltration of previously rejected recharge from runoff

Decreases in discharge

- ➢Decreased groundwater gradients towards surface-water features (such as gaining streams)
- ➢Lowering of the water table in areas where groundwater can evaporate or be transpired by phreatophytes

Decreases in natural recharge

- ➢Decreased groundwater gradients away from surface-water features (such as losing streams)
- ➢Movement of groundwater divides into the basin with artificial recharge
- ➢Raising the water table to the land surface and preventing infiltration that would have previously recharged the aquifer

Increases in discharge

- ➢Increased groundwater gradients towards surface-water features (such as gaining streams)
- ➢Raising of the water table in areas where groundwater can evaporate or be transpired by phreatophytes

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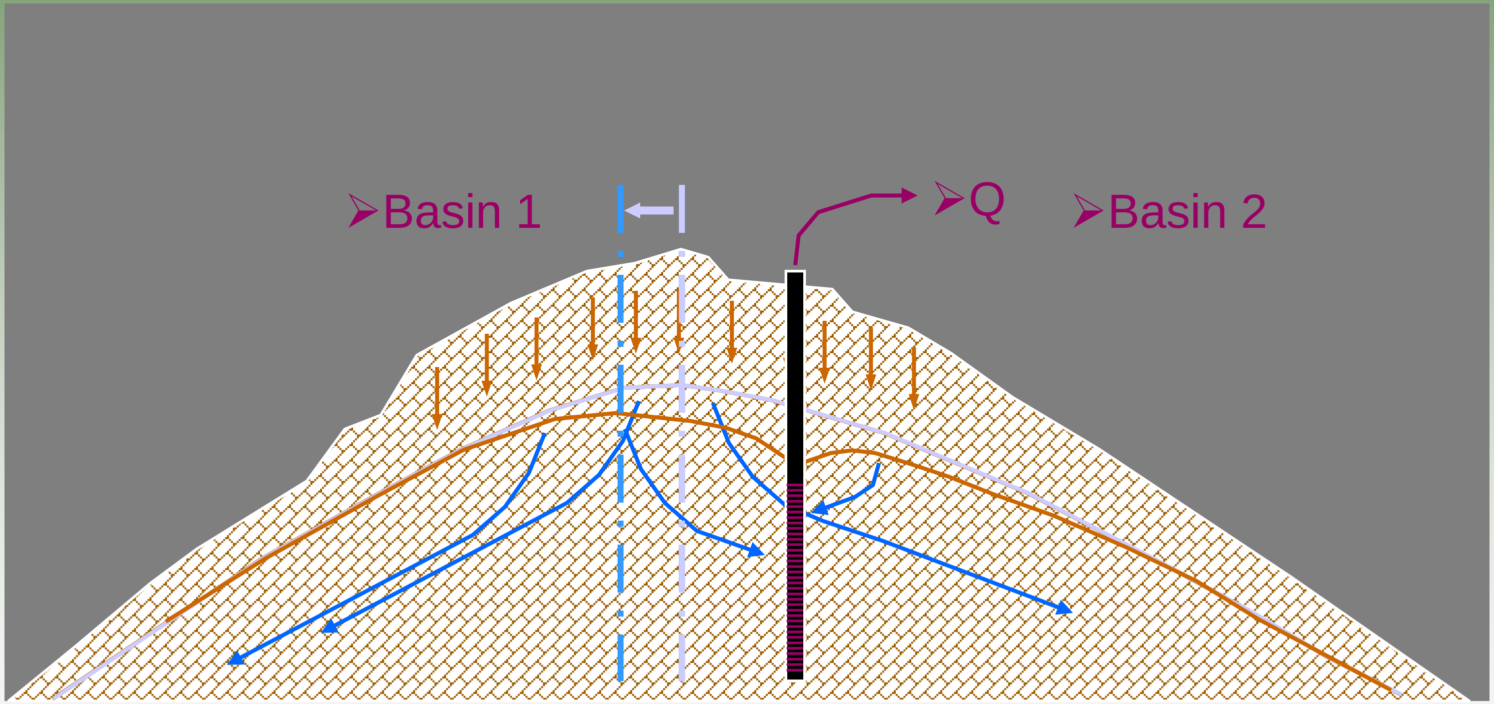
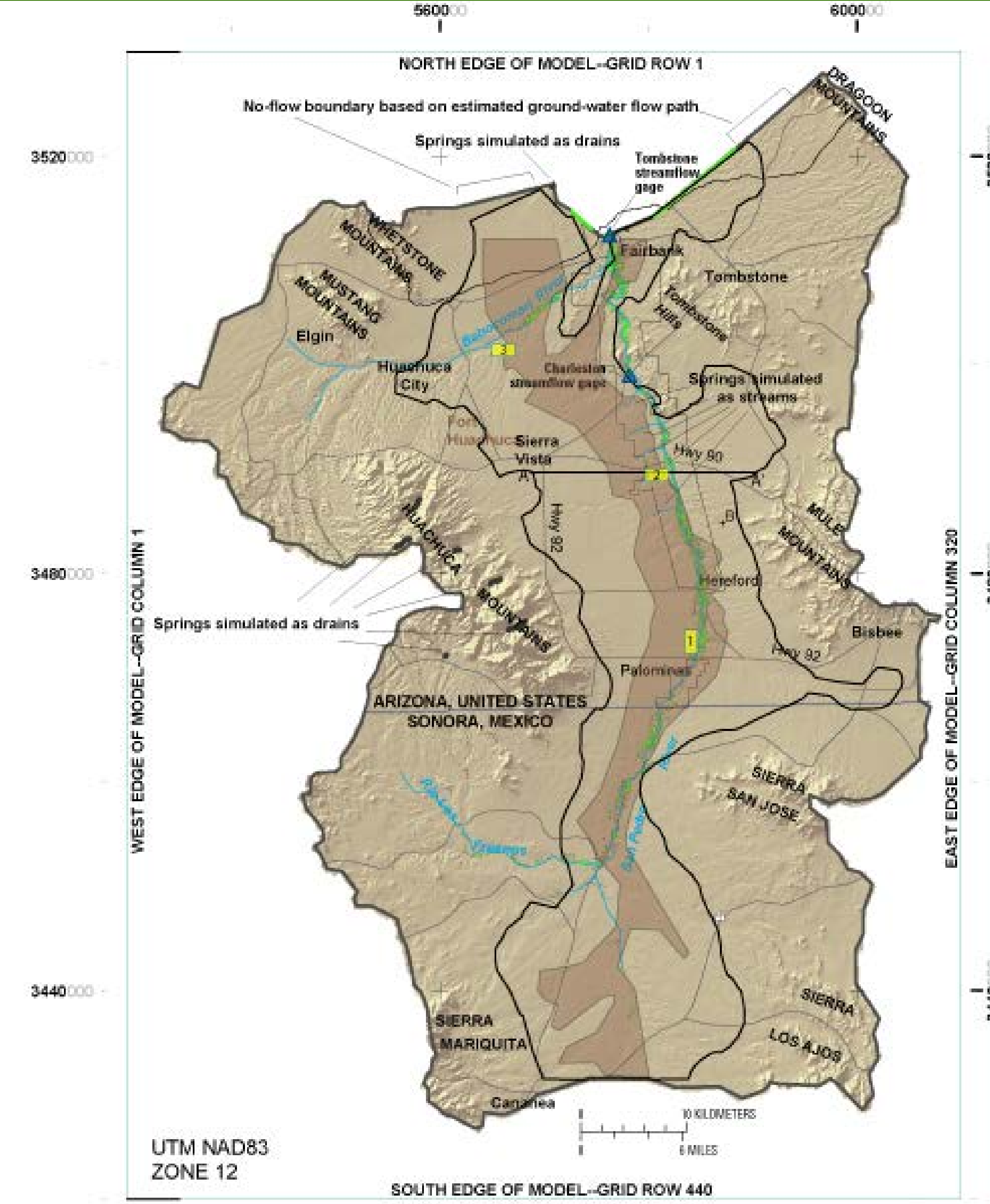
Movement of a Groundwater Divide by Pumping



Thoughts on Long-term Simulations of Groundwater Pumping and Artificial Recharge

- Structure of model layers
- Effects of artificial model boundaries
- Effects of model detail on near-stream recharge simulations


NORTH EDGE OF MODEL--GRID ROW 1
No-flow boundary based on estimated ground-water flow path
Springs simulated as drains
Tombstone streamflow gage
DRAGOON MOUNTAINS
WHETSTONE MOUNTAINS
MUSTANG MOUNTAINS
Elgin
Fairbank
Tombstone
Tombstone Hills
Huachuca City
Charleston streamflow gage
Springs simulated as streams
Fort Huachuca
Sierra Vista
Hwy 90
Hwy 92
A
A'
B
B'
MULE MOUNTAINS
HUACHUCA MOUNTAINS
Hereford
Springs simulated as drains
Bisbee
Palominas
ARIZONA, UNITED STATES
SONORA, MEXICO
SIERRA SAN JOSE
SIERRA MARIQUITA
SIERRA LOS AJOS
Cananea
10 KILOMETERS
6 MILES
UTM NAD83
ZONE 12
SOUTH EDGE OF MODEL--GRID ROW 440
WEST EDGE OF MODEL--GRID COLUMN 1
EAST EDGE OF MODEL--GRID COLUMN 320
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6000000
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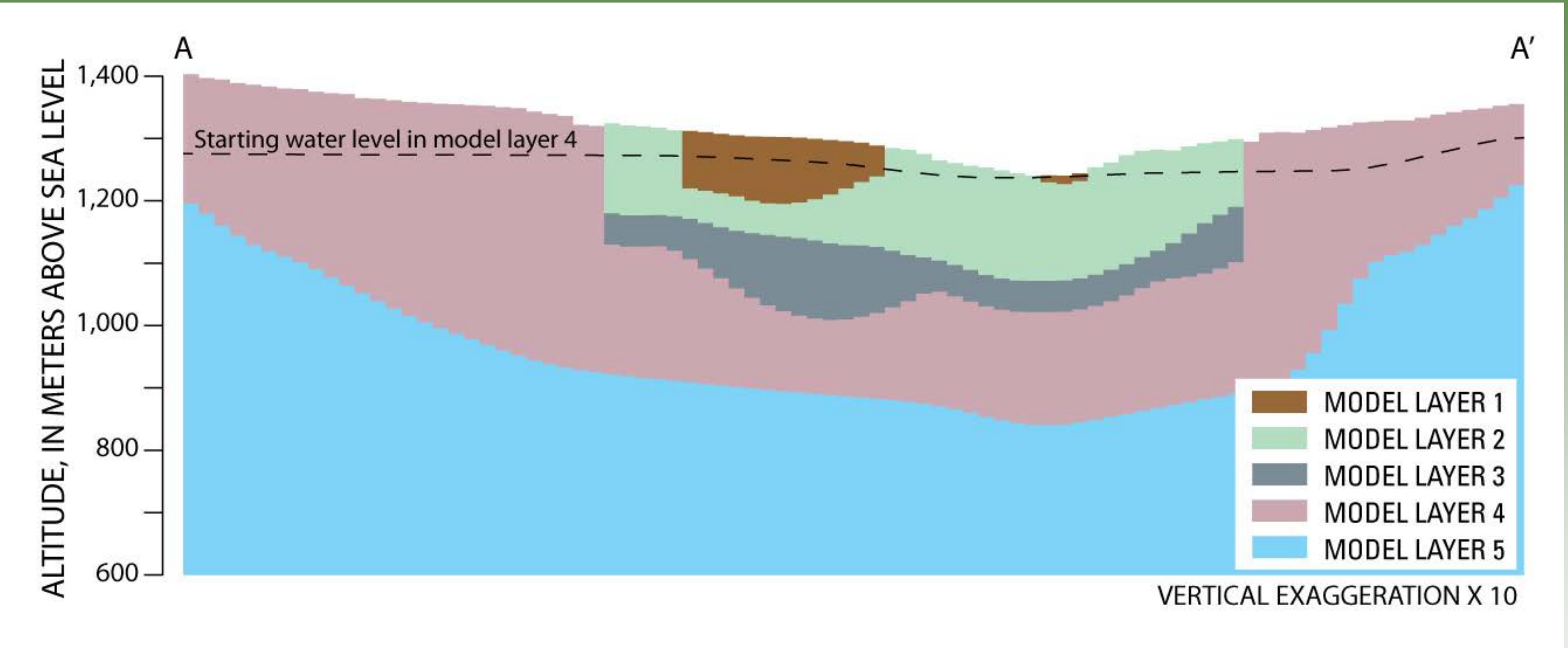
Structure of model layers



