Groundwater Flow Model for Evaluation of Hydrologic Effects of the San Joaquin River Restoration

Presented by Jon Traum, P.E.

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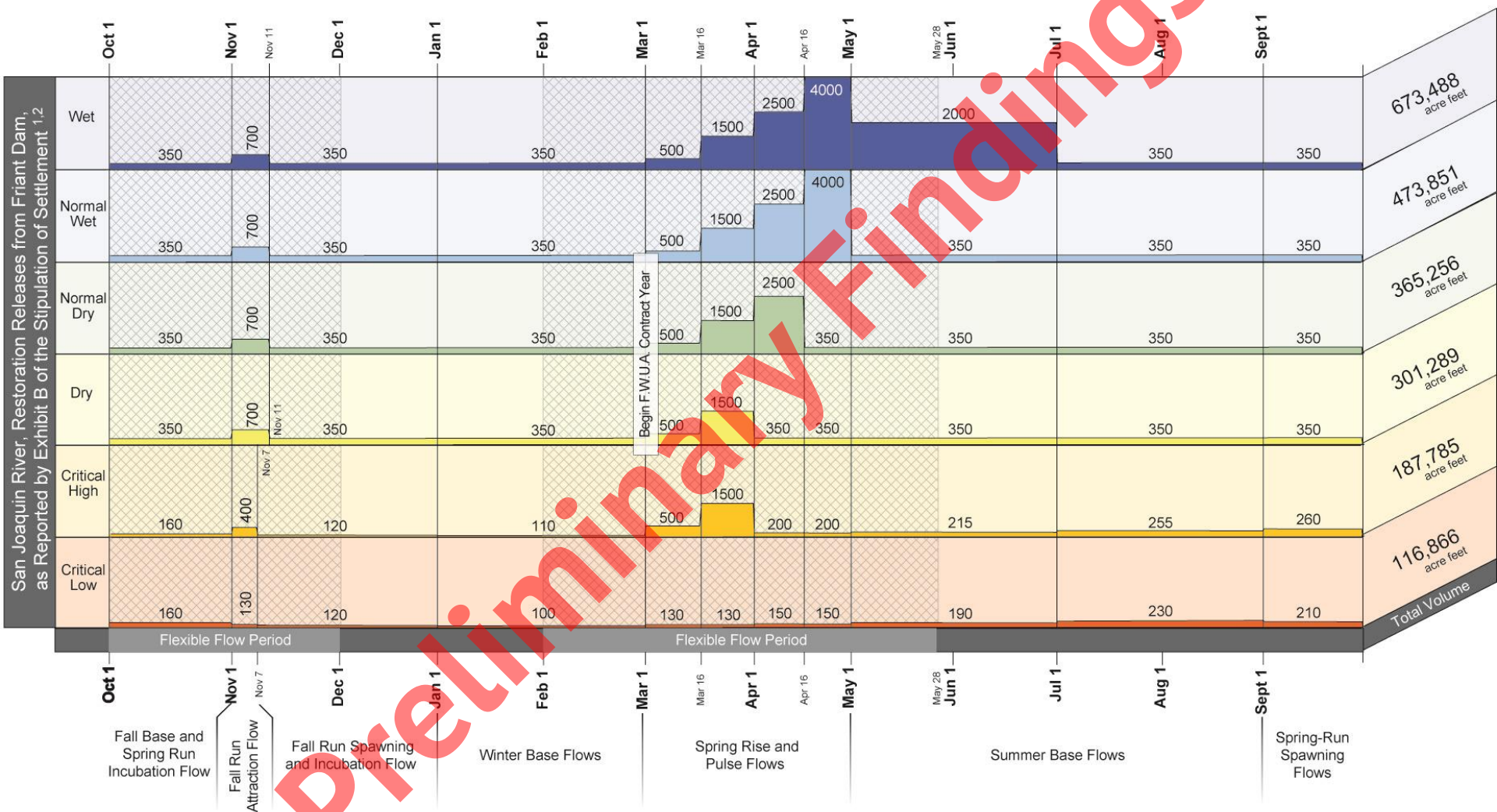
Overview

* San Joaquin River Restoration Program (SJRRP)
* Model development
* Model calibration
* Model results
* Model applications

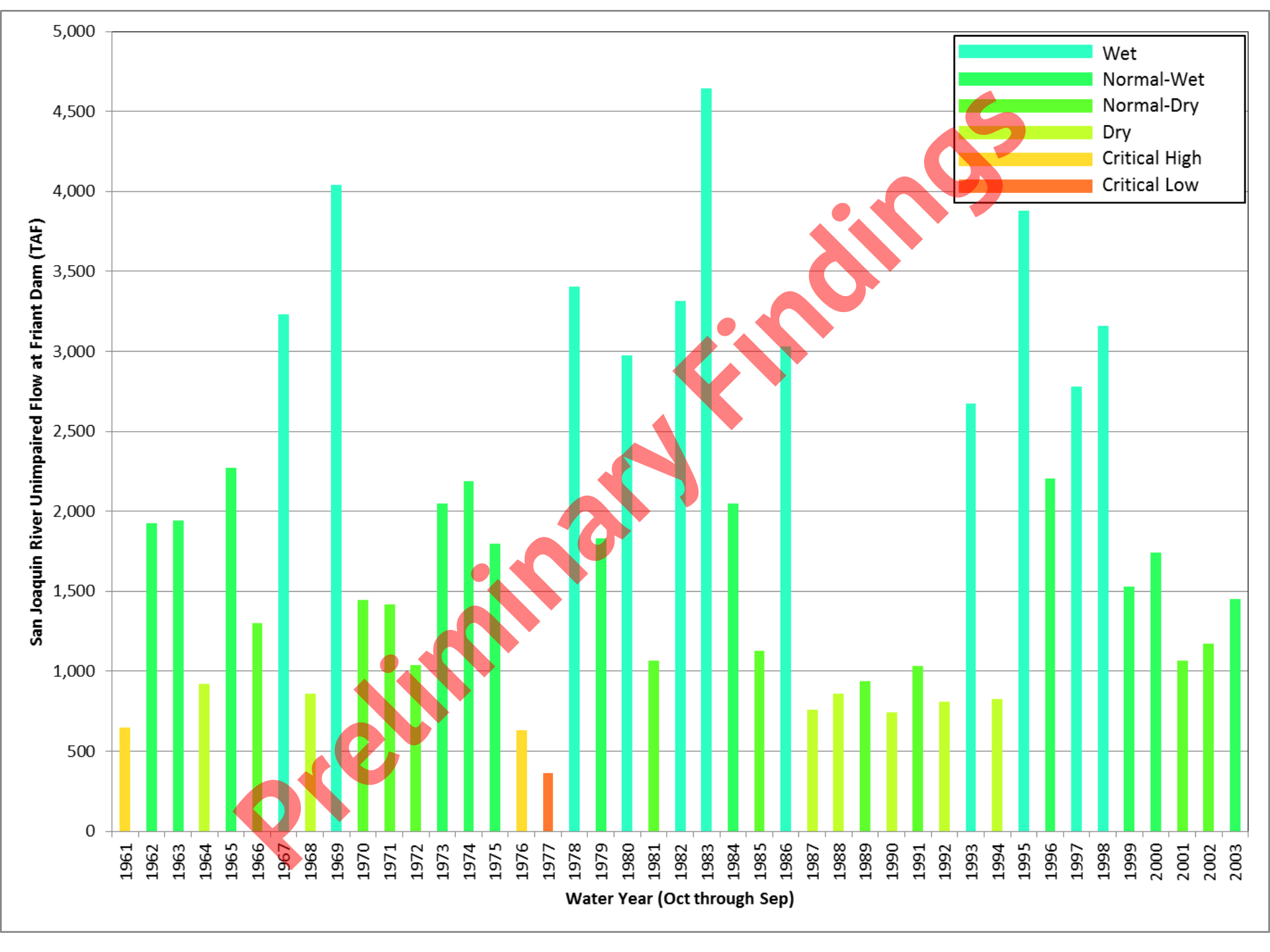
SJRRP Overview

* Restoration Goal
  * To restore and maintain fish populations in "good condition" in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.
* Water Management Goal
  * To reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

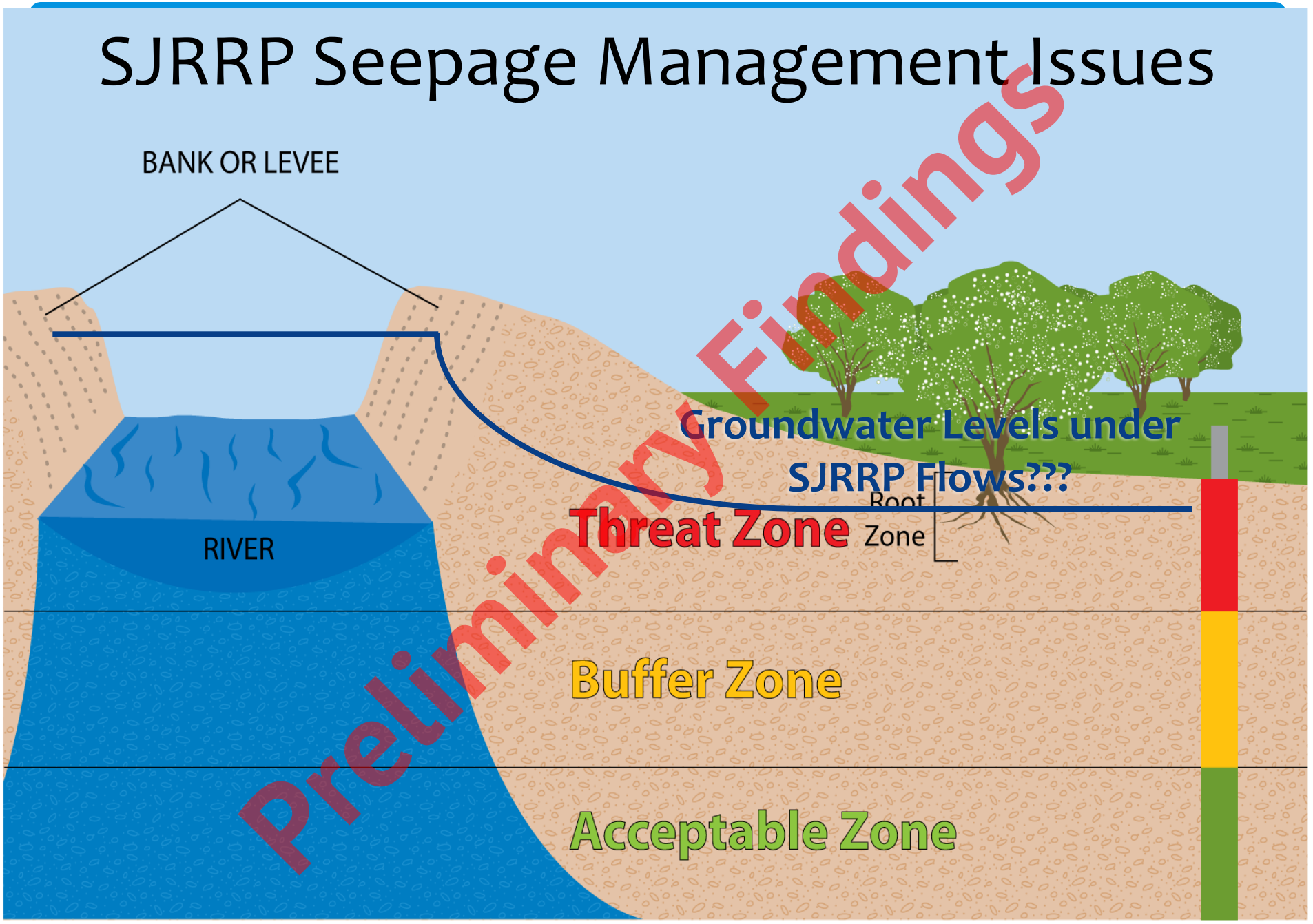
San Joaquin River, Restoration Releases from Friant Dam, as Reported by Exhibit B of the Stipulation of Settlement[1,2]



1 - NRDC v Rodgers, Stipulation of Settlement, CIV NO. S-88-1658 - LKK/GGH, Exhibit B. September 13, 2006
2 - Hydrographs reflect assumptions about seepage losses and tributary inflows which are specified in the settlement


Wet
Normal-Wet
Normal-Dry
Dry
Critical High
Critical Low
San Joaquin River Unimpaired Flow at Friant Dam (TAF)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Water Year (Oct through Sep)
Preliminary Findings

