Analysis of Land and Water Use in Relation to Groundwater Conditions in Colusa County

Prepared by
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Objectives

- In areas within the County where groundwater levels are rapidly declining:
  - Identify and better understand contributing factors
  - Differentiate between the effects of changing land use and changes in other factors affecting groundwater levels

Outline

- Technical Approach
- Regional Setting
- Colusa County “Area of Interest”
- Historical Review
  - Groundwater Levels
  - Precipitation
  - Land Use and Cropping Patterns
- Water Balance Analysis
  - Key Results
  - Interpretations
- Questions

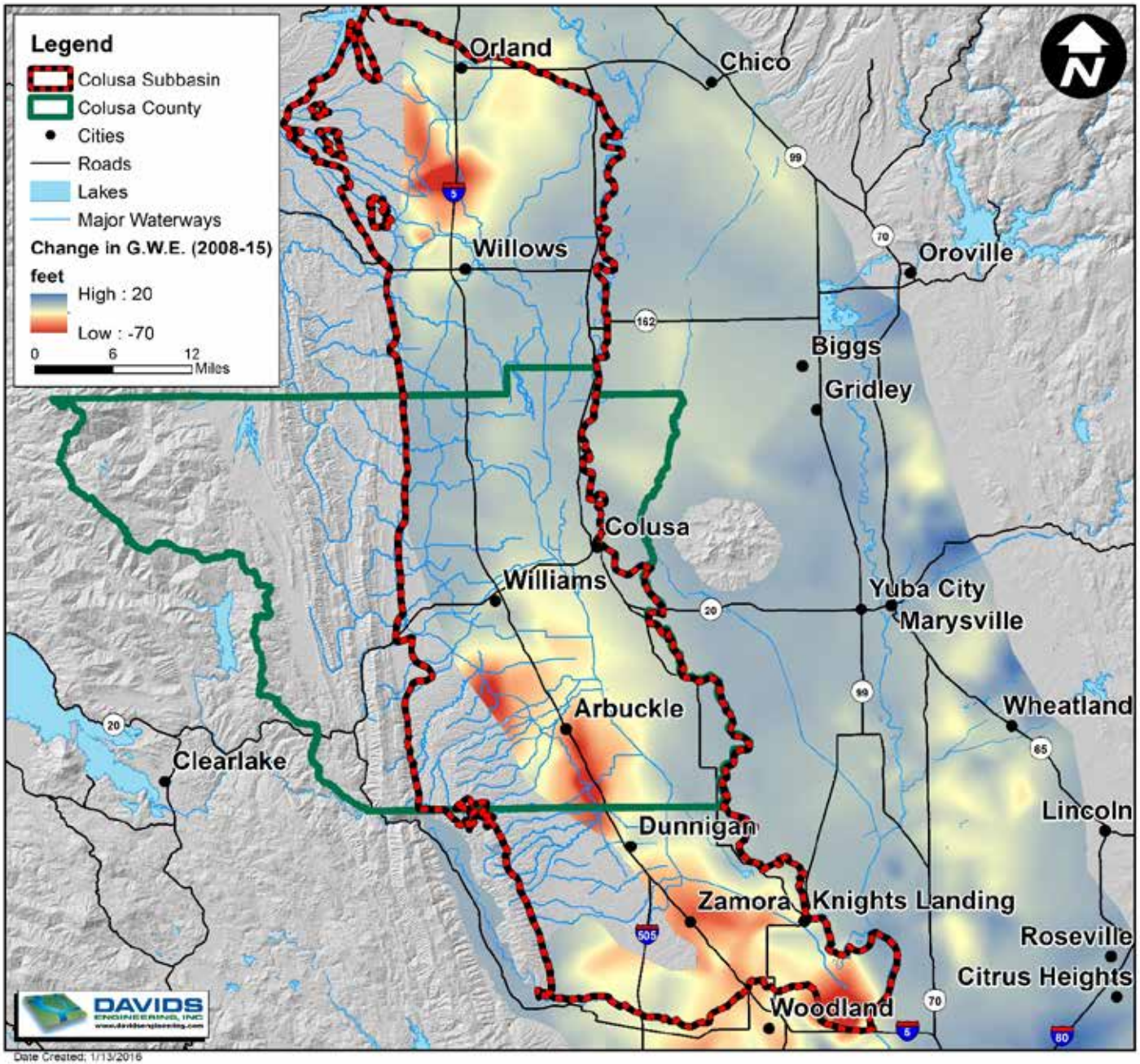
Technical Approach: Two Parts to Classical Groundwater Analyses

- **Part 1:** Analyze "surface layer" land and water use to characterize vertical exchanges of water between the land surface and underlying groundwater
  - Deep percolation of precipitation and applied irrigation water (recharge)
  - Pumping (discharge)
- **Part 2:** Simulate groundwater flows to estimate groundwater levels, given the estimated vertical exchanges, aquifer parameters, assumed boundary conditions, and other factors.

Error and Uncertainty

- “Best available” data is rarely perfect, but it may be adequate
  - Groundwater levels
  - Weather
  - Land use
  - Other
- Acknowledge potential error in data and uncertainty in results
- Trends and differences more reliable than absolute number

Regional Setting with Spring 2008 to 2015 Groundwater Elevation Changes



Groundwater Level Data Source: DWR Groundwater Information Center

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Criteria Defining “Area of Interest” (AOI)

- Recent, relatively large declines in groundwater levels
- Bounded to the maximum practical extent by natural hydrogeologic features
  - Groundwater basin boundaries
  - Rivers, streams, drains
  - Political boundaries, where necessary

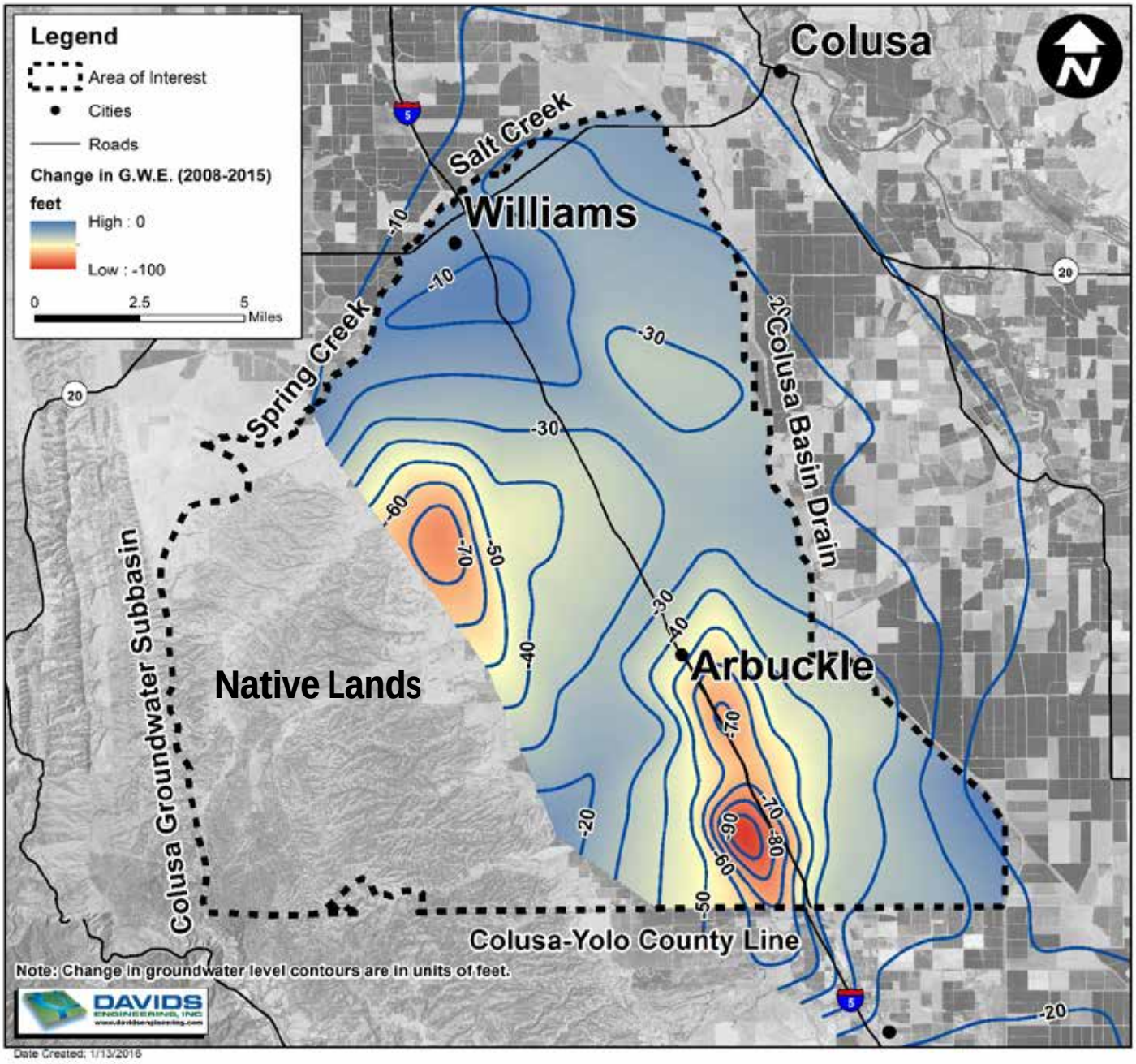
AOI with Spring 2008 to 2015 Groundwater Elevation Changes

155,000 acres total

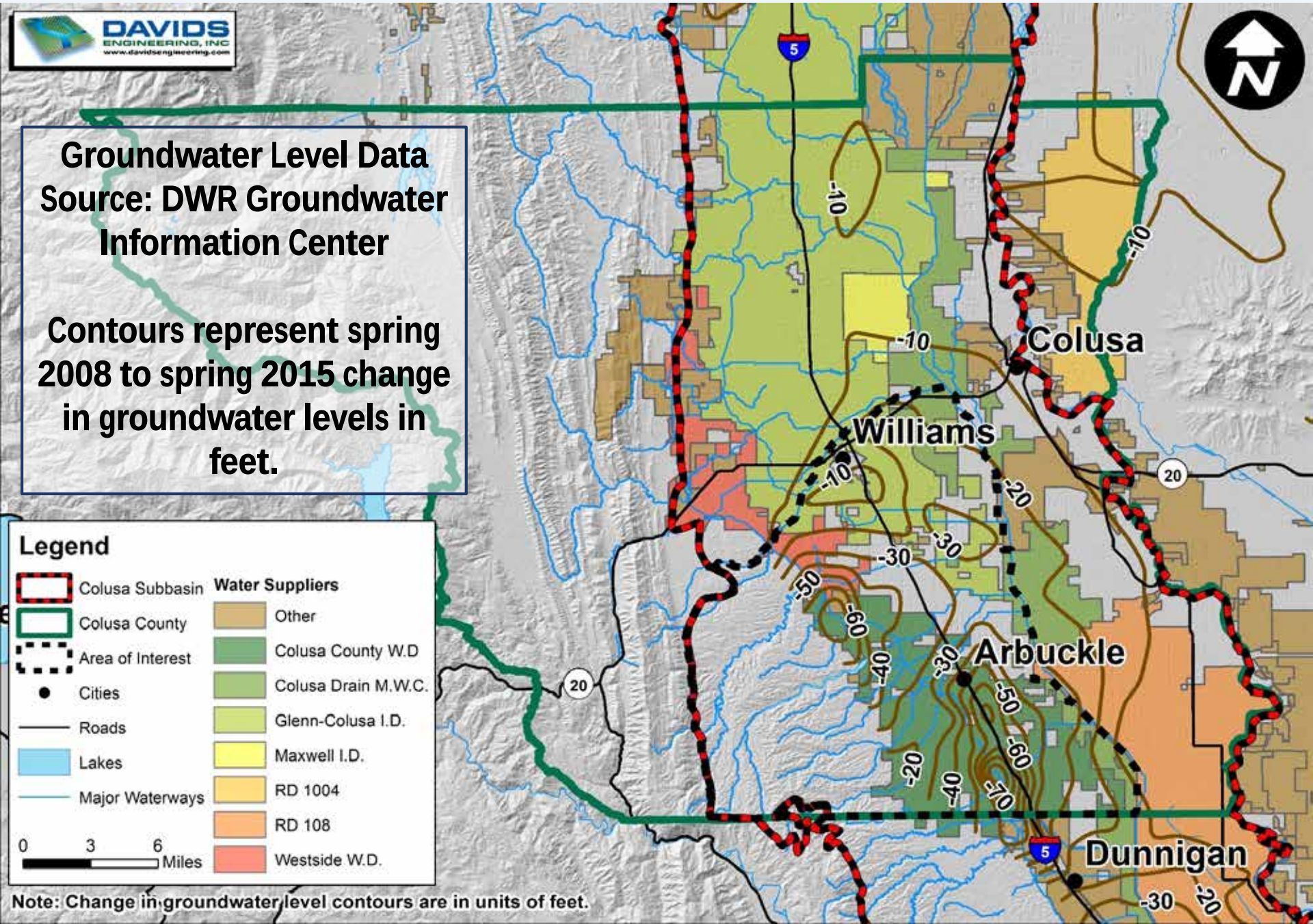
Estimated Storage Decrease = 200,000 to 400,000 acre-feet, excluding Native Lands.

Groundwater Level Data Source: DWR Groundwater Information Center

Contours represent spring 2008 to spring 2015 change in groundwater levels in feet.



