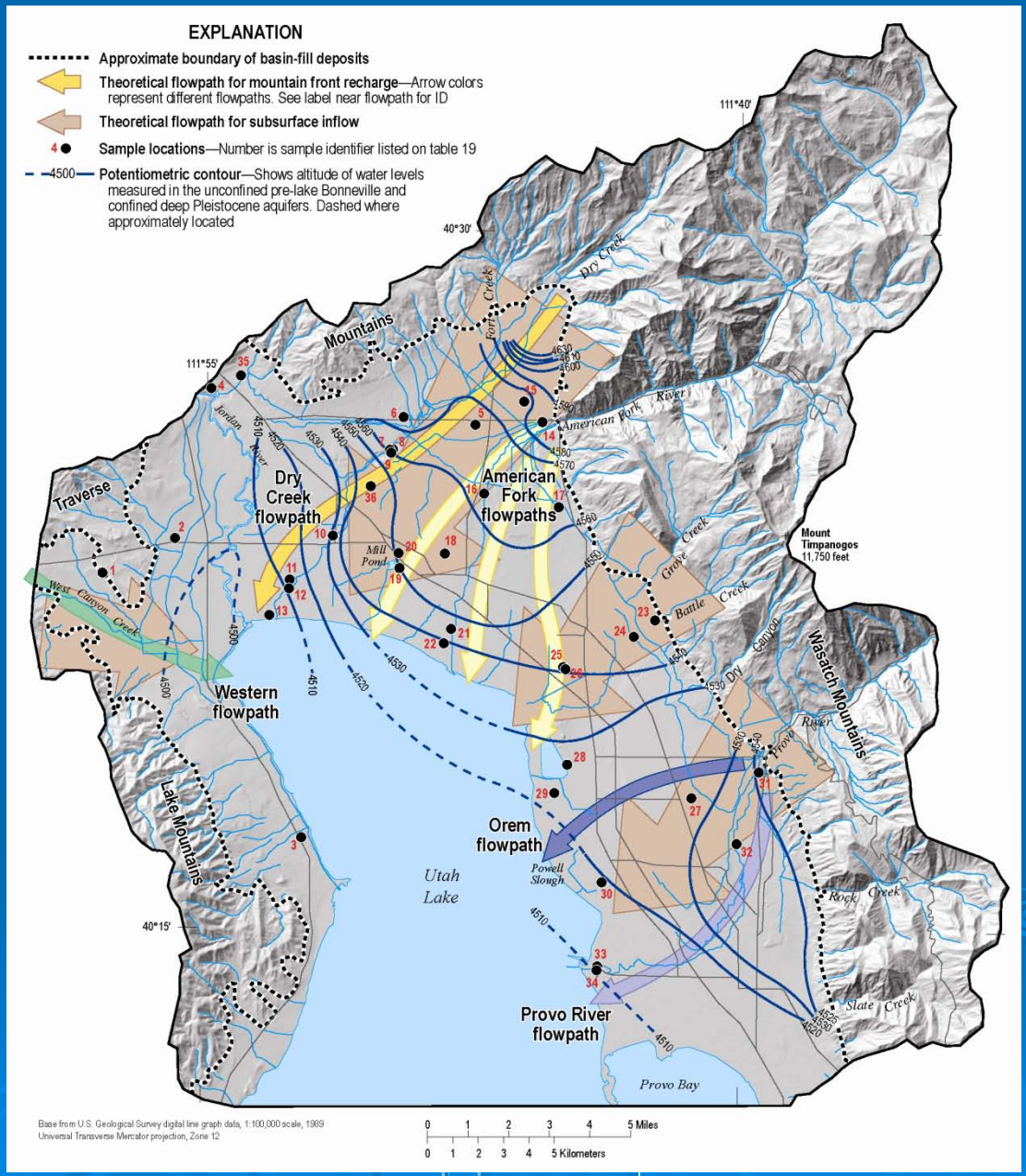
Northern Utah Valley Study *Findings*

- Geohydrology
- GW flow model
- GW budgets
- Test scenarios using flow model



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2003-05 Study Objectives

- Improve understanding of GW flow system
- Provide information and tools to refine GW budget and to estimate effects of future development

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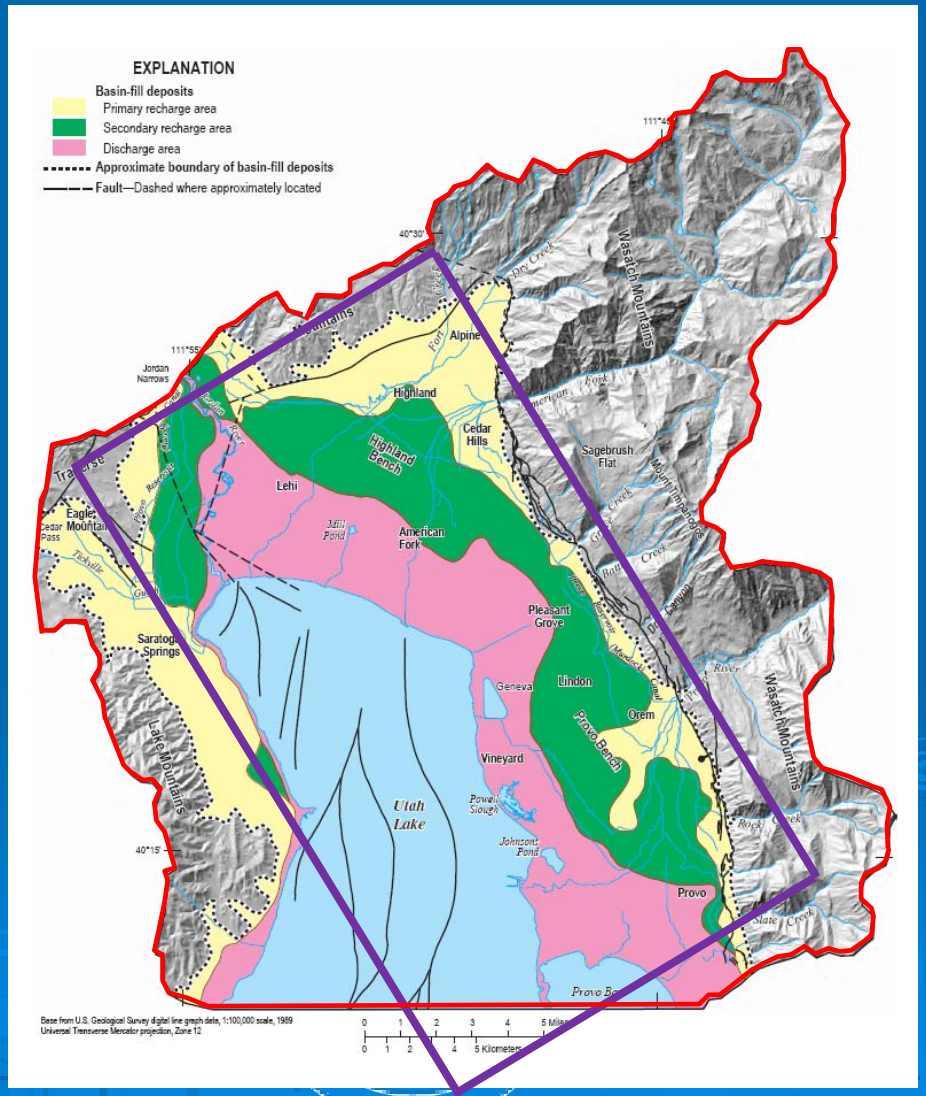
2003-05 NUV Study

- Expanded study boundary beyond Clark & Appel, 1984 – 85 study

Study area includes:

- Mountain block to drainage divide
- Area west of Utah Lake
- Southern boundary line through Utah Lake



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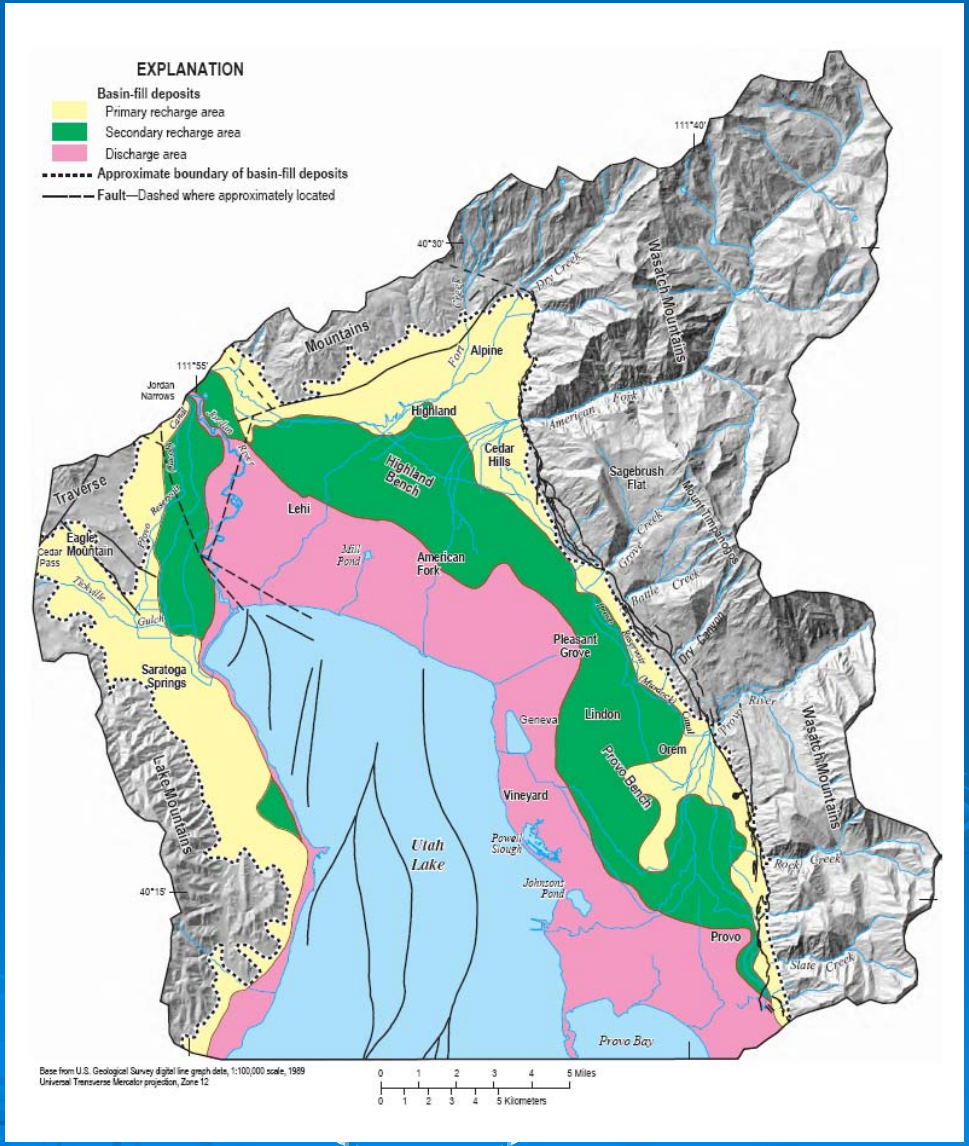
Northern Utah Valley – Hydrology

- Principal GW reservoir is in basin-fill deposits
- Primary recharge area: coarse-grained, downward flow
- Secondary recharge area: confining layers, downward flow
- Discharge area: Confining layers, upward flow



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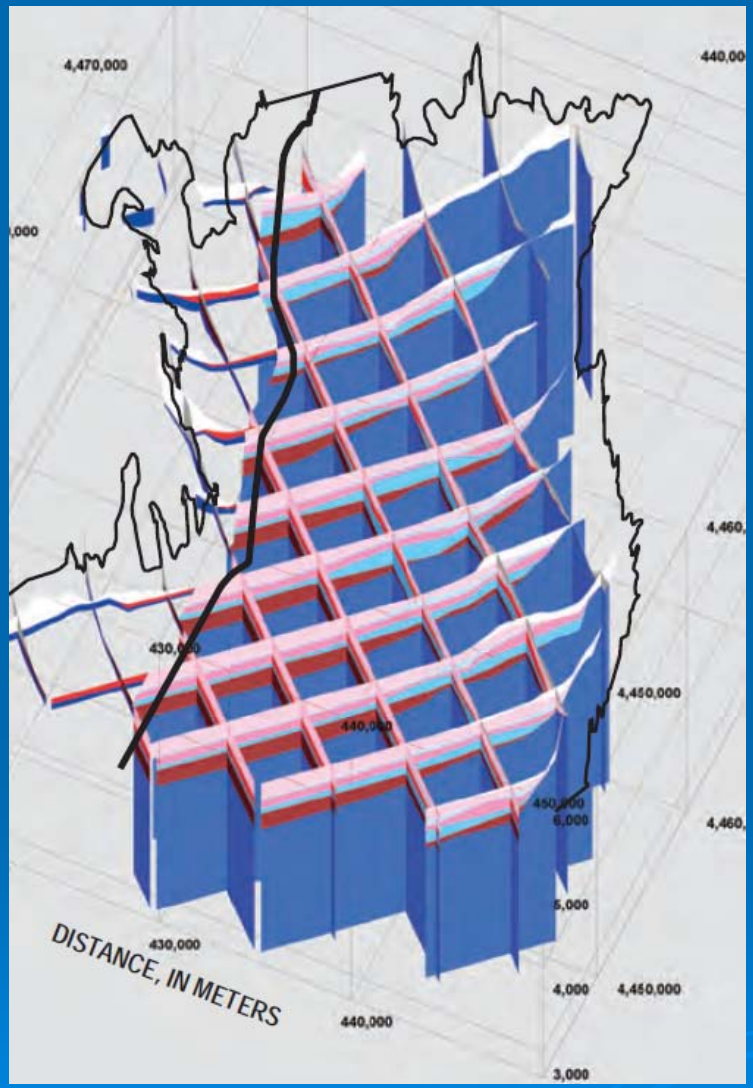
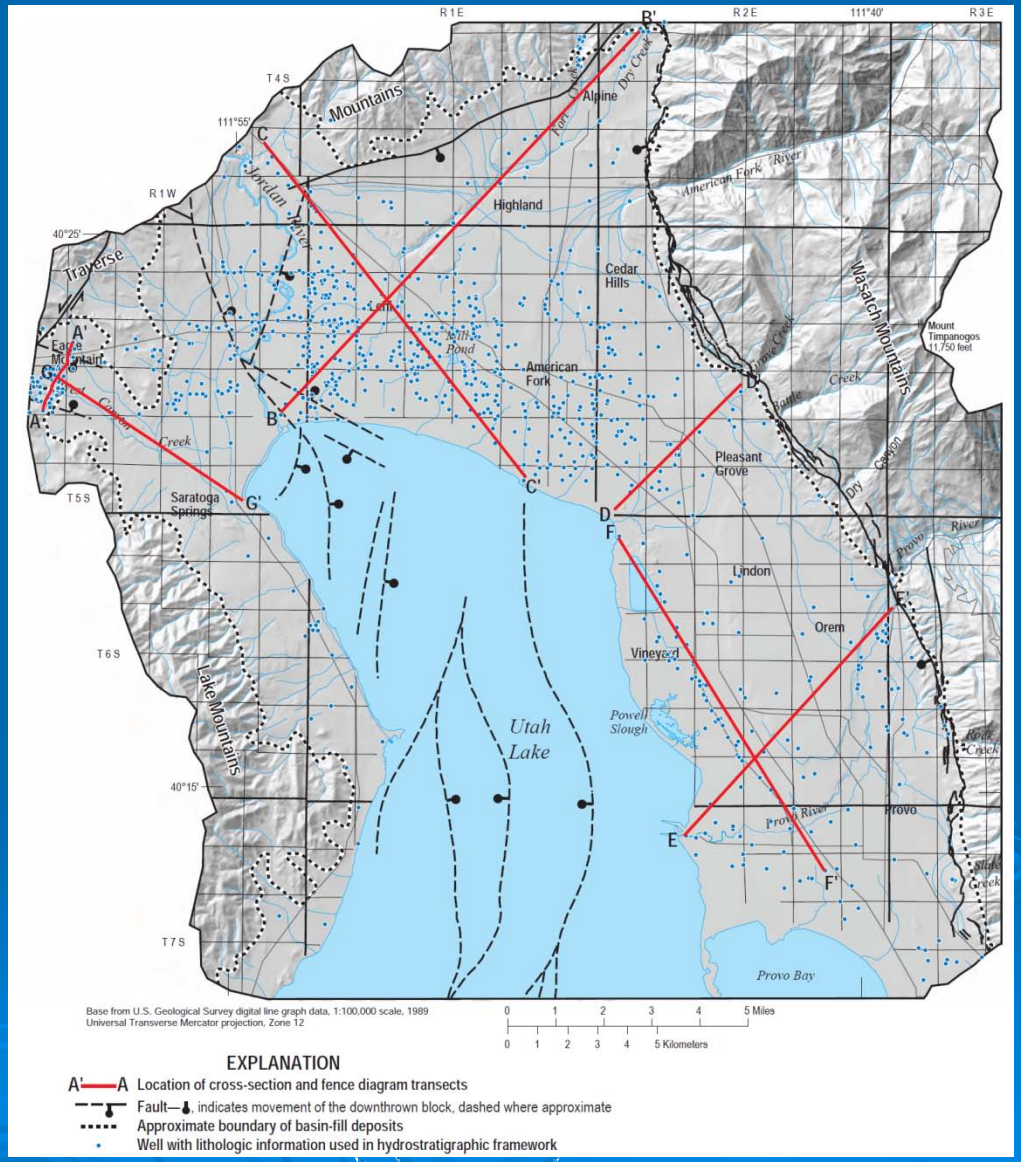
3-D Hydrogeologic Framework