SJRRP Seepage Management Issues




Preliminary Findings

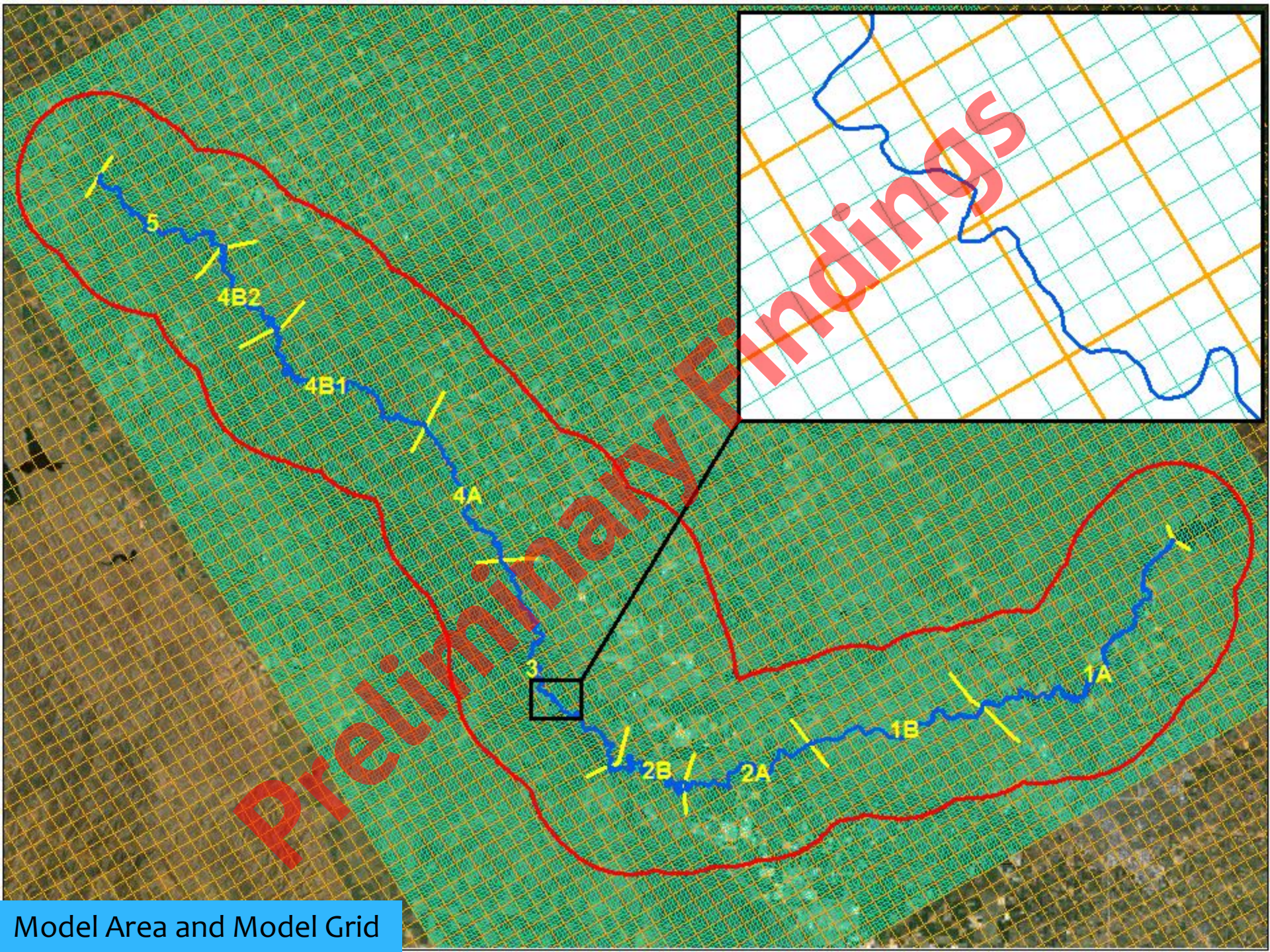

Preliminary Findings

Model Purpose

* Predict change in seepage due to SJRRP flows
* Determine areas likely to developing high water-table conditions
* Evaluate effectiveness of potential management actions
* Provide quantitative information about groundwater flow system

Model Overview

* Developed using MODFLOW Farm Process
* 1,300-square-mile area
* 150-mile reach of the San Joaquin River
* April 1961 – September 2003
* Monthly stress periods
* Simulated features include
  * 3-D aquifer sediment texture
  * Surface-water flow and stream-aquifer interaction
  * Agricultural supply and demand

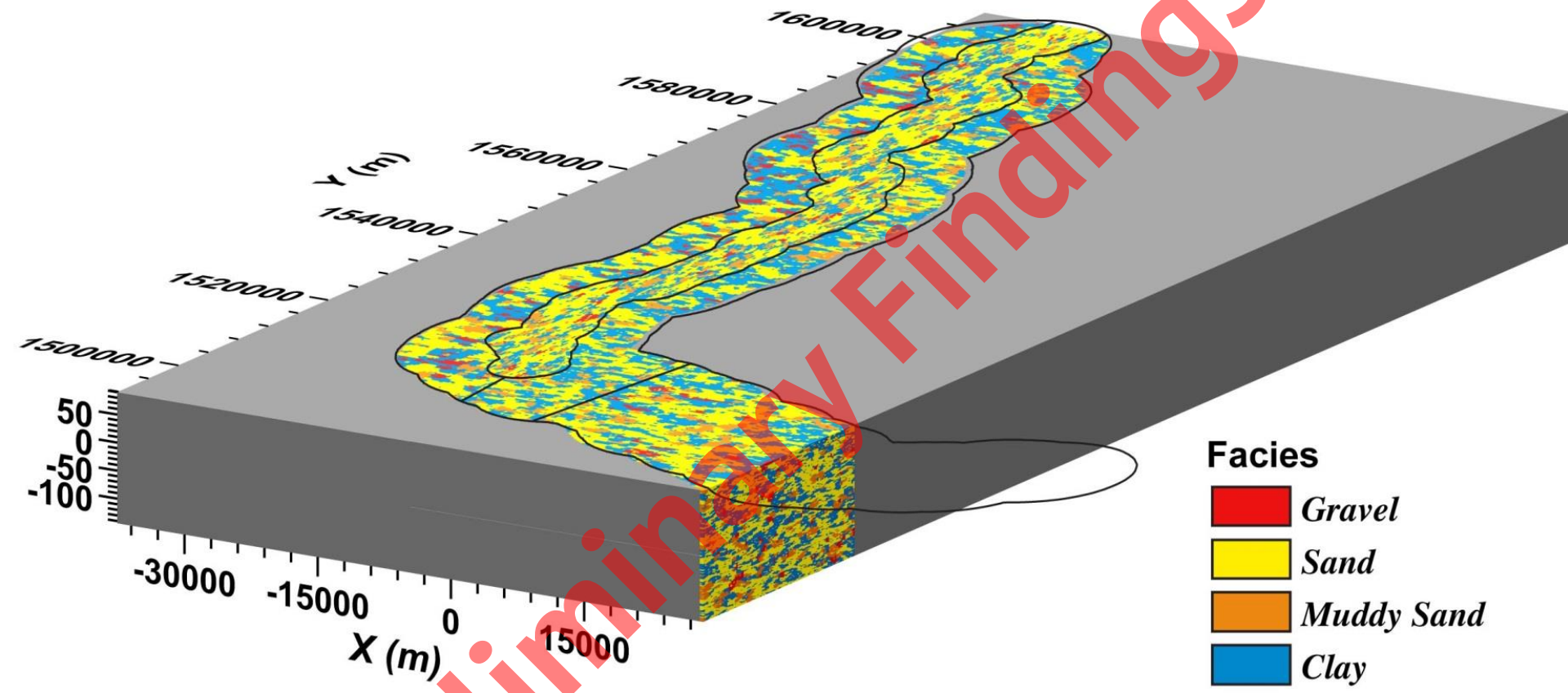


Model Area and Model Grid

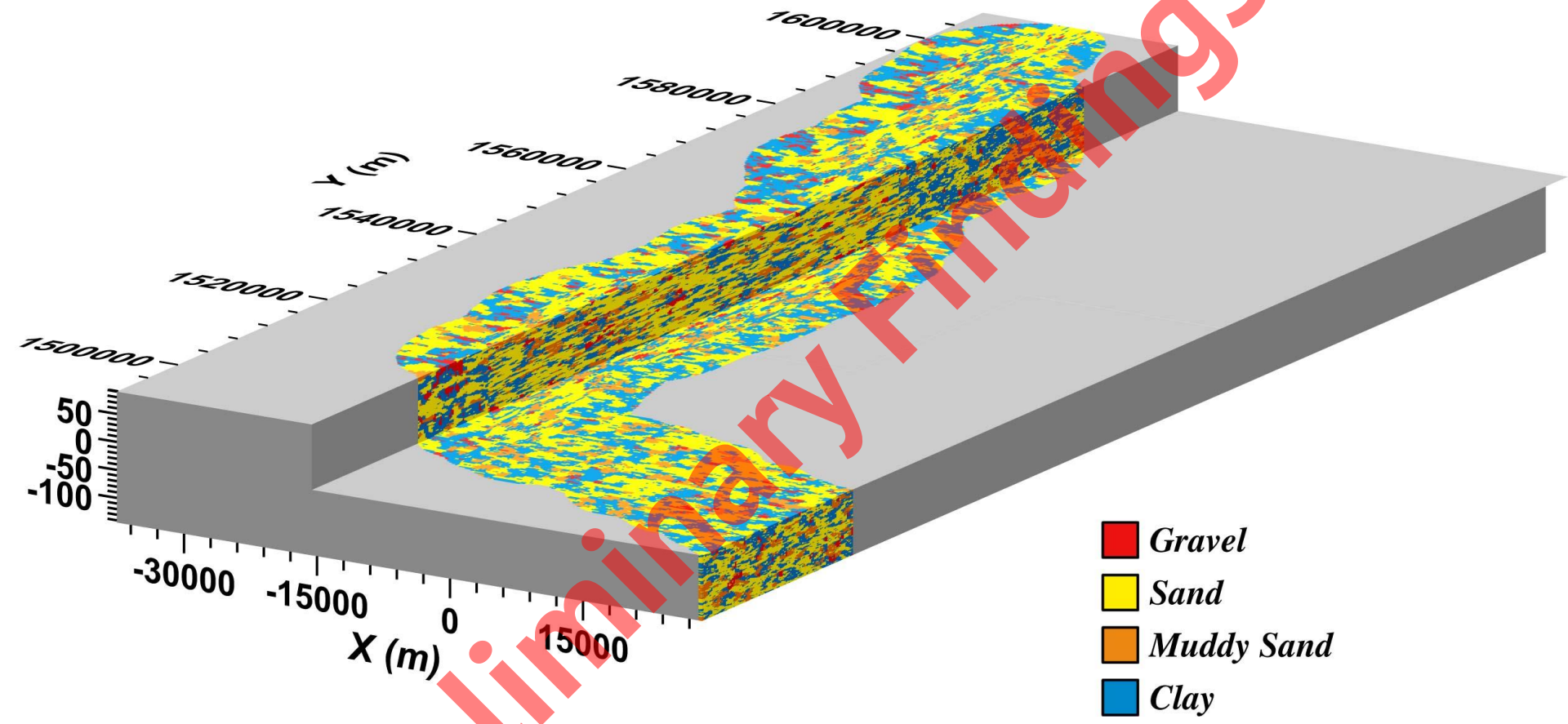
Model Hydrogeology

* Well log data grouped into classes
  * Gravel
  * Sand
  * Muddy Sand
  * Clay
* 3-D dataset developed using Transition-Probability Geostatistical Software (TPROGS)
* Dataset mapped onto model grid using HUF package