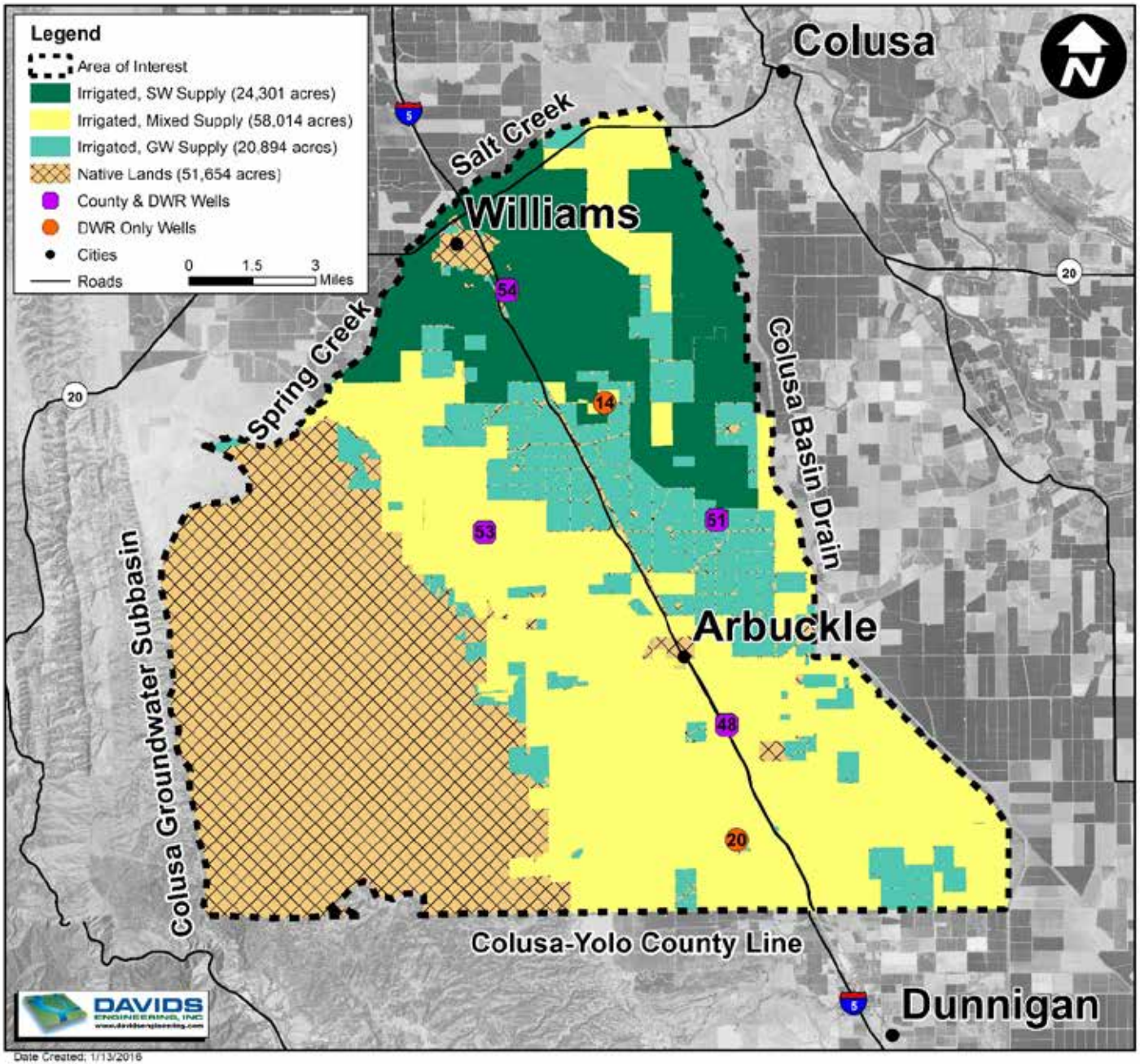
Water Suppliers within Area of Interest

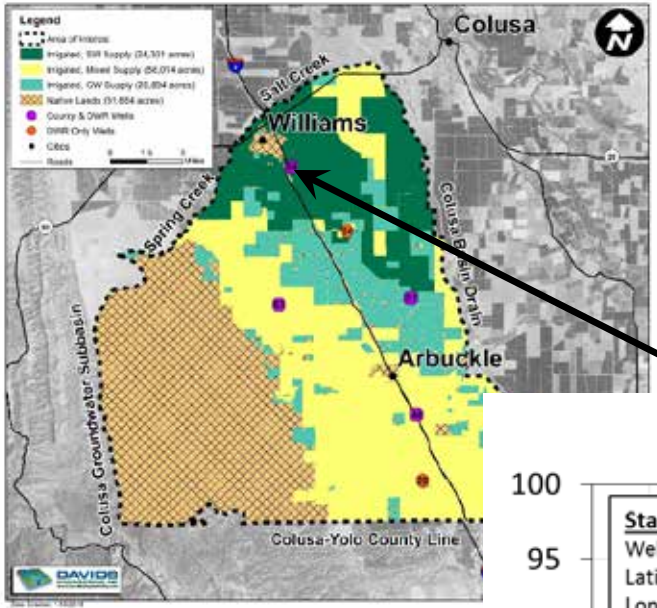


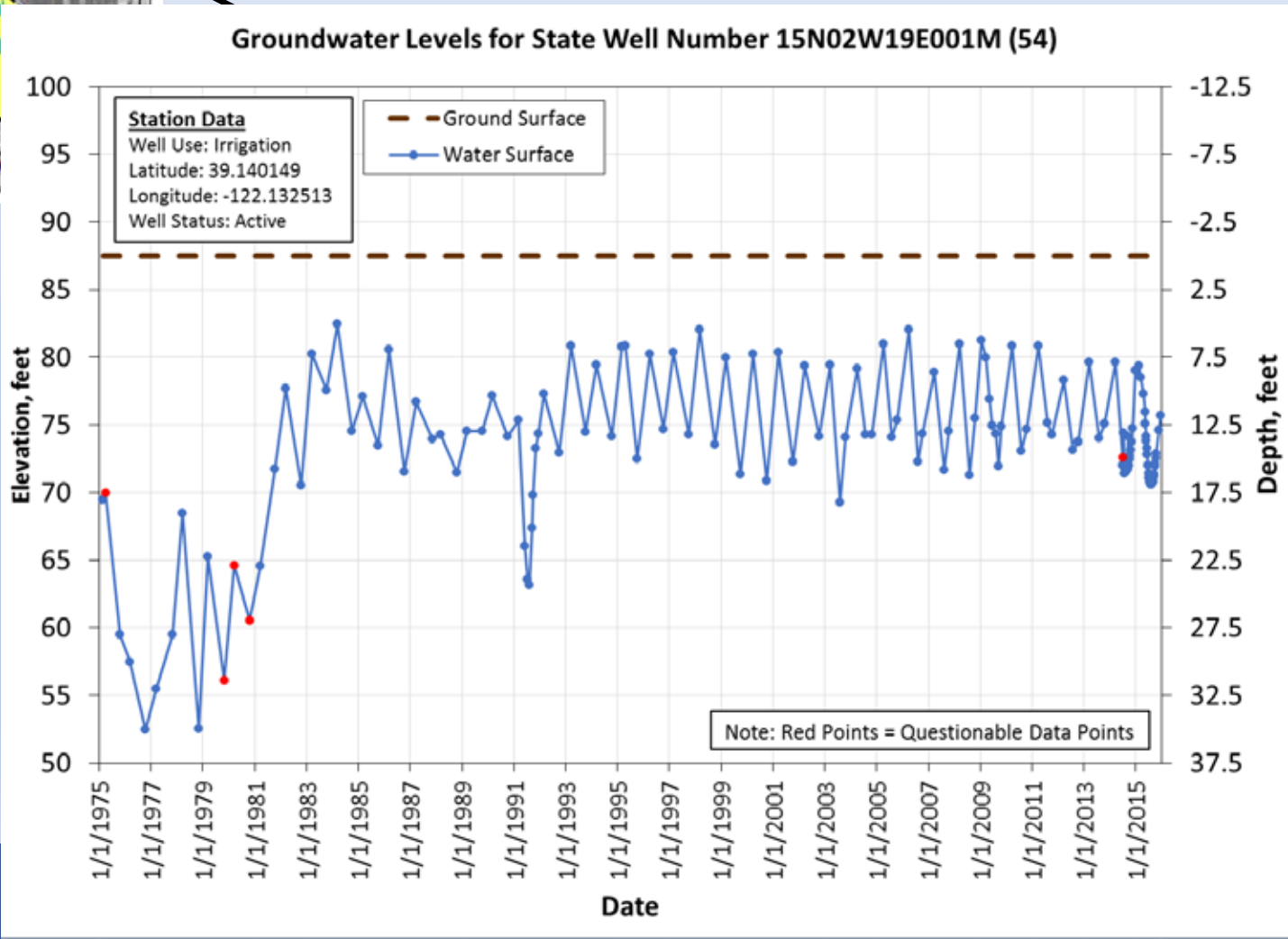
Historical Groundwater Levels in Selected Wells

- **Wells used by Colusa County and/or DWR for monitoring.**
- **Selected for continuous, long term record and for location relative to different water supply zones.**

Groundwater Level Data Source: DWR Groundwater Information Center







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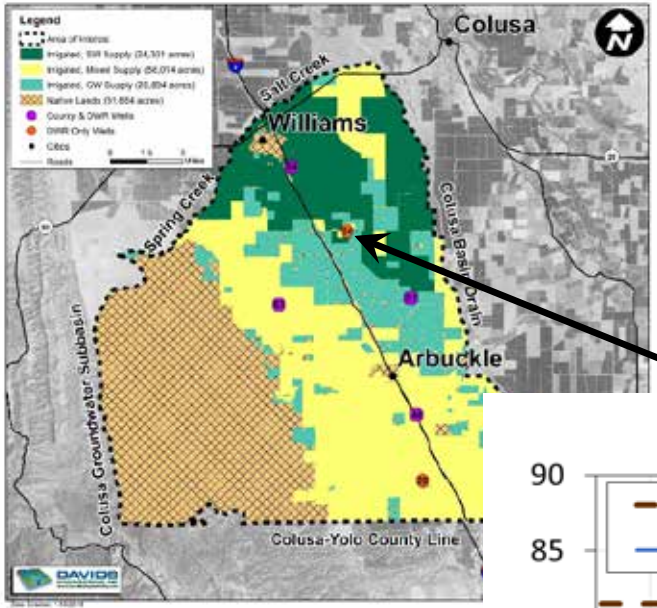

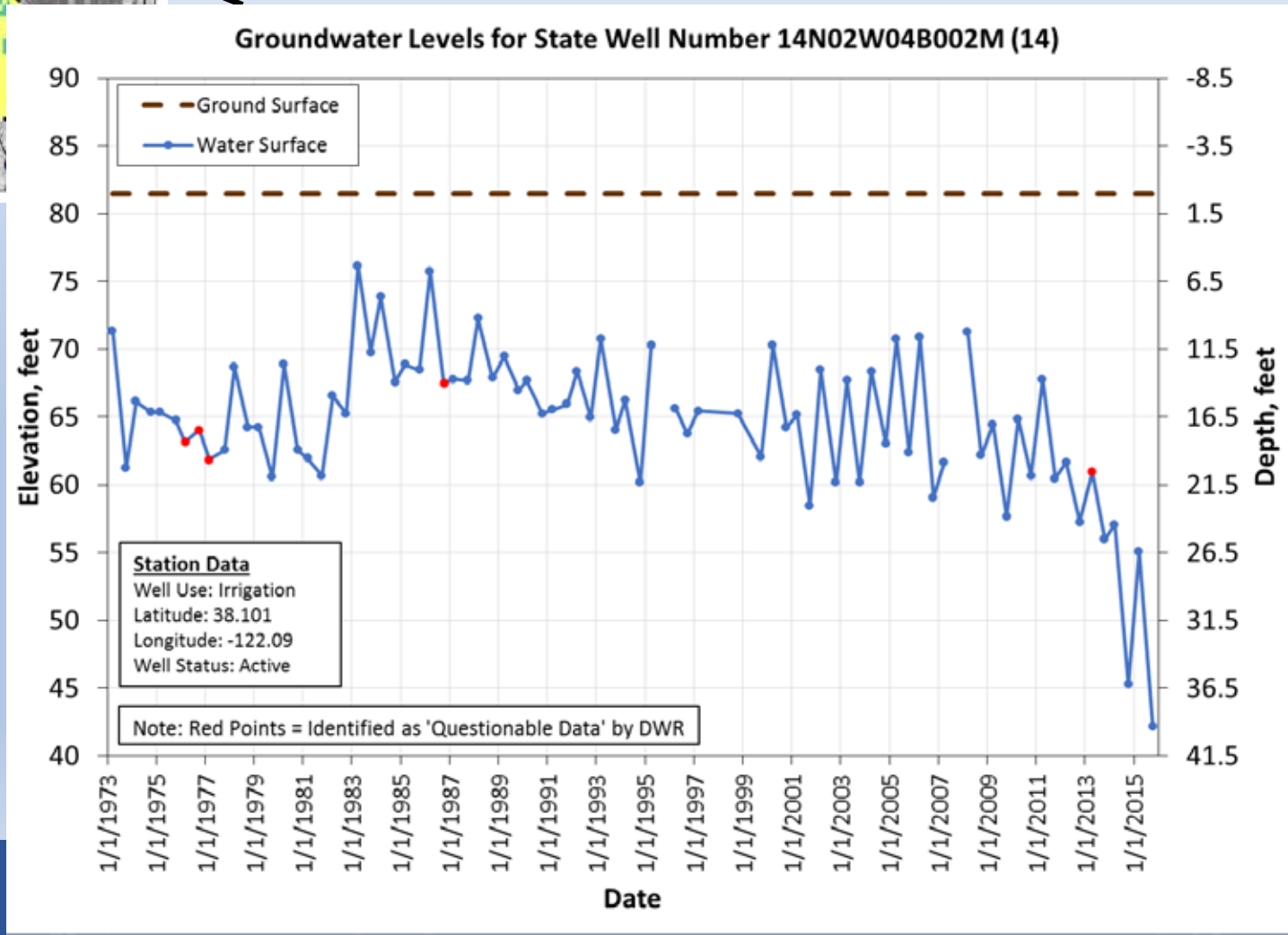

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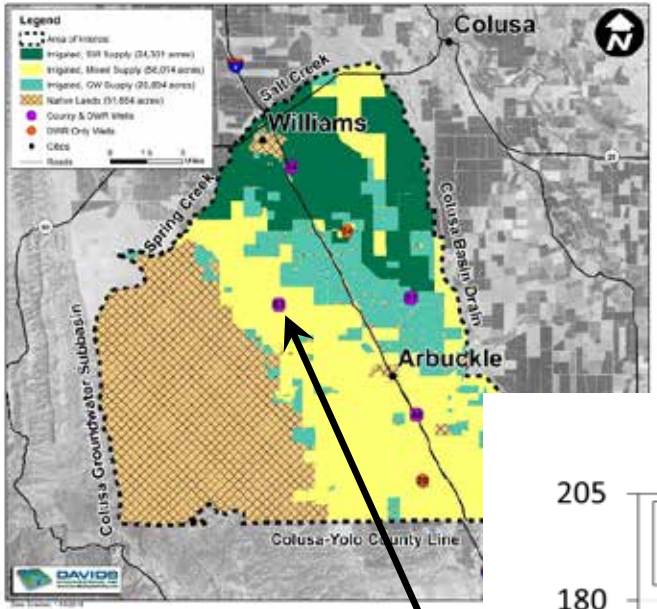

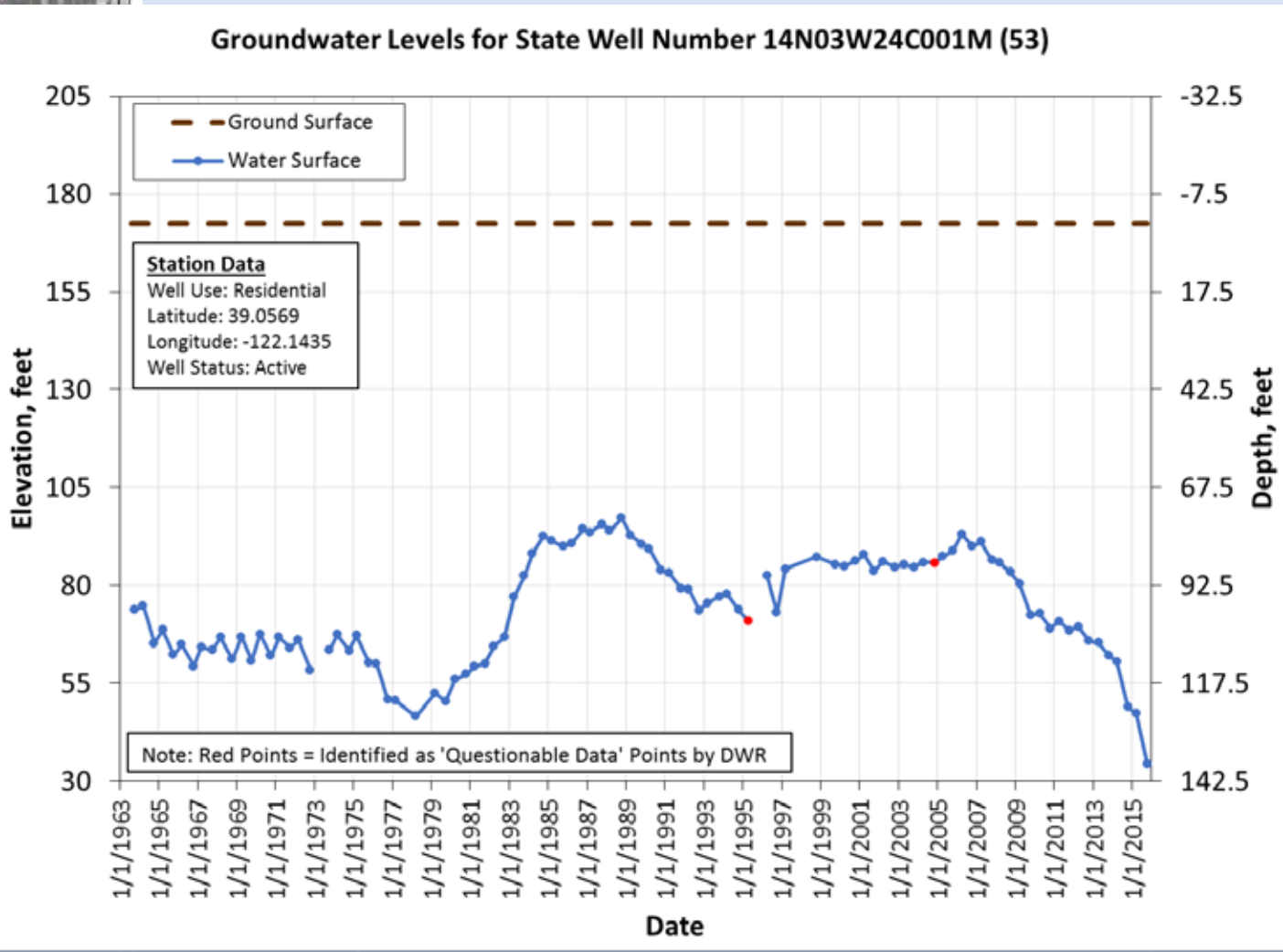

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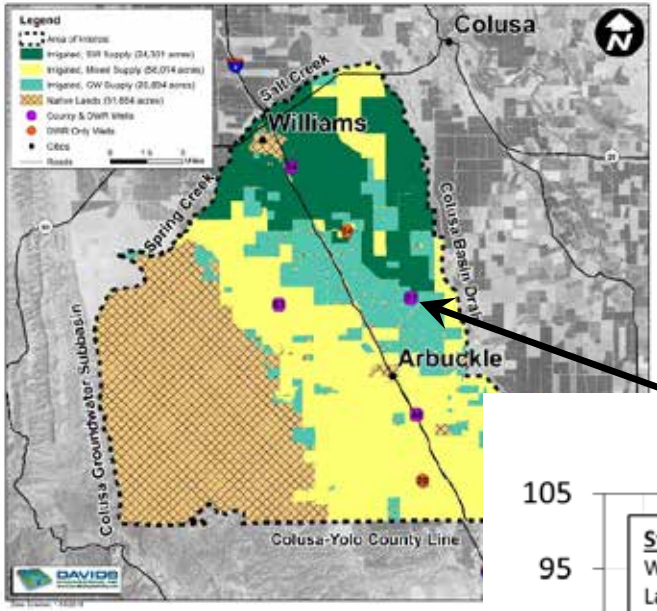

