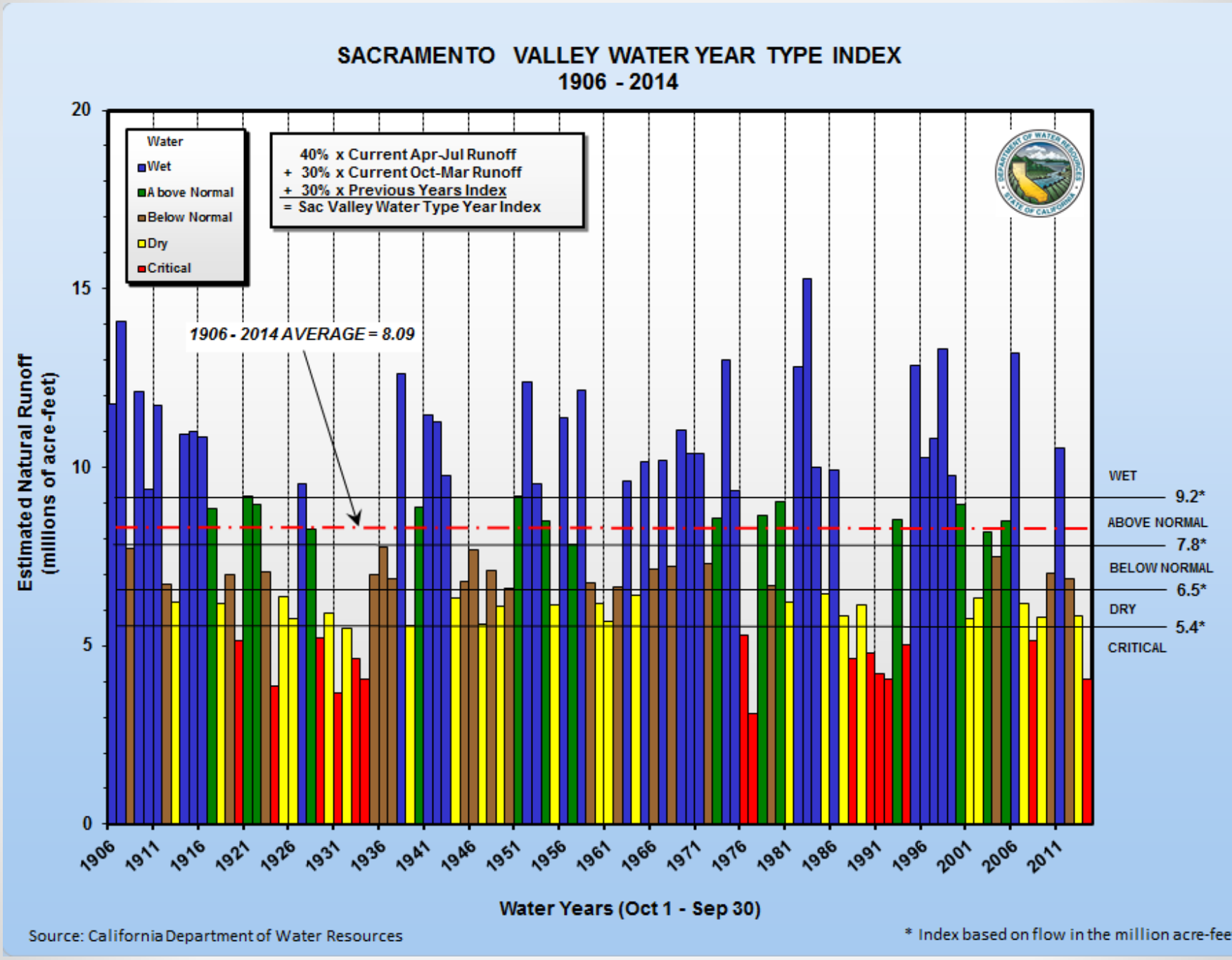
Summer 2015 Groundwater Update and Recent Subsidence Results

Glenn County
Water Advisory Committee Meeting
November 10, 2015

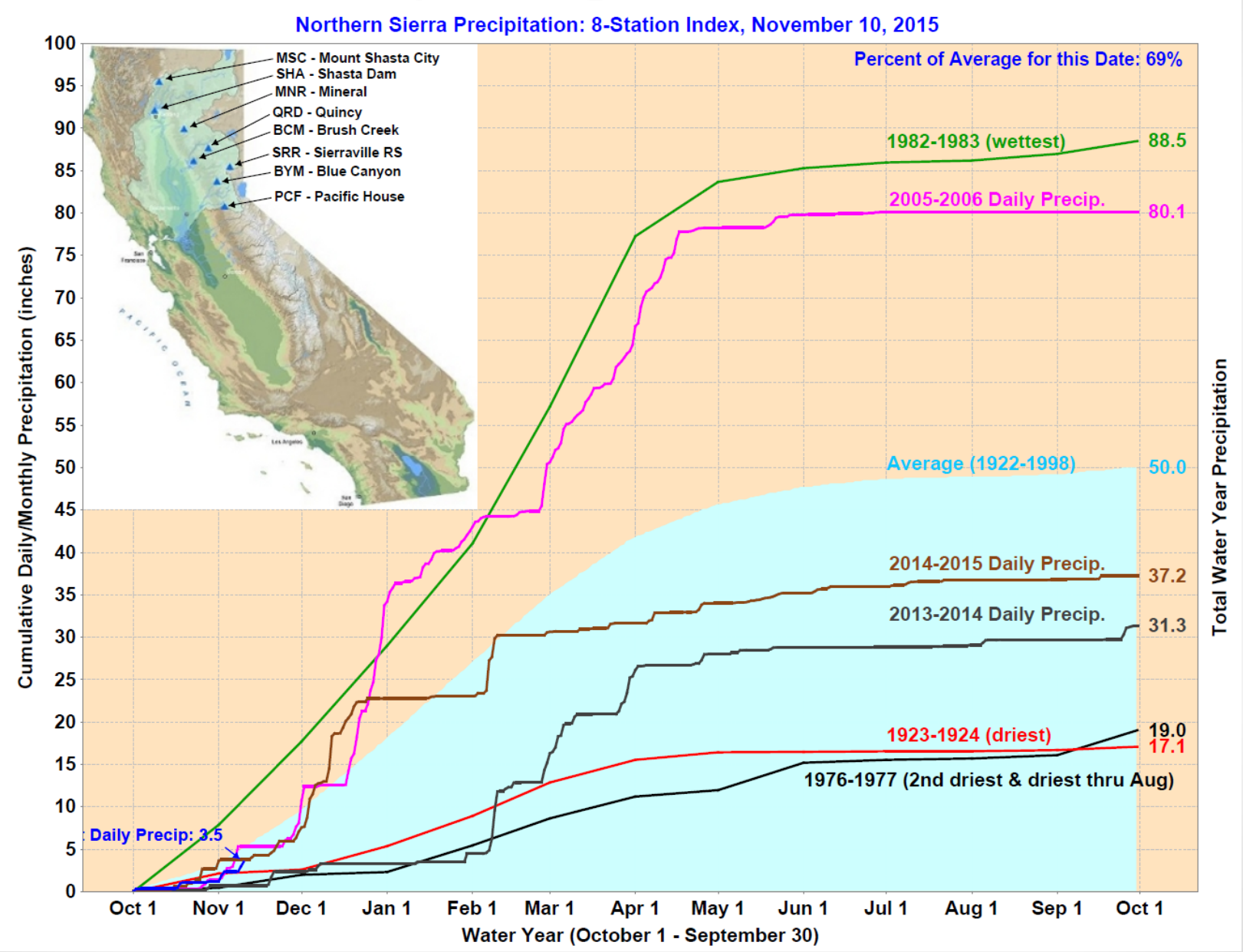
Erin Smith
Engineering Geologist
Northern Region Office
CA Department of Water Resources

Outline

- Water year index and precipitation summary
- Summer 2015 groundwater level results
- Results of spring 2015 subsidence survey


SACRAMENTO VALLEY WATER YEAR TYPE INDEX
1906 - 2014
Water
Wet
Above Normal
Below Normal
Dry
Critical
40% x Current Apr-Jul Runoff
+ 30% x Current Oct-Mar Runoff
+ 30% x Previous Years Index
= Sac Valley Water Type Year Index
1906 - 2014 AVERAGE = 8.09
Estimated Natural Runoff
(millions of acre-feet)
20
15
10
5
0
1906
1911
1916
1921
1926
1931
1936
1941
1946
1951
1956
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
WET
9.2*
ABOVE NORMAL
7.8*
BELOW NORMAL
6.5*
DRY
5.4*
CRITICAL
Water Years (Oct 1 - Sep 30)
Source: California Department of Water Resources
* Index based on flow in the million acre-feet

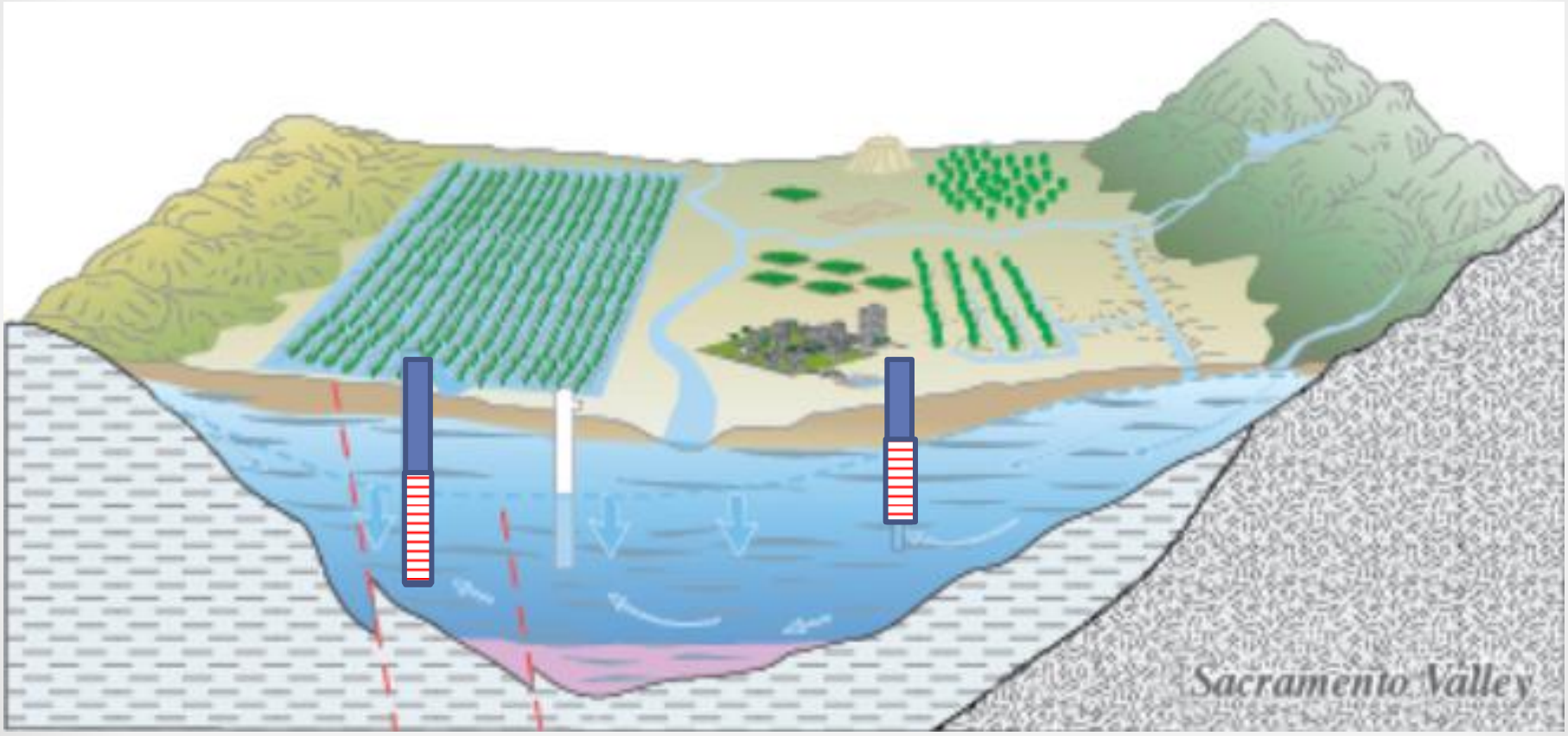
Sacramento Valley Precipitation – 8-Station Index



