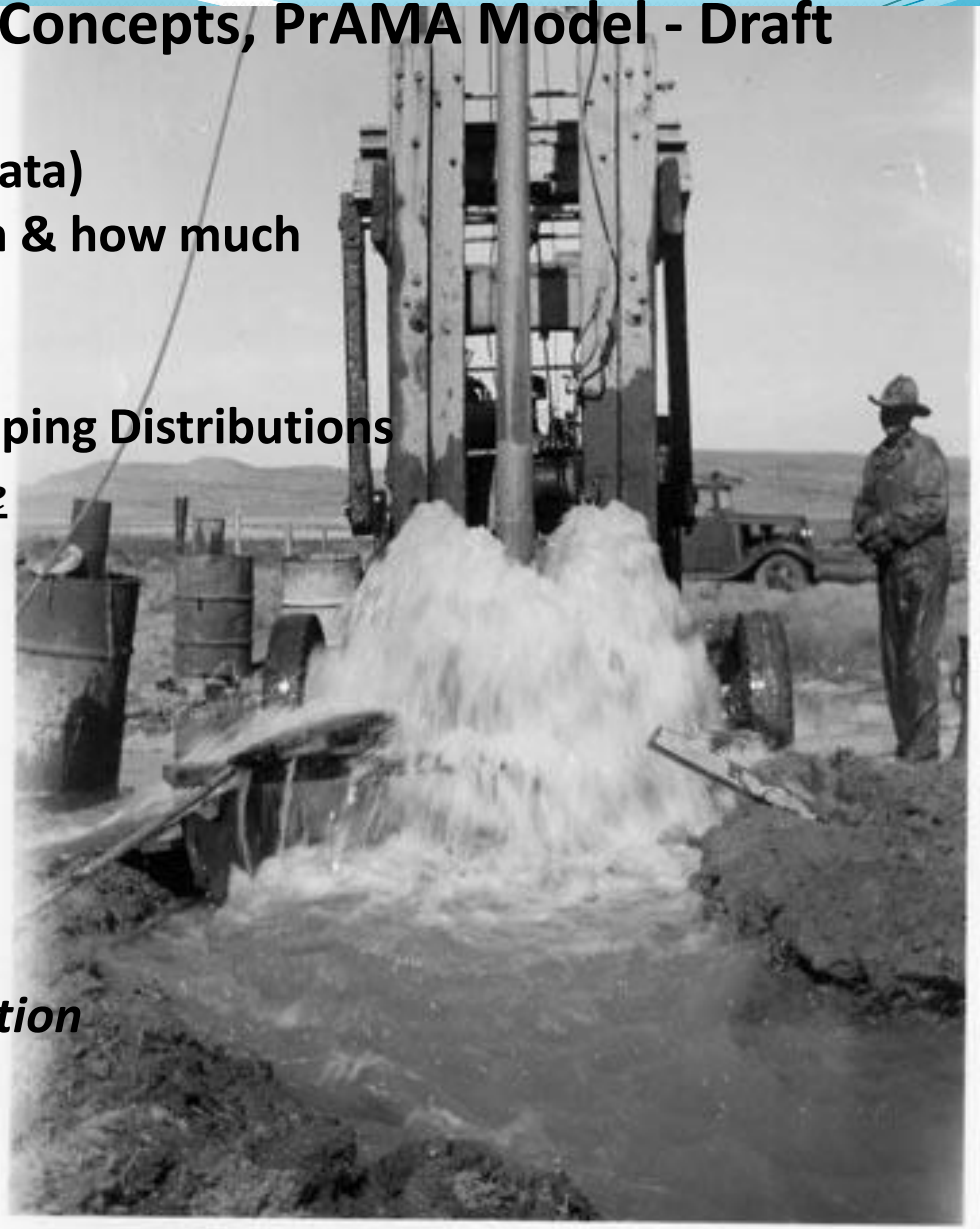
Exploring Water Management Concepts, PrAMA Model - Draft

-Regional Hydrology (as defined by data)
Recharge Distribution: where, when & how much
Aquitard Distribution…

-Compare Base vs. Hypothetical Pumping Distributions
Rejected Recharge & Induced Recharge

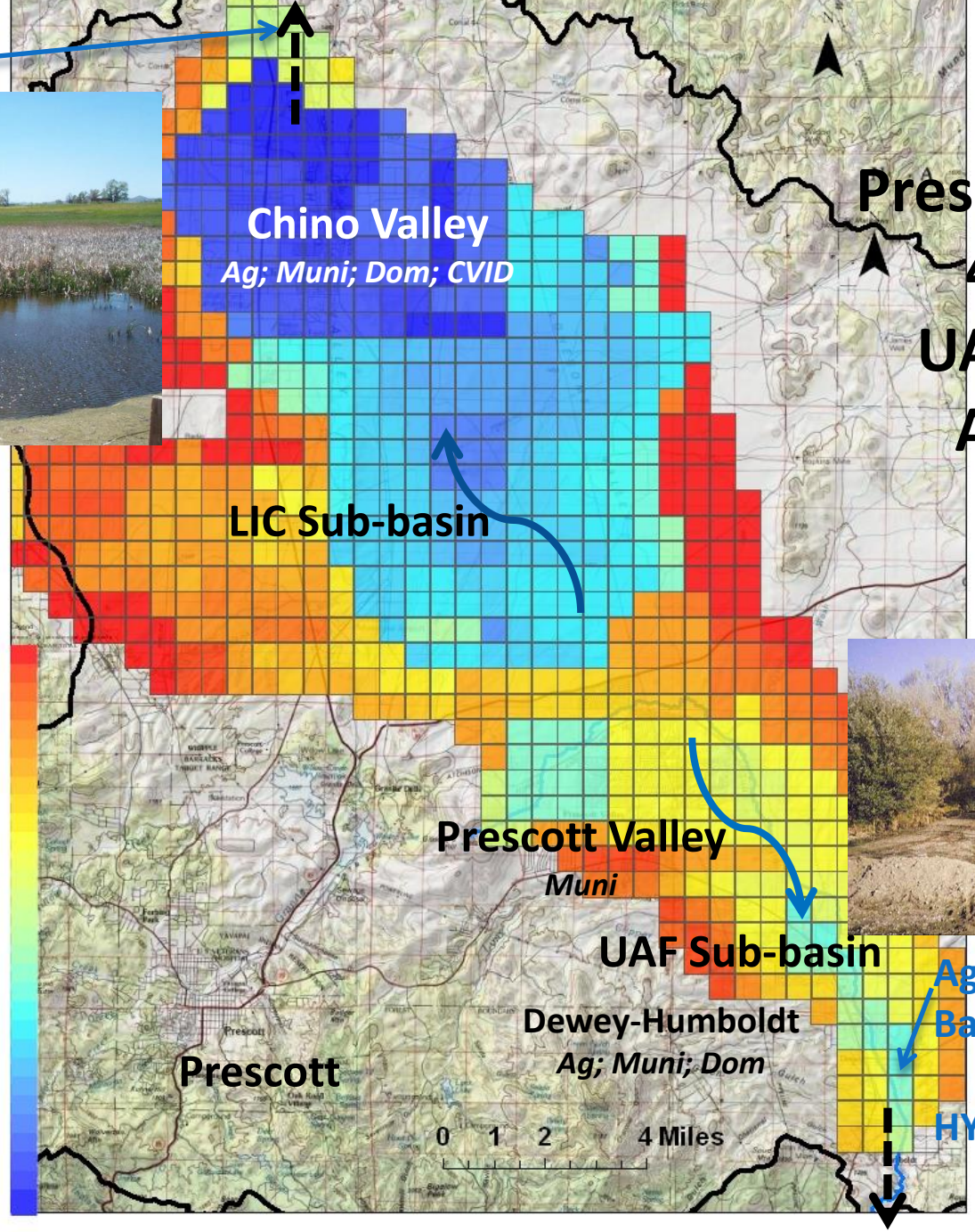
-Possible Projects:
Redirect PPT → EVAP /Runoff
to Effective Recharge Areas



Acknowledgments
ADWR Field Services & Modeling Section
USGS; Drillers, Hydro/geo,
Geotechnical Studies
Stakeholders, Citizens

Contact: kmnelson@azwater.gov

Del Rio Springs



Prescott AMA , 485 mi^2 UAU & LVU Aquifers

Simulated Total Transmissivity

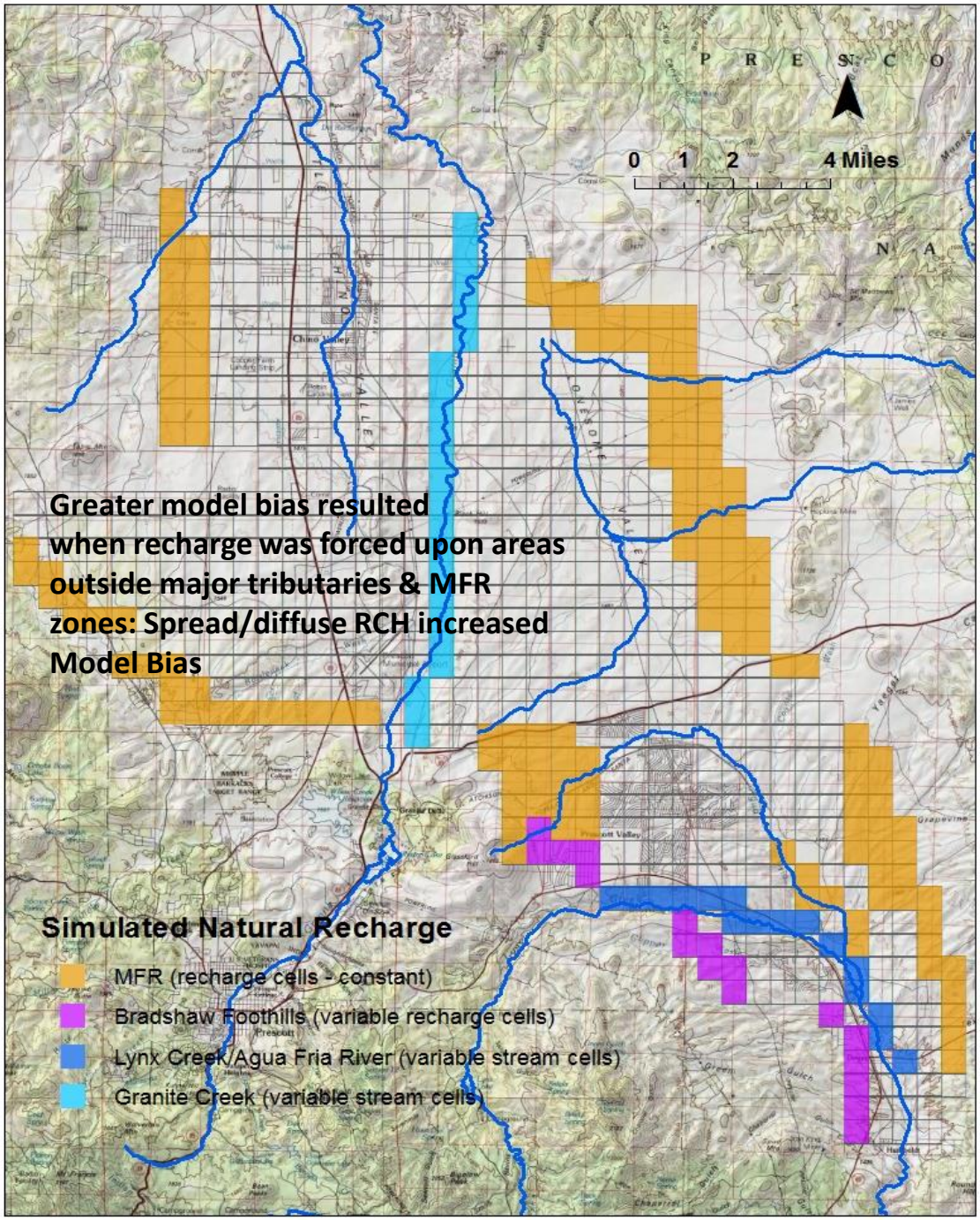
Low T

Modest T

High T

Agua Fria River Baseflow;

HYW 69 Revisited



Plausible Range of Natural Recharge Based on available data (1939-2011):