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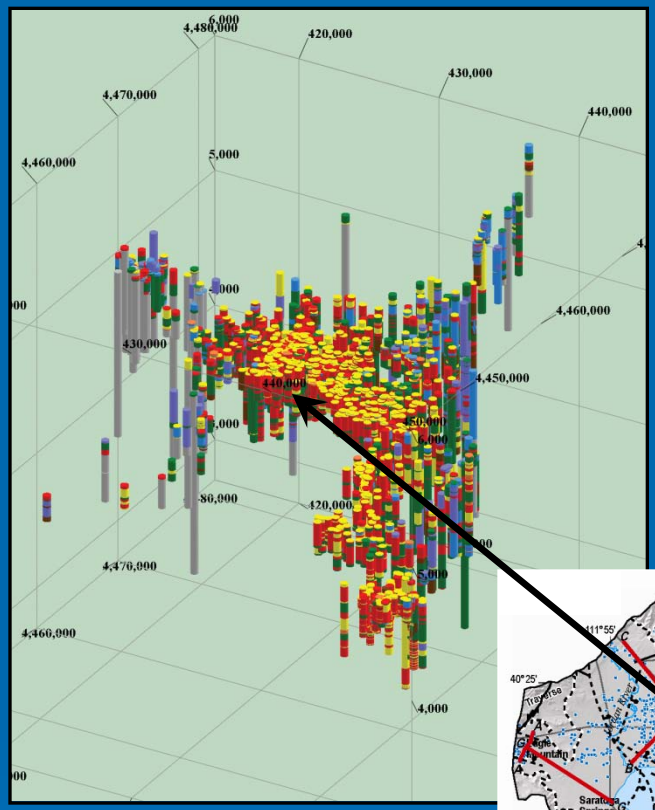

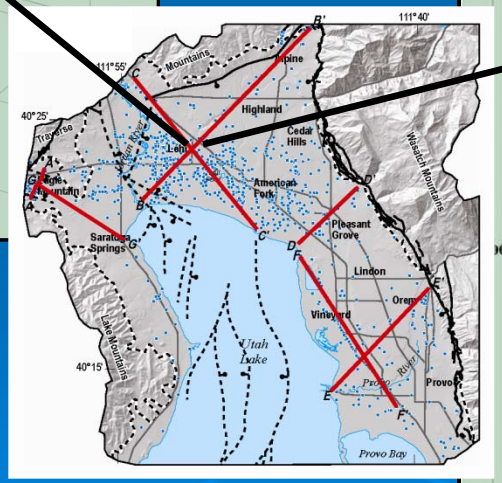

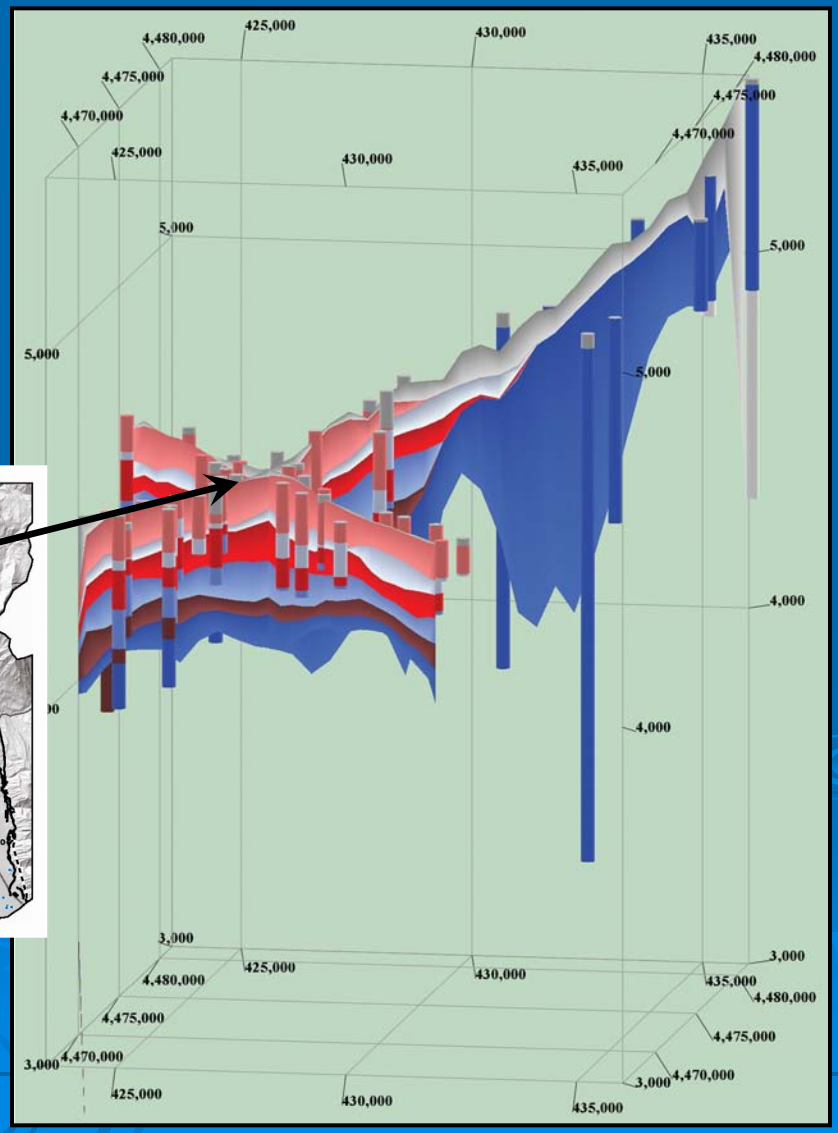

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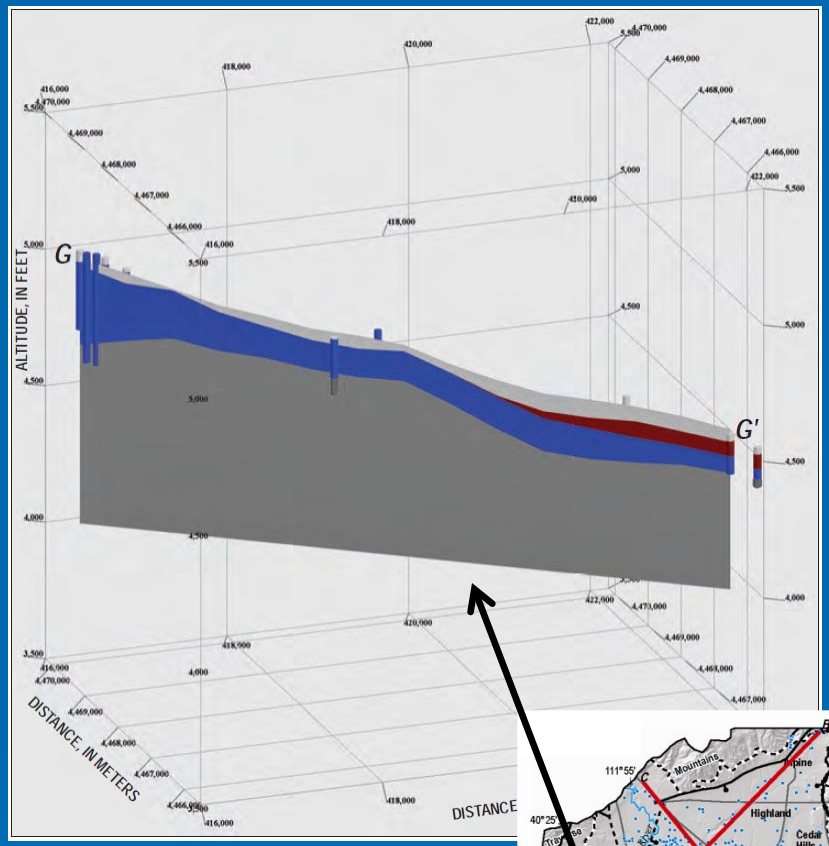

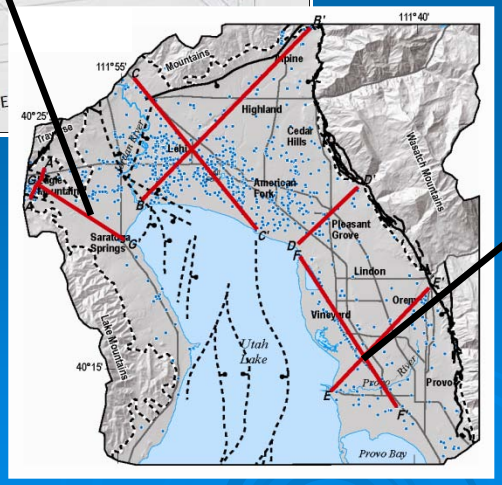

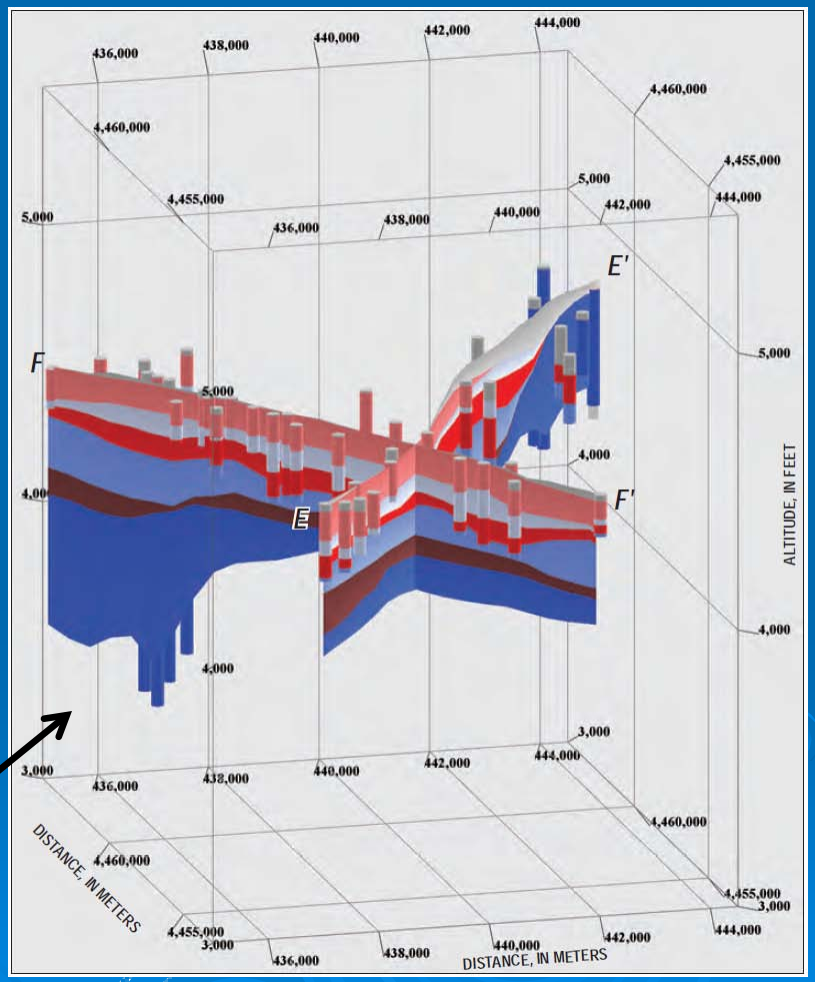

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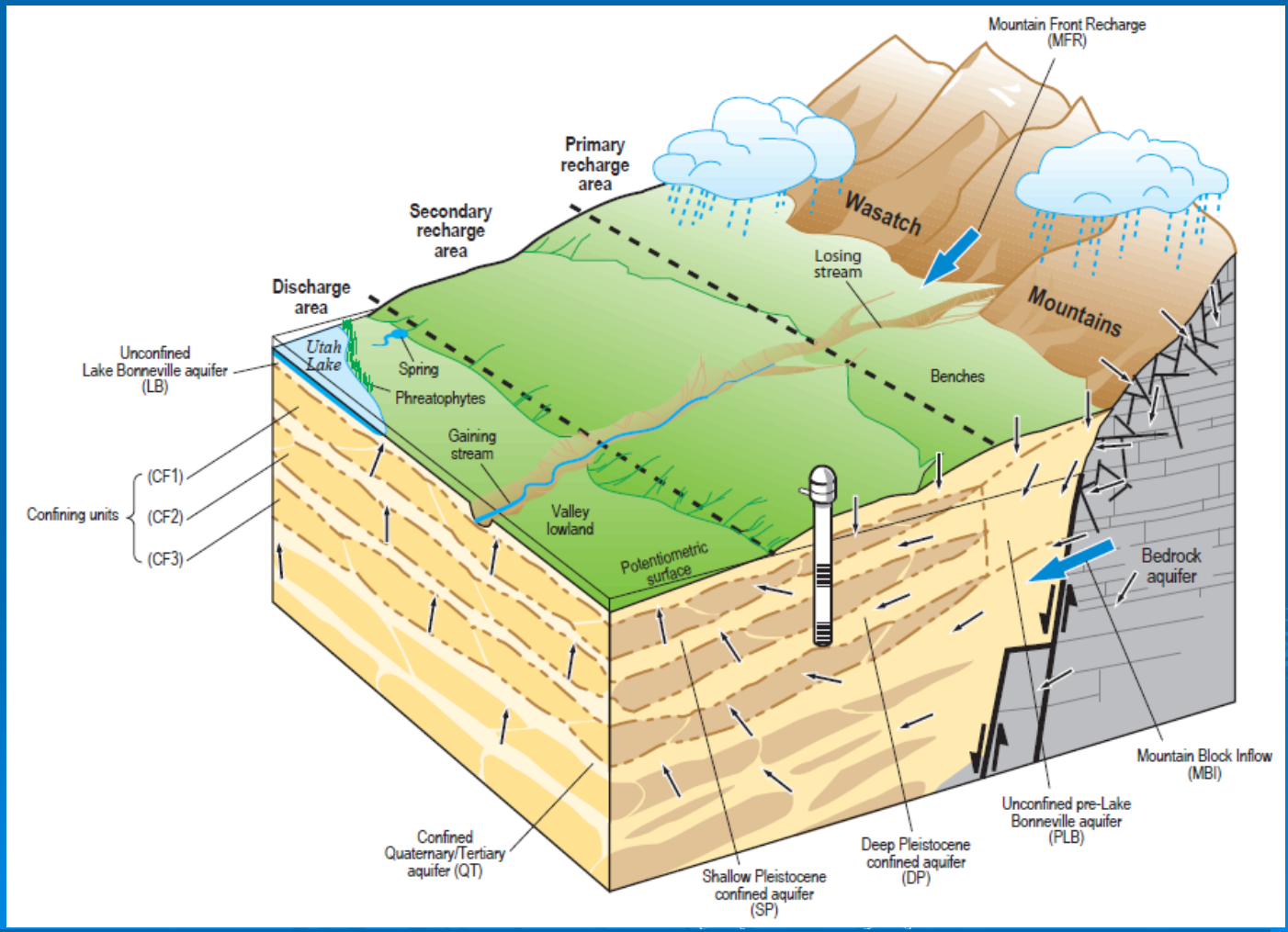
Conceptual Model of East Side of Valley

Unconfined pre-Lake Bonneville aquifer (PLB)

3 confined aquifers (SP, DP, QT)



