MODFLOW-OWHM
Hydrologic Budgets and Case Studies

PRESENTED BY JON TRAUM, P.E.
Outline

- SGMA overview
- Types of hydrologic budgets generated by MF-OHWM
- Examples from case studies scattered within
  - CVHM (Claudia Faunt)
  - SJJRPGW (Jon Traum)
  - MERSTAN (Steve Philips)
  - SBFTM (Scott Paulinski)
  - PVHM (Randy Hanson)
  - Example Problems (Scott Boyce)
SGMA Undesirable Results

- Lowering of groundwater levels
- Reduction of groundwater storage
- Degraded water quality
- Seawater intrusion
- Land subsidence
- Depletions of interconnected surface water
Hydrologic Budgets

- SGMA definition of hydrologic budget
  - Total groundwater and surface water entering and leaving a basin
- MF-OWHM Budgets
  - Groundwater budget
  - Water use budget
  - Streamflow budget
  - MNW2 budget
  - UZF budget
Pre-development

Natural ➔ Engineered
Simple ➔ Complex
2 million acre-feet/year recharge/discharge ➔ 12 million acre-feet/year recharge/discharge

1962-2003/Engineered

Central Valley Aquifer

Precipitation (12.4) ➔ Evapotranspiration (12.6)

Central Valley Surface Processes

Precipitation (15.8) ➔ Evapotranspiration (25.6)

Surface Water Gain (0.3) [sw out]
Surface Water Loss (0.5) [sw in]

Surface Water Recharge from Irrigation and Precipitation (7.8)

Ground Water Pumpage (9.3)

Ground-water Recharge from Ground-water System (2.2)

Agricultural (8.6)
Municipal (1.1)
Flow through Boreholes (0.4)
Change in Storage (including Subsidence) (1.4)

Surface Water System

Surface Water Gain from Ground-water System (2.2)
Surface Water Flow to Delta (0.1)

Surface Water Deliveries (10.2)
Runoff (1.1)

Indicates loss of storage in aquifer system

OUTFLOW to DELTA (27.2)
Processing Budgets

- Many different ways to temporally or spatially aggregate budget
  - Available for every model time step
  - Available at detailed spatial scales (GW Budget by cell, SW Budget by stream reach)
  - Some stored in binary format

- Tools to help
  - Zone Budget: subregional aggregation
  - ModelMuse: visualization
  - GW_Chart: convert to text
Groundwater Budget

- Used to determine reduction of groundwater storage
- Provides the flows into and out of each model cell in binary format
- Also called cell-by-cell budget
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<th>Water-balance subregion</th>
<th>Area (square miles)</th>
<th>Net storage from specific yield and compressibility of water</th>
<th>Net elastic and inelastic storage</th>
<th>Net stream leakage</th>
<th>Net pumpage</th>
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Annual totals
Annual totals
Monthly for selected year types

A. Water Year 1975

B. Water Year 1990

C. Water Year 1998

EXPLANATION
- Net ground-water pumpage
- Water from compaction
- Net ground-water recharge from surface processes
- Water from storage
- Net stream leakage
Average annual totals by subregion
Groundwater Flow Paths

- Cell to cell flow (also called subsurface flow) is a key component of the groundwater budget.
- Used to analyze water quality issues including seawater intrusion.
- MODPATH post-processor to estimate groundwater flow paths from cell-by-cell output.
- MODPATH-OBS post-processor for MODPATH to get concentrations.
- MT3DMS and SEAWAT.
Simulated flow paths
Simulated travel times

- Child-model well-2 pumping well observation location
- Child-model well-3 pumping well observation location
- "Farm 1" recharge
- "Farm 2" recharge
- "Trench" cells
- "Pit" cell
- River recharge
- Parent-observation well-1 spans two layers and shows mixture but predominantly separate inflows from each source with respect to layers

Particle travel time, in years:
- 0
- 4
- 8
- 12
- 16
- 20
Simulated chloride concentrations
Subsidence Term in Groundwater Budget

- Subsidographs are used to determine location and magnitude of subsidence.
- However, budget can be helpful for determining if subsidence is "significant and unreasonable".
Change in groundwater budget due to additional pumping - shallow wells
Change in storage due to pumping deep wells
Streamflow Budget

- Provides the inflows and outflows to the stream network by stream reach
- Can be used to determine depletion of interconnected surface water
Annual Average groundwater and surface water exchange
Water Use Budget

- Provides the flow components related to the supply and demand of crops and other plants for each water balance subregion.
- Also called landscape budget, supply and demand budget, or farm budget.
- Includes groundwater pumping and recharge which are significant components of the groundwater budget.
- Includes the atmospheric budget components of precipitation and evapotranspiration.
EXPLANATION

Landscape budget through time for Pajaro Valley, California

- Blue: Pumpage
- Purple: Precipitation
- Red: Evapotranspiration from groundwater
- Green: Deep percolation
- Orange: Evapotranspiration from precipitation
- Black: Evapotranspiration from irrigation
- Cyan: Runoff

Annual totals
Simulated agricultural pumping

Hotter color = more Ag pumping
Simulated areal recharge

Hotter color = more recharge
For hydrologic year types
Simulated water supply
Simulated water demand
Comparing simulated and reported pumping – annual totals
Comparing simulated and reported pumping – by subregion
Combining budget types can help understand effects.
References – MODFLOW and Tools


References – Case Studies


