HYDROGEOLOGY AND WATER BUDGET FOR GOSHEN VALLEY, UTAH COUNTY, UTAH

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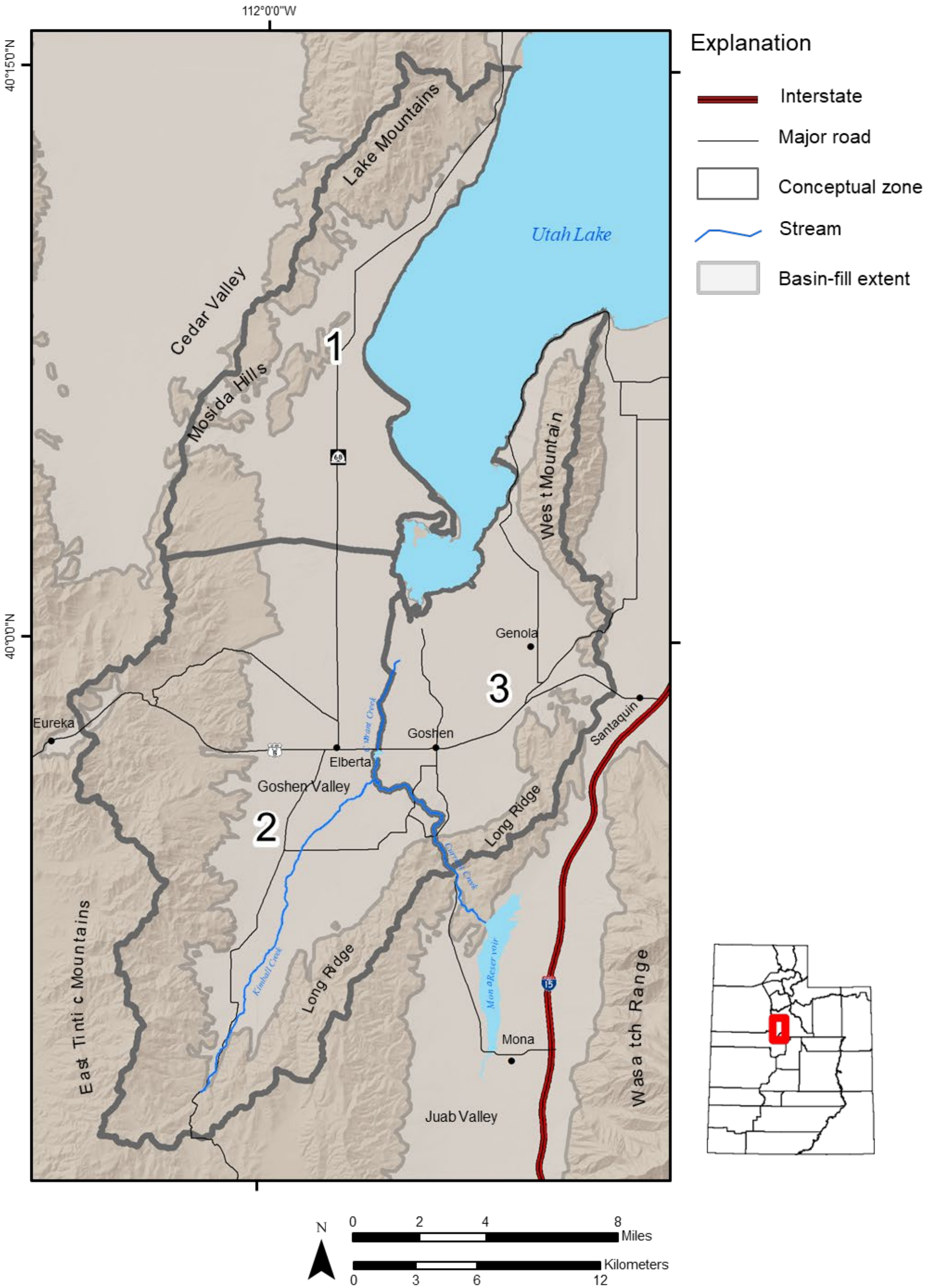
UTAH DNR GEOLOGICAL SURVEY

SPECIAL STUDY 171
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2022

Background

- Goal to characterize aquifers, groundwater conditions, and develop water budget
- Funded by UDWRi, Elberta Valley Ag, Warm Springs Canal Company, USBR, and UDEQ
- UGS Personnel -- S. Kirby, L. Jordan, P. Inkenbrandt, J. Wallace, N. Payne, B. and C. Hardwick
- Fieldwork completed 2018
- Published following peer (USGS and others) review 2022
- Available at https://ugspub.nr.utah.gov/publications/special_studies/ss-171/ss-171.pdf

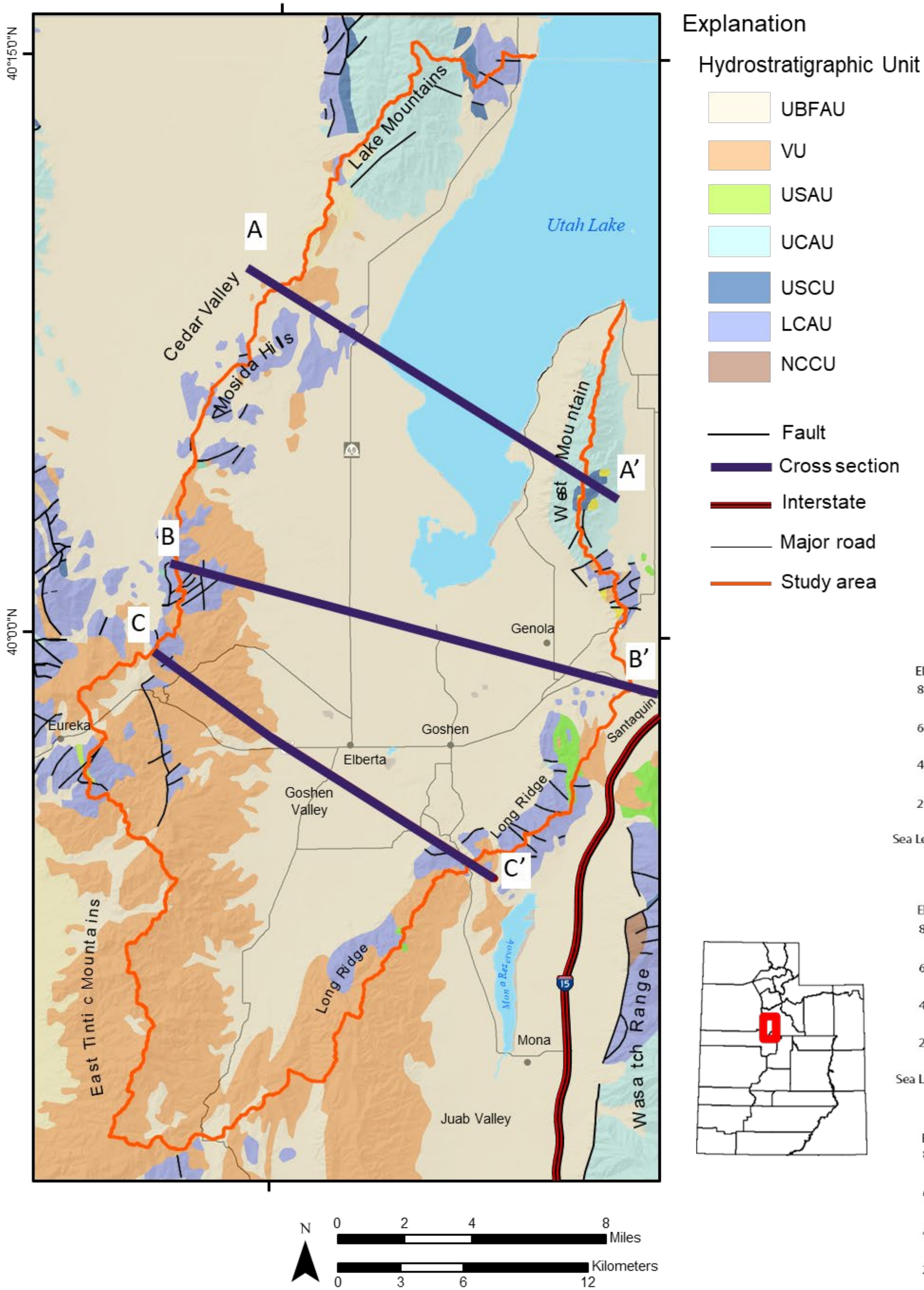


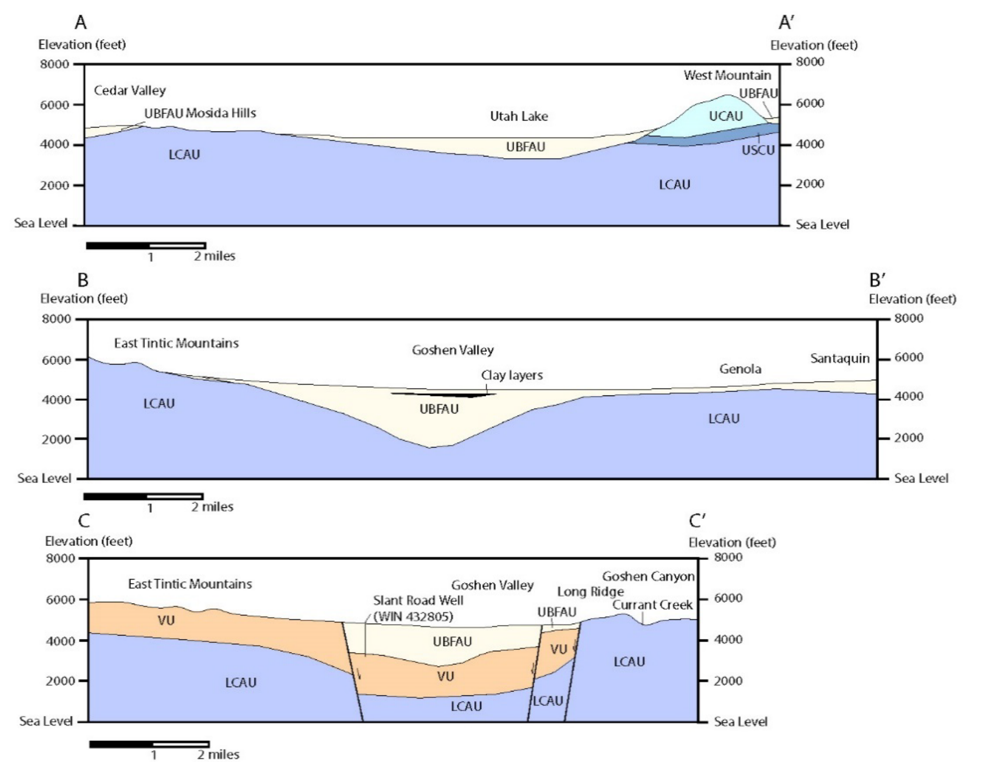
Introduction

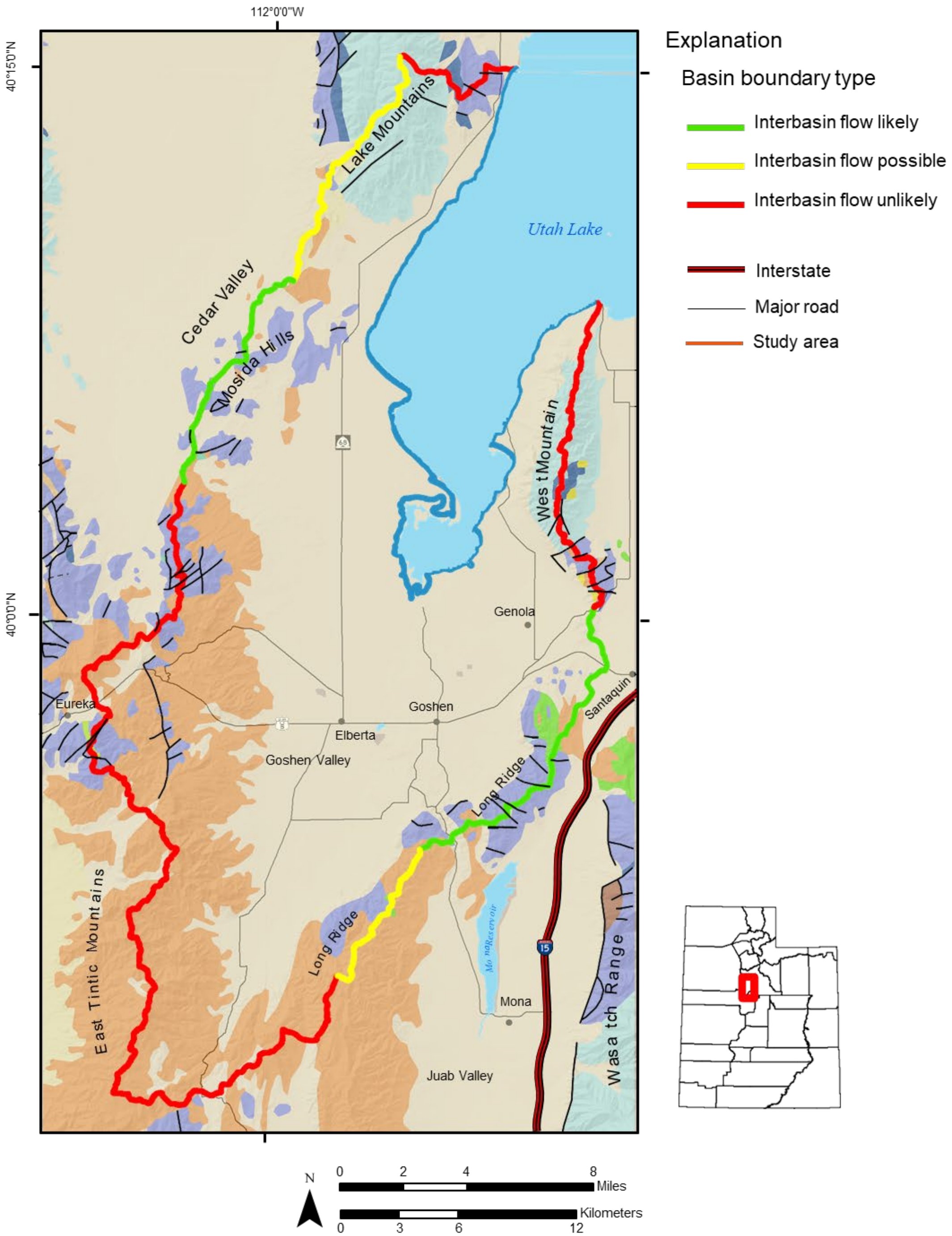
- 1st part hydrogeology, groundwater levels, water chemistry
- 2nd part water budget, surface water flow, well withdrawal, ET
- Goshen Valley broken into 3 zones based on similar characteristics

Hydrogeology

- Based on USGS scheme (Gardner and Kirby, 2012) for adjoining areas; and simplified geology
- Aquifers include Q unconsolidated sand, gravel, clay (UBFAU), Pz limestones (LCAU), and locally Tv (VU), and TK (USAU)
- Aquicludes include Pz shale (USCU) and Qrzts (NCCU), locally Tv (VU)
- Faults (locally important) not addressed by this study







Basin Boundary Conditions

- Potential for interbasin flow based on hydrogeology and groundwater surface
- Areas of interconnected aquifers including Q unconsolidated sand, gravel, clay (UBFAU) and Pz limestones (LCAU) allow flow where gw gradient allows
- Important areas include Mosida Hills and northern end of Long Ridge