Summer 2015 Groundwater Level Results

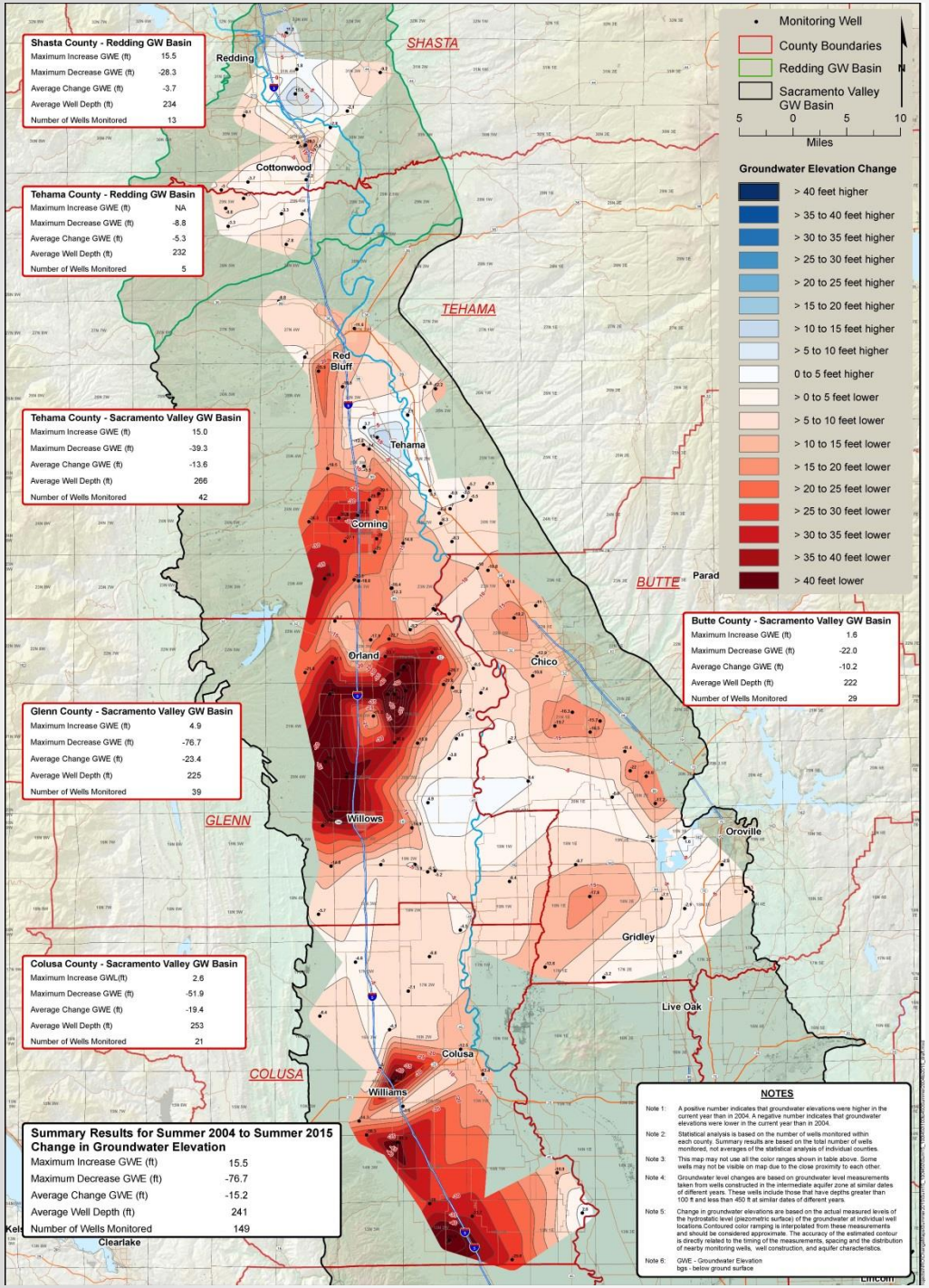
Change Maps and Hydrographs

Groundwater level data are grouped for analysis by well depth



>600 ft **100-450 ft**

Modified from Faunt, 2009



Wells 100-450 Feet Deep

Summer Change 2004-2015

Summary Results for Summer 2004 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	15.5
Maximum Decrease GWE (ft)	-76.7
Average Change GWE (ft)	-15.2
Average Well Depth (ft)	241
Number of Wells Monitored	149

Wells 100-450 Feet Deep

Summer Change 2004-2015

Summary Results for Summer 2004 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	15.5
Maximum Decrease GWE (ft)	-76.7
Average Change GWE (ft)	-15.2
Average Well Depth (ft)	241
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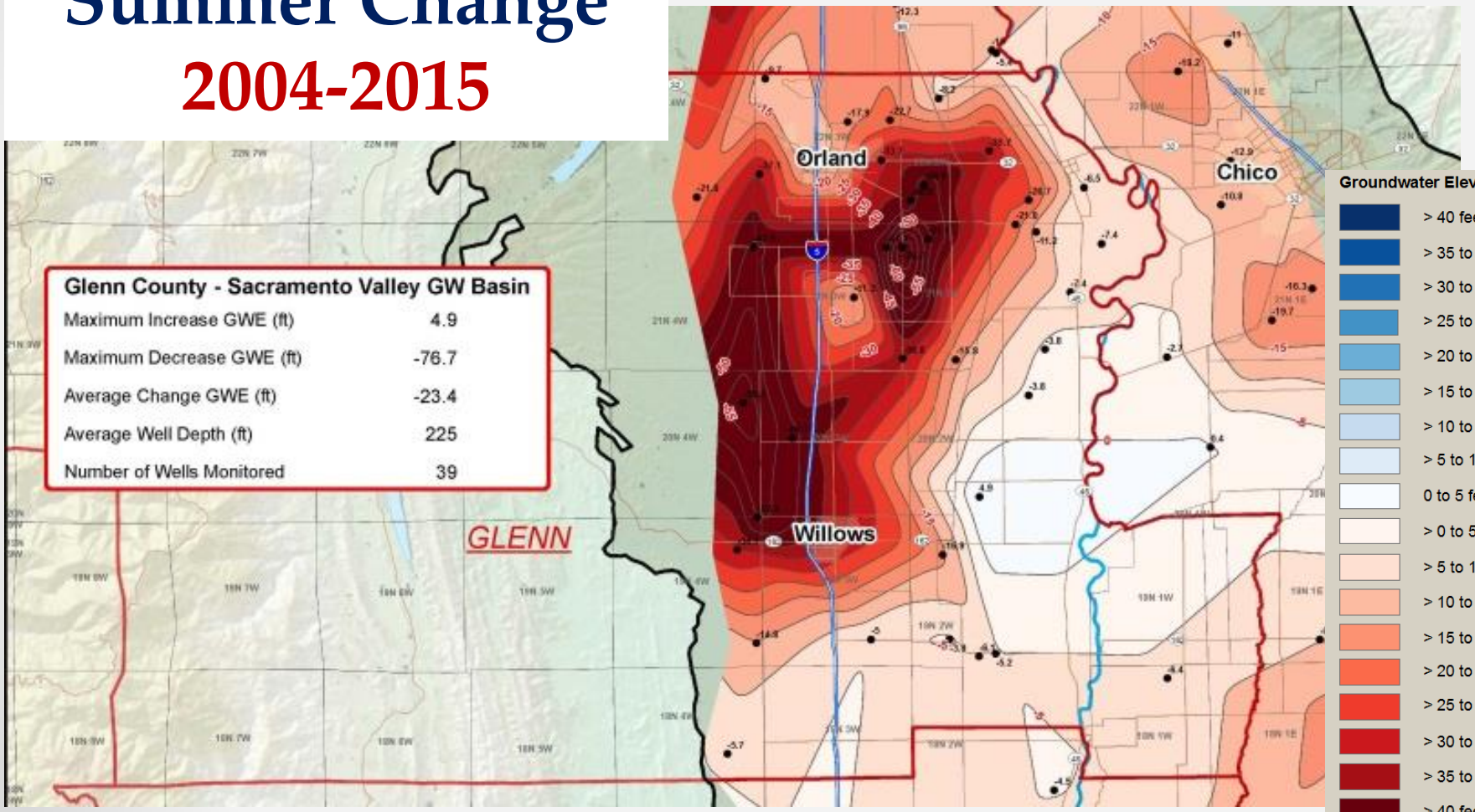
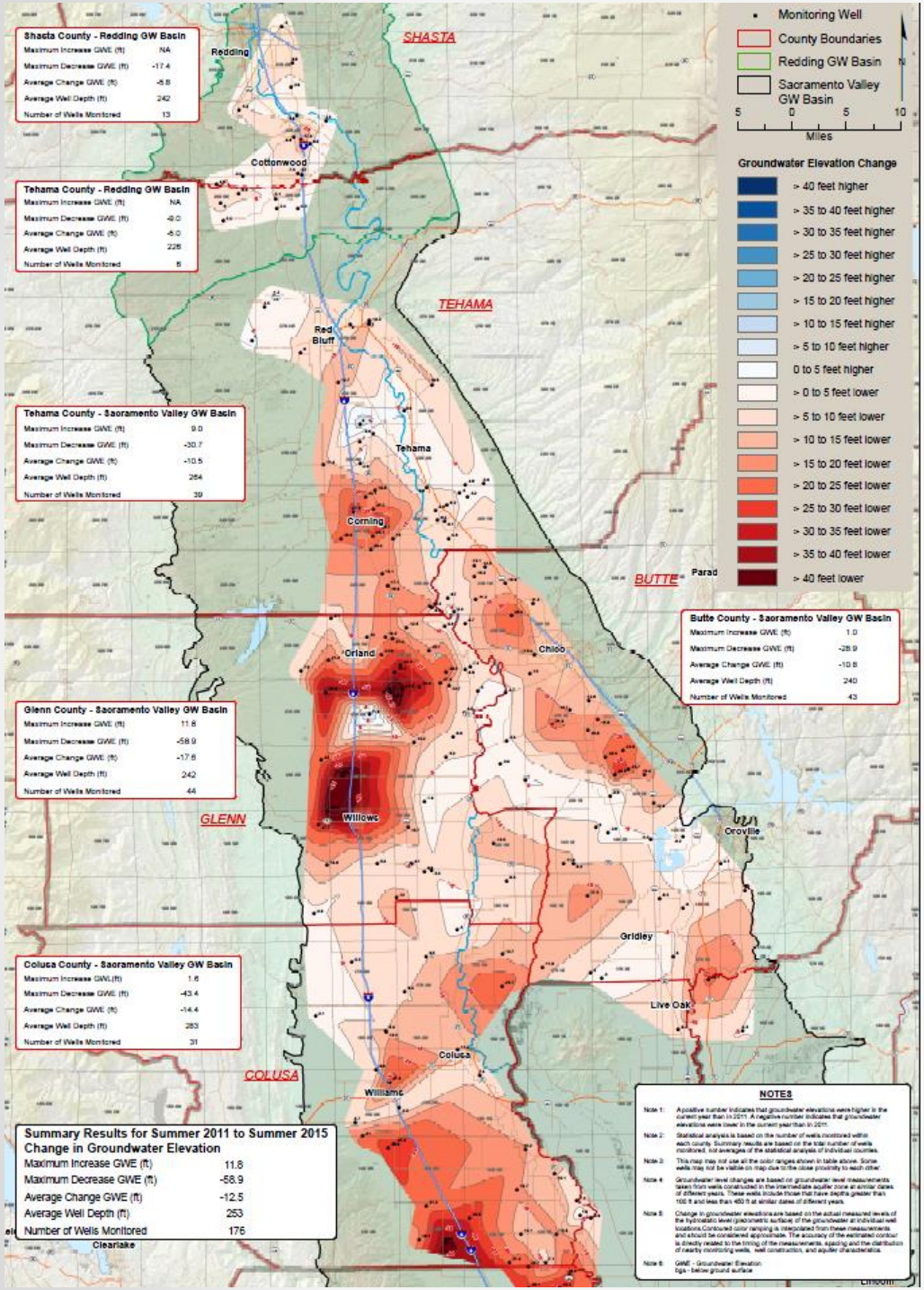


Glenn County - Sacramento Valley GW Basin	
Maximum Increase GWE (ft)	4.9
Maximum Decrease GWE (ft)	-76.7
Average Change GWE (ft)	-23.4
Average Well Depth (ft)	225
Number of Wells Monitored	39



Wells 100-450 Feet Deep

Summer Change 2011-2015

Summary Results for Summer 2011 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	11.8
Maximum Decrease GWE (ft)	-58.9
Average Change GWE (ft)	-12.5
Average Well Depth (ft)	253
Number of Wells Monitored	176

