Design Considerations for Assessing Ground-Water Quality in a Regional Aquifer System: The High Plains Aquifer

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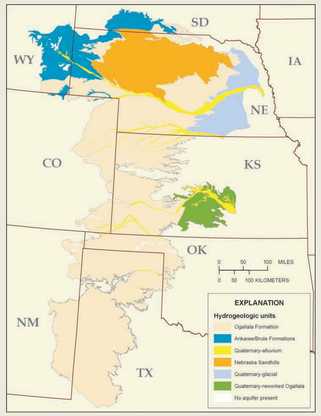
ENVIRONMENTAL SETTING

The High Plains aquifer is an important regional system that covers about 174,000 mi² in parts of eight western states and supports one of the largest agriculture economies in the U.S. The High Plains Regional Ground Water (HPGW) study, part of the USGS National Water-Quality Assessment (NAWQA) Program, was tasked with assessing the current condition of ground-water quality in the High Plains aquifer and investigating the natural and human processes controling this condition.

The High Plains Aquifer System is comprised of six hydraulically connected hydrogeologic units of late Tertiary or Quaternary age each having a different set of ground-water characteristics. The Ogallala Formation of Miocene age is the principal geologic unit comprising about 70% of the aquifer system.

The large geographic area of the High Plains coupled with the variation across the area in the underlying bedrock, climate conditions, land- and water-use, depth to ground water, saturated thickness, and water-table declines present unique challenges to a comprehensive investigation of ground-water quality.

This poster provides visual aids for discussion of the design and implimentation of the HPGW study. This study approach might be useful as a template for other evaluations of regional water-quality conditions.



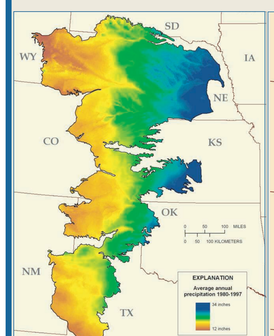
Location of the High Plains aquifer and the hydro-geologic units that comprise the aquifer system.

A National Resource

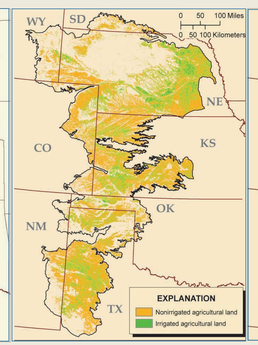
27% of the nation's agriculture
30% of the nation's ground-water irrigation
14.5 million cattle
10.4 million swine
2.3 million people

High Plains Variability

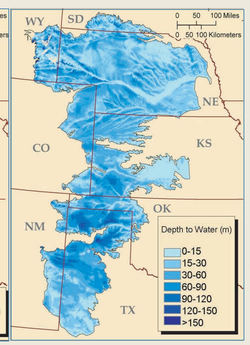
Hydrogeology
Regional Climate Differences
Land-use distribution and rotations
Depth to water and water-table changes
Large range of saturated thickness
Ground-water age (<10 yrs to >10,000 yrs)



Average Annual Precipitation



Distribution of Agriculture



Depth to Ground Water

STUDY DESIGN CONSIDERATIONS: A Holistic Approach

Regional assessment of water quality in the High Plains aquifer required taking into account the large geographic extent of the aquifer and the spatial variation in lithology, depth to water, saturated thickness, and ground-water age. Regional differences in climate, water-use, land-use, and crop types, also influenced the location of process related studies and the choice of analytical methods used for water-quality analysis. Areally and vertically nested measurements of ground-water quality coupled with focused studies of processes controlling water movement, chemical transport, and chemical trans-formation were used to provide comparative results that could later be "scaled up" to a regional understanding of the entire system.

Primary Local Concerns (from survey)

Nutrient contamination of ground water from CAFOs
Effects of saline ground water from bedrock
Effects of urban and agricultural land-use on water quality
Impacts to shallow alluvial aquifers from use of surface water
Effects of focused recharge

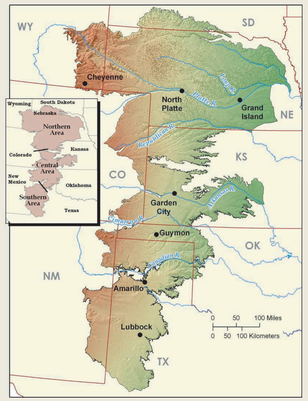
Design Considerations

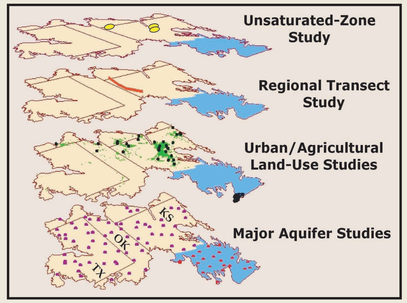
Large area/Limited funding
Multiple hydrogeologic units
Large spatial, vertical, and temporal variation
Multiple scales of assessment
Phased logistics and integration of results