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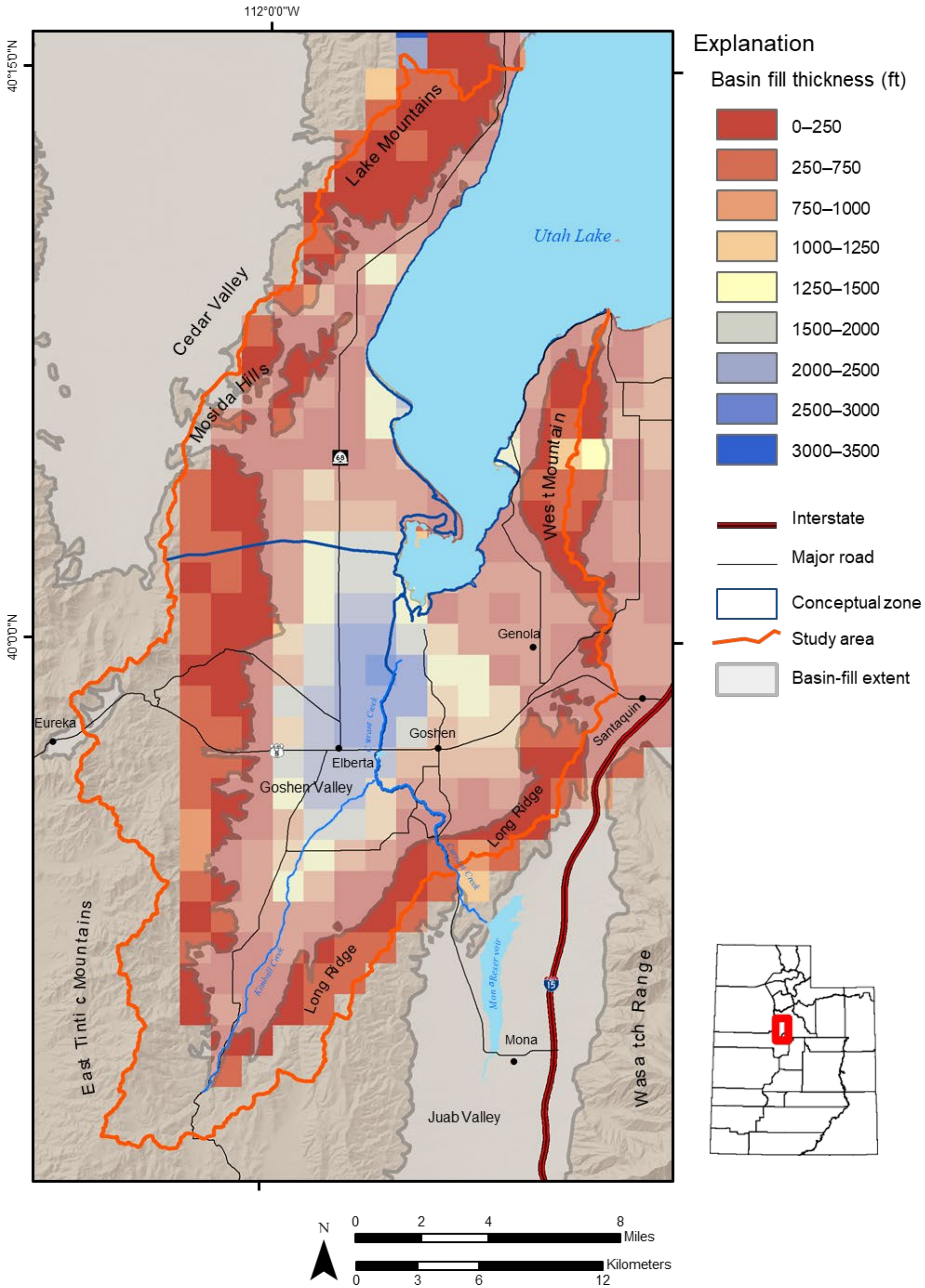
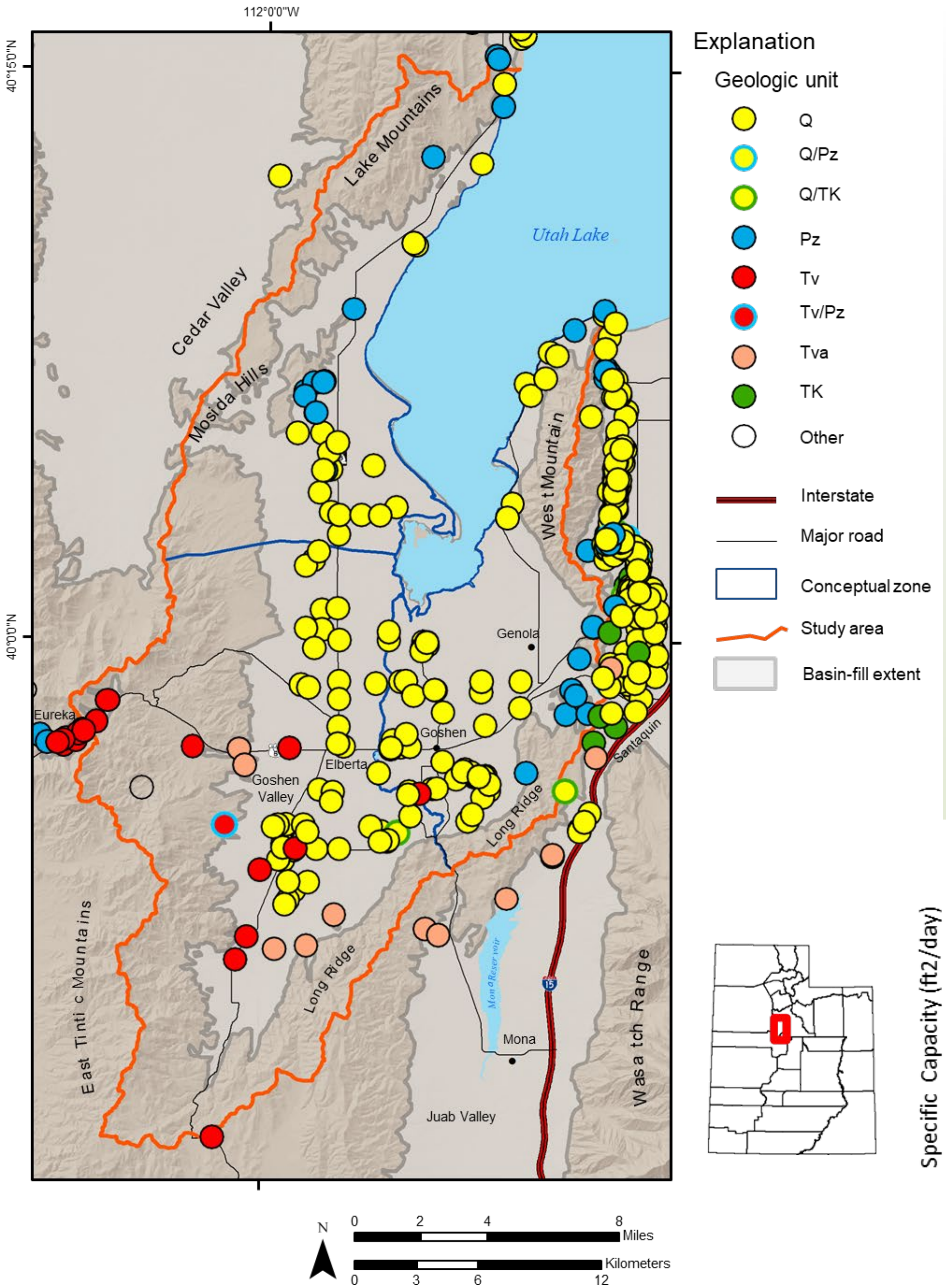


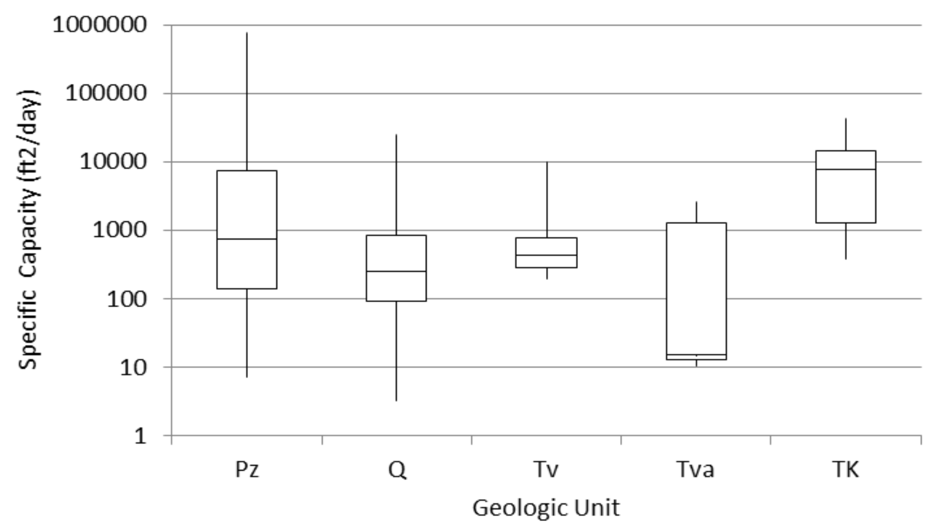
Basin Fill Thickness

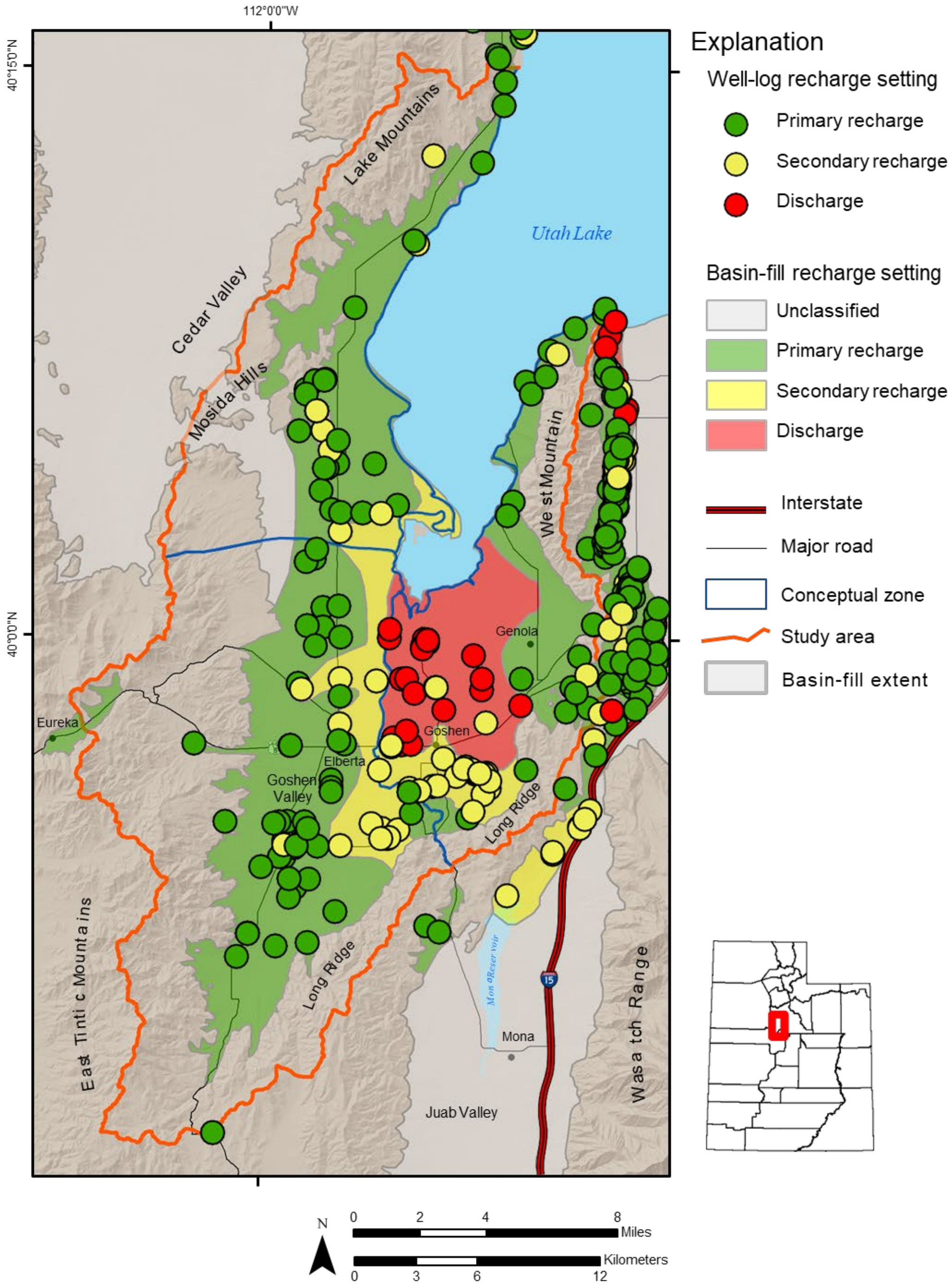
- Depth inversion based on new and compiled isostatic gravity data, well logs for depth control, density contrasts, and regional bedrock signal
- Deepest (> 2000 ft) northwest of Goshen
- ~ Few hundred feet near Goshen Gap, West Mountain and the Mosida Hills
- Conceptual zones?

Well Logs and Aquifer Characteristics

- Summarized from ~ 500 drillers logs
- Most wells completed in Basin Fill (UBFAU) or Pz carbonates (LCAU); fewer in T volcanics(VU); smaller number in other aquifers
- 128 contain Specific Capacity, 94 from Q, 20 from Pz, 8 from Tv or Tva, and 6 from TK
- Highest Capacity in LCAU or UBFAU

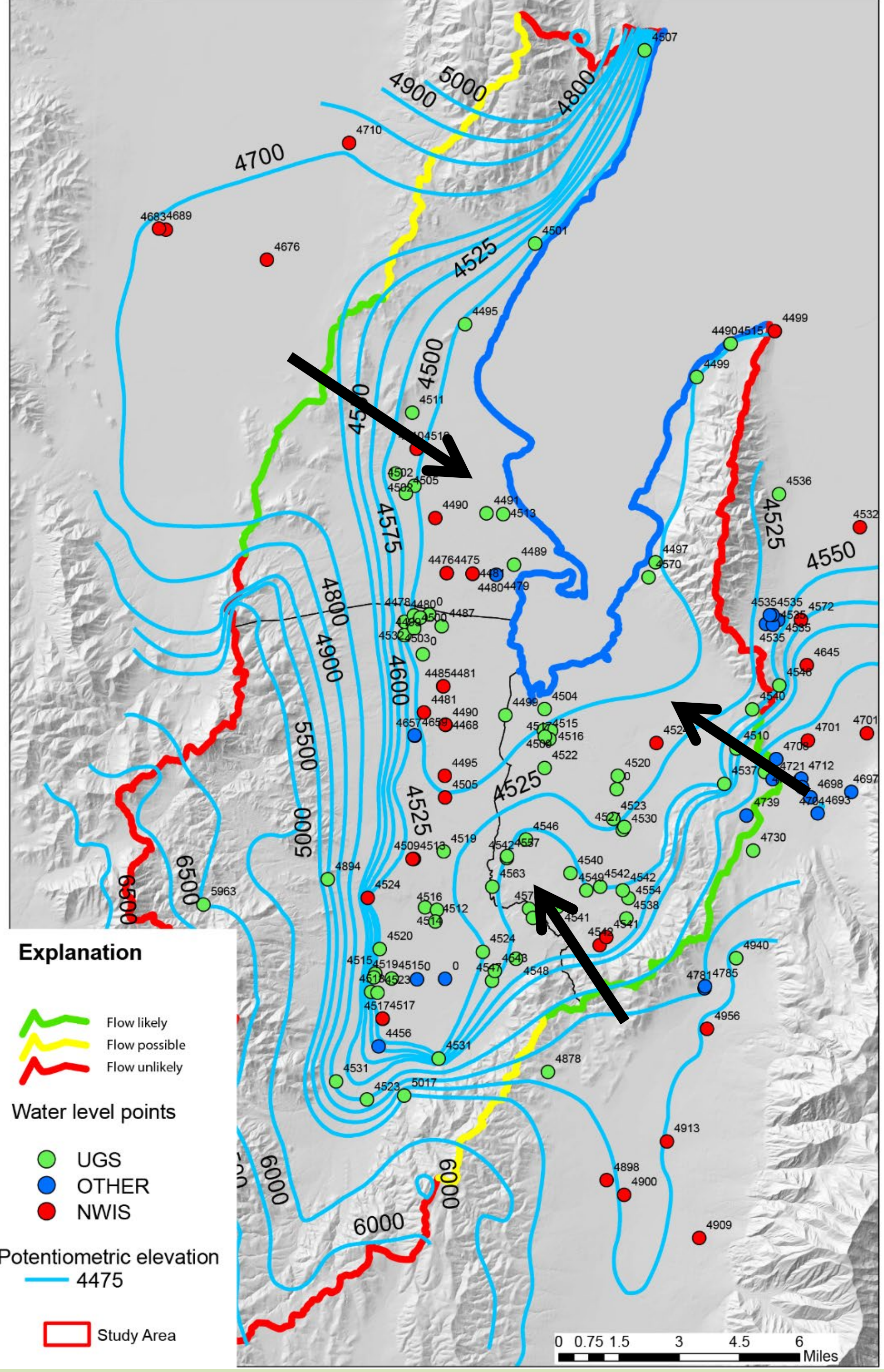






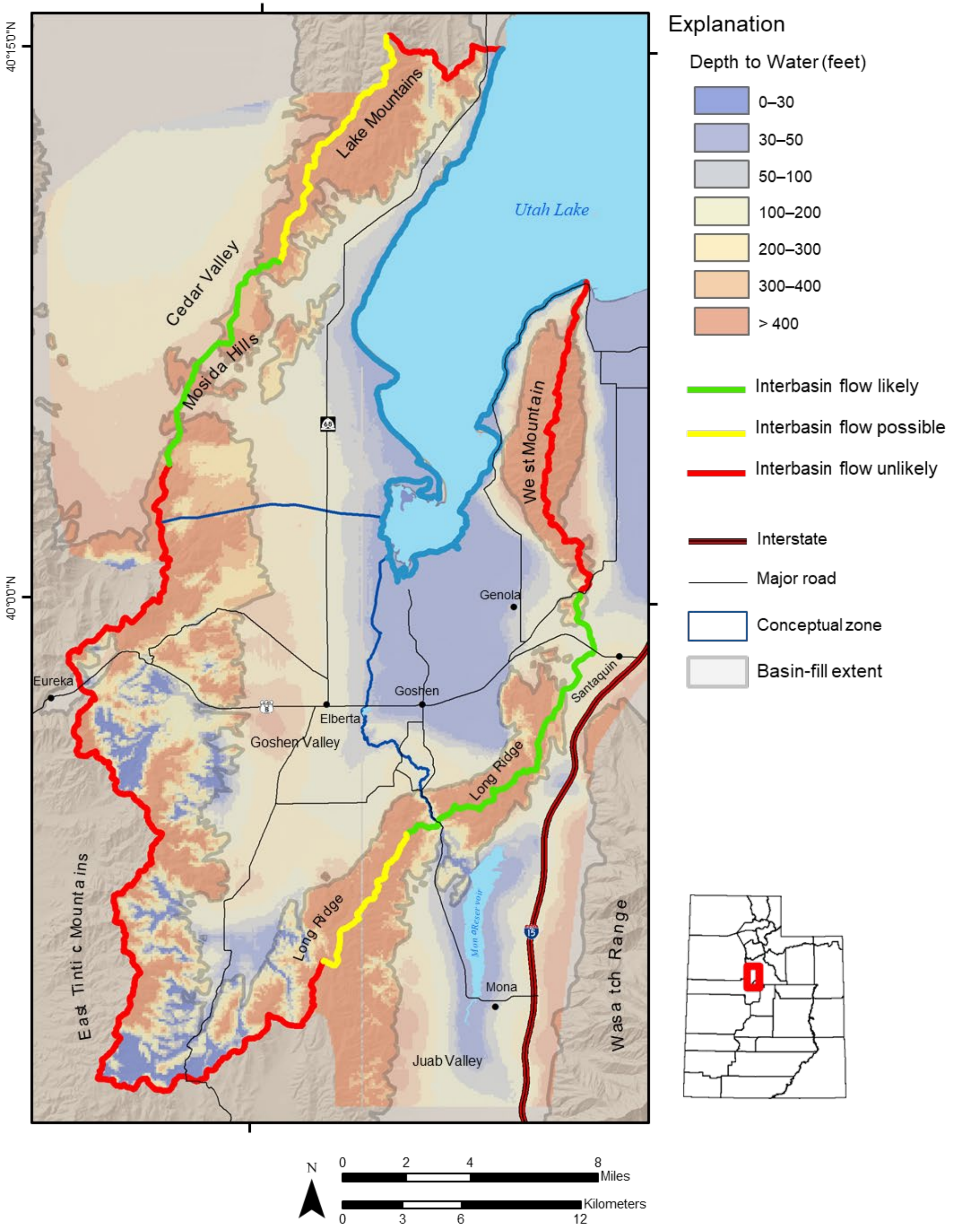
Recharge types

- Based on drillers logs
- Clays thicker than 20’ and relative water level determine types
- Types represent unconfined(primary), locally confined(secondary), confined(discharge)
- Clays outside of discharge area are not laterally continuous and at different elevations



Water Levels

- Refined Potentiometric surface for Spring 2014 (New data collected by L. Jordan) other data from NWIS
- Based on 174 total points ; 132 wells, 42 springs
- Gradients into Goshen Valley
- Water Levels near Currant Creek
- Water levels near Utah Lake