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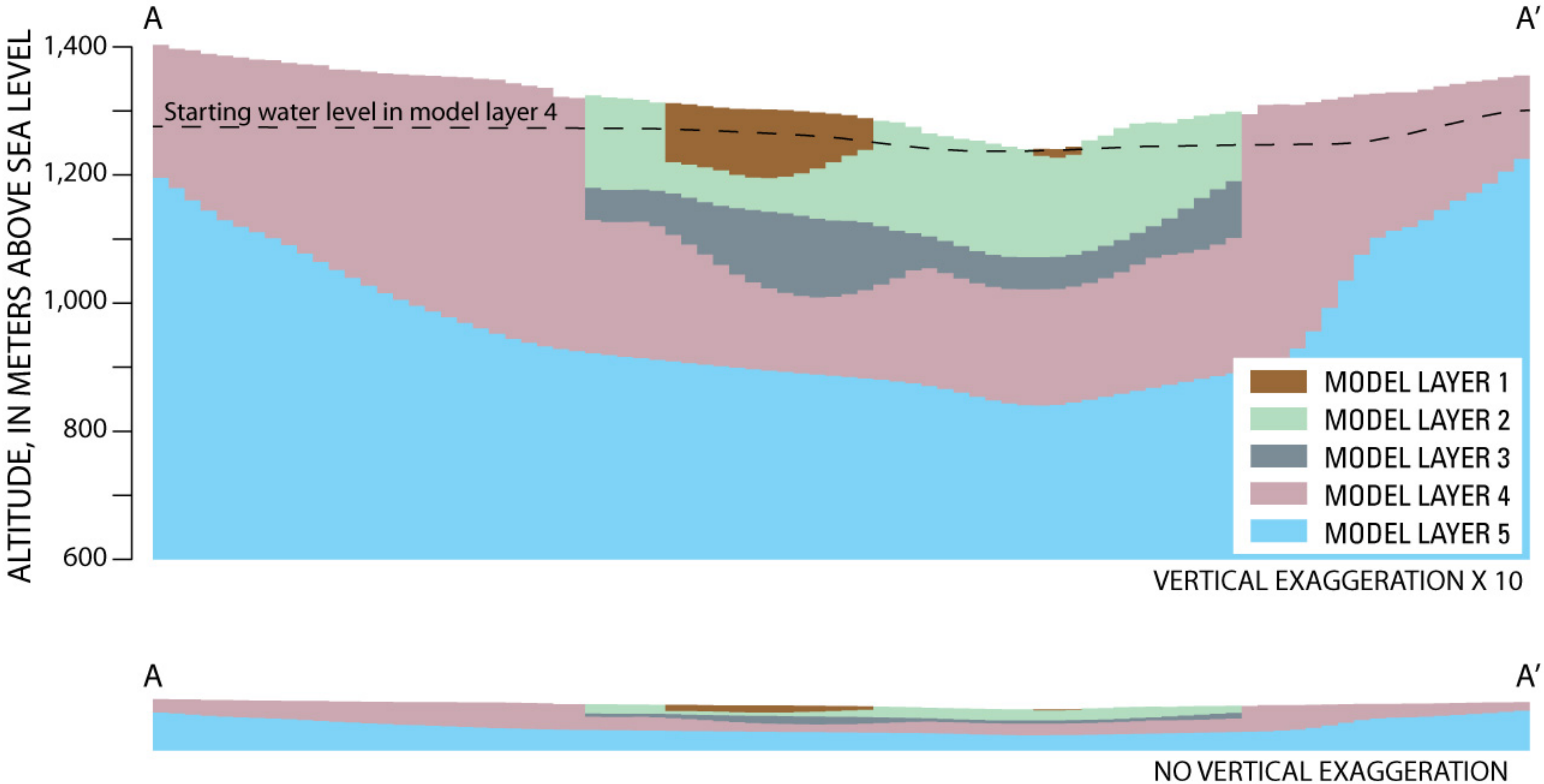
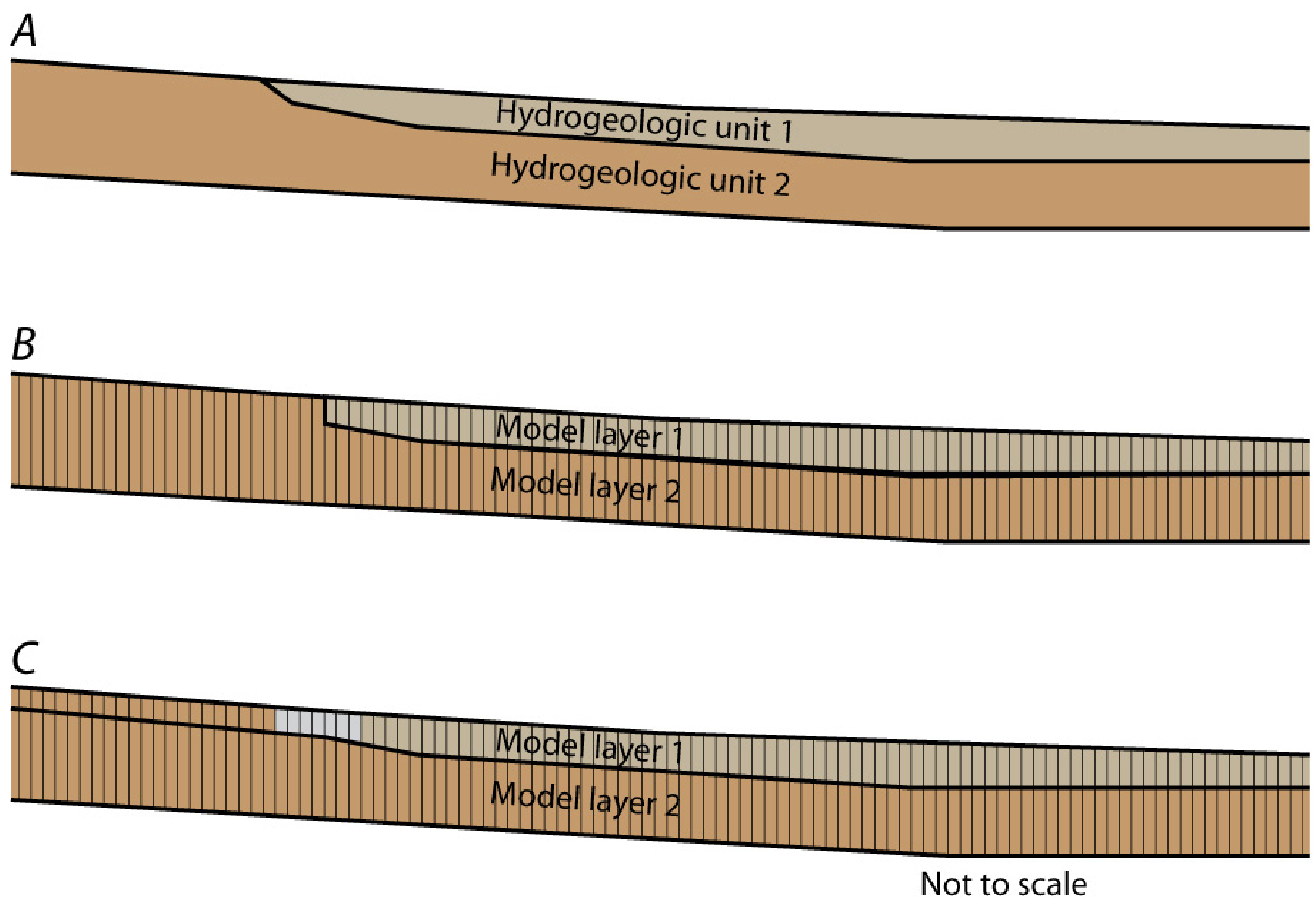
Structure of model layers