The High Plains Regional Ground-Water (HPGW) study was designed around a series of broad-scale and process oriented studies, consistently applied in a regionally phased approach, that proved to be logistically and financially manageable; evaluated most of the primary hydrogeologic, land-use, and climatic settings; addressed local differences; and permitted scaling of results to meet interpretive needs. Primary study components were:

- Major Aquifer Studies: existing domestic wells, broad suite of chemical constituents, assesses regional water quality conditions
- Land-Use Studies: installed water-table monitoring wells, analytes indicative of associated land use, determines impacts of dominant land-use settings on ground-water quality
- Regional Transect Studies: vertically nested monitoring wells, selective analytes and range of age dating techniques, identifies vertical gradients in ground-water chemistry and age (includes effects of underlying bedrock)
- Unsaturated-Zone Studies: various instrumentation between land surface and water table, continuous monitoring of moisture and periodic monitoring of chemistry, understanding of water movement (recharge) and chemical loading to aquifer

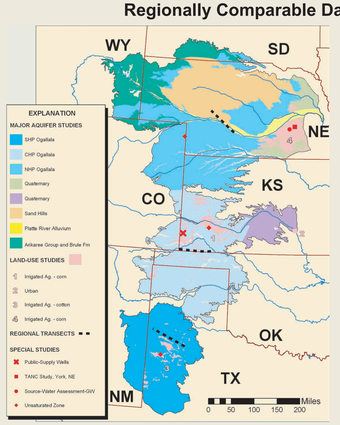
Phased Approach by Sub-Region; Areal Nesting of Studies

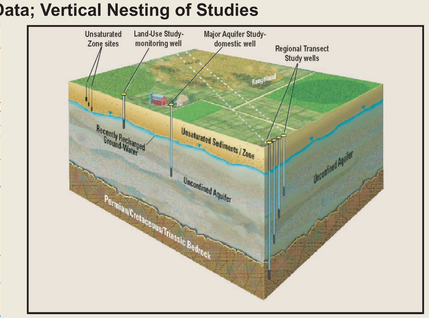




Phased approach lowered annual cost
Assessed both regional gradients and local variability
Resulted in comparable data between sub-regions
Nested process-related studies provide understanding of controls on regional ground-water quality

Regionally Comparable Data; Vertical Nesting of Studies

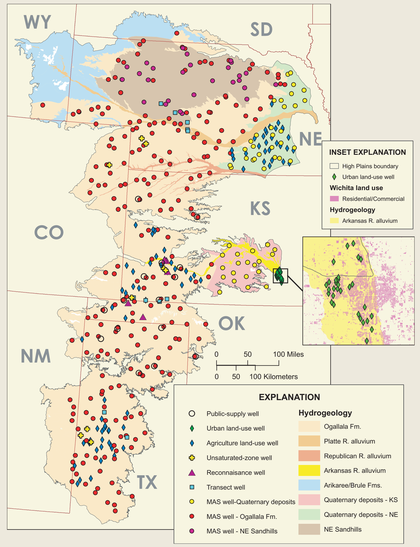




Even distribution of studies
Investigates water/chemical flux from land surface to water table
Assesses vertical differences in ground-water quality
Integrates multiple time scales
Evaluates affect of underlying bedrock

IMPLEMENTATION OF WATER-QUALITY ASSESSMENT

Distribution of High Plains Water-Quality Assessment Sites

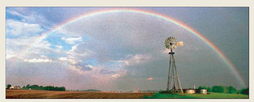


Unsaturated-zone study installation

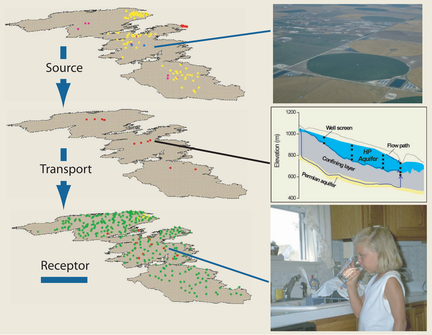
More than 300 domestic wells
About 120 monitoring wells
Nine unsaturated-zone study sites
Three regional transect studies

Benefits of Design

Regionally Comparable Data Sets
Addresses Variability in Controlling Factors
Provides Understanding at Multiple Scales
Regional Differences Observed
Holistic Assessment of Chemical Lifecycle (Source-Transport-Receptor Model)
Revised Conceptual Model



Interpretation using S-T-R model



Future Directions

Integrate with remote sensing
Determine climatic controls on aquifer recharge
Refine techniques for data extrapolation
Update ground-water flow model
Couple climate-change, ground-water flow, and agricultural economic models

For Updates, Data, Publications, and Future Results:
http://co.water.usgs.gov/nawqa/hpgw/HPGW_home.html

Weather station located at rangeland unsaturated zone monitoring site.