Wells 100-450 Feet Deep

Summer Change 2011-2015

Summary Results for Summer 2011 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	11.8
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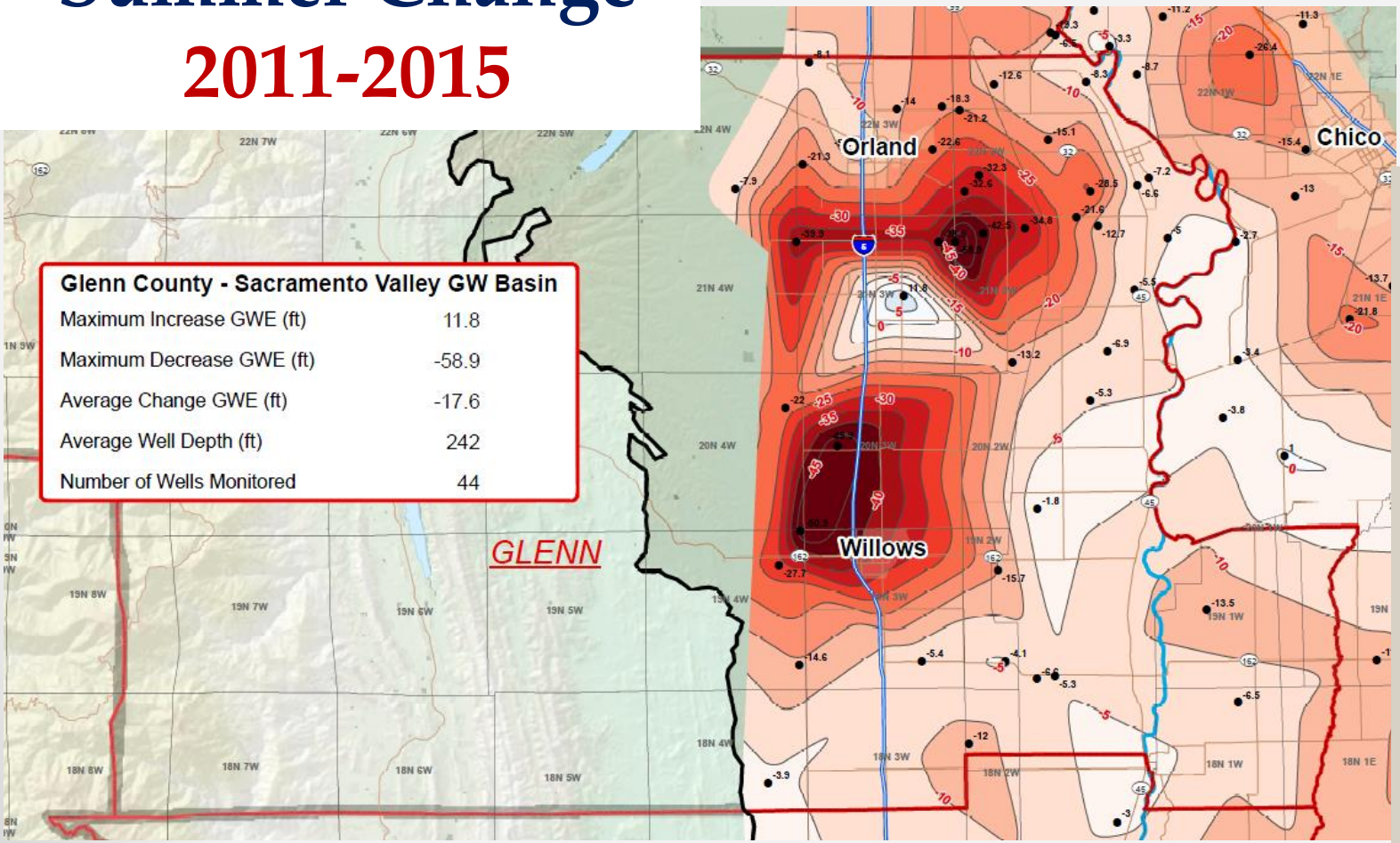

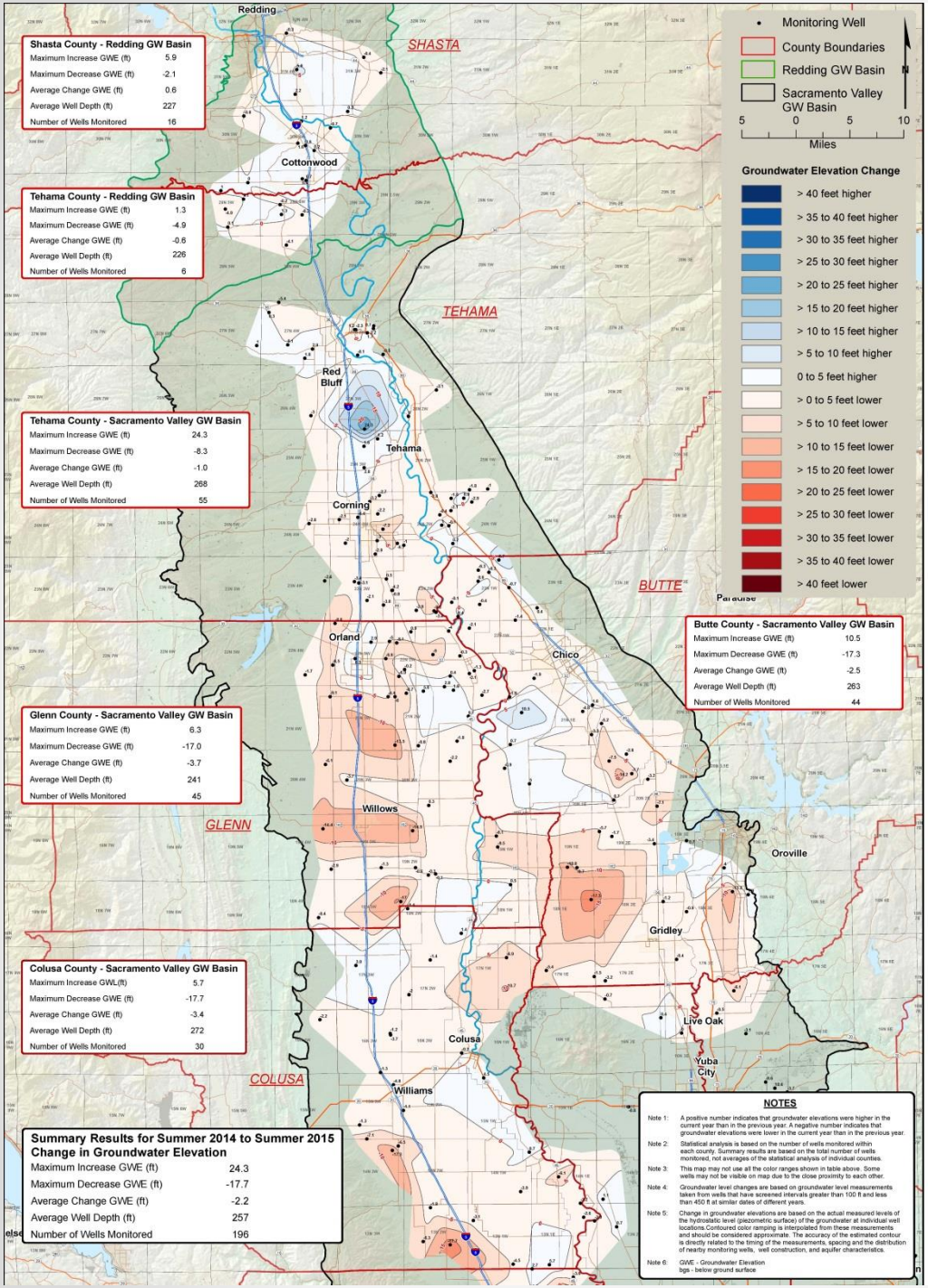

Wells 100-450 Feet Deep

Summer Change 2014-2015

Summary Results for Summer 2014 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	24.3
Maximum Decrease GWE (ft)	-17.7
Average Change GWE (ft)	-2.2
Average Well Depth (ft)	257
Number of Wells Monitored	196

Wells 100-450 Feet Deep

Summer Change 2014-2015

Summary Results for Summer 2014 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	24.3
Maximum Decrease GWE (ft)	-17.7
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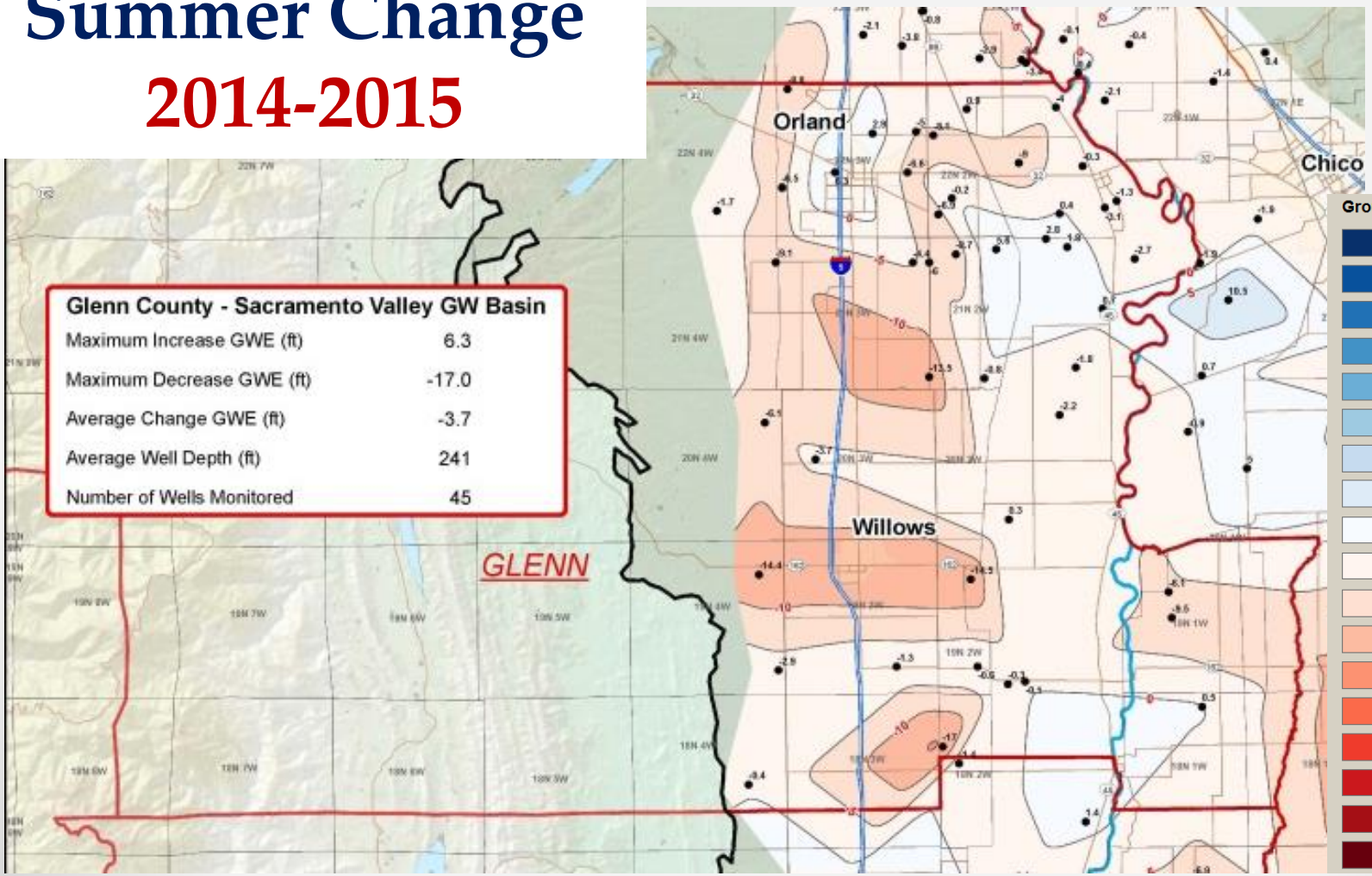
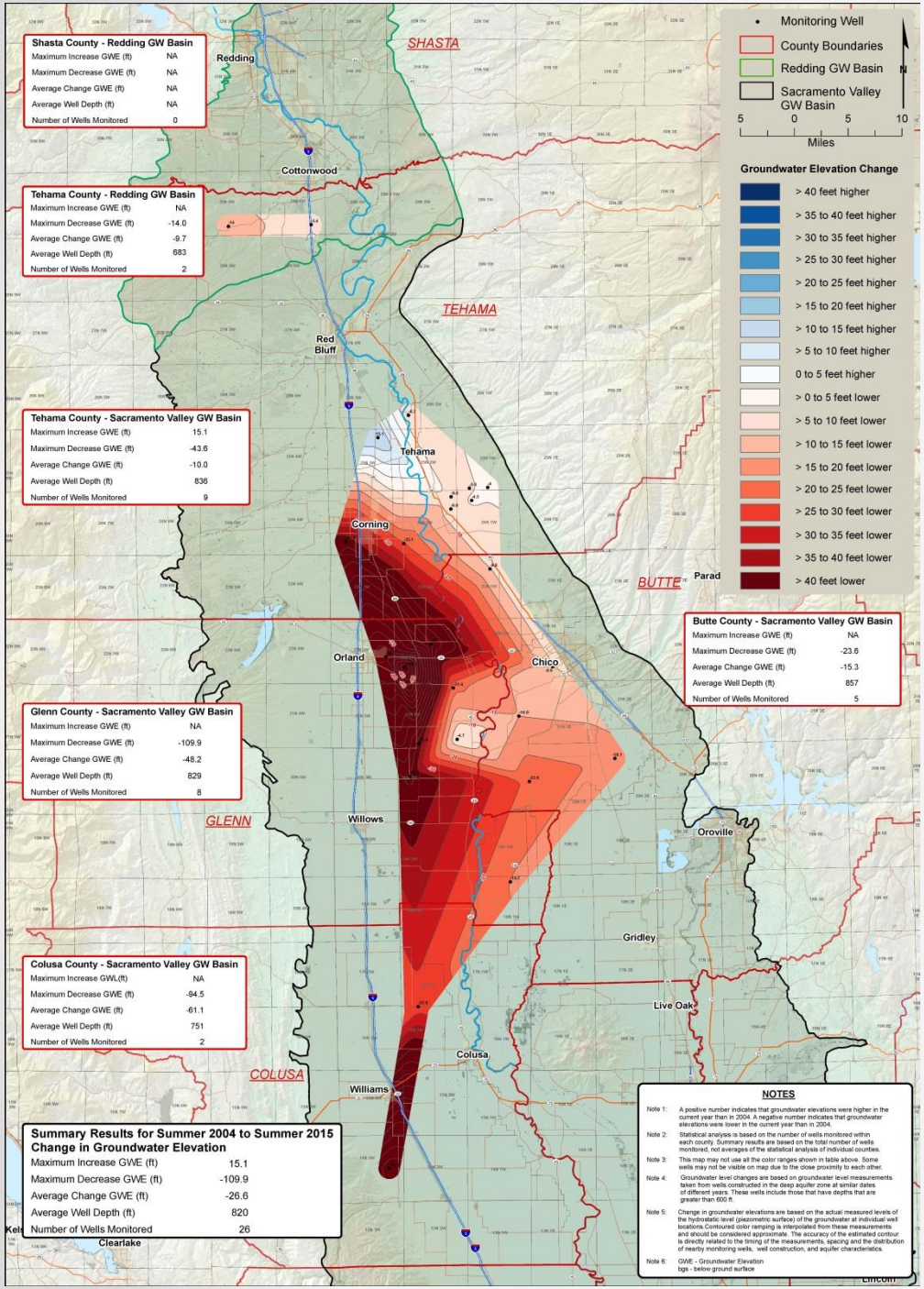