Ways of Representing Hydrogeologic Units With Model Layers

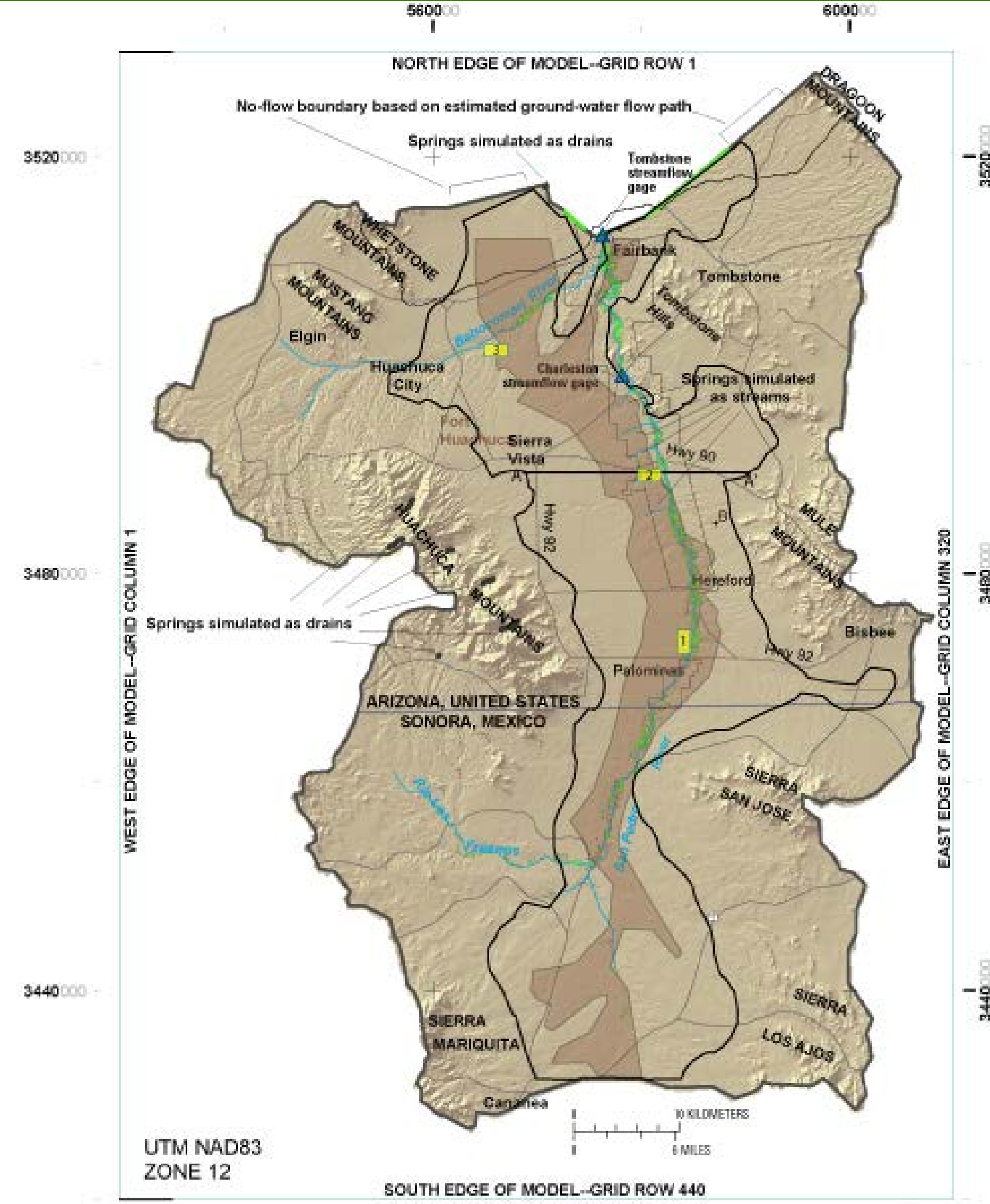


Effects of Artificial Boundaries

Possible areas of concern:

1. Artificial no-flow boundaries along the perimeter of the model

2. Artificial head-dependent boundaries along northern edge of model



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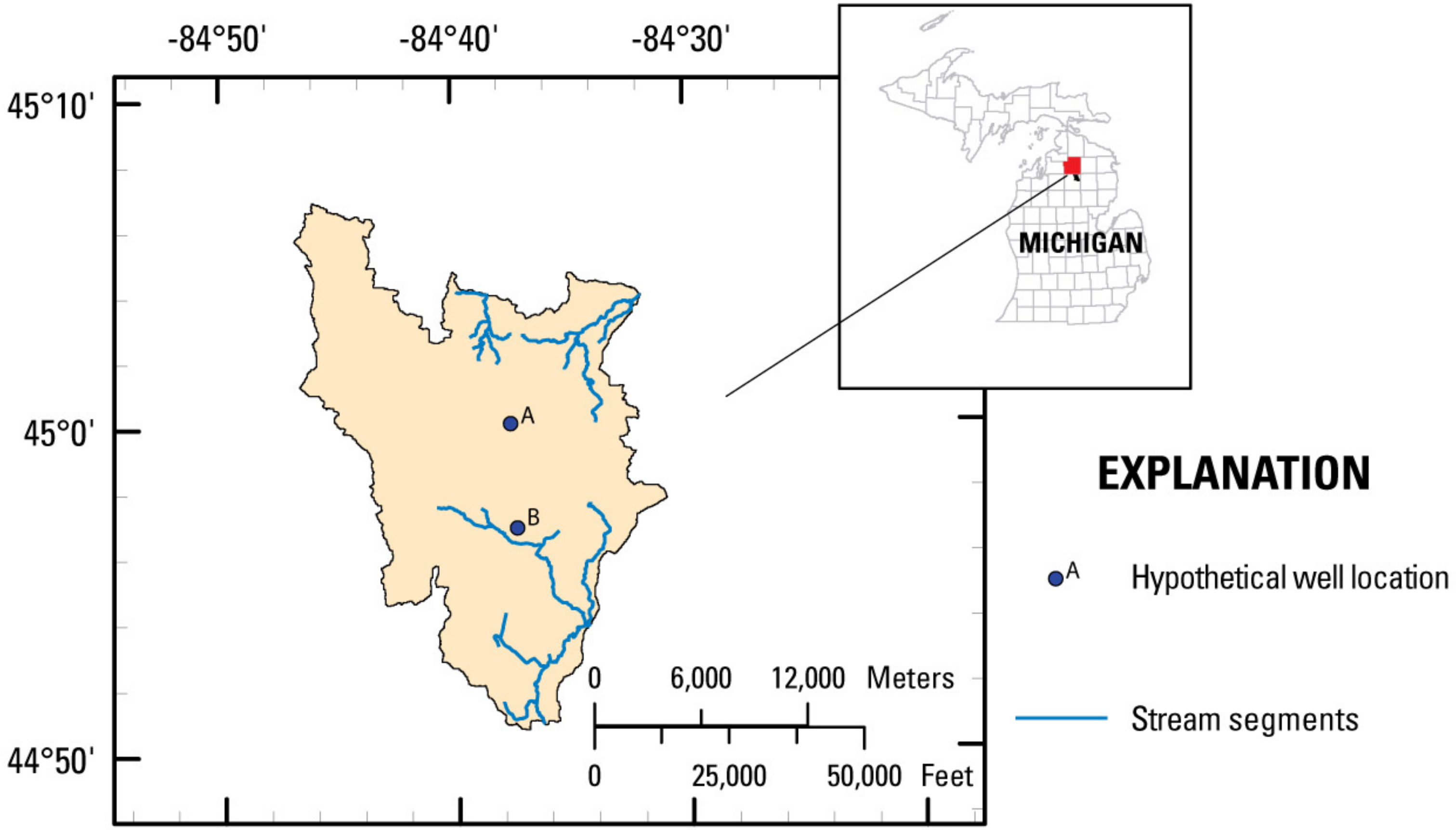
More on boundary conditions



Modified from Reeves and others (2009)

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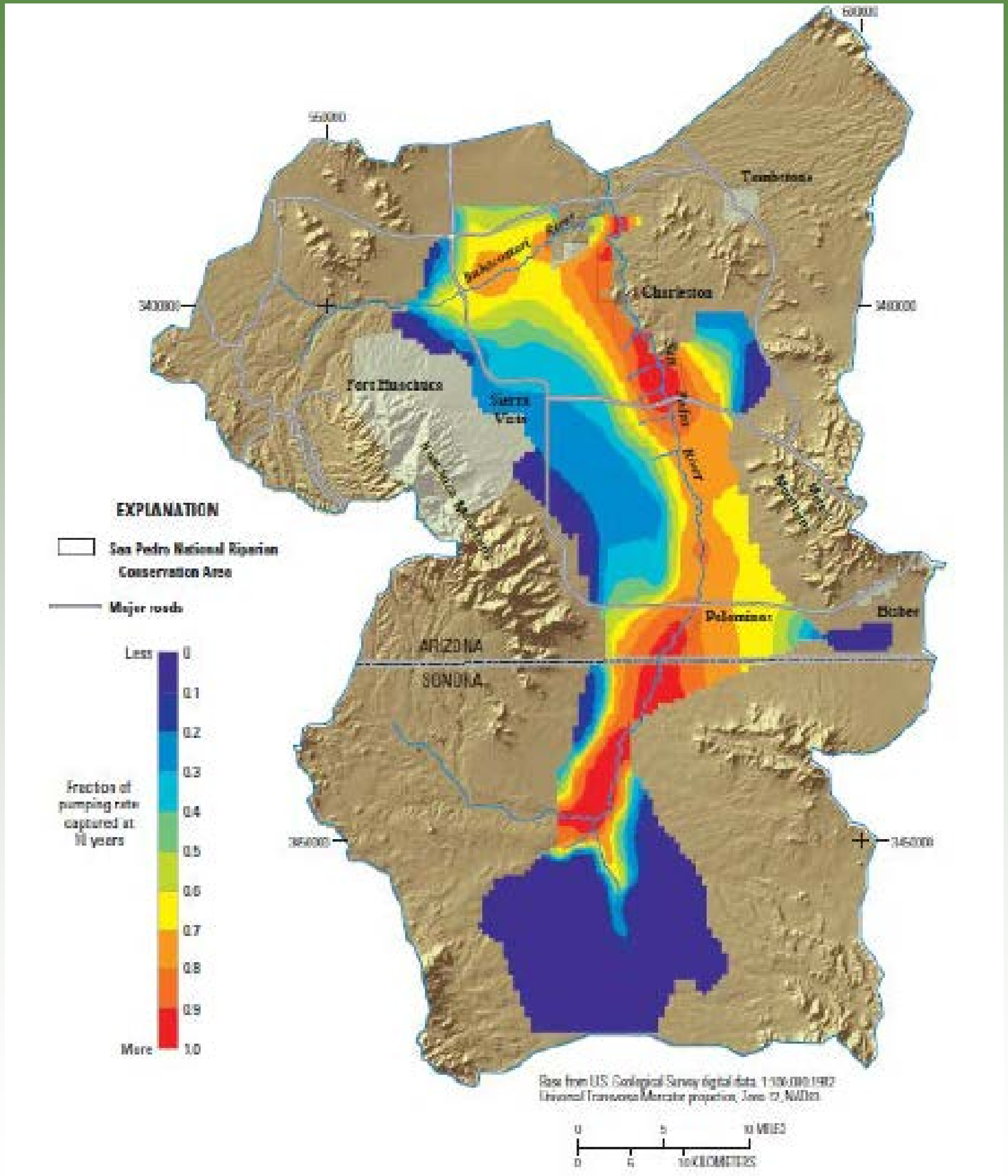
Response Functions, Capture Maps, and Management Scenarios



Total capture after 50 years of pumping, Upper San Pedro Basin, Arizona

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Effects of model detail on near-stream recharge simulations

Possible errors in simulating timing of effects of artificial recharge could come from