7,500 – 12,000 AF/yr *(95% CI, 5K-15K)*

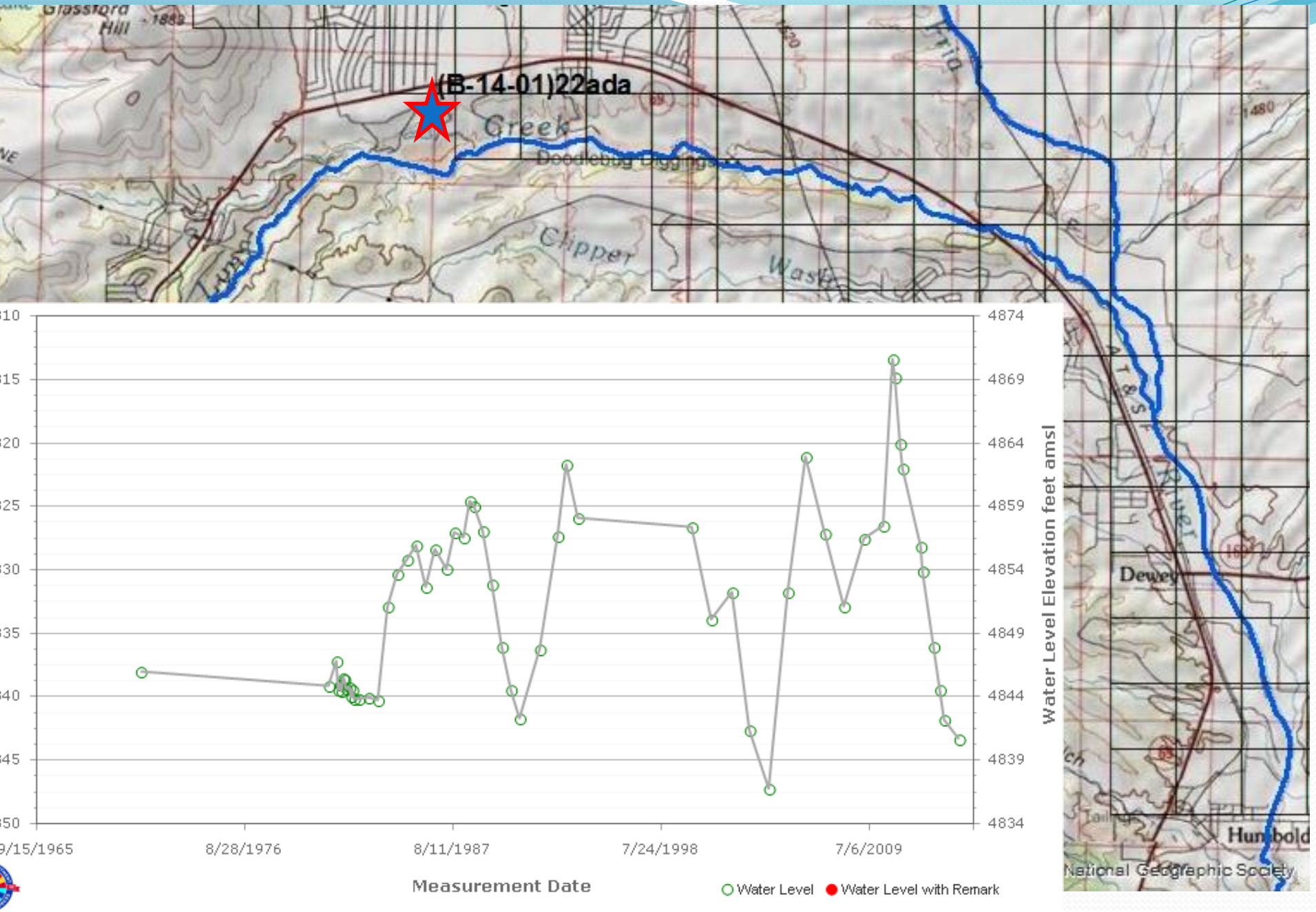
***Long-Term* Natural Recharge Rate**

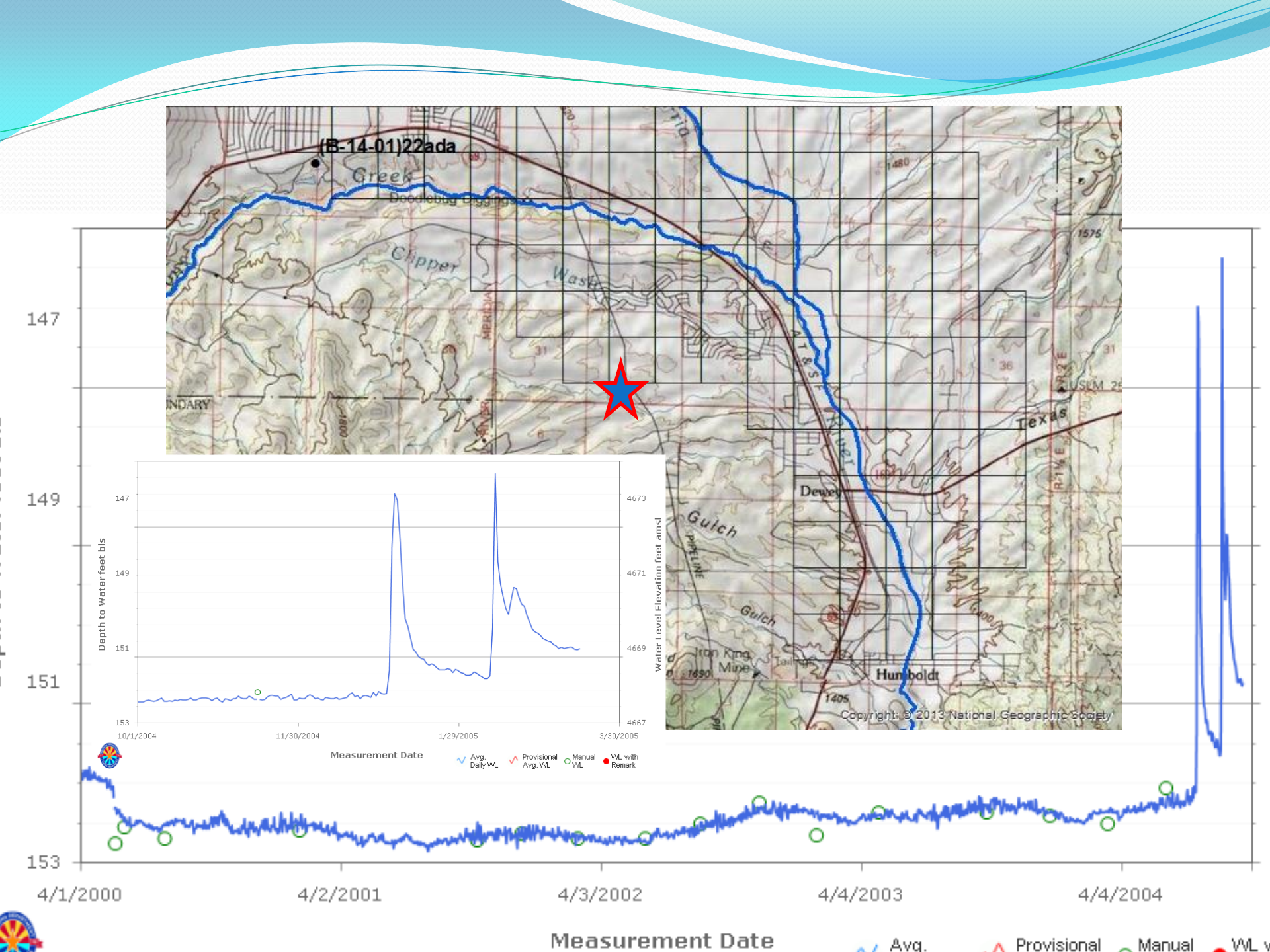
~2/3 Variable Streams

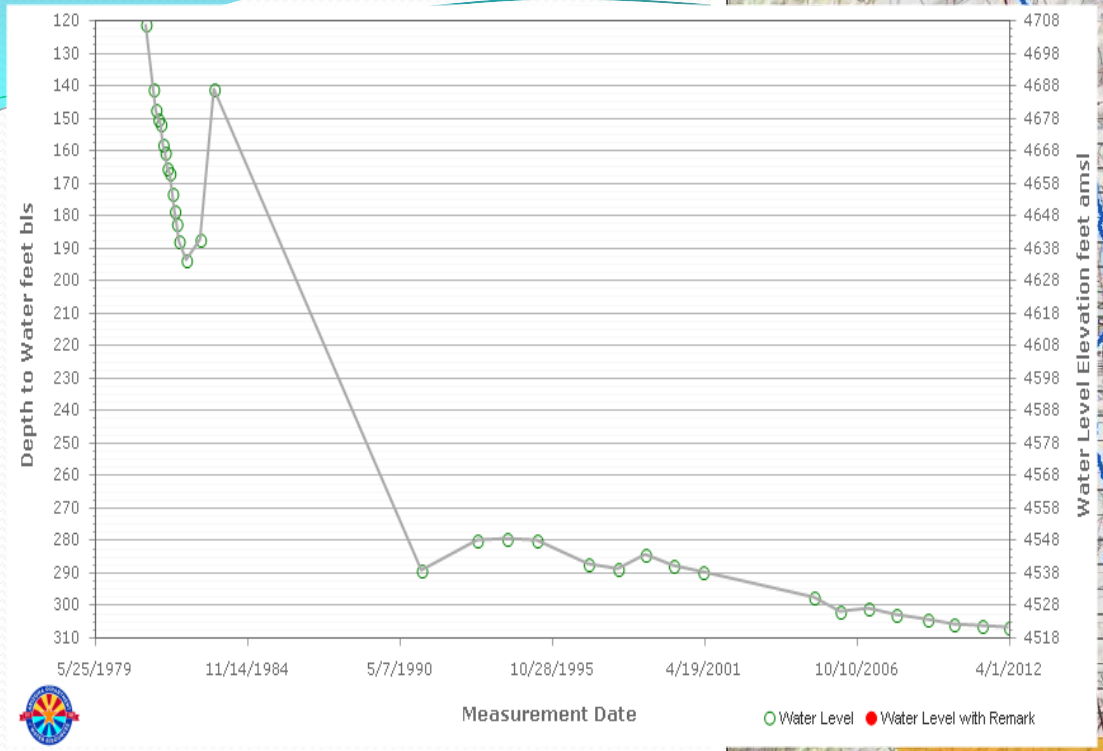
~1/3 Uniform MFR

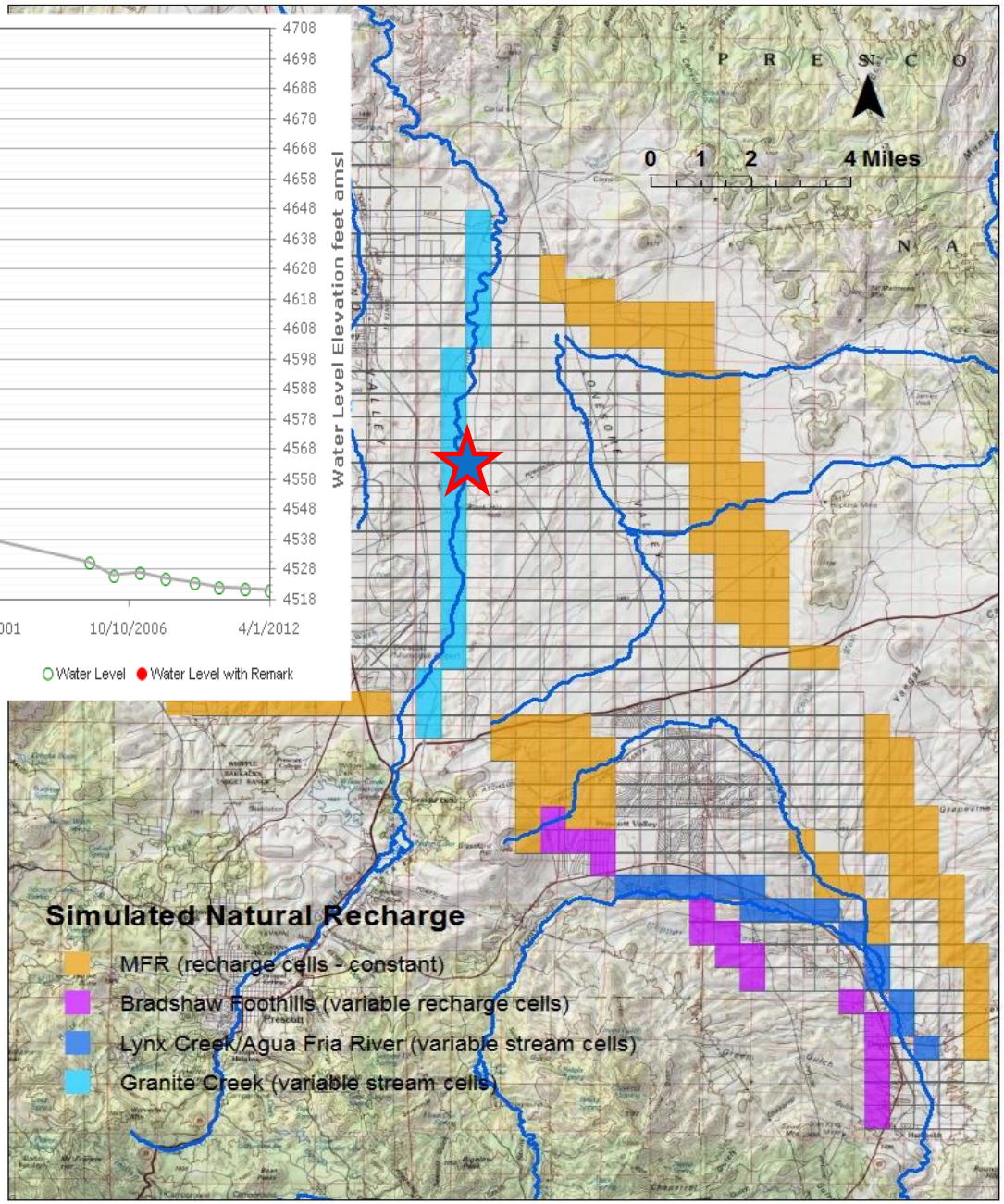
Aquifer Recharge Distribution

Photo, Chino Valley Review; D. McMillian

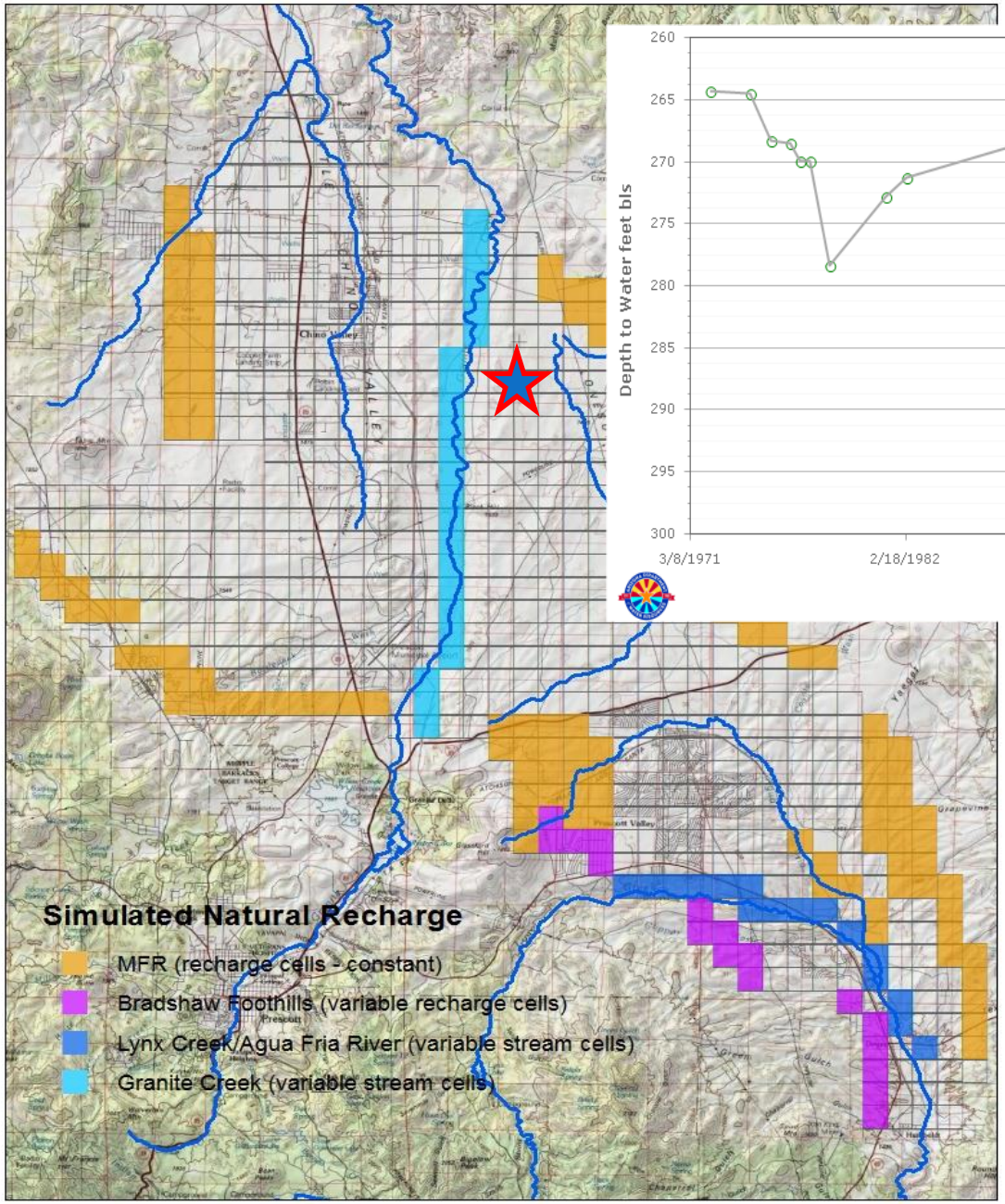

(B-14-01)22ada
Glassford Hill
Creek
Doodlebug Diggings
Clipper
Wash
Dewey
Humbold
National Geographic Society
Water Level Elevation feet amsl
4874
4869
4864
4859
4854
4849
4844
4839
4834
9/15/1965
8/28/1976
8/11/1987
7/24/1998
7/6/2009
Measurement Date
Water Level
Water Level with Remark

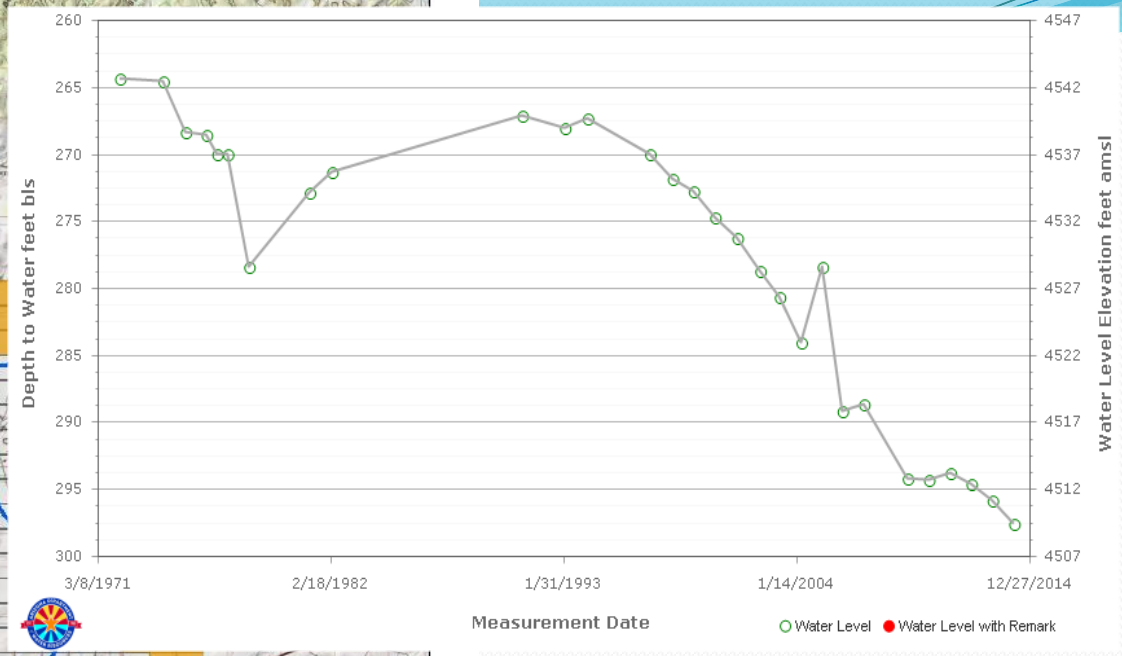

(B-14-01)22ada
Greek
Clipper
Wash
Texas
Dewey
Gulch
Gulch
Iron King Mine
Humboldt
Copyright © 2013 National Geographic Society
Depth to Water feet bls
Water Level Elevation feet amsl
147
149
151
153
4673
4671
4669
4667
10/1/2004
11/30/2004
1/29/2005
3/30/2005
Measurement Date
Avg. Daily WL
Provisional Avg. WL
Manual WL
WL with Remark
4/1/2000
4/2/2001
4/3/2002
4/4/2003
4/4/2004
Measurement Date
Avg.
Provisional
Manual