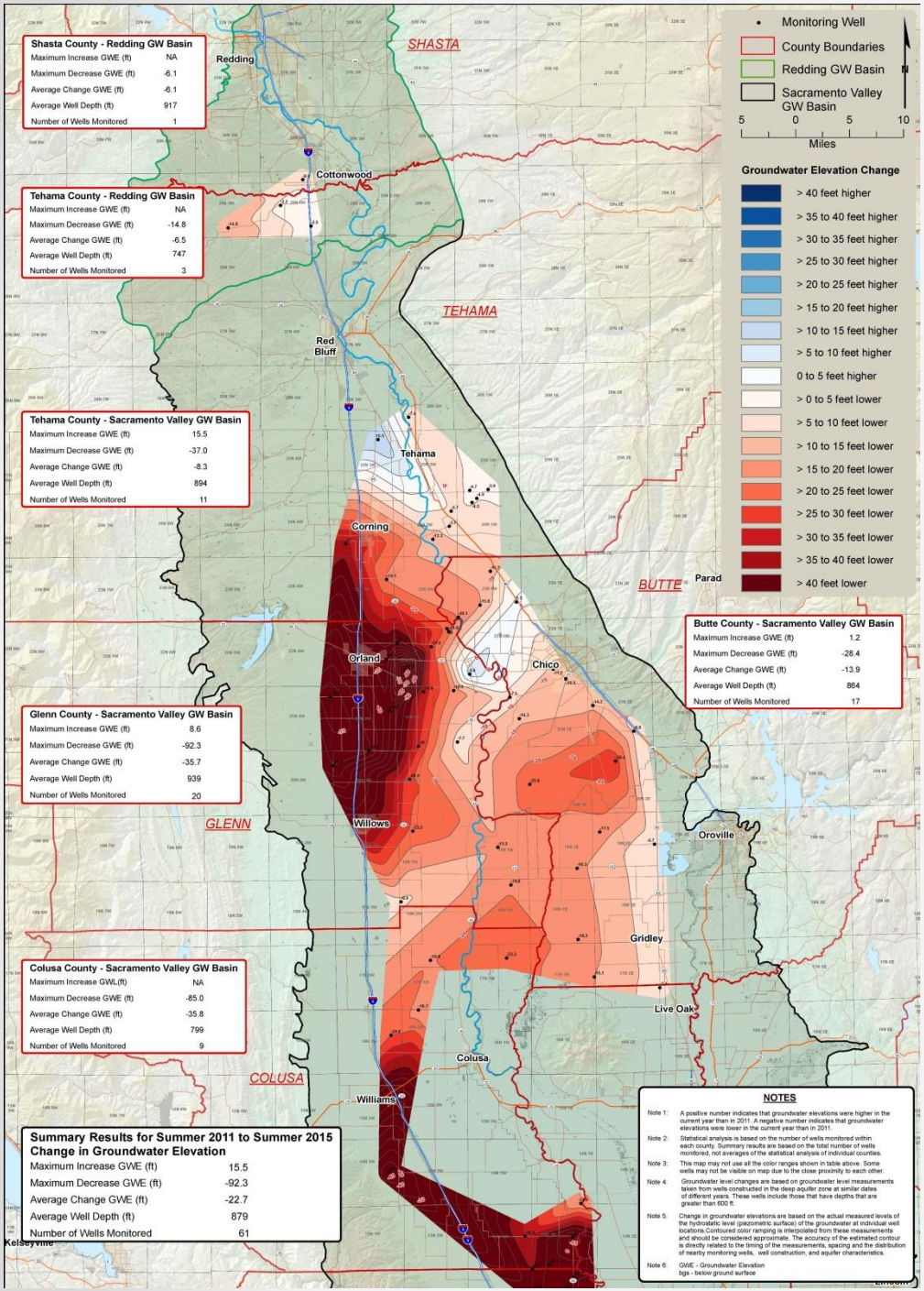


Wells >600 Feet Deep

Summer Change 2004-2015

Summary Results for Summer 2004 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	15.1
Maximum Decrease GWE (ft)	-109.9
Average Change GWE (ft)	-26.6
Average Well Depth (ft)	820
Number of Wells Monitored	26

Glenn County - Sacramento Valley GW Basin	
Maximum Increase GWE (ft)	NA
Maximum Decrease GWE (ft)	-109.9
Average Change GWE (ft)	-48.2
Average Well Depth (ft)	829
Number of Wells Monitored	8

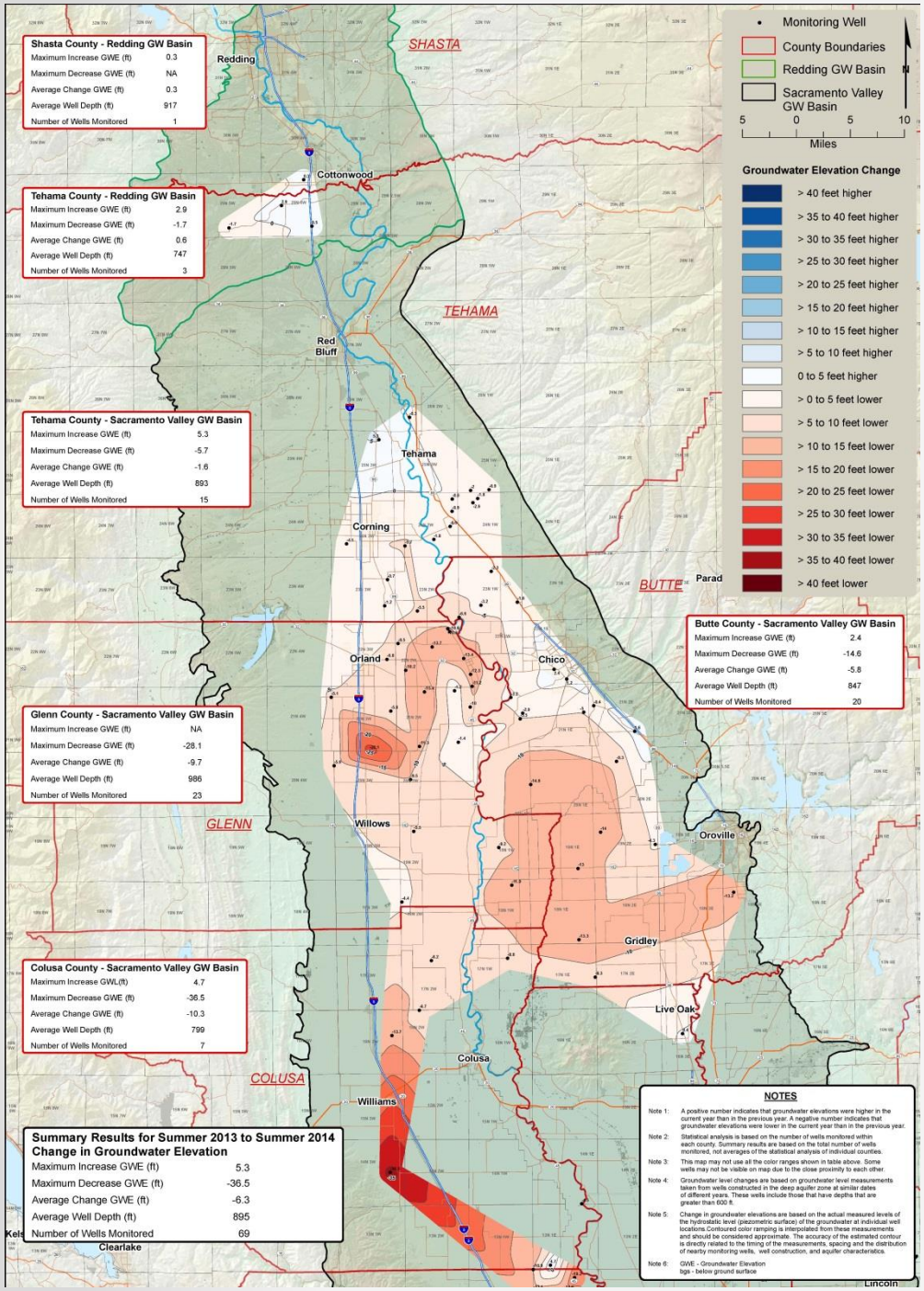


Wells >600 Feet Deep

Summer Change 2011-2015

Summary Results for Summer 2011 to Summer 2015 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	15.5
Maximum Decrease GWE (ft)	-92.3
Average Change GWE (ft)	-22.7
Average Well Depth (ft)	879
Number of Wells Monitored	61

Glenn County - Sacramento Valley GW Basin	
Maximum Increase GWE (ft)	8.6
Maximum Decrease GWE (ft)	-92.3
Average Change GWE (ft)	-35.7
Average Well Depth (ft)	939
Number of Wells Monitored	20



Wells >600 Feet Deep

Summer Change 2014-2015

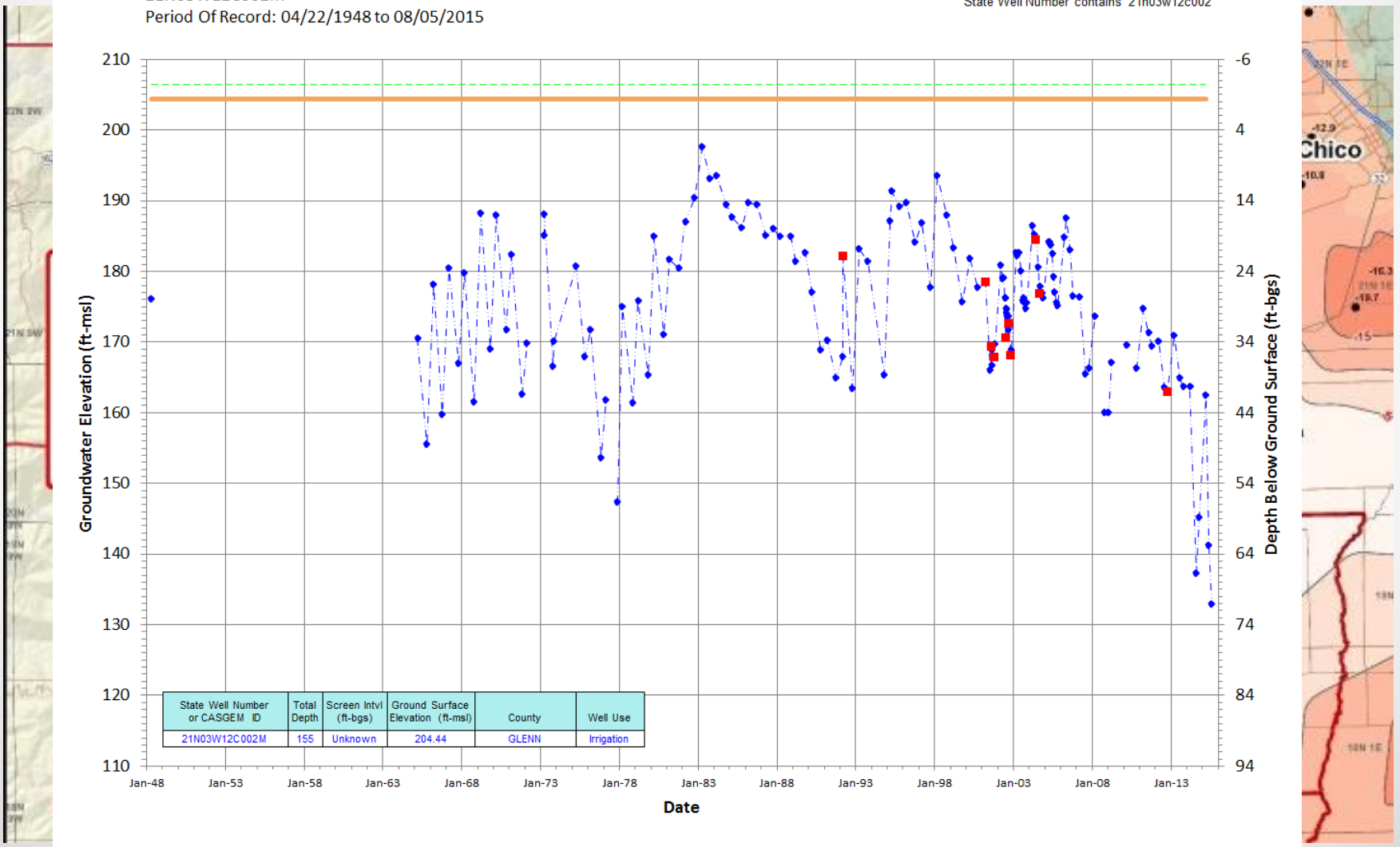
Summary Results for Summer 2013 to Summer 2014 Change in Groundwater Elevation	
Maximum Increase GWE (ft)	5.3
Maximum Decrease GWE (ft)	-36.5
Average Change GWE (ft)	-6.3
Average Well Depth (ft)	895
Number of Wells Monitored	69