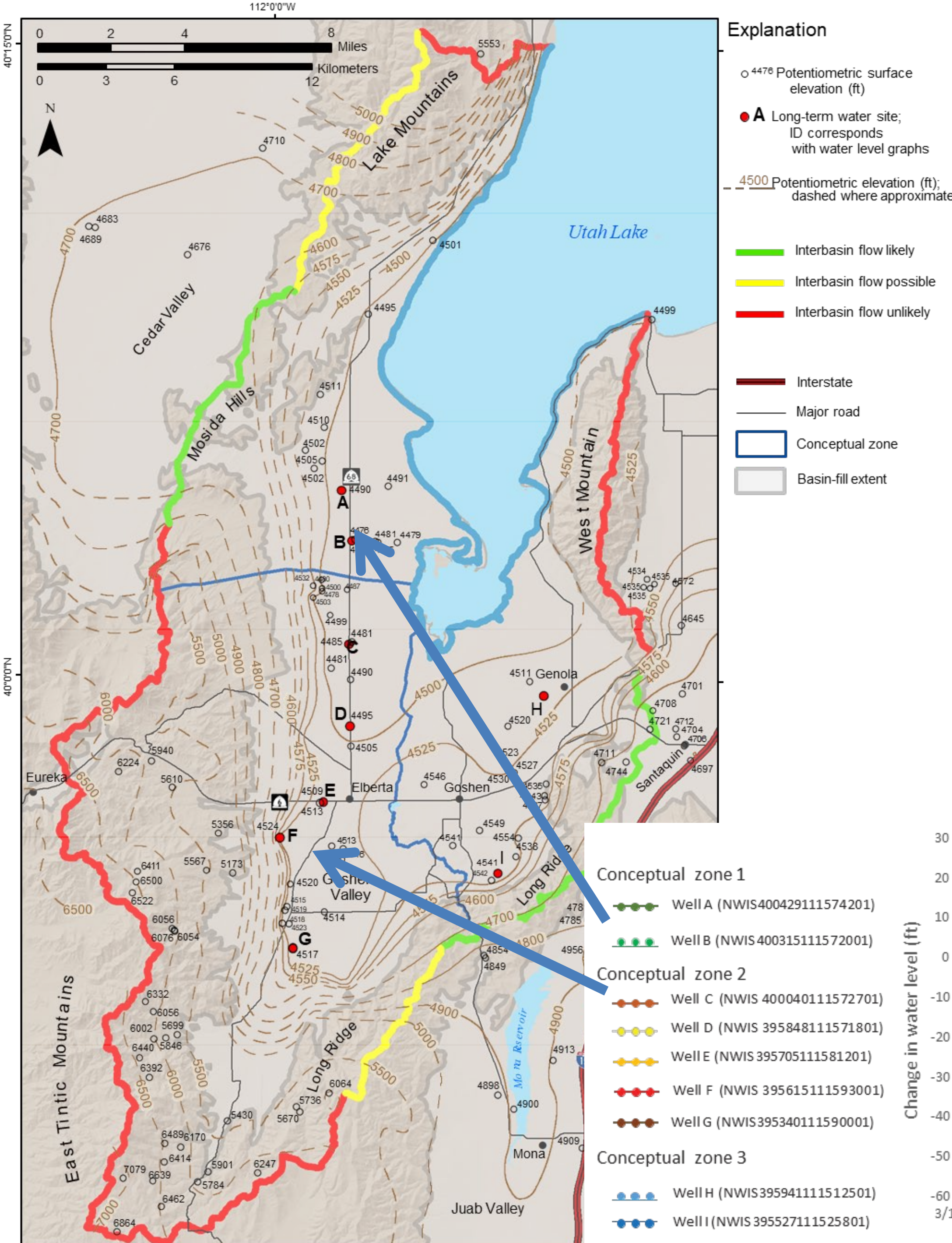


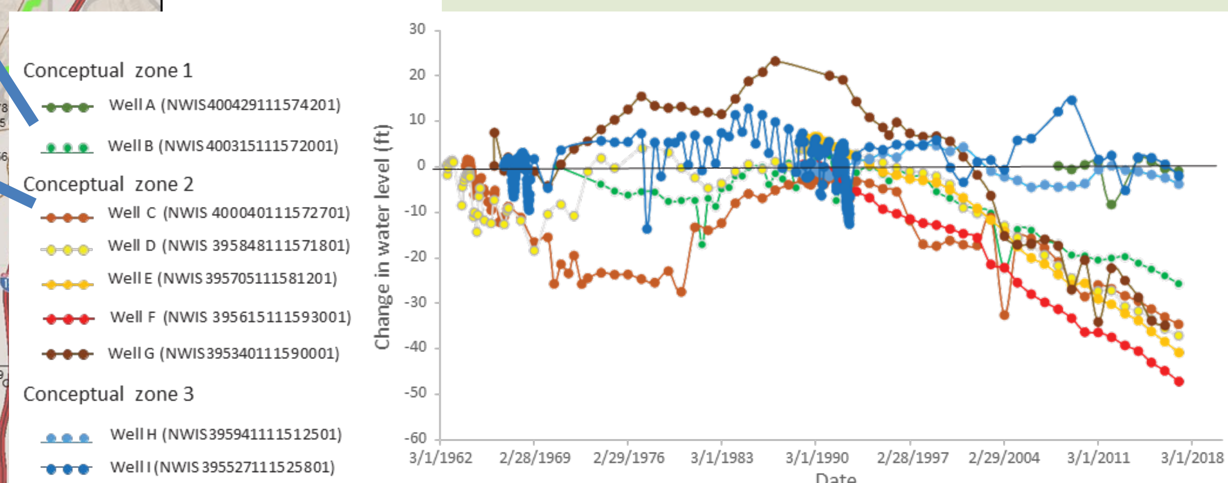
Depth to Water

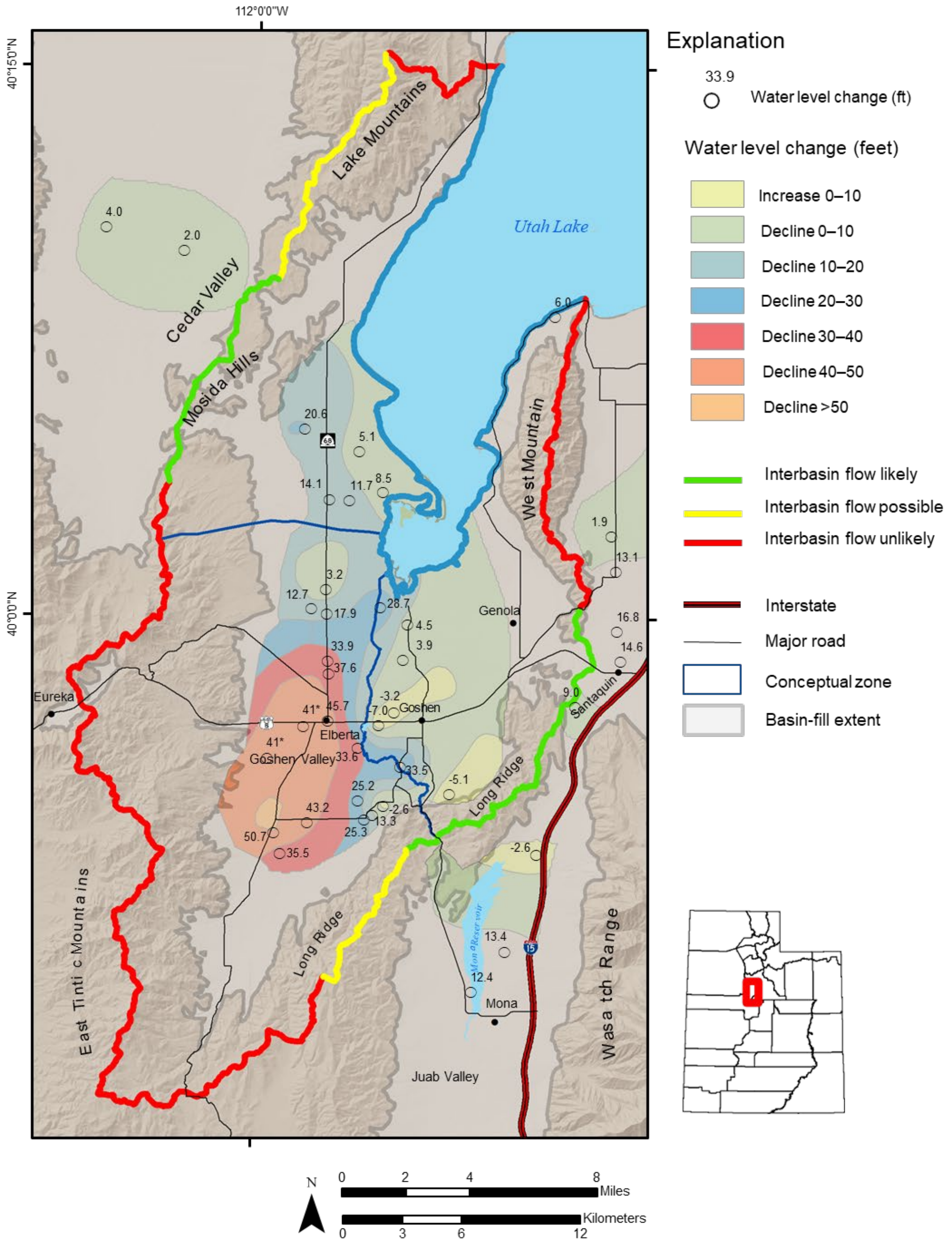
- Based on refined potentiometric surface
- Based on 174 total points ; 132 wells, 42 springs
- Areas of deep gw, shallow across much of the valley floor
- Areas of DTW < 30' could accommodate active ET ~Zone 3

Water Levels

- Groundwater level change over time based on USGS long term measuring sites
- 9 sites across the valley
- Some water level decline in zone 1
- Significant water level decline in zone 2 (~2 ft per year)
- Little or no decline in zone 3
- Graph through 2018; trends continue today







Water level decline

- Based on difference between Potentiometric surface for Spring 2014 and surface for 1975
- Data for 1975 is from NWIS and several unpublished consultants reports
- Most water level decline in the SW up to 50' Zone 2
- Minor long term decline in Zone 1
- Little or no decline in zone 3

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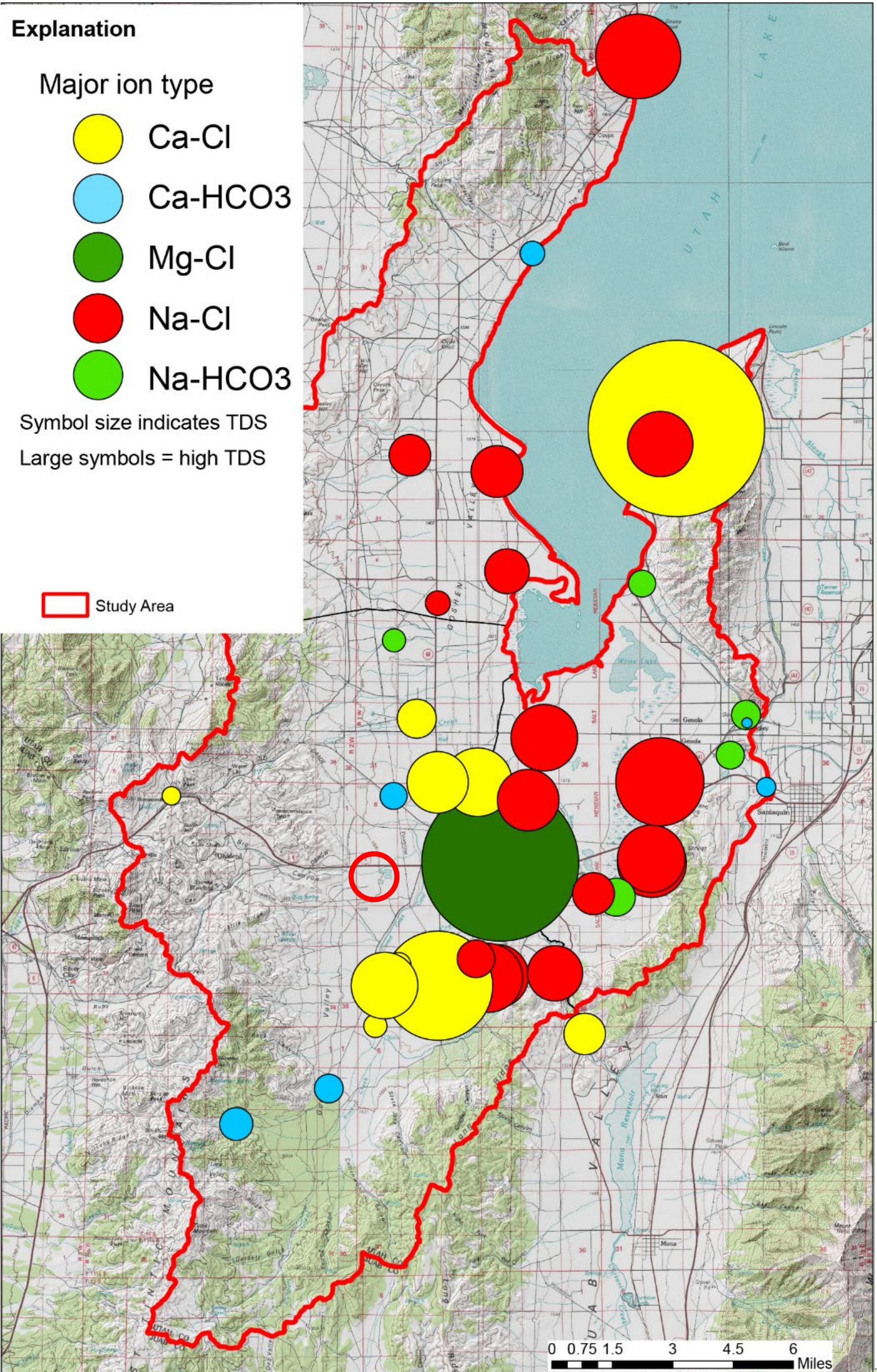
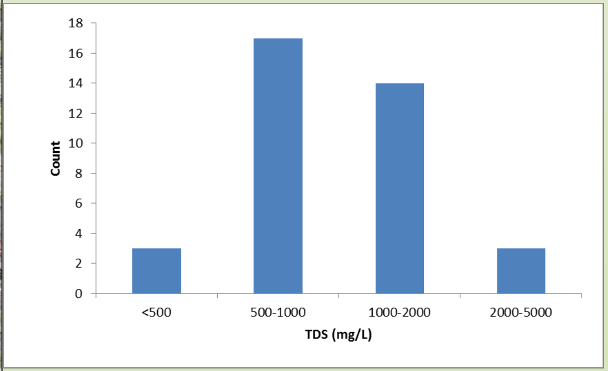
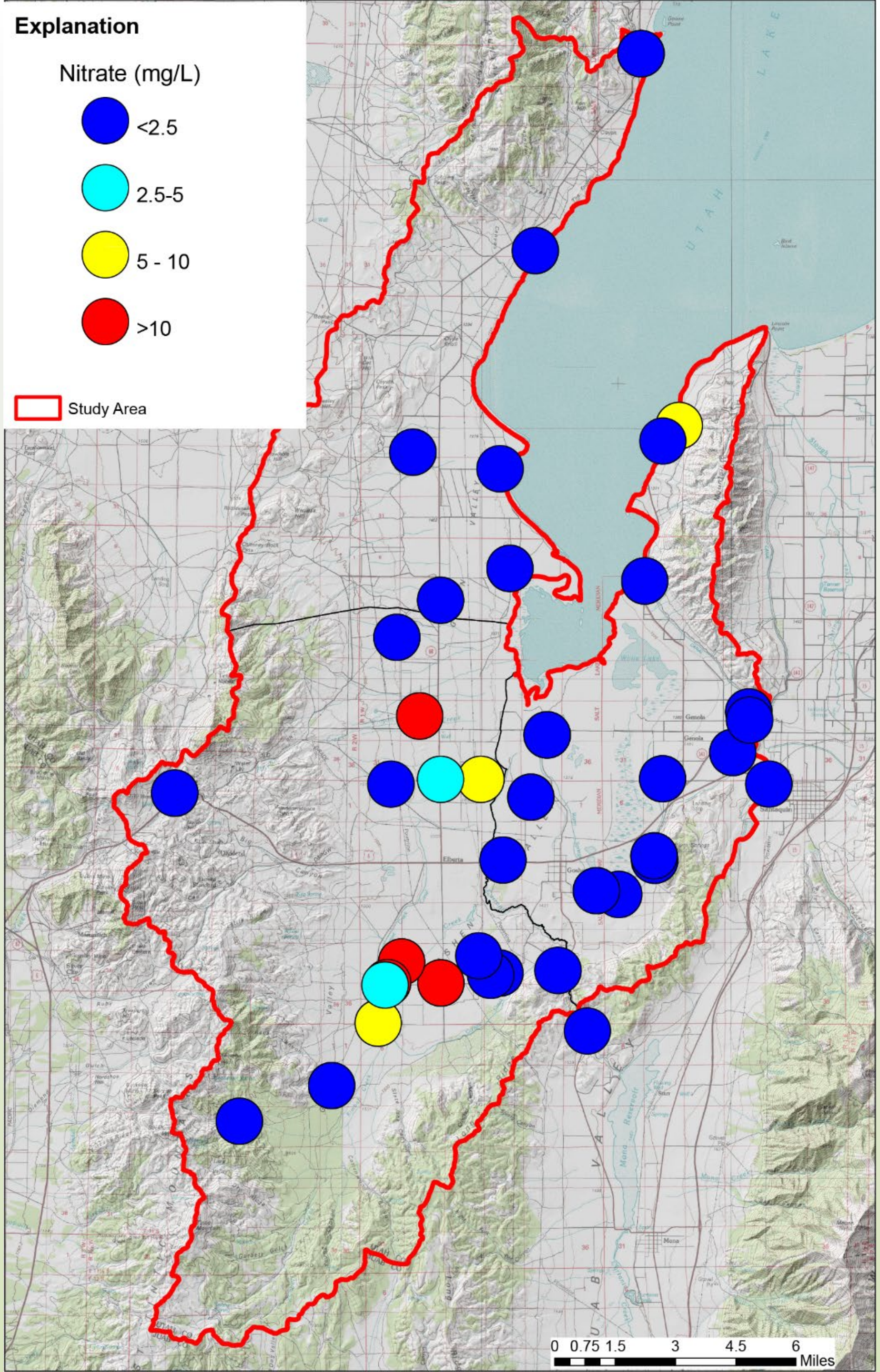
Water Chemistry and Water Quality