Combined Domains
San Joaquin River Restoration

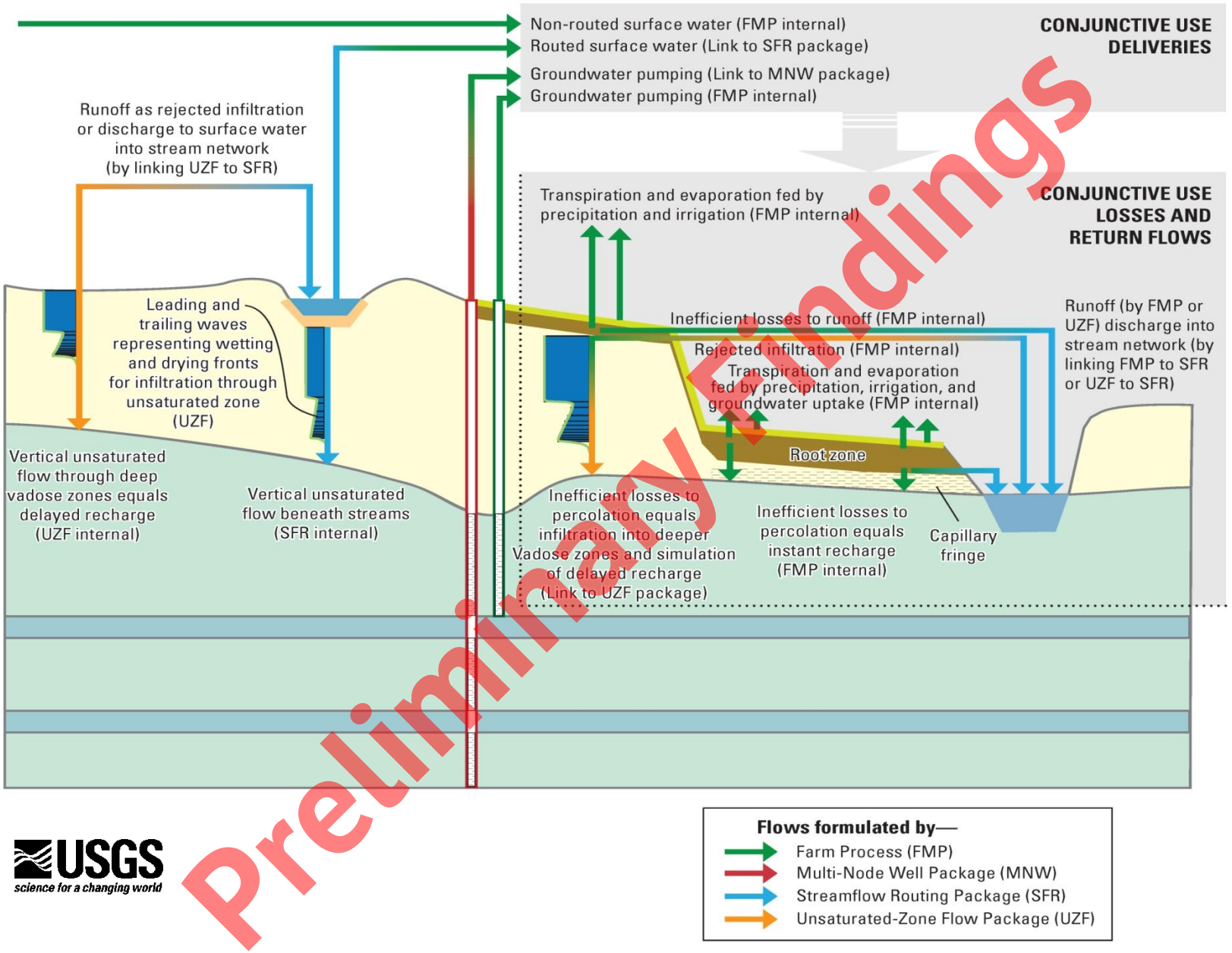


Combined Domains
San Joaquin River Restoration



Agricultural Supply and Demand

* Simulated using USGS Farm Process
* Farm Process simulated components
  * Precipitation
  * Surface water delivery
  * Groundwater pumping
  * Plant uptake of shallow groundwater
  * Plant evapotranspiration
  * Precipitation and irrigation runoff
  * Deep percolation
  * And lots more!
* Farm Process data input using 28 subregions



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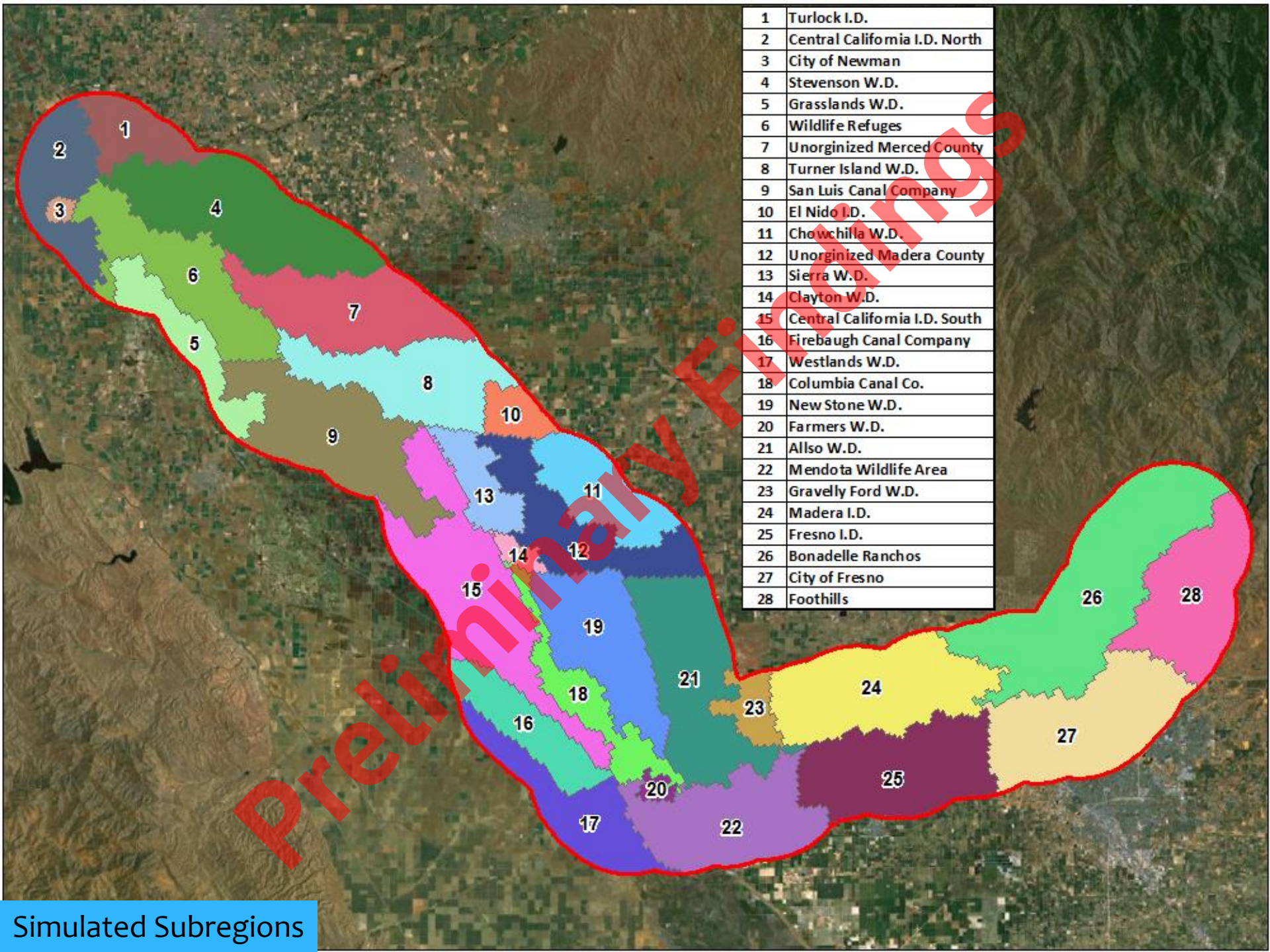
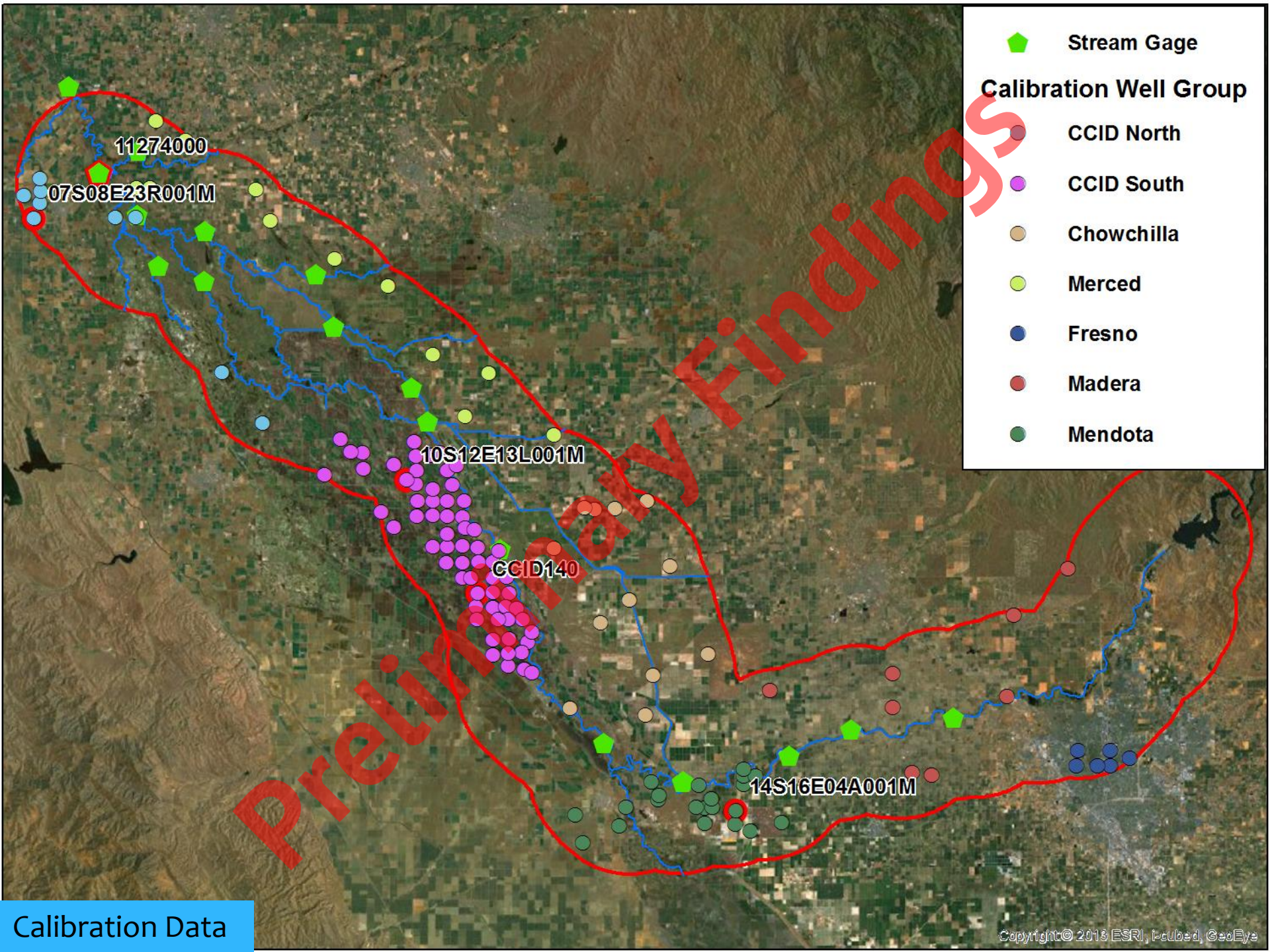