Glenn County - Sacramento Valley GW Basin	
Maximum Increase GWE (ft)	NA
Maximum Decrease GWE (ft)	-28.1
Average Change GWE (ft)	-9.7
Average Well Depth (ft)	986
Number of Wells Monitored	23

Groundwater Level Hydrograph Locations

Summer 2004 to 2015

Average Well Depths 100 to 450 feet



Results of Spring 2015 Subsidence Survey

GPS Subsidence

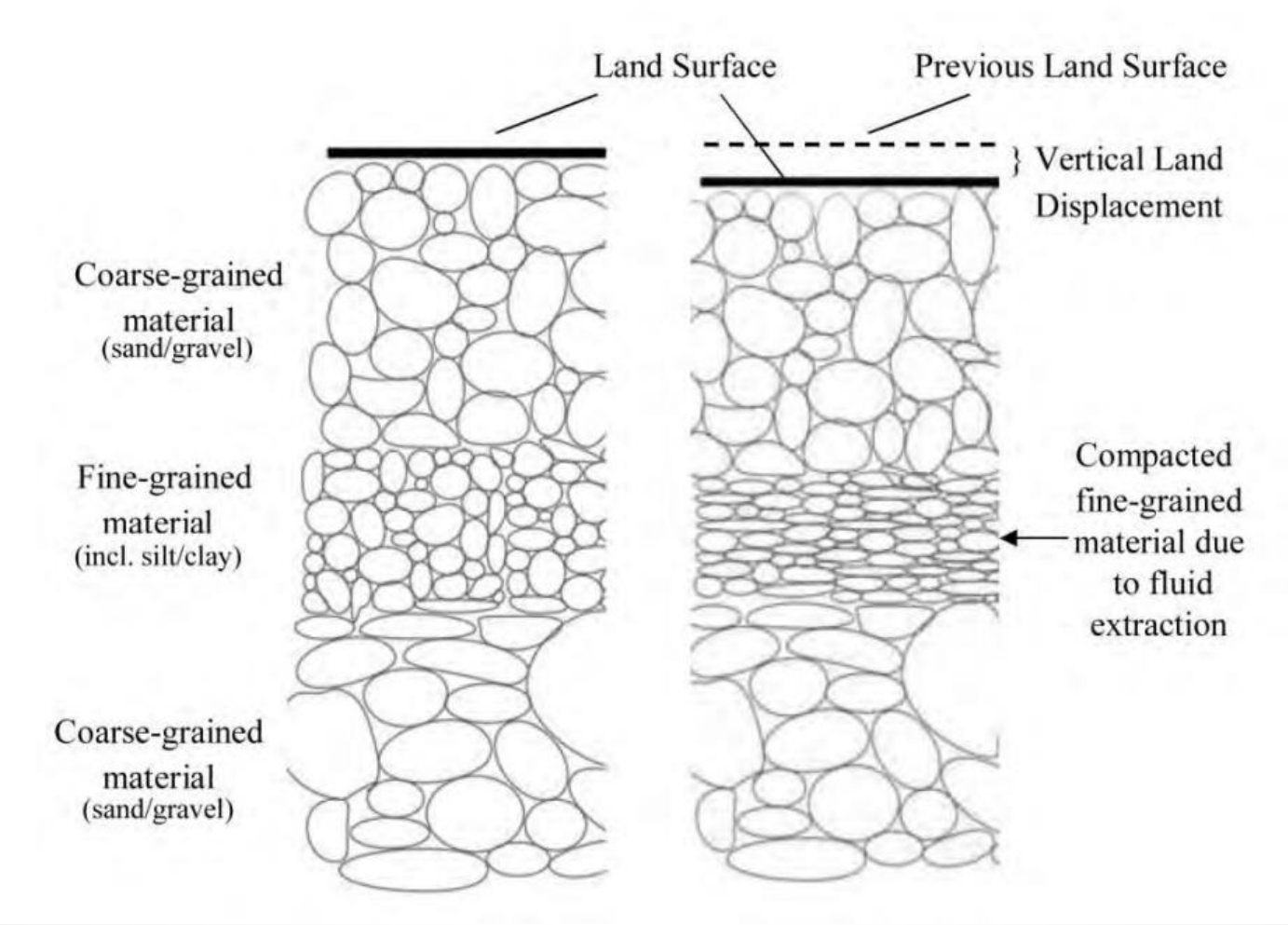
- 2004 – Glenn Co
- 2008 – Sac Valley
- 2015 – Glenn Co focused

Subsidence

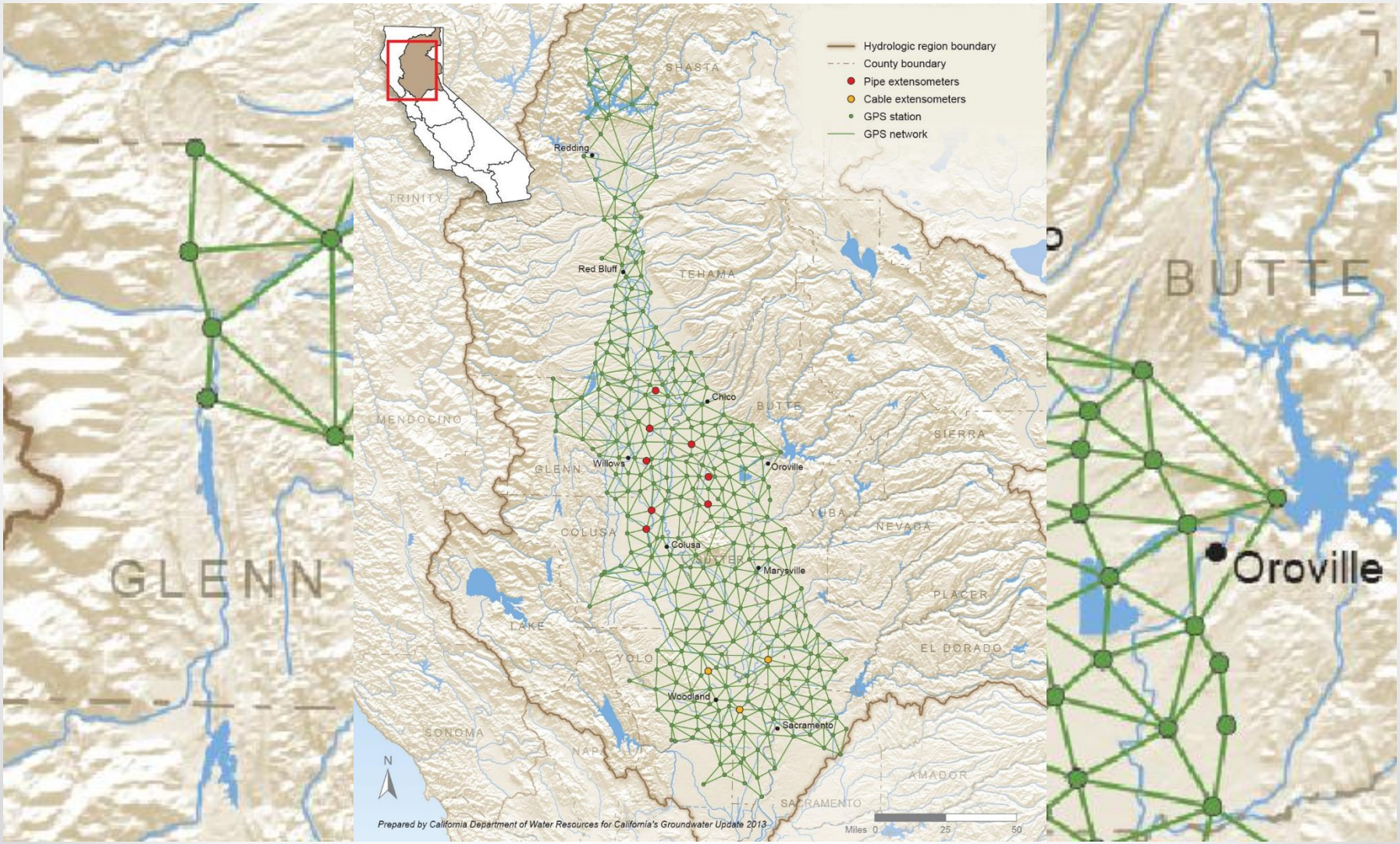
- "Land Subsidence" means the lowering of the ground surface caused by the inelastic consolidation of clay beds in the aquifer system.

- Causes
  - Declining Groundwater Levels
  - Oil, and Gas extractions
  - Tectonics and other local geologic influences

Inelastic Subsidence



Grid established in 2008



Glenn Co

- Resurvey in April 2015 – letter to WAC
- Focused on 2 areas (south of Orland and south of Hamilton City
- The results indicate that between 2004 and 2015 the area subsided a total of 3.24 inches.
- Also, the amount and annual rate of change have increased significantly since 2008.

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY EDMUND G. BROWN JR., *Governor*

DEPARTMENT OF WATER RESOURCES
NORTHERN REGION OFFICE
2440 MAIN STREET
RED BLUFF, CA 96080-2356

August 17, 2015

Glenn County Board of Supervisors
525 West Sycamore Street, Suite B1
Willows, California 95988

Glenn County Water Advisory Committee
Post Office Box 351
Willows, California 95988

Dear Supervisors and Committee members:

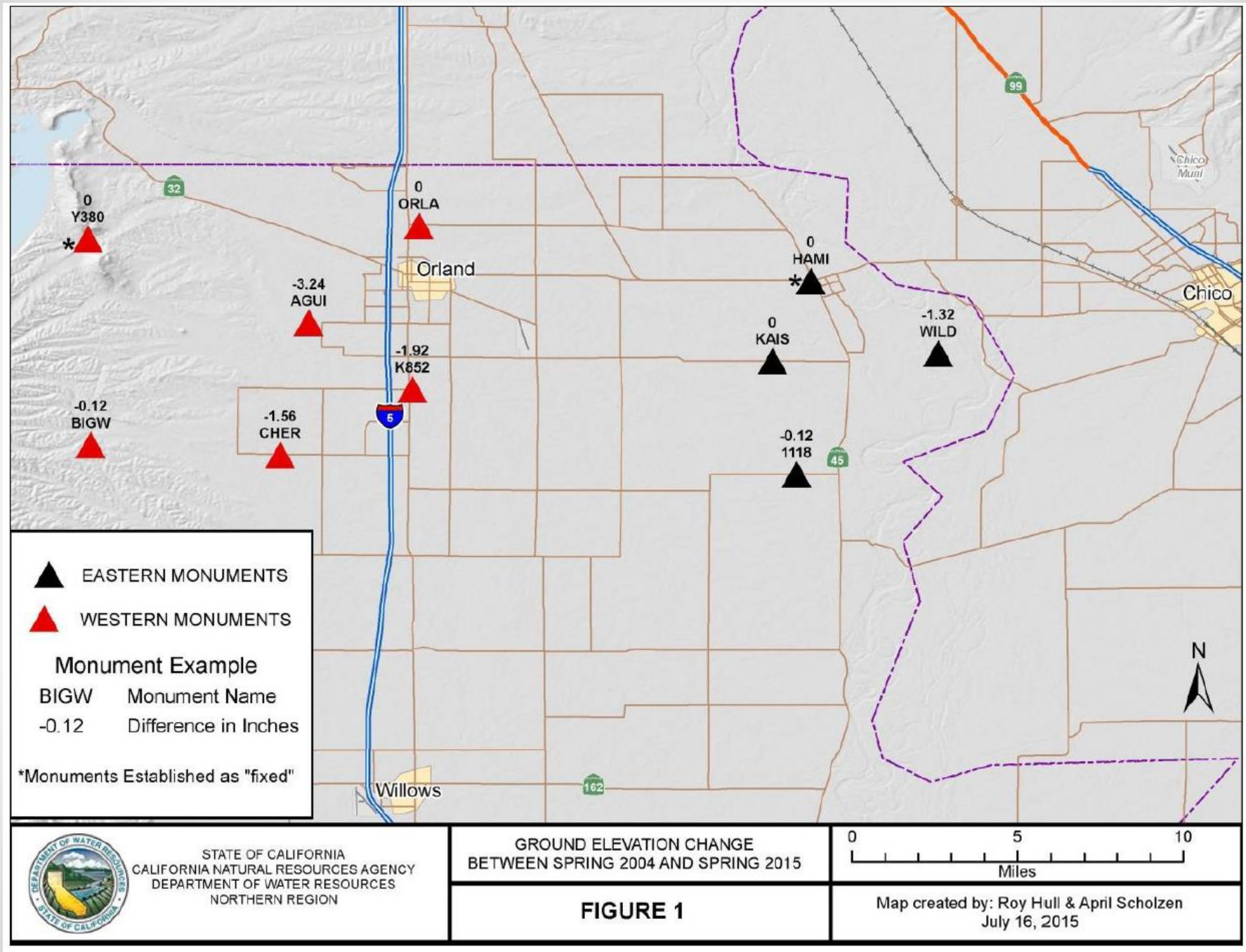
This letter is a follow up to your a request from late 2014 for the Department of Water Resources (DWR) to review and compare two Global Positioning System (GPS) survey datasets (2004 and 2008) within Glenn County.