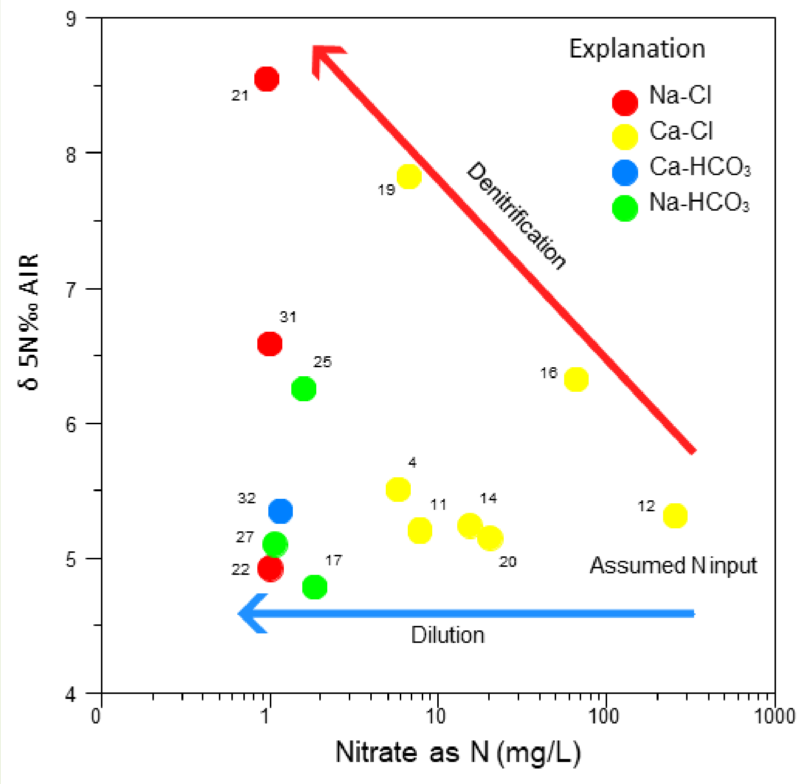
- 44 new samples collected across Goshen Valley
- Mostly groundwater some surface water
- Generally moderate water quality based on TDS
- Most samples are Na-Cl fewer Ca-Cl
- Location and aquifer sampled seems to control water chemistry
- Local high TDS from mine waters W of Elberta (TDS ~2000-6000 mg/L)

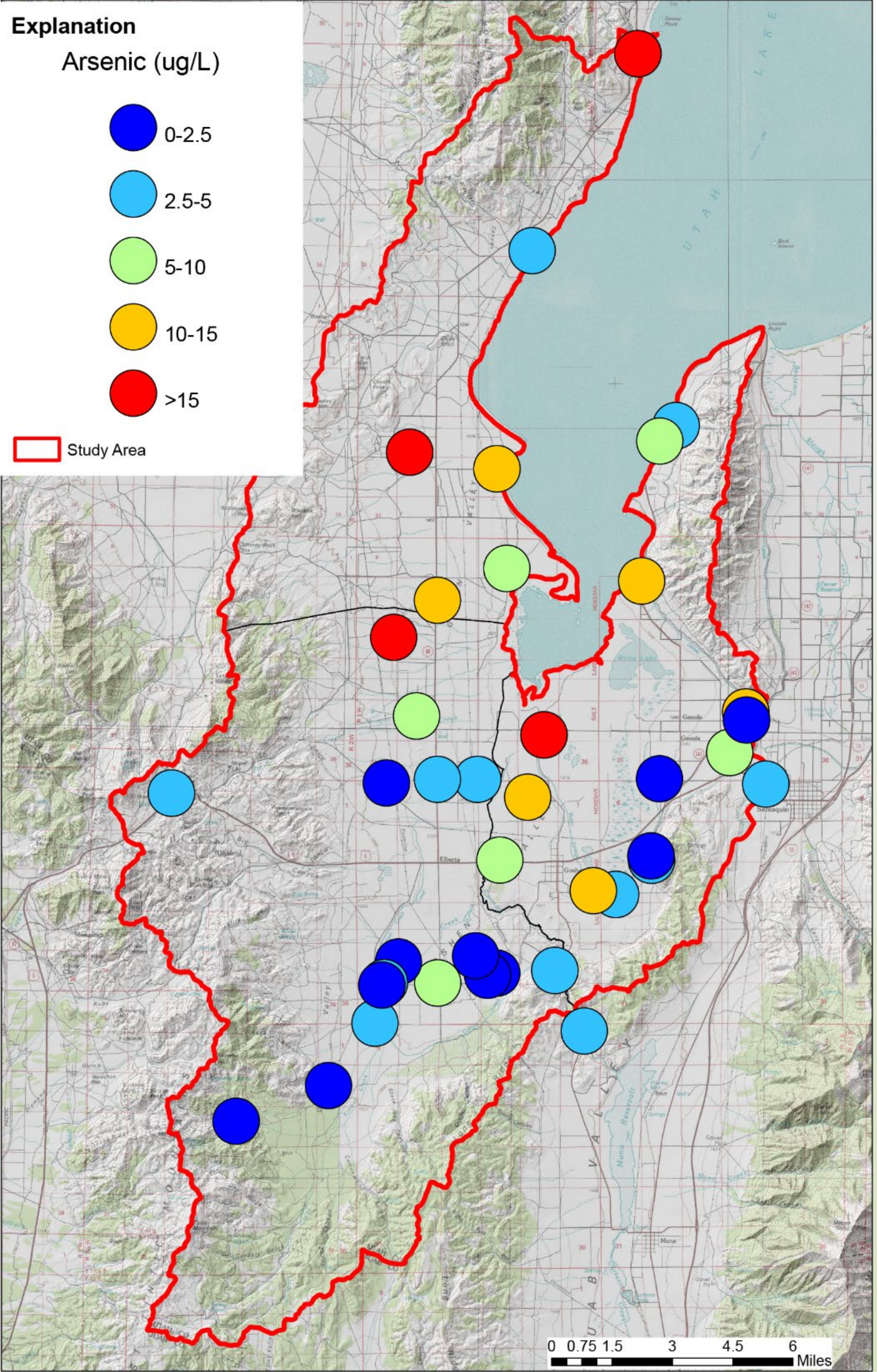




Nitrate

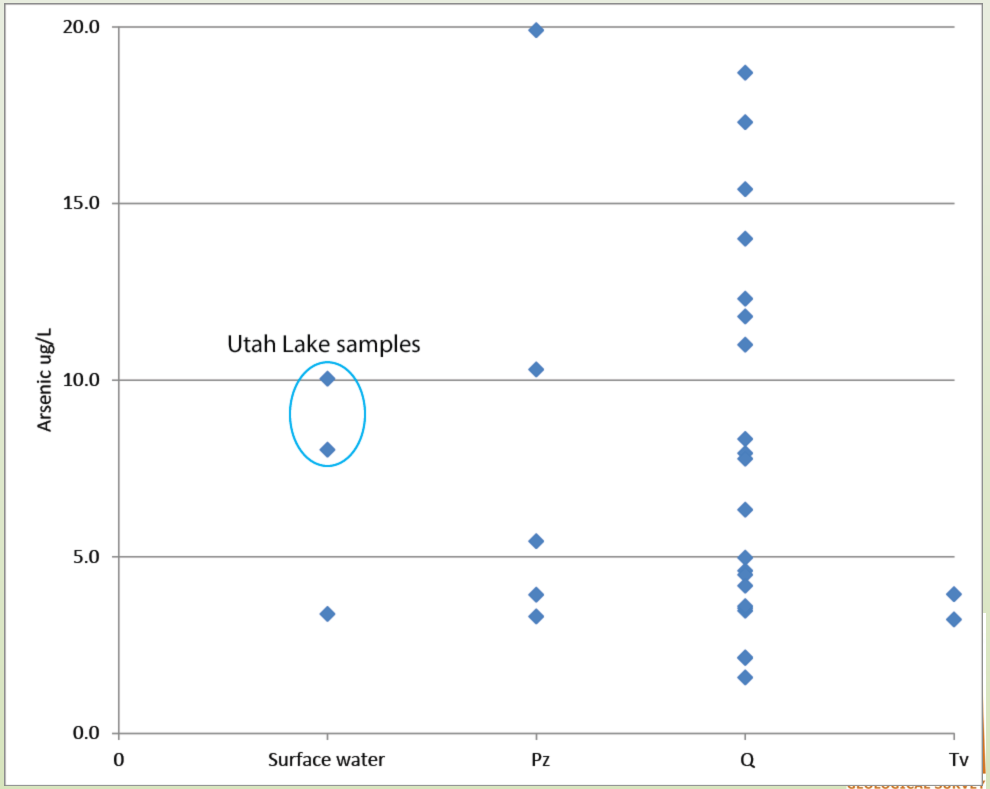
- Most sites have low nitrate
- High nitrate is localized in ag areas; near old feed lots etc.
- Nitrogen isotopes support reduction of nitrate concentrations via natural dilution and denitrification

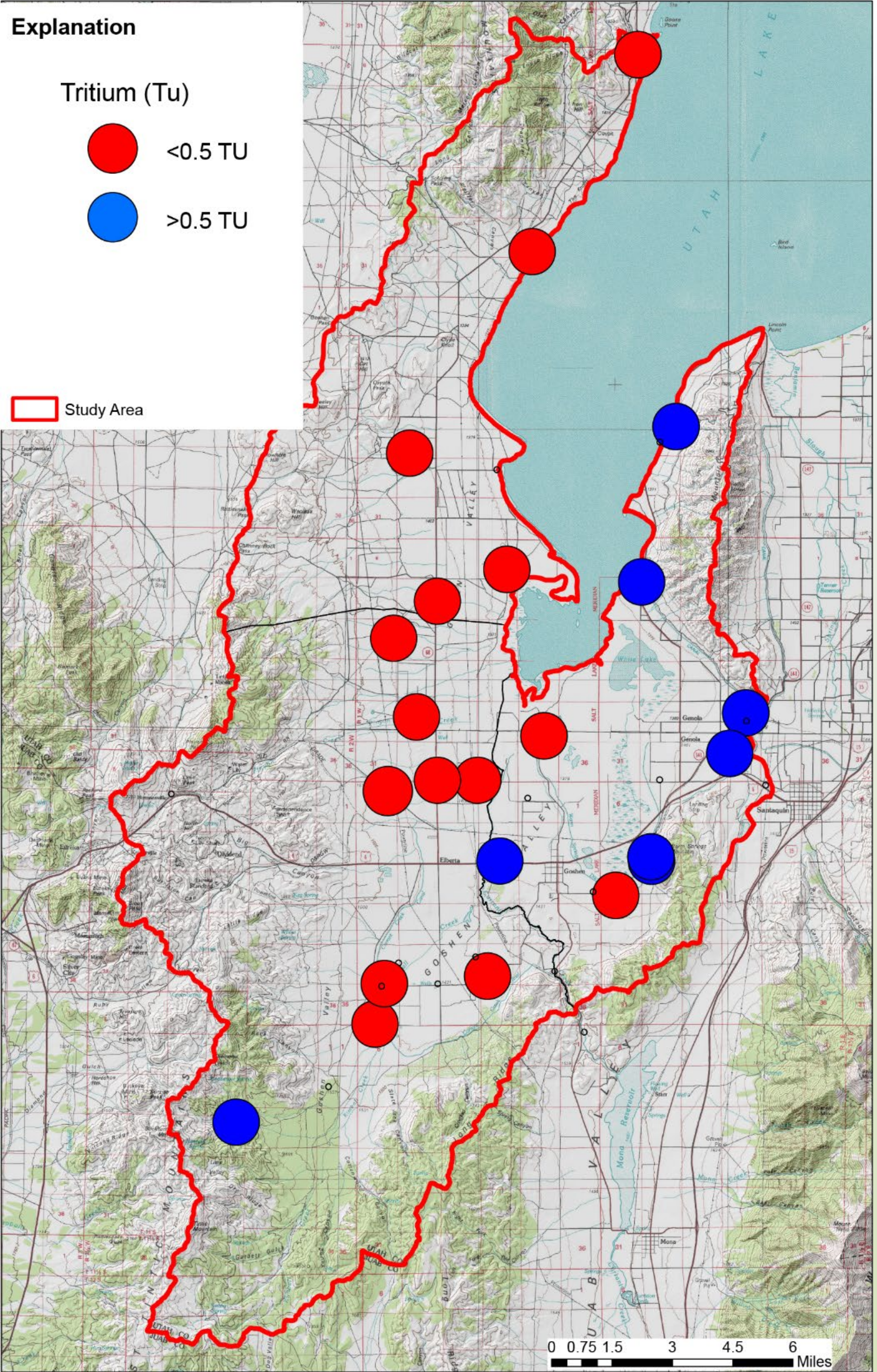




Arsenic

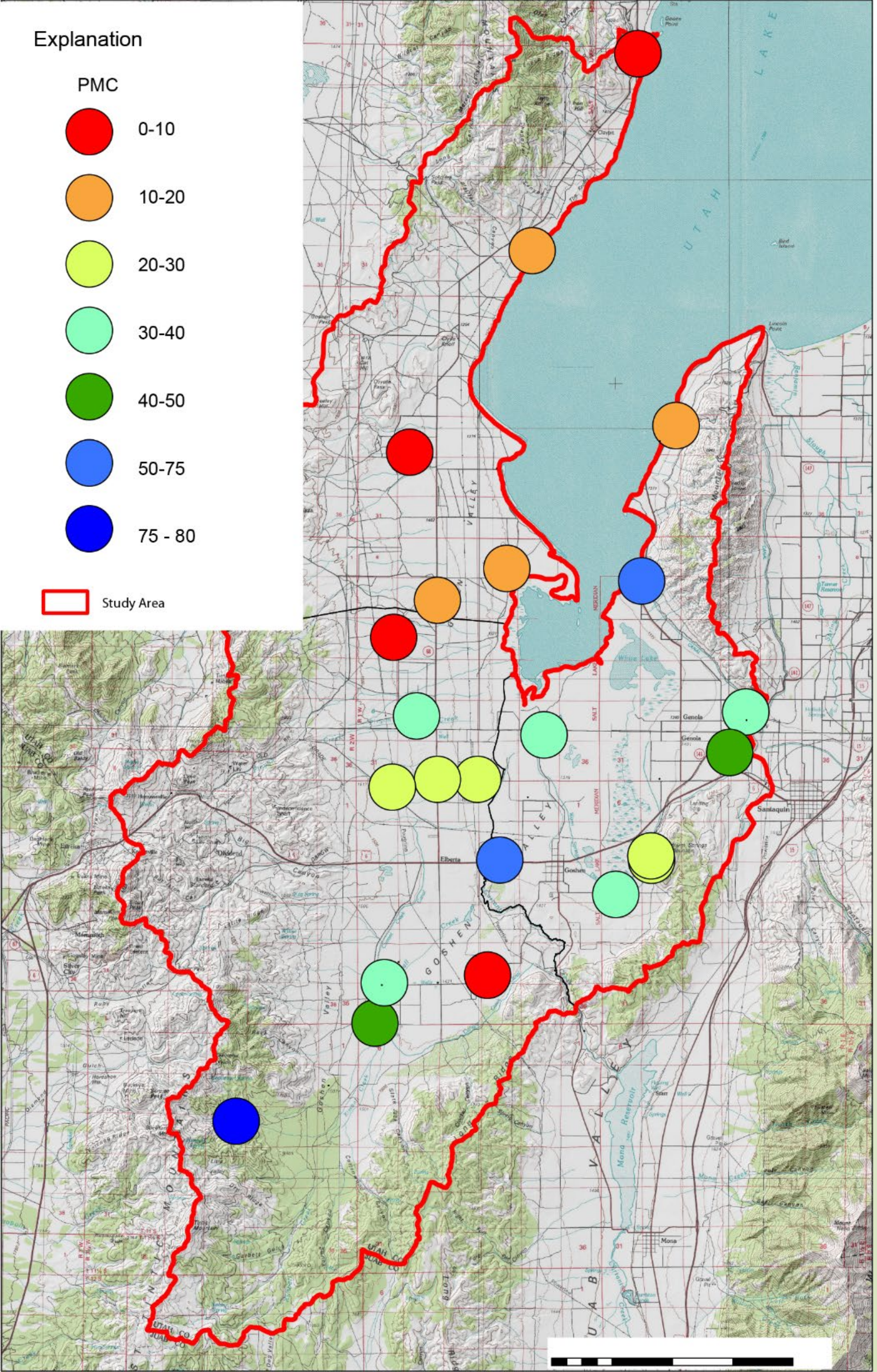
- High arsenic located near the central part of Goshen Valley
- High levels in both Q and Pz aquifers?
- High levels in Lake!?
- High Arsenic zones 1 and 3
- Work by Selck and others (2019, BYU) ties concentration to aquifer (volcs), chem processes, and thermal water





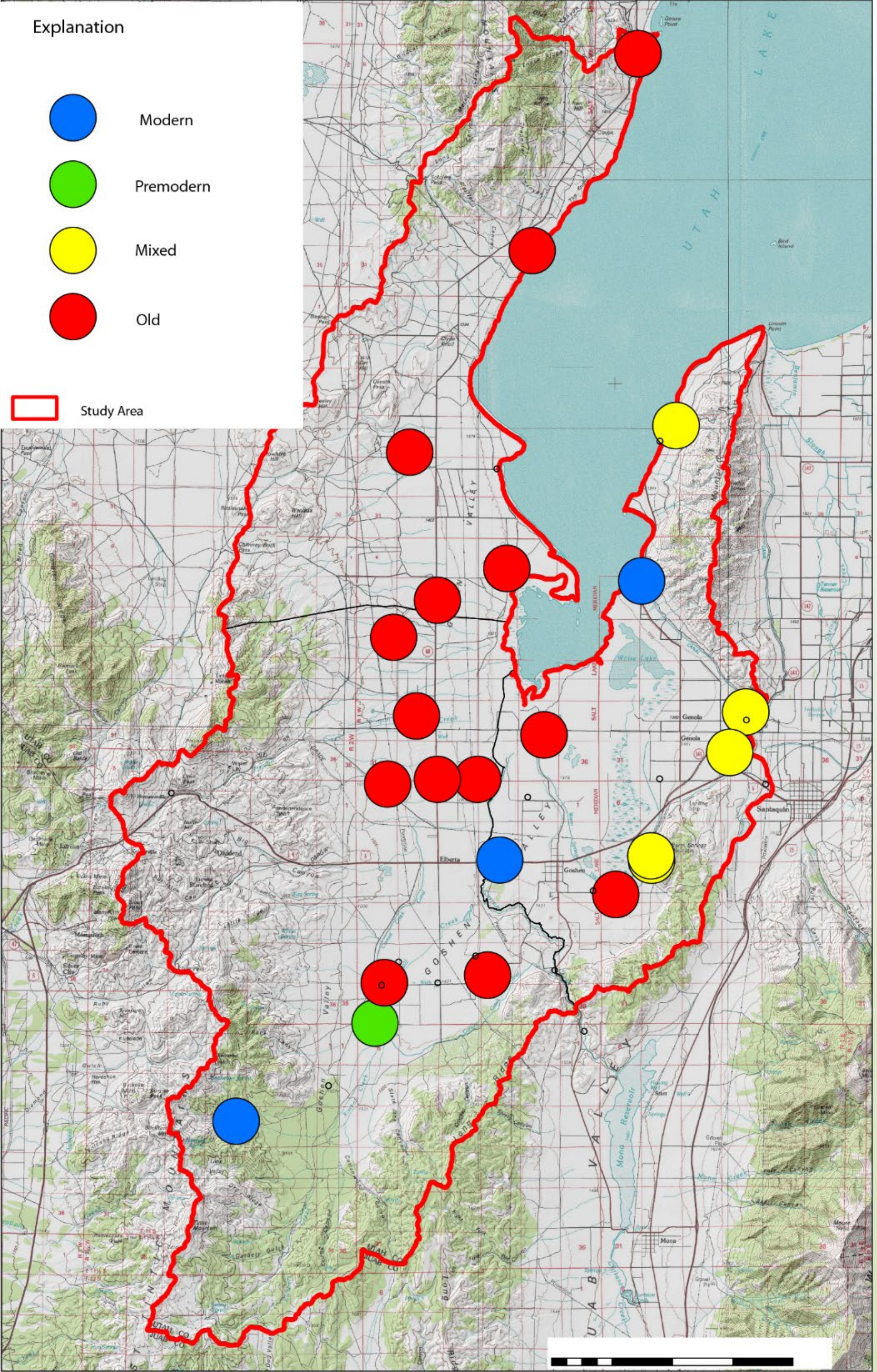
Tritium

- Measured primarily via ingrowth method at U of U
- Young tracer >0.5 TU some recent recharge
- Recent recharge in the NE, Mountains, and along Currant Creek.