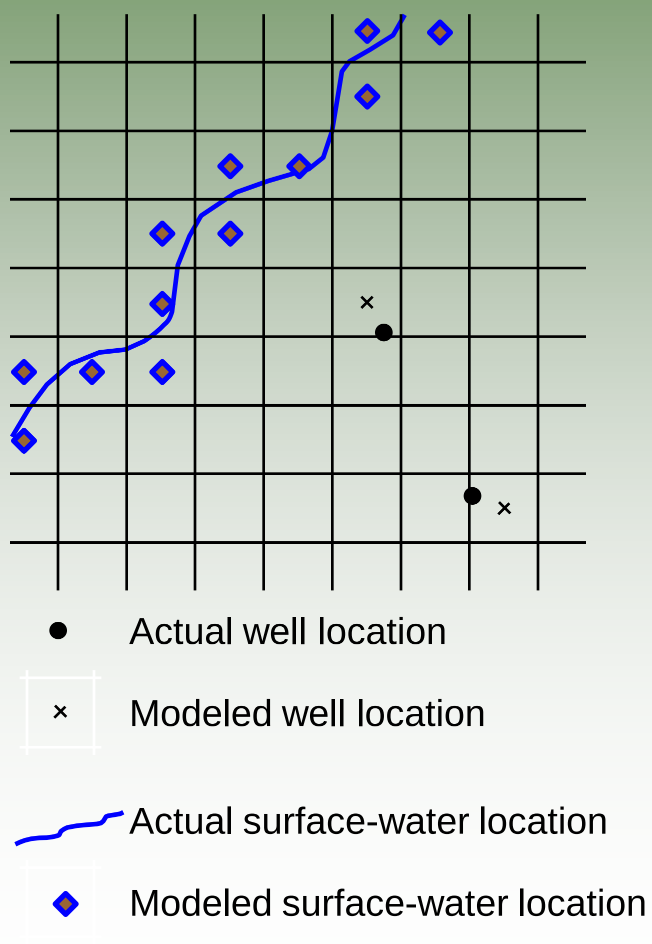
1. Errors in distance between recharge and stream/ET areas caused by 250-meter grid spacing

2. Errors caused by finite-difference approximations of spatial distributions of recharge-induced water-level rises

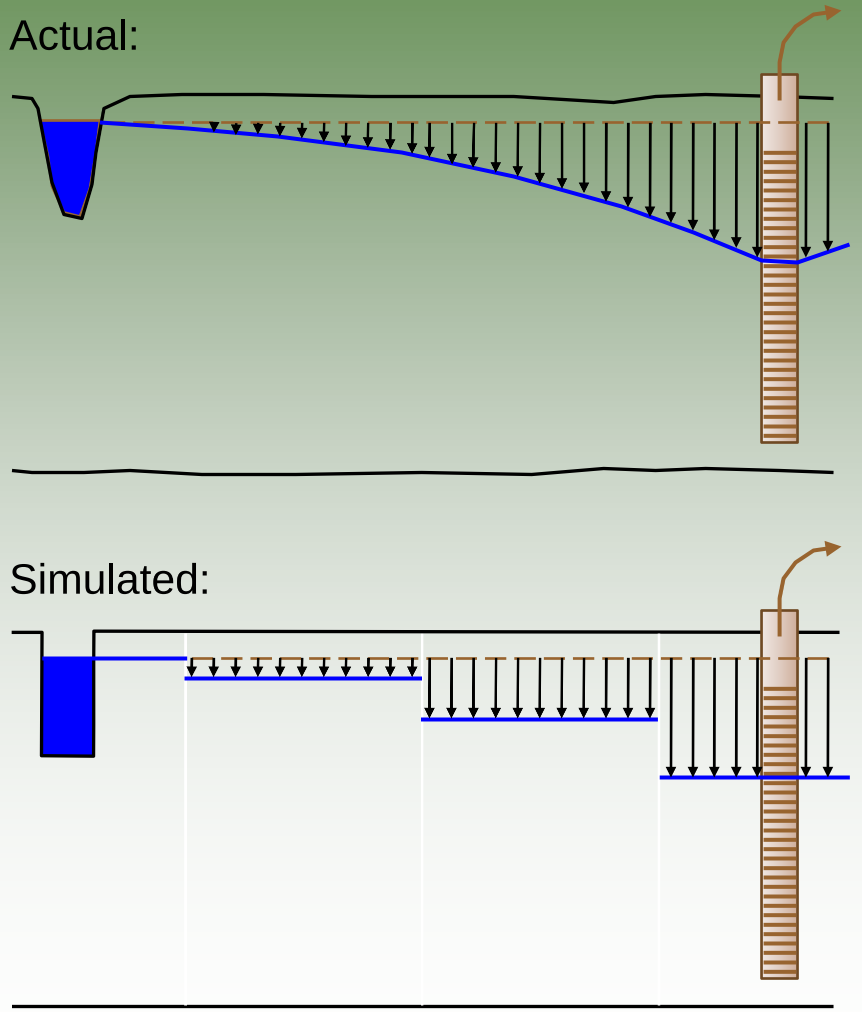
3. Errors related to the crude approximation of the ET function in MODFLOW

Depletion errors related to model grid spacing

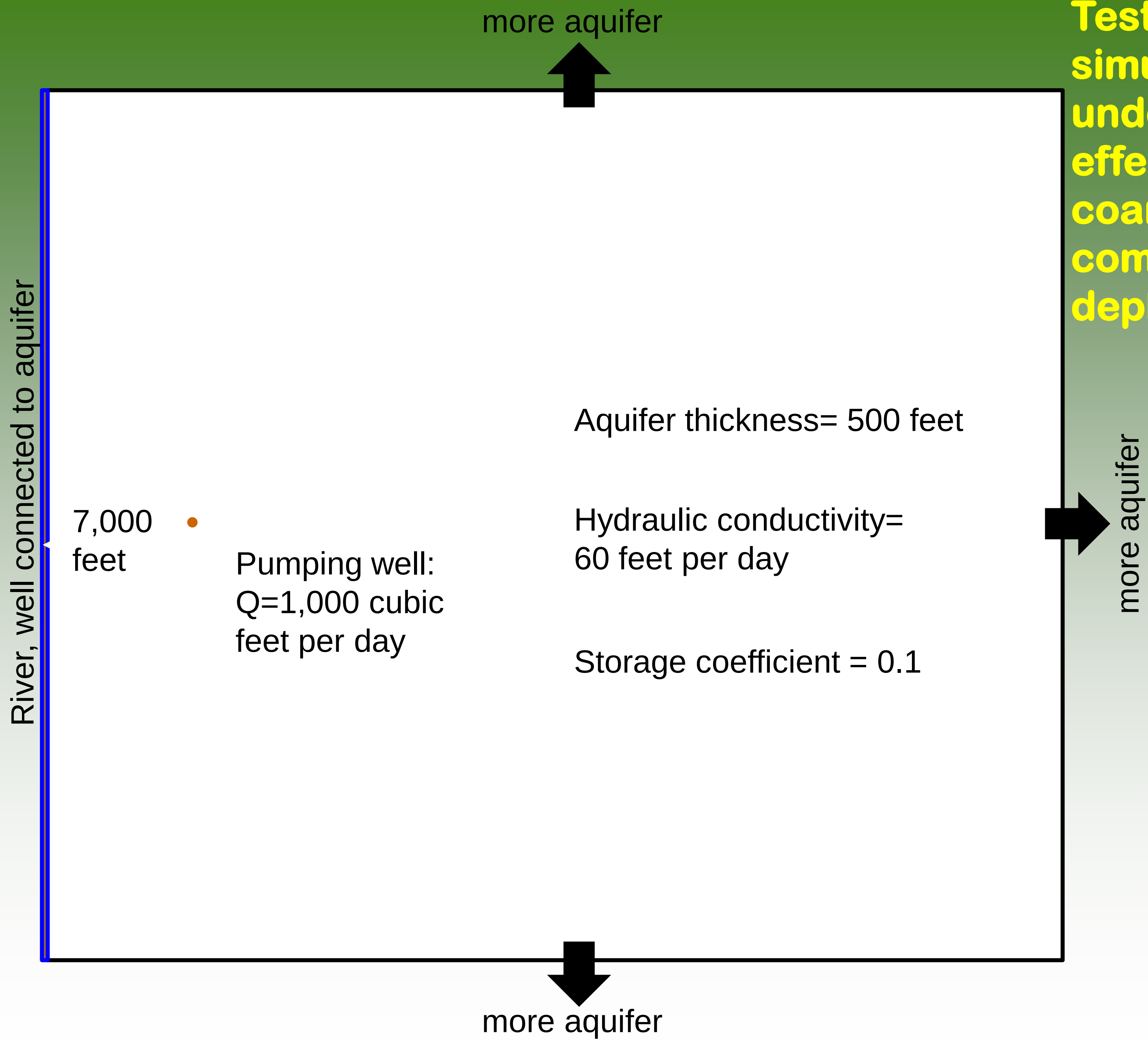
1. Errors in representing true distance between pumping locations and connected surface water.



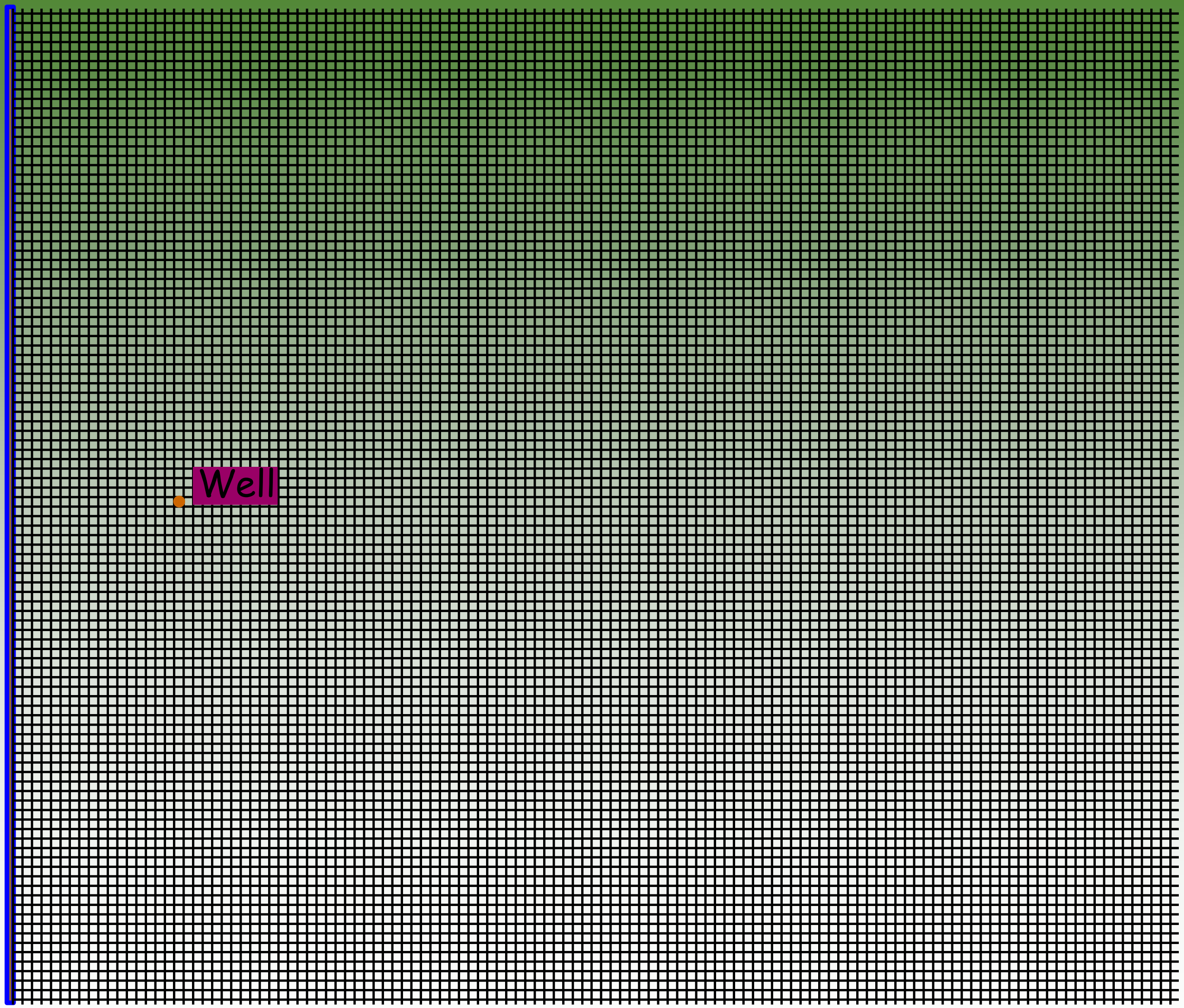
2. Errors in representing distributions of drawdown and storage change.