The objective of the comparison was to identify any inelastic subsidence that may have occurred within the County over the four-year time period. At the conclusion of the

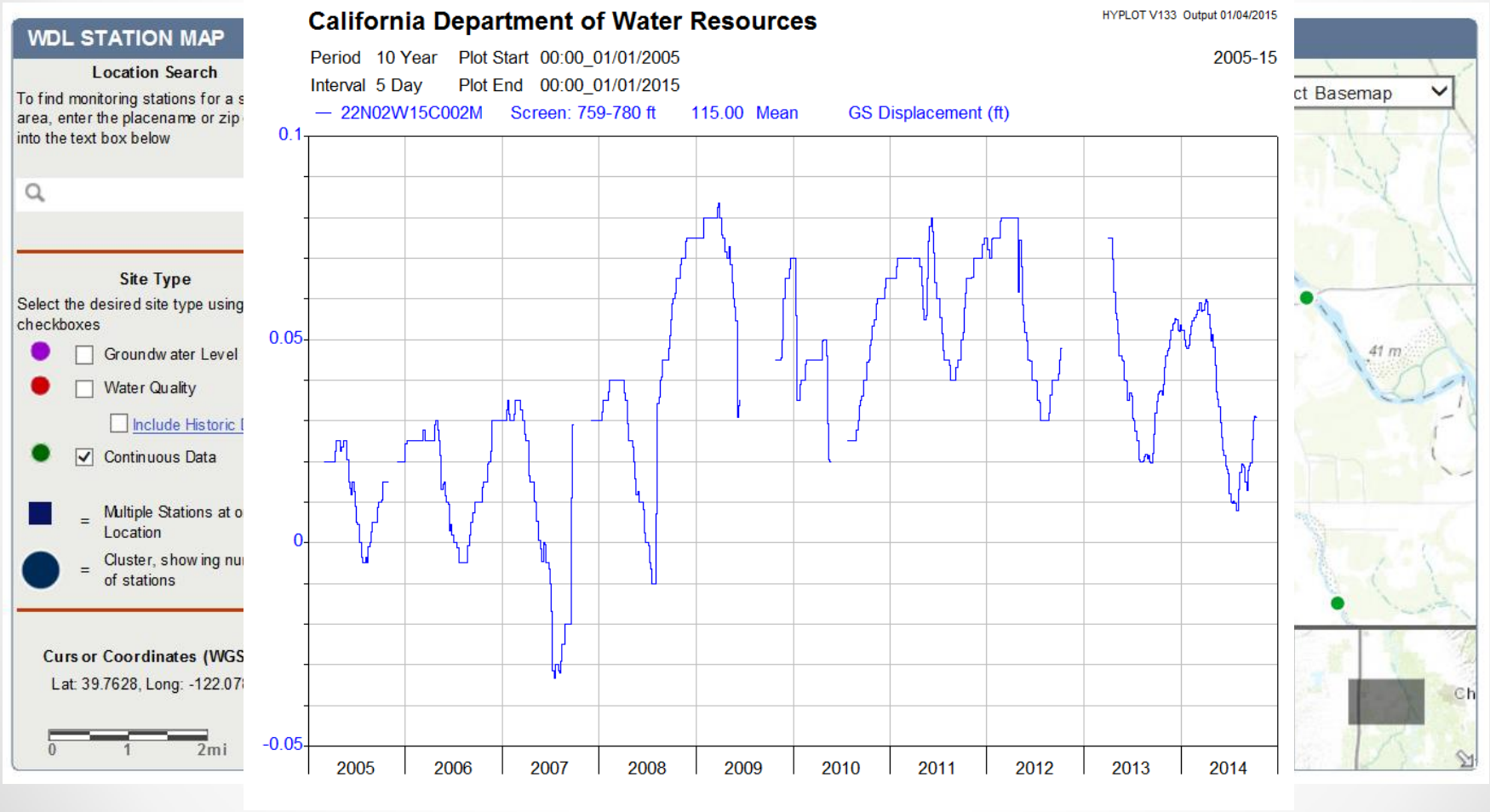
Table 1: West side of Glenn County, south of Orland

Monument	2004 GS Elevation (ft.)[2]	2008 GS Elevation (ft.)[2]	2015 GS Elevation (ft.)[2]	Diff 2004-2008 (in)	Per year 2004-2008 (in)	Diff 2008-2015 (in)	Per year 2008-2015 (in)	Total Diff 2004-2015 (in)	Per year 2004-2015 (in)
ORLA	267.58	267.58	267.58	0	0.00	0	0.00	0	0.00
K852	230.71	230.74	230.55	0.36	0.09	-2.28	-0.33	-1.92	-0.18
AGUI	274.45	274.39	274.18	-0.72	-0.18	-2.52	-0.36	-3.24	-0.30
CHER	230.11	230.15	229.96	0.48	0.12	-2.28	-0.33	-1.80	-0.16
BIGW	457.72	457.77	457.71	0.6	0.15	-0.72	-0.10	-0.12	-0.01
Y380[1]	462.79	462.79	462.79	0	0.00	0	0.00	0	0.00

Notes:
GS Ground Surface
1 – Monument held fixed
2 – North American Vertical Datum of 1988 (NAVD88)
3 – Per year rates rounded to hundredths

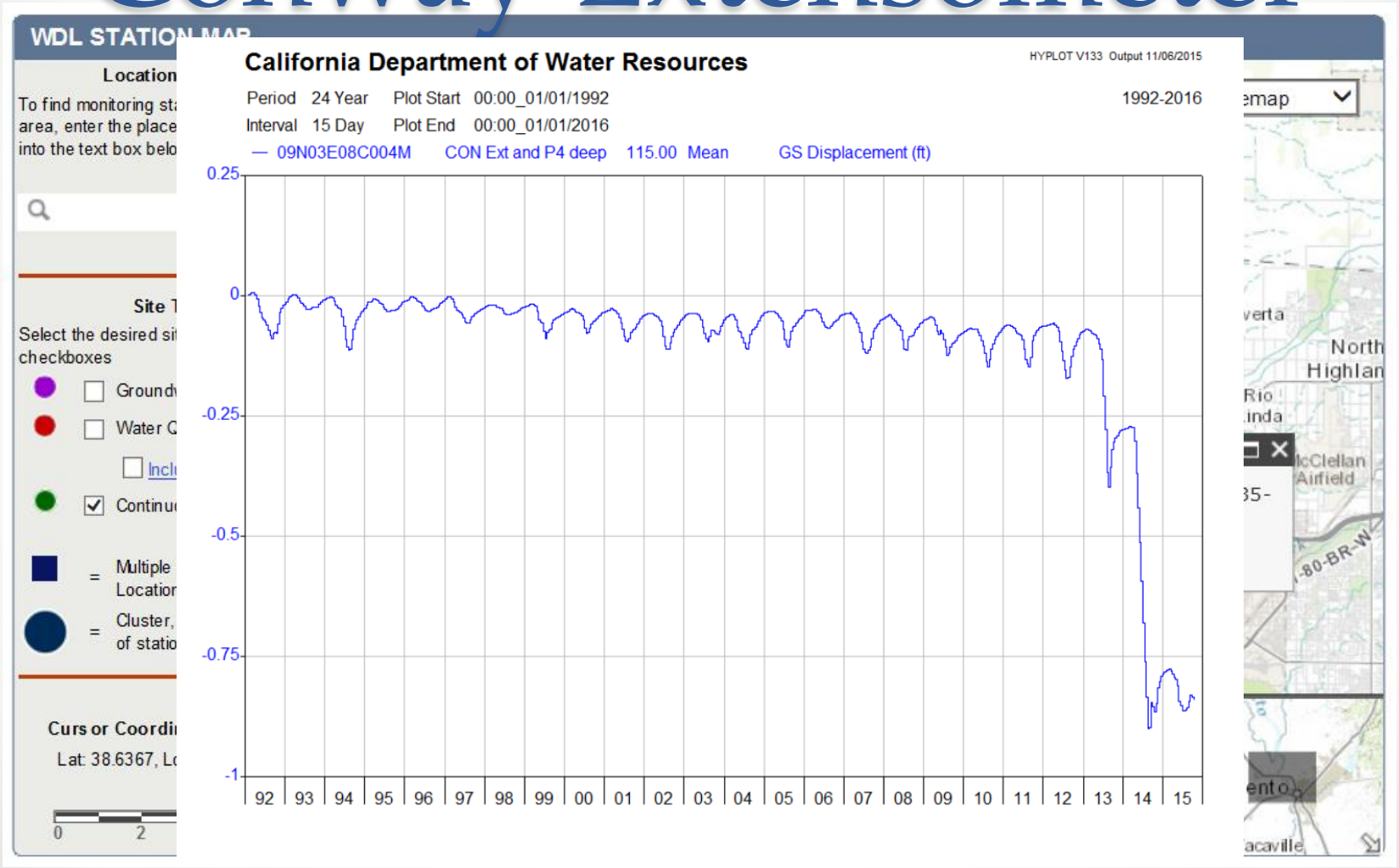

0
Y380
*
0
ORLA
Orland
-3.24
AGUI
-1.92
K852
-0.12
BIGW
-1.56
CHER
Willows
0
HAMI
*
0
KAIS
-1.32
WILD
-0.12
1118
Chico
Chico Muni
99
32
5
45
162
EASTERN MONUMENTS
WESTERN MONUMENTS
Monument Example
BIGW Monument Name
-0.12 Difference in Inches
*Monuments Established as "fixed"
N
STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN REGION
GROUND ELEVATION CHANGE
BETWEEN SPRING 2004 AND SPRING 2015
0 5 10
Miles
FIGURE 1
Map created by: Roy Hull & April Scholzen
July 16, 2015

Local Extensometer



22N02W15C002 880ft

Inelastic Movement. Conway Extensometer



09N03E08C004M 716ft

Next?

- GPS – Sac Valley Grid
  - Letters to DWR Director
    - Director response within weeks
  - DWR funding – not secured yet
  - Cooperative effort

Thank You

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Department of Water Resources
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Basin Management Objective Revisions