Simulated Subregions

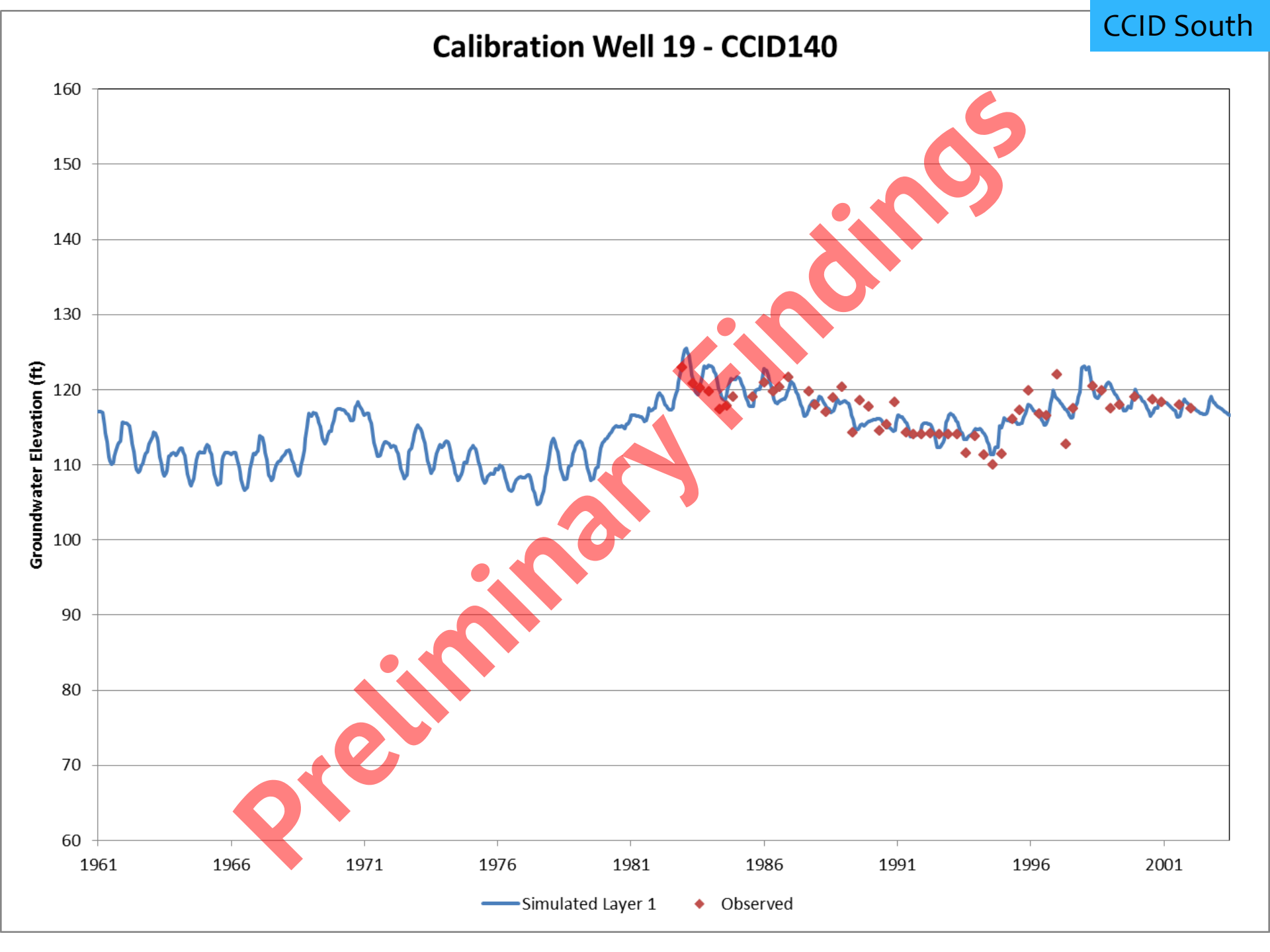
Model Calibration

* 55 CCID monitoring wells
* 78 DWR/USGS database wells
* 19 stream flow gages
* 81 model parameters
* Semi-automated calibration using PEST



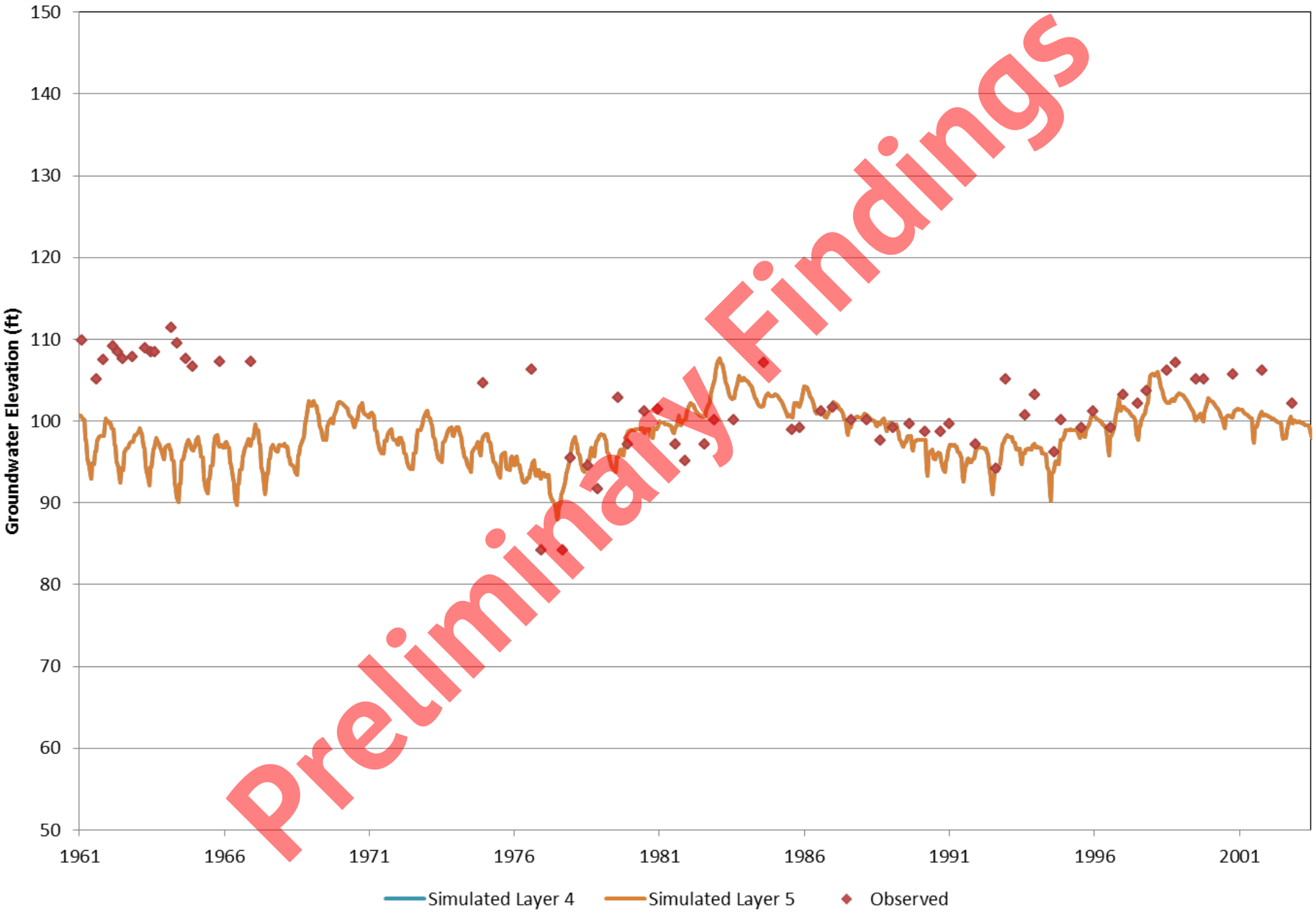
Calibration Data

CCID South

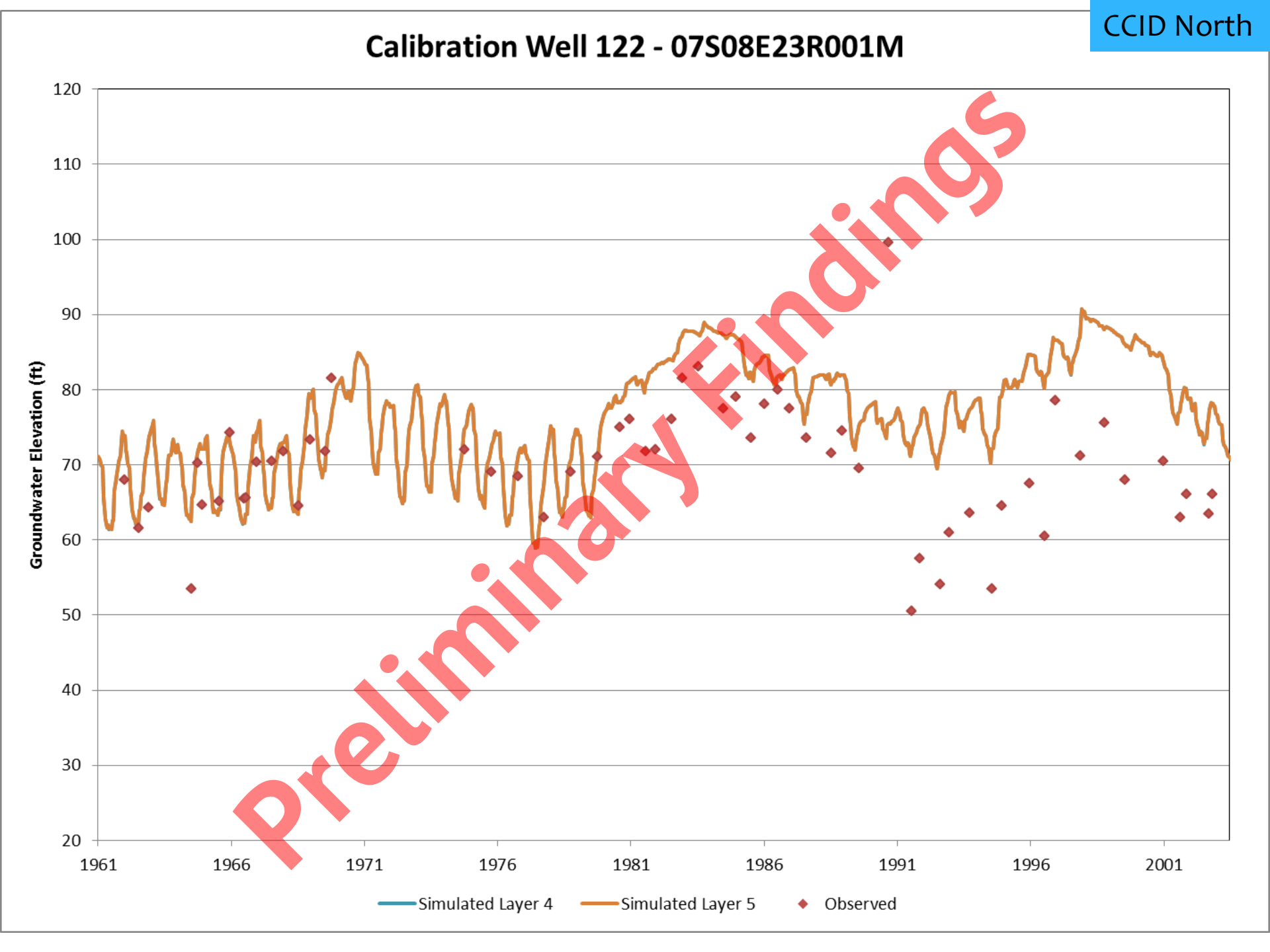

Calibration Well 19 - CCID140
Groundwater Elevation (ft)
160
150
140
130
120
110
100
90
80
70
60
1961
1966
1971
1976
1981
1986
1991
1996
2001
Simulated Layer 1
Observed
Preliminary Findings