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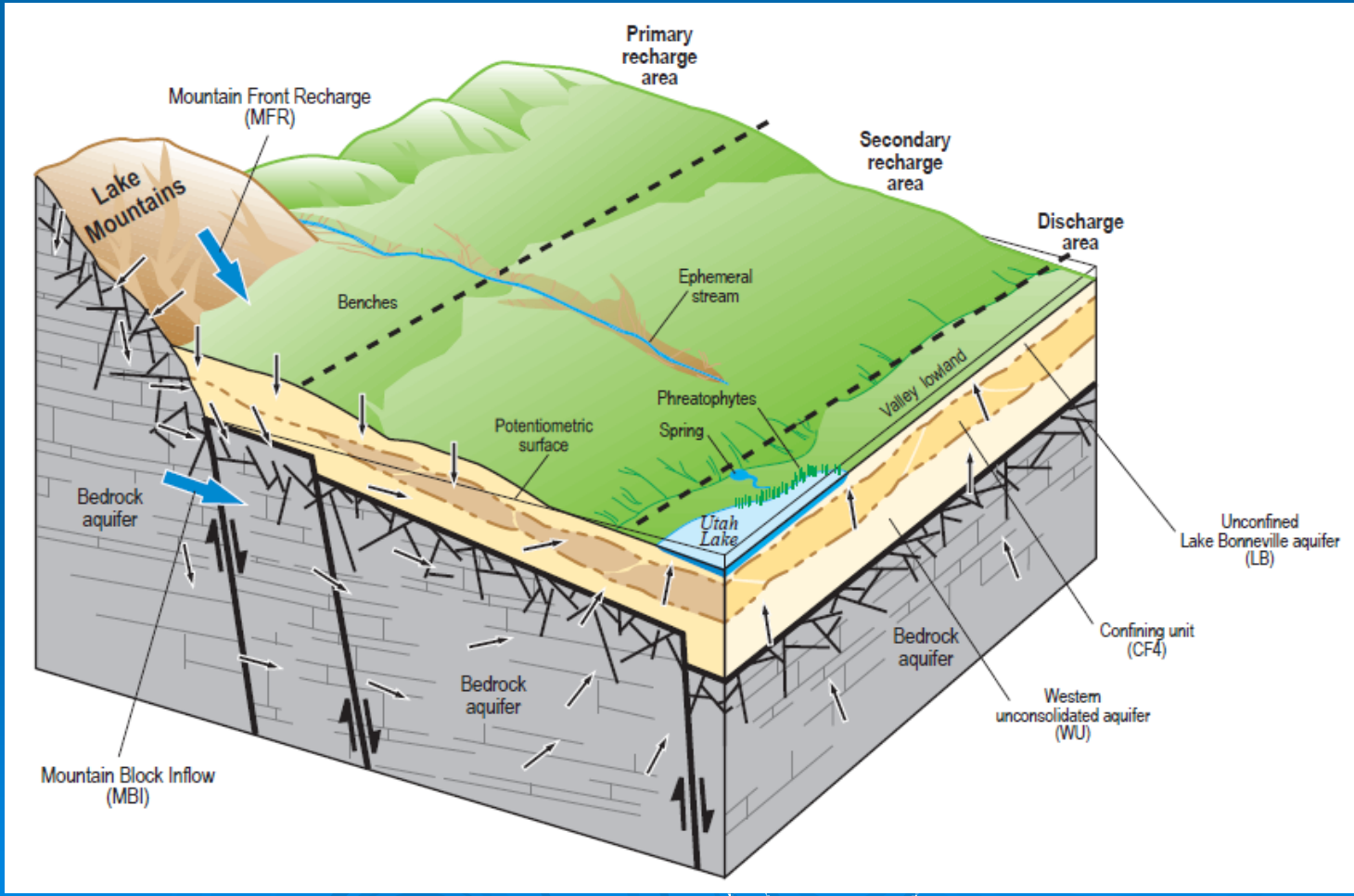
Conceptual Model of West Side of Valley

Western unconsolidated aquifer (WU)

Shallow, fractured bedrock aquifer



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Groundwater Budgets

Sources of recharge and discharge	1975–2004 annual average (estimated error) (Cederberg and others, 2009)	1980–82 (Clark and Appel, 1985)	2003–2004 (Cederberg and others, 2009)	Simulated 1947 (Gardner, 2009)	Simulated 2004 (Gardner, 2009)
Estimated recharge, in acre-feet					
Stream and canal seepage (MFR)	68,700 (± 6,900)	73,000	56,500	72,700	66,800
Mountain-block recharge (MBR)	66,000 (± 20,000)	112,000	56,000	62,500	67,700
Subsurface inflow - Cedar Valley	7,500 (± 2,500)	—	—	8,800	9,800
Irrigated fields, lawns & gardens	7,900 (± 800)	10,000	5,600	7,000	5,500
Infiltration of precipitation	3,200 (± 1,300)	5,000	—	3,100	3,100
Total (rounded)	**153,000** (± 31,500) (122,000 – 185,000)	**200,000**	—	**154,000**	**153,000**
Estimated discharge, in acre-feet					
Wells	61,000 (± 10,000)	68,000	58,800	34,200	61,100
Discharge around Utah Lake	69,000 (± 6,900)	100,000	54,700	73,500	42,200
Discharge beneath Utah Lake	25,500 (± 6,000)	37,000	20,400	31,200	24,000
Seepage to Jordan River	3,100 (± 700)	3,500-5,600	2,500	5,500	3,500
Evapotranspiration	5,500 (± 1,500)	8,000	4,400	8,800	7,200
Subsurface outflow to Salt Lake V	2,600 (± 800)	2,000	—	2,500	1,800
Release from storage	—	—	—	—	12,700
Total (rounded)	**167,000** (± 25,900) (141,000 – 192,000)	**220,000**	—	**156,000**	**152,000**

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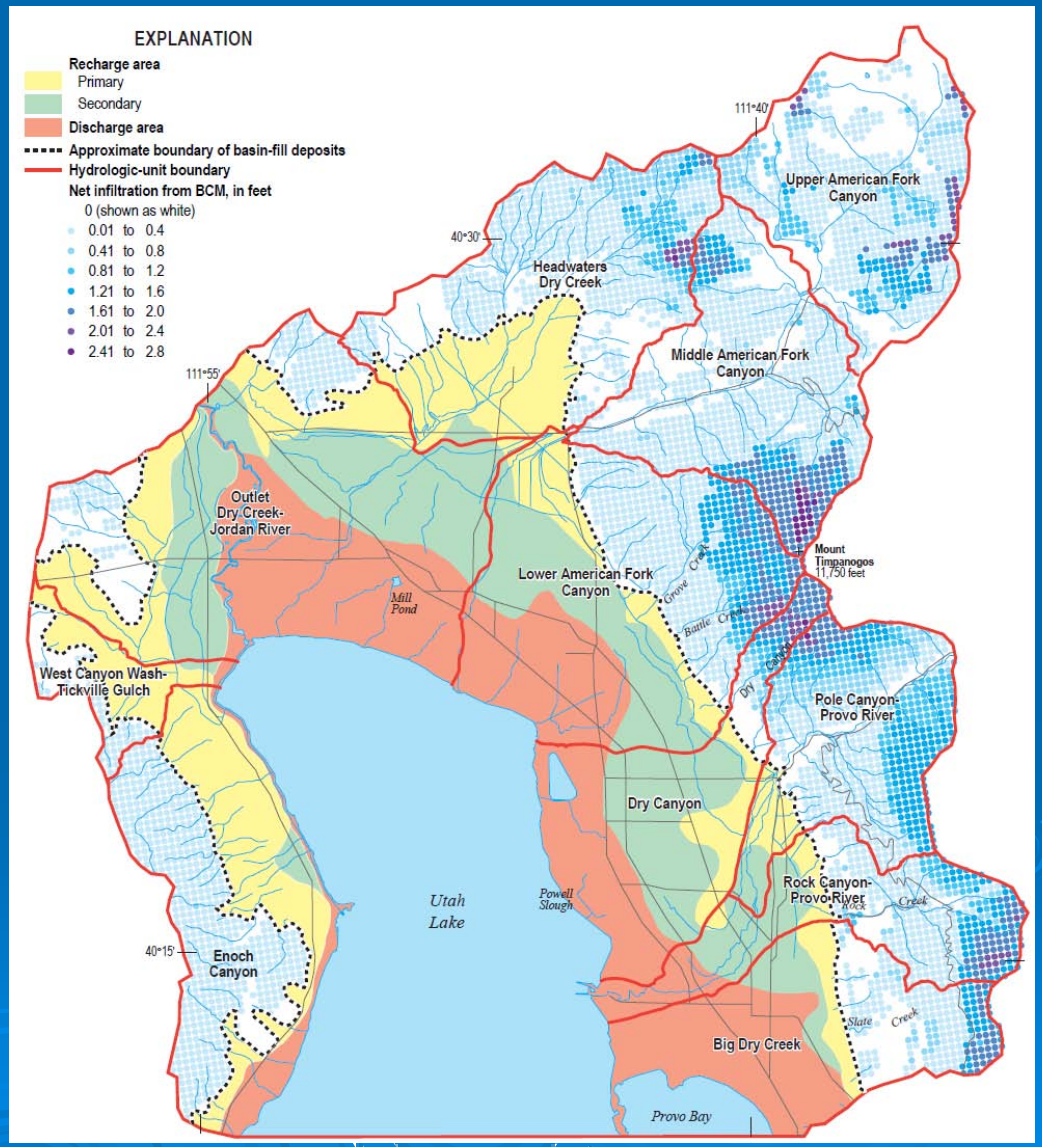
Mountain-Block Inflow

- Net infiltration of precipitation on mountains =

  Precip – ET – Runoff
- Mountain-block subsurface inflow (MBR) = Net infiltration – Base flow to streams
- 1975-2004 ave MBR = 66,000 acre-ft/yr (+/- 30%)



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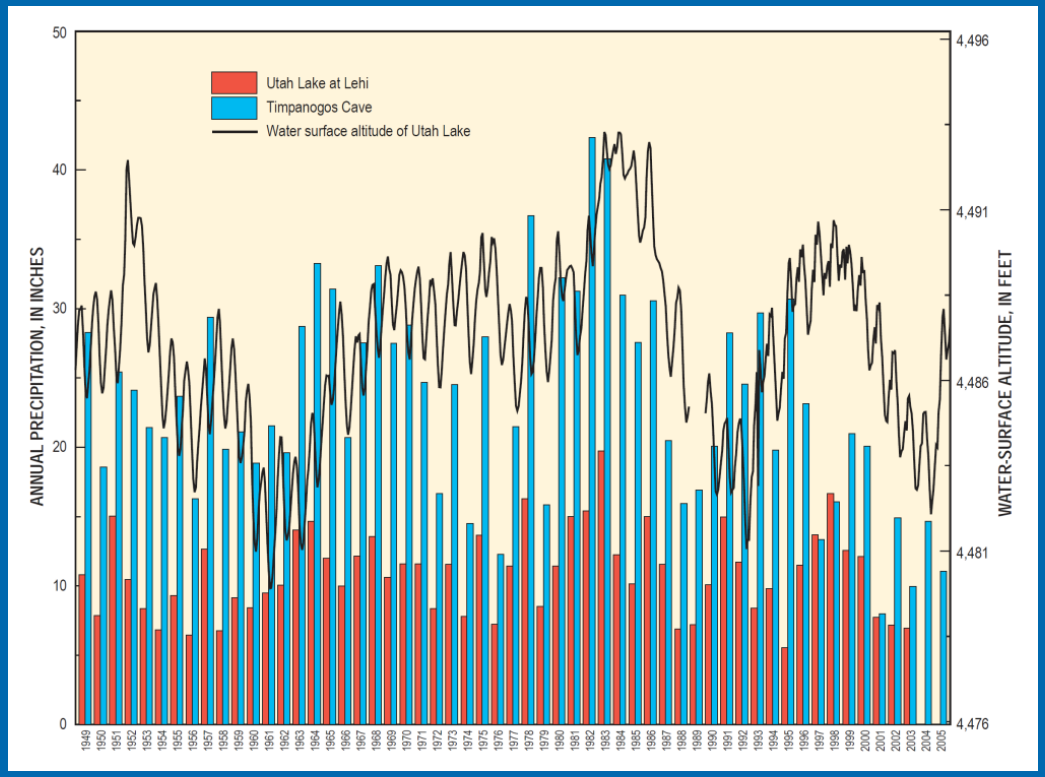
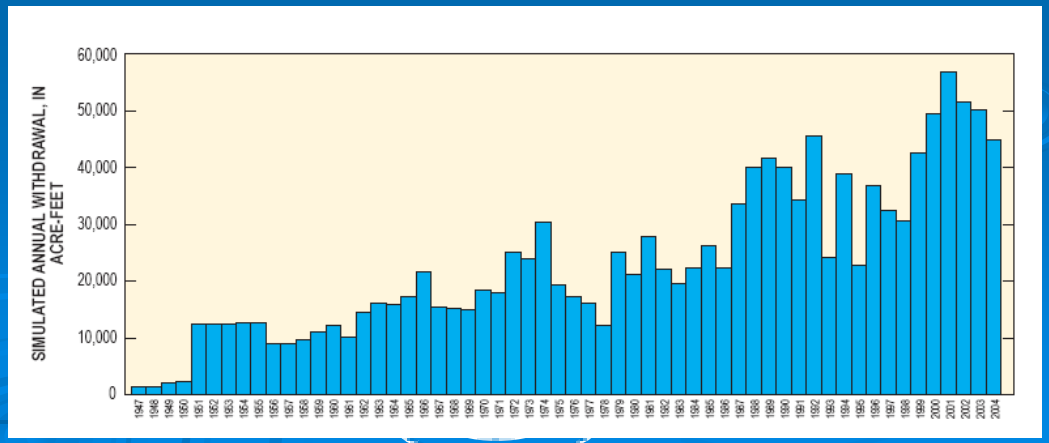
Data Collection

- Assembled data 1947 – 2004
  - Groundwater levels
  - Utah Lake levels
  - Stream & canal flows
  - Spring and drain discharges
  - Land-use changes
  - Pumping records
  - Precipitation data





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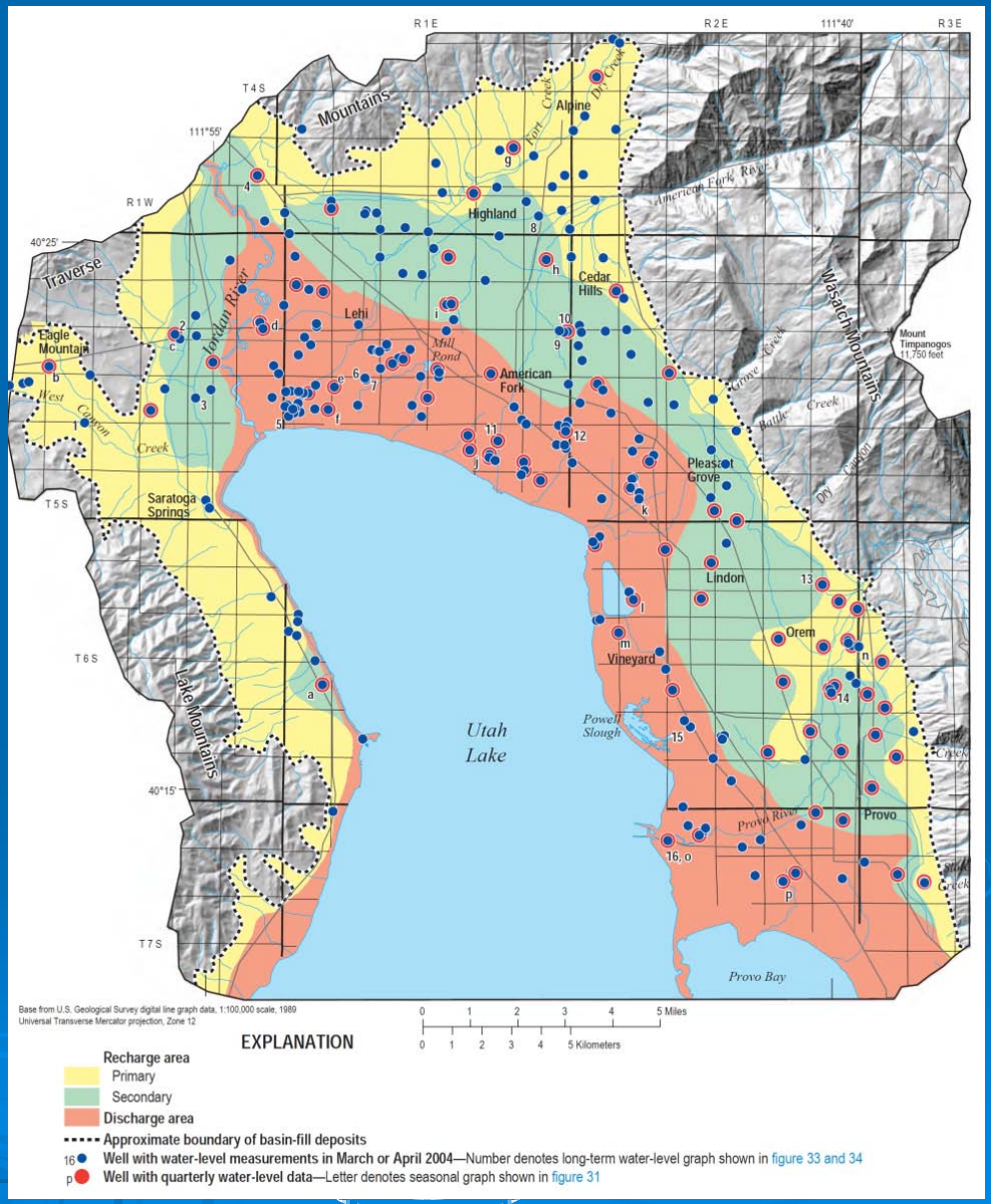
Data Collection

- Collected new data
  - Water levels
  - Spring and drain discharge
  - Isotopes, dissolved-gas, & major-ion chemistry



