CGA-GGA Joint Technical Advisory Committee (TAC) DRAFT Annual Report Update

Davids Engineering and LSCE

03/10/2023

COLUSA SUBBASIN

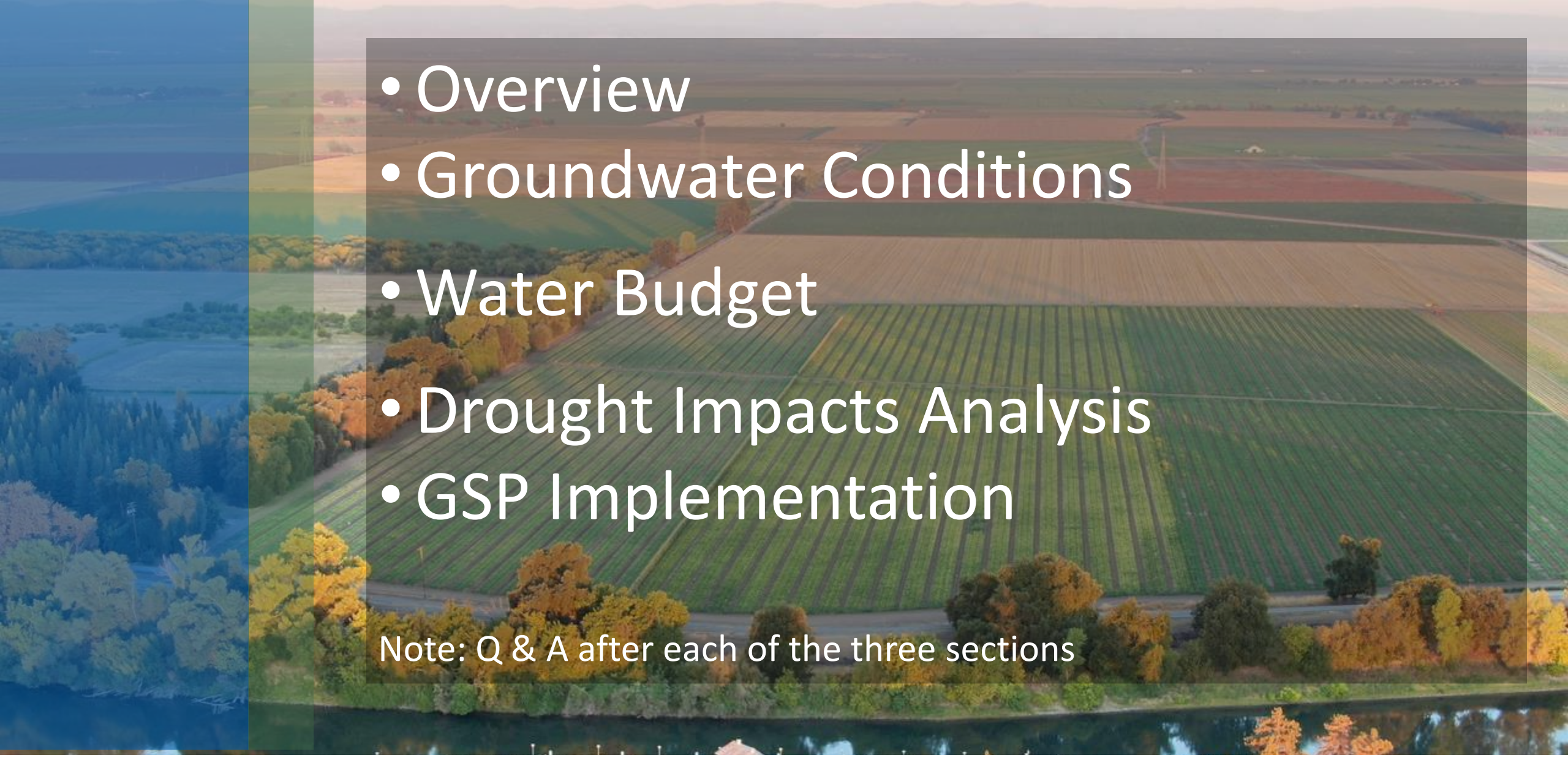
Luhdorff & Scalmanini Consulting Engineers

DAVIDS ENGINEERING, INC

Serving Stewards of Western Water Since 1993

Introductions

- Katie Klug, PhD (Davids Engineering or DE)
- Eddy Teasdale, PG, CHG (Luhdorff & Scalmanini or LSCE)
- Jeff Davids, PhD, PE (DE)