Groundwater Levels for State Well Number 14N02W13N001M (51)

Station Data
Well Use: Irrigation
Latitude: 39.0602
Longitude: -122.0411
Well Status: Active

Ground Surface
Water Surface

Note: No Questionable Data Points

Elevation, feet: 105, 95, 85, 75, 65, 55, 45, 35, 25, 15, 5

Depth, feet: -42.5, -32.5, -22.5, -12.5, -2.5, 7.5, 17.5, 27.5, 37.5, 47.5, 57.5

Date: 1/1/1957, 1/1/1959, 1/1/1961, 1/1/1963, 1/1/1965, 1/1/1967, 1/1/1969, 1/1/1971, 1/1/1973, 1/1/1975, 1/1/1977, 1/1/1979, 1/1/1981, 1/1/1983, 1/1/1985, 1/1/1987, 1/1/1989, 1/1/1991, 1/1/1993, 1/1/1995, 1/1/1997, 1/1/1999, 1/1/2001, 1/1/2003, 1/1/2005, 1/1/2007, 1/1/2009, 1/1/2011, 1/1/2013, 1/1/2015

Groundwater Level Data Source: DWR Groundwater Information Center

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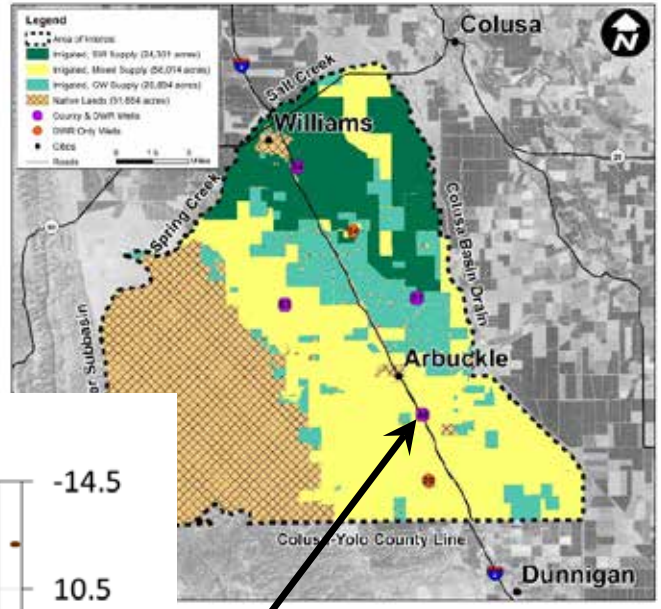

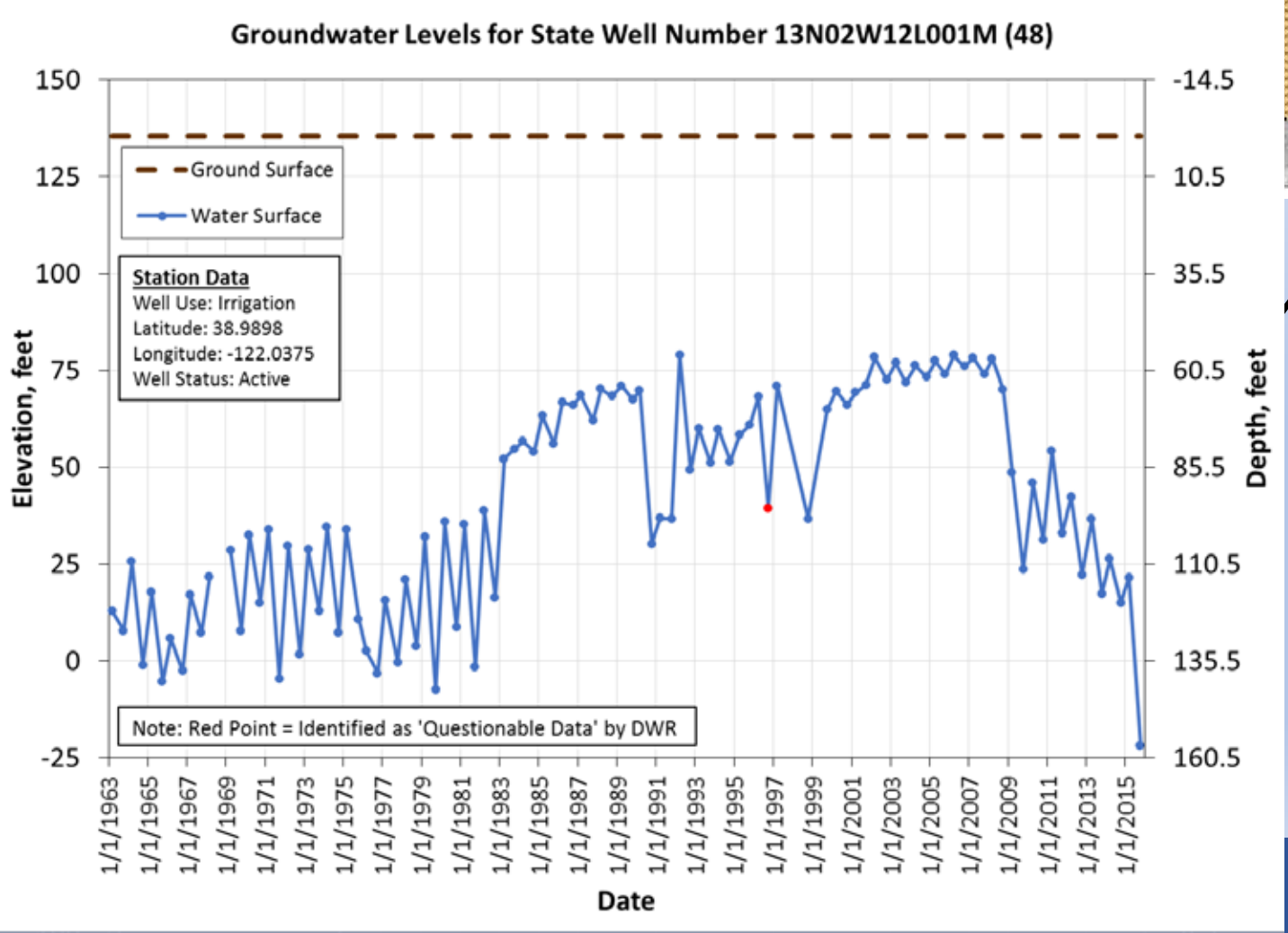

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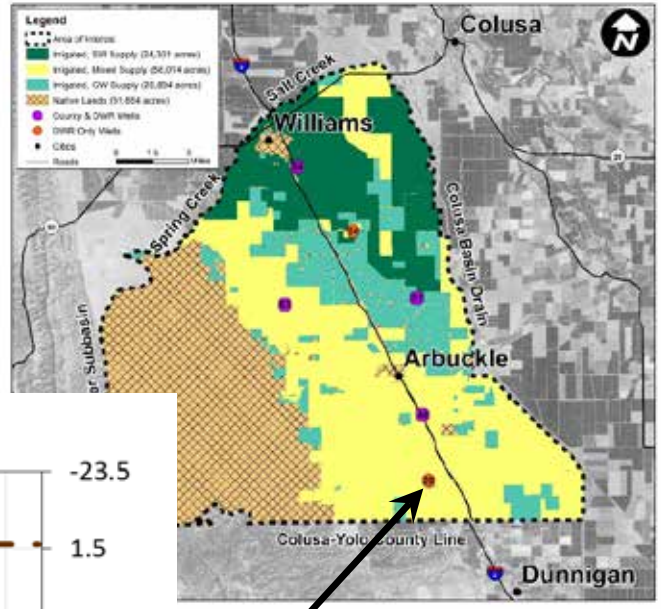
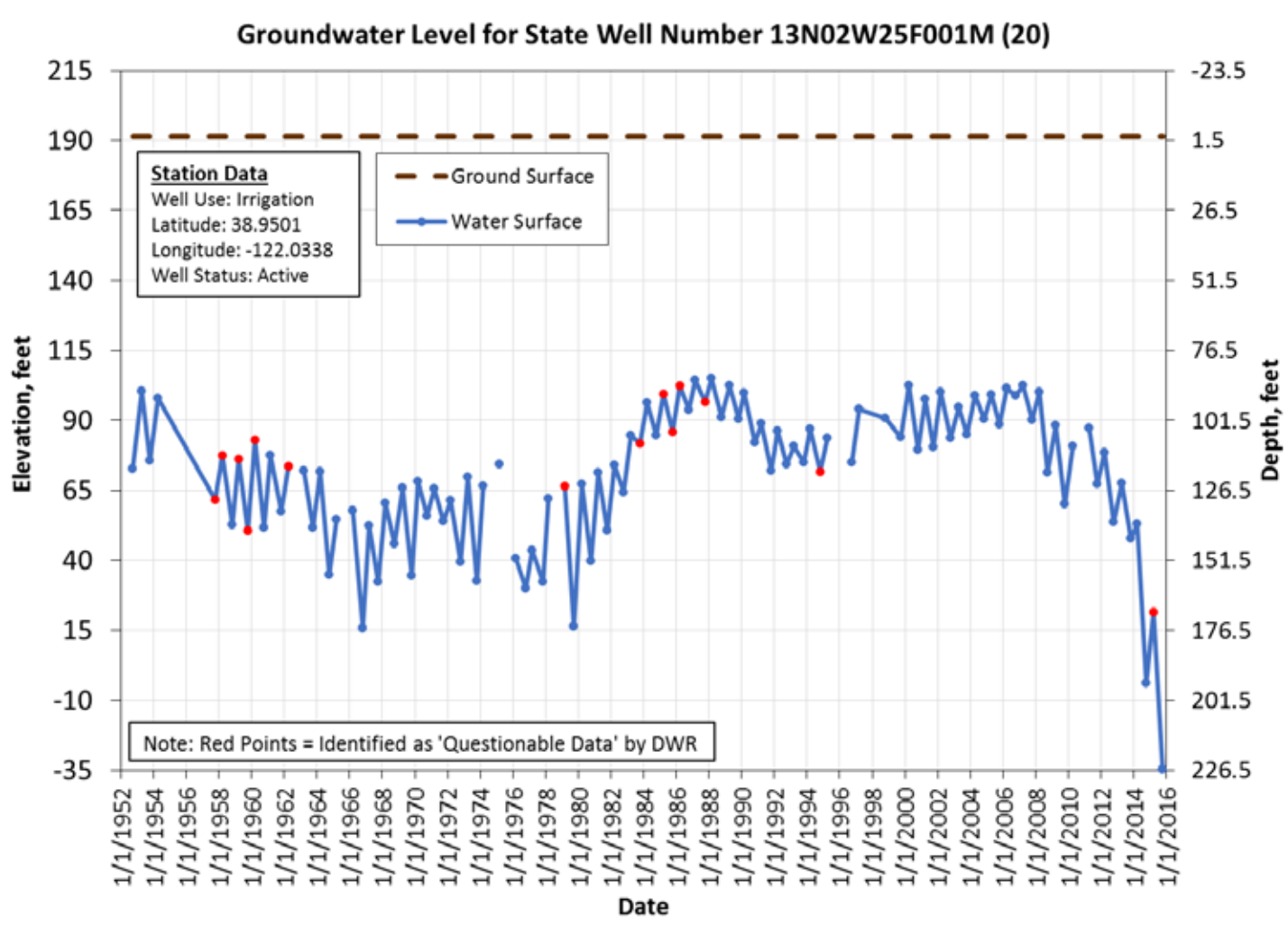
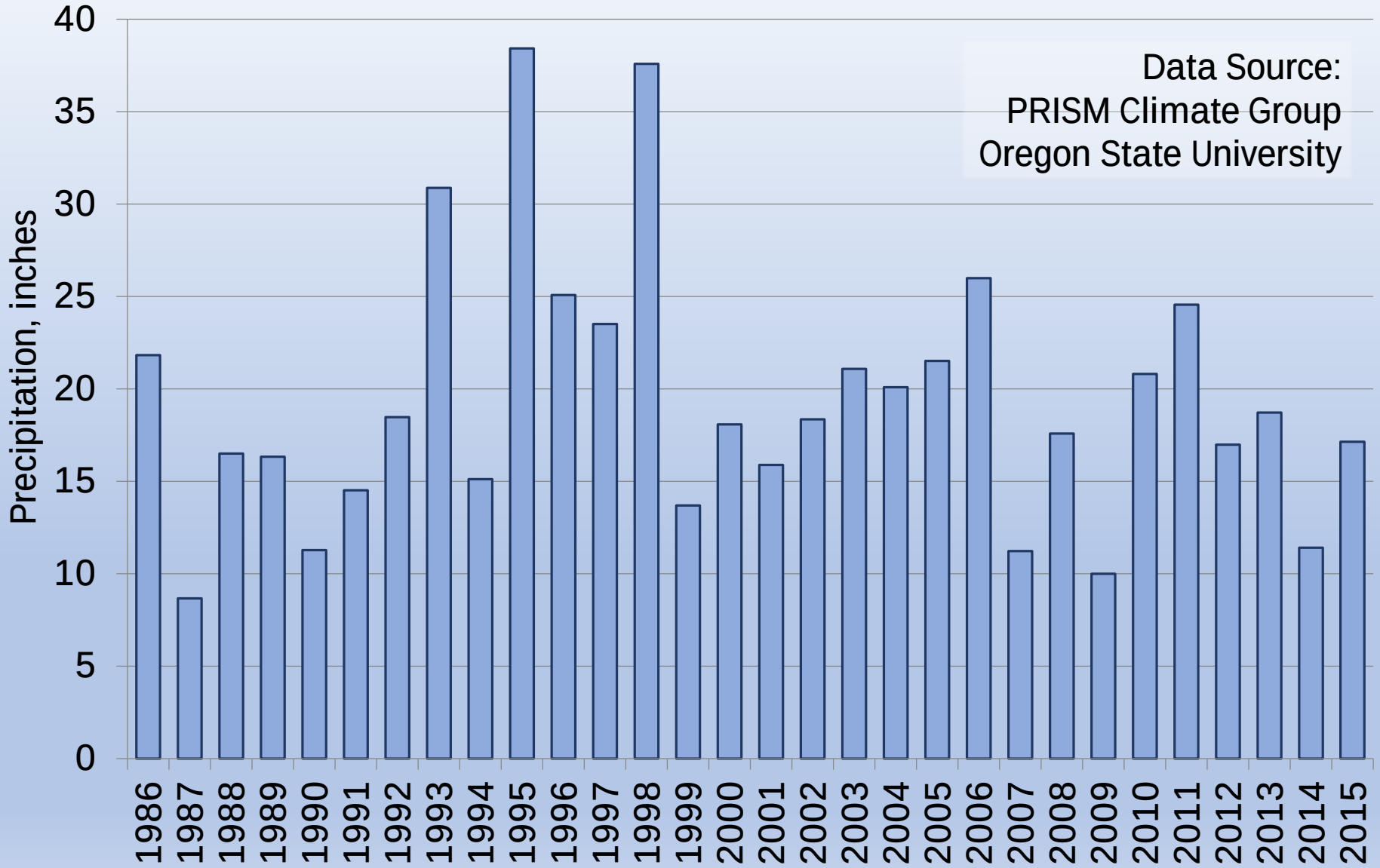