CCID South

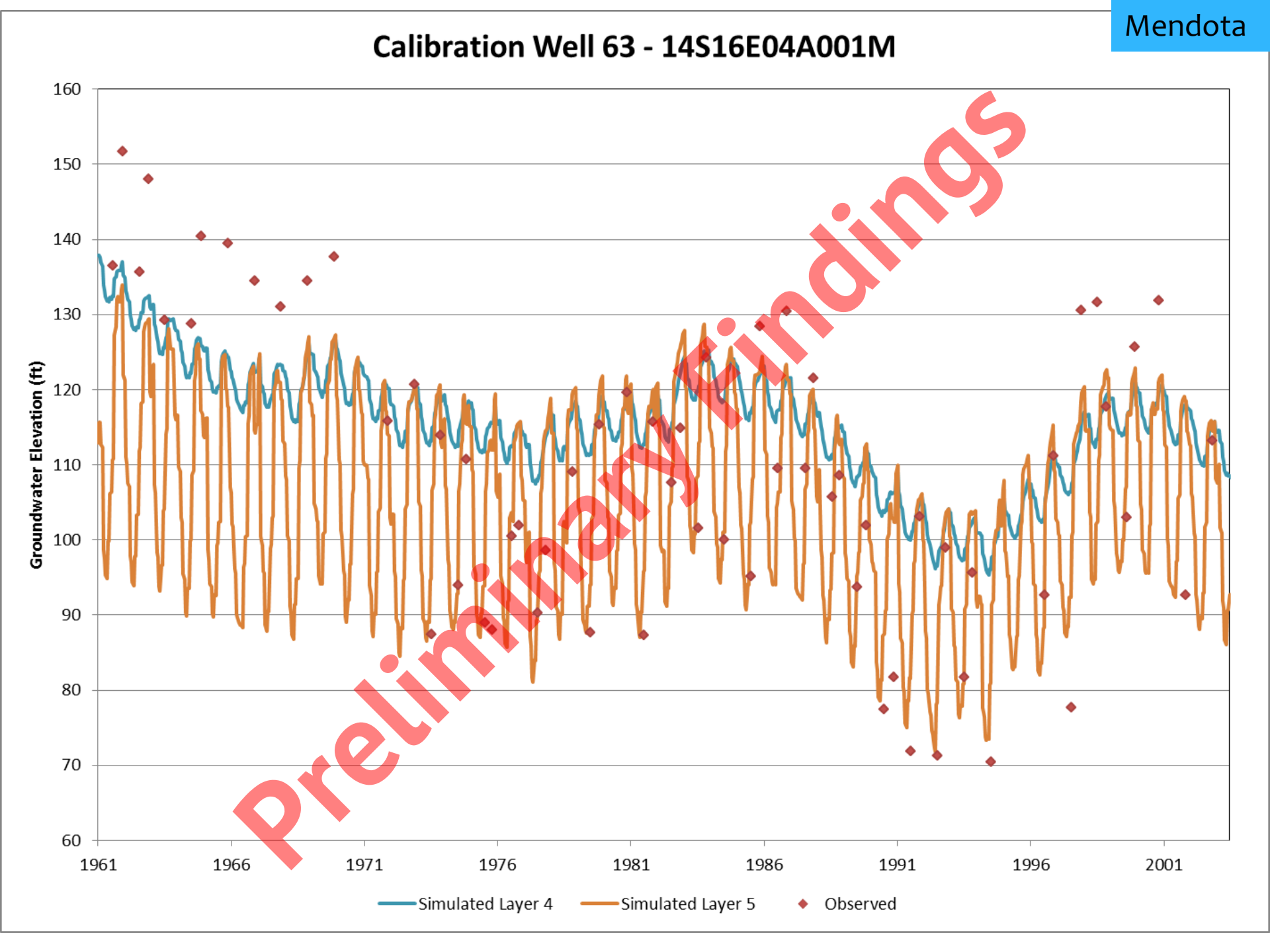
Calibration Well 105 - 10S12E13L001M



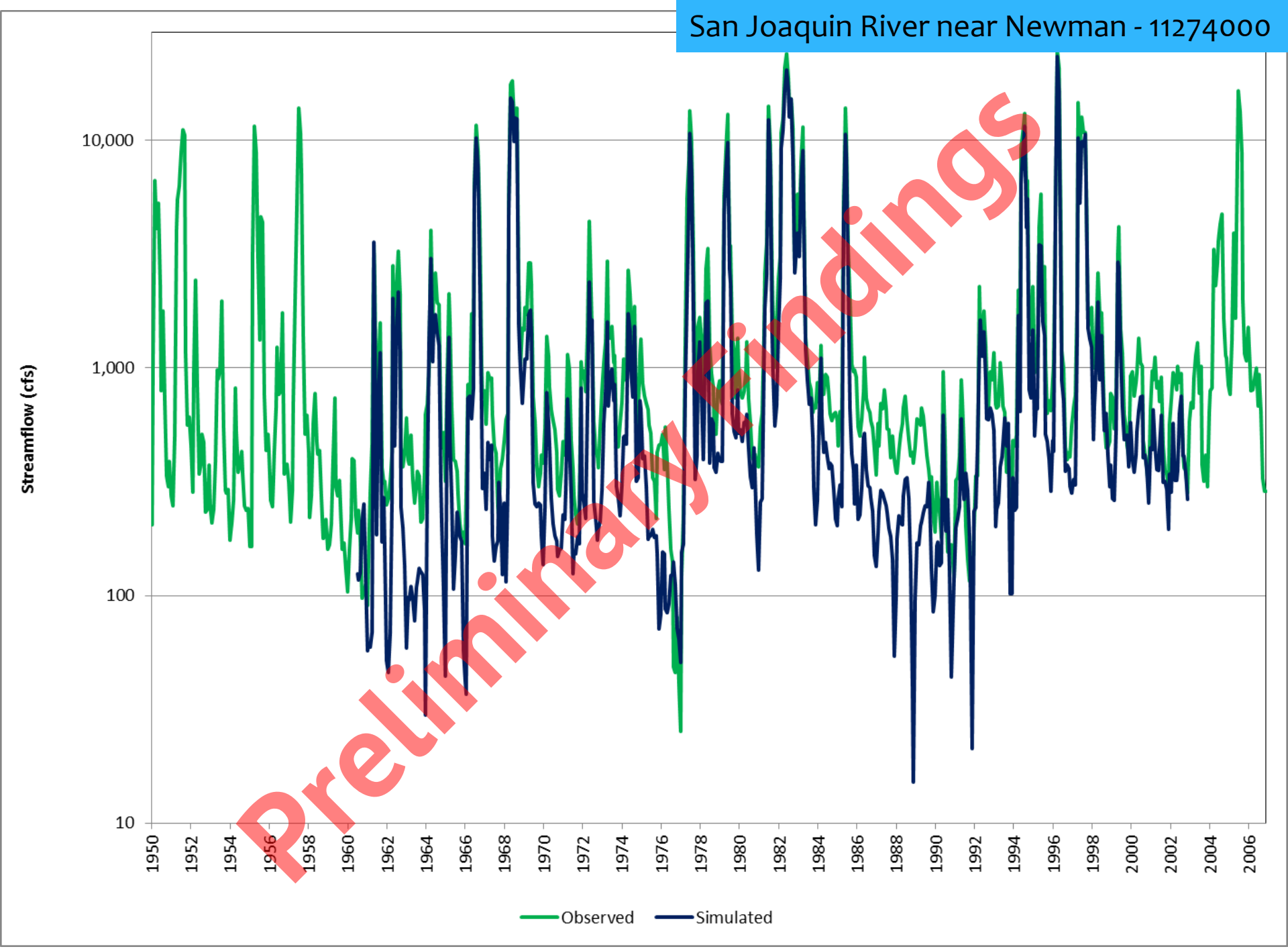
CCID North


Calibration Well 122 - 07S08E23R001M
Groundwater Elevation (ft)
120
110
100
90
80
70
60
50
40
30
20
1961
1966
1971
1976
1981
1986
1991
1996
2001
Simulated Layer 4
Simulated Layer 5
Observed
Preliminary Findings

Mendota

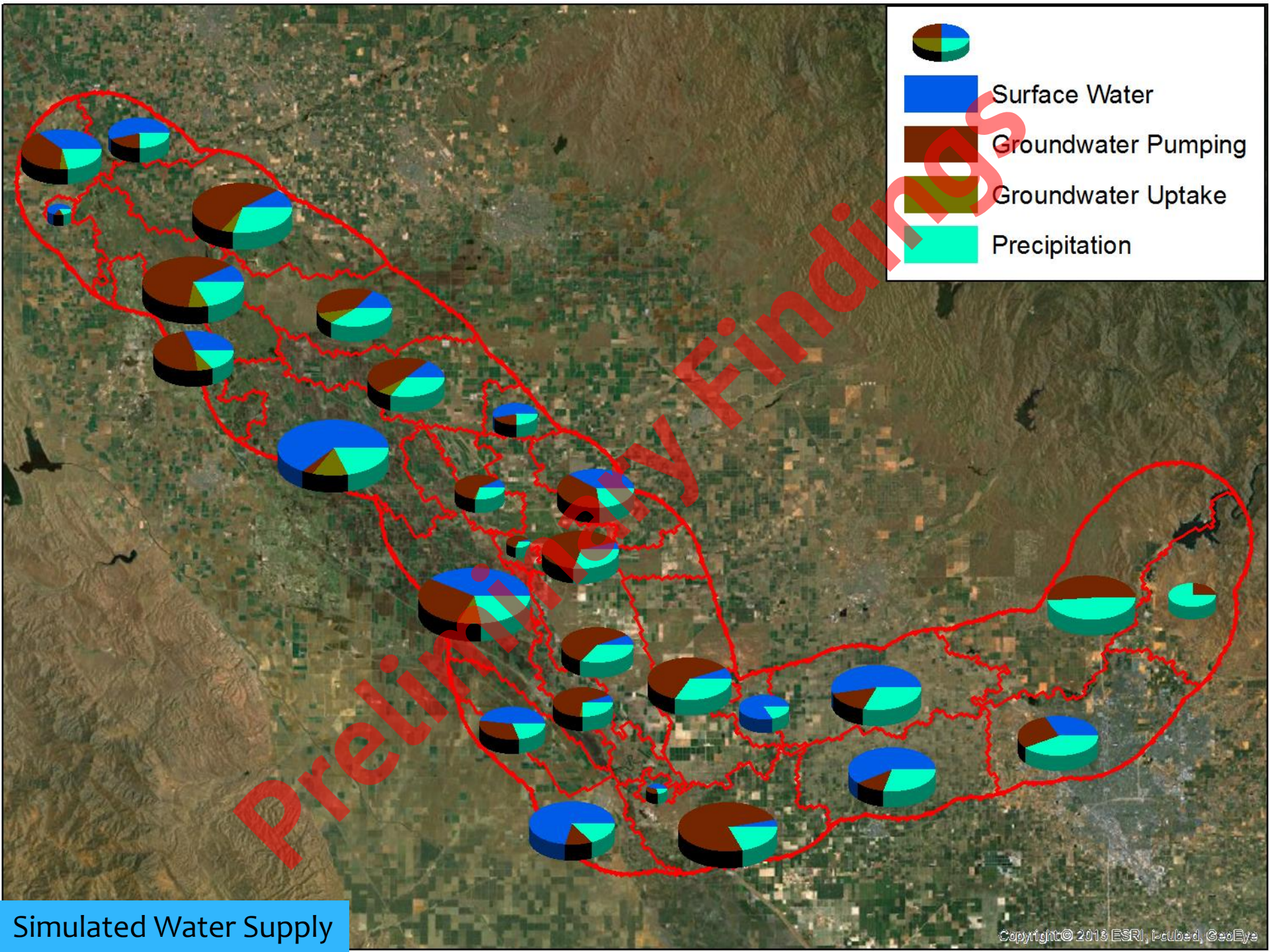

Calibration Well 63 - 14S16E04A001M
Groundwater Elevation (ft)
160
150
140
130
120
110
100
90
80
70
60
1961
1966
1971
1976
1981
1986
1991
1996
2001
Simulated Layer 4
Simulated Layer 5
Observed
Preliminary Findings

San Joaquin River near Newman - 11274000

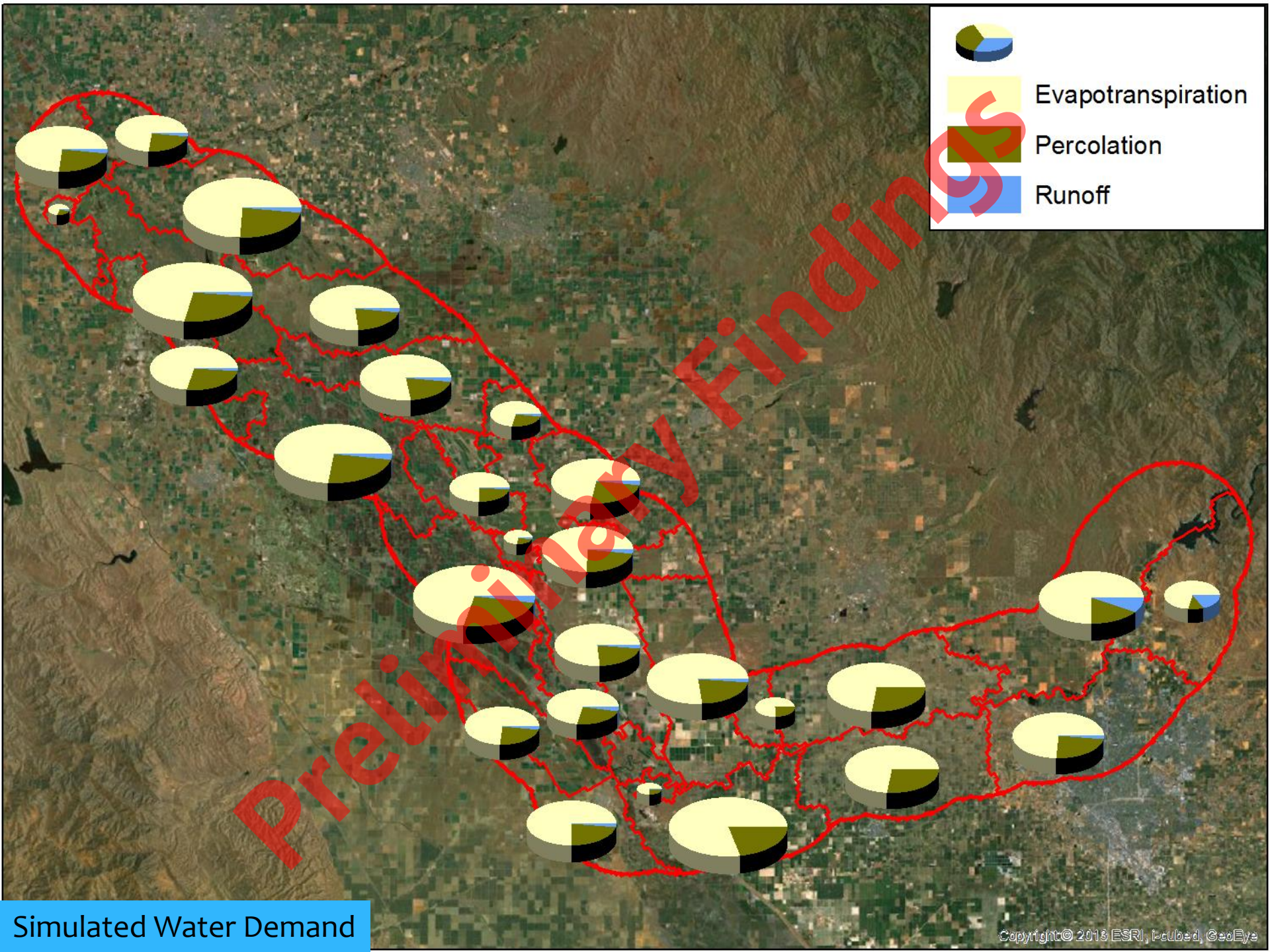


Model Results – Water Use Budget

* Inflows (Supply)
  * Precipitation
  * Surface Water Delivery
  * Agricultural Groundwater Pumping
  * Groundwater Uptake by Plants
* Outflows (Demand)
  * Crop Consumptive Use
  * Runoff to Streams
  * Percolation to Groundwater