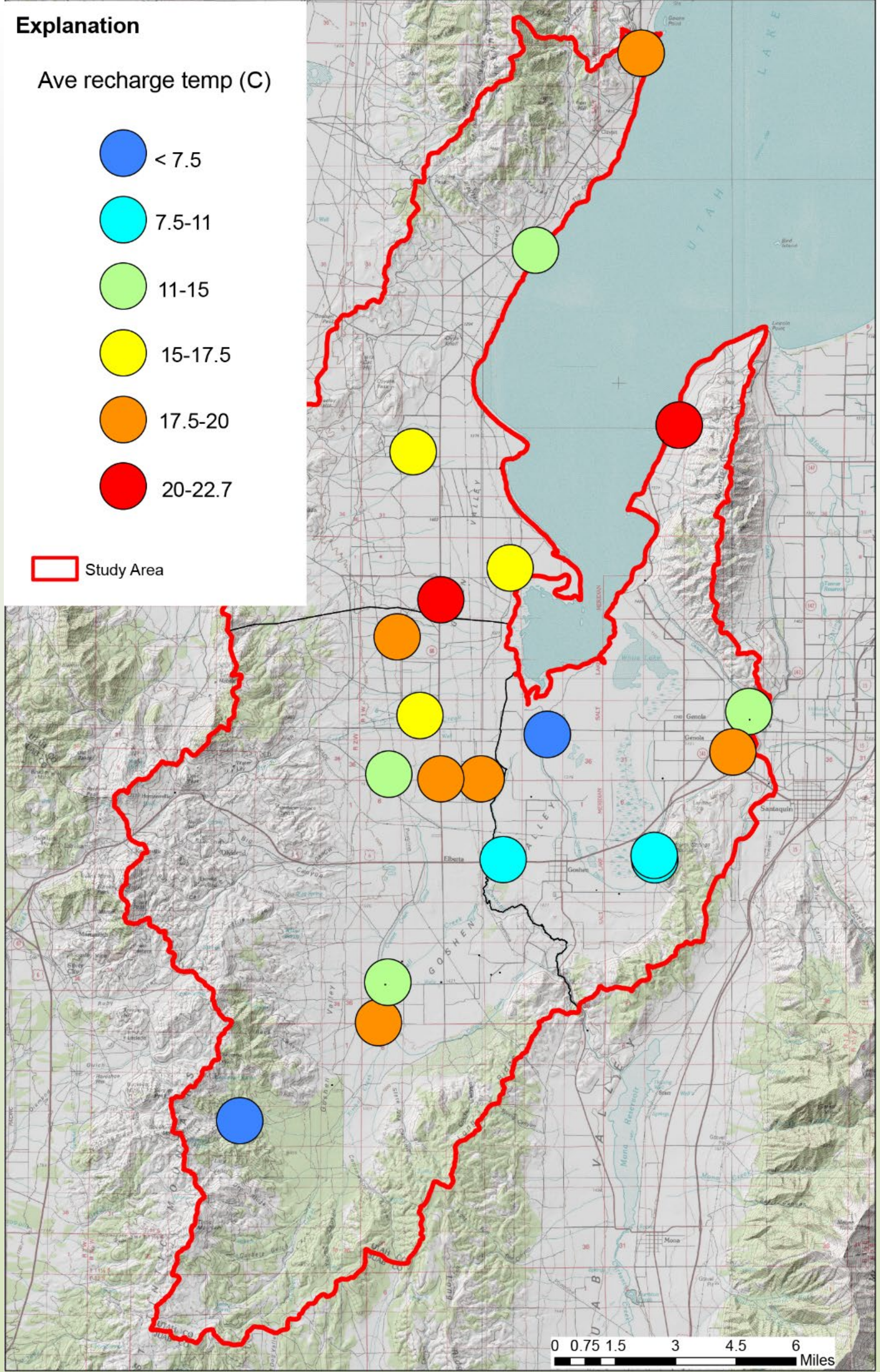
Percent modern carbon

- Old tracer
- Limited young water based on pmc
- Youngest waters in the Mountains and in southern part of the valley (Goshen Gap)
- Oldest waters to the northwest



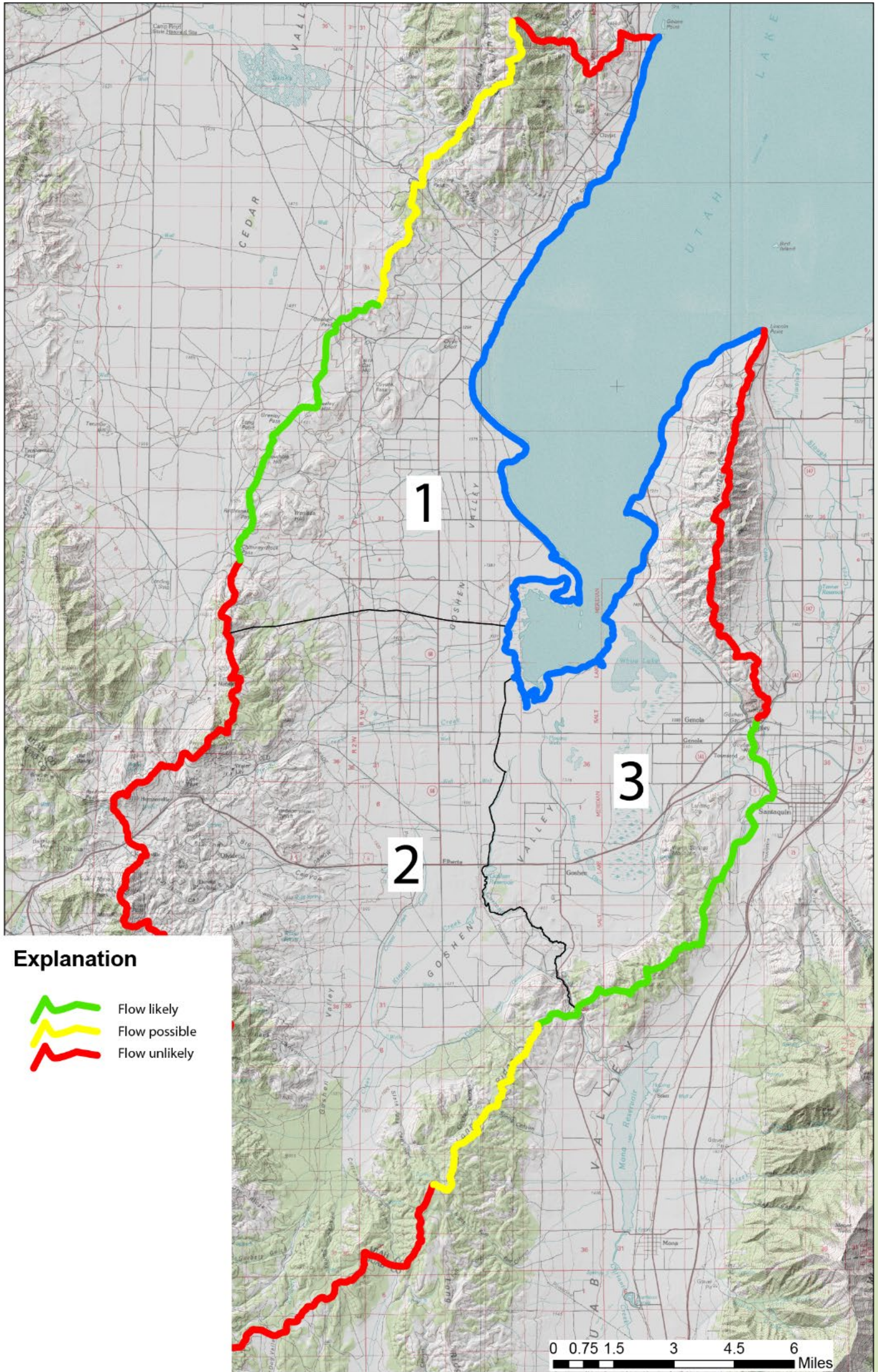
Qualitative Age

- Based on tritium and pmc
- Modern = recharged within ~ 60 years ago
- Premodern = recharged > 60 and < 1000 years ago
- Mix = components of young and old
- Old = recharged more than 1000 years ago
- Locations of recharge



Recharge temperature

- 20 sample sites for DG
- Temps modeled from dissolved gas data
- Cool temps generally represent higher elevation recharge… out of Goshen Valley?
- Warm temps? Recharge along flanks of the Tintics



Conceptual Zones

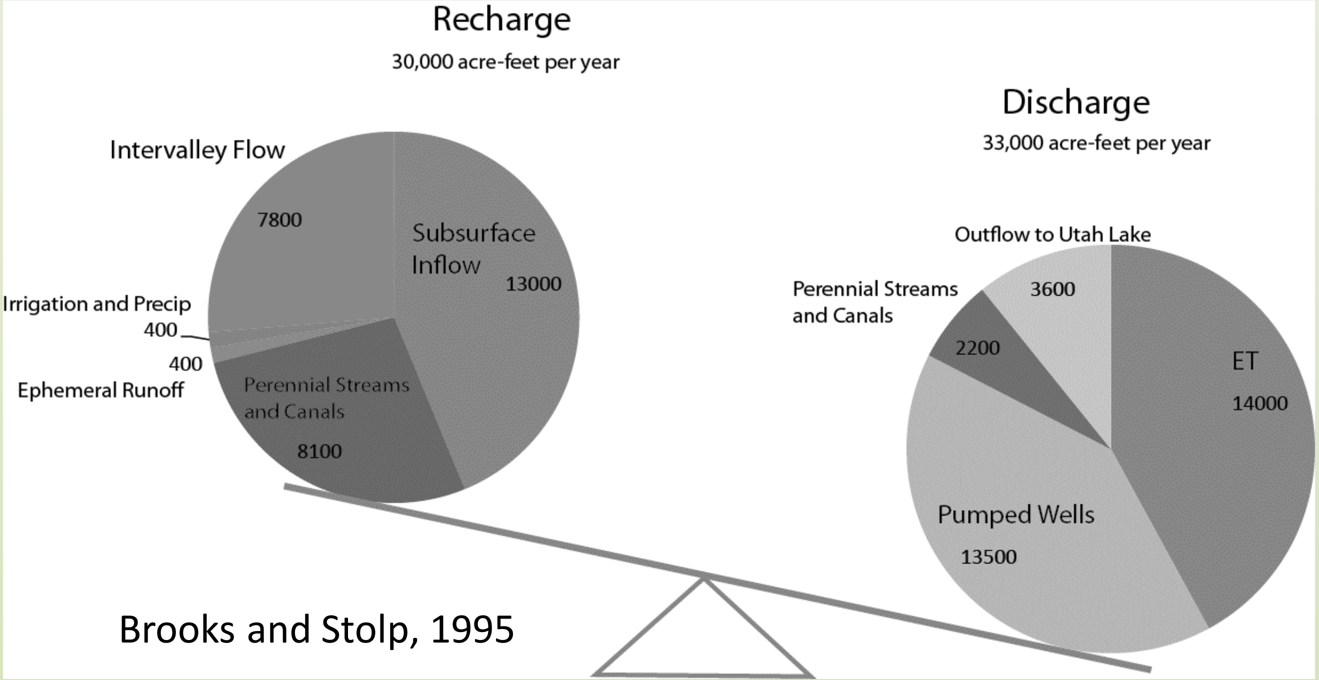
- Zone 1
  - Basinfill, Carbonates, permeable boundary, shallow basin fill, high arsenic otherwise moderate water quality, old water, minor decline in water levels, significant DTW
- Zone 2
  - Basinfill, Volcanics, impermeable boundary, deep basin fill, high NO3 and TDS, old water, declining water levels, significant DTW
- Zone 3
  - Basinfill, Carbonates, permeable boundary, shallow basin fill, high arsenic otherwise moderate water quality, mixed young and old water, consistent water levels, shallow DTW

Groundwater framework summary

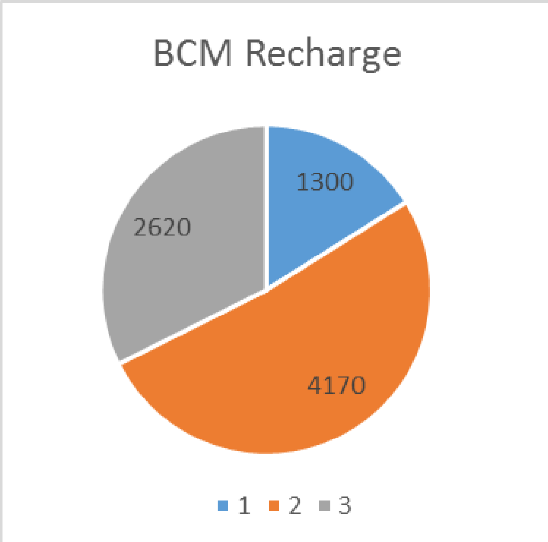
- Water may move across basin boundaries at least locally based on geology and hydraulic head… Goshen Gap, Northern Long Ridge, Mosida Hills
- Water levels show gradients into Goshen Valley and temporal decline in the west and southwest part of the valley
- Water quality issues include locally high TDS, high nitrate, and high arsenic
- Nitrate likely related to land use, arsenic from WRI with aquifer materials
- Most groundwater is old, localized areas of recharge
- DG recharge temps support localized recharge outside of Goshen
- 3 distinct conceptual zones

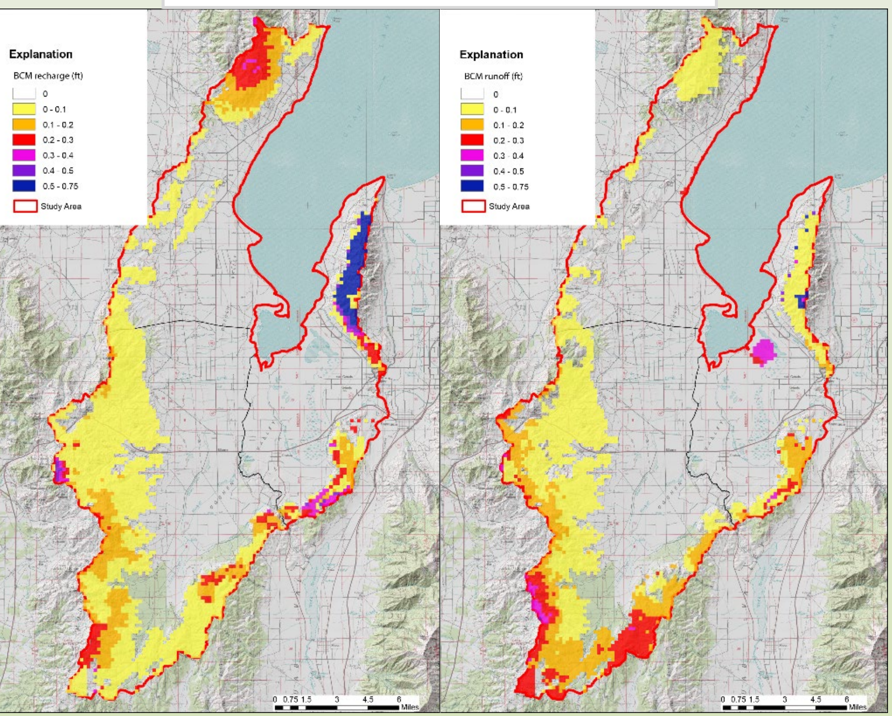
Water Budget

- Goal to update (Brooks and Stolp, 1995) and better constrain an annualized water budget for the groundwater system
- Water budgets are a balance of recharge (precipitation, subsurface inflow, surface water infiltration, etc.) against discharge (evapotranspiration, well withdrawal, outflow, etc.)
- New budget completed for 3 conceptual zones using measured data