Groundwater Level Data Source: DWR Groundwater Information Center

1986-2015 Water Year Precipitation in AOI (Valley Floor)



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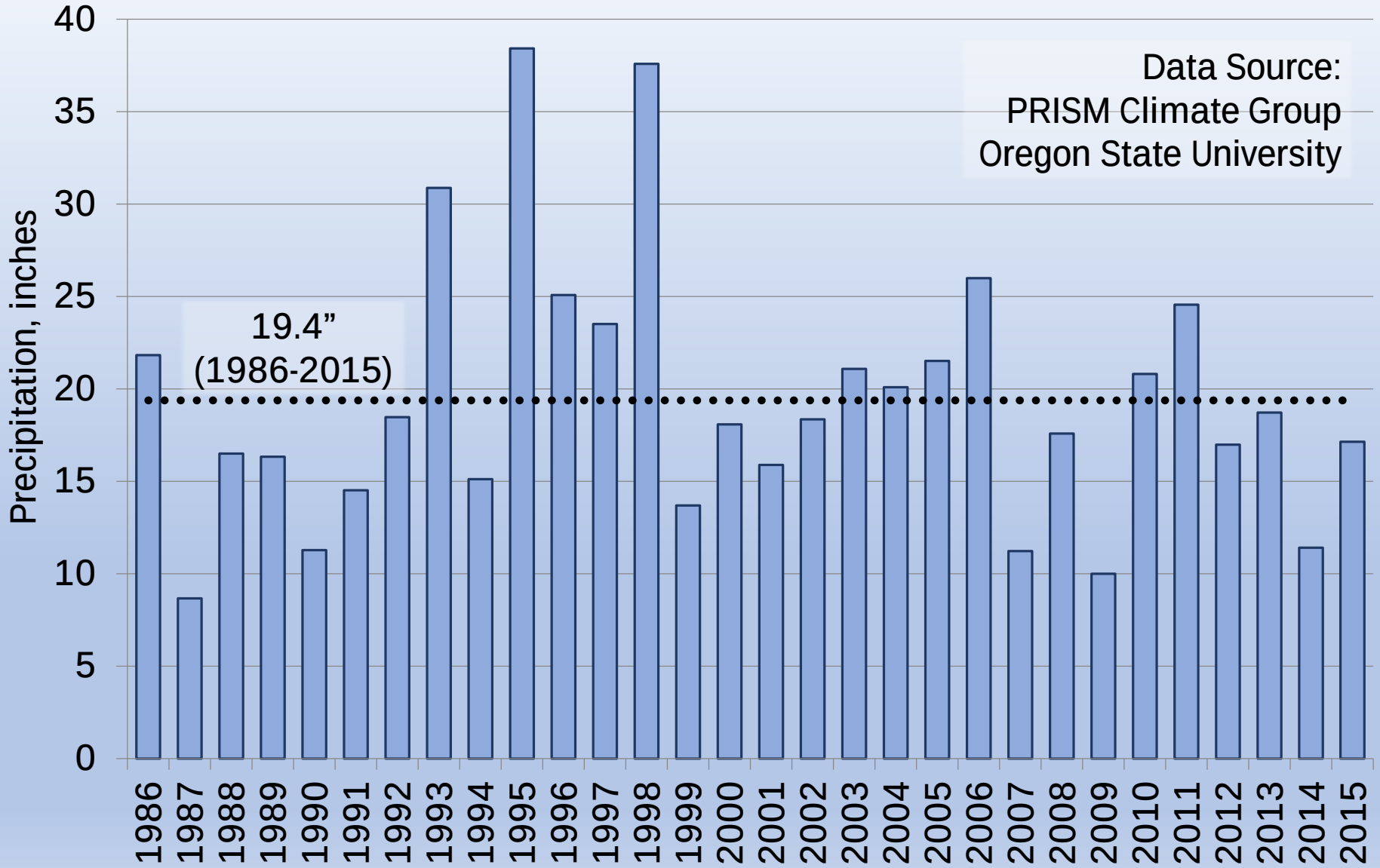

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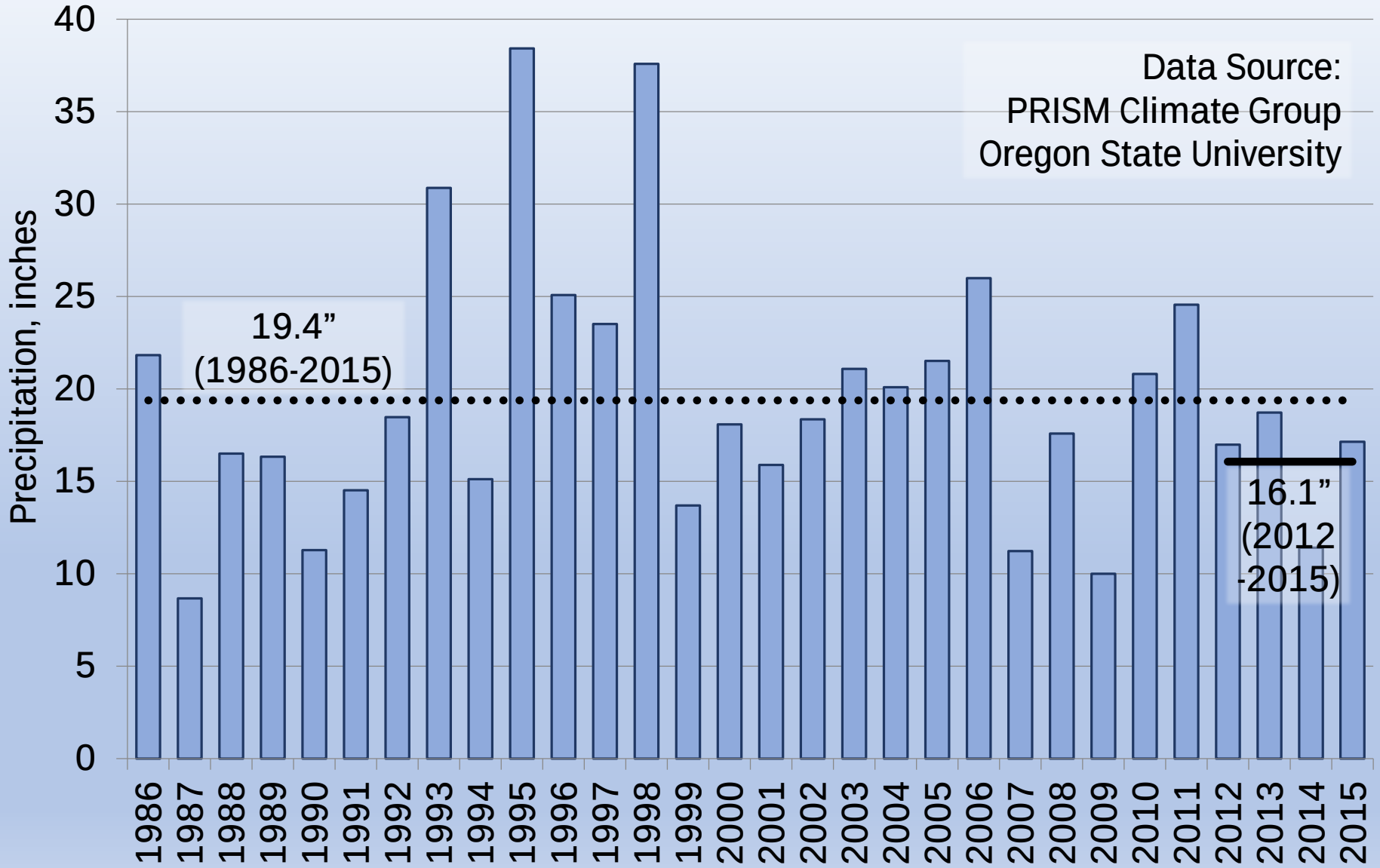

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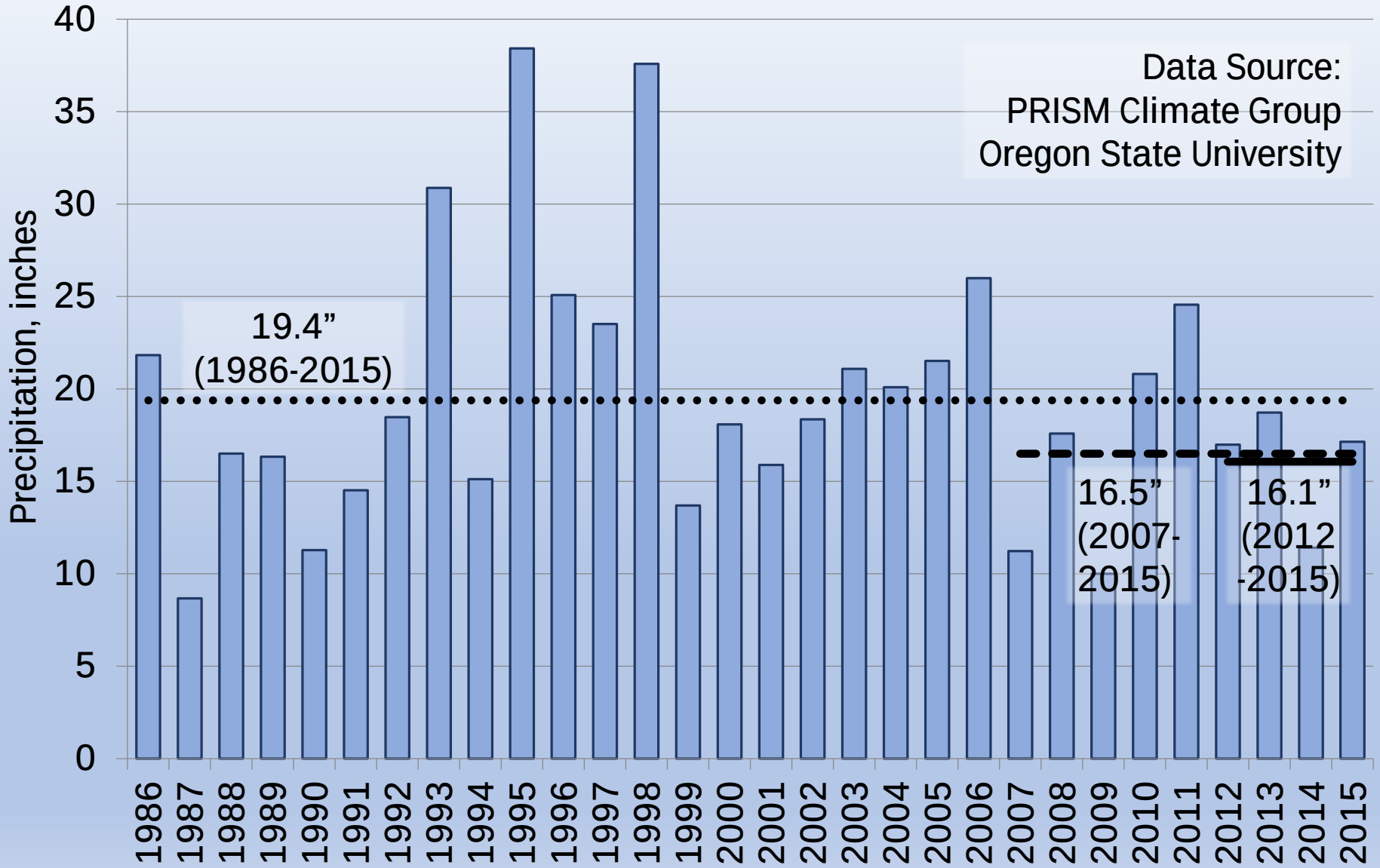

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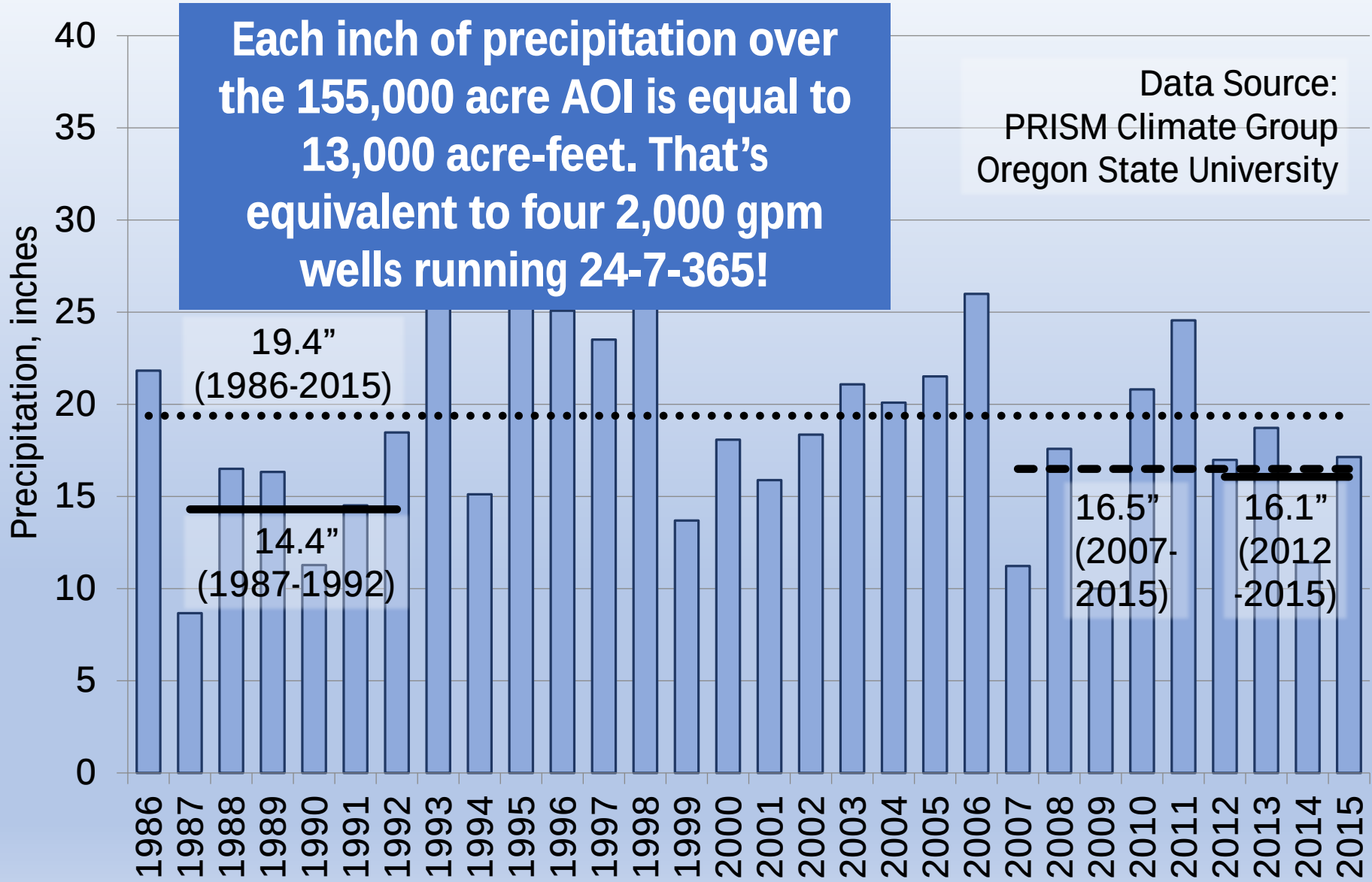
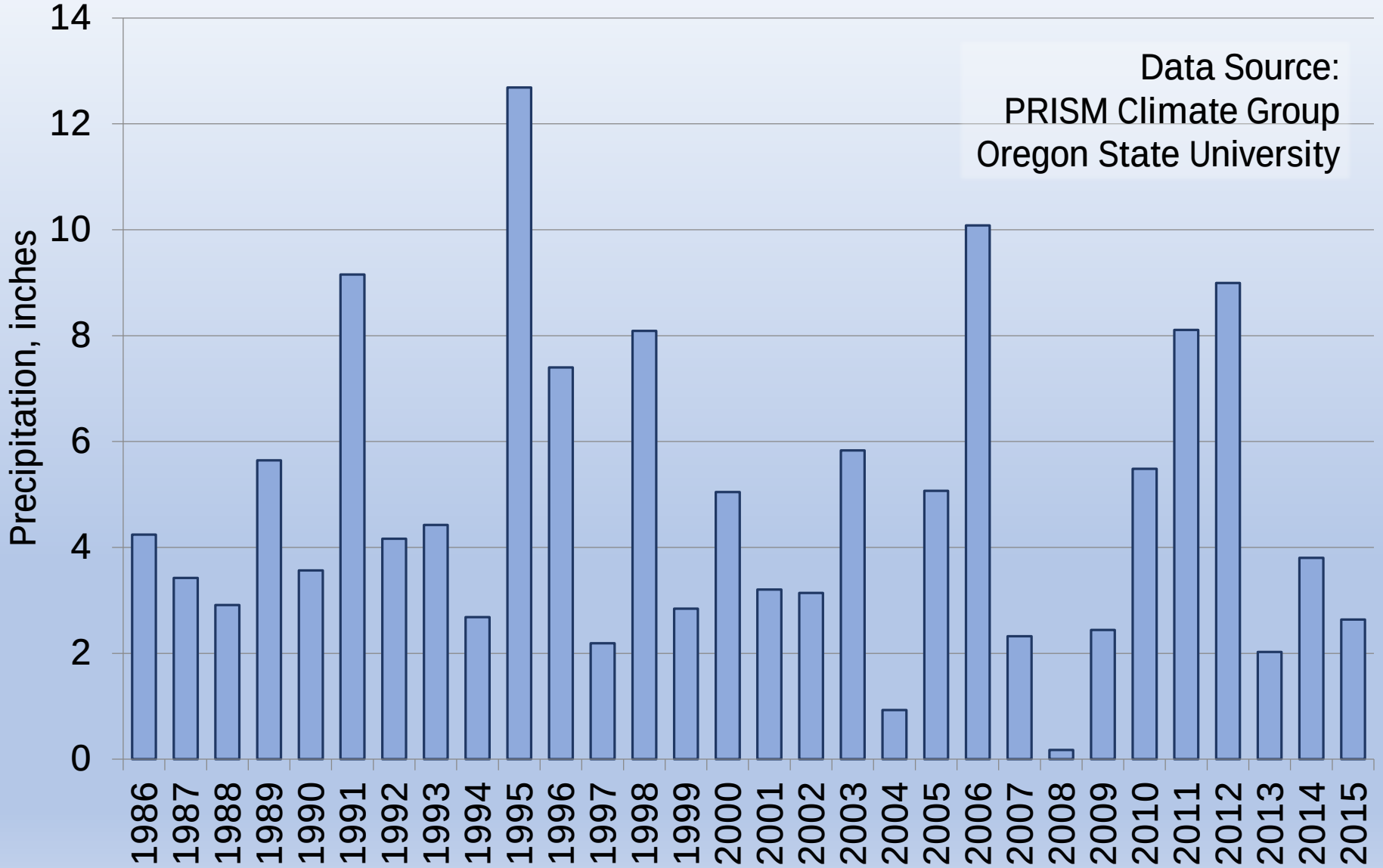