- Overview
- Groundwater Conditions
- Water Budget
- Drought Impacts Analysis
- GSP Implementation

Note: Q & A after each of the three sections

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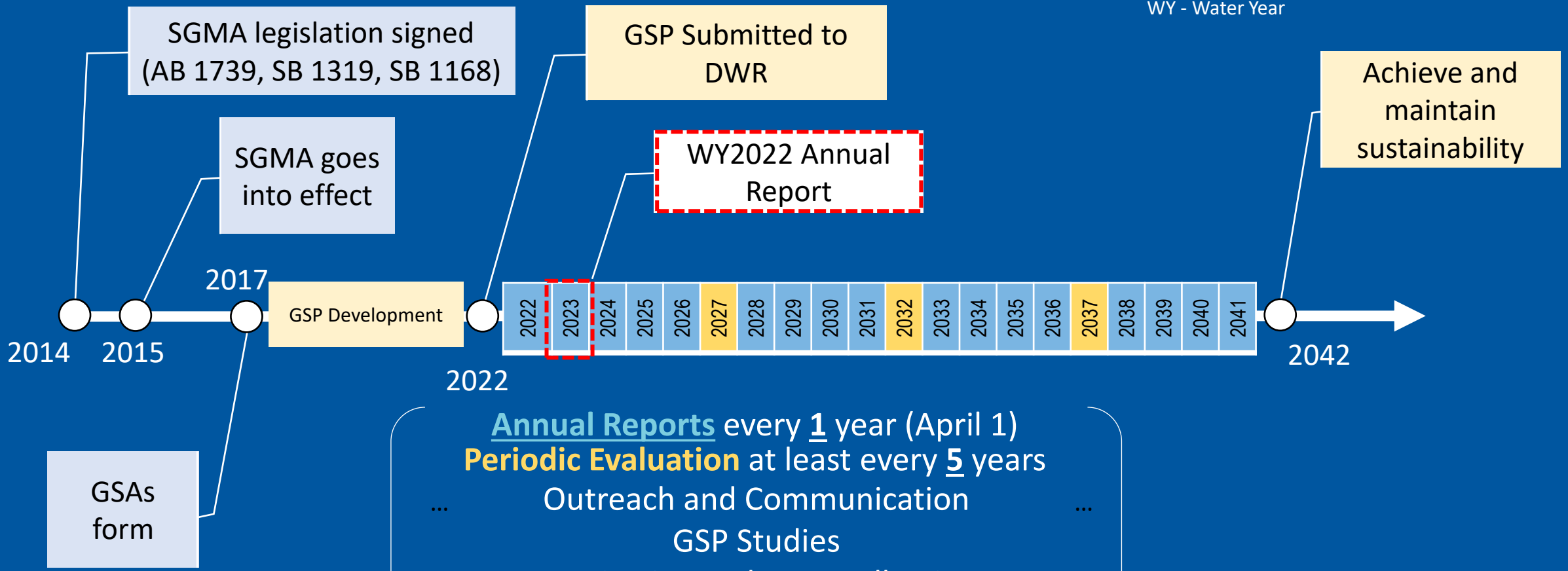
SGMA Implementation Timeline

Abbreviations:
AB - Assembly Bill
DWR - Department of Water Resources
GSA - Groundwater Sustainability Agency
GSP - Groundwater Sustainability Plan
SB - Senate Bill
SGMA - Sustainable Groundwater Management Act
WY - Water Year