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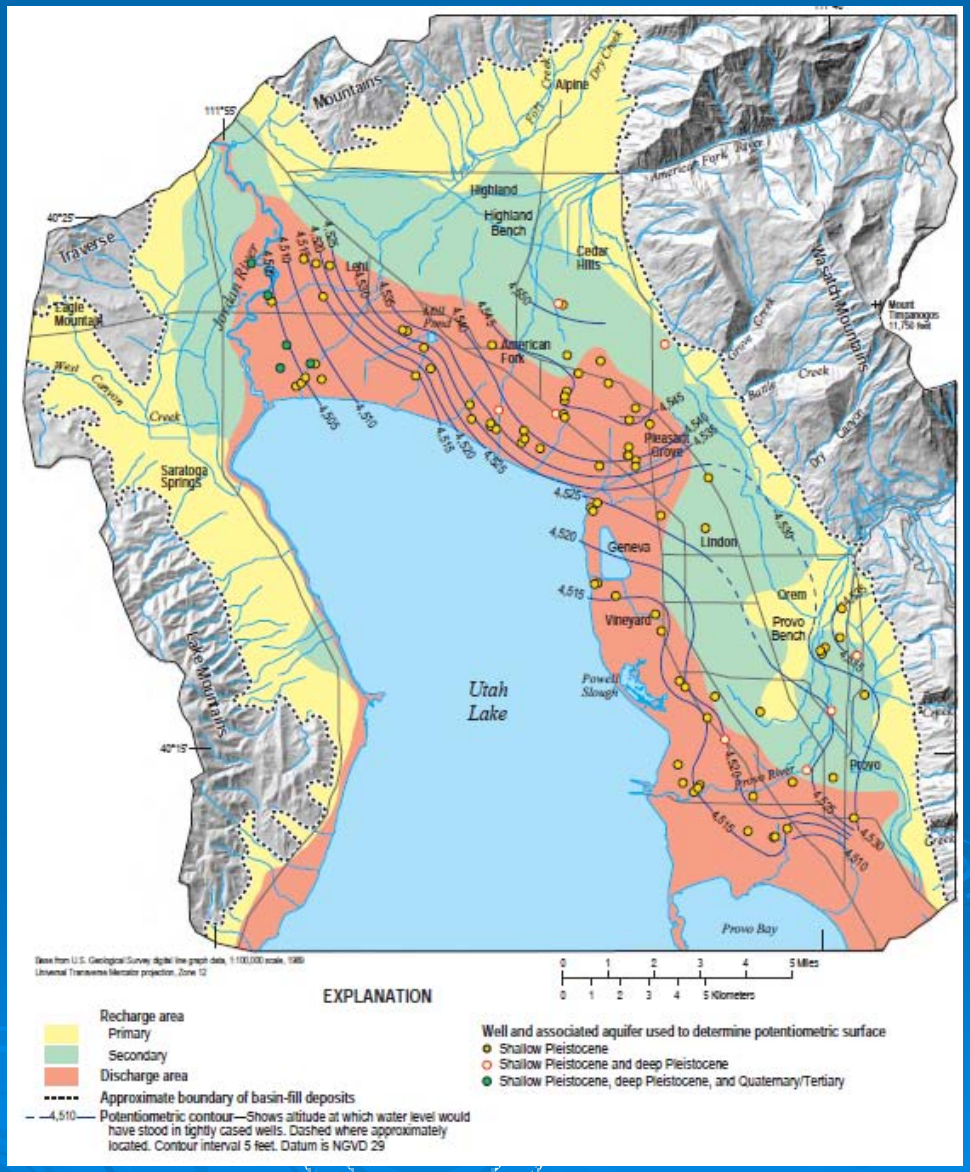
2004 Water Levels

- Shallow Pleistocene aquifer (SP): 79 wells



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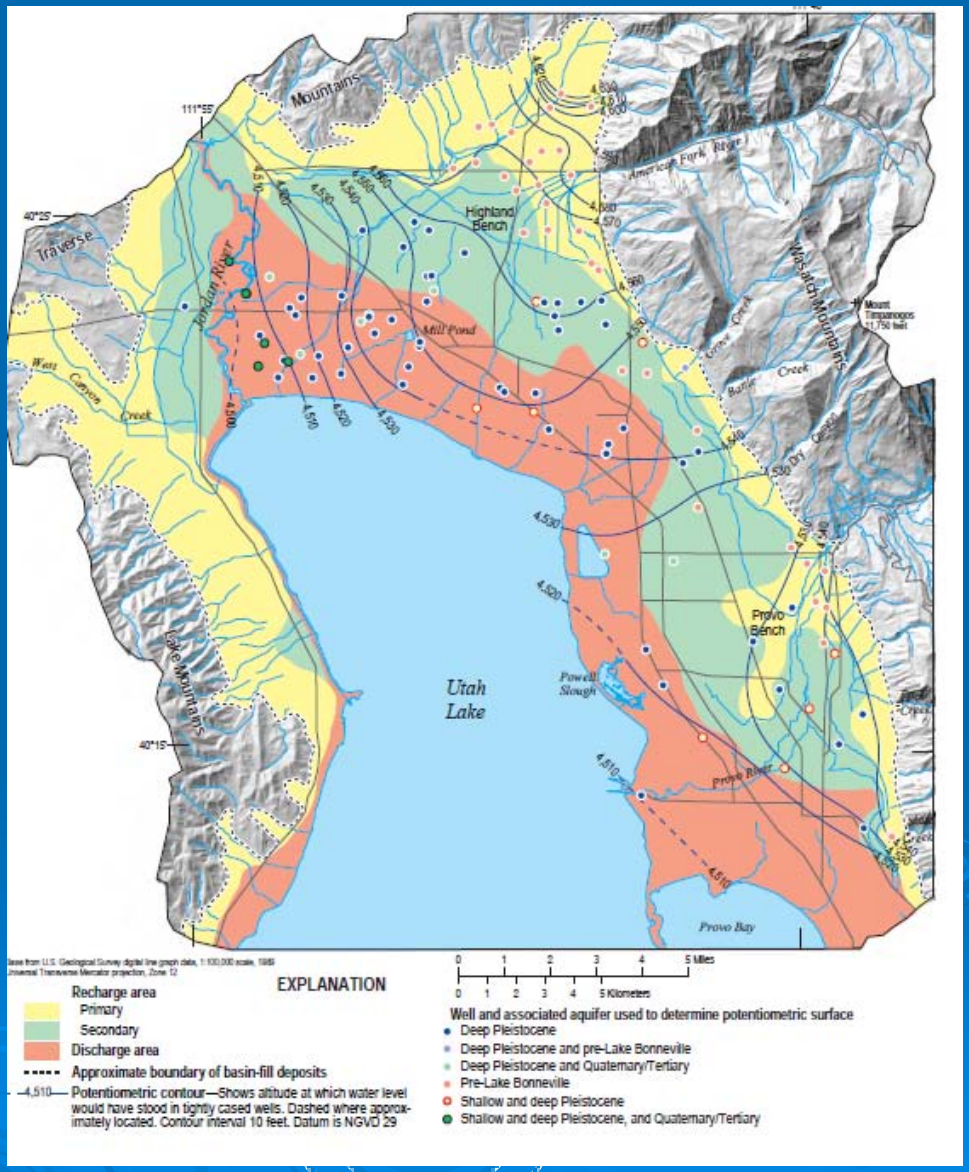
2004 Water Levels

- Deep Pleistocene aquifer (DP): 55 wells
- Pre-Lake Bonneville aquifer (PLB): 37 wells



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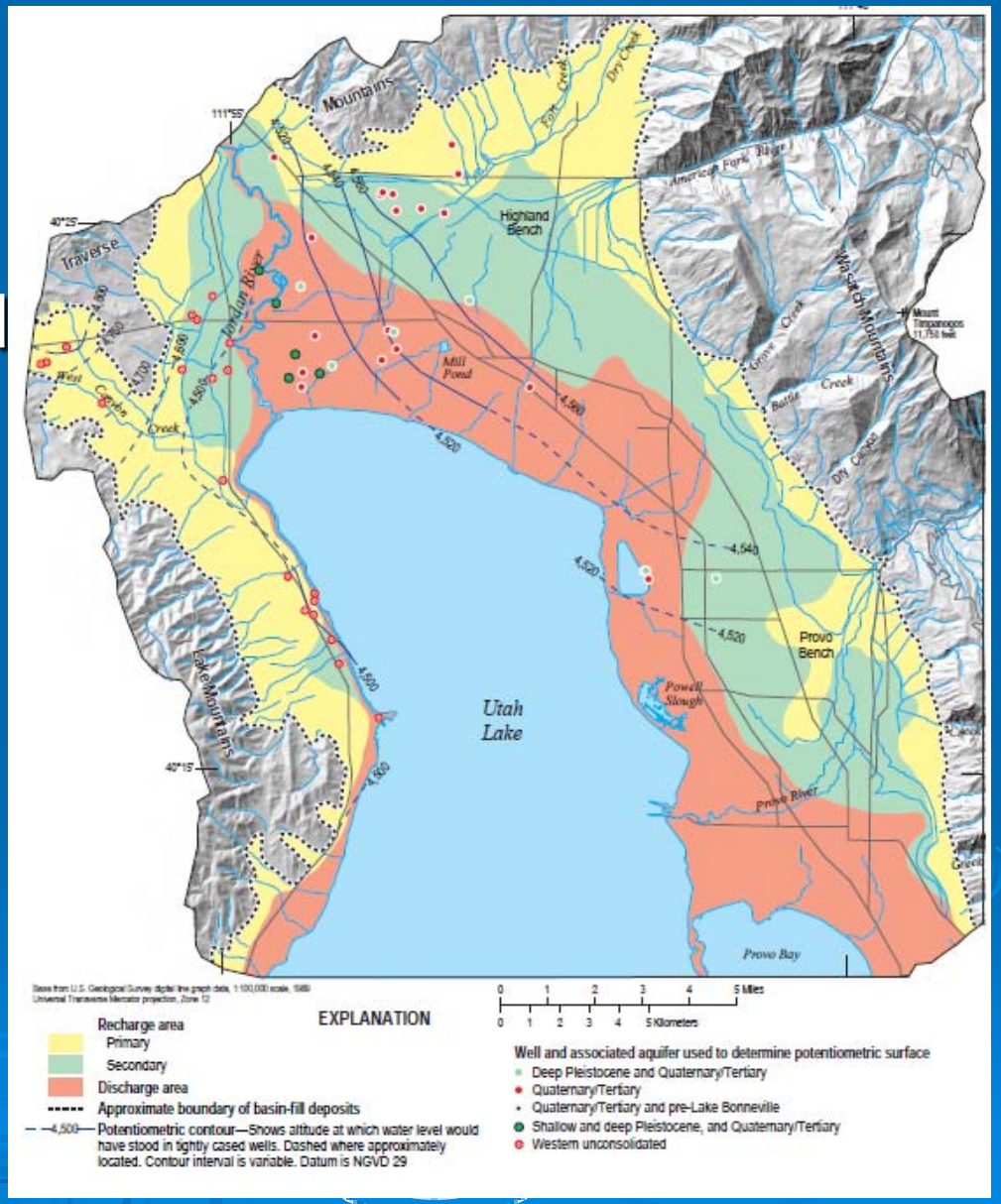
2004 Water Levels

- Quaternary/Tertiary aquifer (QT): 31 wells
- Western Unconsolidated aquifer (WU): 21 wells



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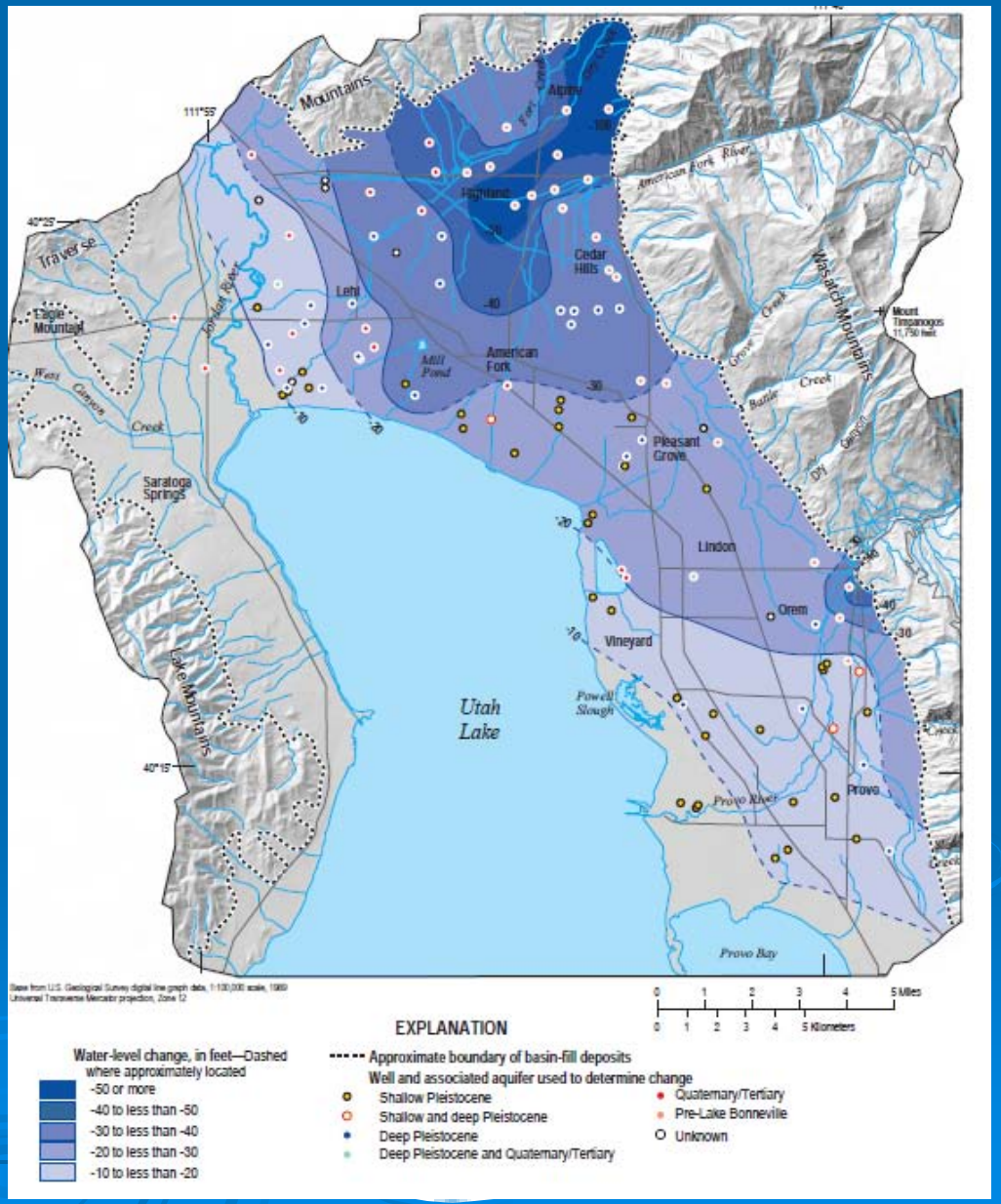
Water-Level Change 1981 – 2004

- 108 wells measured in both 1981 – 82 and 2004 – 05
- Average decline of 22.7 ft in all aquifers
- Largest decline 108 ft in PLB aquifer
- Declines due partly to 1999 – 2004 drought



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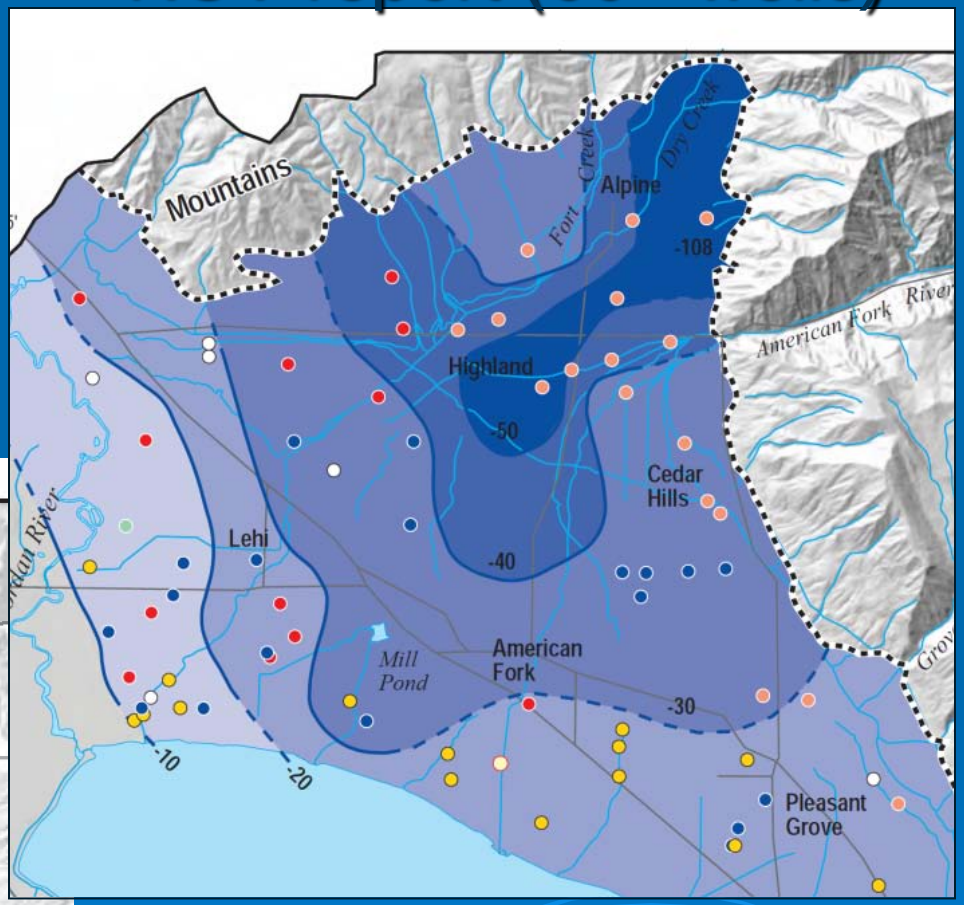
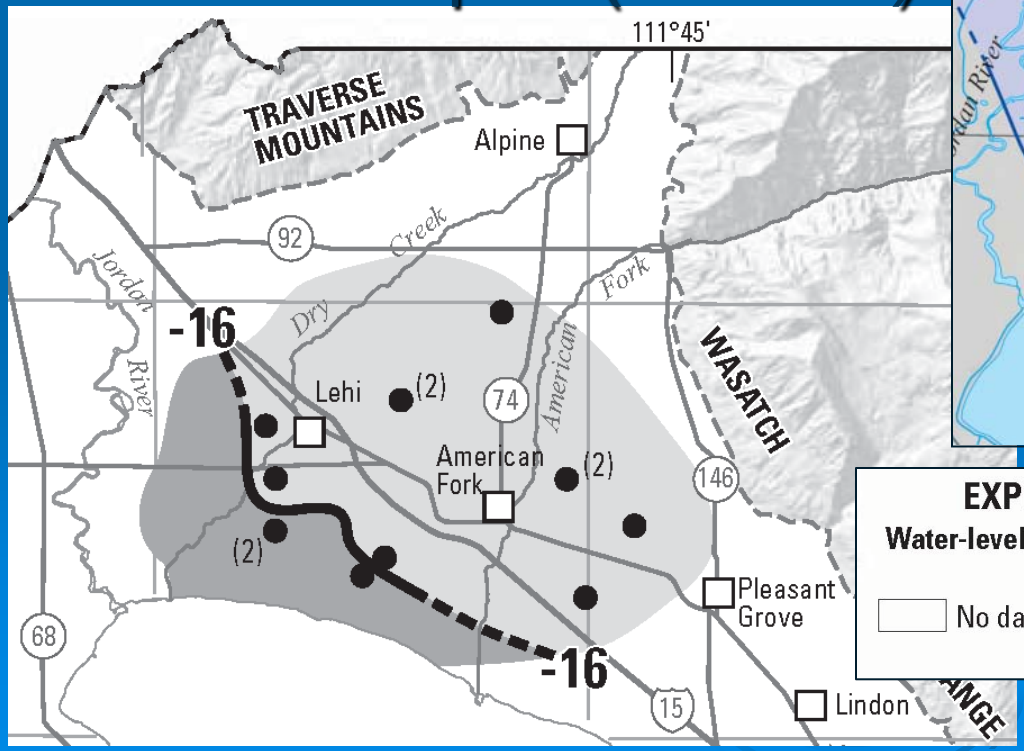
Water-level change maps