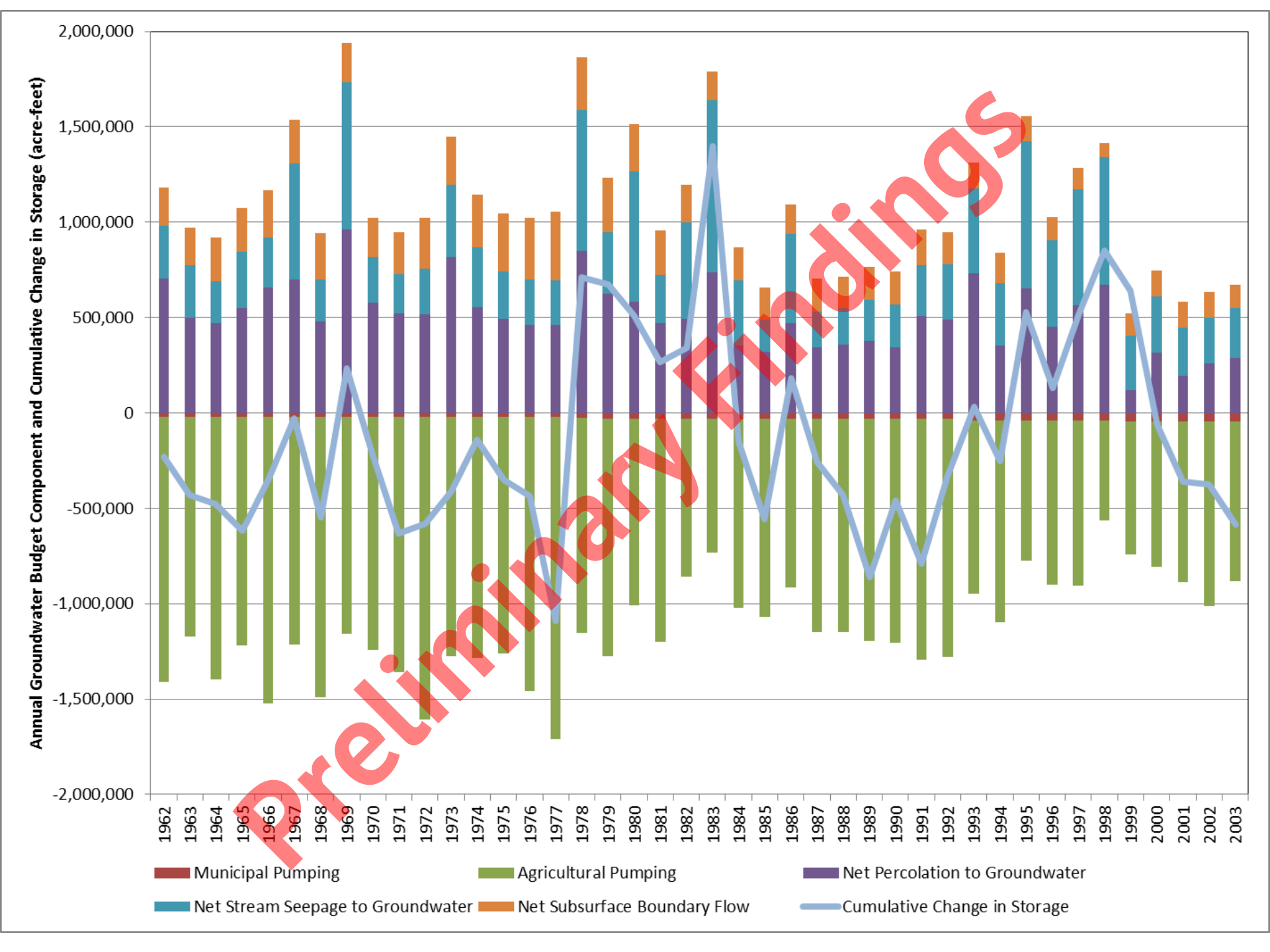
Simulated Water Supply



Simulated Water Demand

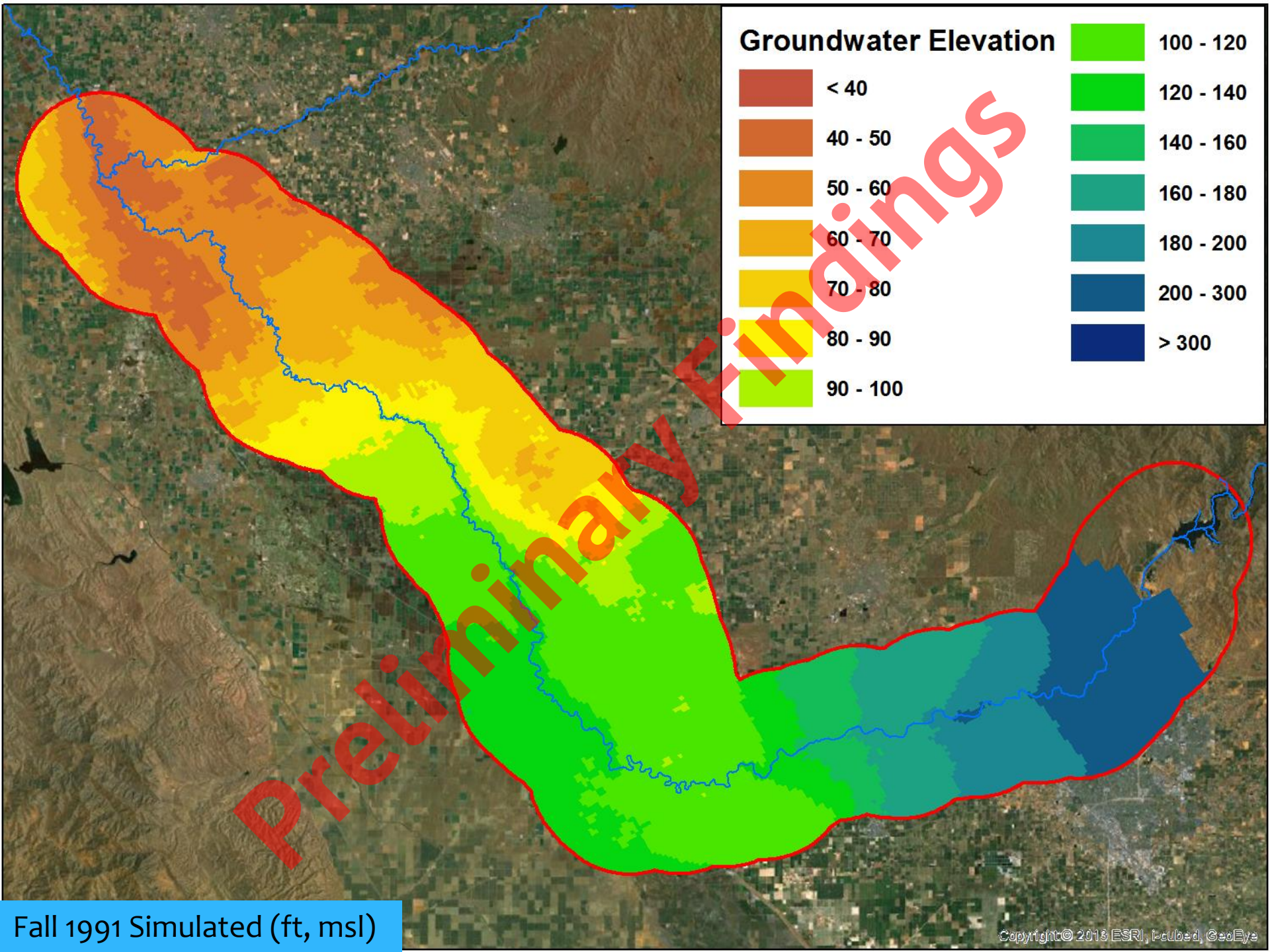
Model Results – Groundwater Budget

* Outflows
  * Municipal Groundwater Pumping
  * Agricultural Groundwater Pumping
* Inflows
  * Net Percolation to Groundwater
  * Net Stream Seepage to Groundwater
  * Net Subsurface Boundary Flow
* Change in Storage = Inflows - Outflows


Annual Groundwater Budget Component and Cumulative Change in Storage (acre-feet)
2,000,000
1,500,000
1,000,000
500,000
0
-500,000
-1,000,000
-1,500,000
-2,000,000
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Municipal Pumping
Agricultural Pumping
Net Percolation to Groundwater
Net Stream Seepage to Groundwater
Net Subsurface Boundary Flow
Cumulative Change in Storage
Preliminary Findings

Model Result Maps

* Groundwater elevation
* Depth to groundwater
* Groundwater & surface water interaction