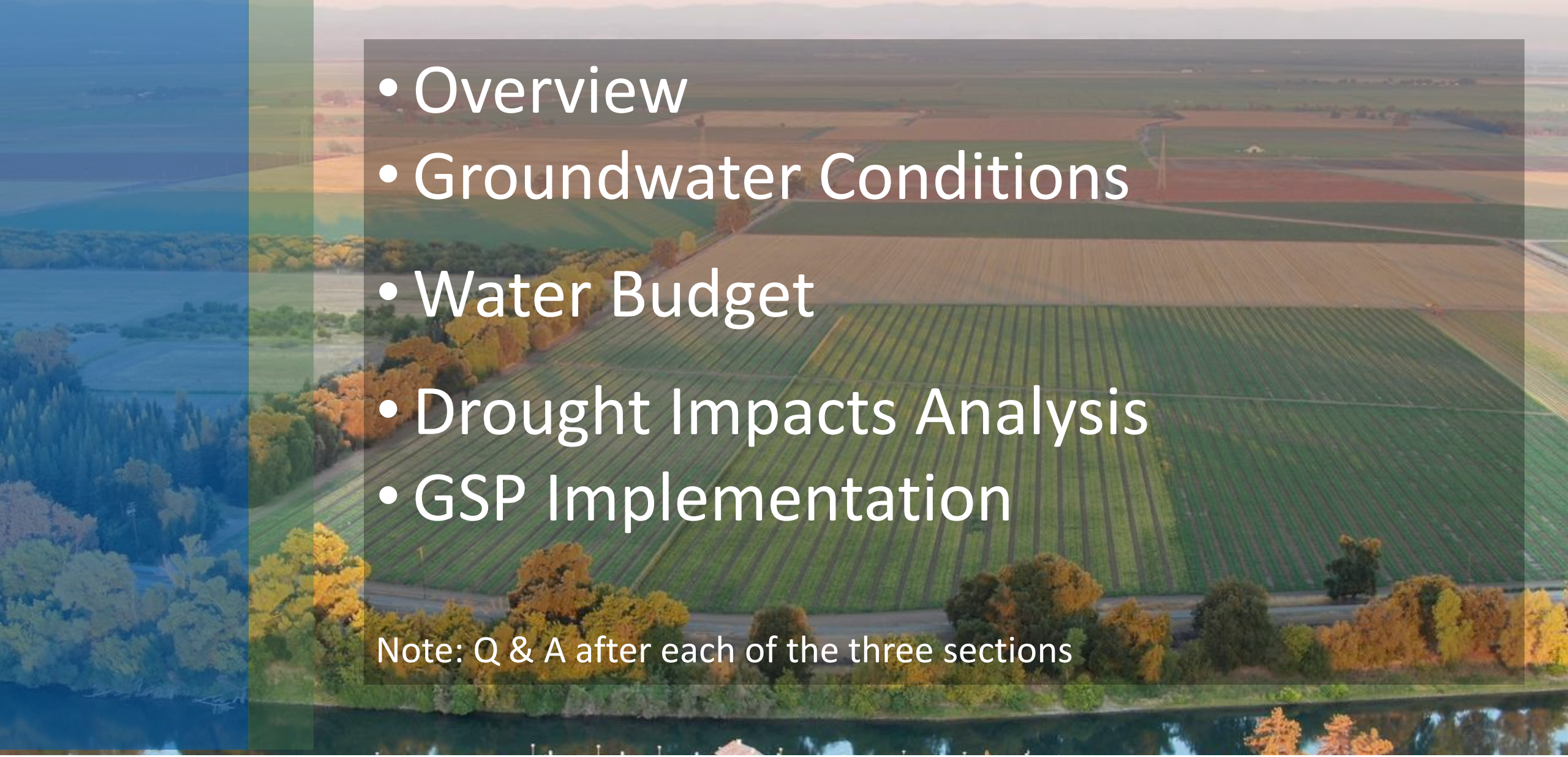


Overview

- The **GSP is a dynamic planning document** that will guide how groundwater will be managed over the next two decades.
- **As conditions change, so too will the GSP.**
- GSP describes groundwater conditions and how groundwater management will avoid adverse impacts to all beneficial users of groundwater.
- Sustainable management criteria created for five sustainability indicators

Annual Report Requirements (23 CCR §356.2)

- Updates on Groundwater Conditions
  - Groundwater Elevation (Hydrographs, Contour Maps)
  - Change in Groundwater Storage
- Water Supply and Water Use
  - Groundwater Extraction
  - Surface Water Supplies
  - Total Water Use
- Progress Toward Plan Implementation (e.g., implementation of planned projects and management actions)