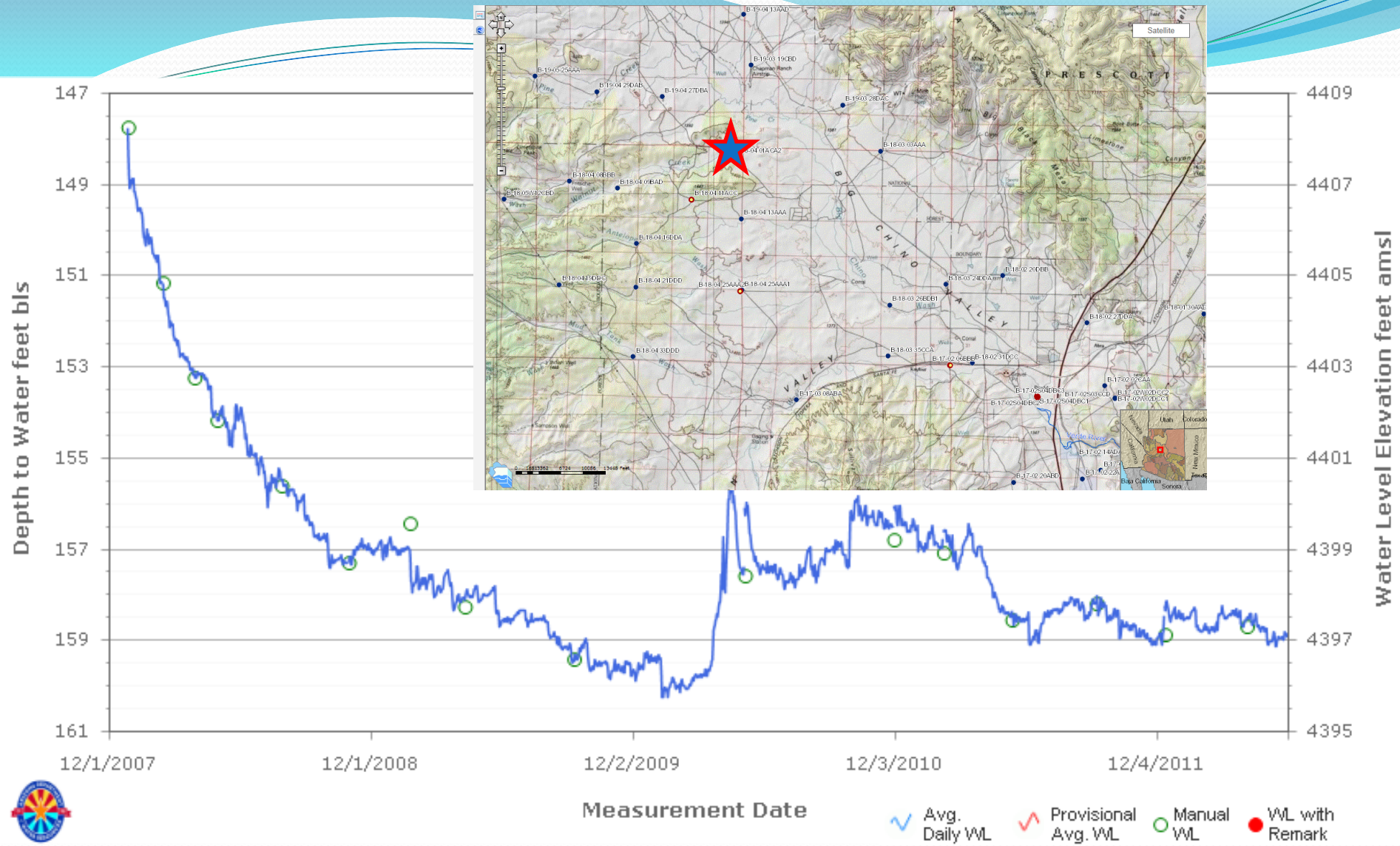


(B-15-01)BBB2
Frequent Stream Recharge
Mid-1970's – 80's
+
Significant Incidental AG
Recharge <1980's


Simulated Natural Recharge
MFR (recharge cells - constant)
Bradshaw Foothills (variable recharge cells)
Lynx Creek/Agua Fria River (variable stream cells)
Granite Creek (variable stream cells)

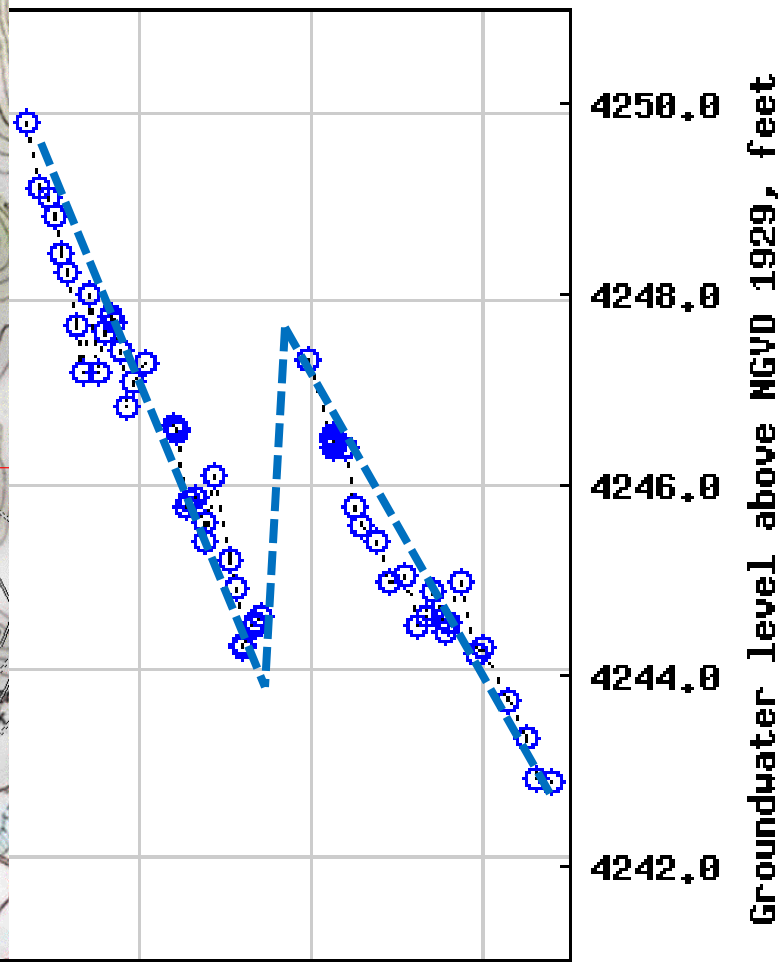

Depth to Water feet bls
260
265
270
275
280
285
290
295
300
Water Level Elevation feet amsl
4547
4542
4537
4532
4527
4522
4517
4512
4507
3/8/1971
2/18/1982
1/31/1993
1/14/2004
12/27/2014
Measurement Date
Water Level
Water Level with Remark

(B-16-01)28BCA

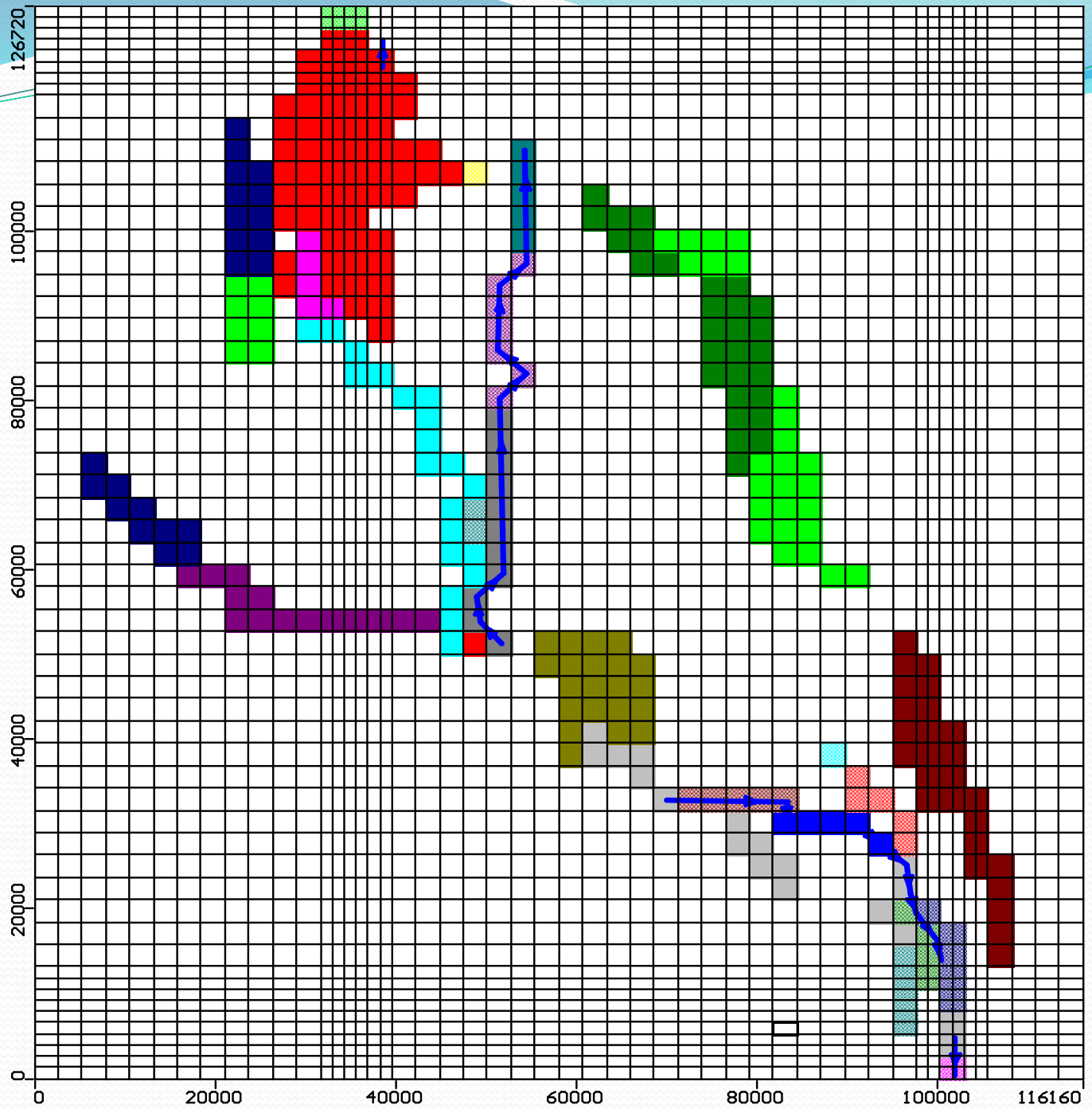


(B-18-04)01aca2, Big Chino (recessional) recharge from Walnut Creek Floods 2004/05; Recharge from 2010 El Nino

USGS 345528112283201 B-18-02 28ABA [Paulden North]



---- Provisional Data Subject to Revision ----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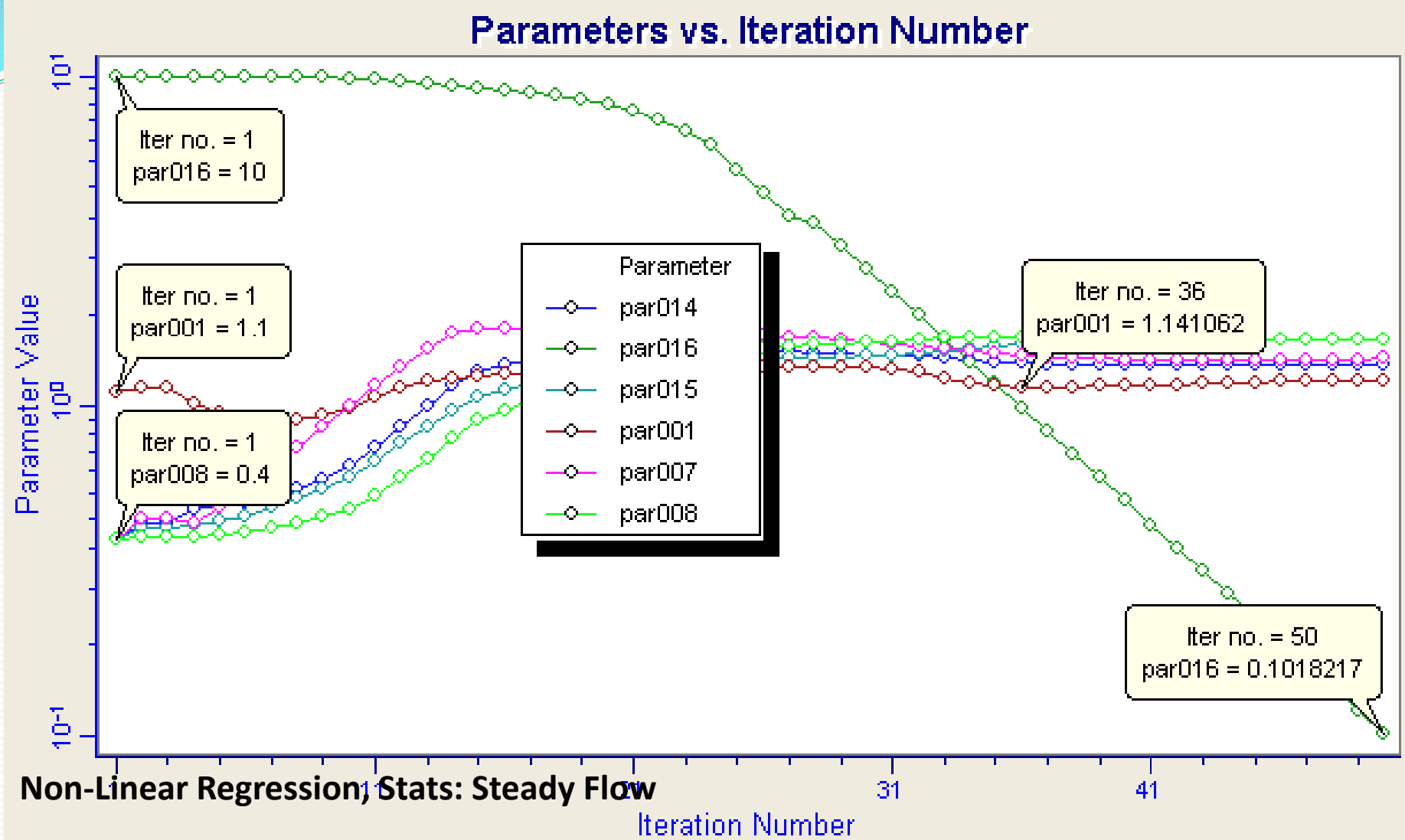
80000
60000
40000
20000
0
0
20000
40000
60000
80000
100000
116160