1986-2015 March-May Precipitation in AOI (Valley Floor)



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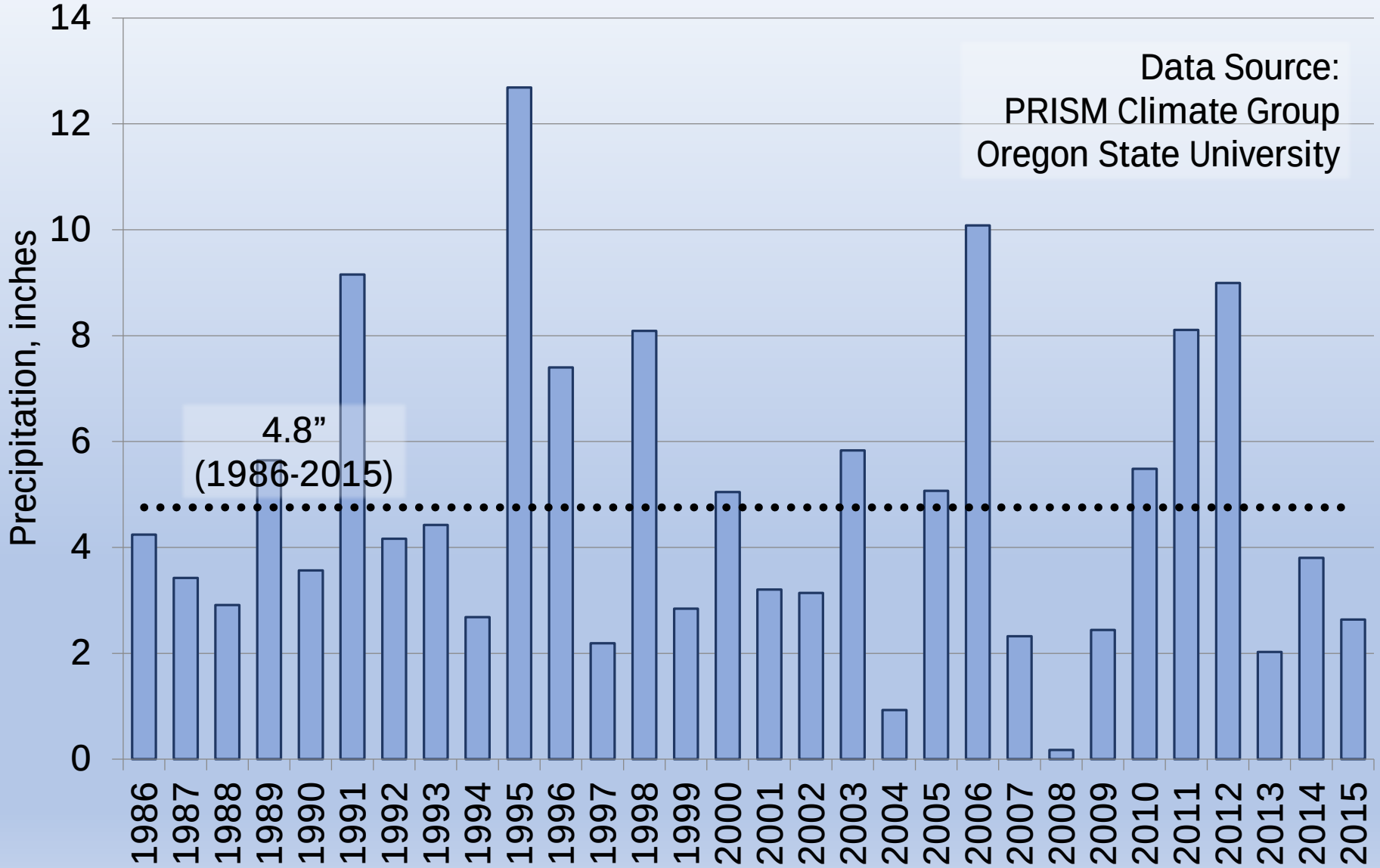

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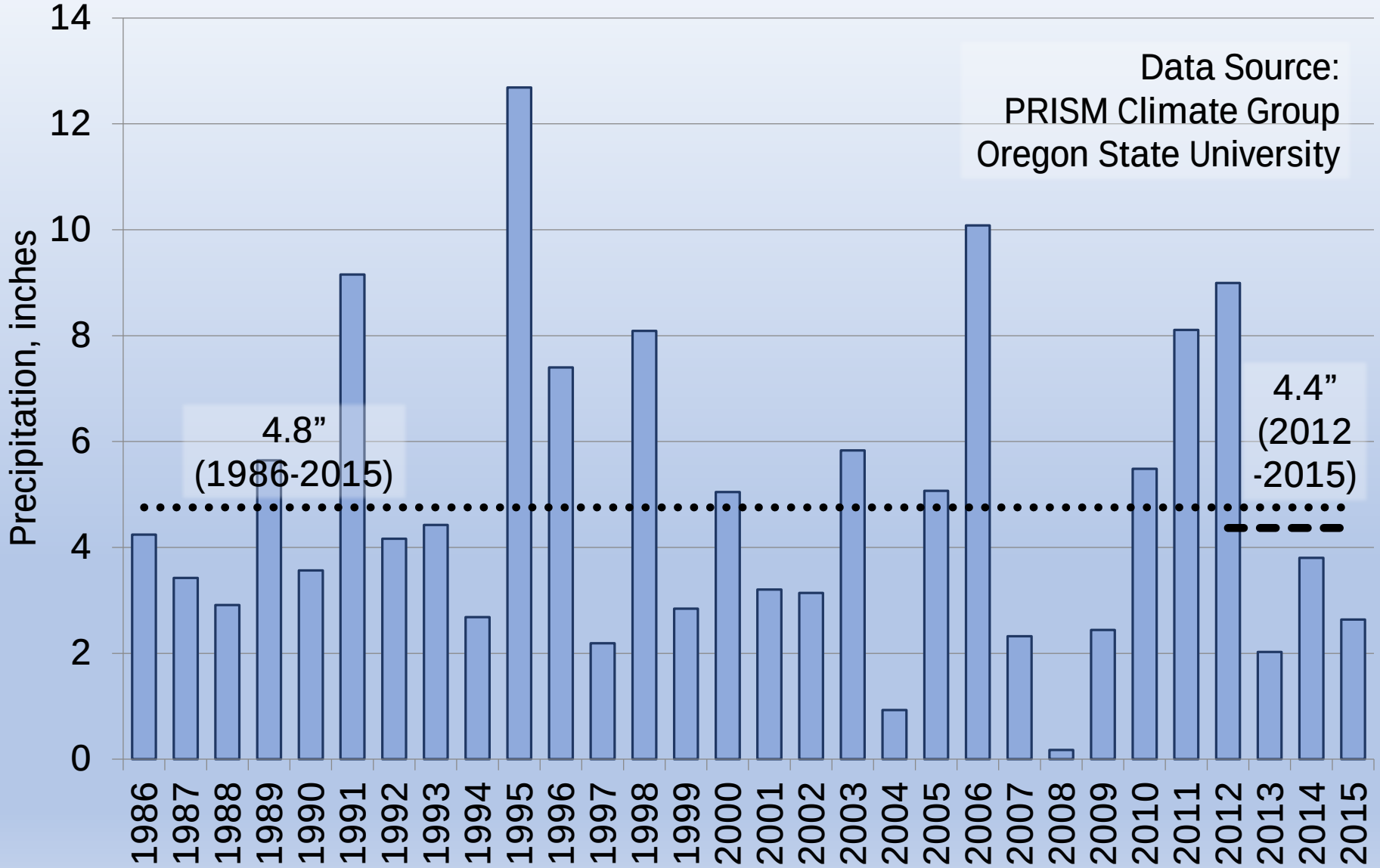

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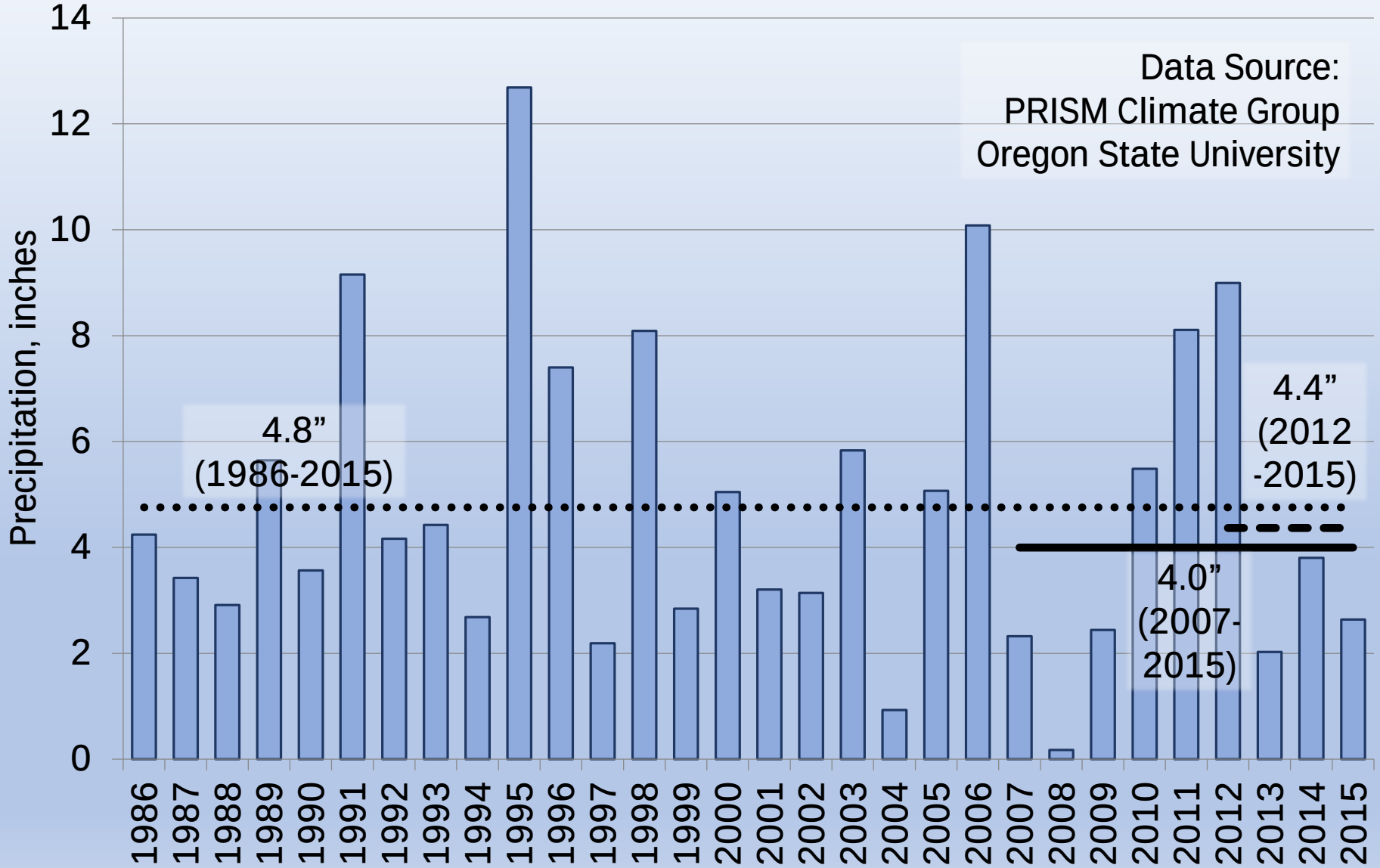