- Magnitude of water level change
  - Number of wells and timing
- Delineation of change
  - Depth of well and aquifer

NUV report (60+ wells)



2010 GW report (10 wells)



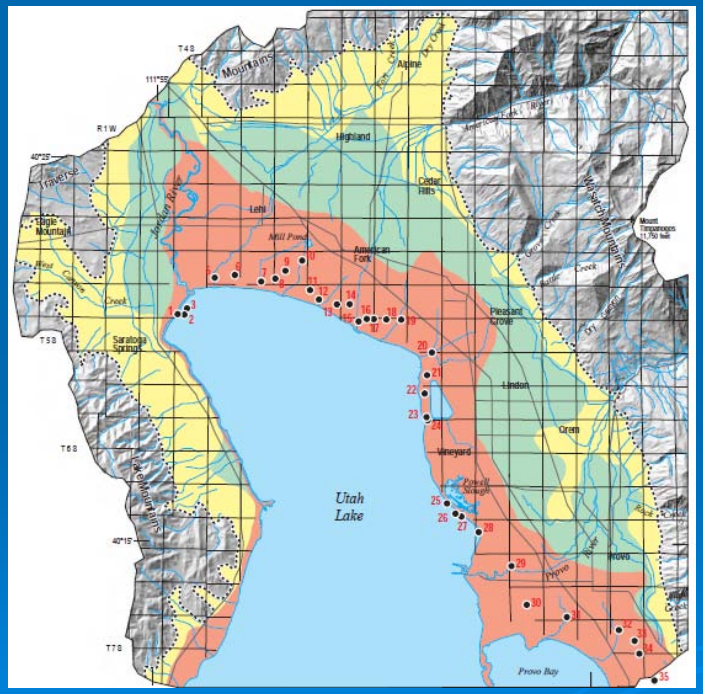
Declines in Drain Discharge

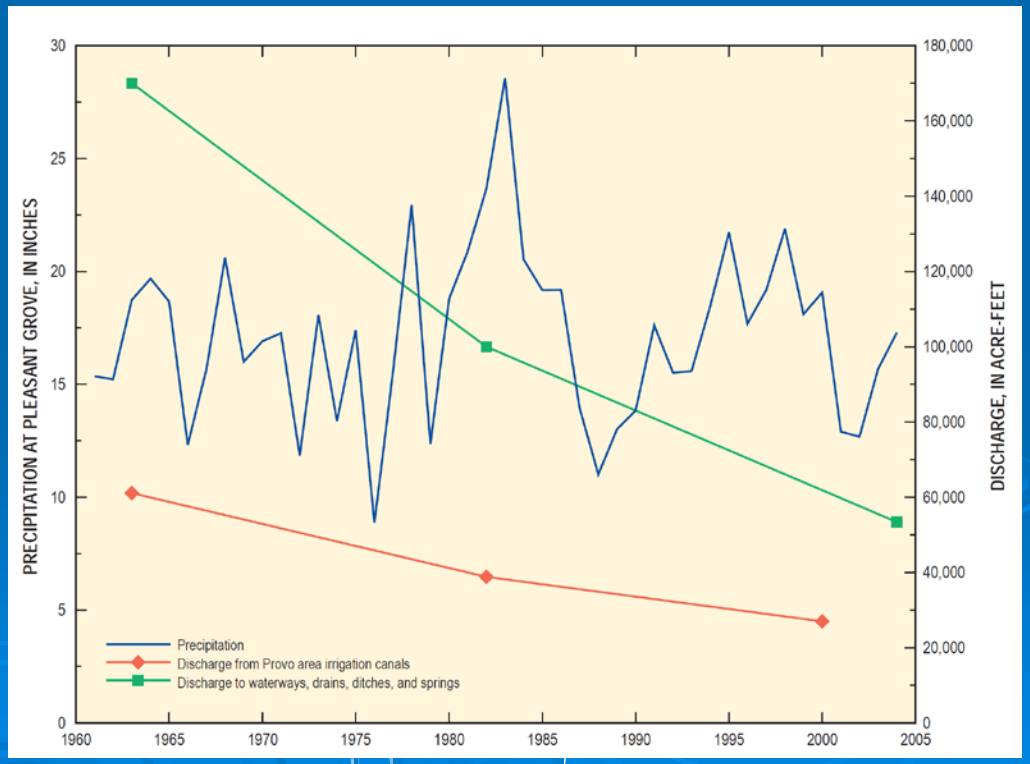
Land-use change from agricultural to residential/commercial

Decrease in confined aquifers hydrostatic pressure

Drought conditions in 1999 – 2004

Estimated at about 55,000 acre-ft in 2003 – 04





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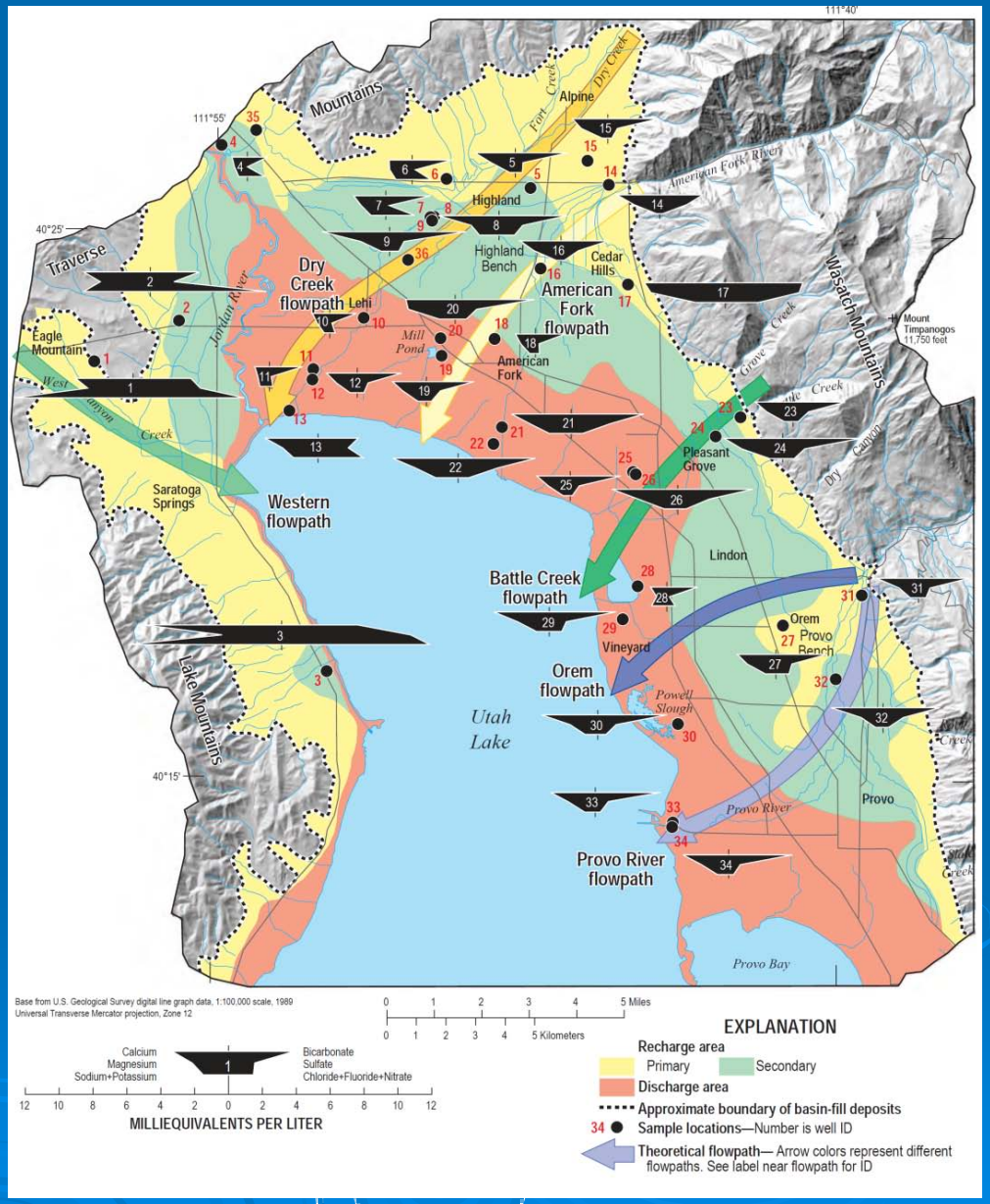
Water Quality

- Sampled 36 wells & springs along expected flow paths
- Nested samples
- TDS lower on east side
- TDS decreased with depth



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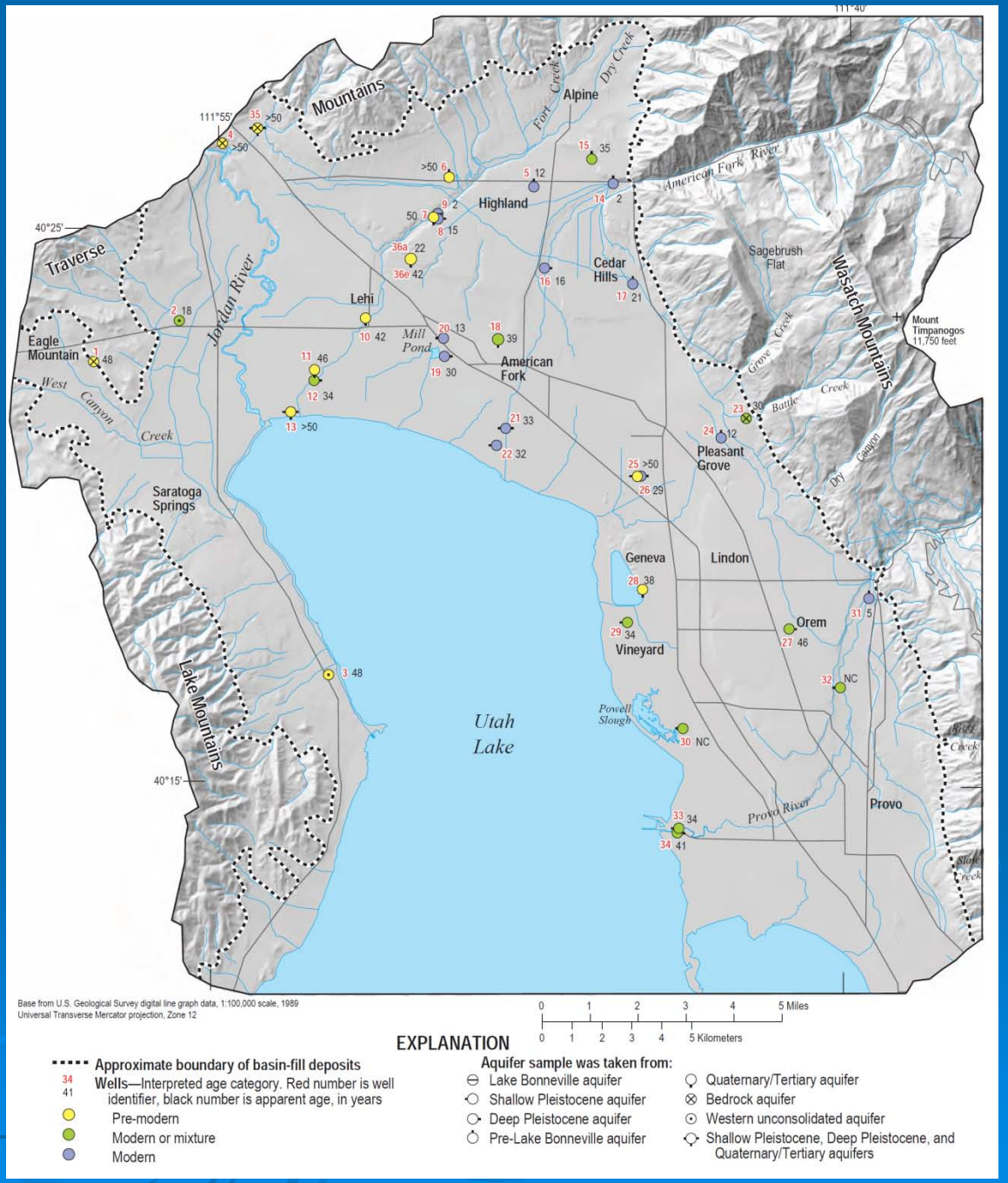
$^3H/^3He$ GW Ages

- Age range 2 to greater than 50 years
- Age increases away from the mountains
- Age increases with depth
- Mixtures of modern and pre-modern water



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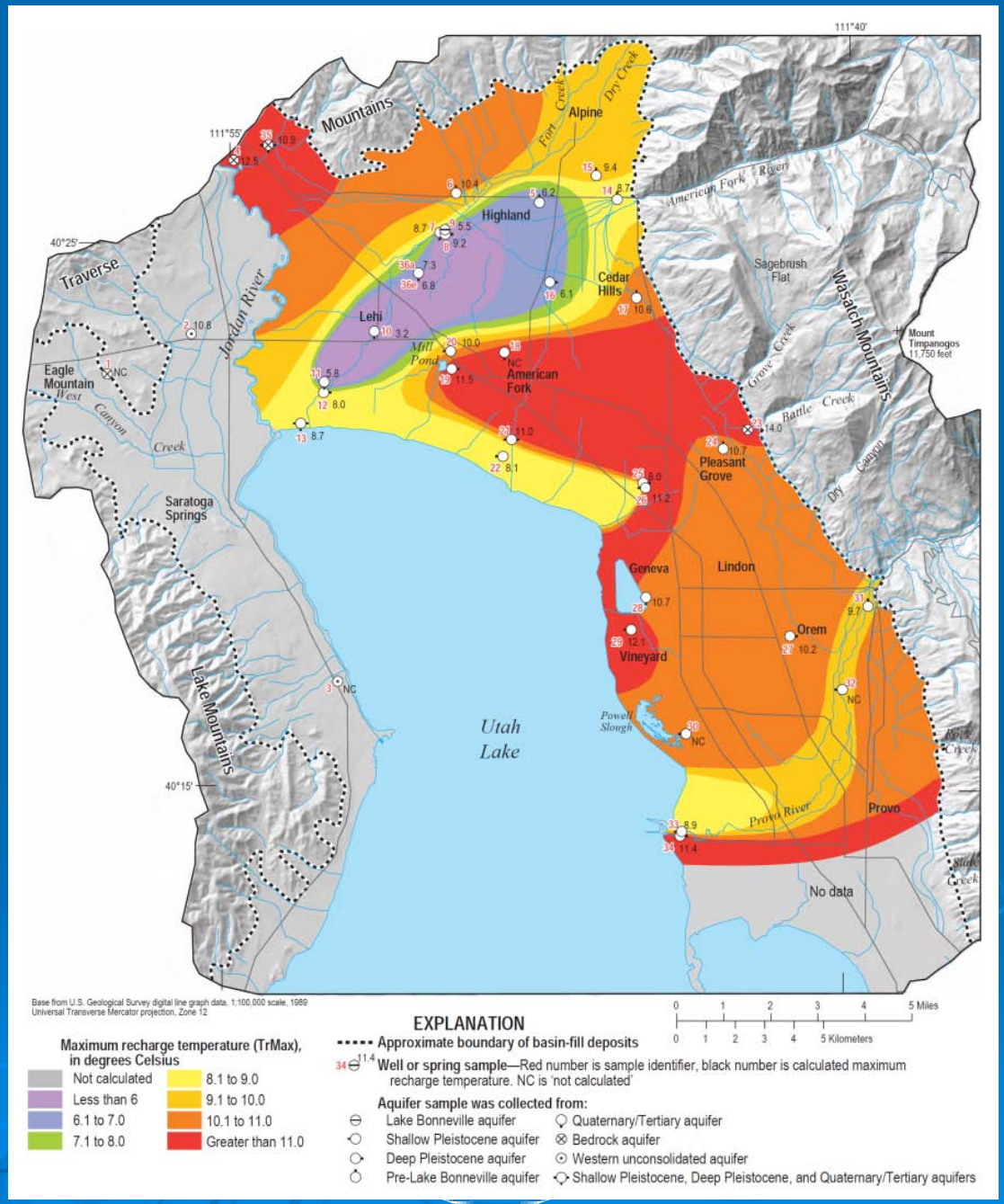
Recharge Temperatures