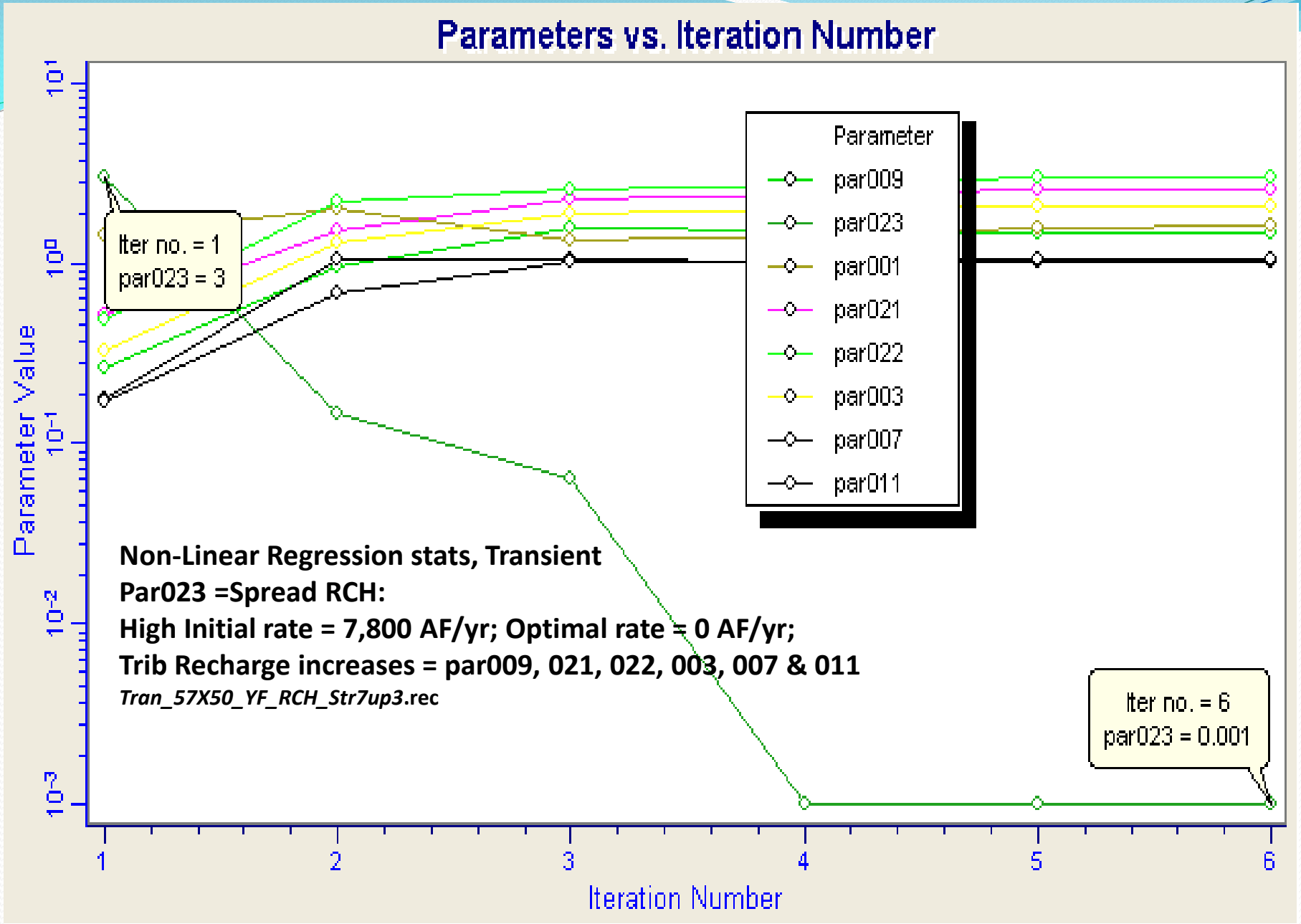


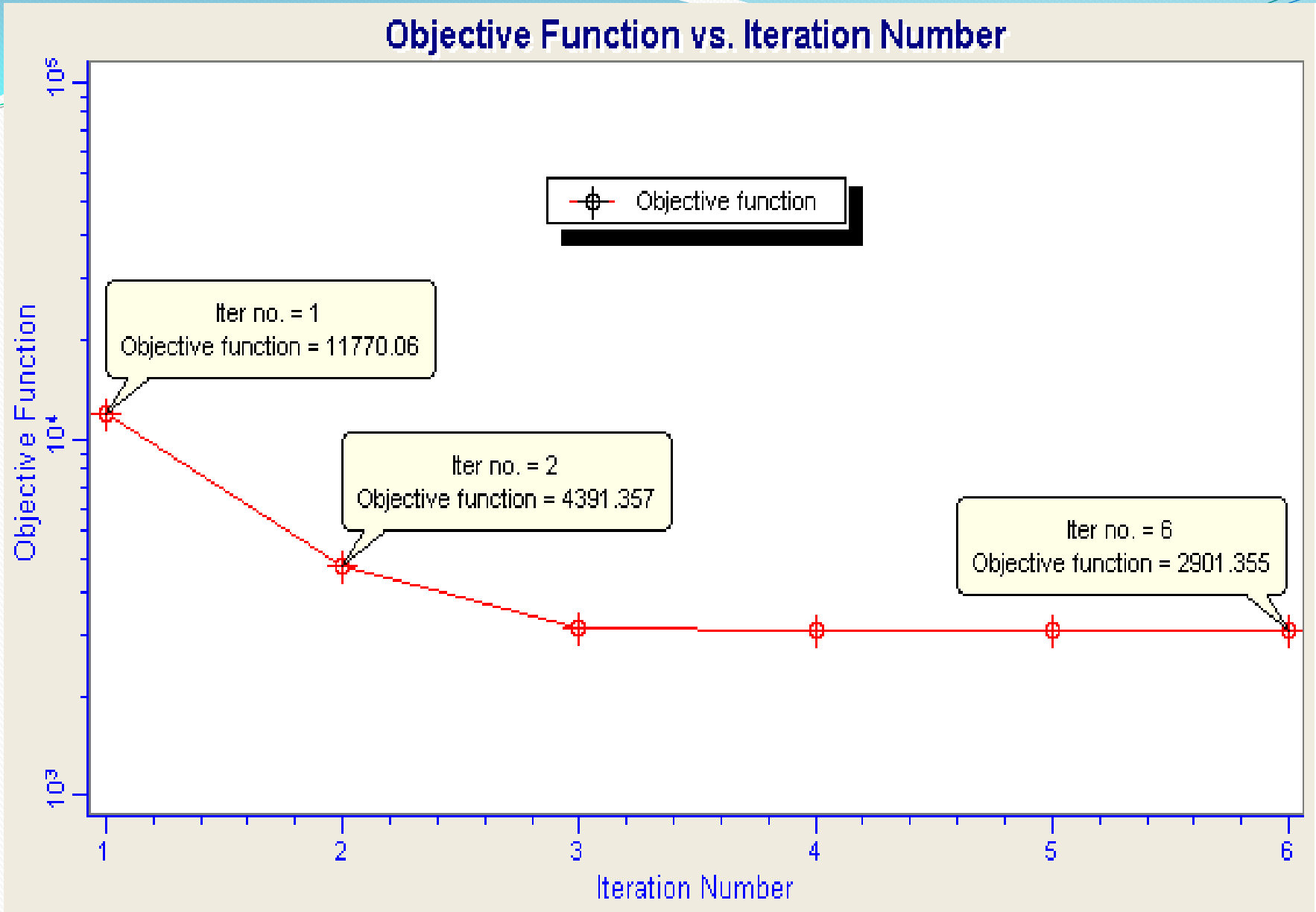
Non-Linear Regression, Stats: Steady Flow

Par016 = spread RCH, Initial rate= 2,600 AF/yr; Optimal rate= 25 AF/yr

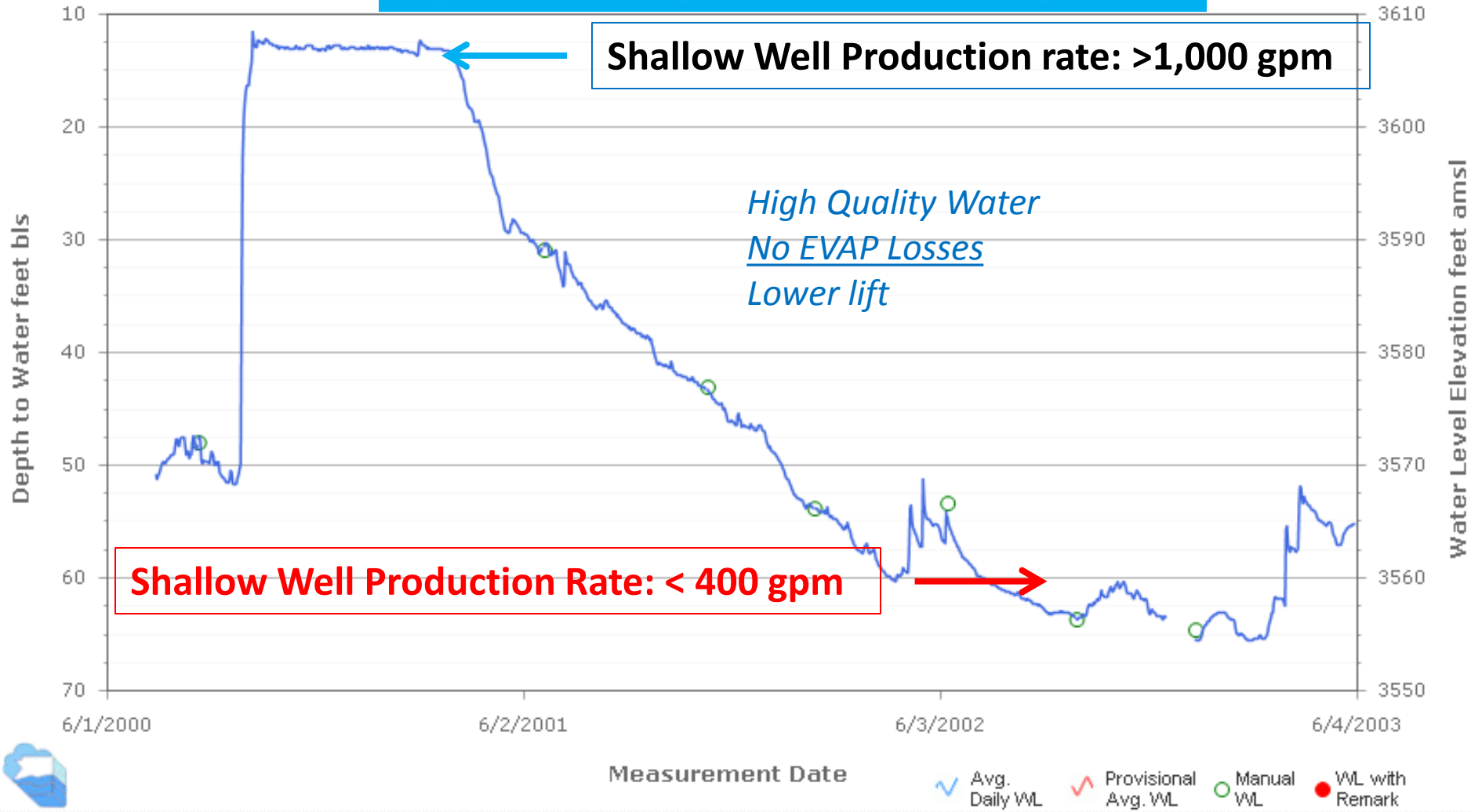
-Trib recharge increase; -Dispersed recharge decrease

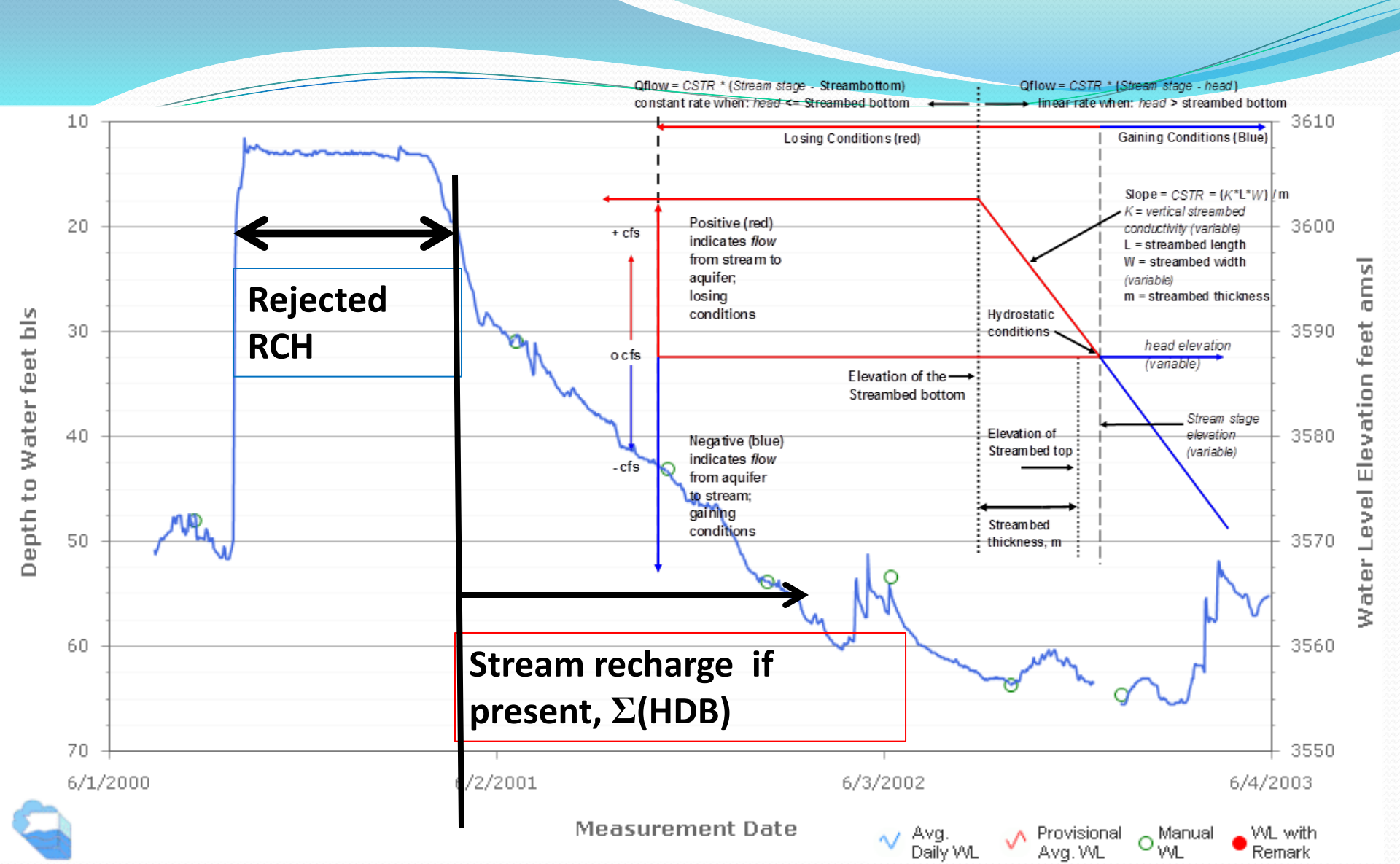
PostSS_YF_57X50Z12_XX.rec


Parameters vs. Iteration Number
Parameter Value
Iteration Number
Parameter
par009
par023
par001
par021
par022
par003
par007
par011
Iter no. = 1
par023 = 3
Iter no. = 6
par023 = 0.001
Non-Linear Regression stats, Transient
Par023 =Spread RCH:
High Initial rate = 7,800 AF/yr; Optimal rate = 0 AF/yr;
Trib Recharge increases = par009, 021, 022, 003, 007 & 011
Tran_57X50_YF_RCH_Str7up3.rec

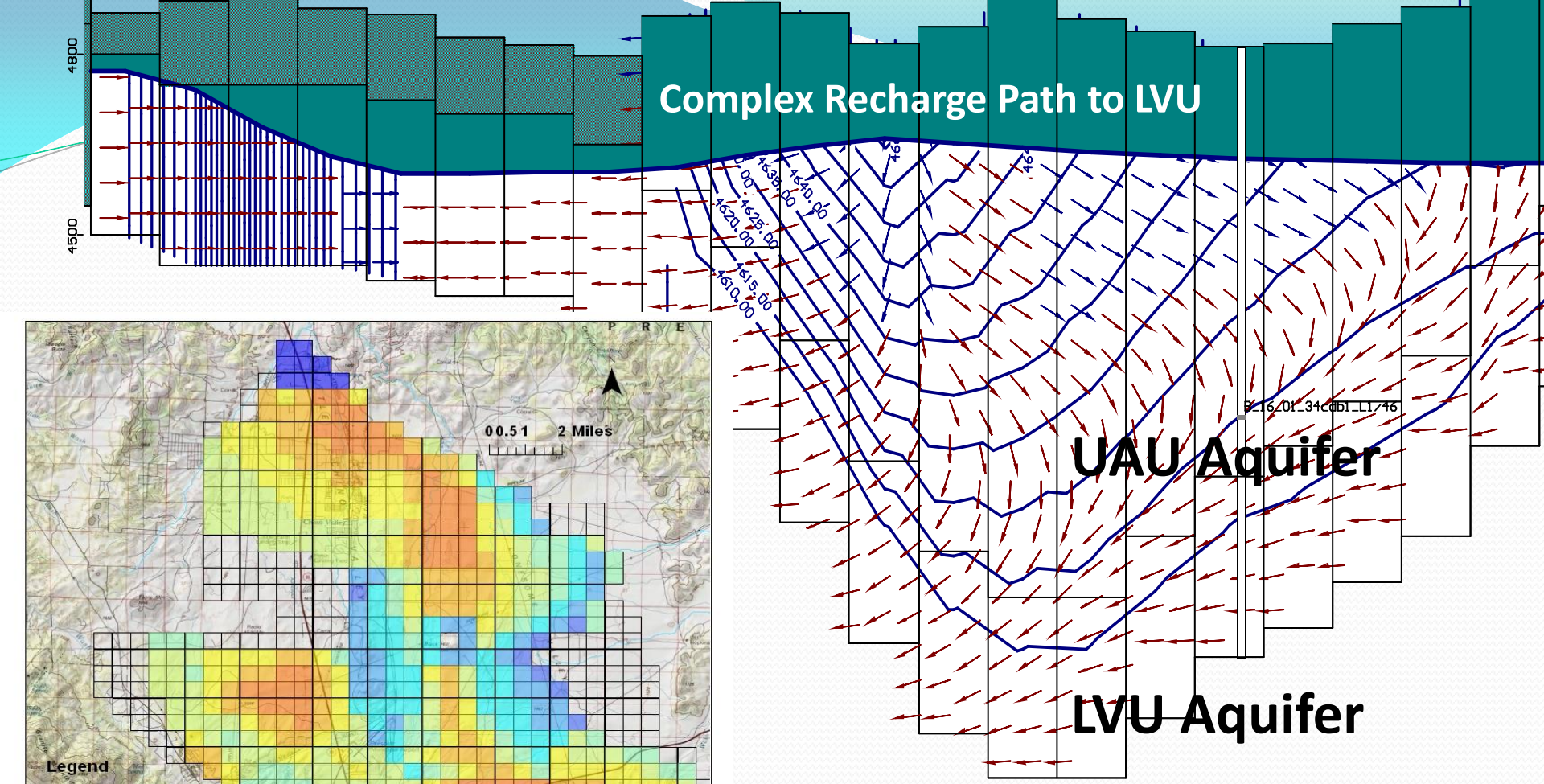

Objective Function vs. Iteration Number
Objective function
Iter no. = 1
Objective function = 11770.06
Iter no. = 2
Objective function = 4391.357
Iter no. = 6
Objective function = 2901.355
Objective Function
Iteration Number
10^5
10^4
10^3
1
2
3
4
5
6