Water Advisory Committee

November 10, 2015

Potential New Method

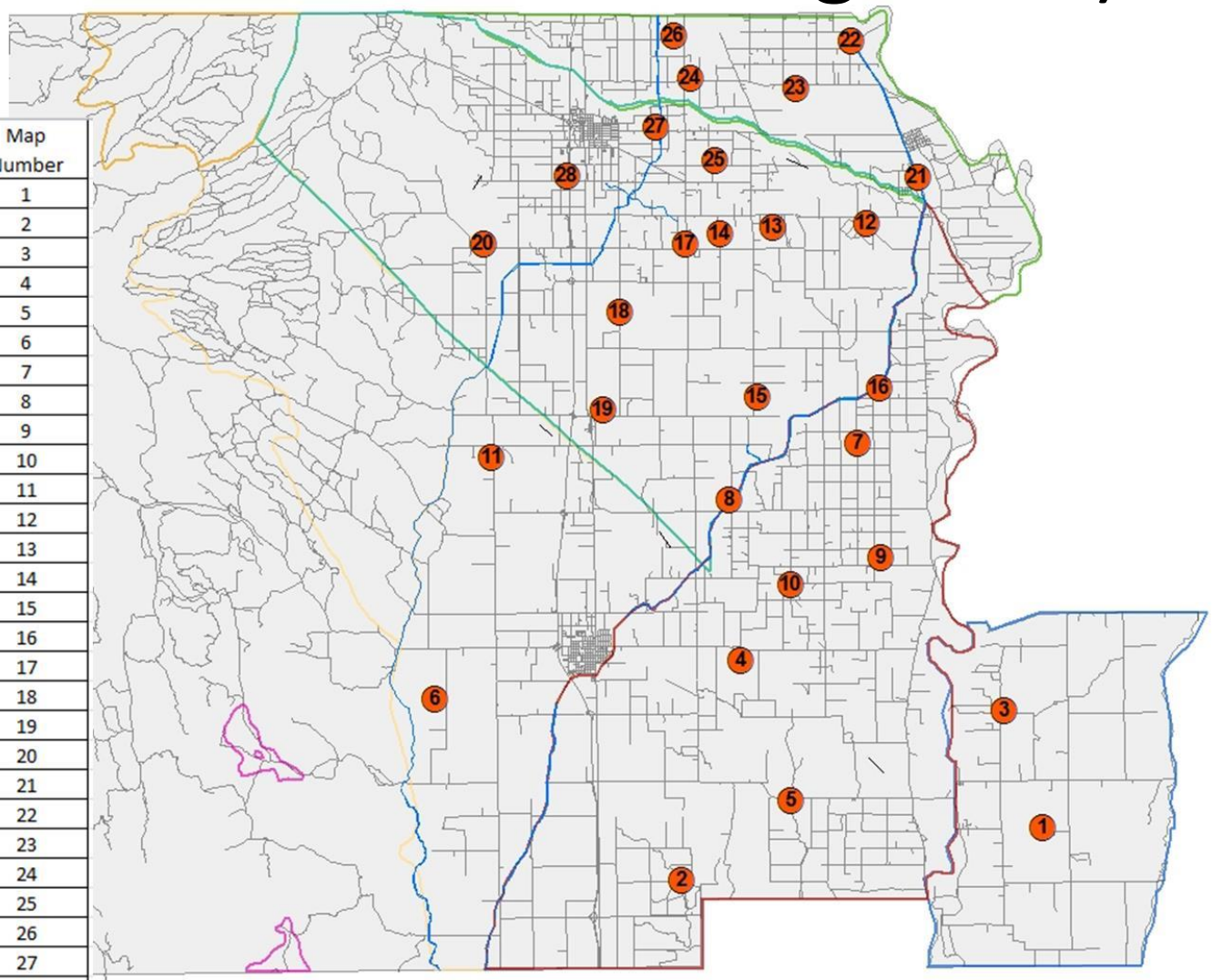
- Ad hoc committee of TAC to develop a method
  - Uses current groundwater conditions and current well infrastructure
  - Sensitive to varying groundwater conditions
- The new process is meant to be used as a tool
  - Analyze risk to current well infrastructure
  - Economy of groundwater conditions
  - Slide rule concept
  - Policy still needs to be defined
- TAC reviewed in August and November

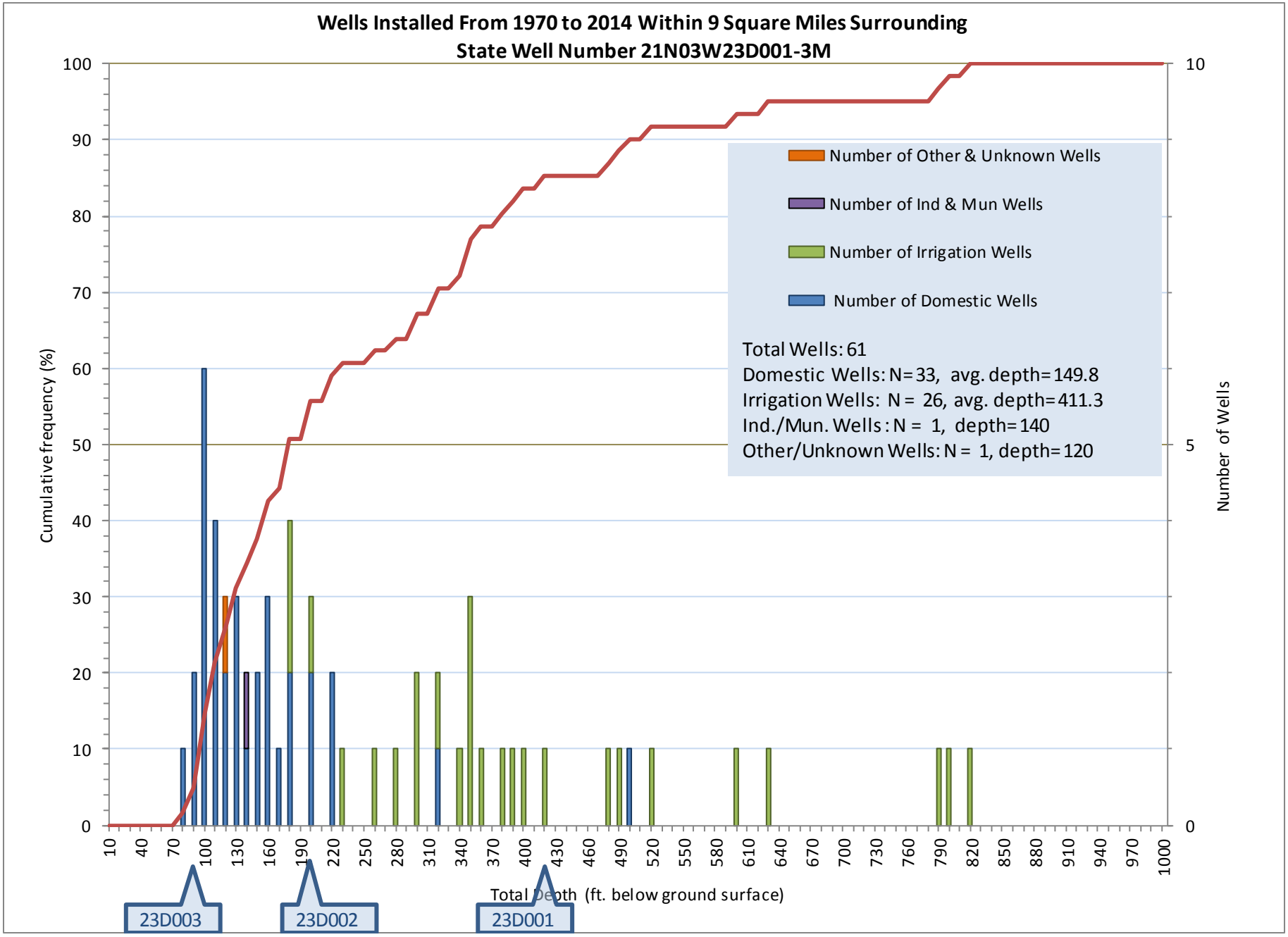
Proposed Method Utilizes:

- Dedicated monitoring wells
  - Representative Zone
- Annual lows
- Well infrastructure within 9 square miles of the dedicated monitoring well
- Rate of change in groundwater levels over the period of record for the well (typically 10-15 years)

Proposed Monitoring Network (Dedicated Monitoring Wells)

Well Number	Map Number
18N01W02E001_3M	1
18N02W18D001_4M	2
19N01W22D004_7M	3
19N02W08Q001_3M	4
19N02W33K001M	5
19N04W14M002M	6
20N02W11A001_3M	7
20N02W18R005_8M	8
20N02W25F001_4M	9
20N02W33B001M	10
20N03W07E001_4M	11
21N02W01F001_4M	12
21N02W04G002_5M	13
21N02W05M001_3M	14
21N02W33M001_3M	15
21N02W36A002M	16
21N03W01R002M	17
21N03W23D001_3M	18
21N03W34Q002_4M	19
21N04W12A002-4M	20
22N01W29N001_4M	21
22N02W01N001_4M	22
22N02W15C002_5M	23
22N02W18C001_4M	24
22N02W30H002_4M	25
22N03W01R001-3M	26
22N03W24E001-3M	27
22N03W28P001_3M	28




Wells Installed From 1970 to 2014 Within 9 Square Miles Surrounding
State Well Number 21N03W23D001-3M
Cumulative frequency (%)
Number of Wells
Total Depth (ft. below ground surface)
Number of Other & Unknown Wells
Number of Ind & Mun Wells
Number of Irrigation Wells
Number of Domestic Wells
Total Wells: 61
Domestic Wells: N=33, avg. depth=149.8
Irrigation Wells: N= 26, avg. depth=411.3
Ind./Mun. Wells: N= 1, depth=140
Other/Unknown Wells: N= 1, depth=120
23D003
23D002
23D001

MAP ID # 9		MAX WELL DEPTH (FT)	PERCENT OF WELLS SHALLOWER THAN THE CORRESPONDING MAX WELL DEPTH CATEGORY	REMAINING DRAWDOWN FROM 2014 LOW (FT)*	CUMULATIVE NUMBER OF WELLS SHALLOWER THAN CORRESPONDING MAX WELL DEPTH CATEGORY	PROJECTED NUMBER OF YEARS TO REACH MAX WELL DEPTH CATEGORY AT THE OBSERVED AVERAGE ANNUAL RATE OF CHANGE	PROJECTED NUMBER OF YEARS TO REACH MAX WELL DEPTH CATEGORY AT THE MODERATELY HIGH OBSERVED AVERAGE ANNUAL RATE OF CHANGE**	PROJECTED NUMBER OF YEARS TO REACH MAX WELL DEPTH CATEGORY AT THE HIGHEST OBSERVED AVERAGE ANNUAL RATE OF CHANGE***
WELL NUMBER	**20N02W25F003M**							
PERIOD OF RECORD	2002-2014	70	2.9%	38.33	1	21.3	5.3	3.0
TOTAL WELLS IN 9 SQUARE MILE AREA	34	80	8.8%	48.33	3	26.9	6.7	3.8
GSE (FT ASL)	102.18	80	8.8%	48.33	3	26.9	6.7	3.8
WELL DEPTH (FT BGS)	283	80	8.8%	48.33	3	26.9	6.7	3.8
SCREEN (FT BGS)	190-260	90	14.7%	58.33	5	32.4	8.1	4.6
		90	14.7%	58.33	5	32.4	8.1	4.6
2014 LOW WSE (FT ASL)	70.51	100	35.3%	68.33	12	38.0	9.5	5.4
2014 LOW DEPTH TO GW (FT)	**31.67**	100	35.3%	68.33	12	38.0	9.5	5.4
		100	35.3%	68.33	12	38.0	9.5	5.4
AVERAGE LOW ANNUAL CHANGE=CHANGE/YEAR IN FT/YR	**-1.8**	100	35.3%	68.33	12	38.0	9.5	5.4
		100	35.3%	68.33	12	38.0	9.5	5.4
1 STD IN FT	**5.4**	100	35.3%	68.33	12	38.0	9.5	5.4
		100	35.3%	68.33	12	38.0	9.5	5.4
FLUCTUATION AT 1 STD IN FT	3.6 TO -7.2	100	35.3%	68.33	12	38.0	9.5	5.4
FLUCTUATION AT 2 STD IN FT	9.0 TO -12.6	110	38.2%	78.33	13	43.5	10.9	6.2
		120	41.2%	88.33	14	49.1	12.3	7.0
		130	44.1%	98.33	15	54.6	13.7	7.8
		130	44.1%	98.33	15	54.6	13.7	7.8
		150	50.0%	118.33	17	65.7	16.4	9.4
		150	50.0%	118.33	17	65.7	16.4	9.4

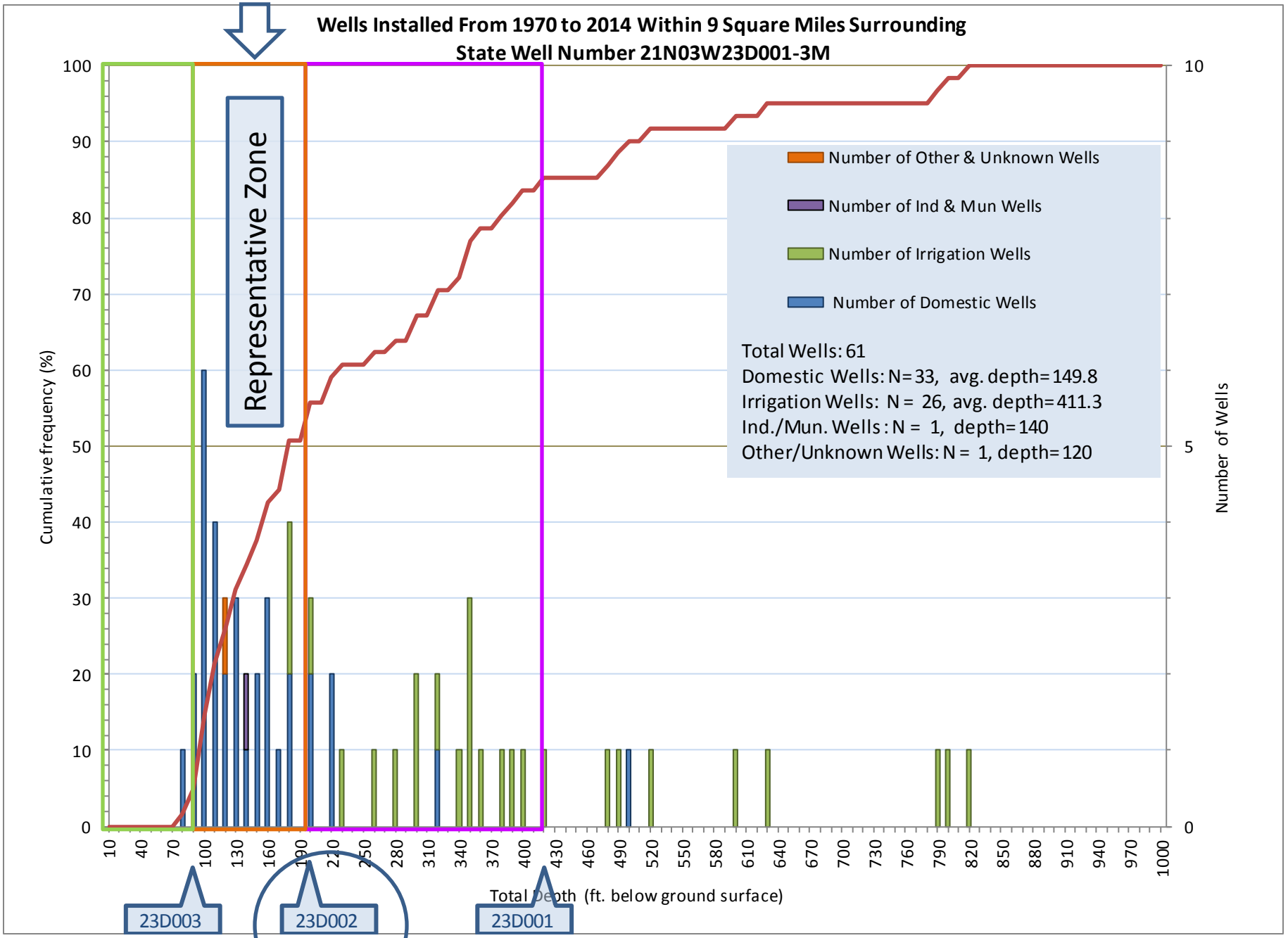
* Depth that the groundwater level can still drop before wells in the corresponding max well depth category may be affected.