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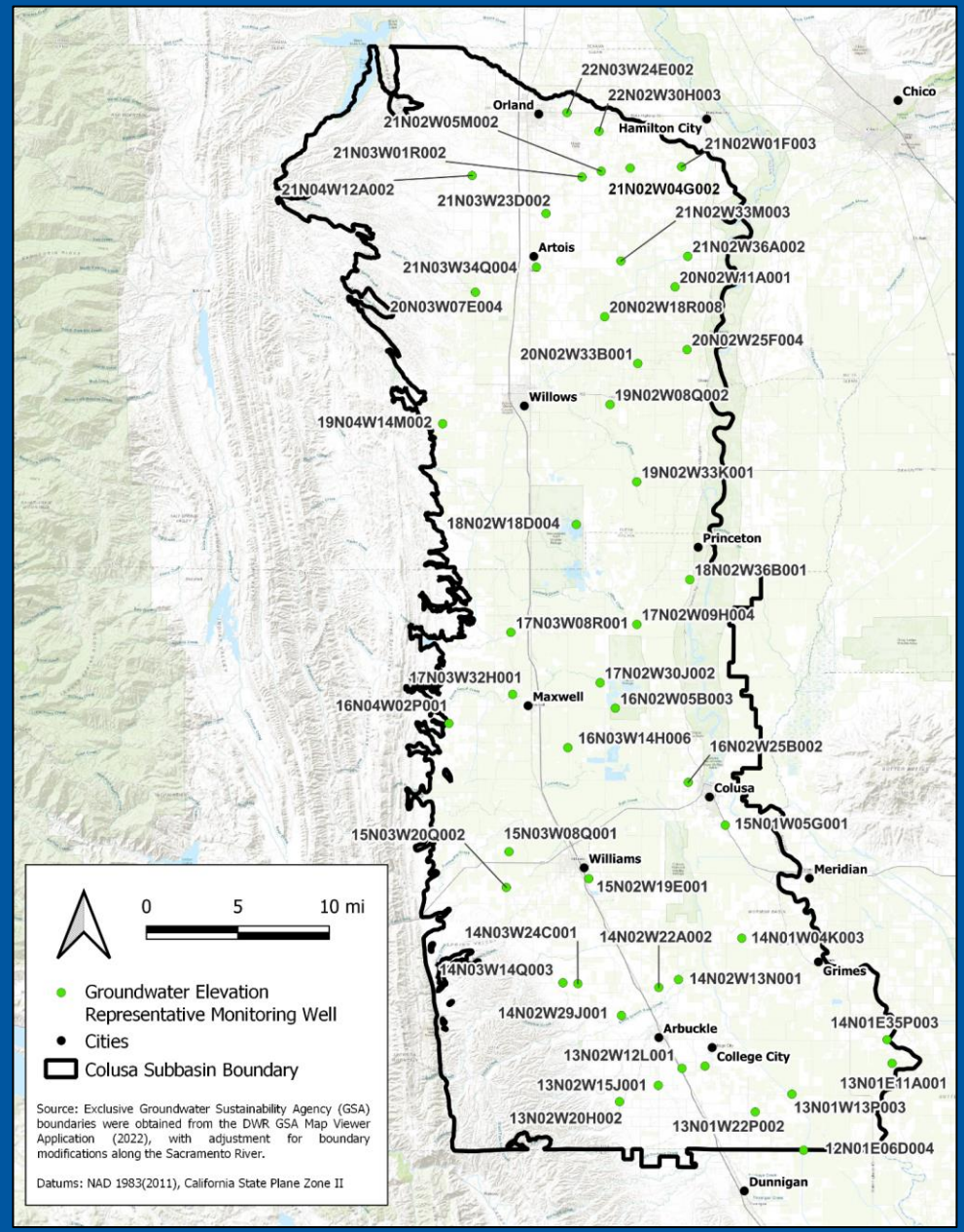
Groundwater Conditions

- Groundwater elevations (48 Representative Monitoring Site Wells (RMS Wells)
  - Contour maps
  - Individual RMS Well hydrographs
- Groundwater storage
- Subsidence