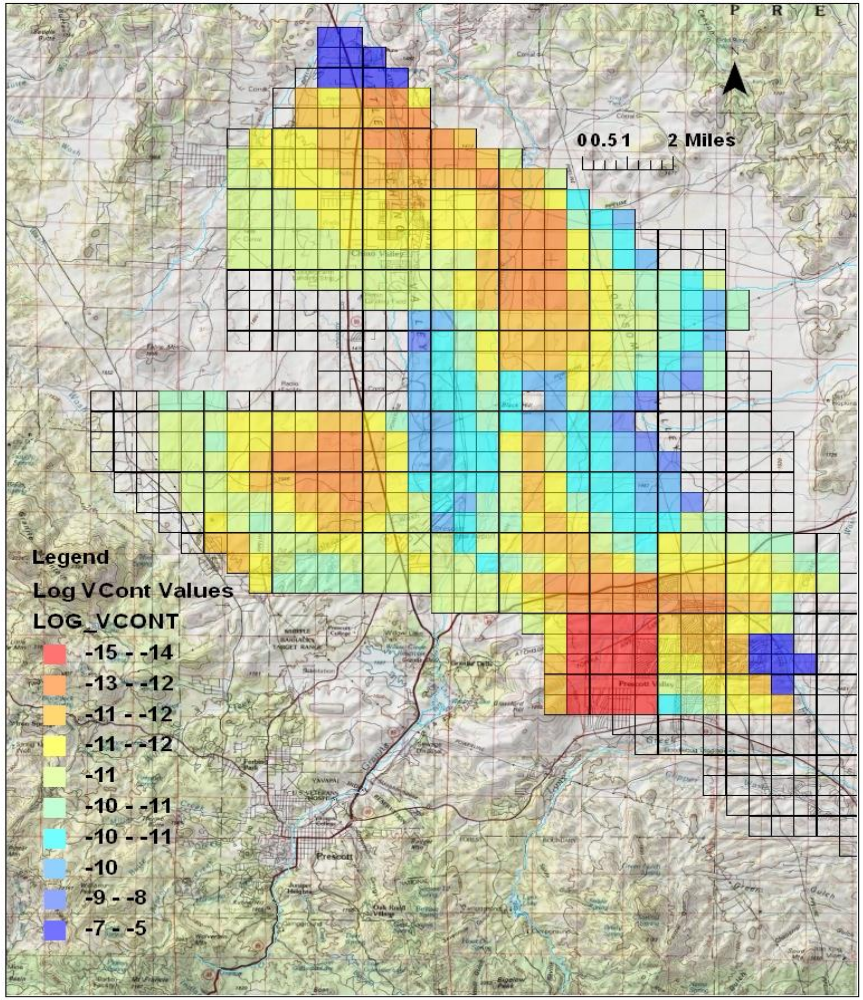
Rejected Recharge vs. Stream Recharge




Qflow = CSTR * (Stream stage - Streambottom)
constant rate when: head <= Streambed bottom
Qflow = CSTR * (Stream stage - head)
linear rate when: head > streambed bottom
Losing Conditions (red)
Gaining Conditions (Blue)
Slope = CSTR = (K*L*W) / m
K = vertical streambed conductivity (variable)
L = streambed length
W = streambed width (variable)
m = streambed thickness
+ cfs
Positive (red) indicates flow from stream to aquifer; losing conditions
Hydrostatic conditions
head elevation (variable)
0 cfs
Elevation of the Streambed bottom
Stream stage elevation (variable)
Elevation of Streambed top
- cfs
Negative (blue) indicates flow from aquifer to stream; gaining conditions
Streambed thickness, m
Rejected RCH
Stream recharge if present, Σ(HDB)
Depth to Water feet bls
Water Level Elevation feet amsl
10
20
30
40
50
60
70
3610
3600
3590
3580
3570
3560
3550
6/1/2000
6/2/2001
6/3/2002
6/4/2003
Measurement Date
Avg. Daily WL
Provisional Avg. WL
Manual WL
WL with Remark

Complex Recharge Path to LVU

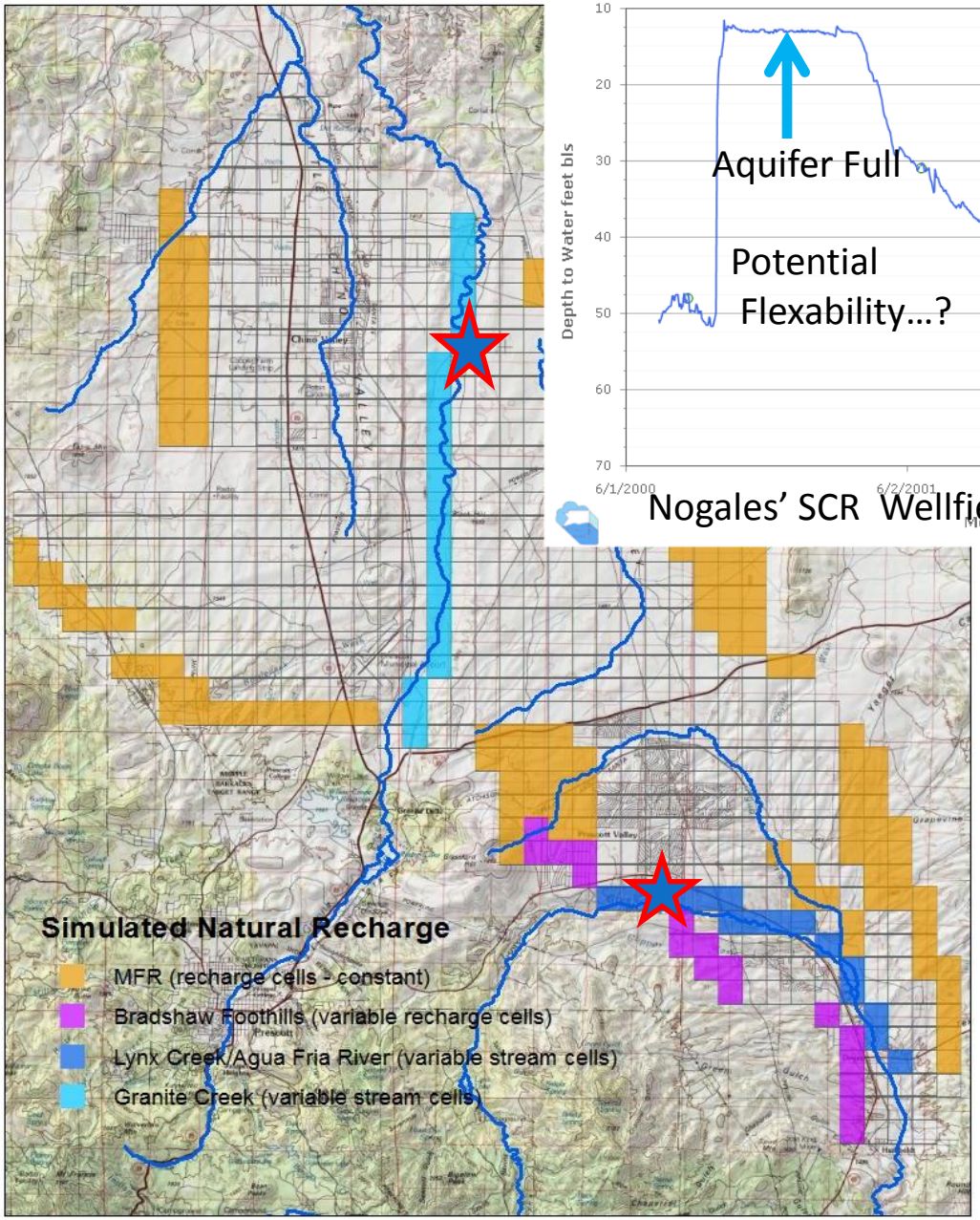


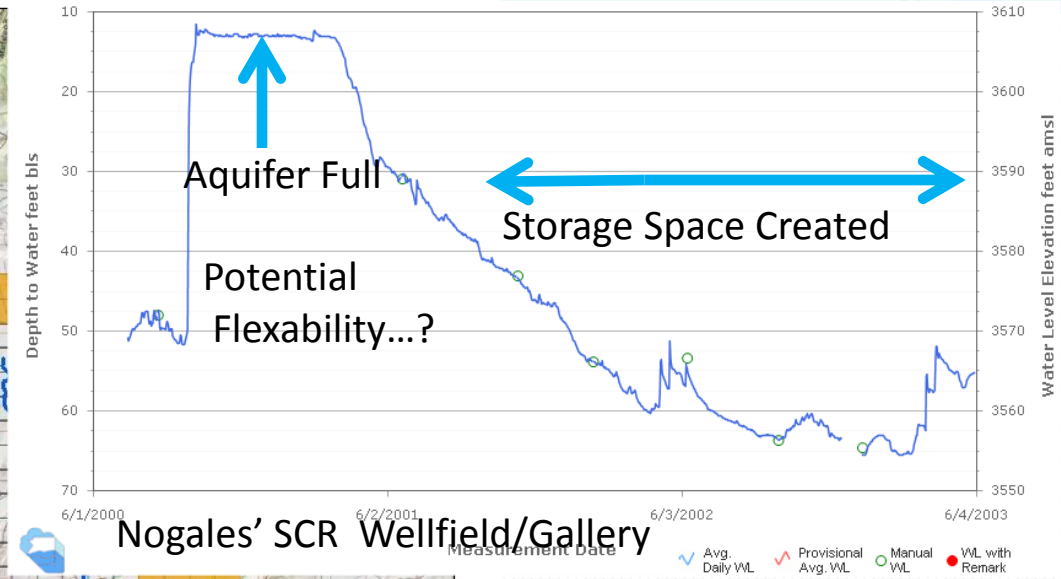


Primary Aquitard, Sensitive

Kz3 95% CI: ≈0.0007– 0.003 feet/day

Data suggest Kz3 increases during tran (well cross flow); Kz26 ≤ 1E-6 ft/d, very strong hydraulic isolation between UAU and LVU





Hypothetical Withdrawal (UAU)

Pumpage and/or infiltration gallery

1978-1984 (5.6 years)

North Granite Creek
5X -100,000 ft^3/day
23,360 AF

Upper Lynx Creek
5X(-100,000 ft^3/day)
23,360 AF

Same Long-term Pumping Rate, Different Distribution (UAF)

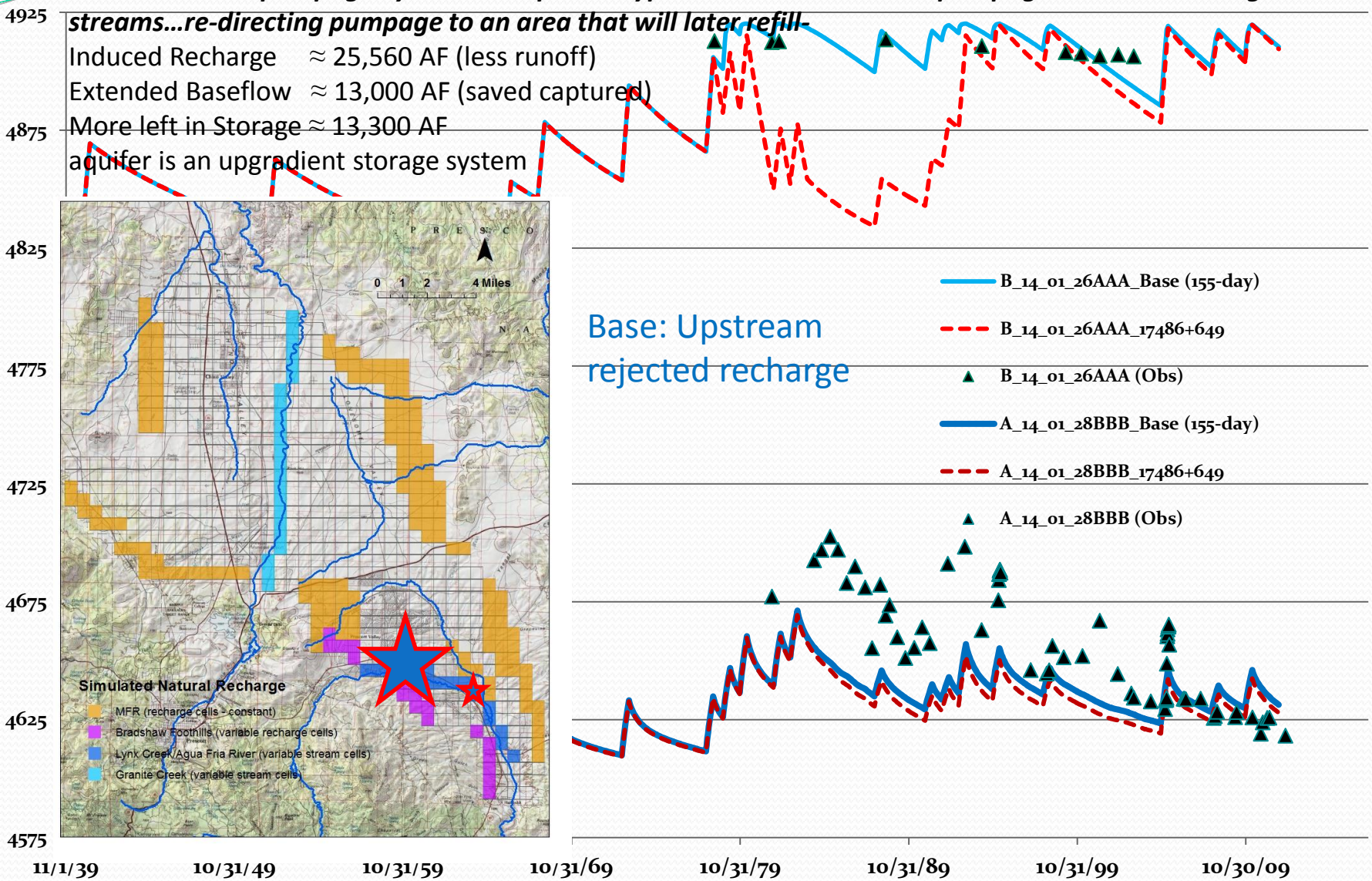
Decreased base pumpage by amount equal to hypothetical concentrated pumpage distributed along streams…re-directing pumpage to an area that will later refill-

Induced Recharge ≈ 25,560 AF (less runoff)

Extended Baseflow ≈ 13,000 AF (saved captured)

More left in Storage ≈ 13,300 AF

aquifer is an upgradient storage system



Base: Upstream rejected recharge

Same long-term Pumping Rate, Different Distribution (LIC)

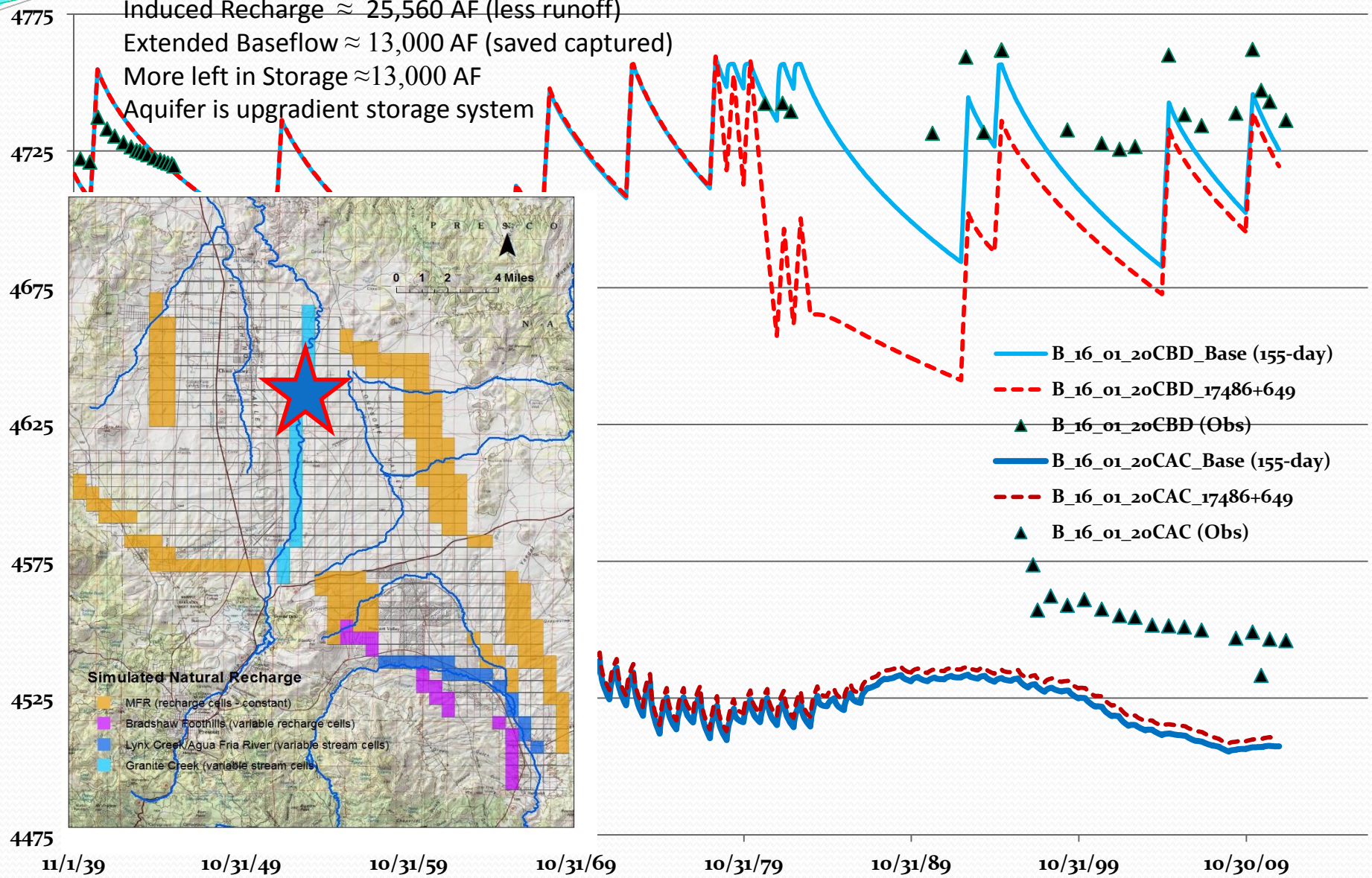
Decreased base pumpage by rate equal to hypothetical pumpage along stream