**Moderately high observed annual rate of change represents rates of change that have occurred at a frequency of 1 in 3 years.

*** Highest observed annual rate of change represents rates of change that have occurred at a frequency of 1 in 20 years.

Development of Gradient Map

- Uses the representative zone for each dedicated well
- Meant to provide a visual reference
- Not meant to make a policy decision based solely on the gradient lines
- Gradient based on number of **years** until groundwater levels reach the depth of 50% of the wells in that area at the current rate of change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Cumulative frequency (%)
Number of Wells
Total Depth (ft. below ground surface)
23D003
23D002
23D001
3
31
18
9 unrepresented

Summary

MAP WELL NO	WELL DEPTH (FT)	WELLS WITHIN 9 SQ MILES	NUMBER OF WELLS REPRESENTED	DEPTH OF ZONE REPRESENTED (FT)	2014 LOW DEPTH TO GW (FT)	OBSERVED ANNUAL RATE OF CHANGE (FT/YR)	50% MAX WELL DEPTH CATEGORY	PROJECTED NUMBER OF YEARS TO REACH 50% MAX WELL DEPTH CATEGORY AT THE OBSERVED ANNUAL RATE OF CHANGE
1	200	34	19	0-200	30.44	-0.8	170	174.5
2	280	13	11	0-280	44.22	-0.7	240	279.7
3	380	41	26	130-380	41.94	-0.5	260	436.1
5	260	14	10	0-260	11.9	-0.1	250	2381
6	147	21	8	0-150	32.15	-1.5	160	85.2
7	510	27	13	170-510	37.7	-0.5	150	224.6
8	225	32	25	0-230	15.19	-0.6	190	291.4
9	283	34	14	120-290	31.67	-1.8	150	65.7
10	320	25	22	0-320	13.66	-0.2	160	731.7
11	515	31	16	170-520	183.81	-14.2	480	20.9
12	385	42	21	130-390	72.79	-1.5	180	71.5
13	327	55	33	110-330	91.82	-1.9	220	67.5
14	490	105	55	180-490	98.89	-4.3	180	18.9
15	210	37	20	0-210	39.53	-0.8	200	200.6
16	145	47	25	0-150	38.78	-0.5	150	222.4
17	255	65	40	0-255	109.55	-6	210	16.7
18	200	61	31	100-200	79.69	-3.4	180	29.5
19	720	86	72	120-720	134.17	-8.2	170	4.4
20	659	32	19	340-660	253.23	-8.1	560	37.9
21	400	60	40	130-400	48.1	-1	190	141.9
22	440	52	29	120-440	54.53	-1.9	140	45
23	258	70	39	110-260	113.26	-2.5	170	22.7
24	188	178	95	100-190	102.96	-2.5	140	14.8
25	291	200	139	100-300	99.57	-4.8	140	8.4
26	314	87	52	120-320	103.21	-1.4	150	33.4
27	225	263	188	100-230	87.96	-3.3	130	12.7
28	304	421	397	80-310	94.12	-2	120	12.9

Gradient Map vs. GWL Change Maps

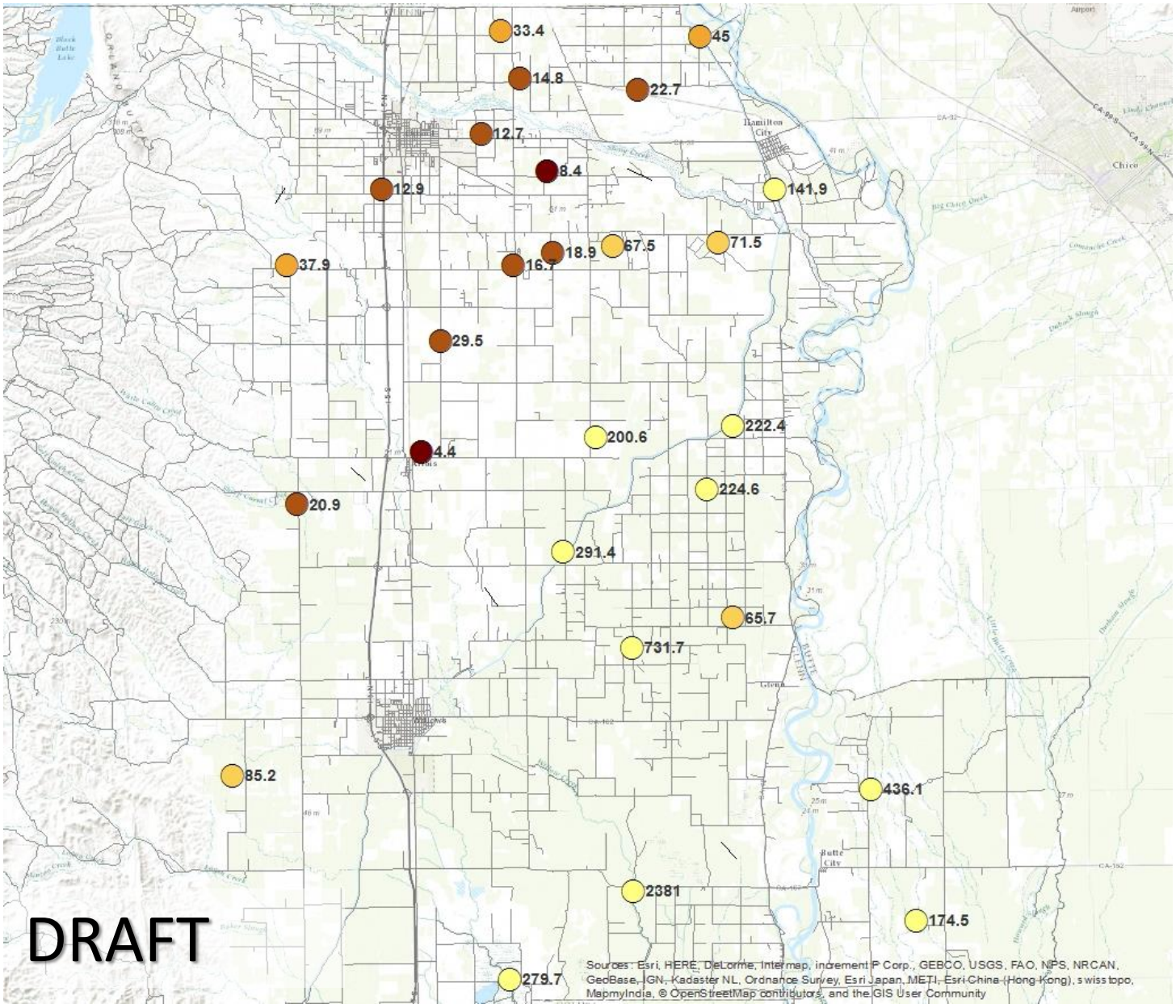
Gradient Map

- Projections of data
  - Based off rate of change in GWLs for period of well
- Low density
  - Lower confidence
- Assumes consistent rate of change over time
  - However if trends change map can be updated

GWL Change Maps

- Real data
  - Measured levels in the field
- Higher density
  - Higher confidence
- Compares 2 time periods in the past
  - No assumption/projection of current trends

Number of years at current rate of change for groundwater levels to reach the 50% well depth.



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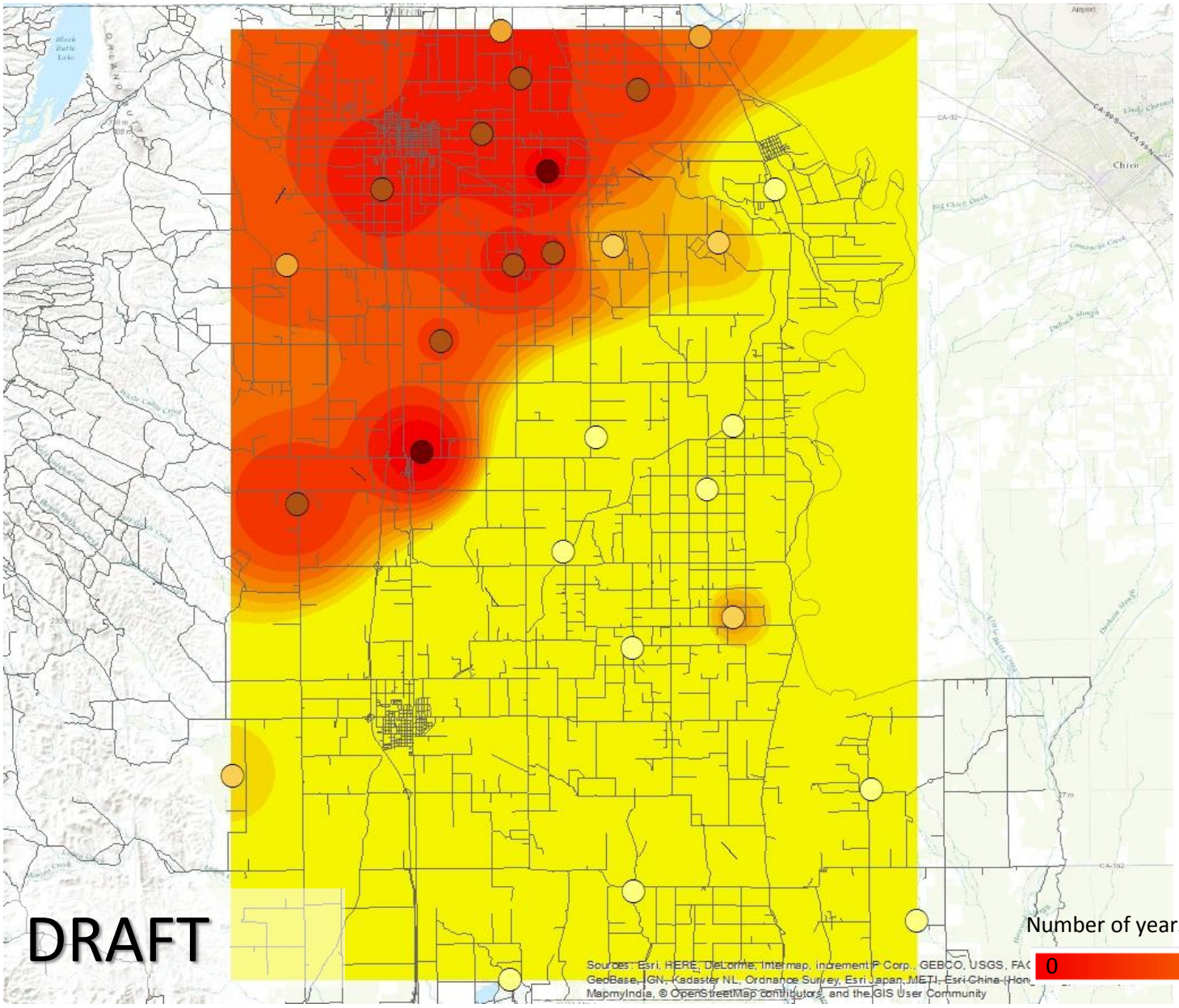
Legend:

Years

- 0-10
- 10.01-30
- 30.01-50
- 50.01-100
- 100+

Gradient representing the number of years at current rate of change for groundwater levels to reach the 50% well depth.



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Discussion and Feedback

Provide Direction

- Potential BMO Stage Alert Levels
  - How many levels?
  - Example: 4 levels including monitoring, outreach/voluntary, minimal regulation, regulation

Provide Direction

- Potential BMO Actions
  - What types of actions could be associated with each level?
  - Examples could include:
    - Monitoring
    - Specific Outreach
    - Voluntary actions
    - Recharge requirements
    - Specific permit requirements
    - Limit pumping amount
    - Reporting requirements

Provide Direction

- When to Rescind BMO Actions/Levels
  - Examples could include:
    - When rate of decline stabilizes (equals 0)
    - When specific actions have been taken