Source: WY2022 Annual Report Section 1.2

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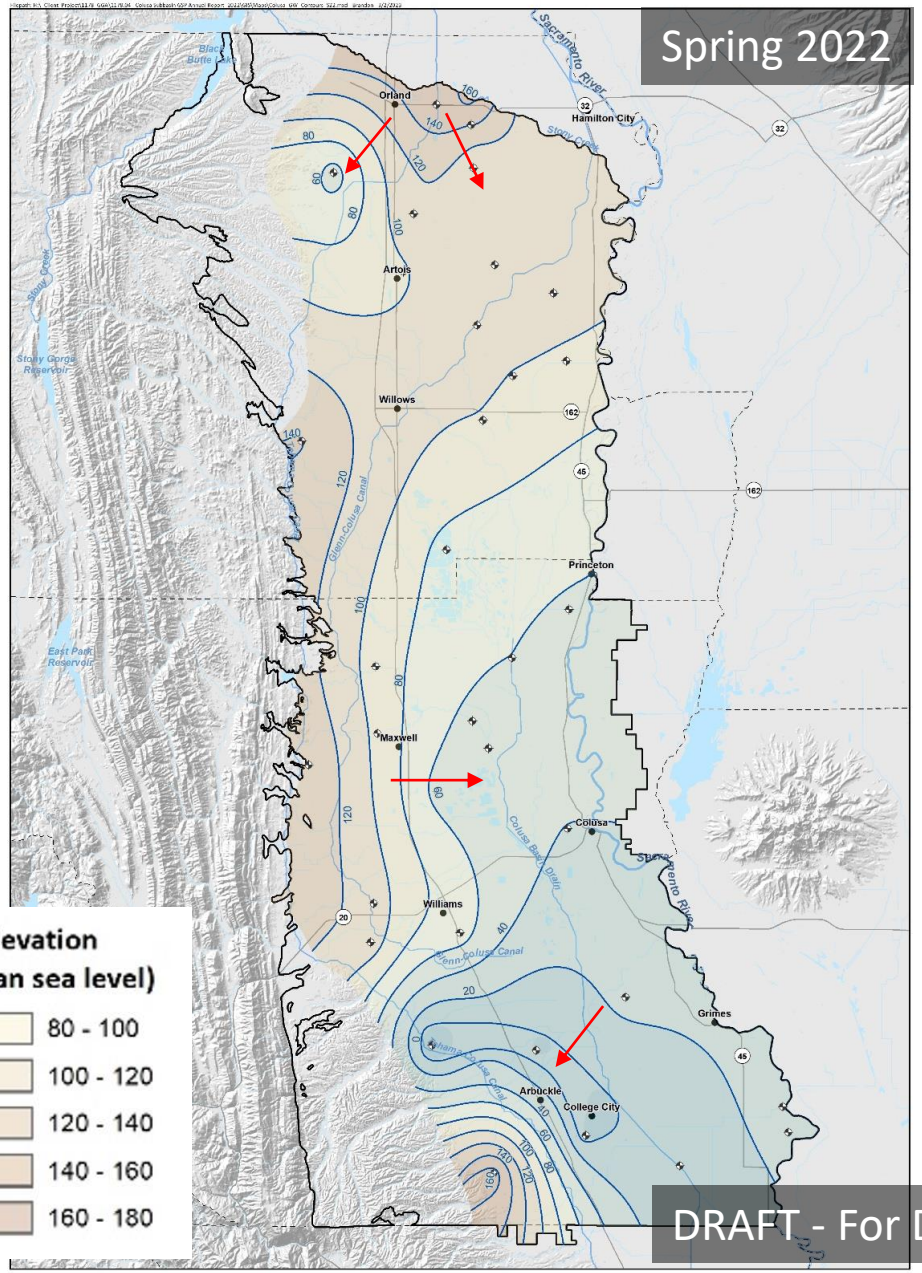
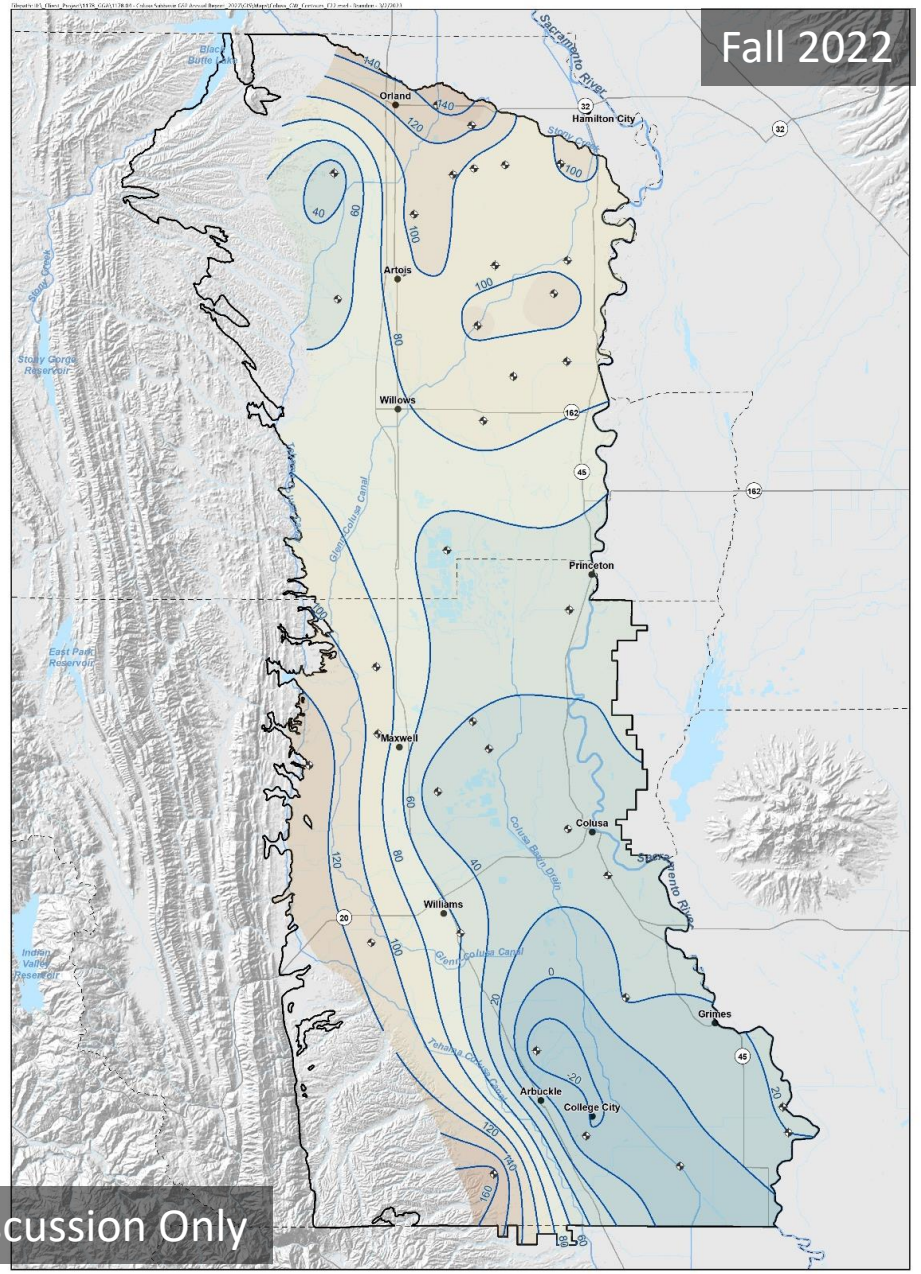
2022 Contours