Induced Recharge ≈ 25,560 AF (less runoff)

Extended Baseflow ≈ 13,000 AF (saved captured)

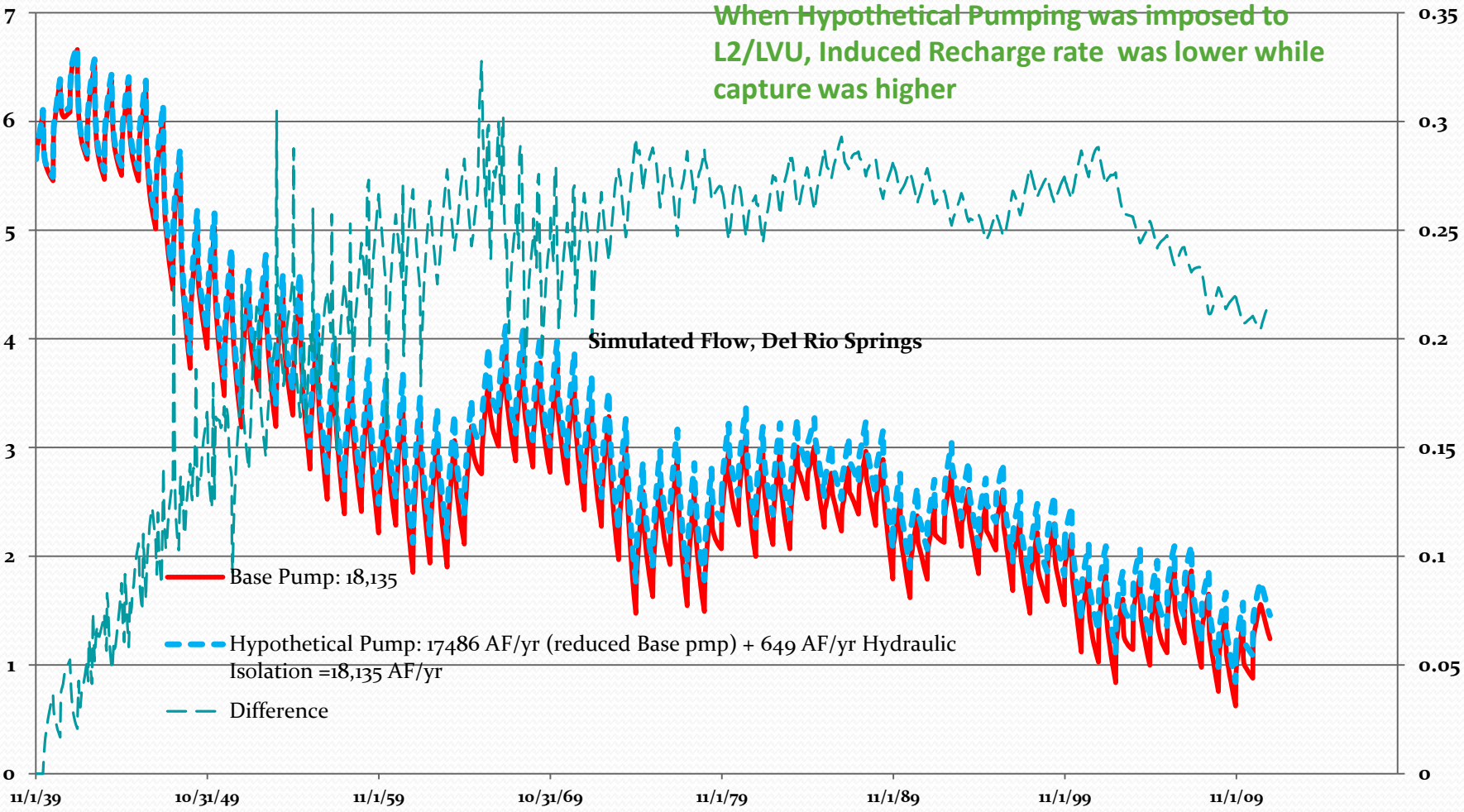
More left in Storage ≈13,000 AF

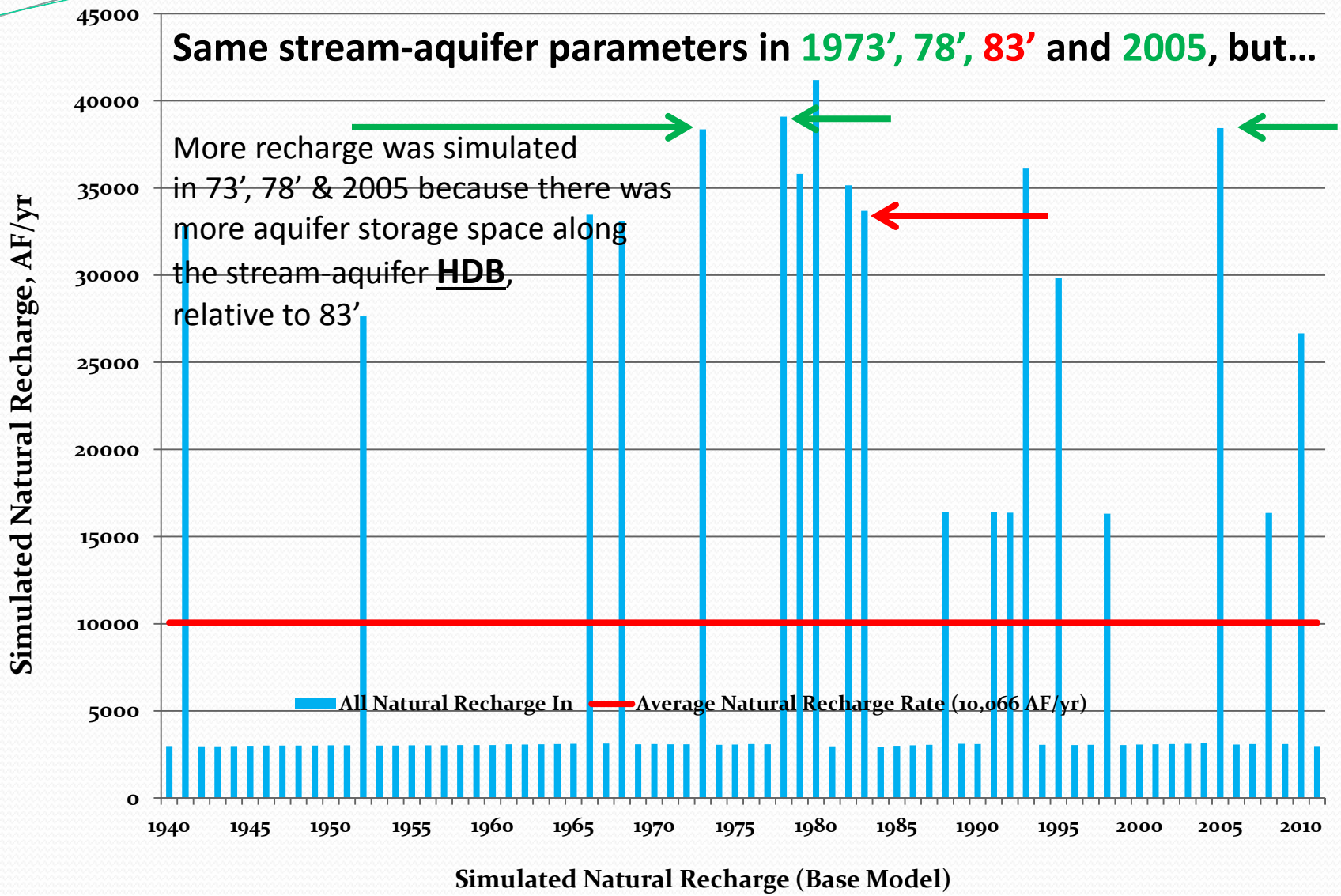
Aquifer is upgradient storage system



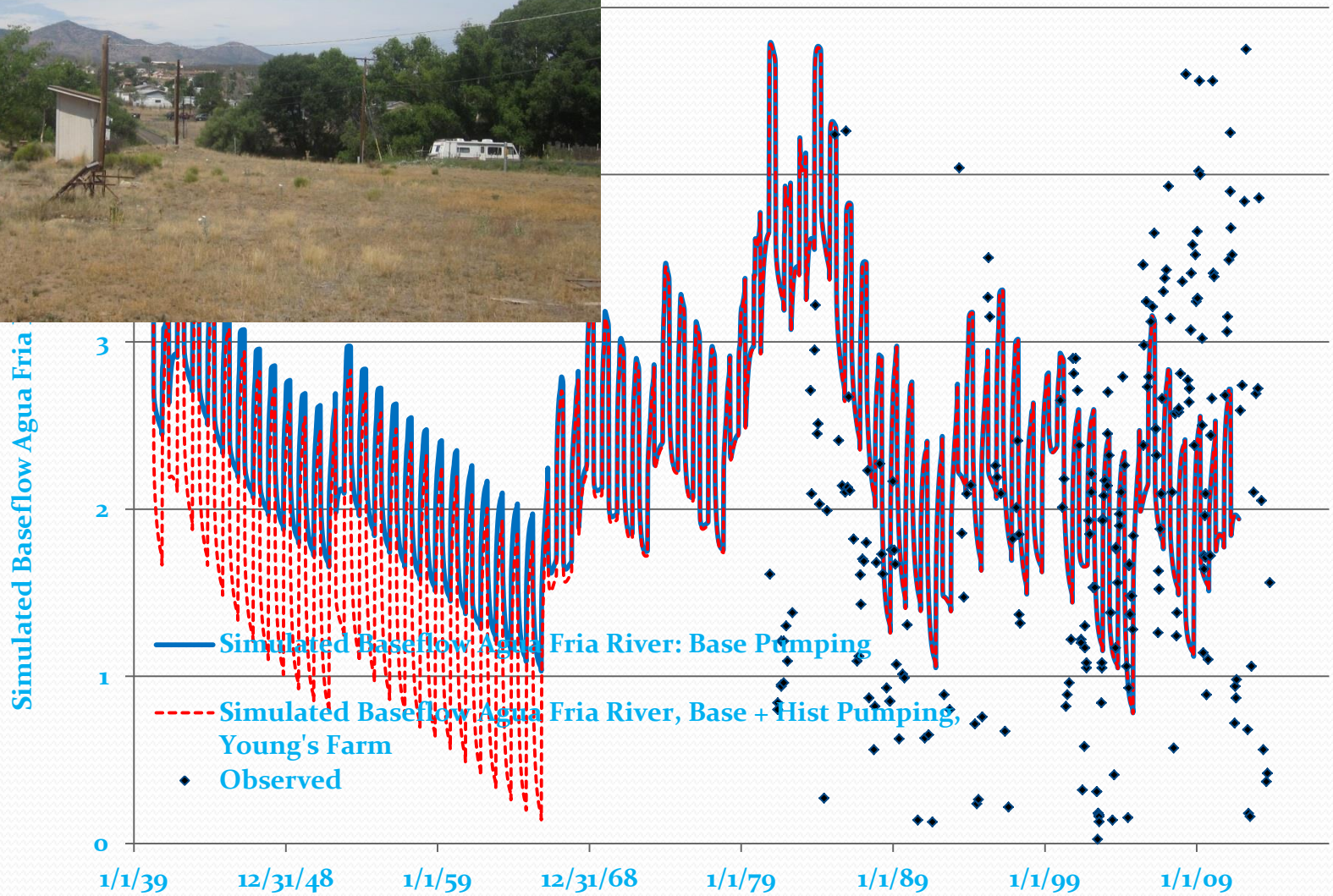
Simulated Groundwater Discharge, Del Rio Springs: Hypothetical, Displaced Pumpage to Hydraulically-Buffered Areas Resulted in Less Capture At Del Rio Springs {nearly 13,000 AF/(1939-2011)} wrt Base Pumping Distribution: **Tradeoff between**

1) reduction in runoff vs. 2) more storage & higher rate of sustained baseflow

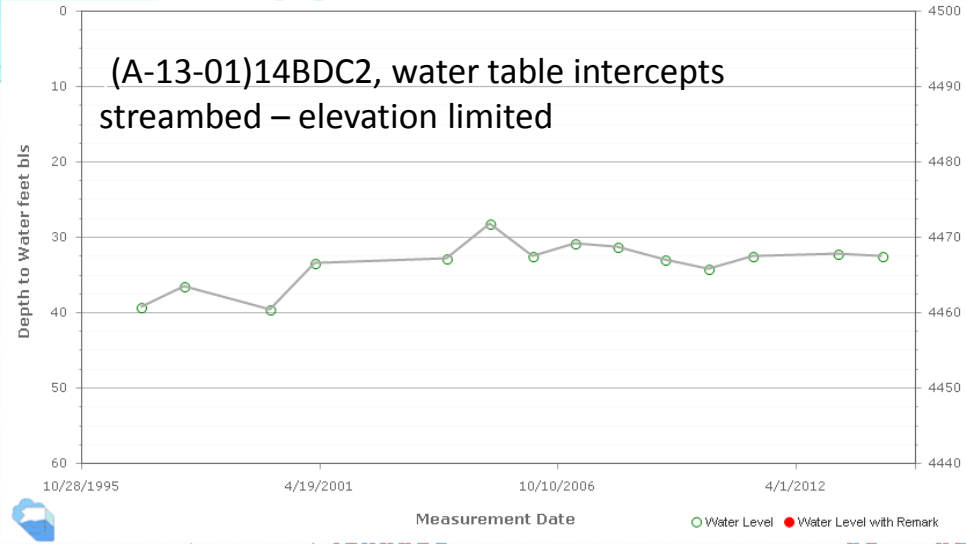


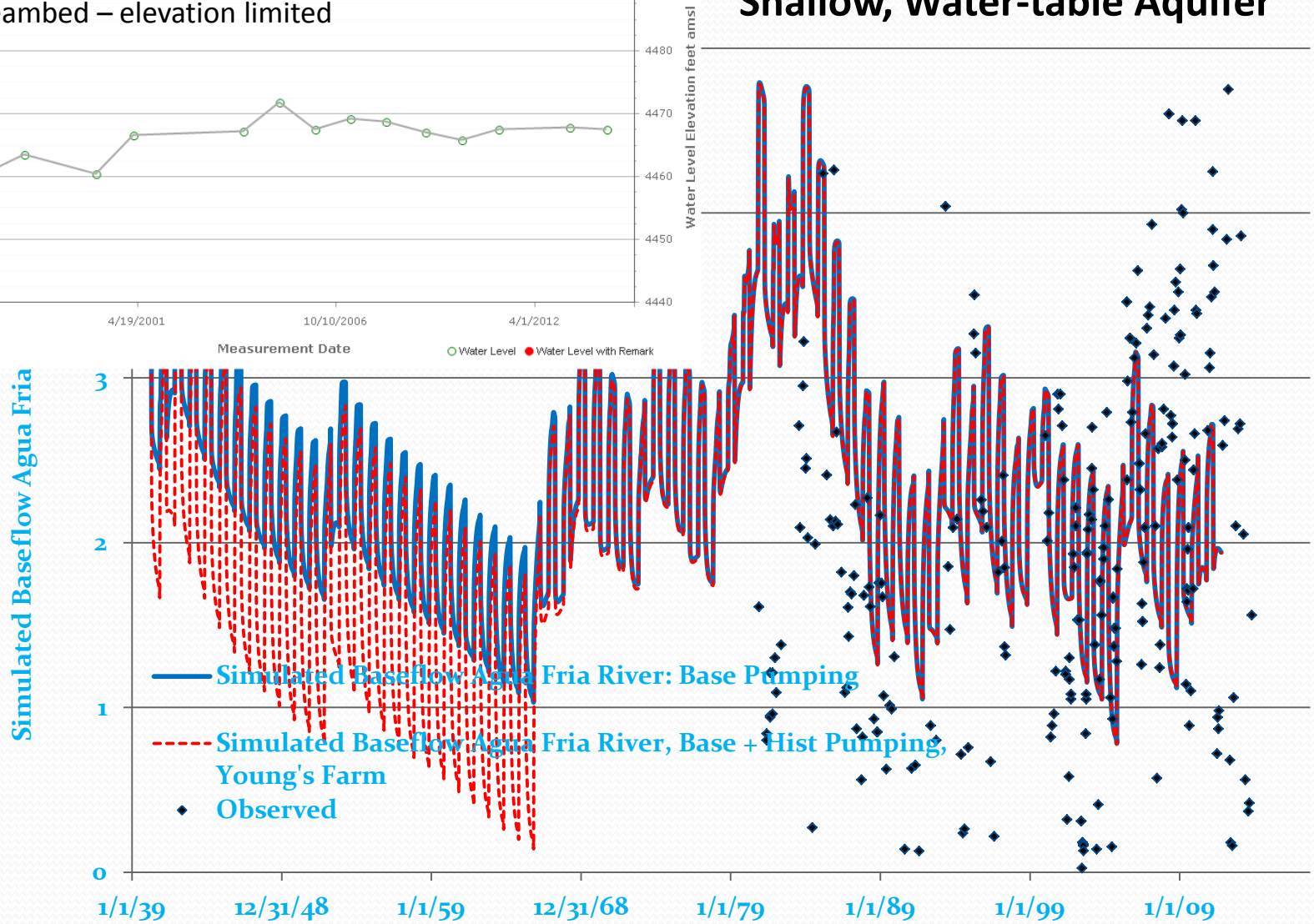

Same stream-aquifer parameters in 1973', 78', 83' and 2005, but…
More recharge was simulated in 73', 78' & 2005 because there was more aquifer storage space along the stream-aquifer HDB, relative to 83'
Simulated Natural Recharge, AF/yr
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
All Natural Recharge In
Average Natural Recharge Rate (10,066 AF/yr)
Simulated Natural Recharge (Base Model)