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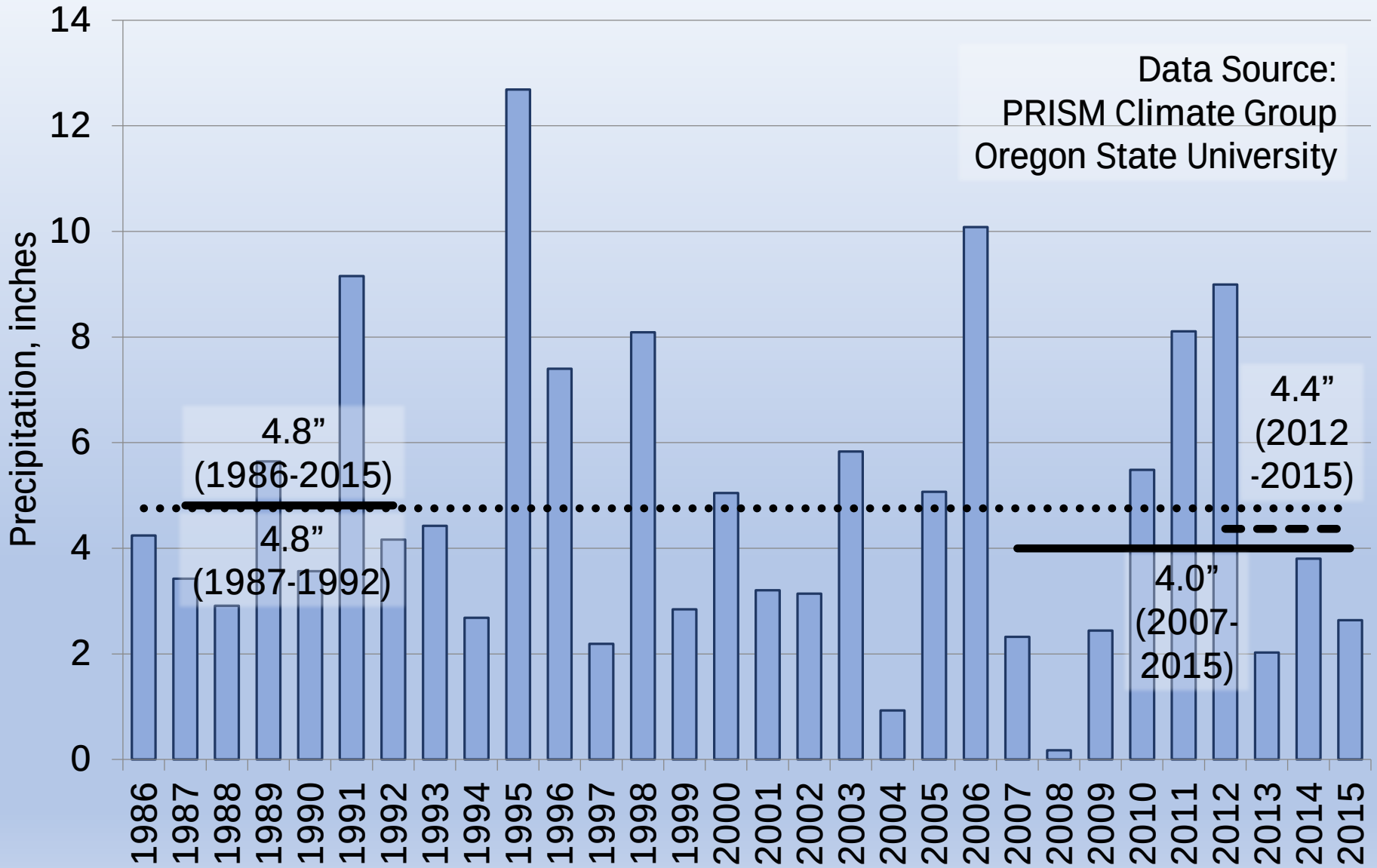


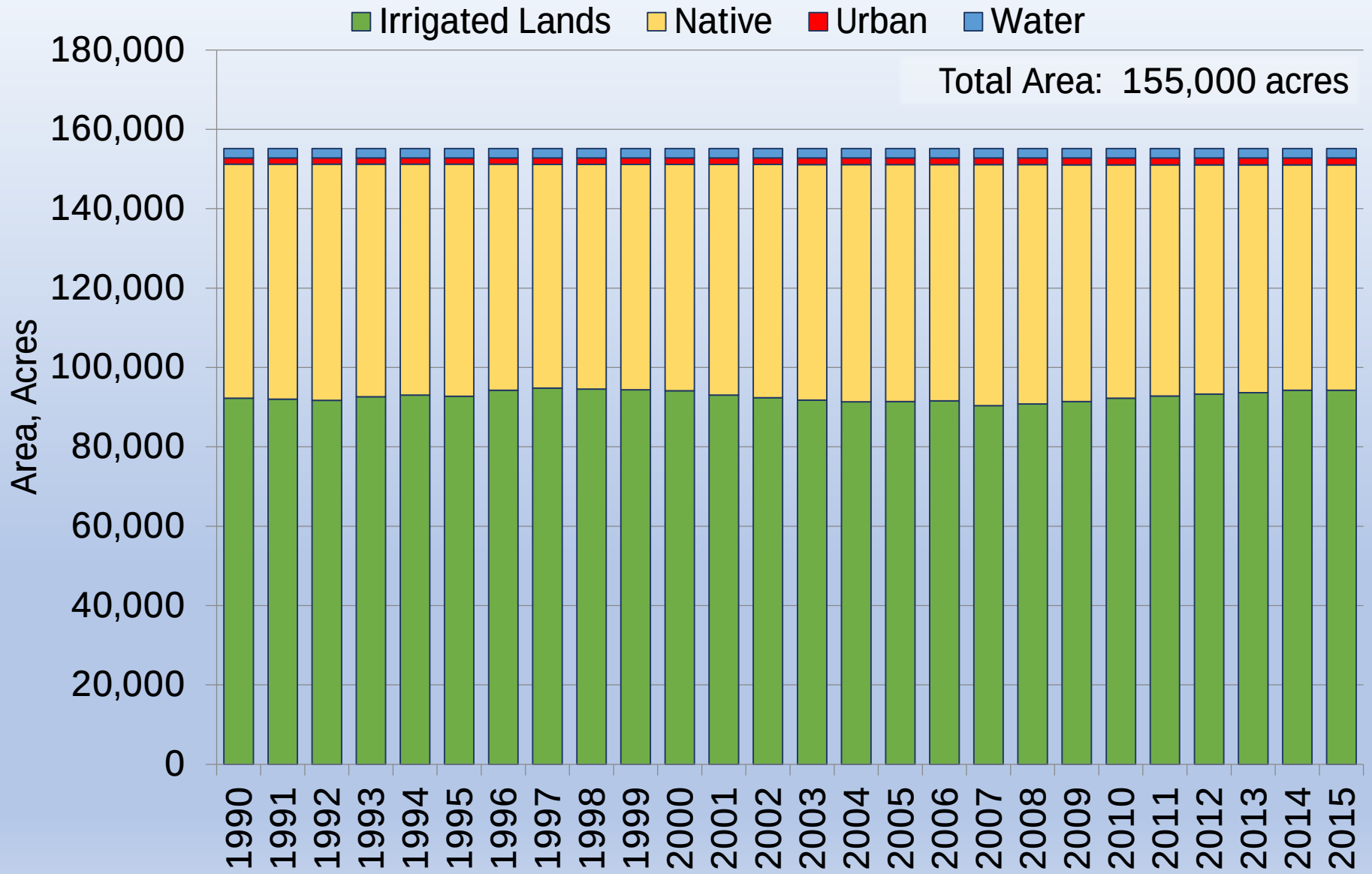
Summary of Key Points Thus Far

- Groundwater levels *generally* display:
  - Recovery during the early 1980's
  - Stable trends from mid 1980's to mid 2000's
  - Declining trends from the mid/late 2000s to the present time
- Most wells currently near or below historical lows
- Estimated decrease in groundwater storage of 200,000 AF to 400,000 AF between 2008 and 2015 (approx. 25,000 to 50,000 AF/year), excluding native lands
- In terms of local precipitation, current drought began in 2007, not 2012
- Local precipitation is an important water source

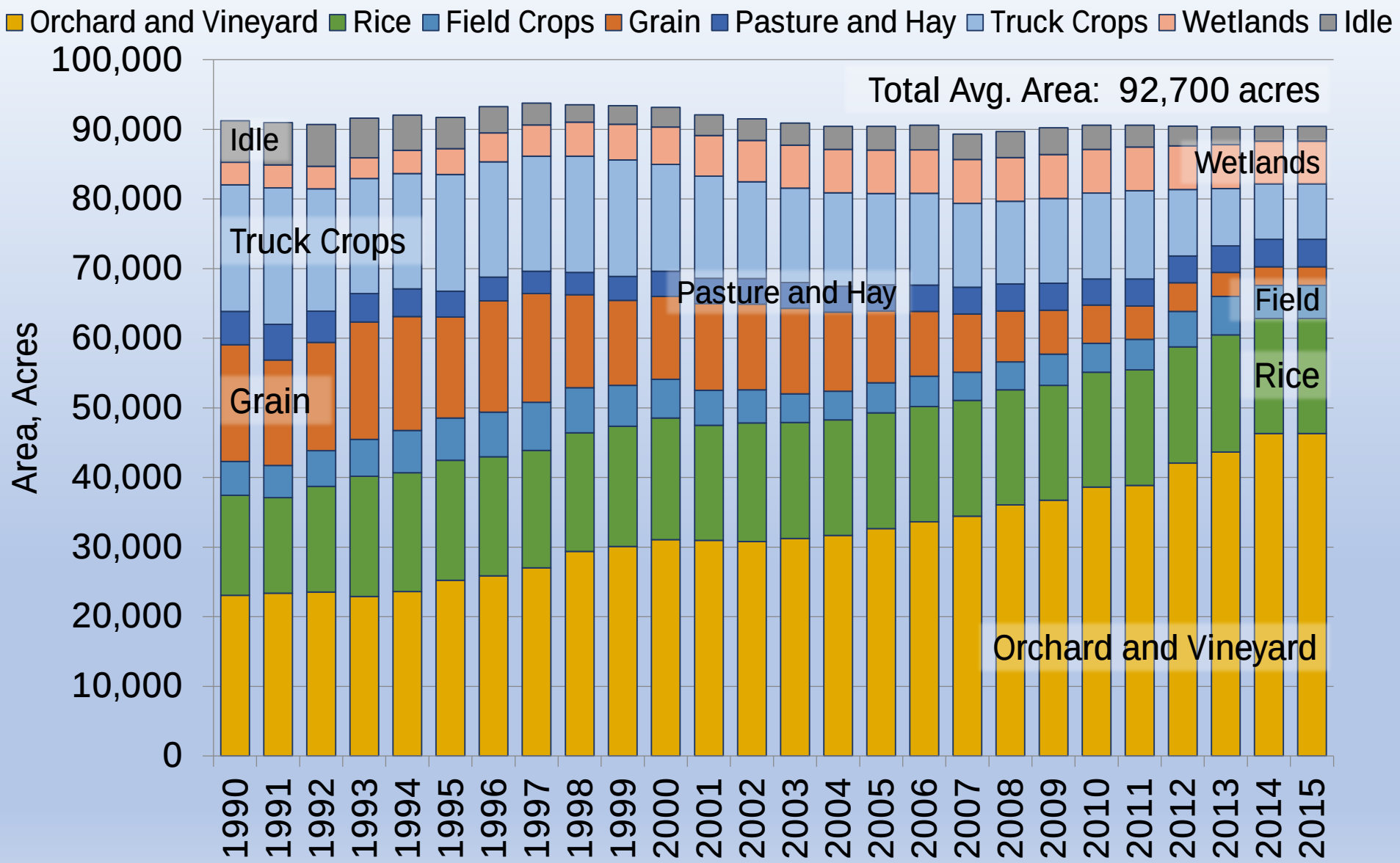
Historical Land Use and Cropping

- Based on DWR land use surveys in:
  - 1993
  - 1998
  - 2003
  - 2009 (unreleased)
  - 2014 (unreleased)
- Colusa County Ag Commissioner data used to interpolate between survey years to get annual time series

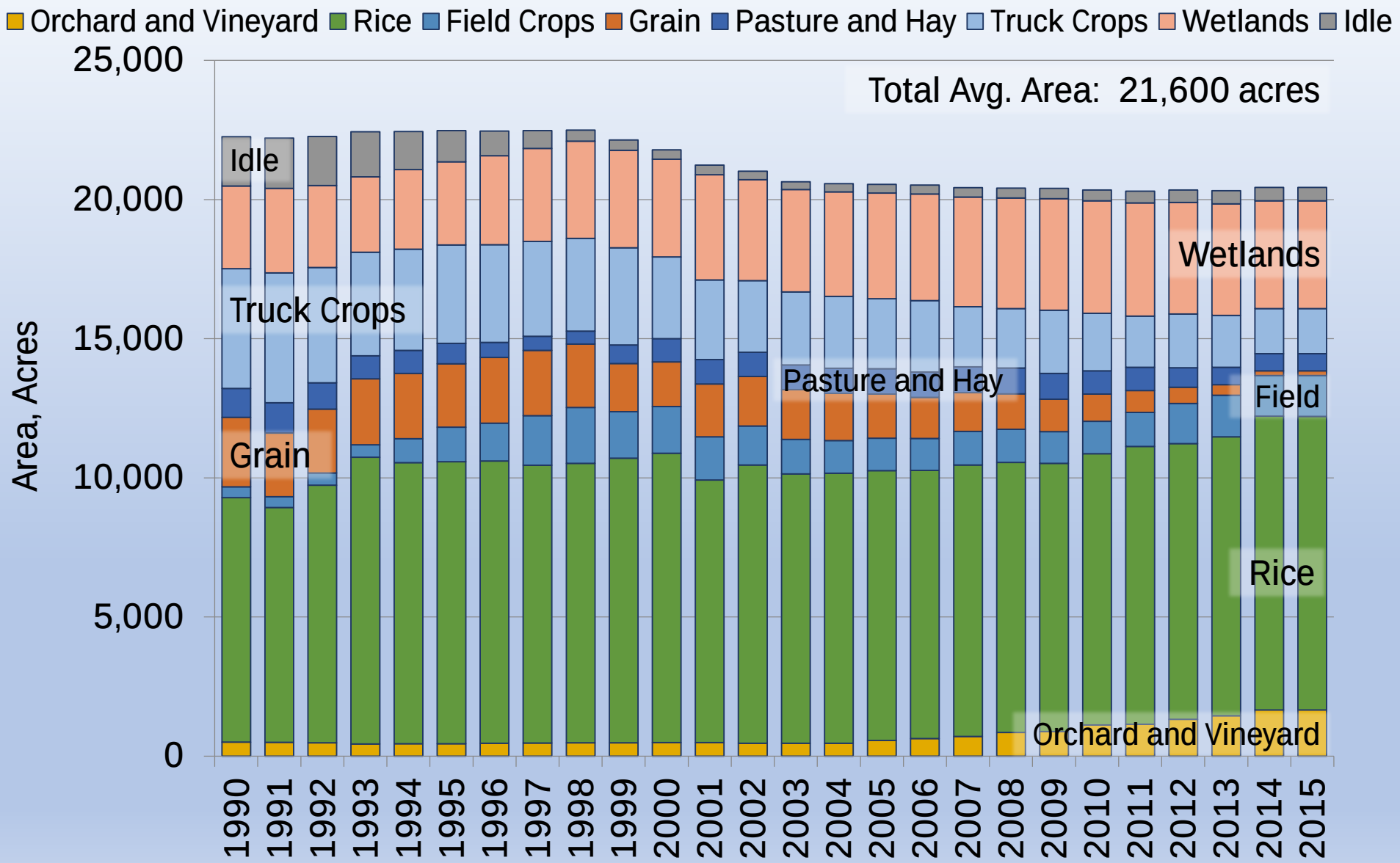
General Land Use in the Area of Interest



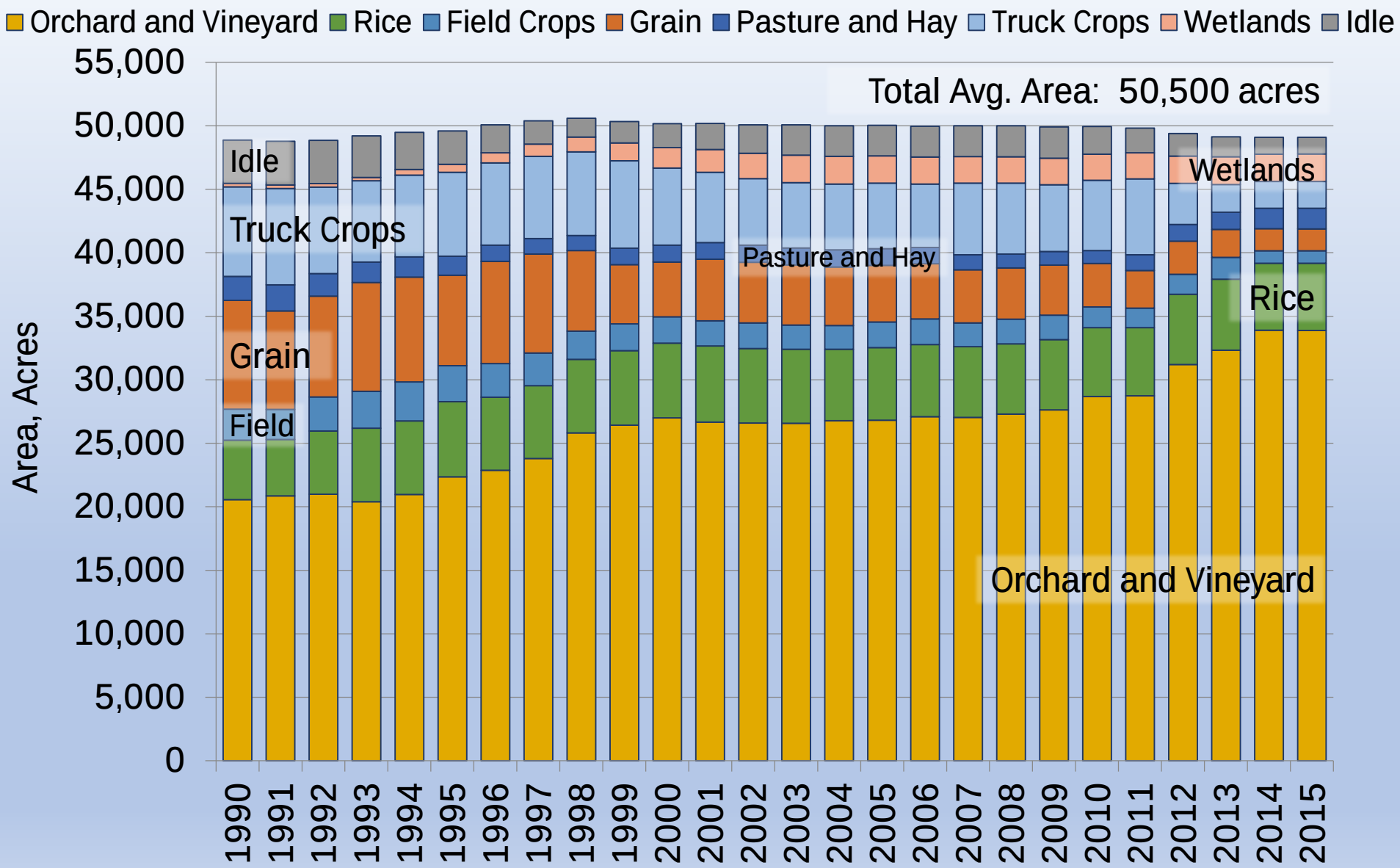
Area of Interest Cropping (1990–2015, All Irrigated Lands)