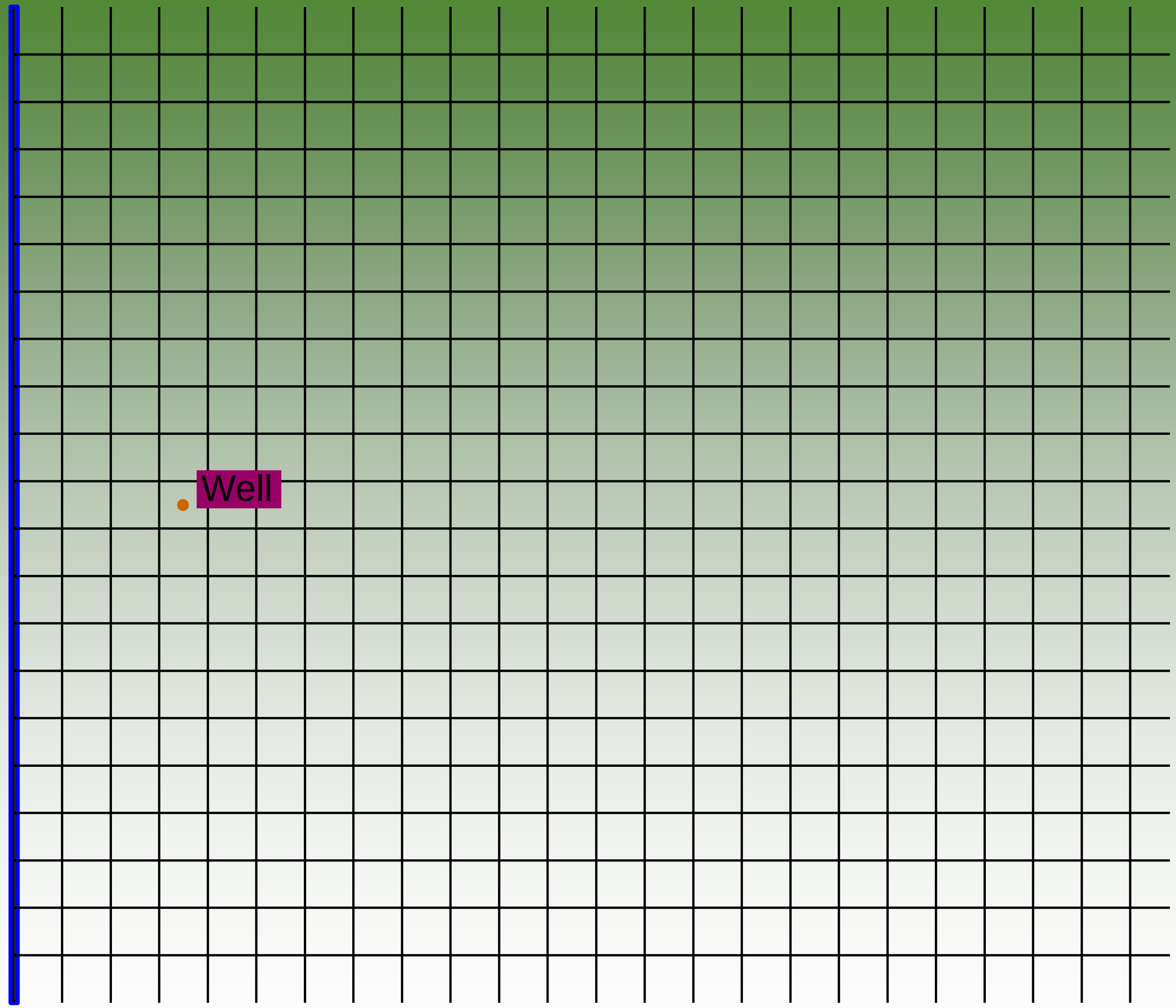
Test simulations to understand effects of grid coarsening on computed depletion