- DRAFT for Discussion





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Groundwater Elevation Measurement (Well Used for Contouring)

Groundwater Elevation Contour (20-Foot Interval)

Colusa Subbasin Boundary

Groundwater Elevation (feet above mean sea level)

-20 - 0	80 - 100
0 - 20	100 - 120
20 - 40	120 - 140
40 - 60	140 - 160
60 - 80	160 - 180

Source: WY2022 Annual Report Section 1.2

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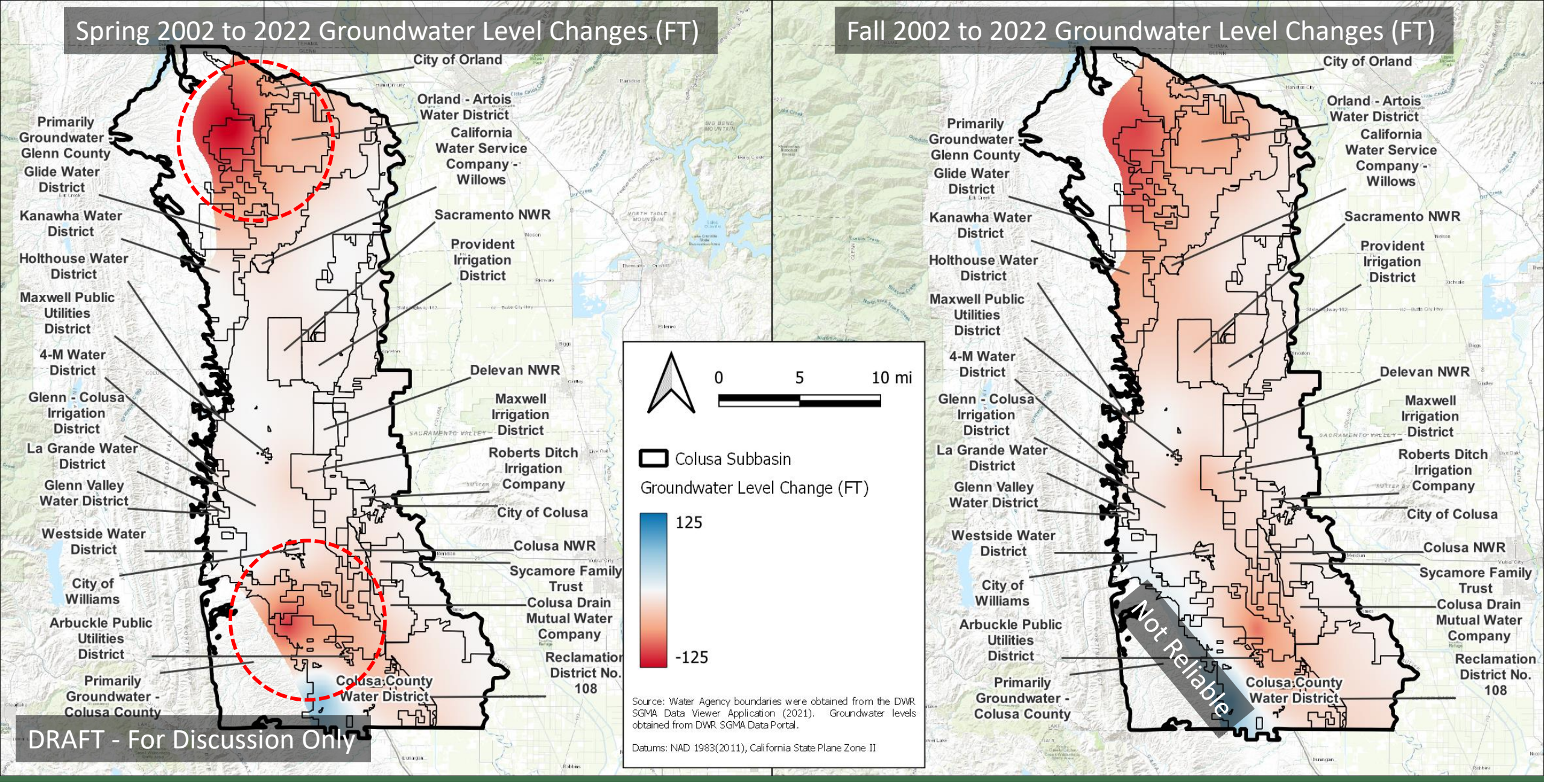
Spring 2002 to 2022 Groundwater Level Changes (FT)
Fall 2002 to 2022 Groundwater Level Changes (FT)
City of Orland
Orland - Artois Water District
California Water Service Company - Willows
Primarily Groundwater Glenn County
Glide Water District
Kanawha Water District
Holthouse Water District
Maxwell Public Utilities District
4-M Water District
Glenn - Colusa Irrigation District
La Grande Water District
Glenn Valley Water District
Westside Water District
City of Williams
Arbuckle Public Utilities District
Primarily Groundwater - Colusa County
Sacramento NWR
Provident Irrigation District
Delevan NWR
Maxwell Irrigation District
Roberts Ditch Irrigation Company
City of Colusa
Colusa NWR
Sycamore Family Trust
Colusa Drain Mutual Water Company
Reclamation District No. 108
Colusa County Water District
0
5
10 mi
Colusa Subbasin
Groundwater Level Change (FT)
125
-125
Source: Water Agency boundaries were obtained from the DWR SGMA Data Viewer Application (2021). Groundwater levels obtained from DWR SGMA Data Portal.
Datums: NAD 1983(2011), California State Plane Zone II
Not Reliable
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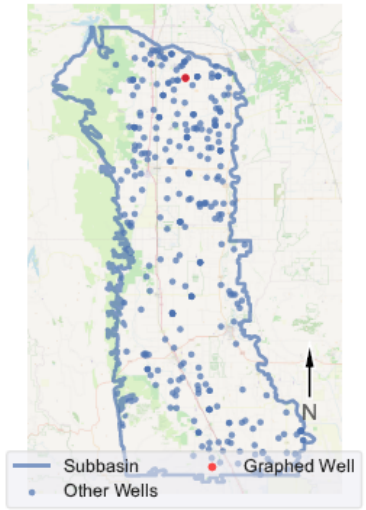
COLUSA Subbasin - State Well Number (SWN): 21N02W05M002M