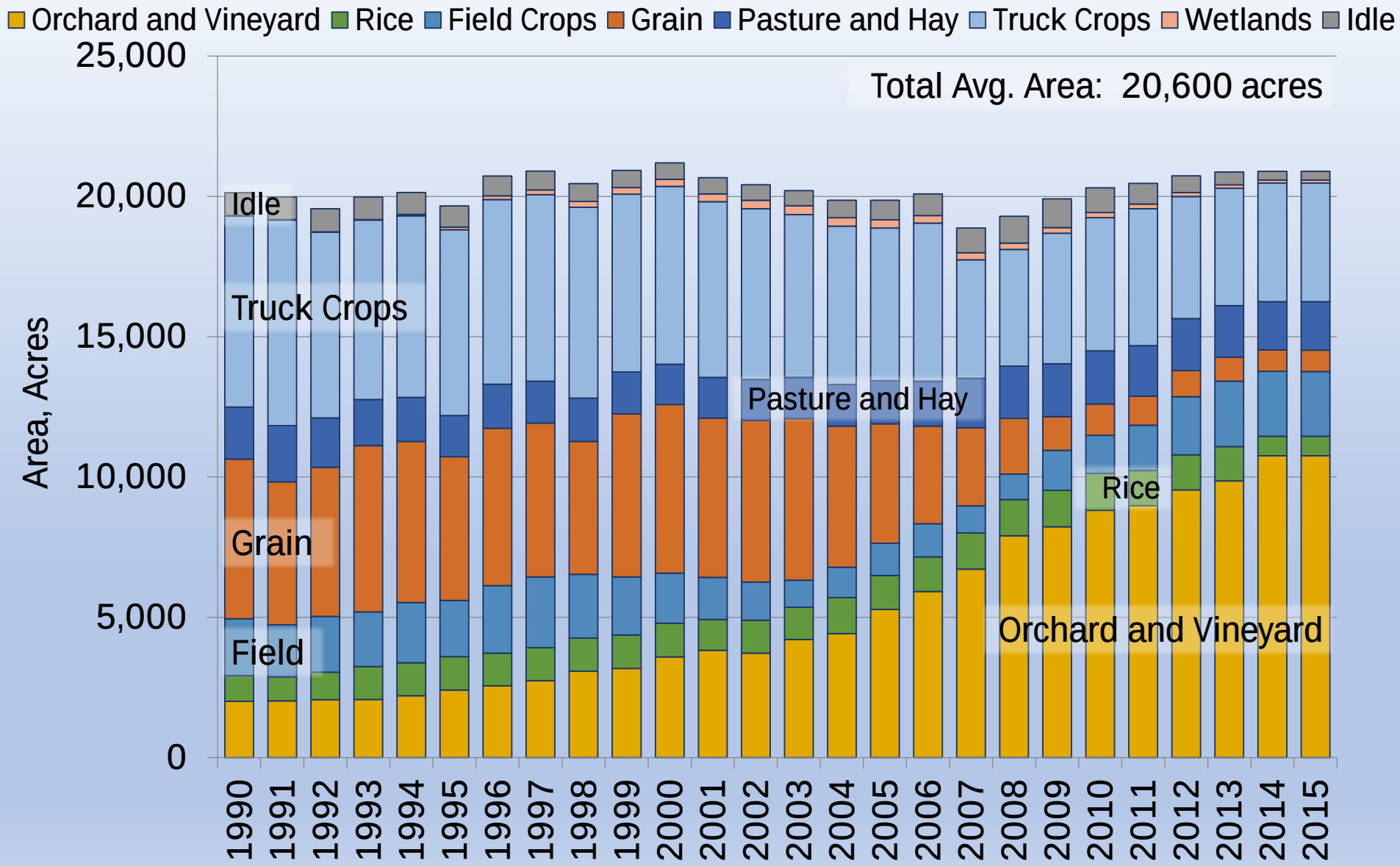
Surface Water Supply Area Cropping (1990 – 2015)



Mixed Water Supply Area Cropping (1990 – 2015)



Groundwater Supply Area Cropping (1990 – 2015)



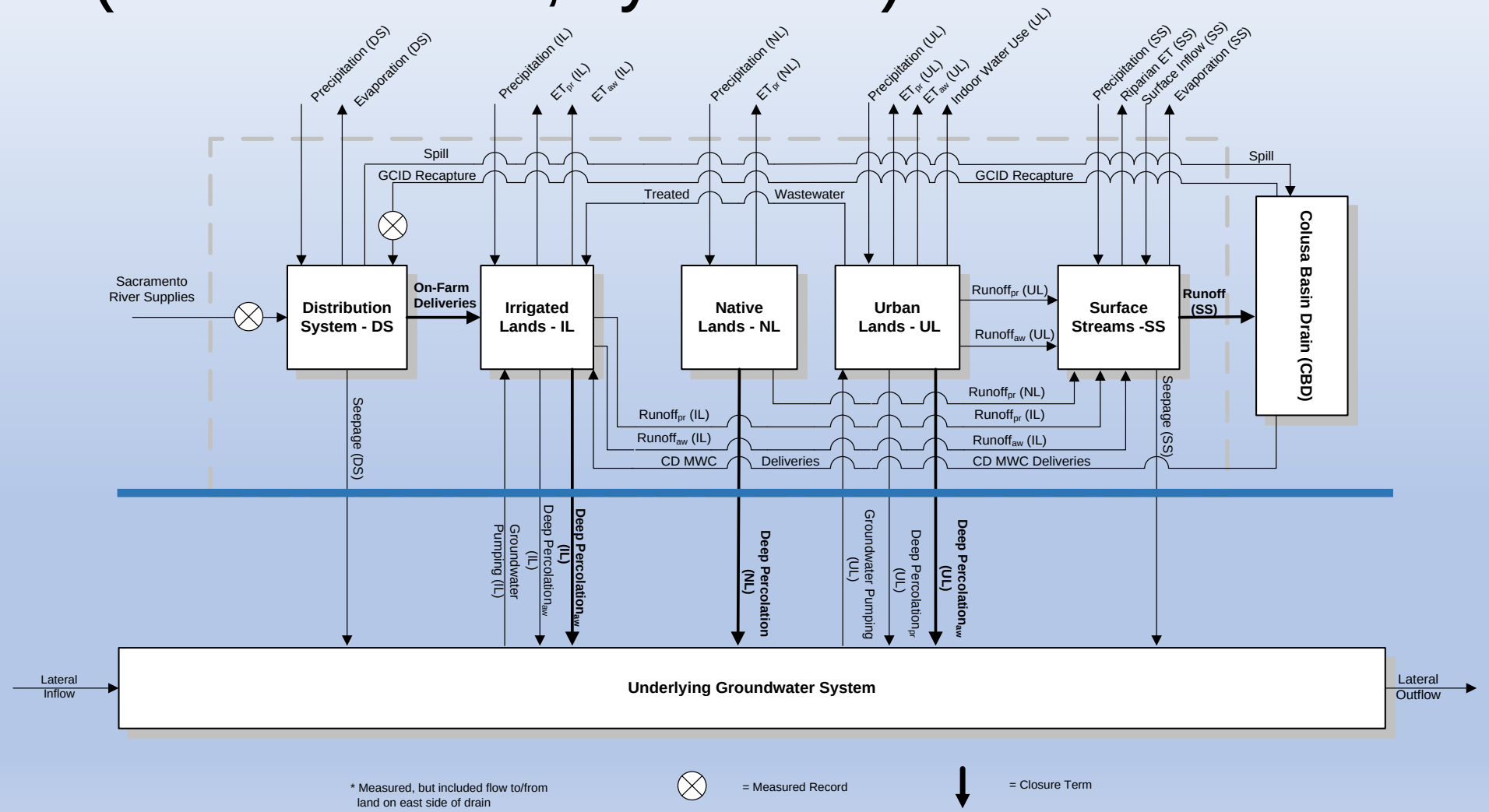
1990 – 2015 Land Use and Cropping Summary

- The total cropped area in the AOI has remained stable at between 90,000 and 95,000 acres per year, averaging 92,700 acres
- Permanent cropping has doubled, from about 23,000 acres to 46,000 acres, offset by declines in grain and truck crops
  - Most change occurred in mixed supply and groundwater supply areas
  - Permanent crops have higher water use than grain and truck crops
- Areas planted to other crops have remained fairly stable

Water Balance (or “Budget”) Analysis

- A complete accounting of all water flowing into and out of a defined area over a specified period of time
- Water balance principle:
  - Inflow - Outflow ± Change in Storage = 0
- Just like your checking account:
  - Deposits - Withdrawals ± Change in Balance = 0

Area of Interest Water Balance Structure (1990 – 2015, by month)



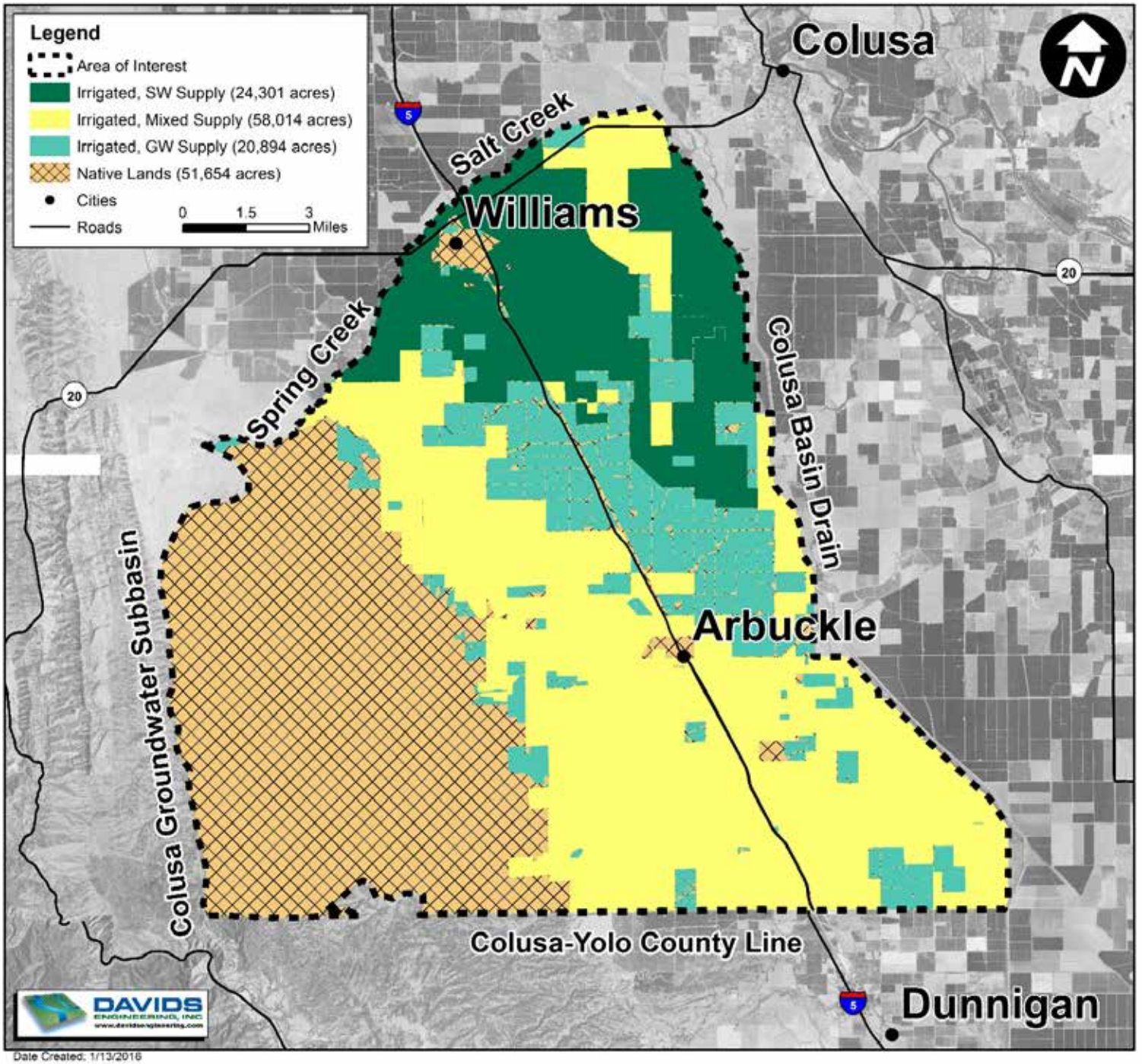
AOI Net Recharge

- Net Recharge =

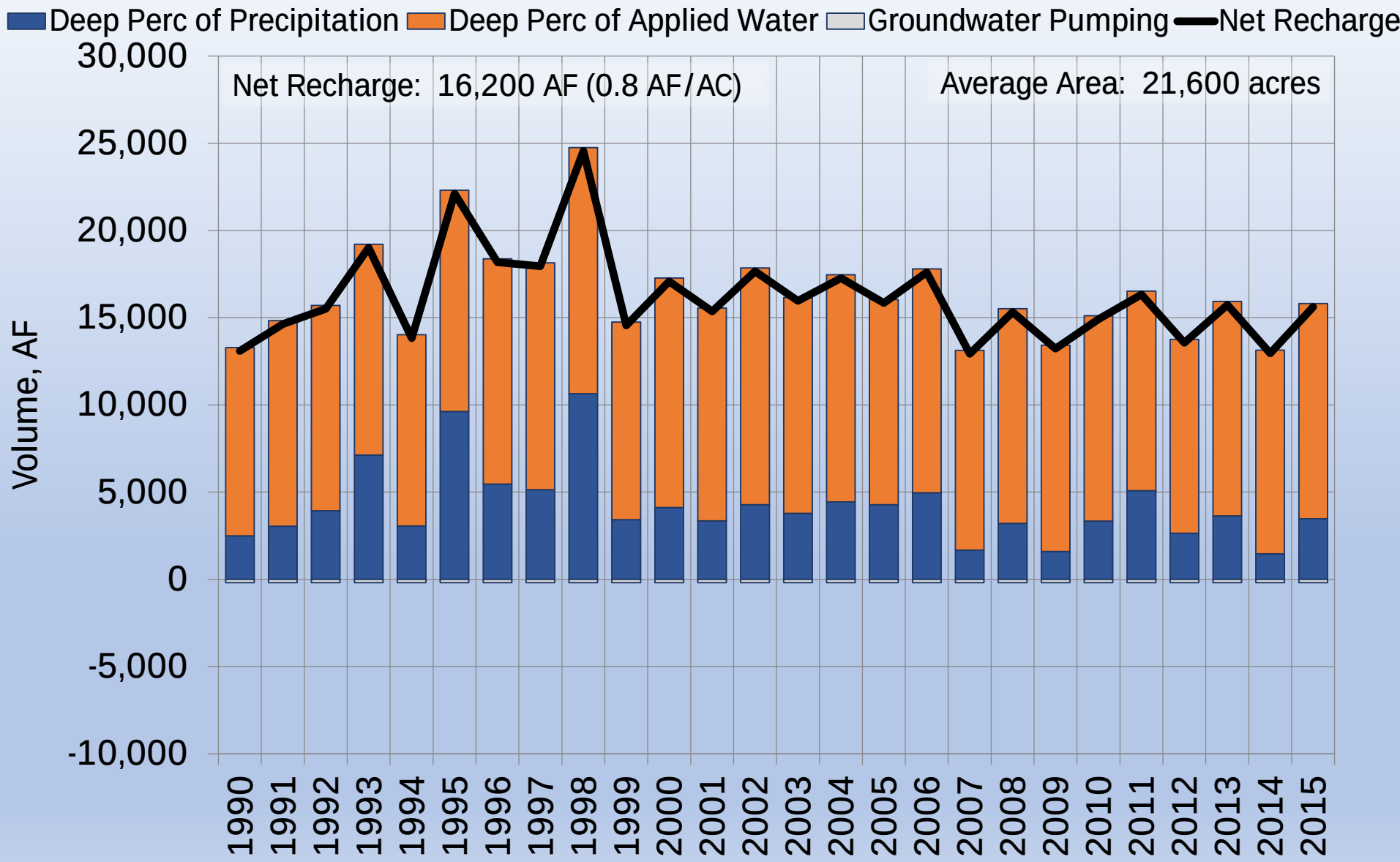
  + deep percolation of precipitation
  + deep percolation of applied irrigation water
  + seepage from streams
  - groundwater pumping