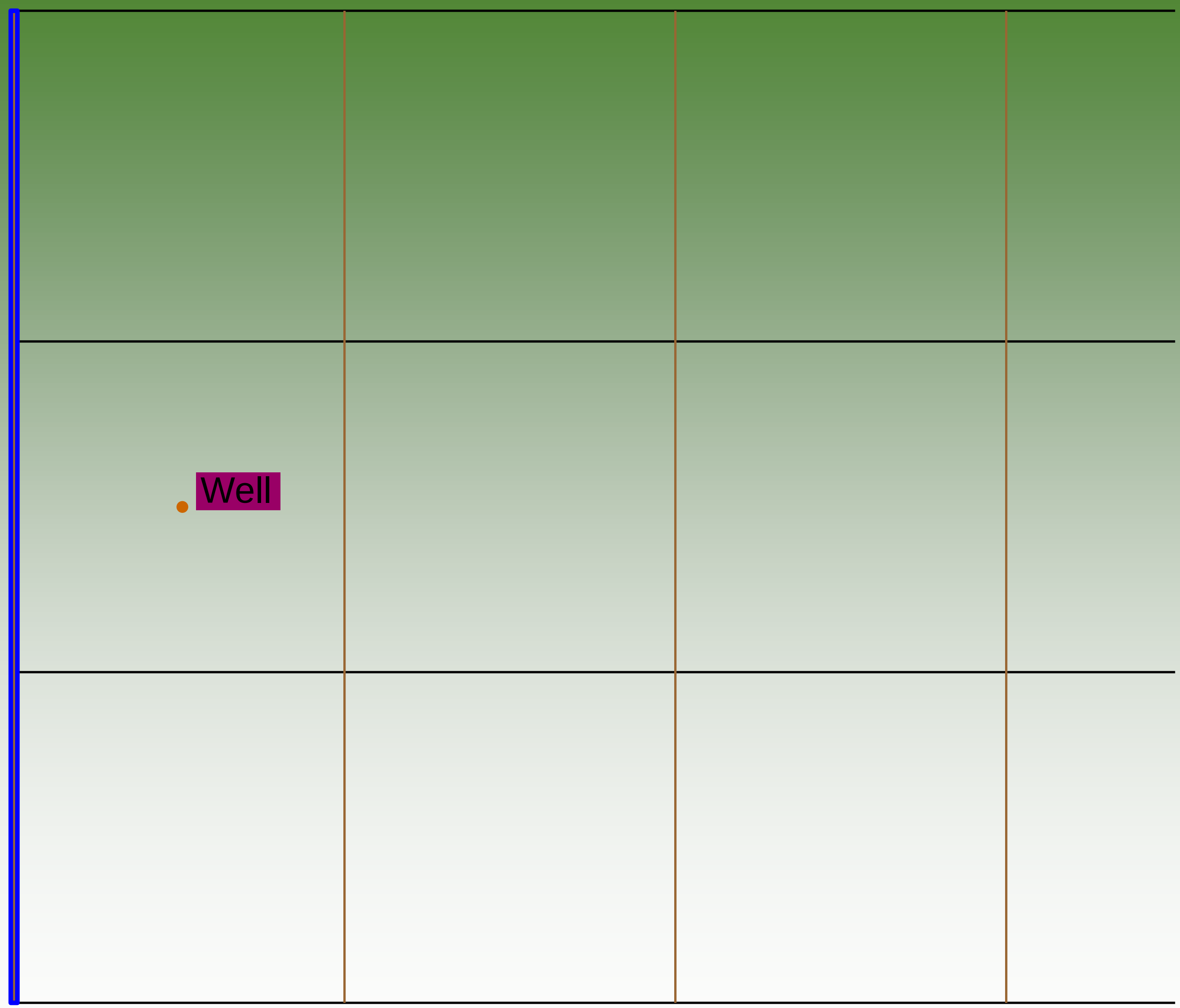
Model 1: grid spacing = 400 feet



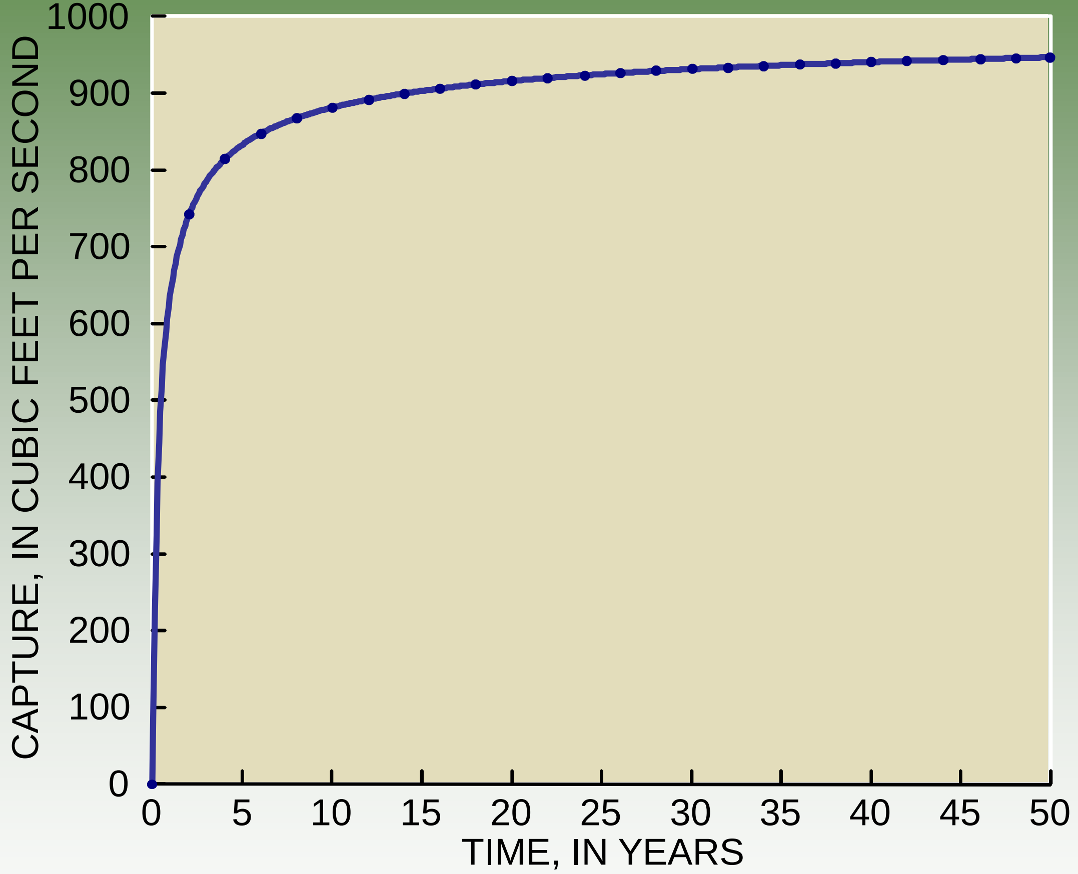
Model 2: grid spacing = 2,000 feet



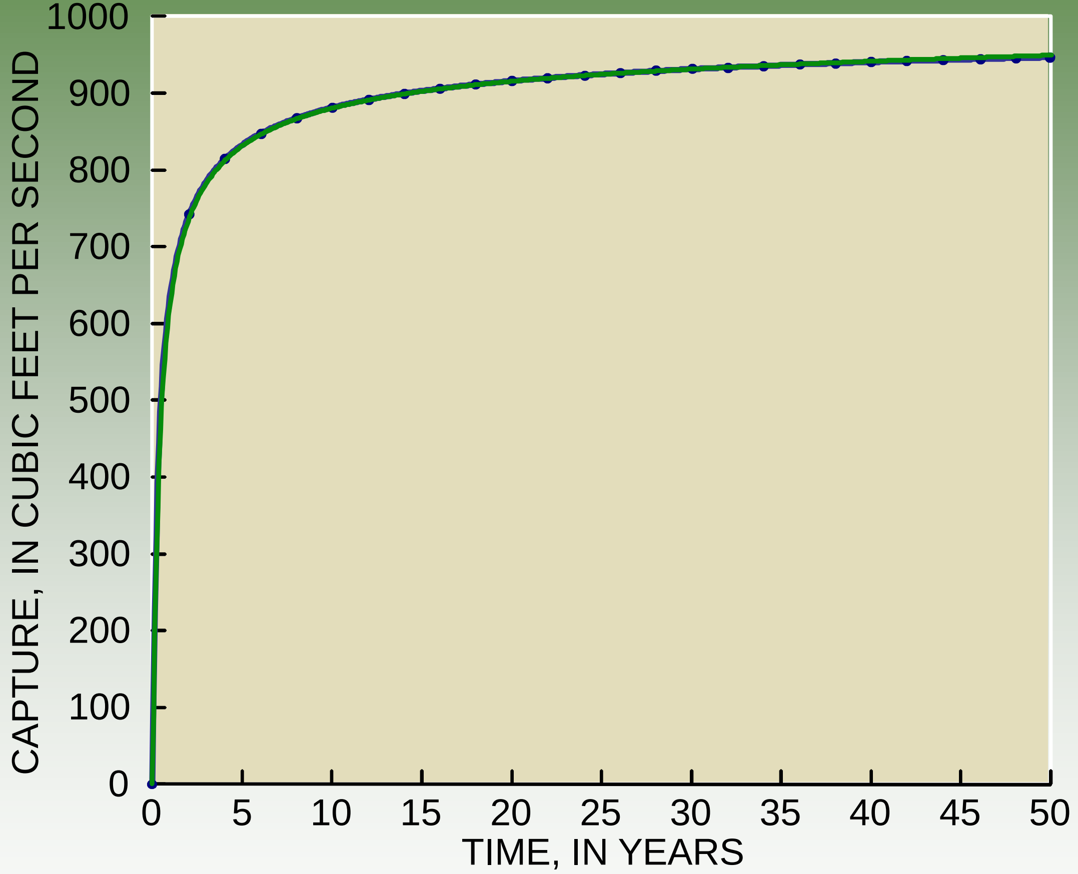
Model 3: grid spacing = 14,000 feet



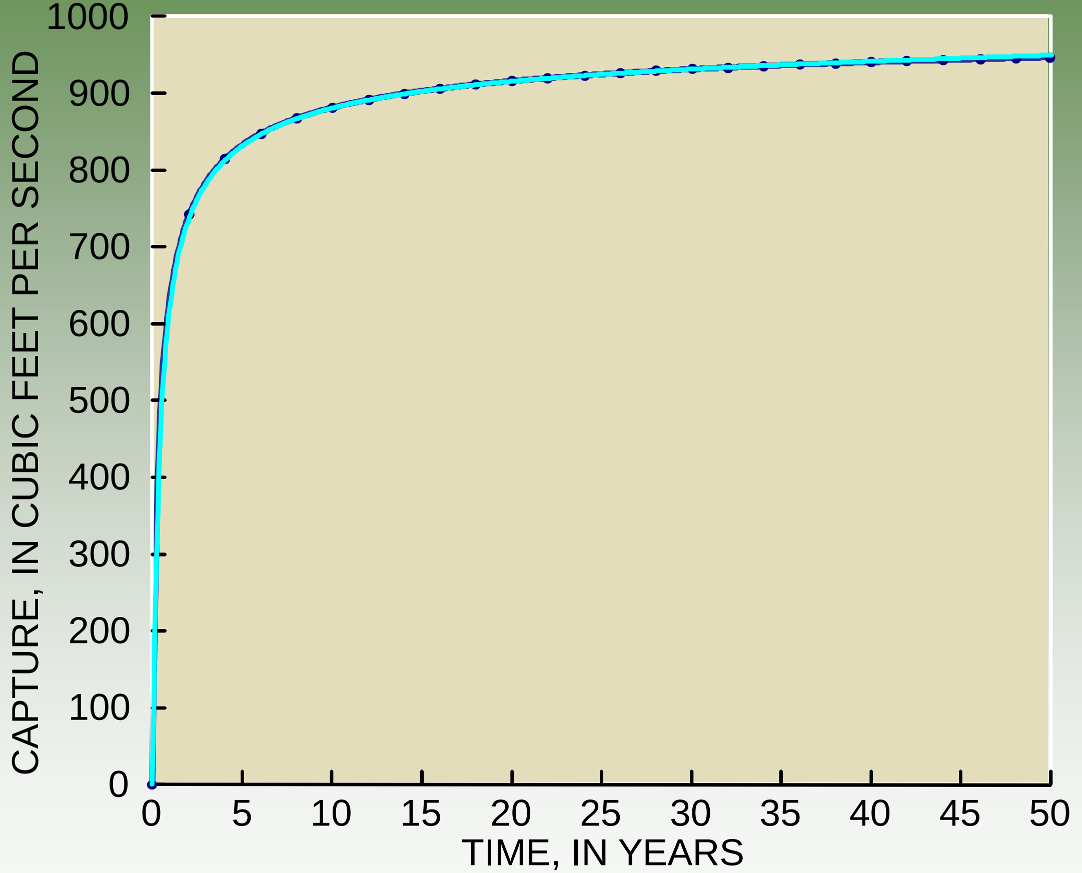
Analytical (exact) solution that does not use a model grid:



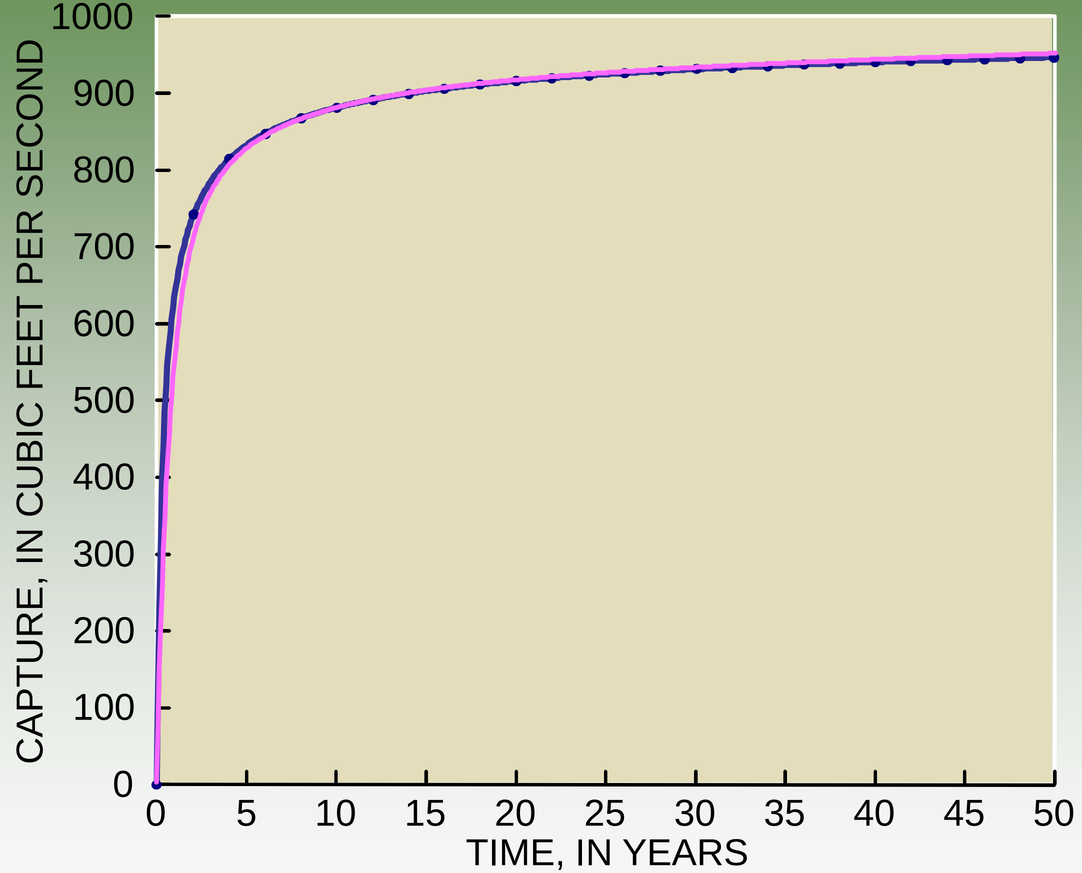
Model 1, 400 foot grid spacing (green curve) versus analytical solution



Model 2, 2,000 foot grid spacing (cyan curve) versus analytical solution



Model 3, 14,000 foot grid spacing (magenta curve)
versus analytical solution



GRID-SPACING SUMMARY

- ✓ Coarse-grid related errors in distance from pumping to surface water may be significant for wells close to surface water, but these errors should be random and unbiased for groups of wells, and should diminish with distance from connected surface water.
- ✓ Errors related to approximating drawdown and storage change distributions were not great for even the coarsest grid in the test simulations.
- ✓ The effect of coarsening of the model grid for this test was to slightly underestimate capture.