Recharge from precip

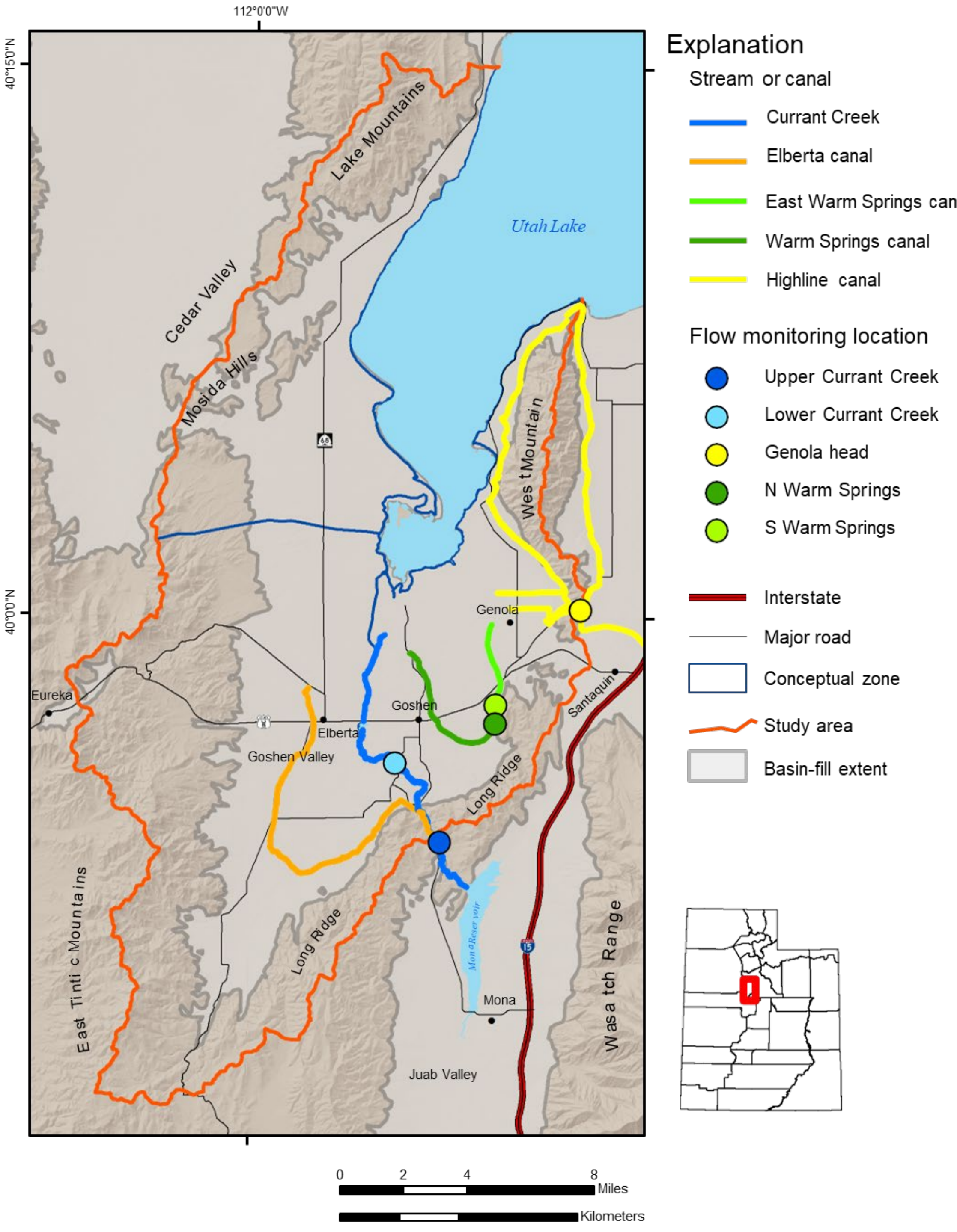




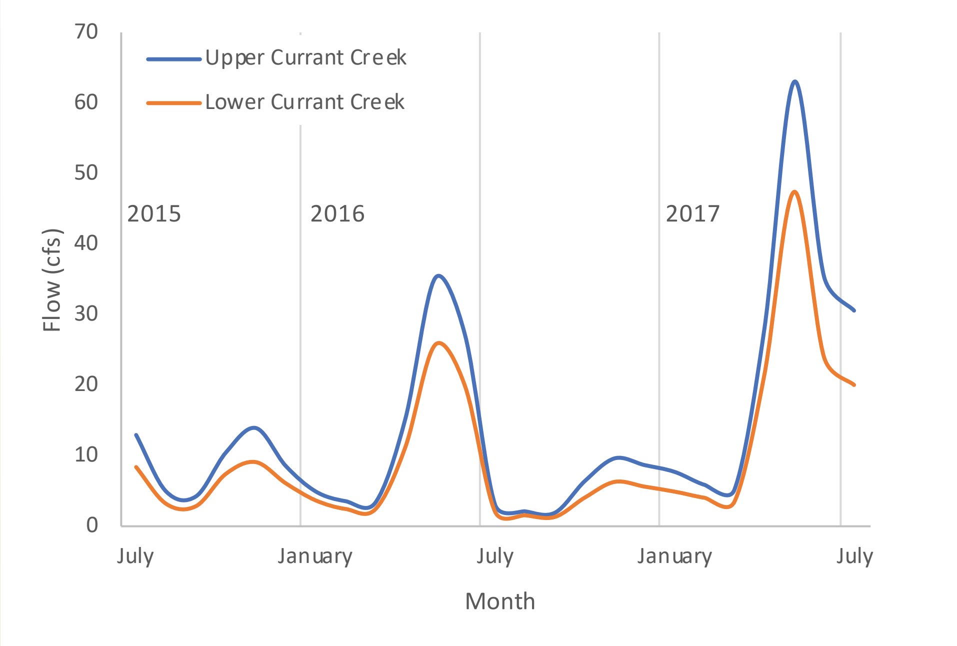
- Natural recharge from precip
- Based on grid data from BCM USGS SIR2010-5193
- Grid size 250 x 250 m
- Total recharge = recharge + 30 %(runoff)
- Total Recharge (acre-ft/yr) : Zone 1 = 1300, Zone 2 = 4170, Zone 3 = 2620, and Goshen = 8090

Surface flow

- Goal to constrain surface flow and its relation to GW budget
- Based on seepage run flow measurements, continuous records where possible, and mapping



Comparison of flow at Flumes



- Continuous record for both flumes
- Good correlation
- Lag in time for troughs and peaks
- Annual average flow of 14 cfs at Currant Creek
- Reduction in flow between 23% and 45% of total volume
- The difference in flow likely represents groundwater recharge
- Recharge assuming 34% loss is 4.8 cfs or 3480 acre-feet/year
- Remainder 9.2 cfs or 6660 acre-feet per year consumed for ag, veg ET and wetlands below Goshen Reservoir

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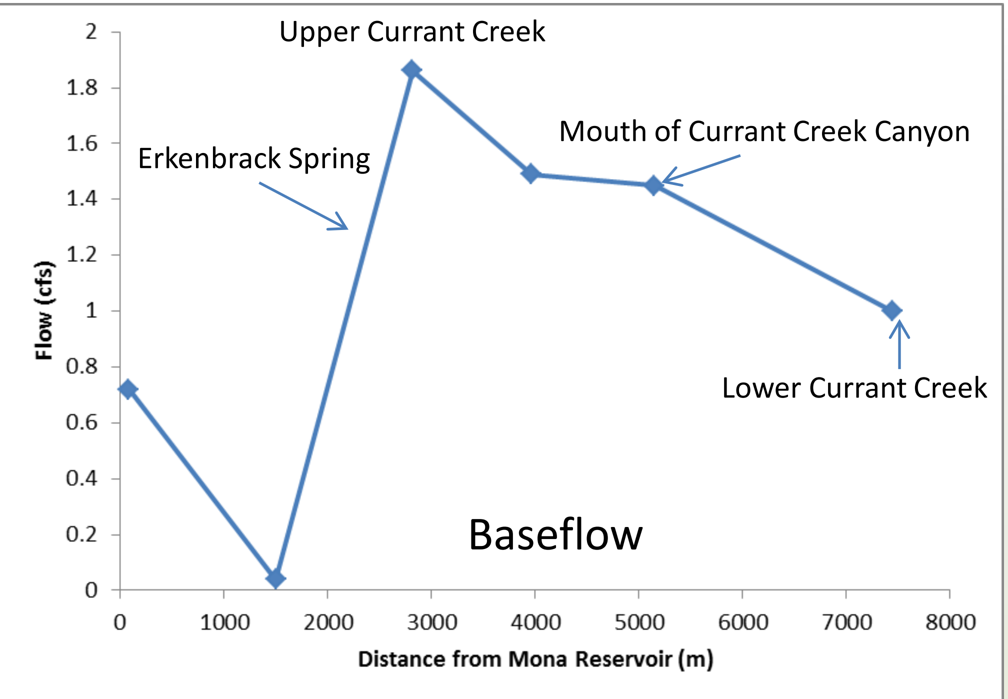
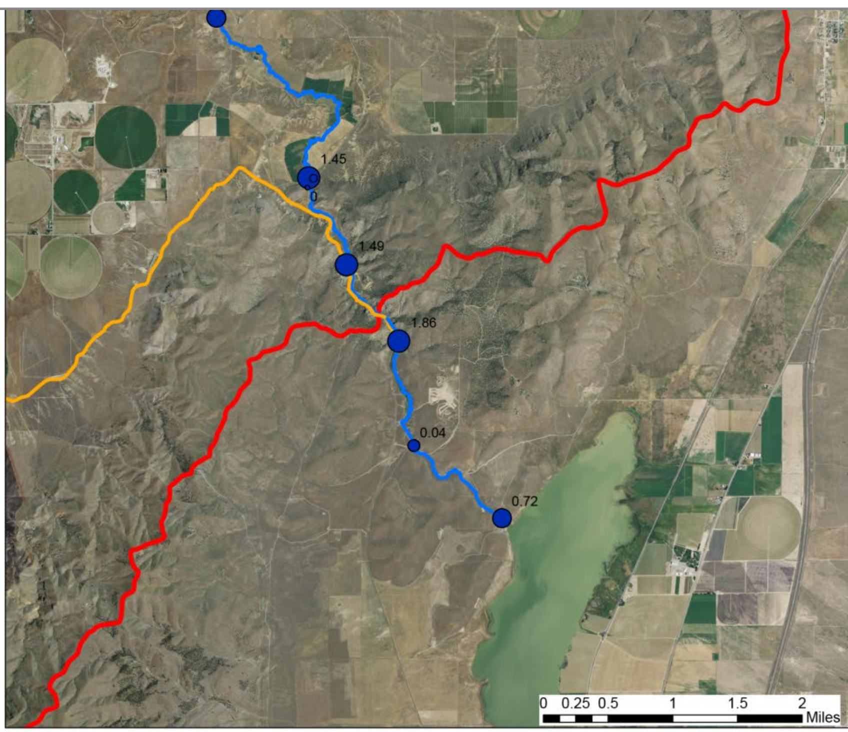
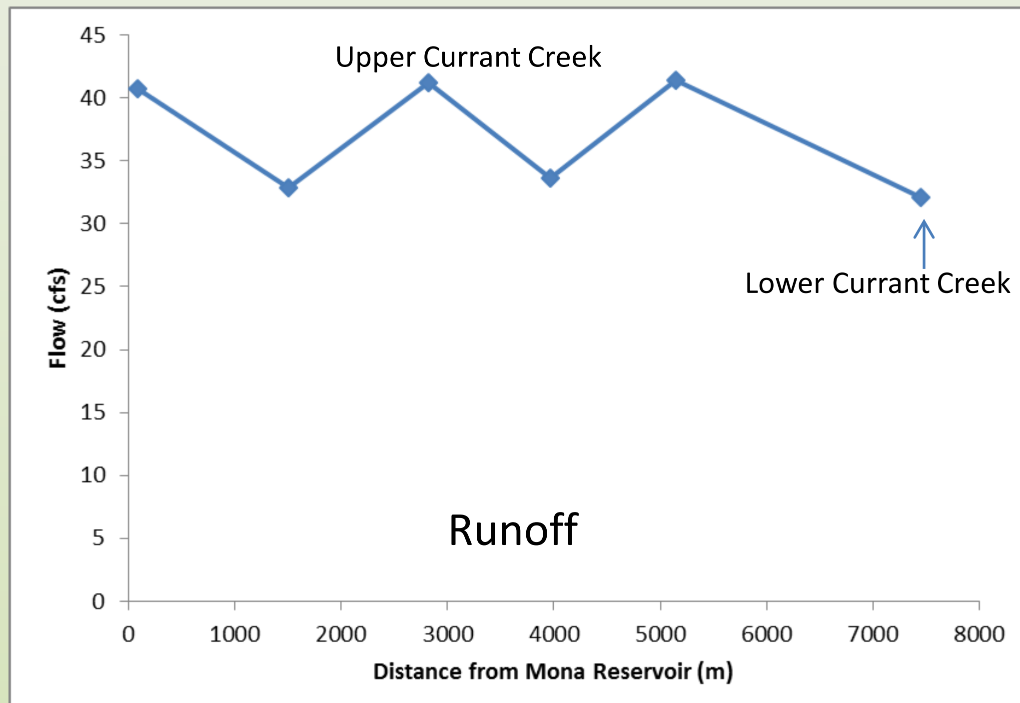
Currant Creek

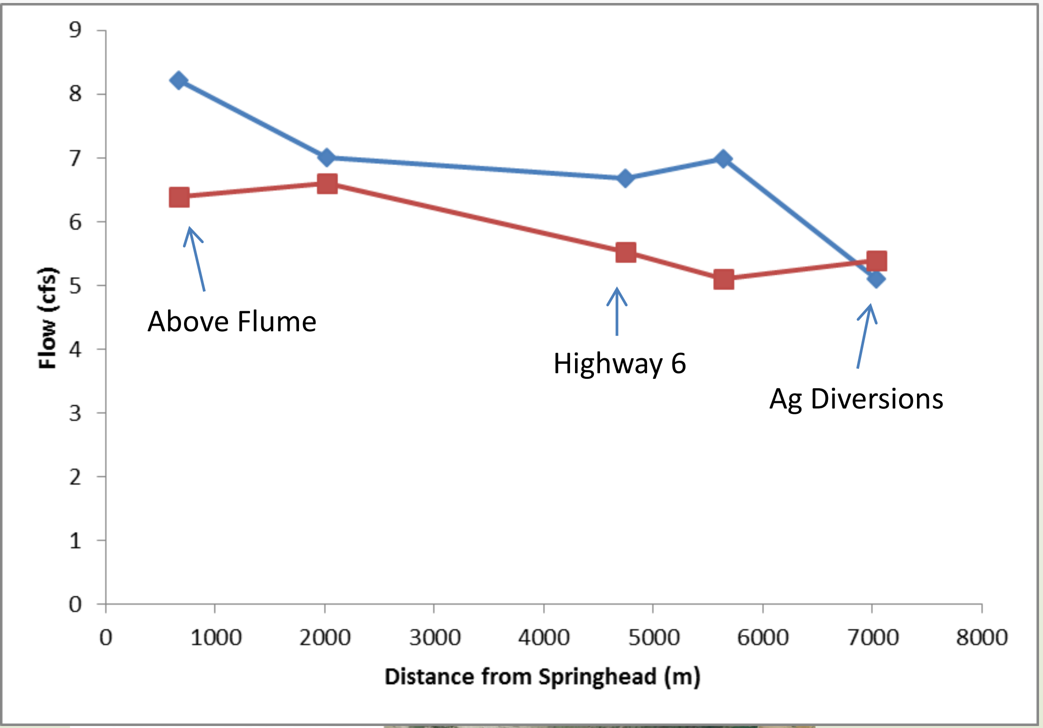
- Measured in channel and at flumes on 8/24/15 and 5/12/16
- Good baseflow and runoff conditions
- Low flow from Mona
- Gains from springs, losses to GW? below flume
- Loss between flumes is 0.86 cfs or ~ 45% of total flow at baseflow and 9 cfs or ~23% of total flow at runoff



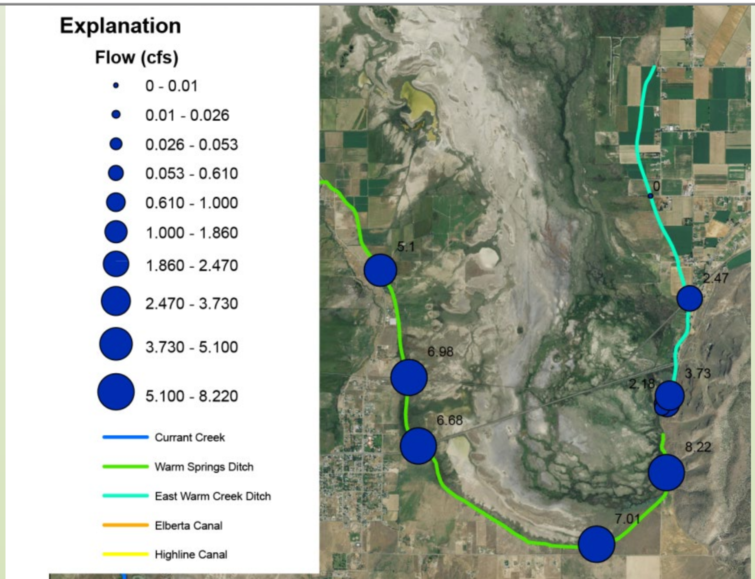


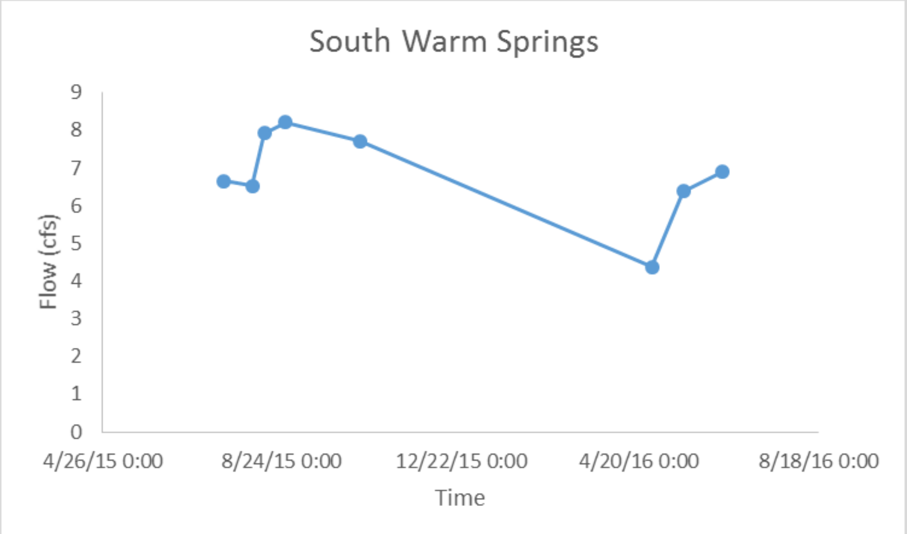


S Warm Springs Canal

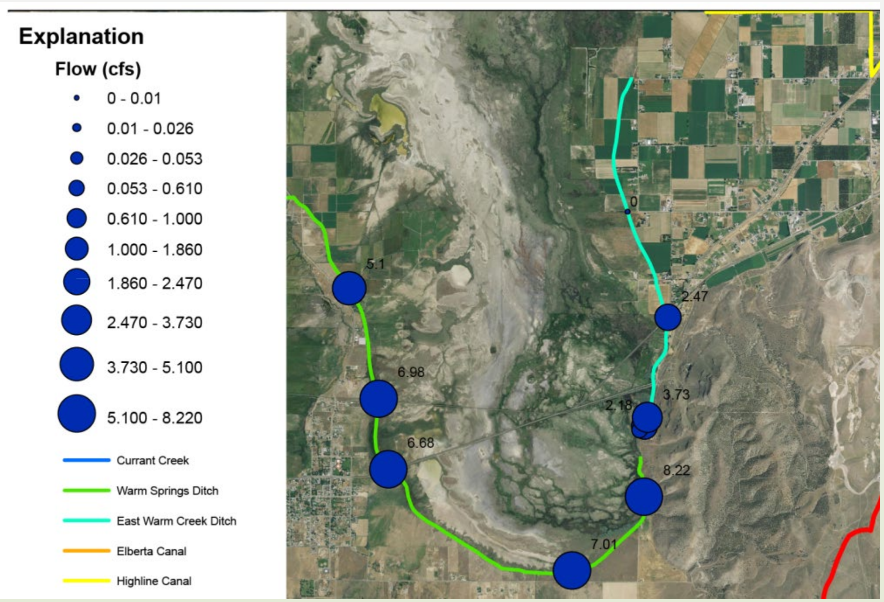


- Continous flow varies from 8 – 4 cfs depending on season
- Seepage measured 8/26/15 and 5/17/16 in channel and at structures (culverts, headframes)
- Decreases along canal ~ 5 cfs
- Most of this loss is likely surface flow onto wetlands… smaller portion could enter GW