- Represents the net effect on the groundwater balance due to water use on the overlying land

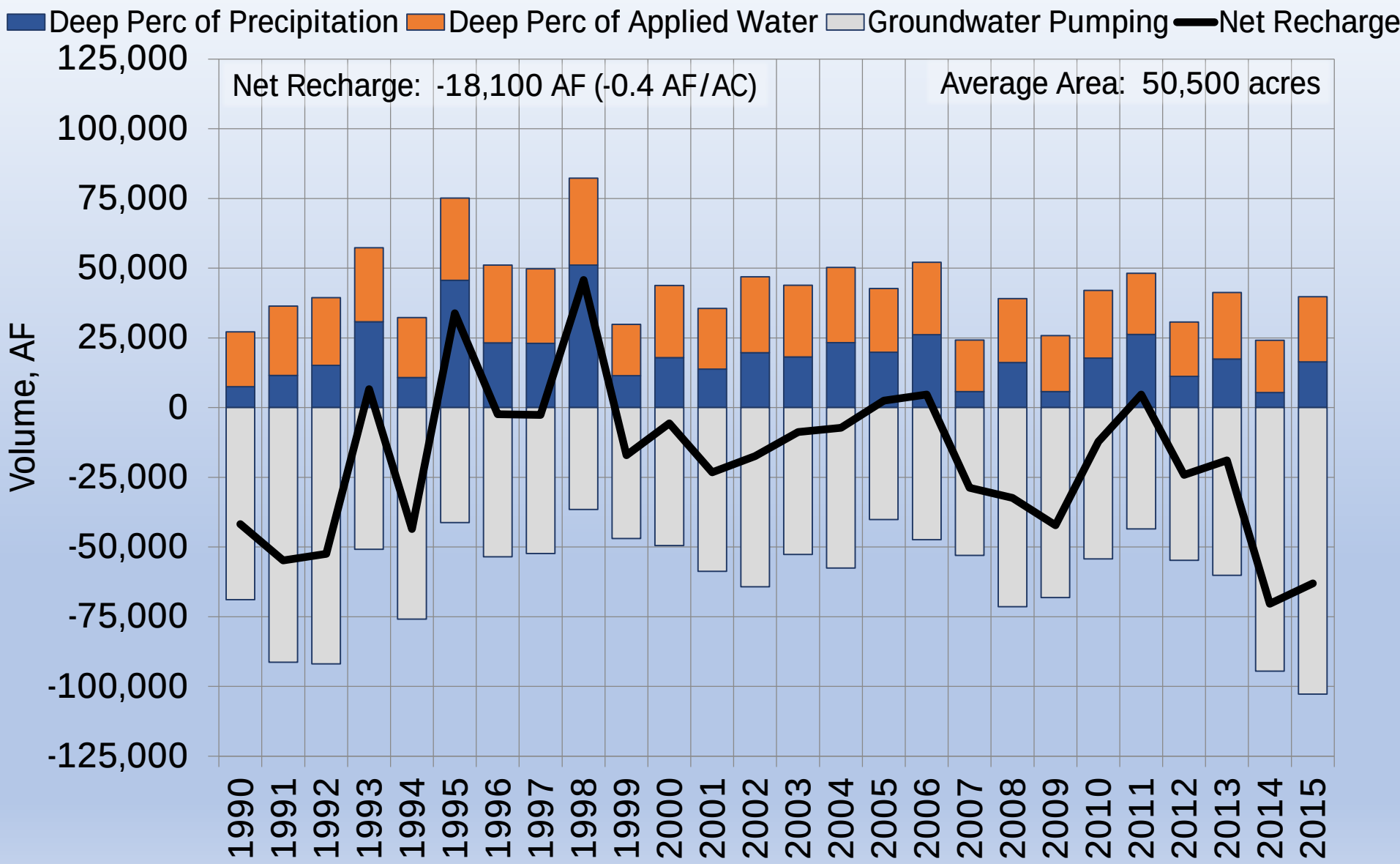
AOI Water Supply Areas



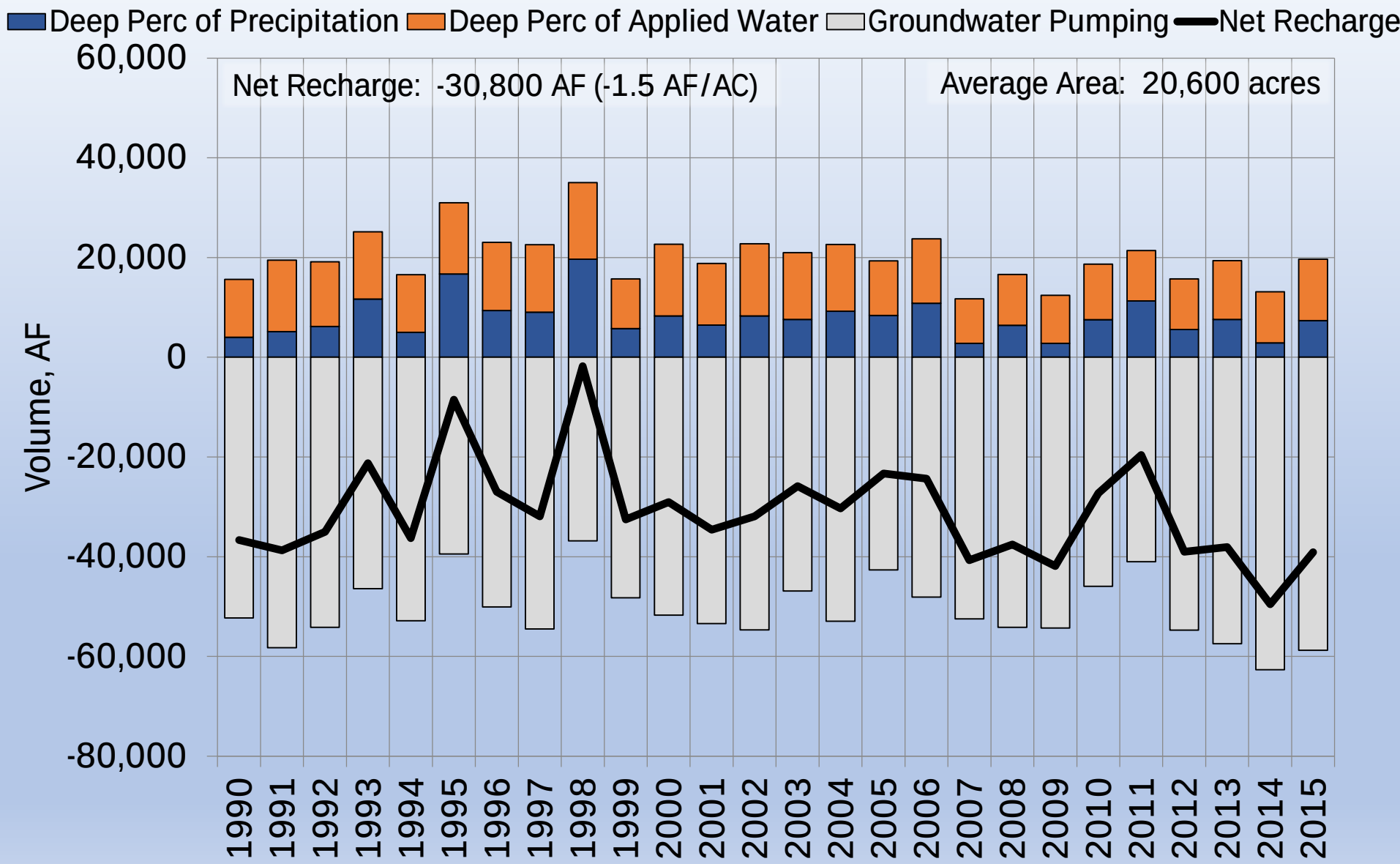
Surface Supply Area Net Recharge (1990 – 2015)



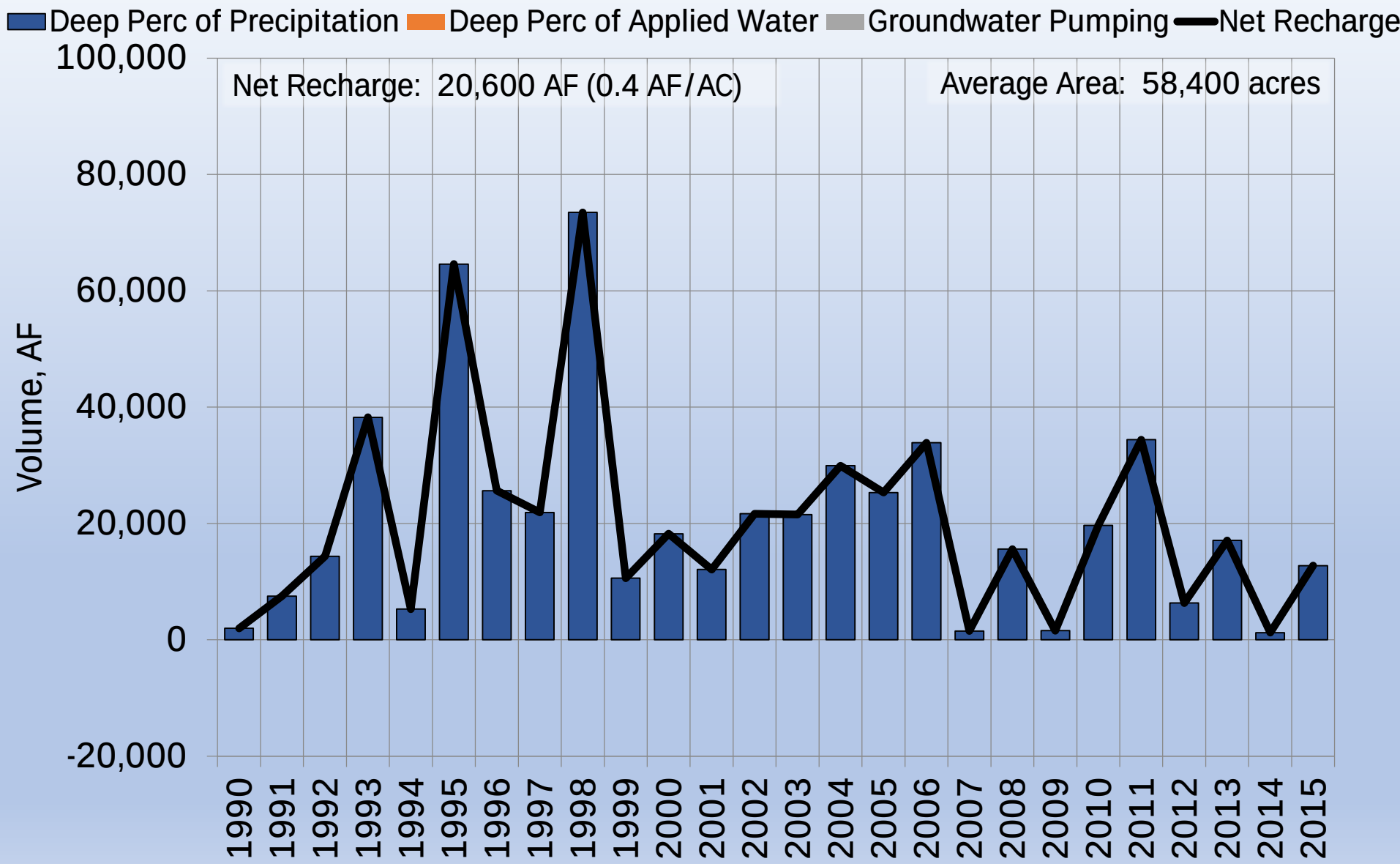
Mixed Supply Area Net Recharge (1990 – 2015)



Groundwater Supply Area Net Recharge (1990 – 2015)



Native Lands Area Net Recharge (1990 – 2015)



Comparison of Net Recharge for "Normal" and "Dry" Periods

- "Dry" Period
  - 2007 through 2015 (9 years)
  - Average annual precipitation (AOI Valley Floor) = 16.5"
  - Generally declining groundwater levels
- "Normal" Period
  - 1998 through 2006 (9 years)
  - Average annual precipitation (AOI Valley Floor) = 21.4"
  - Generally stable groundwater levels
- Included net recharge from streams and urban areas for full accounting

Comparison of Average Annual Net Recharge by Accounting Center for Normal and Dry Periods

Accounting Center	Average Net Recharge AF/year		Difference AF/year
	1998 - 2006	2007 - 2015	
Ag (Surface Water)	24,700	21,800	-2,900
Ag (Mixed Supply)	1,100	-27,900	-29,000
Ag (Groundwater Only)	-26,000	-37,000	-11,000
Urban	-1,300	-2,400	-1,100
Native	27,400	12,200	-15,200
Surface Streams	12,200	8,600	-3,600
Totals (for all AOI)	38,100	-24,700	-62,800

How Much of Net Recharge Difference is Due to Land Use Crop Changes versus Other Factors?

- Simulated the AOI water balance for the Dry Period (2007 through 2015) with average Normal Period cropping (1998 through 2006)
  - All other factors held constant
    - Weather/precipitation
    - Surface water supply availability
  - Difference between Dry and Normal periods represents change due to “Other Factors”
- By difference, we know the change in Net Recharge due to Land Use changes

Change in Net Recharge Due to Land Use Changes between 1998-2006 and 2007-2015

Accounting Center	Average Net Recharge AF/year		Difference AF/year	% Difference Due to Land Use Changes
	1998 - 2006	2007 - 2015		
Ag (Surface Water)	24,700	21,800	-2,900	62%
Ag (Mixed Supply)	1,100	-27,900	-29,000	12%
Ag (Groundwater Only)	-26,000	-37,000	-11,000	44%
Urban	-1,300	-2,400	-1,100	11%
Native	27,400	12,200	-15,200	0%
Surface Streams	12,200	8,600	-3,600	0%
Totals	38,100	-24,700	-62,800	16%

Summary Conclusions

- Net Recharge in the AOI over the most recent nine-year period (2007 through 2015) has been about 63,000 AF per year less than the preceding nine-year period (1998 through 2006)
  - Cumulative Net Recharge reduction of approximately 570,000 acre-feet
- About one-sixth of the reduction in Net Recharge is associated with land use (primarily crop) changes, and five-sixths due to “other factors”, primarily significantly below average precipitation and reduced surface water supplies
- “Drought” (beginning in 2007) has had the dominant effect on declining groundwater levels

Prognosis:

- Current groundwater conditions reflect the accumulation of nine years of dry conditions (as well as land use changes)
- If “Normal” conditions ensue, it likely will take multiple years for groundwater levels to recover
- The rate of recovery could be hastened by increasing use of supplemental surface water in the mixed supply and groundwater supply areas
- The rate of recovery will be slowed to the extent that recent trends toward relatively high water use crops continue

Questions?