Groundwater Elevation
< 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
100 - 120
120 - 140
140 - 160
160 - 180
180 - 200
200 - 300
> 300
Preliminary Findings
Fall 1991 Simulated (ft, msl)
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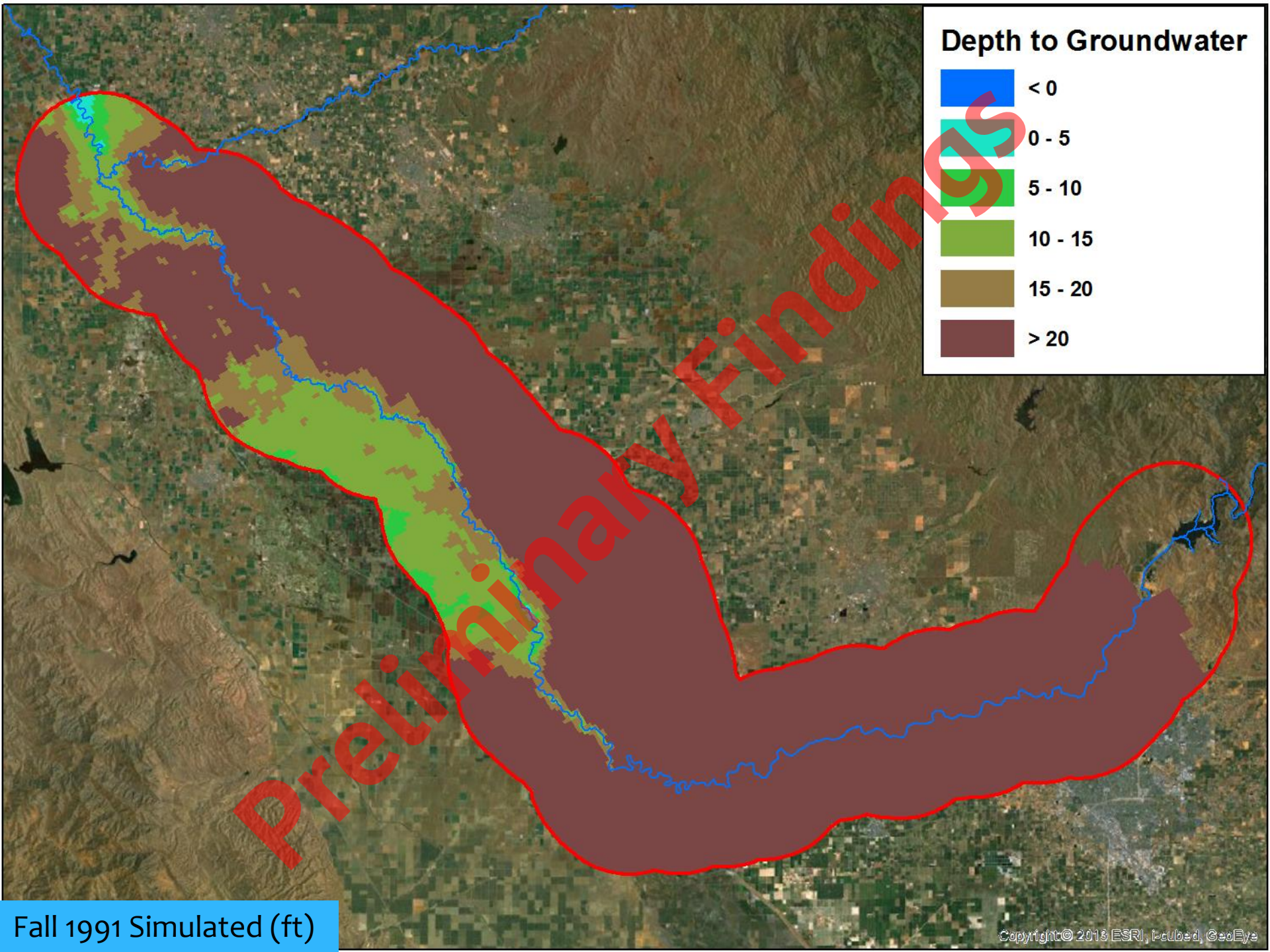
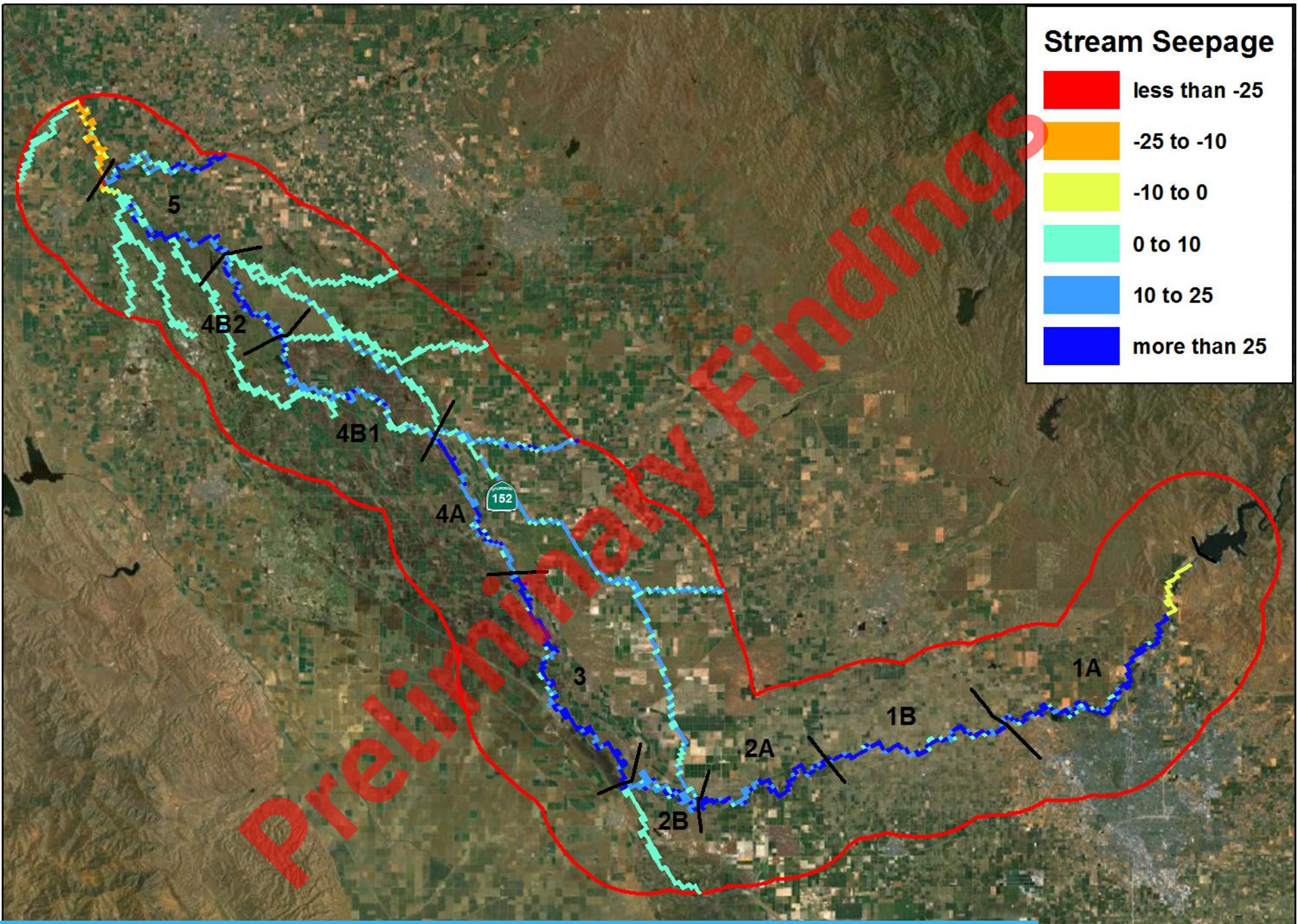
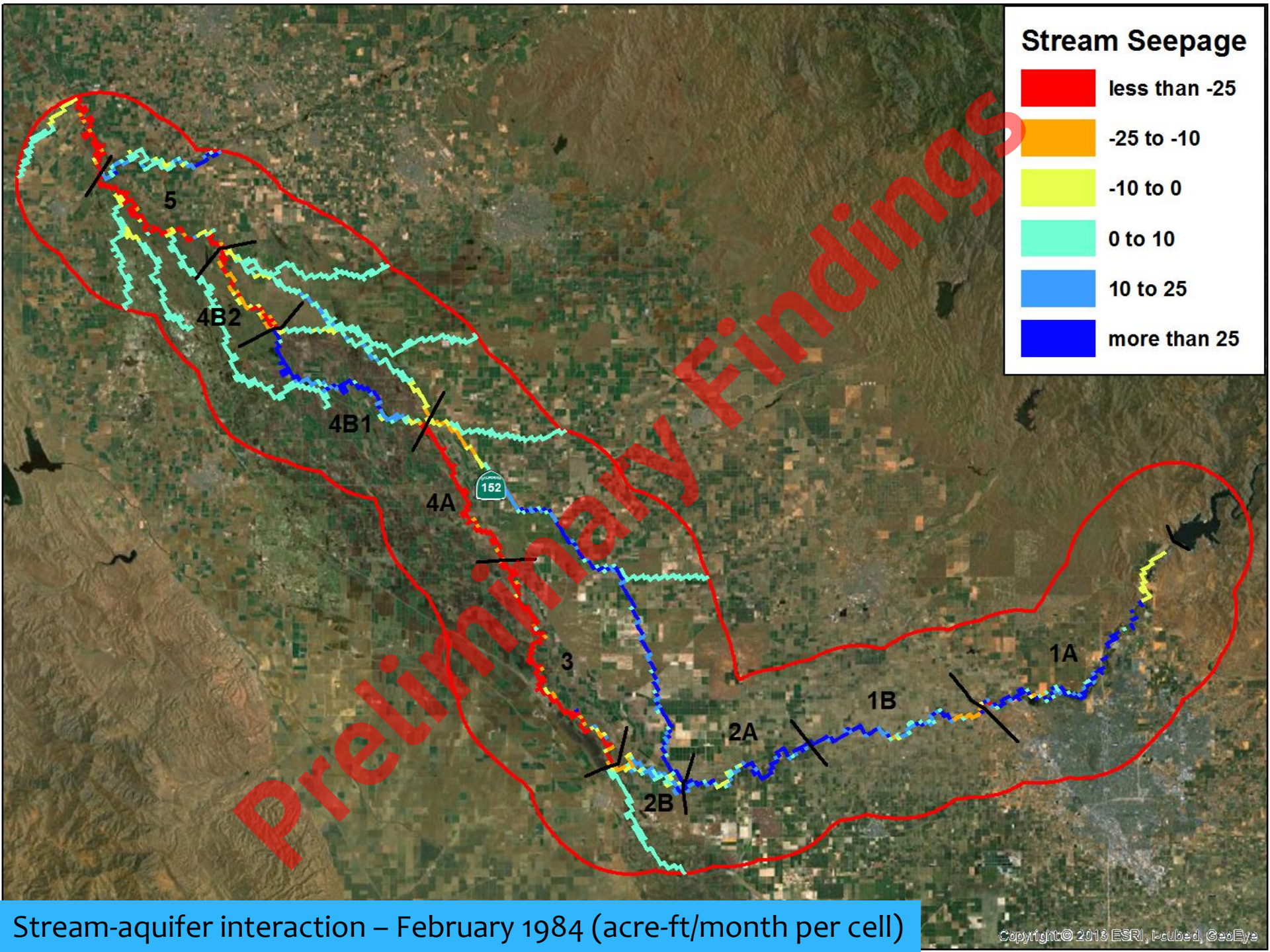


Fall 1991 Simulated (ft)



Stream-aquifer interaction – 1961 to 2003 average (acre-ft/month per cell)

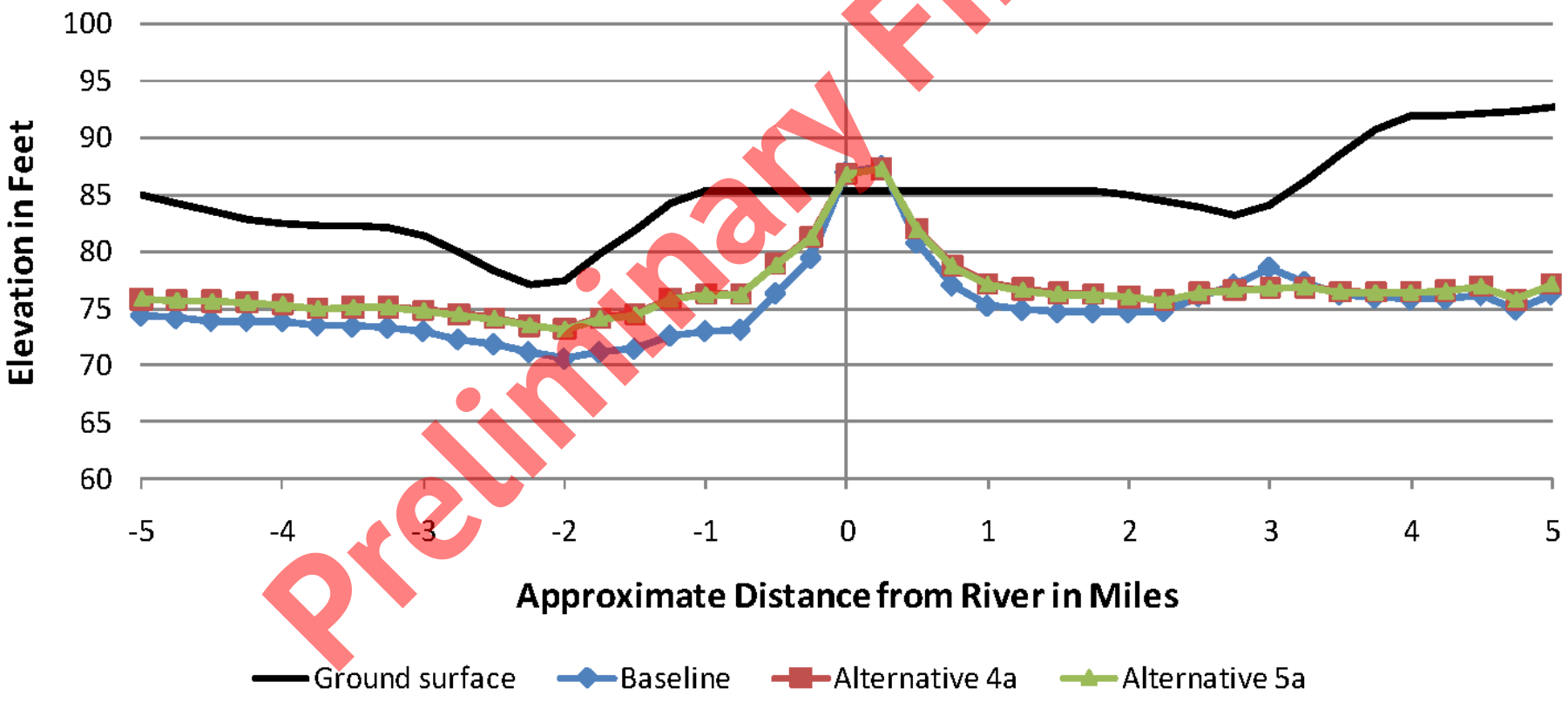


Stream-aquifer interaction – February 1984 (acre-ft/month per cell)