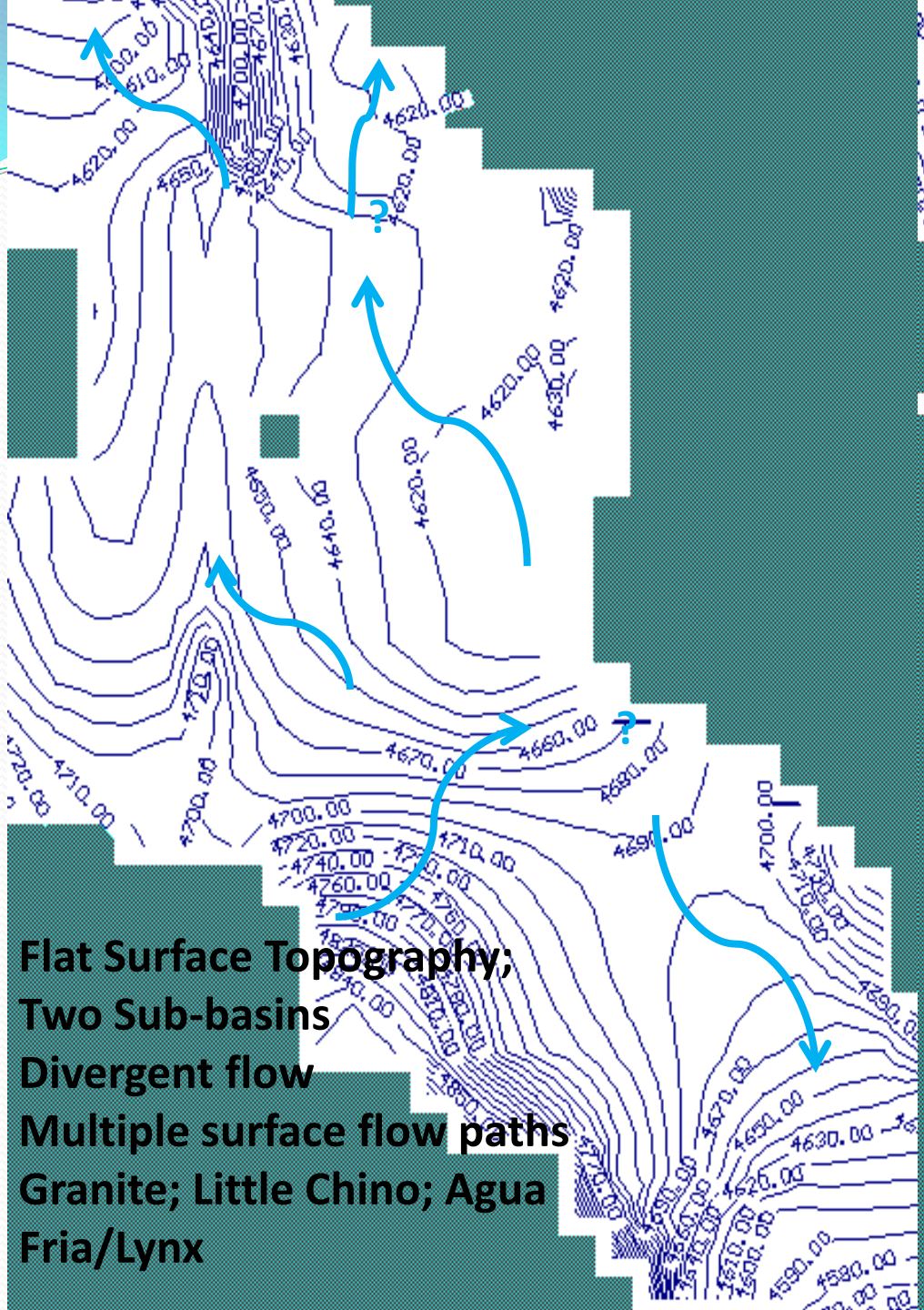
Inner Valley Hydrologic System "Resets" due to Finite Storage Capacity of Shallow, Water-table Aquifer



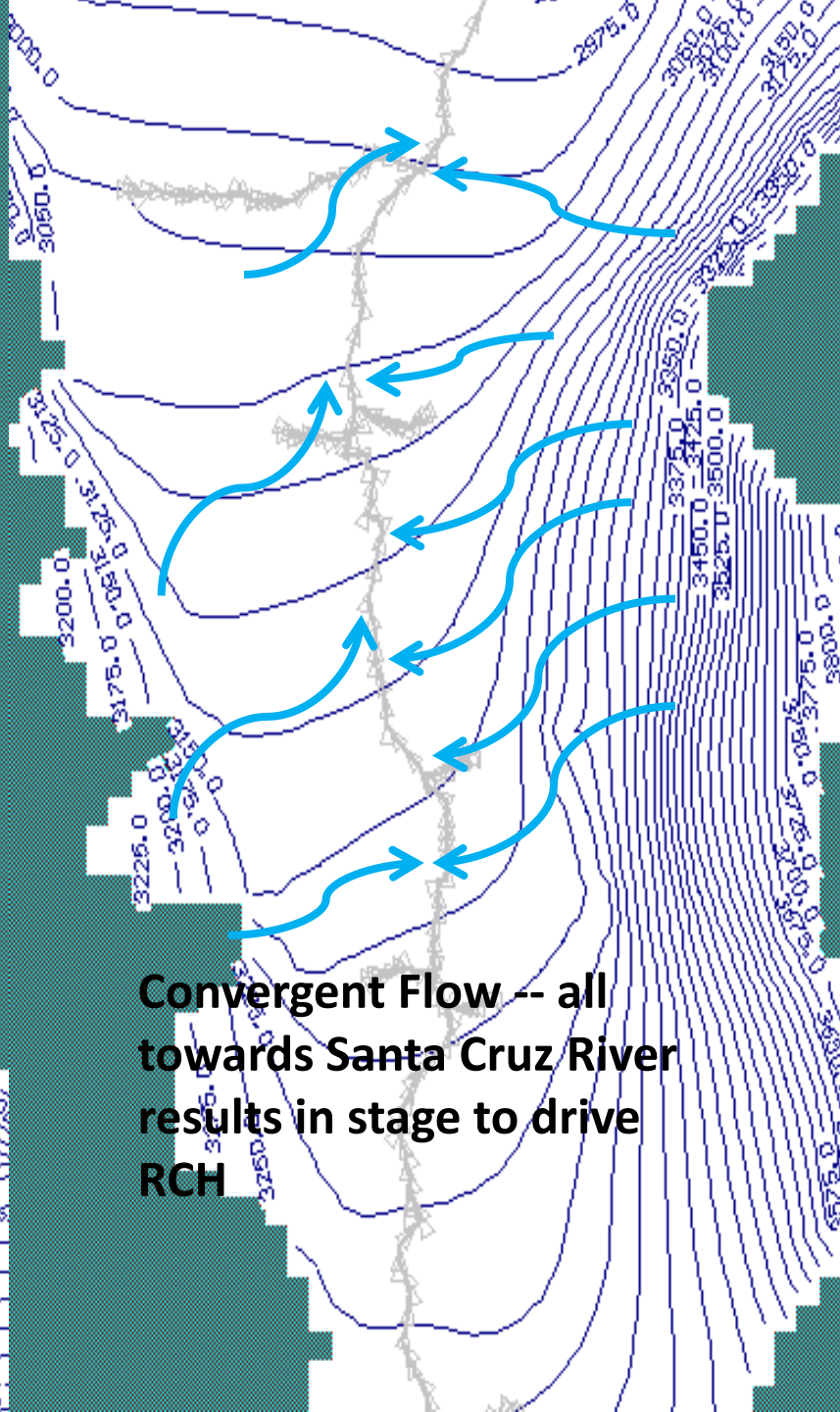
Inner Valley Hydrologic System "Resets" due to Finite Storage Capacity of Shallow, Water-table Aquifer







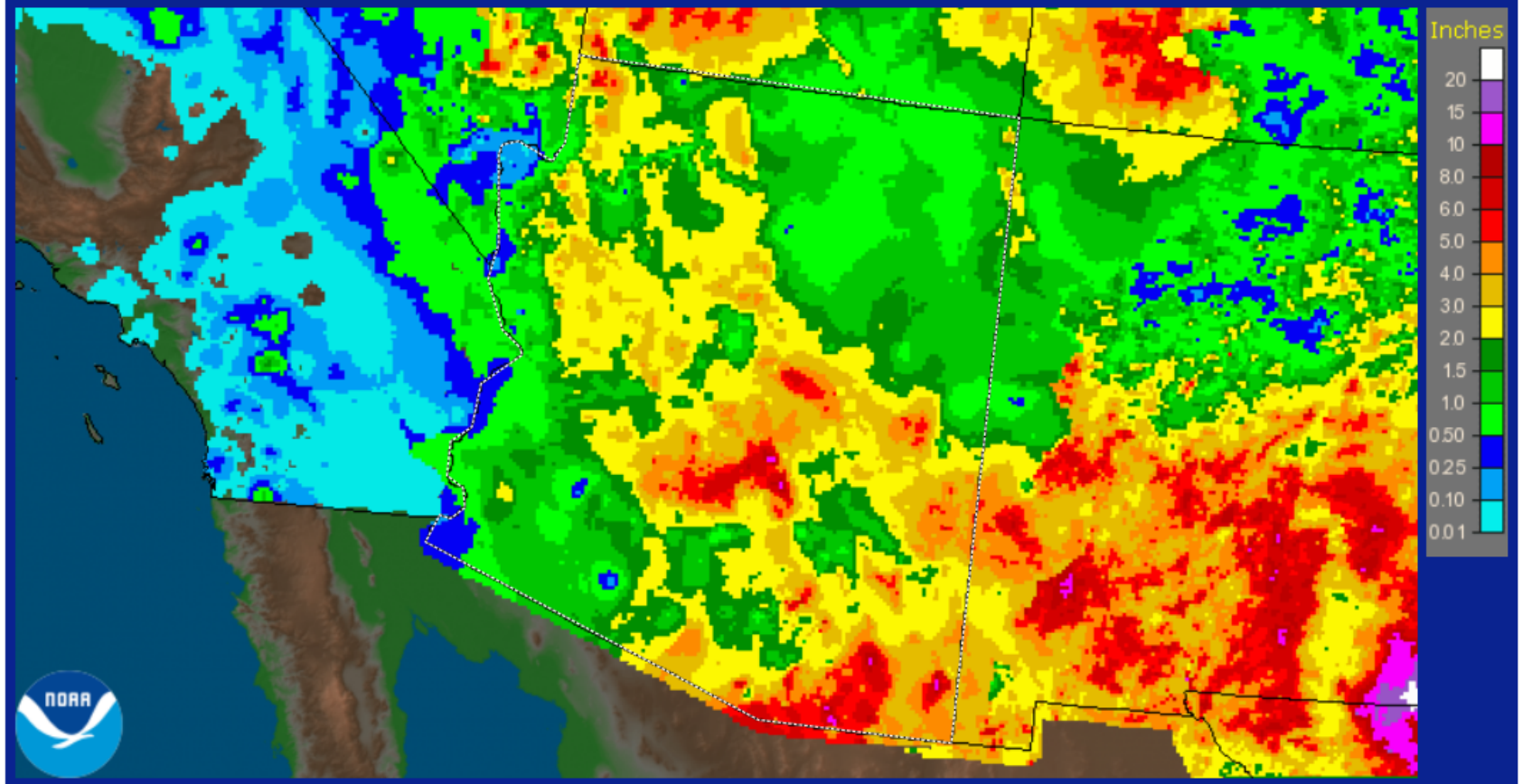
Flat Surface Topography;
Two Sub-basins
Divergent flow
Multiple surface flow paths
Granite; Little Chino; Agua Fria/Lynx



Convergent Flow -- all towards Santa Cruz River results in stage to drive RCH

The Precipitation Generation Process is currently running and began at 2014/12/10 15:30.

Arizona: September, 2014 Monthly Observed Precipitation
Valid at 10/1/2014 1200 UTC - Created 10/3/14 23:56 UTC



☑ Topo ☑ Pcpn Amount ☐ Counties ☐ Rivers ☑ States ☐ Highway/City ☐ RFC Boundary

1. Timeframe
- ○ Current Data
- ◉ Archive: Month/Year
- ○ Archive: Daily

Year: 2014
Month: September

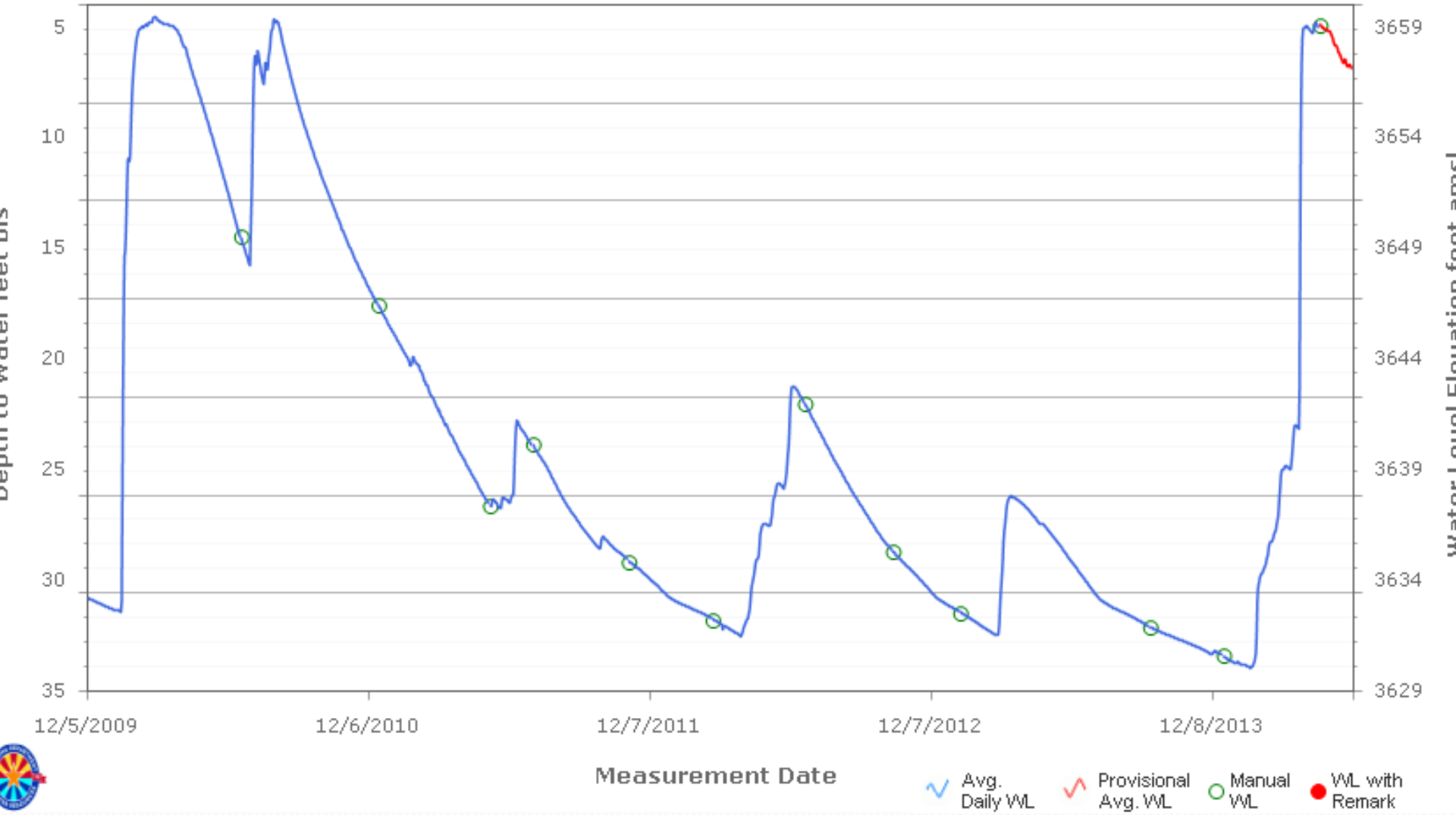
2. Product
- Observed
- Normal
- Departure from Normal
- Percent of Normal