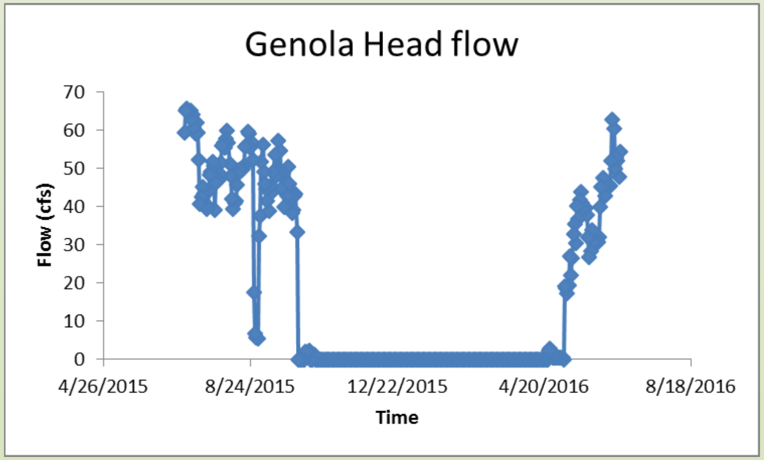
N Warm Springs



- N Warm Springs flow 3.7 cfs – 4.1 cfs; assume 3.9 cfs or 2820 acre-feet per year
- Flow quickly shunted onto ag lands and wetlands to the west
- Total Warm Springs flow N and S is ~10-12 cfs
- Previous chemistry supports Warm Springs discharge originating outside basin

Surface Water Details

- Total Warm Springs based on seepage runs is 12.3 cfs or 8960 acre-feet/year most lost to wetlands, less to Ag
- Major surface water supplied by Highline canal to zone 3
- Highline canal annual flow 19 cfs or 13,760 acre-feet per yr, taken from genola head (data available online)
- Utah lake water supplied to zones 1 and 2
- Annual flow 6.8 cfs or 4940 acre-feet per yr, taken as average of data supplied by Farmland Reserve
- Annual flow Bateman declining through time average 2.7 cfs or 1960 acre-feet/year



Surface Water Summary

- Annual average Currant Creek flow is 14 cfs
- ~34 %, 4.8 cfs or 3480 acre-feet/year for recharge, remainder 9.2 cfs or 6660 acre-feet/year likely consumed by ET, wetlands, and Ag
- Total discharge from Warm Springs is 12.3 cfs or 8960 acre-feet/year
- Highline at Genola Head average annual is 19 cfs or 13760 acre-feet/year
- Utah Lake water 6.8 cfs or 4940 acre-feet/year for Farmland Reserve; Bateman declining through time average 2.7 cfs or 1960 acre-feet/year
- Little if any surface water to Utah Lake (Water Managers) and obs
- This water is likely consumed via ET, Natural and Ag in zone 3

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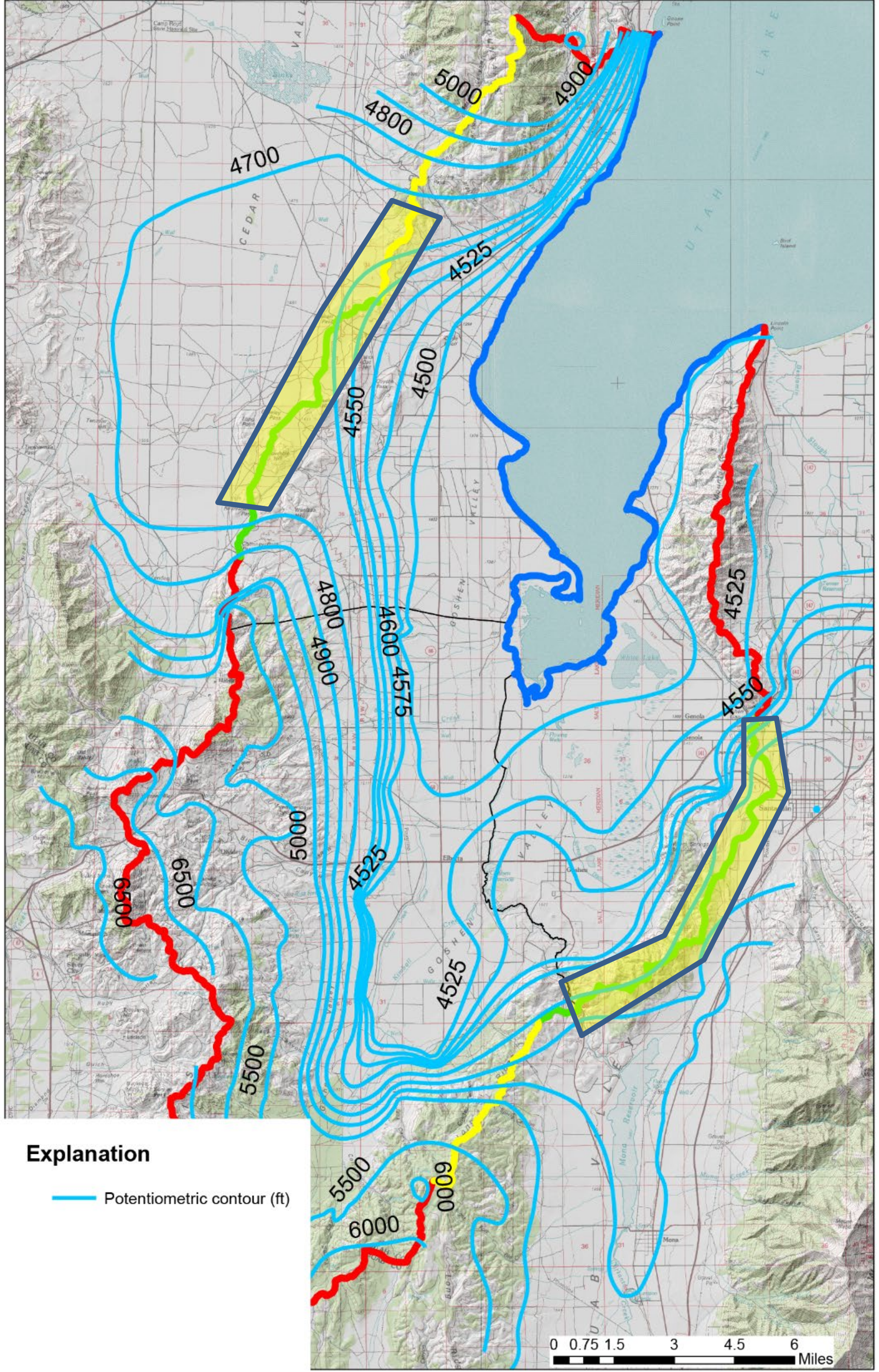

Subsurface inflow

- Infow into zone 1 and 2
- Mosida Hills, N. Long Ridge
- Mosida Hills Previous Est. 2300-5000 acreft/yr via Darcy Flux (Hood and others, 1969)
- Model calibrated 4700 acreft/yr (Jordan and Sabbah, 2012)
- Darcy Flux method for Long Ridge Q = TIL, where Q = Flux, T=Transmissivity, I=Potentio Gradient, and L=Section Length
- Darcy flux for Long Ridge is between 16.6 and 19.5 cfs or (12,000 and 14,200 acre-ft/yr)
- Values are high but reasonable… we already have measured discharge from Warm Springs ~12cfs most of which likely sourced outside basin (see Hurlow and others, 2022)

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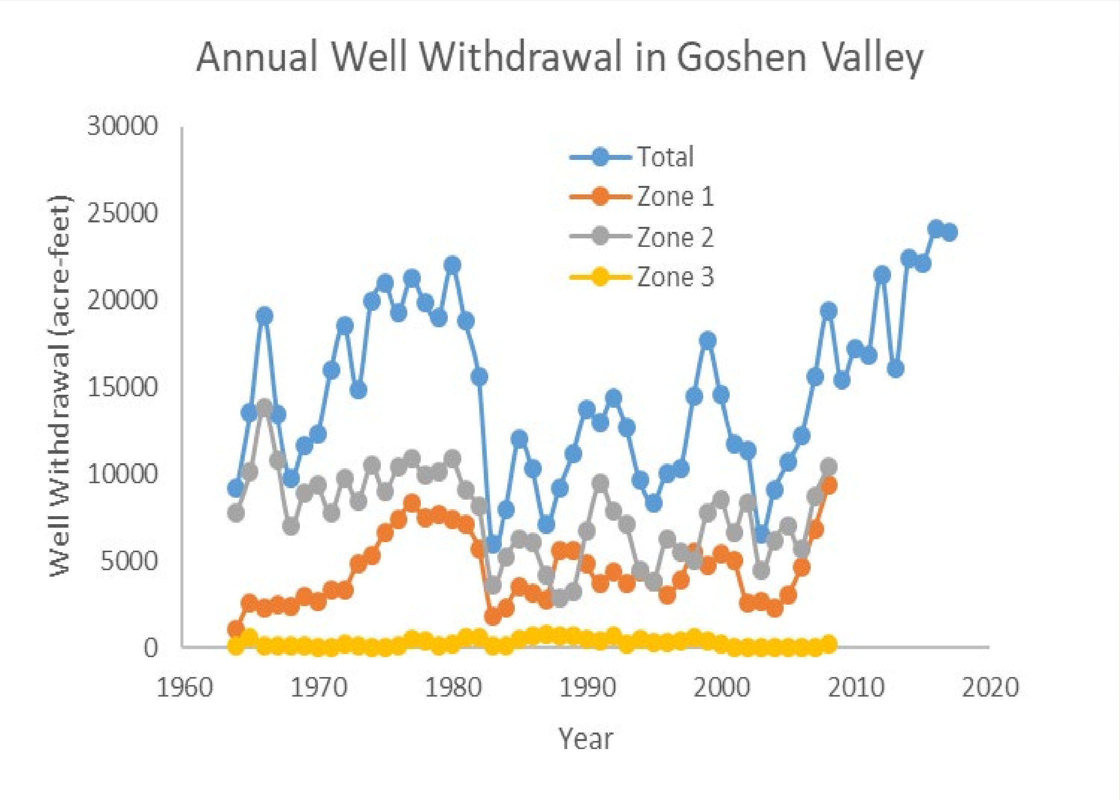
Well Withdrawal



- Data from USGS; due to lack of recent data by zone, averages based on long term, Zone 1 = 35%, Zone 2 = 62%, Zone 3 = 3%
- Apply Zone averages to recent total pumping 2008-2017 (to fit with irrigated areas ET)
- **Total Goshen Average Withdrawal 19,910 acre-feet/yr**
- Average Zone 1 = 6930 acre-feet/yr
- Average Zone 2 = 12430 acre-feet/yr
- Average Zone 3 = 550 acre-feet/yr

Wetlands ET Community Mapping

Shrubland

Meadow

Sparse Shrubland

Moist Bareground

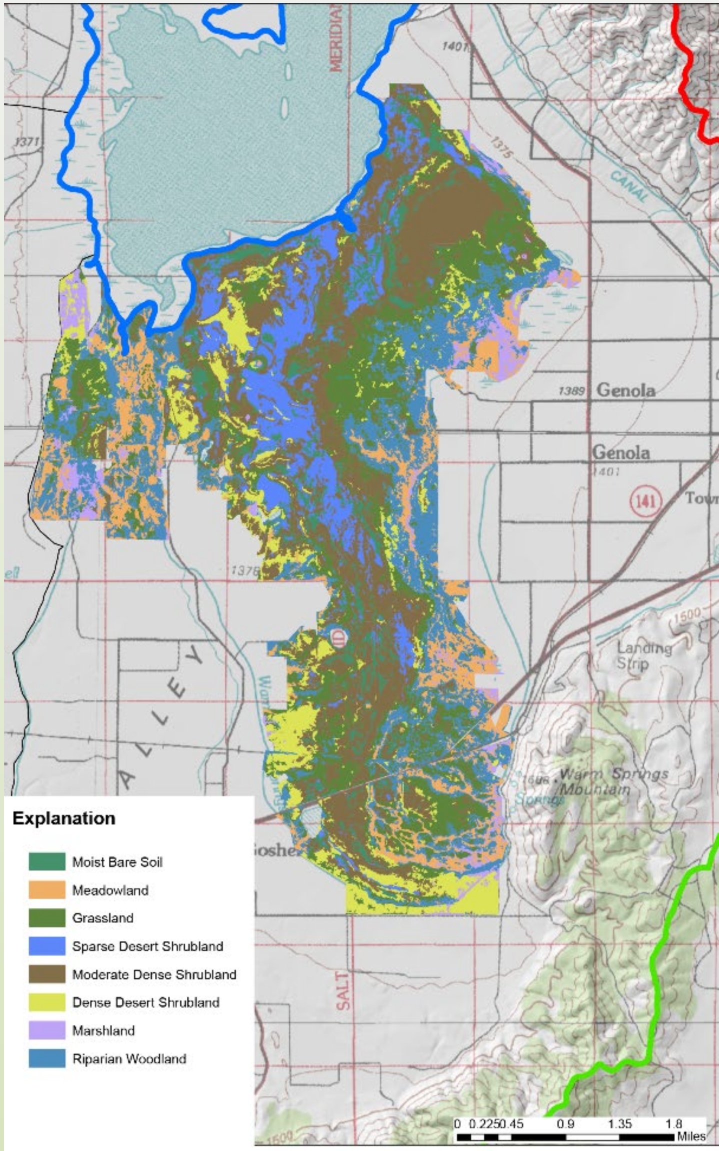
Emergent

Grassland

Wetlands ET estimate

- Previous ET estimates are between 27,000 and 14,000 acreft/yr (Cordova, 1970; Brooks and Stolp, 1995)
- ET calculated using mapped acreage and existing measured ET rates (Welch and others, 2007; Leenhouts and others, 2006)
- Natural ET 17,600 acre-ft/yr is large
- Water available for ET includes Significant Surface Water Supply plus GW
- GW ET = Total ET (Ag+Natural) – Potential Surface Water Supply
- We still need Ag ET in adjoining areas to calculate GW ET

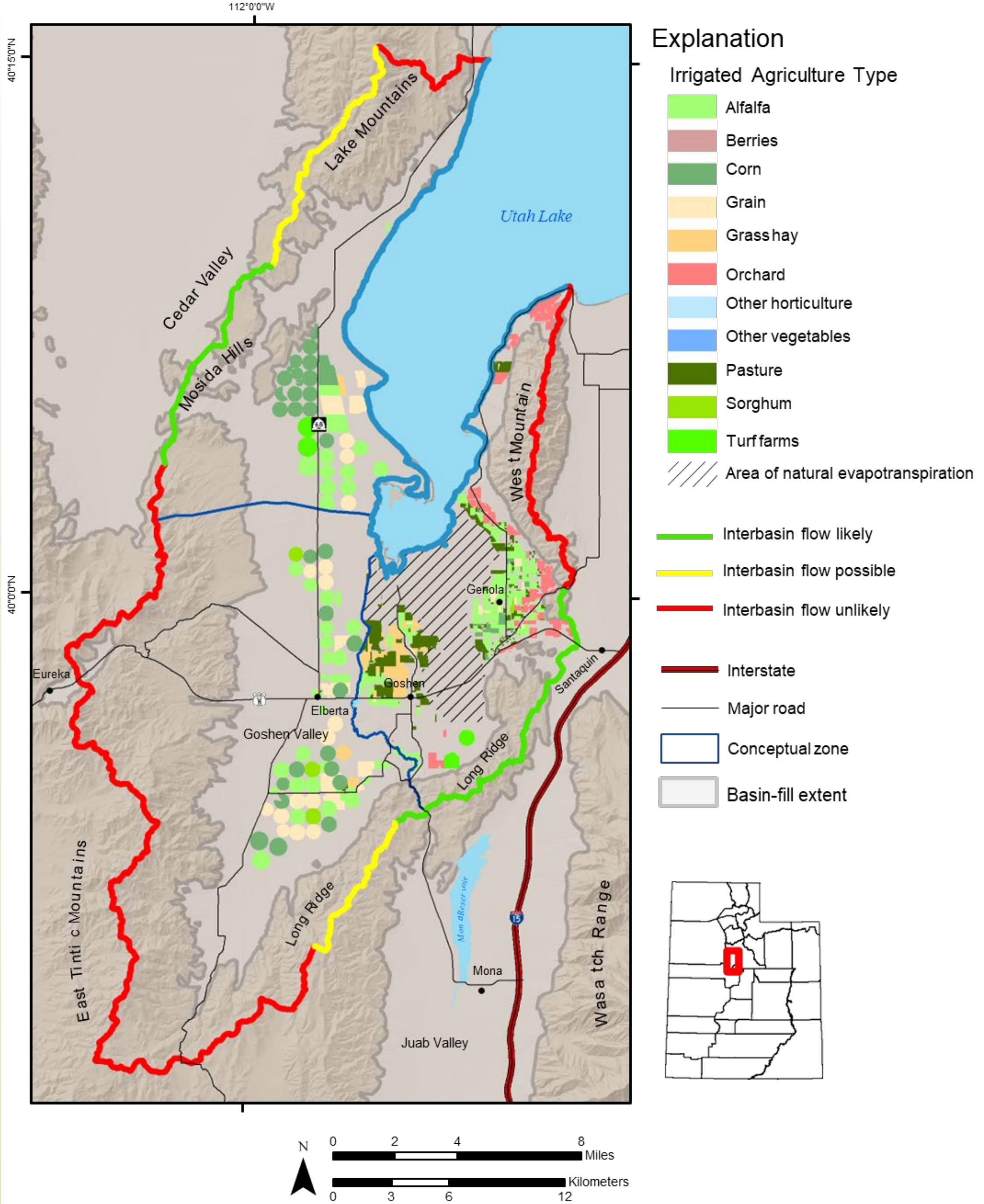
ET community	Area(acres)	annual ET (ft)	Annual ET volume (acre-ft/yr)
Moist Bare Soil	482	2	964
Grassland	1920	2.14	4109
Meadowland	1022	2.59	2647
Sparse Desert Shrubland	864	0.9	778
Moderate Dense Shrubland	2152	1.07	2303
Dense Desert Shrubland	892	1.24	1106
Riparian Woodland	1506	3	4518
Marshland	292	4.07	1188
Total	9130		17613