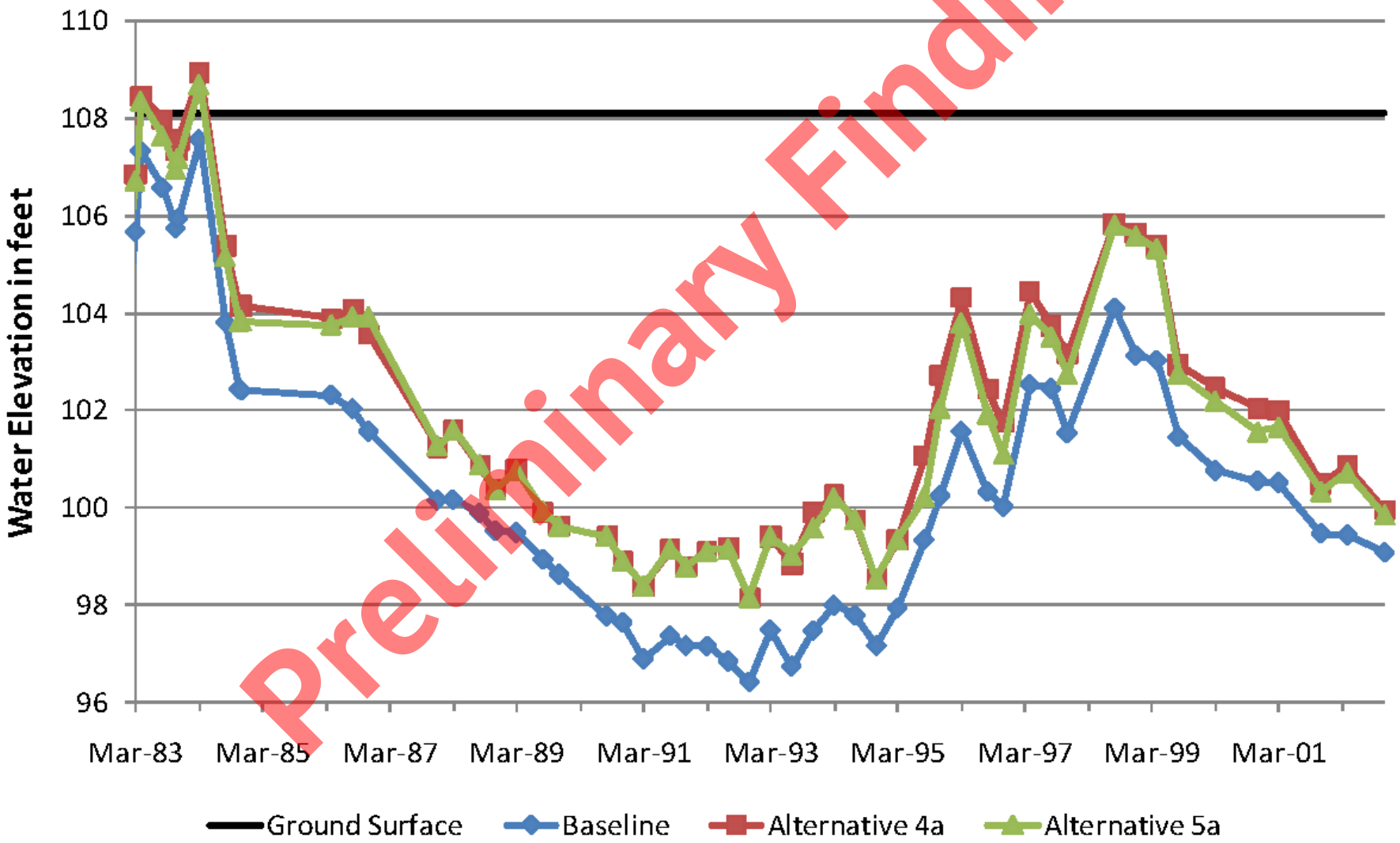
Model Application
Impacts of SJRRP Flows

* Baseline
  * No SJRRP flows
  * Historical conditions and hydrology
* Several scenarios with different SJRRP flow routing and timings

Groundwater Level Cross Section at Mariposa Bypass – January 1997



Groundwater Level Time Series near Sand Slough



Potential Seepage Mitigation Alternatives

* Install slurry walls
* Install interceptor drains
* Install new pumping wells

0 2,000 4,000 Feet

SAN JOAQUIN RIVER RESTORATION PROGRAM

Legend

- Existing Flow Gage
- Weir
- Existing Monitor Well
- Richie Iest Property
- Conceptual Drain Sump & Lift Pump
- Conceptual Facility

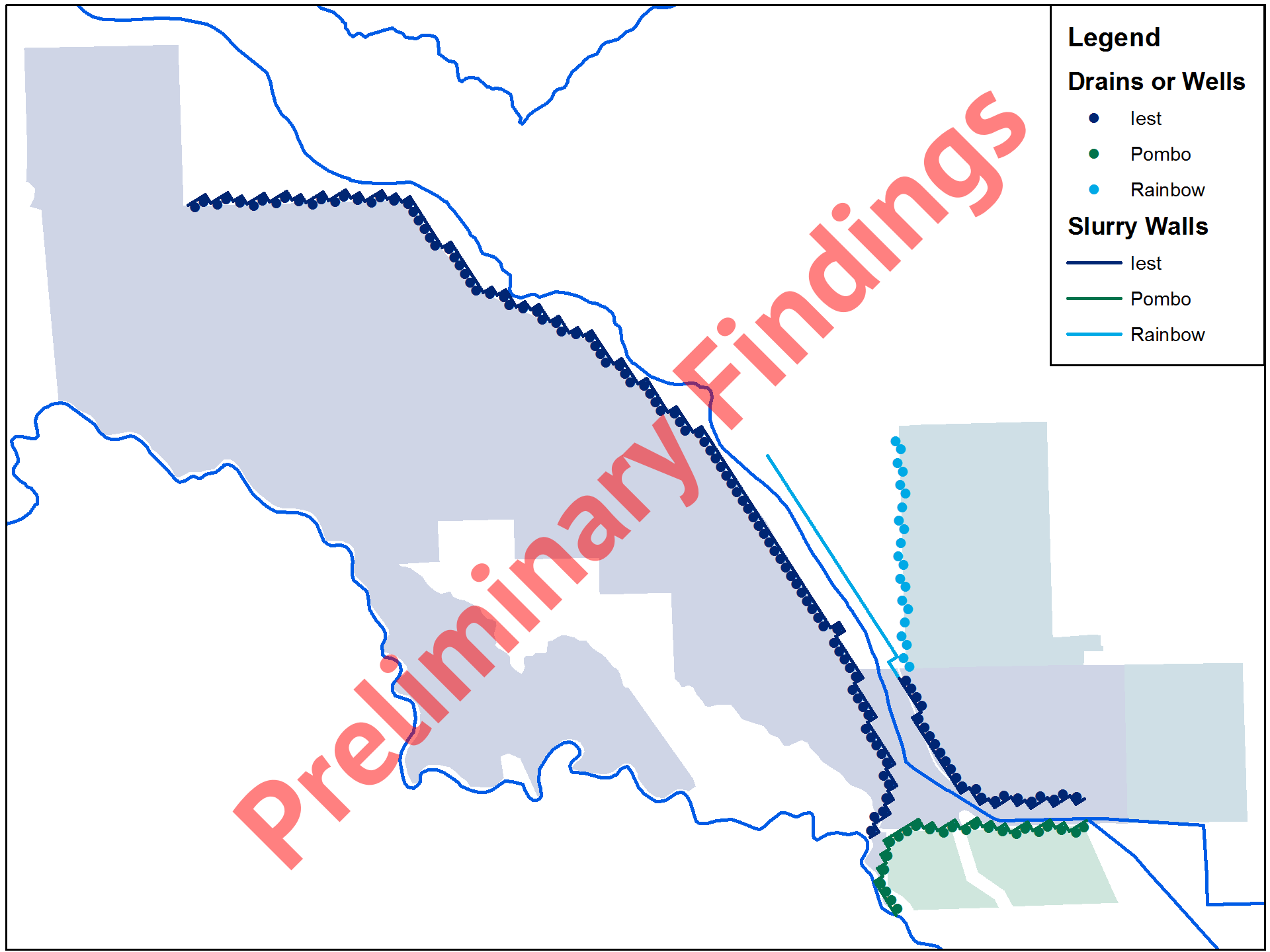
USBR Seepage Management Plan

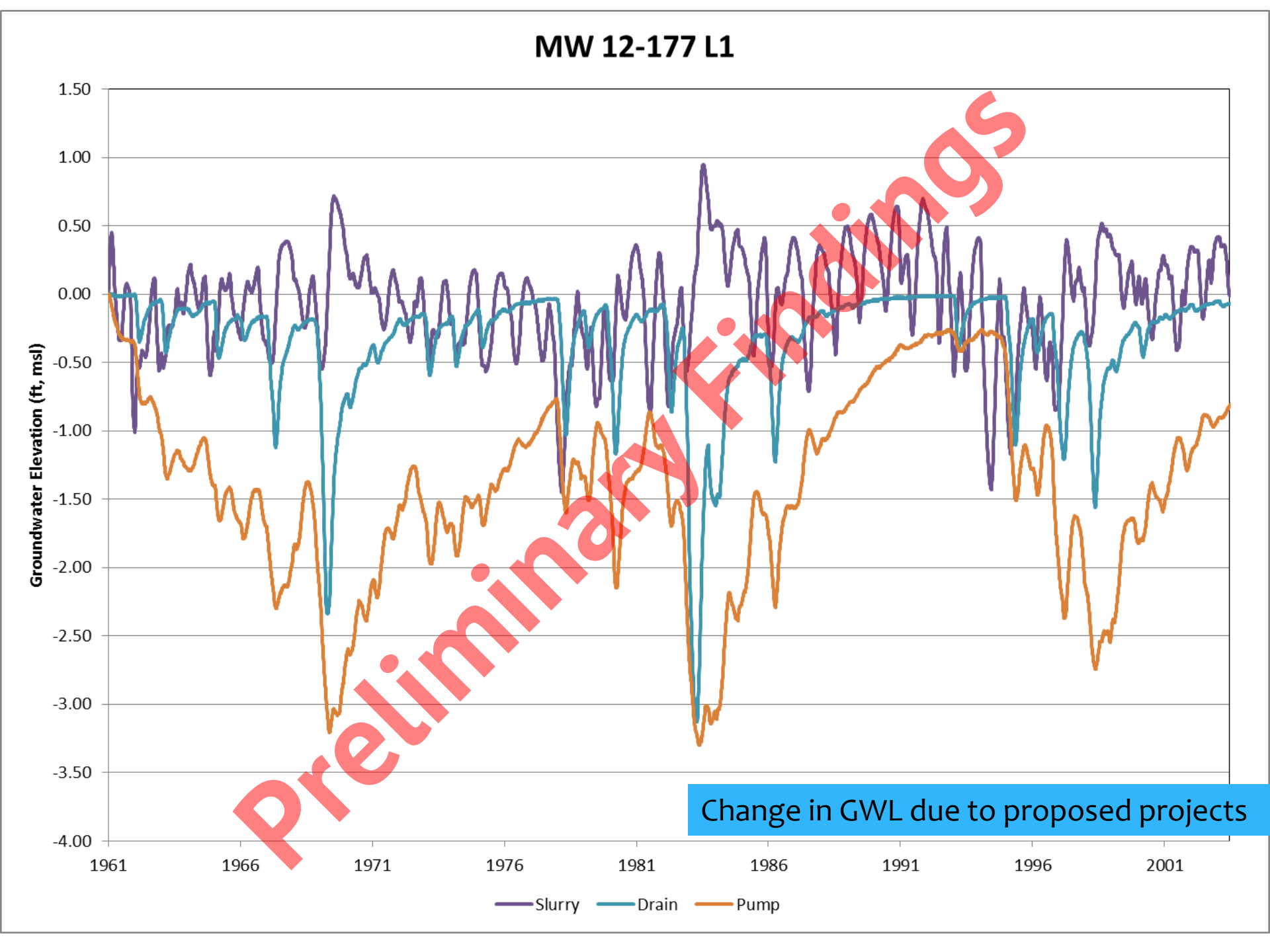
Richie Iest Property (PG 167)

Seepage Project Improvements

FIGURE 6-2

2/4/2013 : G:\Clients\CDM-1902\190211C1-USBR Seepage\GIS\Map\Wells\improvements_iest.mxd


Legend
Drains or Wells
Iest
Pombo
Rainbow
Slurry Walls
Iest
Pombo
Rainbow
Preliminary Findings


MW 12-177 L1
Groundwater Elevation (ft, msl)
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
1961
1966
1971
1976
1981
1986
1991
1996
2001
Slurry
Drain
Pump
Preliminary Findings
Change in GWL due to proposed projects

Acknowledgements

* SJRRPGW Development Team
  * Jon Traum (USGS), Primary Modeler
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  * Katrina Harrison (USBR), USBR Project Manager
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  * John Doherty (Watermark Numerical Computing), BeoPEST Developer
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  * Keith Halford (USGS) and Howard Reeves (USGS), Technical Review
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  * Chris White (CCID) and Chris Montoya (DWR), Unpublished Data

Questions?