3. Location
- ◉ States
- ○ NWS RFC/Regions
- ○ NWS WFOs

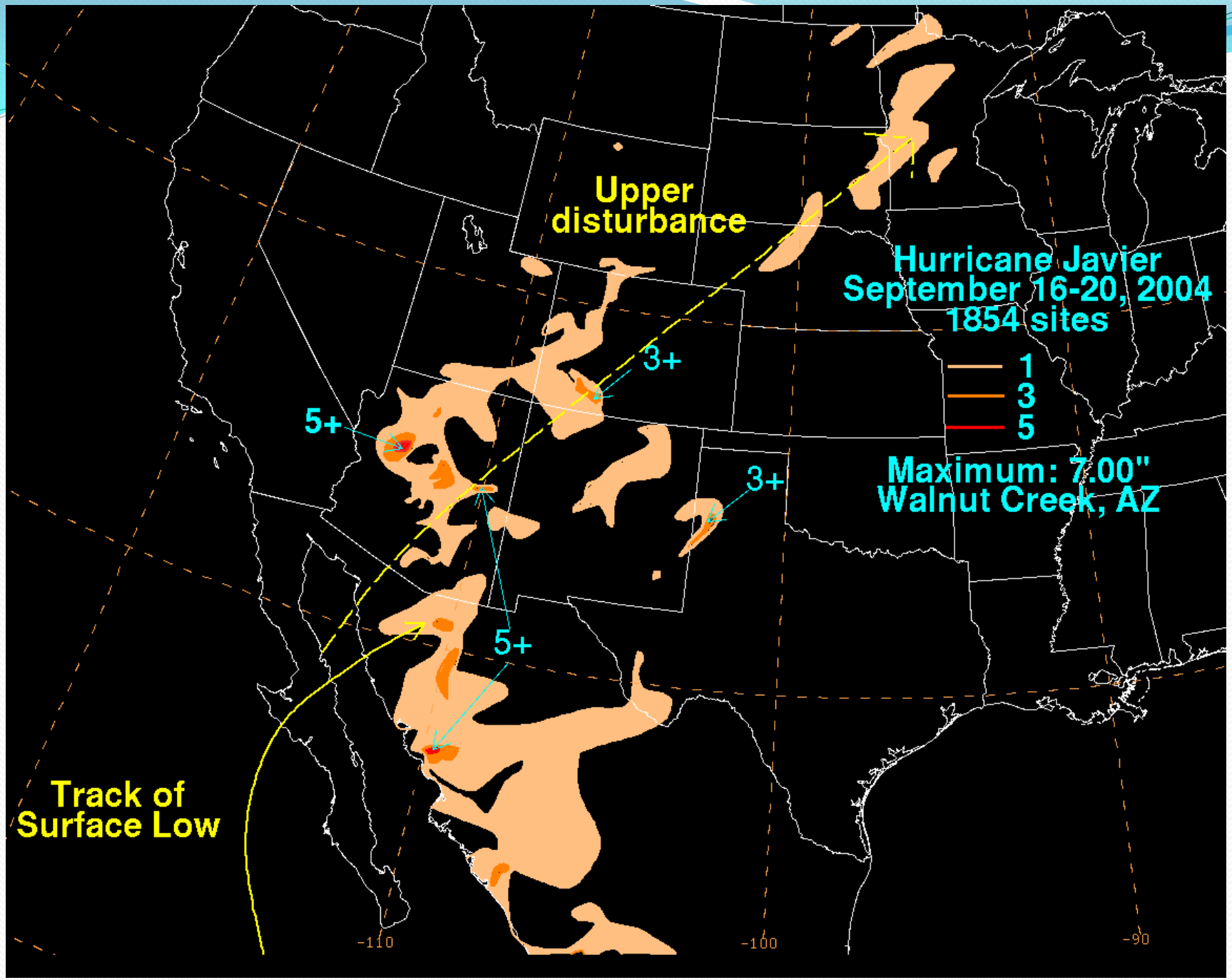
CONUS + Puerto Rico
Alabama
Arizona
Arkansas
California

4. Units
- ◉ English
- ○ Metric

Missing Data


Depth to Water feet bls
5
10
15
20
25
30
35
Water Level Elevation feet amsl
3659
3654
3649
3644
3639
3634
3629
12/5/2009
12/6/2010
12/7/2011
12/7/2012
12/8/2013
Measurement Date
Avg. Daily WL
Provisional Avg. WL
Manual WL
WL with Remark

2-3 Billion gallons of ppt in local area


Upper
disturbance
Hurricane Javier
September 16-20, 2004
1854 sites
1
3
5
Maximum: 7.00"
Walnut Creek, AZ
3+
5+
3+
5+
Track of
Surface Low
-110
-100
-90

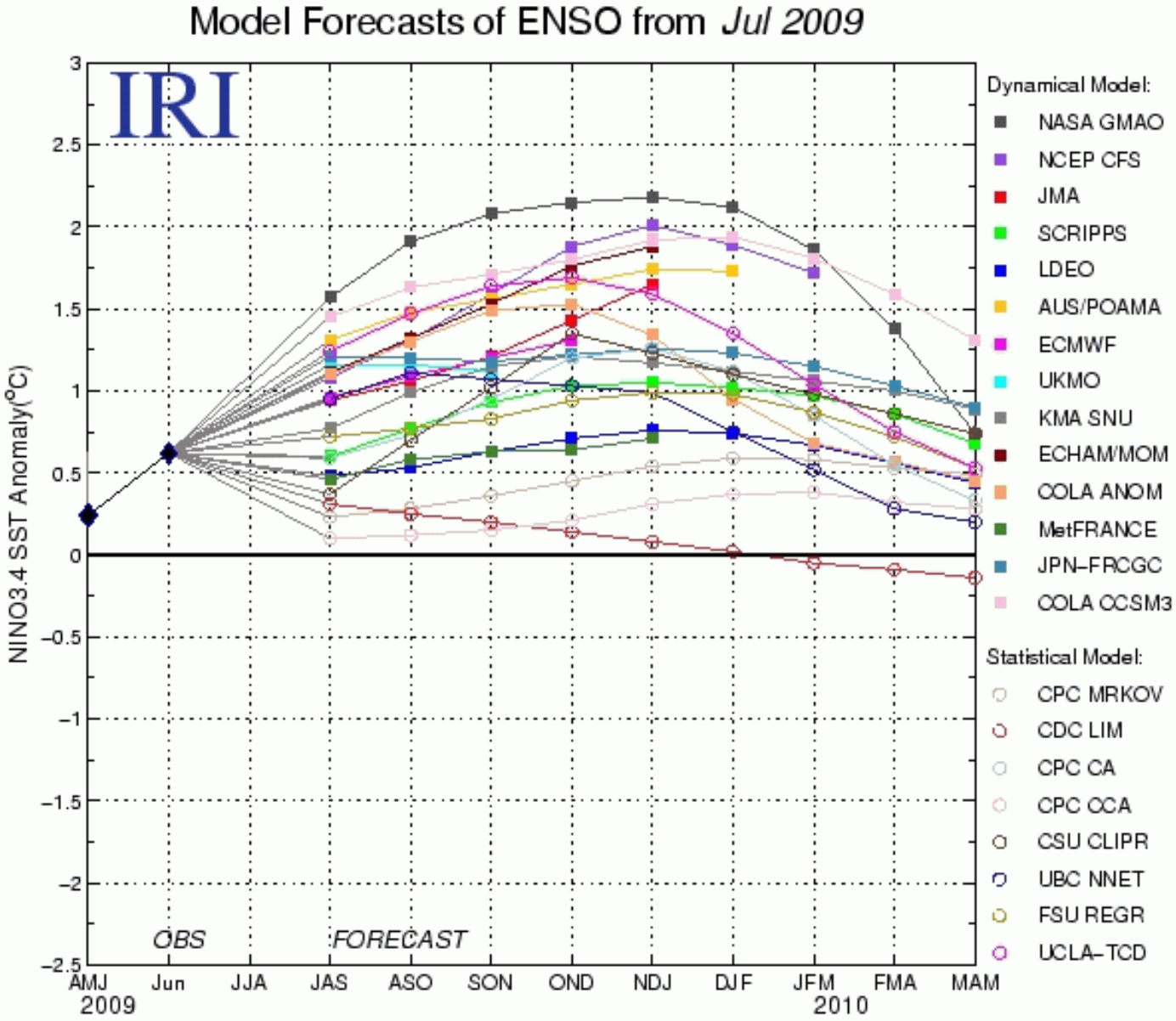
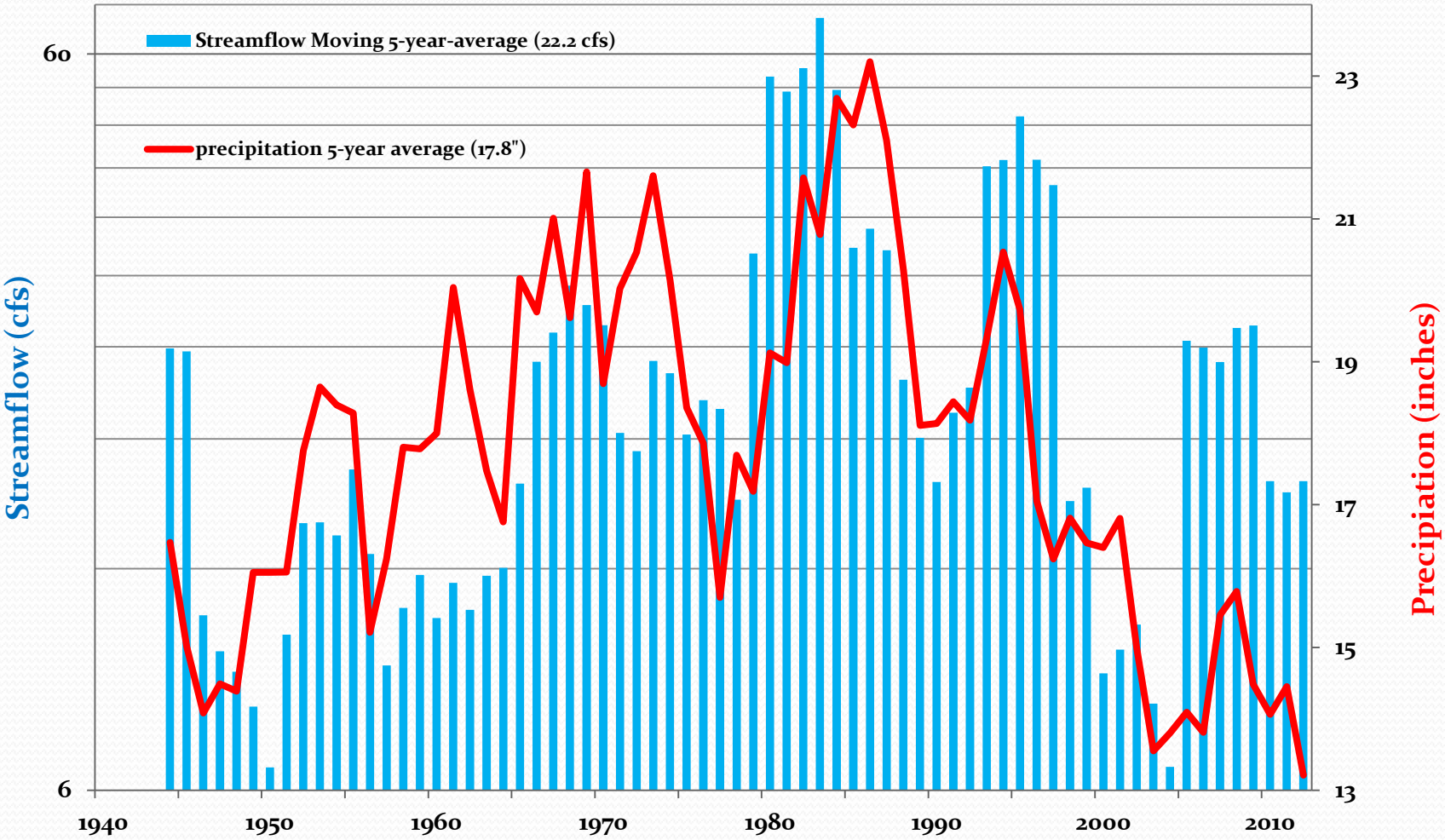
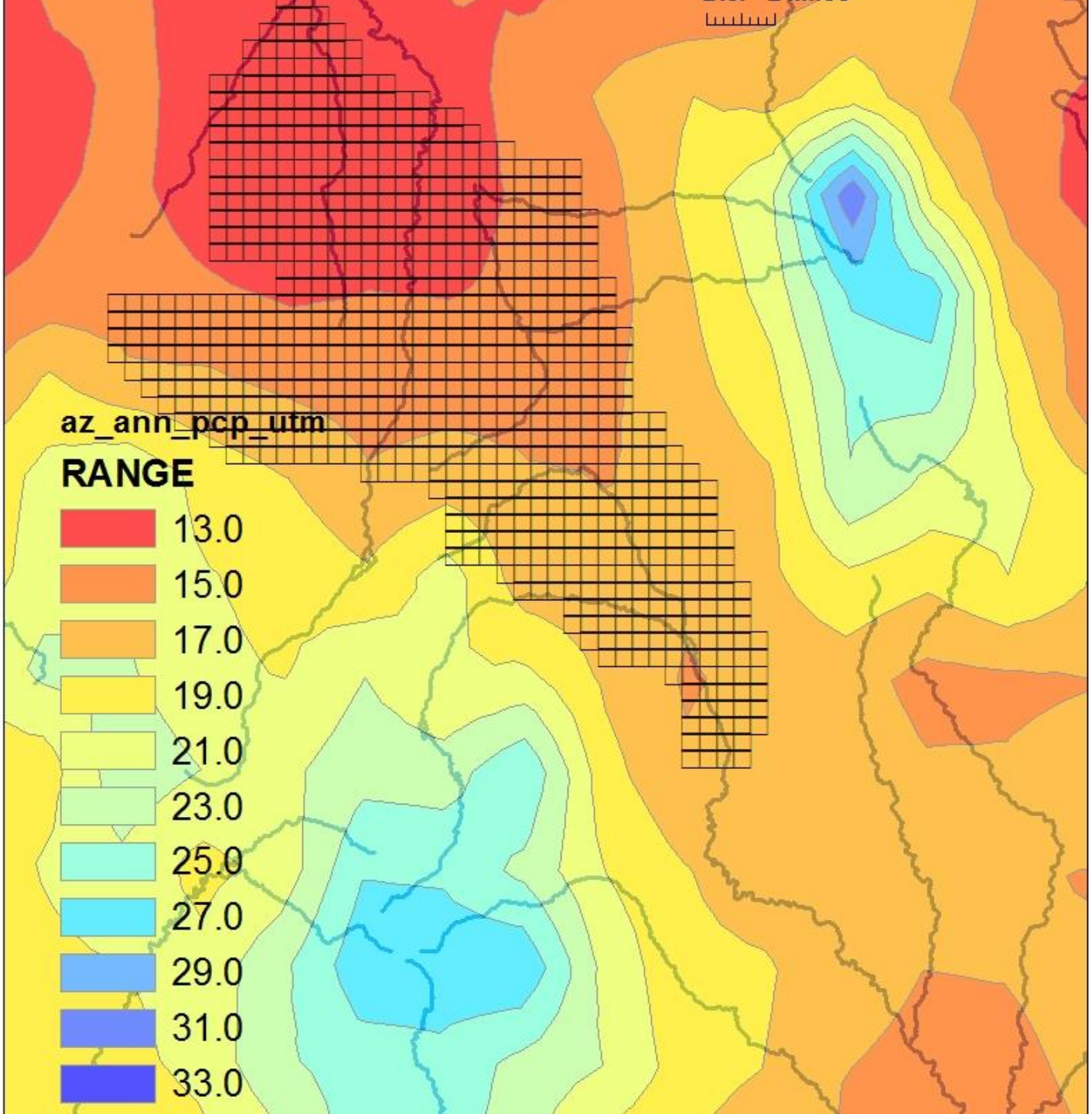


Figure 6. Forecasts of sea surface temperature (SST) anomalies for the Niño 3.4 region (5°N-5°S, 120°W-170°W). Figure courtesy of the International Research Institute (IRI) for Climate and Society. Figure updated 16 July 2009.

5-Year Moving Average Streamflow along Agua Fria River near Mayer AZ (1940-2012) and Precipitation in Prescott AZ (1940-2012)




az_ann_pcp_utm
RANGE
13.0
15.0
17.0
19.0
21.0
23.0
25.0
27.0
29.0
31.0
33.0