- Determined from dissolved gases

  Generally,

  - Cool T_r → MBR
  - Warm T_r → MFR
  - Estimated fraction of mountain versus valley recharge

  - Valley water table = 12 to 14°C
  - Mountain springs = 0 to 10°C



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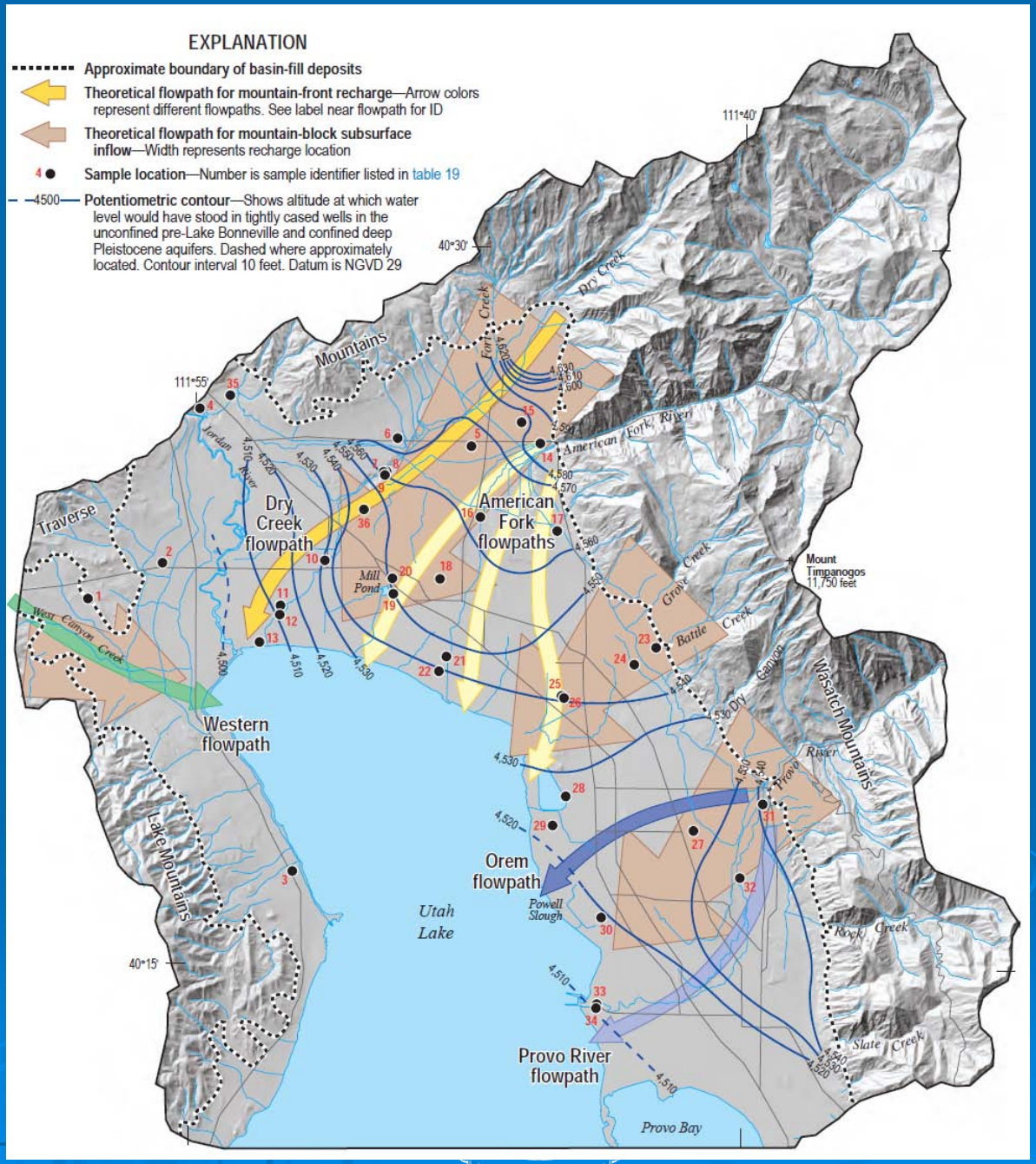
GW Flow Paths

- MBR flow paths
  - Deeper
  - Broader area
- MFR flow paths
  - Localized near streams & canals
  - Follow more transmissive deposits



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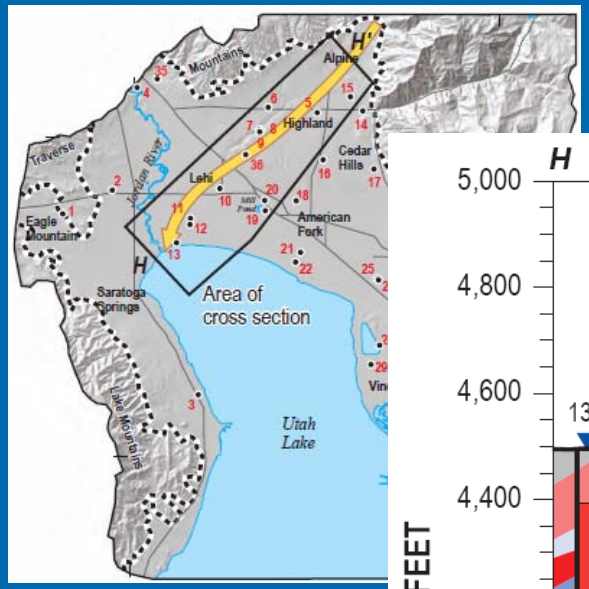
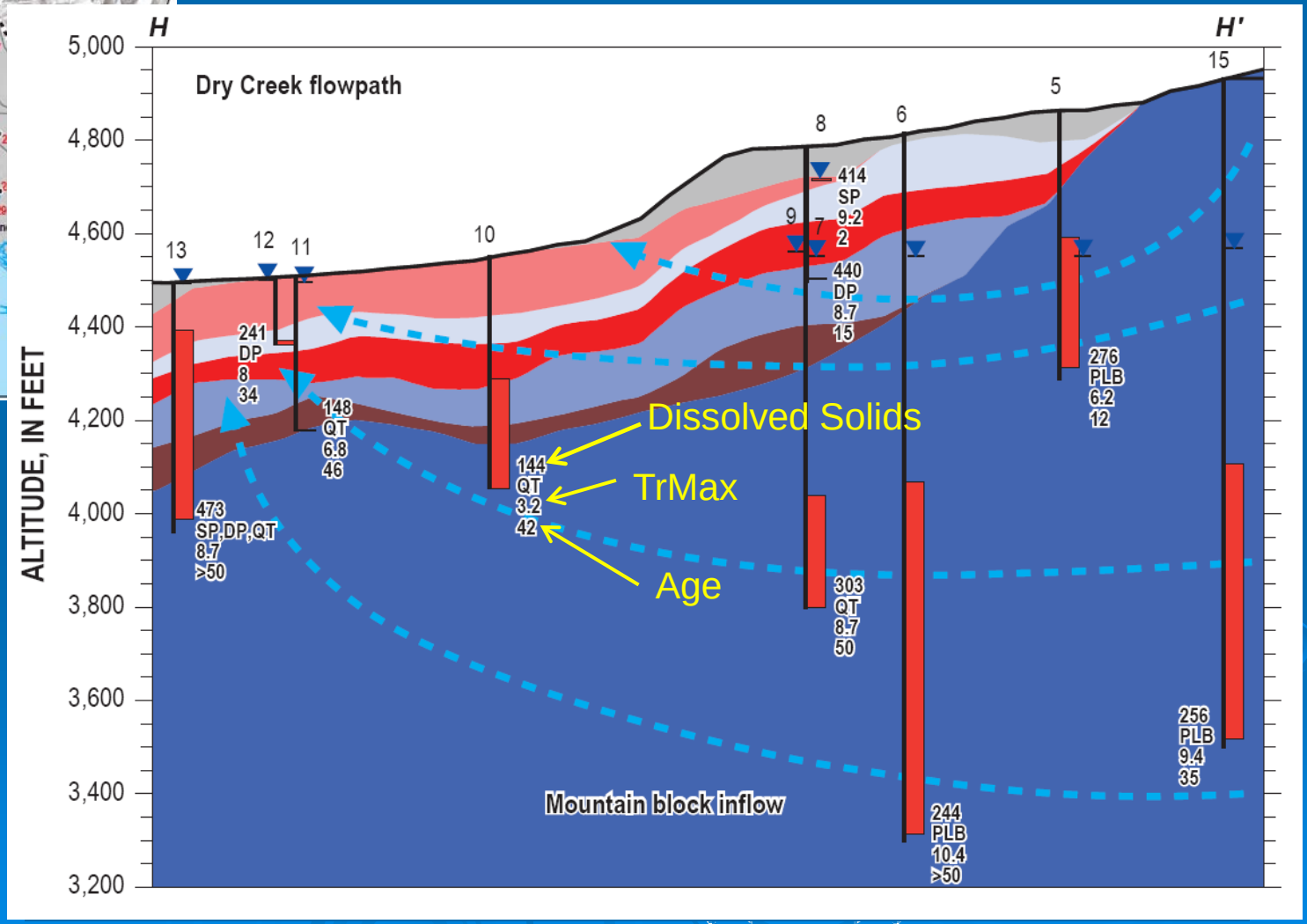
Flow Path Characterization





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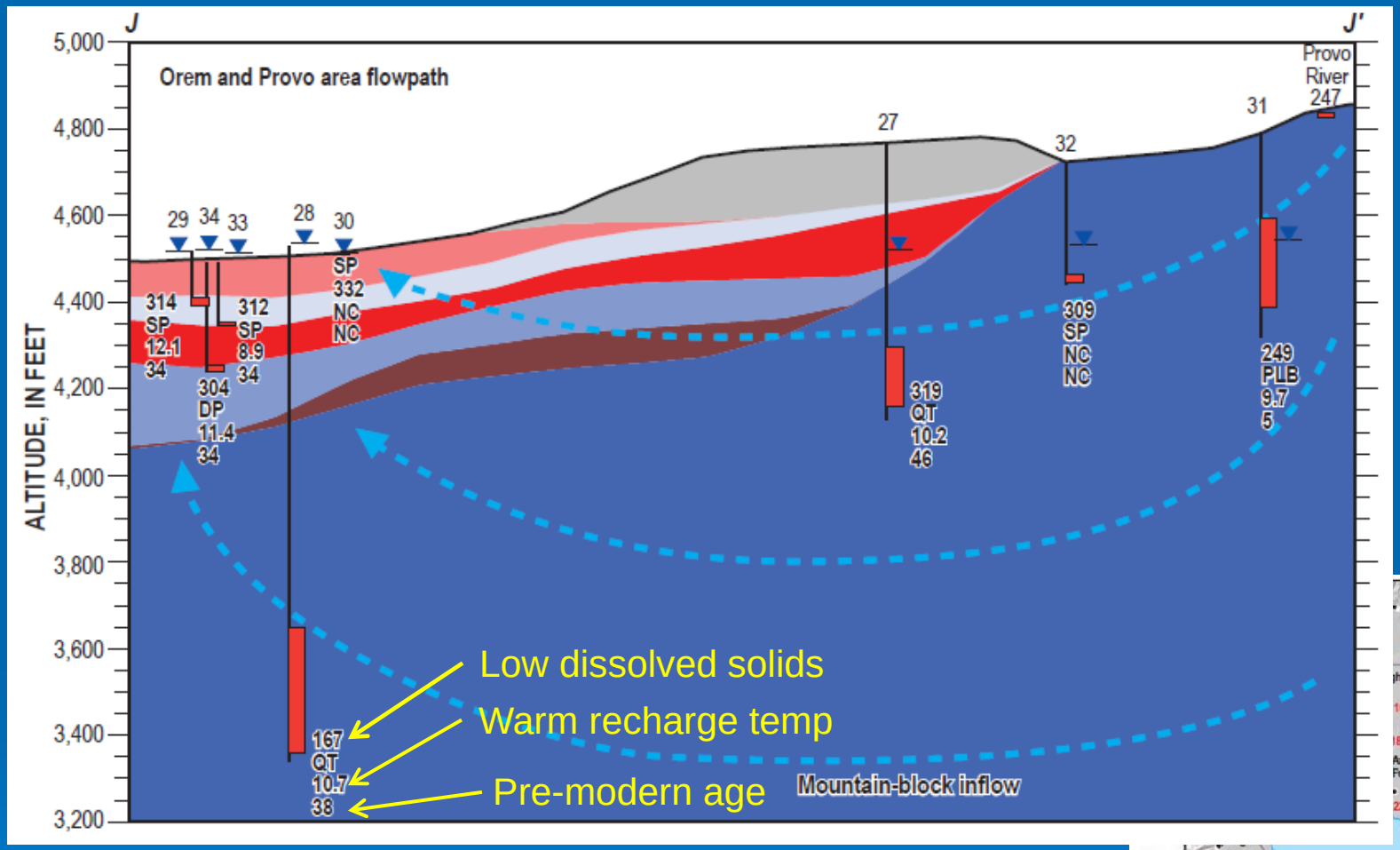