Crop ET

- Taken from land use data (UDWR) and crop use tables (USU extension)
- These data are broadly consistent with applied water amounts
- Preferred after consideration of Metric analog models and SSEBop data; both of which did not yield results consistent with applied water; likely due to averaging problems
- Used to come up with unconsumed irrigation

Zone	AG ET using standard rates
1	8210
2	13560
3	16830



Groundwater ET

Zone 3 groundwater ET					
Available surface supply			ET		
Currant Creek	Goshen Warm Springs	Highline Canal	Natural ET	Ag ET	Groundwater ET
6660	8690	13760	17600	16830	-5320

- Possible in areas of shallow gw <20 feet
- DTW considerations largely rule out zones 1 and 2
- Groundwater ET taken as remainder of available surface water minus all ET
- Assumed to occur primarily in wetland areas in zone 3

Other ET and Unconsumed Irrigation

- Groundwater ET taken as remainder of available surface water minus all ET Possible in areas of shallow gw <20 feet. DTW considerations largely rule out zones 1 and 2.
- Unconsumed Irrigation. Taken as residual between applied water and crop ET zone 1 and 2

Zone	AG ET using standard rates
1	8210
2	13560
3	16830

Zone 3 groundwater ET

Available surface supply			ET		
Currant Creek	Goshen Warm Springs	Highline Canal	Natural ET	Ag ET	Groundwater ET
6660	8690	13760	17600	16830	-5320

	Unconsumed irrigation Applied water Well withdrawal	Utah Lake Pumpage	Total applied water	Ag ET	Unconsumed irrigation
Zone 1	6930	1960	8890	8210	680
Zone 2	12430	4940	17370	13560	3810

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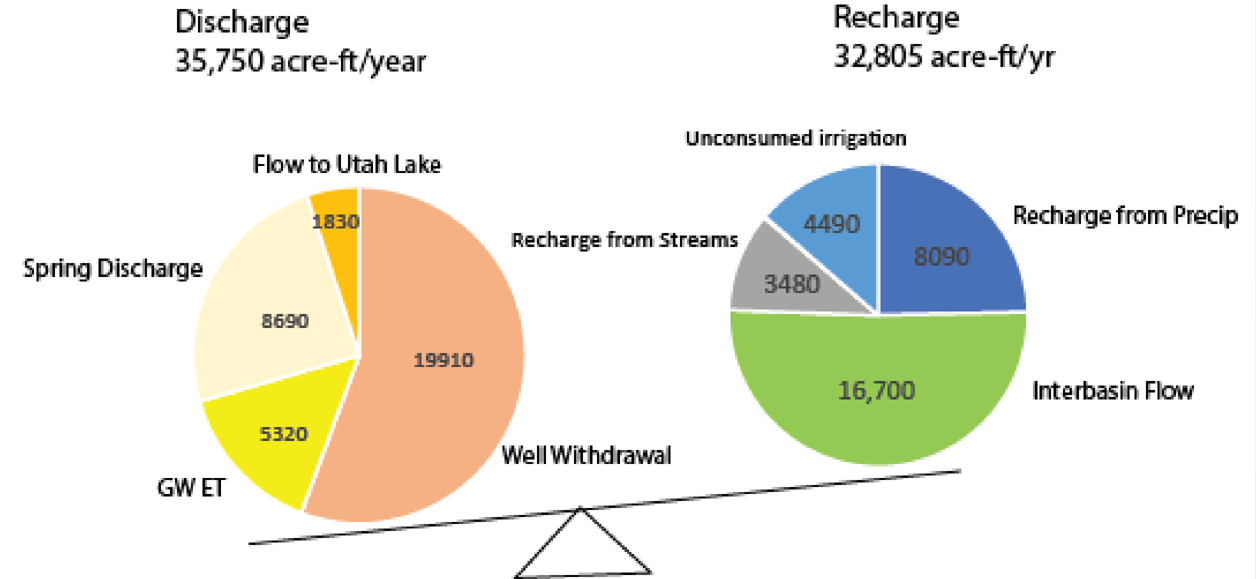
Water Budget Components

	Component	Zone 1	2	3	Total
Recharge	Recharge (precip+runoff infil)	1300	4170	2620	8090
	Interbasin flow	4700	0	12000	16700
	Perennial stream seepage	0	1740	1740	3480
	Domestic return flow	5	10	30	45
	Unconsumed irrigation	680	3810	0	4490
	Total Recharge	6685	9730	16390	32805
Discharge	Well withdrawal	6930	12430	550	19910
	Groundwater ET	0	0	5320	5320
	Spring discharge	0	0	8690	8690
	GW discharge to Utah Lake	0	0	1830	1830
	Total discharge	6930	12430	16390	35750
	Change in storage	-245	-2700	0	-2945

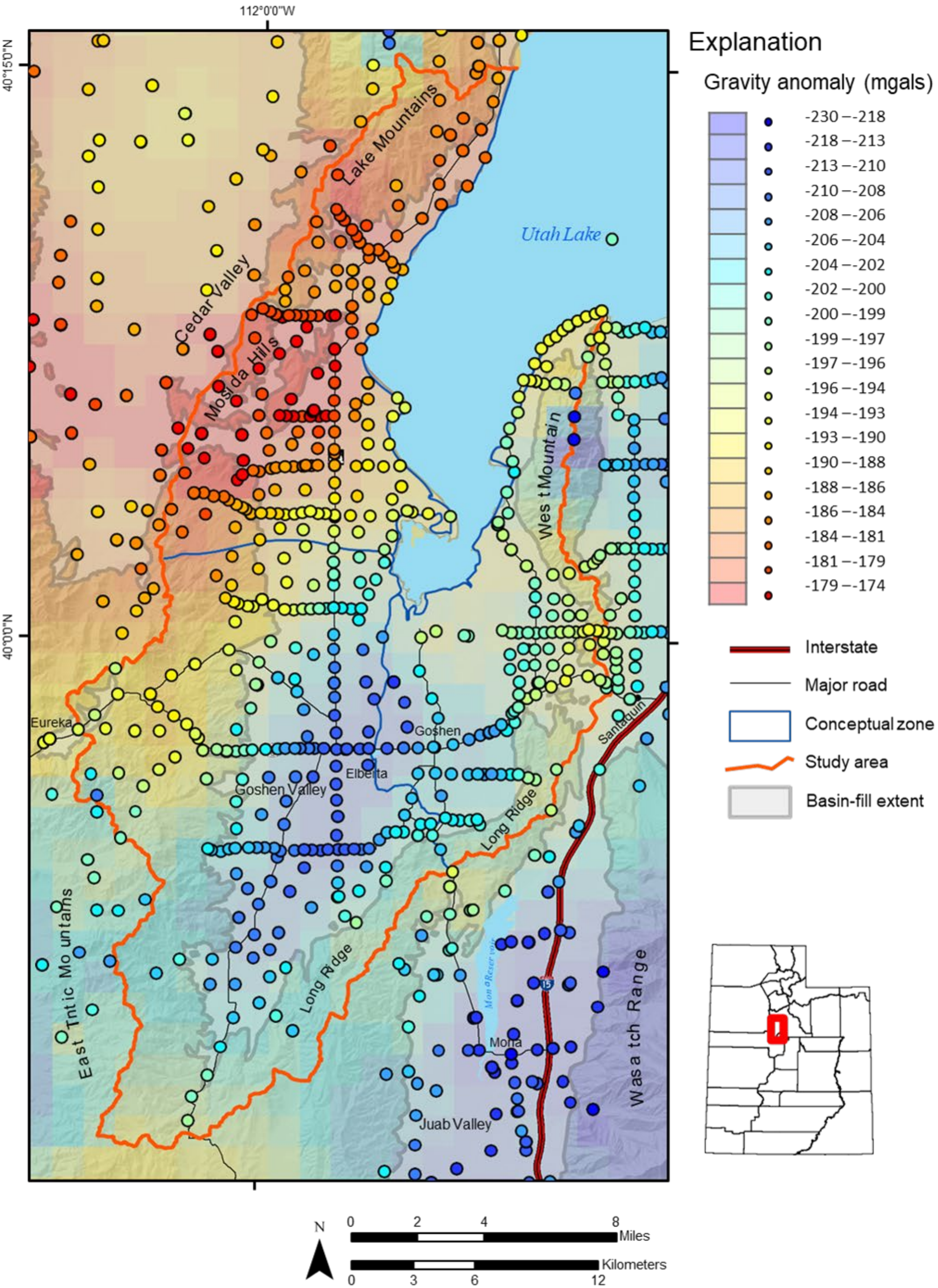
- Flow to Utah lake is residual, likely not required… may be possible in zone 3
- Change in storage taken as remainder in zones that have declining water levels
- Broadly consistent with conceptual model and previous work



Water budget summary

- Total Recharge 32,805 acre-ft/yr
- Most recharge likely from interbasin flow, lesser from precip and infiltration of surface water
- Total Discharge 35,750 acre-ft/yr
- Most discharge from well withdrawal, lesser from spring discharge and GW ET
- Difference between recharge and discharge is -2945 acre-ft/yr, this is change in storage in zones 1 and 2 (water level decline)
- Potentially very little GW discharge to Utah Lake

End



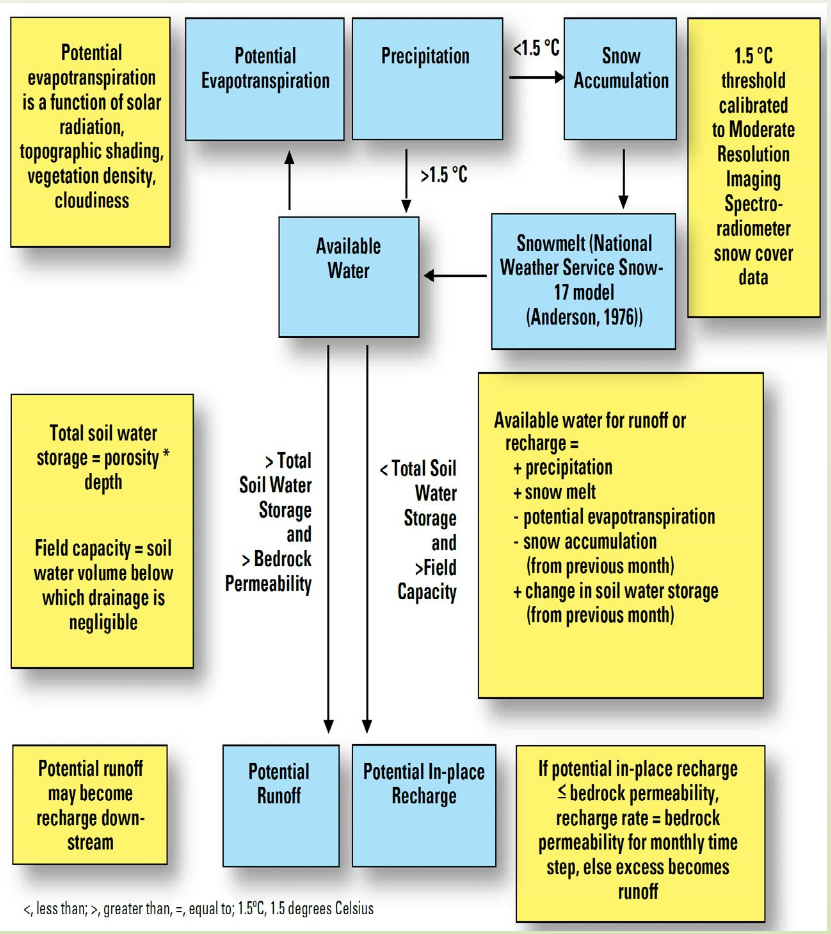
Geophysics and Basin Fill Thickness

- Goal to define basin fill thickness with well constraints
- Low grav = thick basin fill
- High grav = thin basin fill or bedrock
- Several hundred new points collected
- Low and deepest basin fill W of Goshen
- Used to model actual basin fill thickness

UTAH DNR GEOLOGICAL SURVEY

BCM description

- Standard USGS Recharge and Runoff Model based on climate inputs, soil water balance, and geology (Flint and others, 2004; Flint and Flint, 2007; Heilwiel and Brooks, 2011)
- Based on climate data from 1940-2006, applied across the western US
- “hand calibrated” to surface stream flow
- Output is grid of recharge and runoff (Heilwiel and Brooks, 2011)
- Unfortunately BCM Code is unavailable!



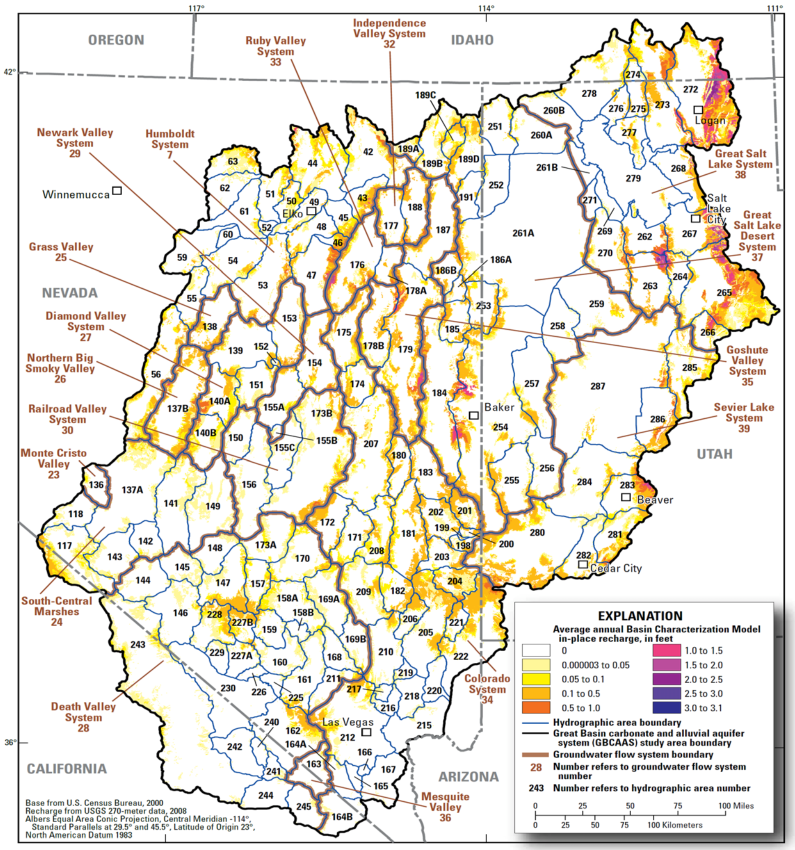
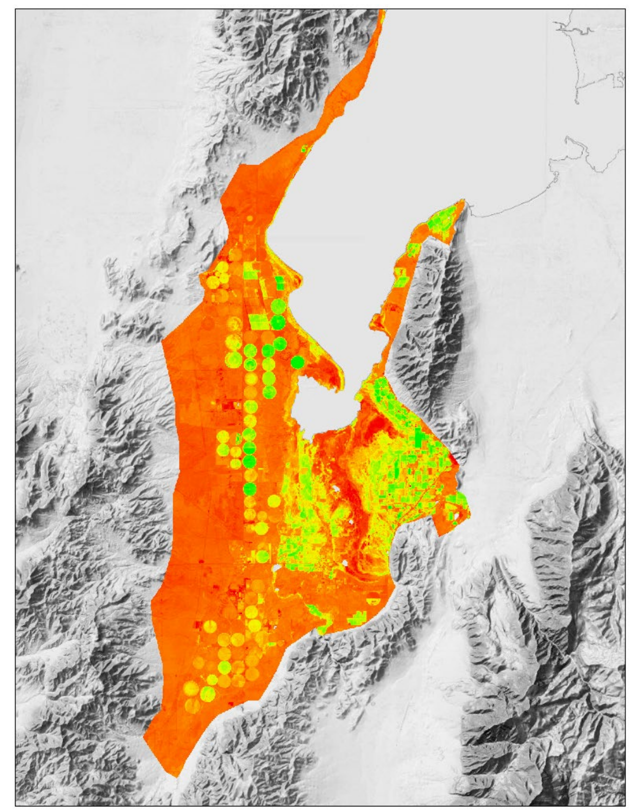


Figure D–5. Distribution of average annual 1940–2006 Basin Characterization Model (BCM) in-place recharge for the Great Basin carbonate and alluvial aquifer system study area.

Unconsumed Irrigation Water

	Unconsumed irrigation				
	Applied water				
	Well withdrawal	Utah Lake Pumpage	Total applied water	Ag ET	Unconsumed irrigation
Zone 1	6930	1960	8890	8210	680
Zone 2	12430	4940	17370	13560	3810

- Taken as residual between applied water and crop ET
- Crop ET taken from standard irrigation tables for Santaquin and applied to land use
- Zone 3 does not require any unconsumed irrigation, ie crop ET greater than applied water; ie crops consume GW in shallow DTW areas or within error of ET or applied water



Stable isotopes

- Stable isotopes 2H and 18O conservative tracer that records sources of recharge (vary's with temperature and elevation of precip, evap)
- Measured for all samples, includes surface water and groundwater
- Difference between surface sources and groundwater
- Overlap across the system