Effects of model detail on near-stream recharge simulations

If the interest is in long-term effects, applications of the USGS model such as were carried out by Lacher are reasonable

1. Errors in distance between recharge and stream/ET areas caused by 250-meter grid spacing

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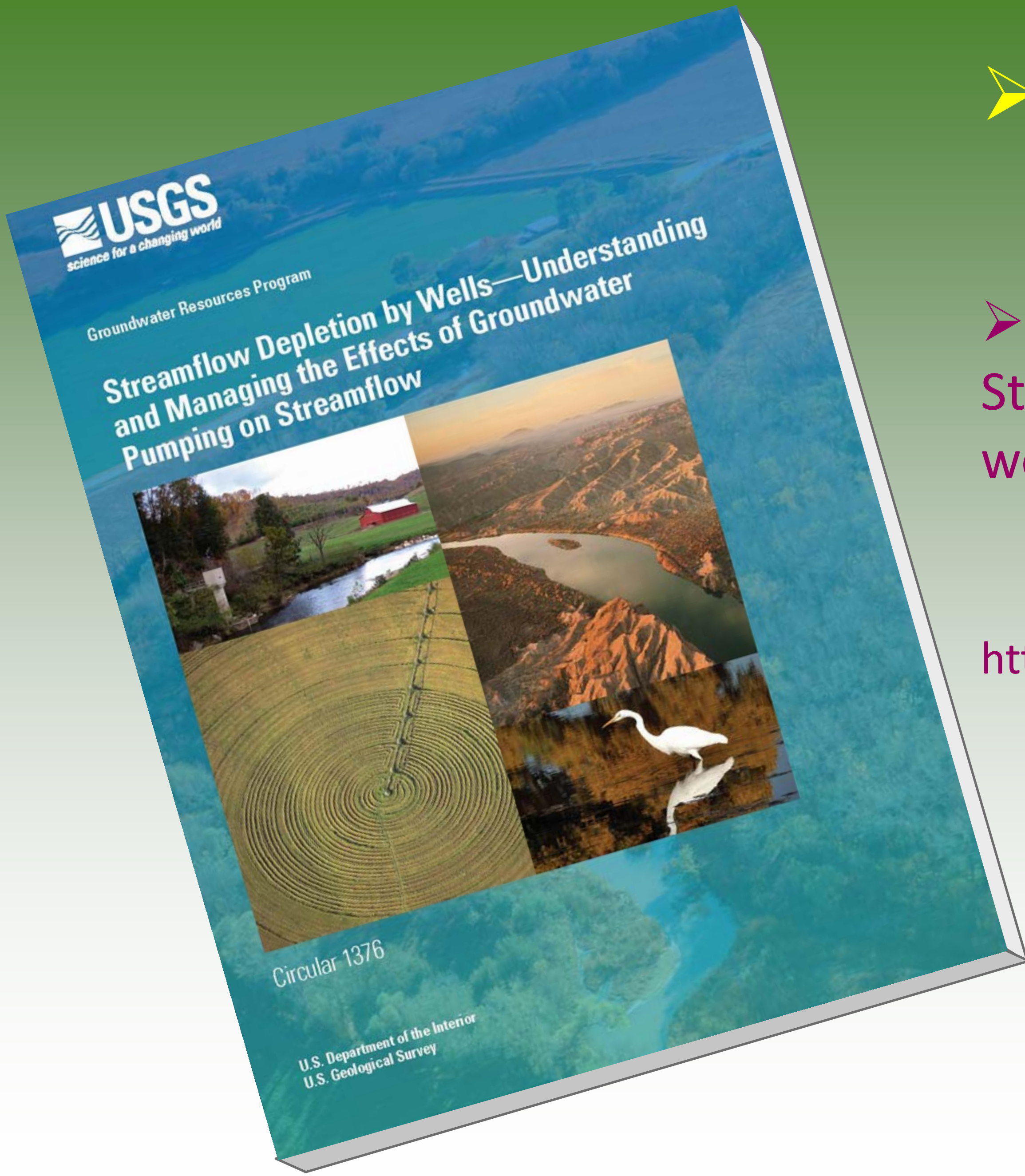
Effects of model detail on near-stream recharge simulations

If the interest is in long-term effects, applications of the USGS model such as were carried out by Lacher are reasonable.

Overall Conclusions Related to Model Applications by Lacher

Lacher made updates and a few corrections to the USGS groundwater flow model. In spite of concerns relating to artificial boundary conditions, her applications constitute a reasonable use of the model for basin-wide evaluations of effects for groundwater pumping and artificial recharge.

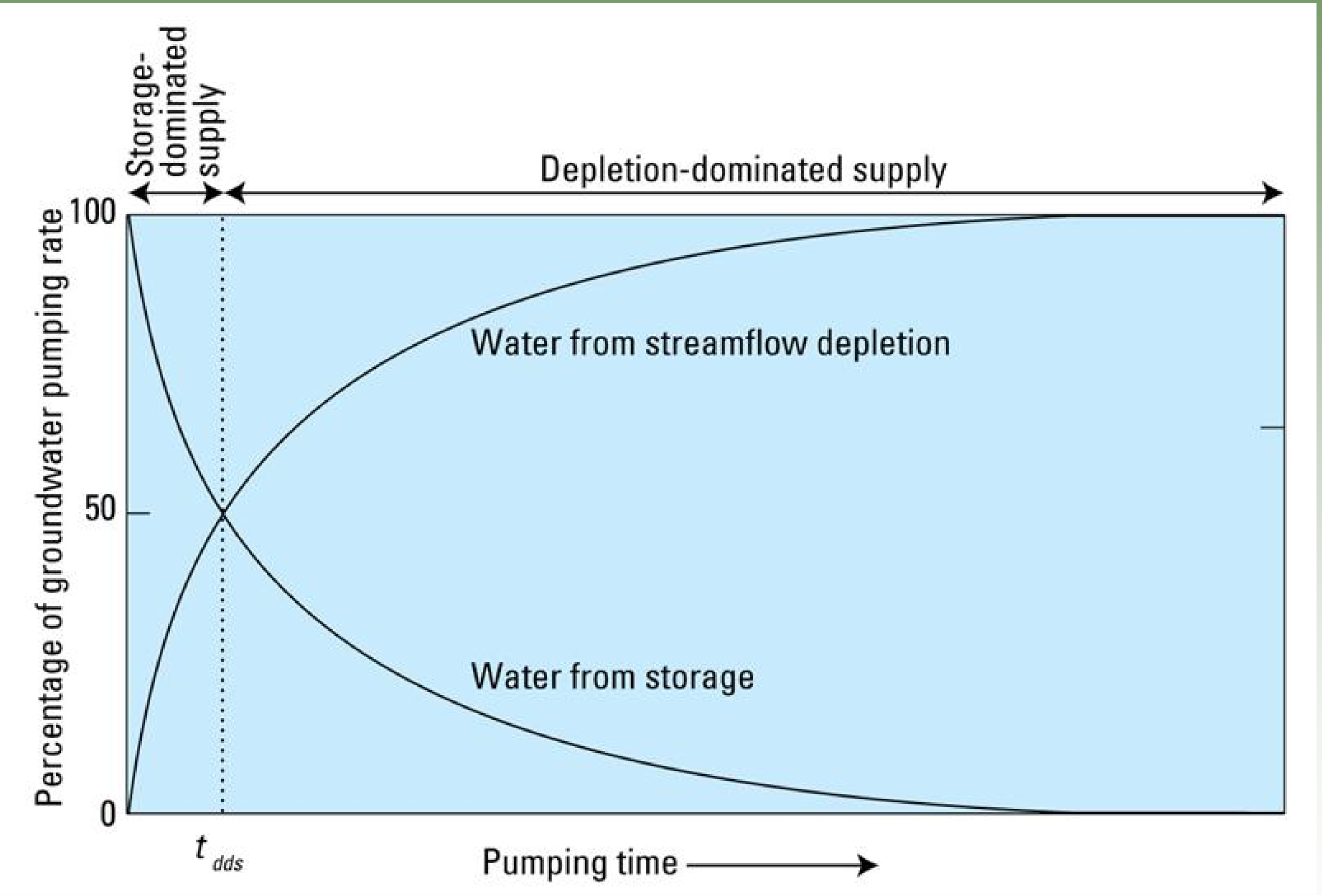


➢New USGS report:

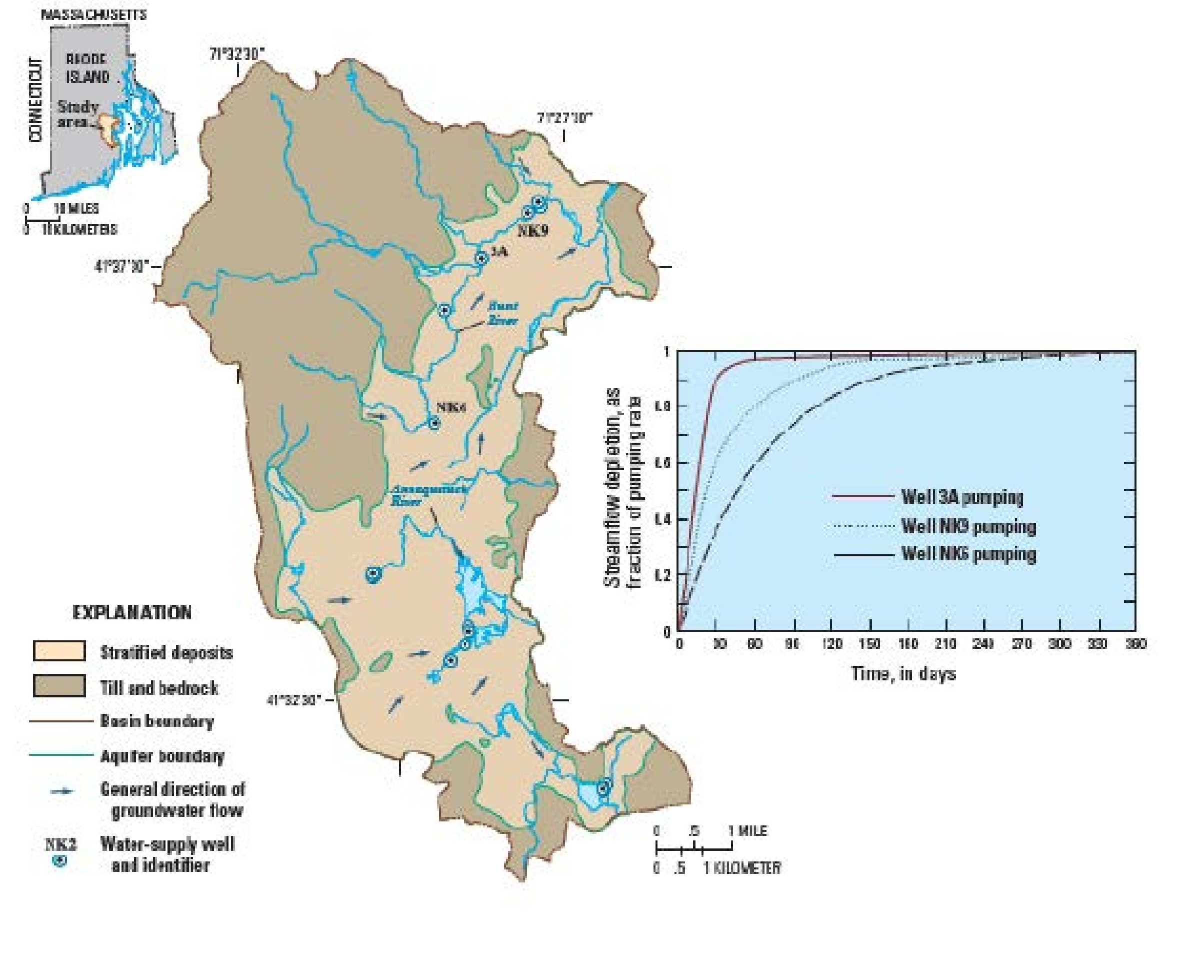
- ➢Circular 1376—Streamflow depletion by wells