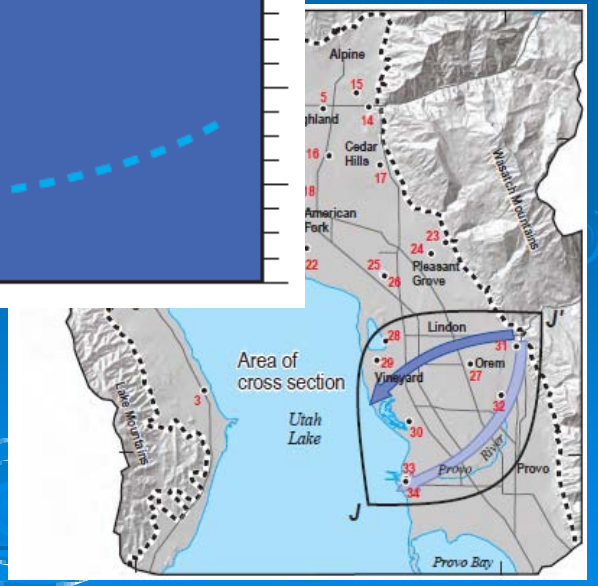

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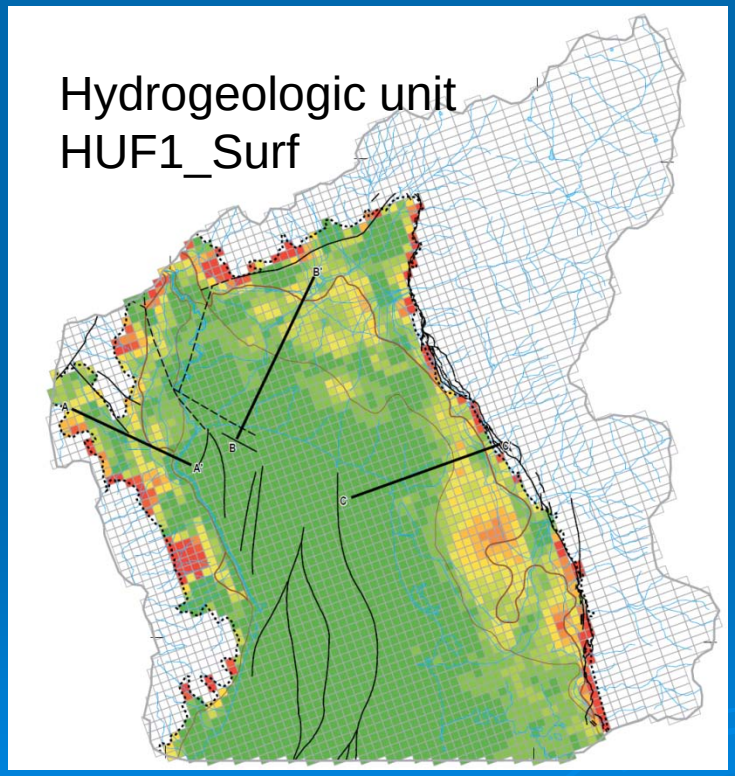
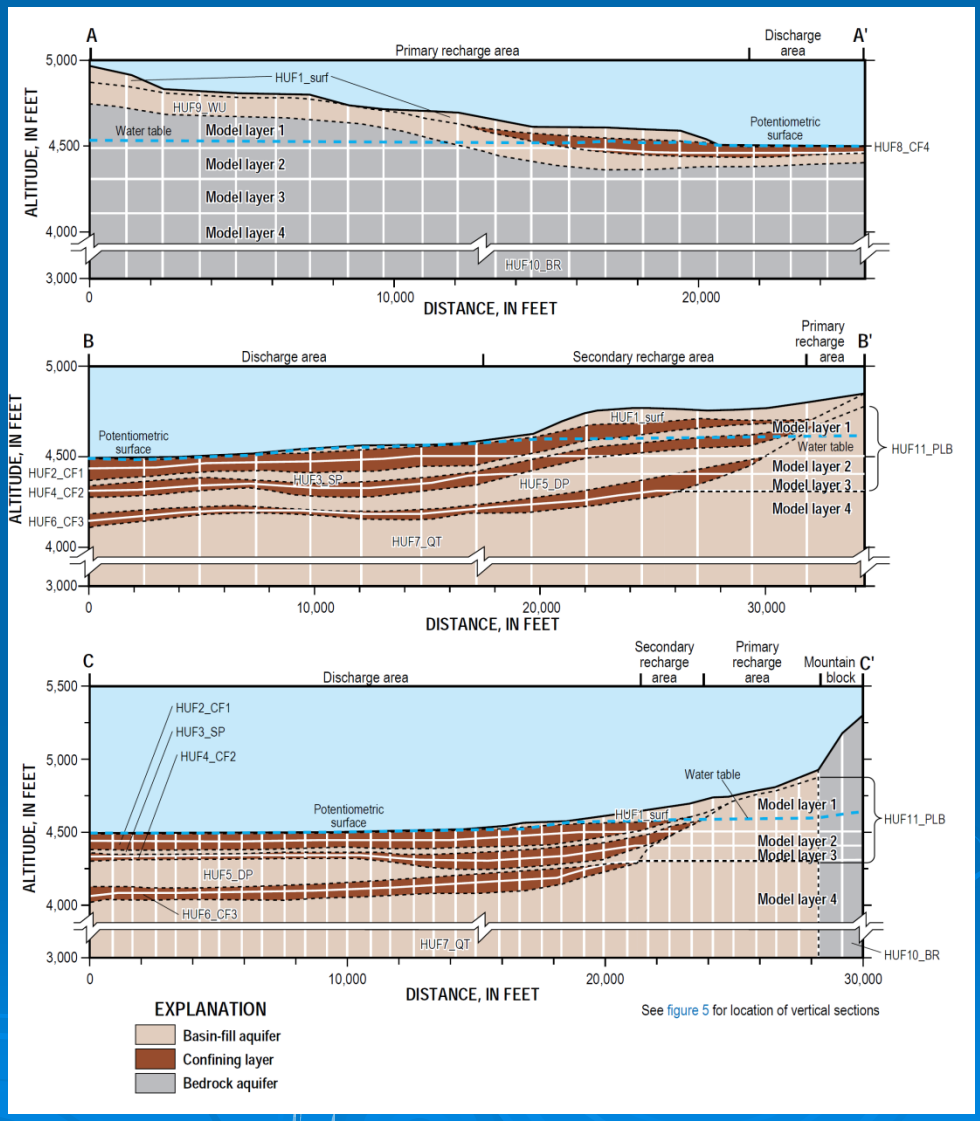
NUV Numerical Model

Refined conceptual model used to develop new MODFLOW model





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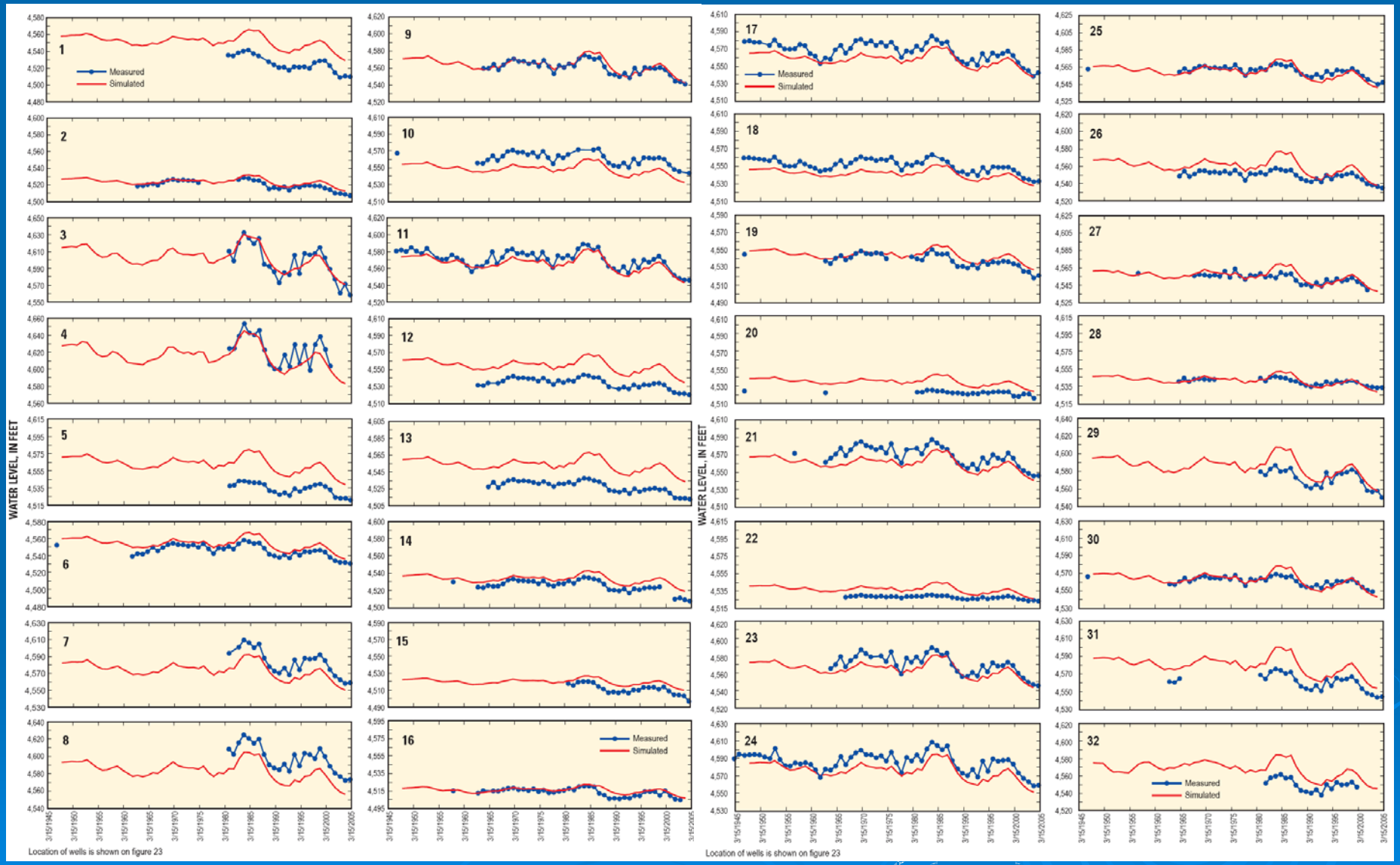
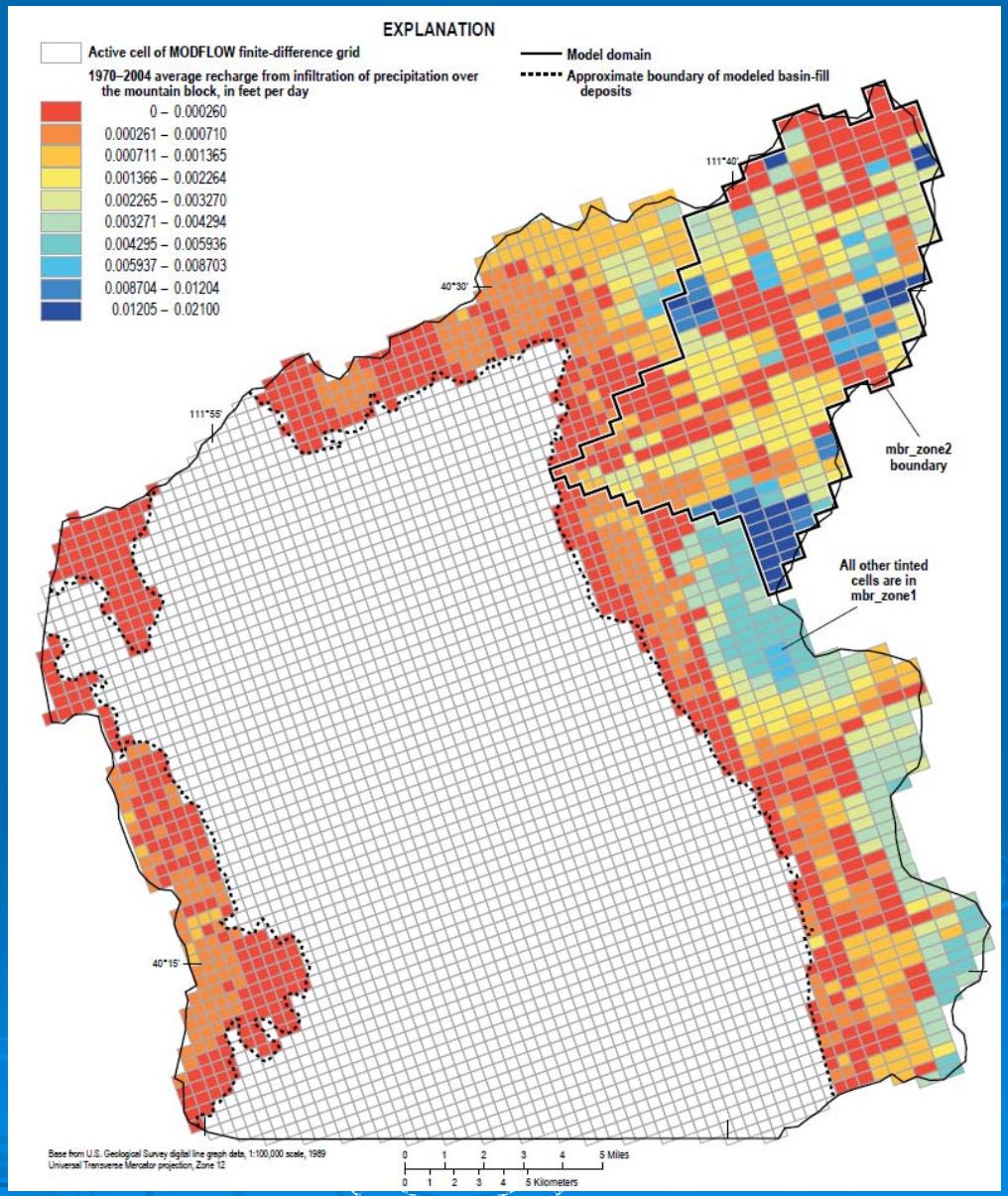
Computed vs Measured Head 1947 – 2004



Simulated Mountain-Block Inflow

Simulated mountain-block recharge

- Recharge increased in American Fork drainage
- 1947 simulated MBR = 62,500 acre-ft
- 2004 simulated MBR = 67,700 acre-ft



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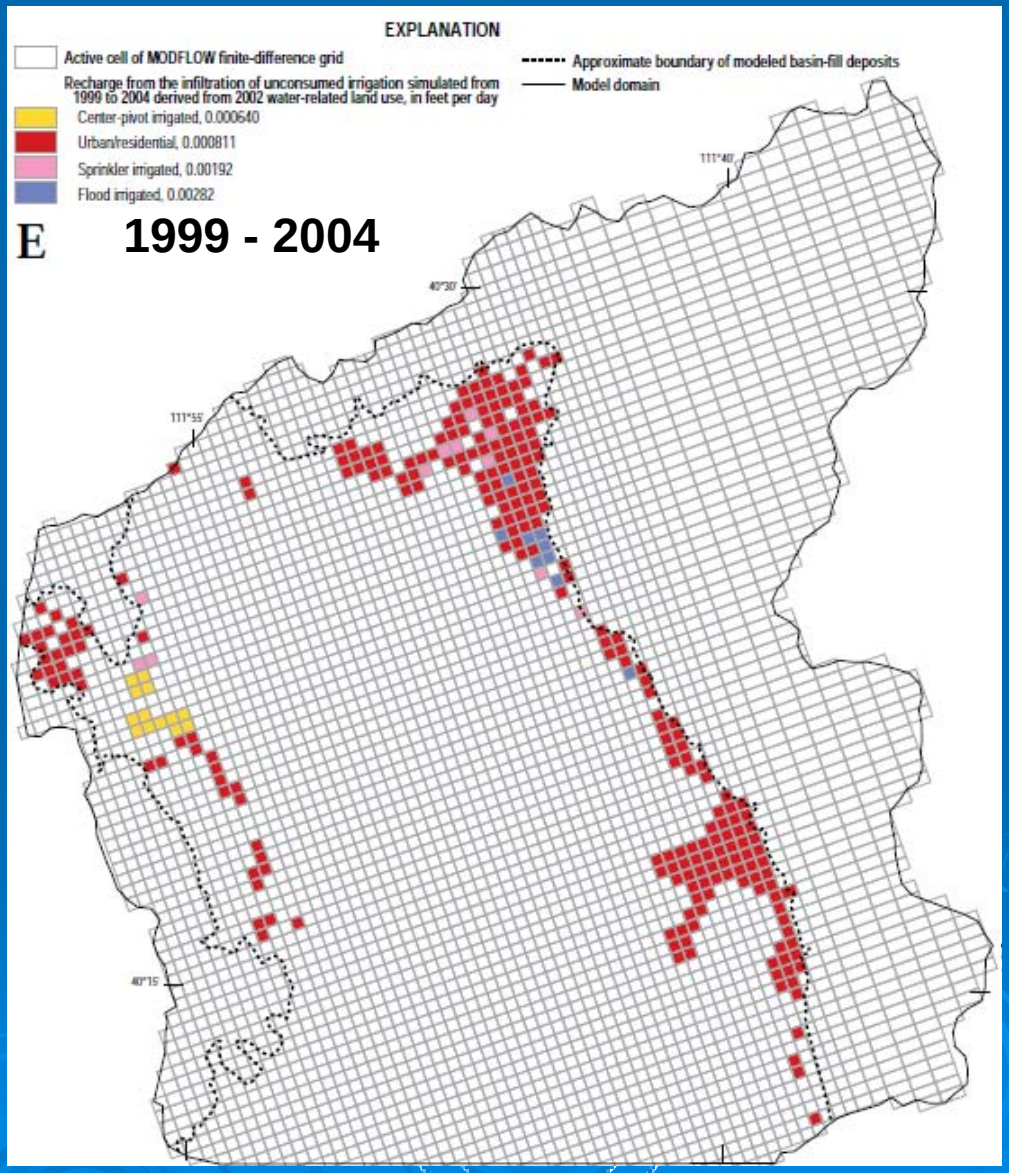
Simulated Areal Recharge

Infiltration of unconsumed irrigation water from fields, lawns, and gardens

~ 9,000 acre-ft/yr early years
~ 6,000 acre-ft/yr mid 1990s
~ 5,600 acre-ft/yr late years

Recharge from precipitation in primary recharge area of valley
1,400 – 5,000 acre-ft/yr



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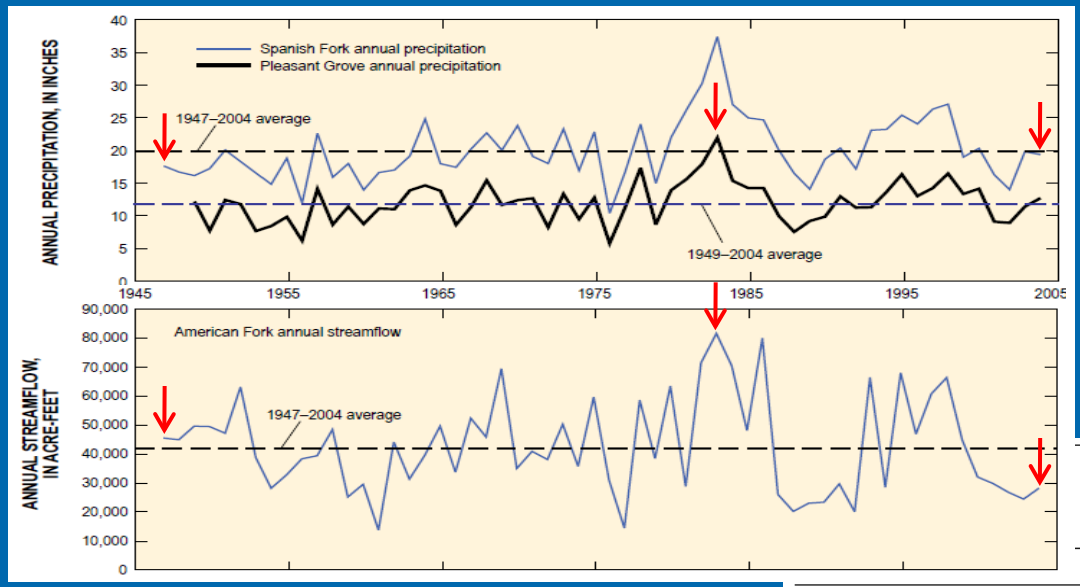
Groundwater Budgets



