Groundwater Availability: An Issue of Scale and Science-Based Water Management

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Kevin Dennehy is the principal expert and overall program leader for the U.S. Geological Survey’s Groundwater Resources Program in Reston, Virginia. He has more than 30 years of experience in the analysis of the quantity and quality of water resources and is the author and co-author of numerous publications on topics like water availability and sustainability, surface water and groundwater interactions, unsaturated zone processes, surface water and groundwater simulation, surface water and groundwater quality sampling and analysis, and aquifer test analysis. Currently his focus is on assessing the nation’s groundwater availability by conducting multidisciplinary regional scale studies of principal aquifers. Kevin received undergraduate and graduate degrees from the University of New Hampshire and the University of South Carolina, respectively.

Figure 1. Presentation introduction.
Figure 2. Sustainability of water resources is under continued threat.

Figure 3. Linking water demand to current and future stresses.
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Figure 4. Percentage of groundwater bodies in poor quantitative status across the European Union.

Figure 5. Information not available in consistent spatial and temporal scales.

Information Not Available in Consistent Spatial and Temporal Scales

- Quaternary Atlas (surficial map)
- 15 million water-well records compiled into a single database
- Developing 3D framework of glacial aquifer system
- Sand and Gravel Thickness

USGS and others, 2013
What is the appropriate scale of investigation?

Principal Aquifers of the United States
(Source: http://nationalatlas.gov/atlasftp.html)

Figure 6. What is the appropriate scale of investigation?

What do we need to know to assess the Nation’s groundwater availability?

- Quantify resource (supply) and
- Information about its use (demand).

Figure 7. Assessing the nation’s groundwater availability.
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Figure 8. Factors that affect water availability.

Figure 9. How to assess groundwater.

Figure 10. 3-D hydrogeologic framework.
Account for water with a “budget”

Water budgets: a unifying theme for assessment of groundwater availability

Understanding water budget components can be used to aid management of resource

Precipitation + Inflow = ET + Storage Change + Outflow

Figure 11. Account for water with a “budget.”

Northern Atlantic Coastal Plain Groundwater Model

Current Model:
Rows: 250
Columns: 500
Layers: 19

Horizontal Grid Spacing:
1 x 1 mile

Figure 12. Northern Atlantic Coastal Plain Groundwater Model.
Figure 13. Cumulative volumetric groundwater depletion (1900-2008).

Figure 14. Global stresses suggest regional approach.
• 20,000 square miles
• Using about 1% of U.S. farmland, California’s Central Valley
  - Produces more than 250 different crops
  - Supplies 7% of the U.S. agricultural output (by value) — including about half of the Nation’s fruits, nuts, and vegetables
• Approximately 10-20% of the Nation’s groundwater is pumped from the Central Valley aquifer system every year.

Figure 15. California’s Central Valley.

Figure 16. Texture analysis used in defining 3-D hydrogeologic framework.
Figure 17. Regional water budget.

Figure 18. Modeling tool useful in forecasting system response.
Summary

- Analyzing entire groundwater system has practical advantages
- Local water managers are focusing on different scales than required to address aquifer sustainability
- Regional analysis can address aquifer sustainability using a holistic approach
- Regional studies advance state-of-knowledge of large groundwater systems

Figure 19. Summary.

Summary (Cont.)

- Models helpful in hypothesis testing which aid in management of resource
- Management of these resources by local government should be done with awareness of the regional system

Figure 20. Summary (Cont.).