http://pubs.usgs.gov/circ/1376/

Timing of the Sources of Water to a Well

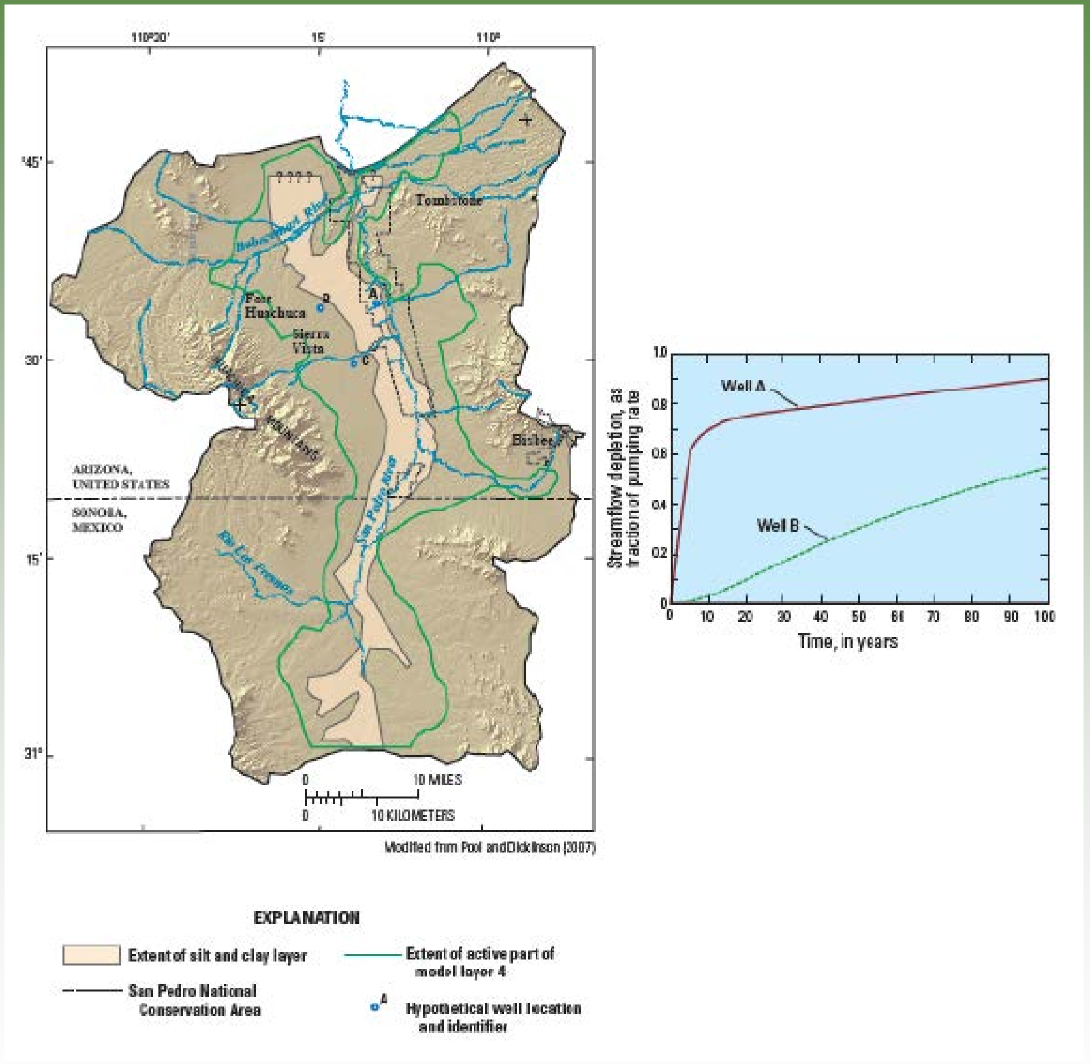


Hunt River Basin, Rhode Island



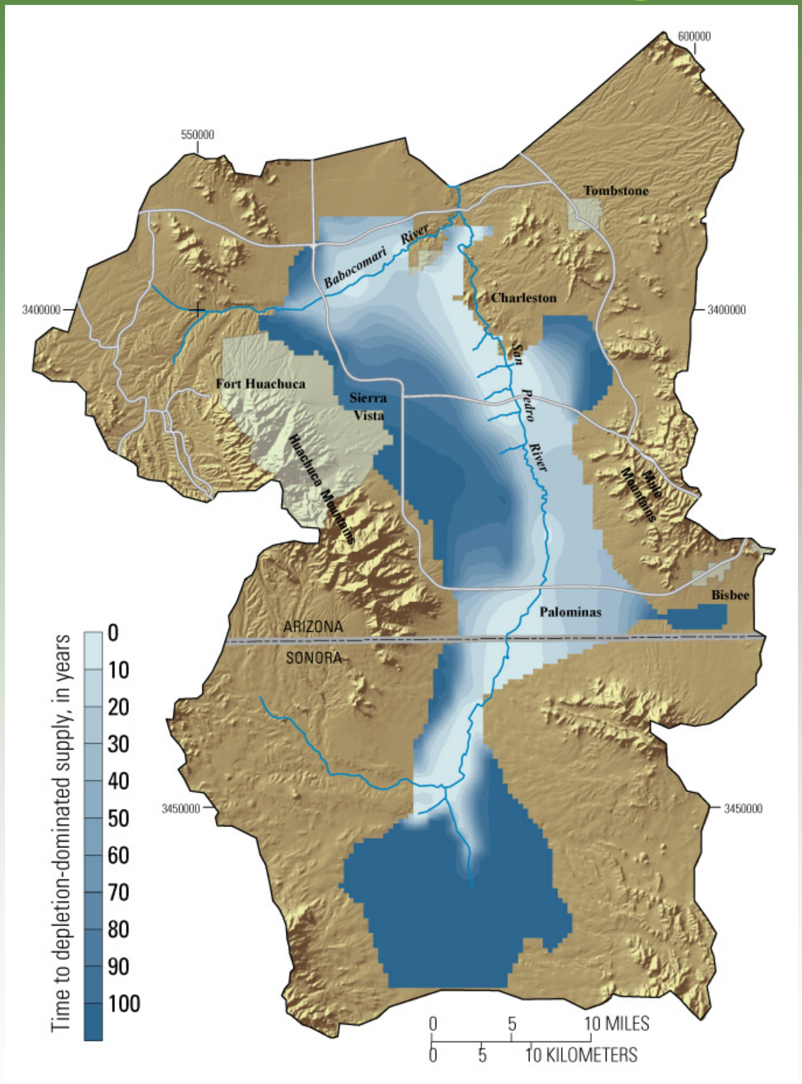
Time to depletion-dominated supply is days to months.

Upper San Pedro Basin, Arizona

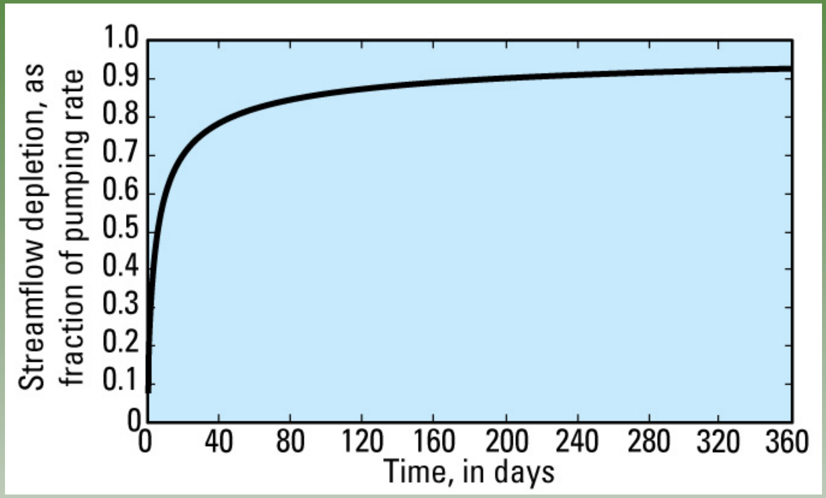


Time to depletion-dominated supply is years to decades.

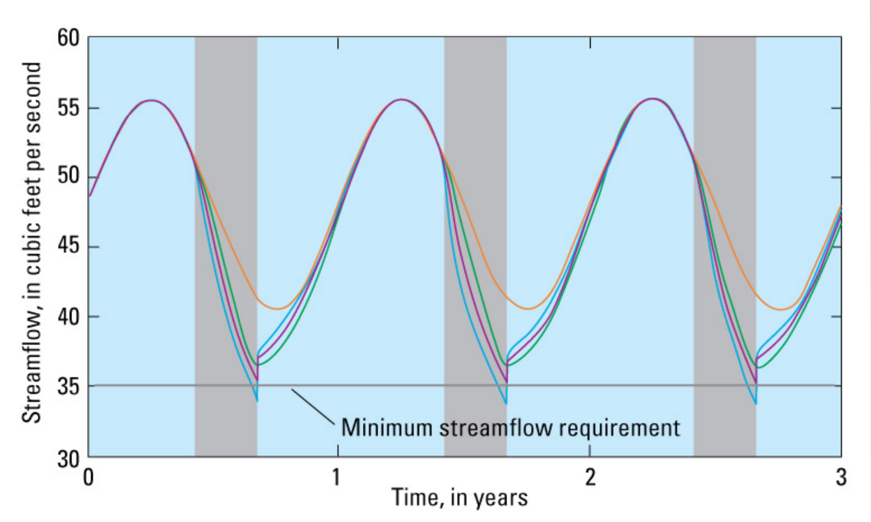
Response Functions, Capture Maps, and Management Scenarios



Pumping time to reach depletion-dominated supply, Upper San Pedro Basin, Arizona



Transient response function



Trial-and-error simulations or optimization techniques

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