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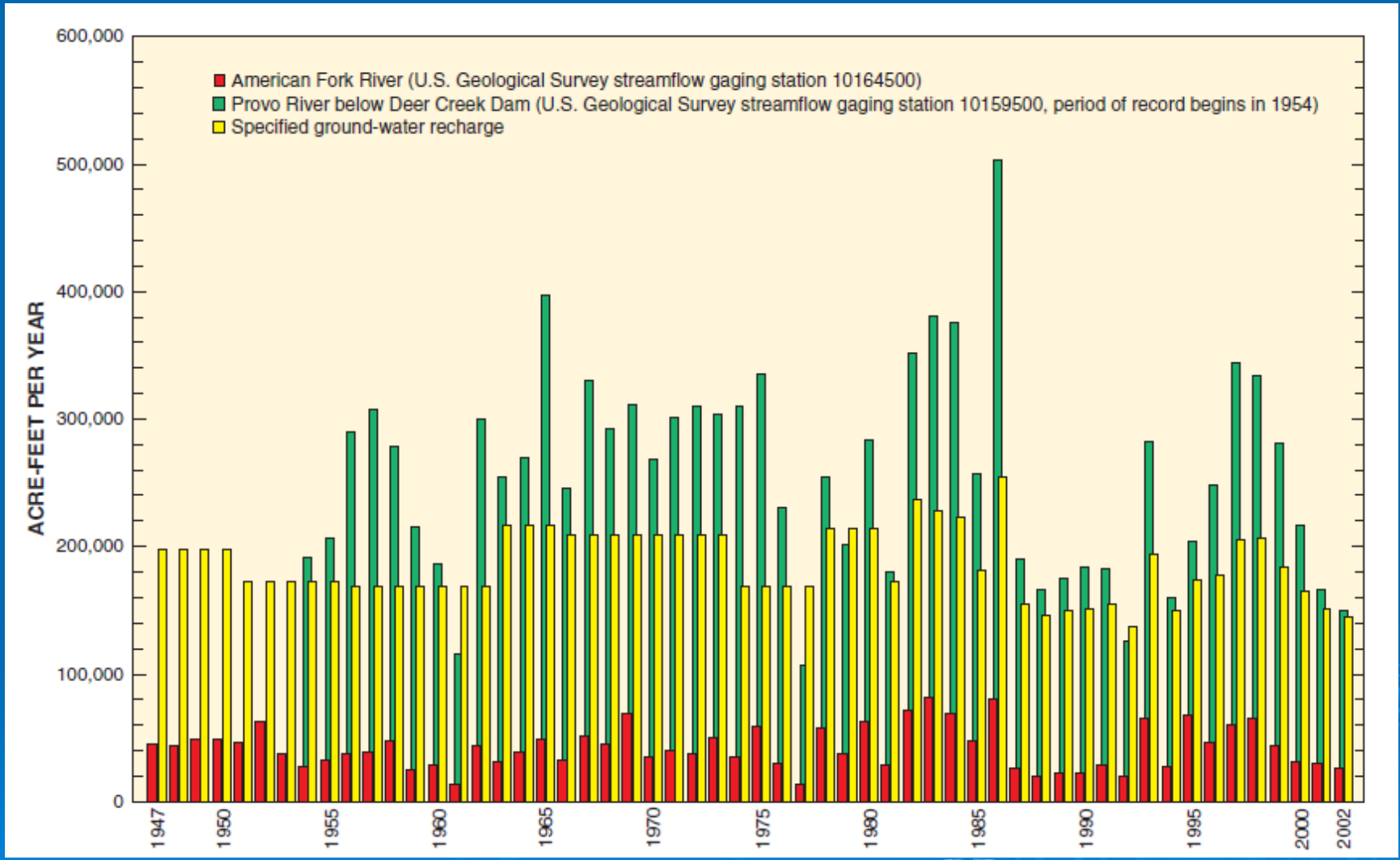
Recharge Specified in Updated Clark Model



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Model Uses and Limitations

- Model Uses
  - Examine large-scale aquifer responses to stresses over time periods of several years
  - Particle tracking (not accurate for timing and concentration but for direction and vulnerability)
    - Contaminant
    - Sources of water

- Limitations
  - Aquifer properties on the west side of the Utah Lake
  - Pumping near no flow boundaries
  - Fractured bedrock areas

Test Scenario 1:
30 years to double pumping

- Begin at hypothetical 2004 steady state
  - Average annual recharge
  - Average annual stream flow
  - 2004 Flowing well withdrawal
- Linear pumping increase to 2x in 30 years
  - Current (2004) distribution of pumping wells

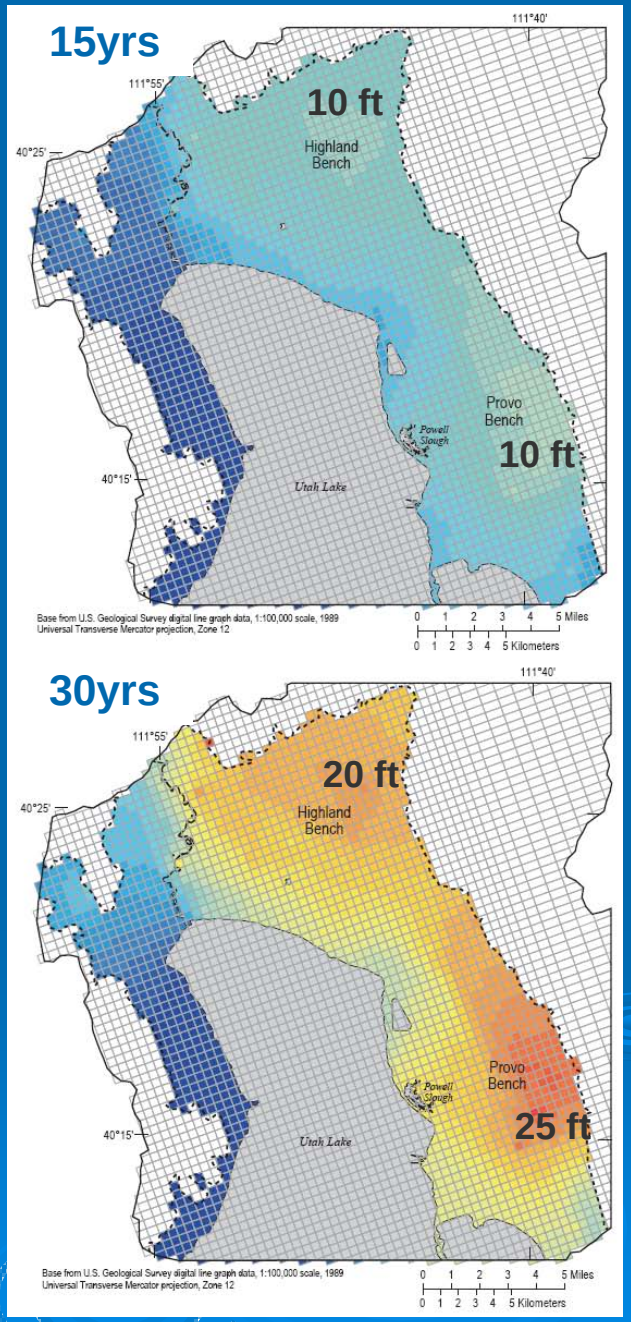
Test Scenario 1

Steady-state groundwater fluxes

Utah Lake	25,000 af
Drains, Springs, & Flowing Wells	86,000 af
Evapotranspiration	82,000 af
Jordan River	4,500 af

Changes in groundwater fluxes

	15yrs	30yrs
Utah Lake	-22%	-22%
Drains, Springs, & Flowing Wells	-37%	-37%
Evapotranspiration	-15%	-15%
Jordan River	-25%	-25%



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Test Scenario 2: addition of artificial recharge

- Begin at hypothetical 2004 steady state
  - Average annual recharge
  - Average annual stream flow
  - 2004 Flowing well withdrawal
- Linear pumping increase to 2x in 30 years
  - Current (2004) distribution of pumping
- **Artificial recharge** of 20,000 acre-ft/year, every year, over ~1 mi^2 near mouth of American Fork Canyon beginning in year 2.

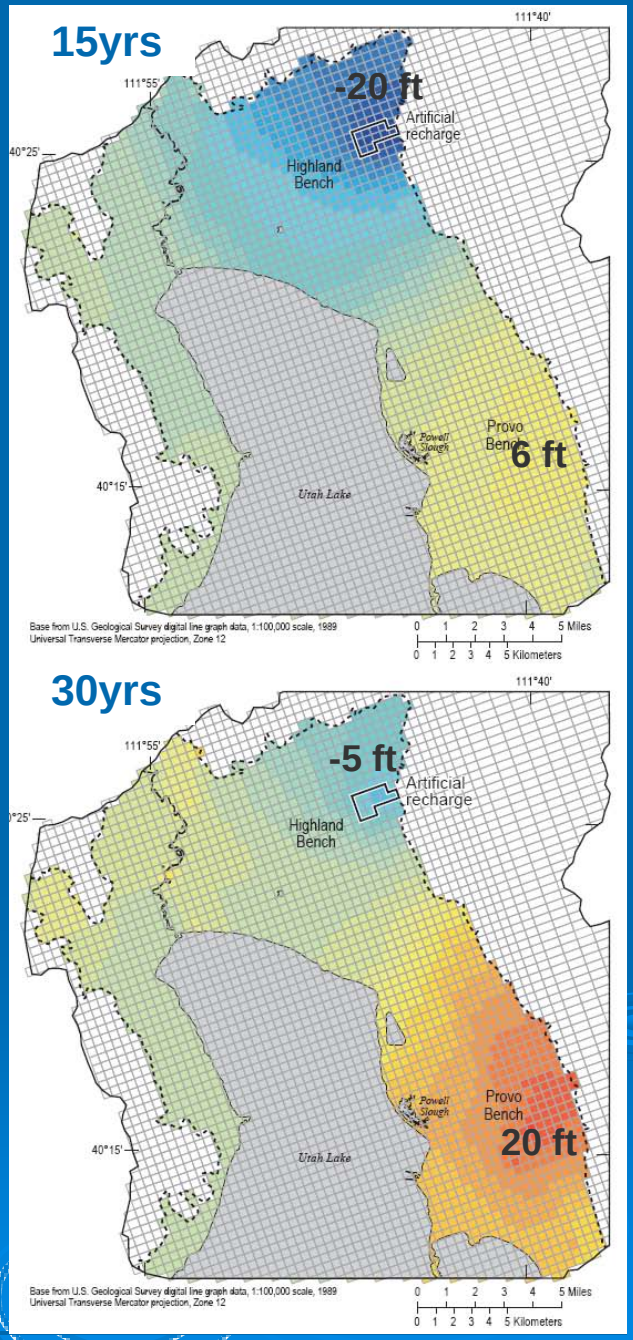
Test Scenario 2

Steady-state groundwater fluxes

Utah Lake	25,000 af
Drains, Springs, & Flowing Wells	86,000 af
Evapotranspiration	82,000 af
Jordan River	4,500 af

Changes in groundwater fluxes

	15yrs	30yrs
Utah Lake	+3%	-9%
Drains, Springs, & Flowing Wells	0%	-20%
Evapotranspiration	-1%	-8%
Jordan River	+7%	-7%



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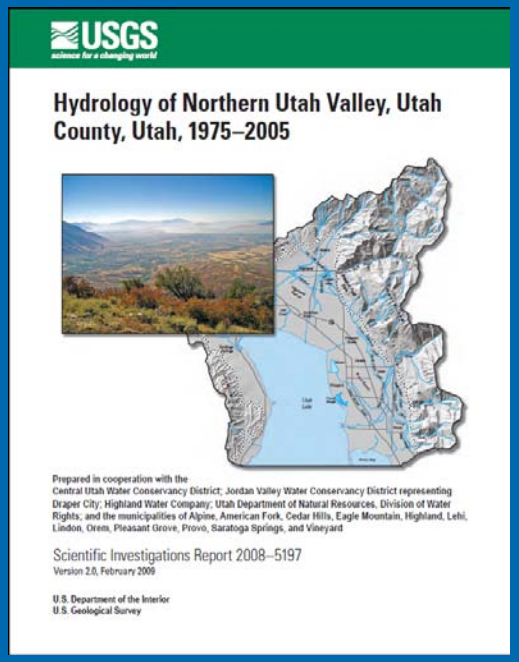
Reports Available Online

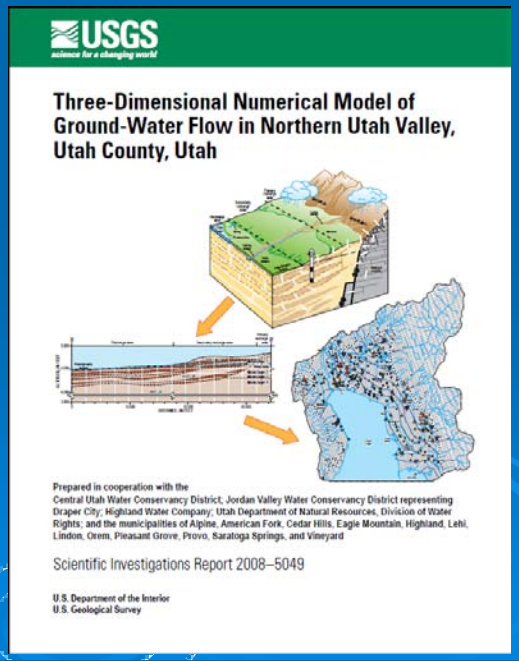
Hydrology of Northern Utah Valley, Utah County, Utah, 1975-2005

http://pubs.usgs.gov/sir/2008/5197/

Three-Dimensional Numerical Model of Ground-Water Flow in Northern Utah Valley, Utah

http://pubs.usgs.gov/sir/2008/5049/





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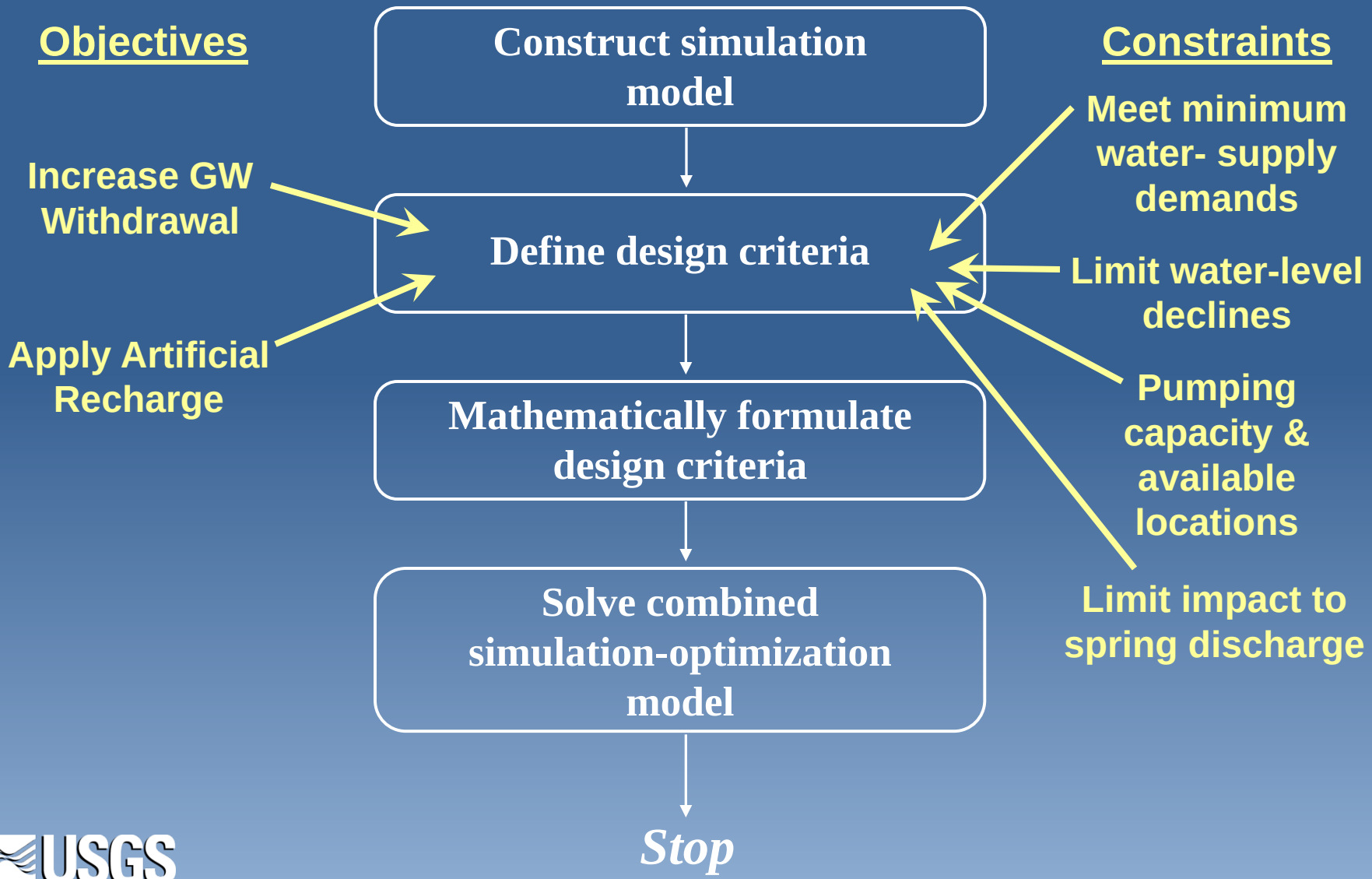
Alternative (Optimal) Design Approach



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