Well Location Map



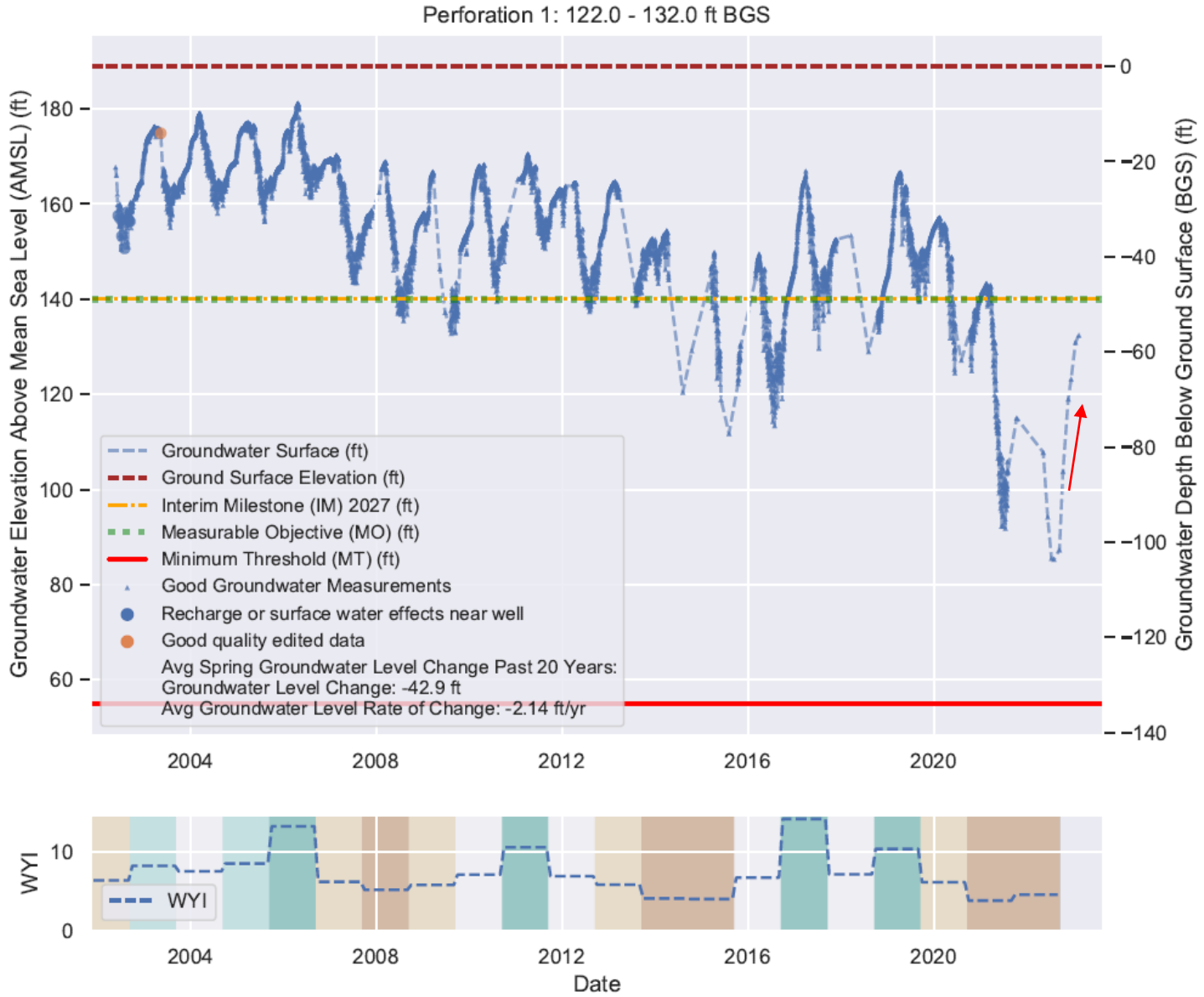
Sustainable Management Criteria:

IM (2027) = 140.0 ft AMSL
MO = 140.0 ft AMSL
MT = 55.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



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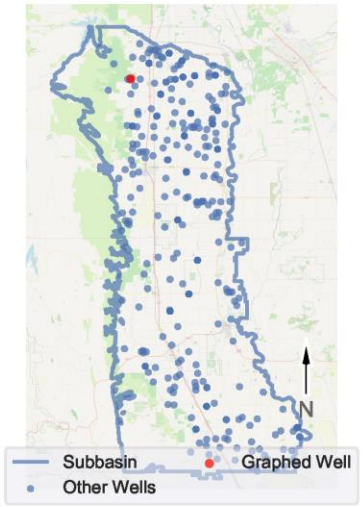
Source: WY2022 Annual Report Appendix B

COLUSA Subbasin - State Well Number (SWN): 21N04W12A002M

Well Location Map



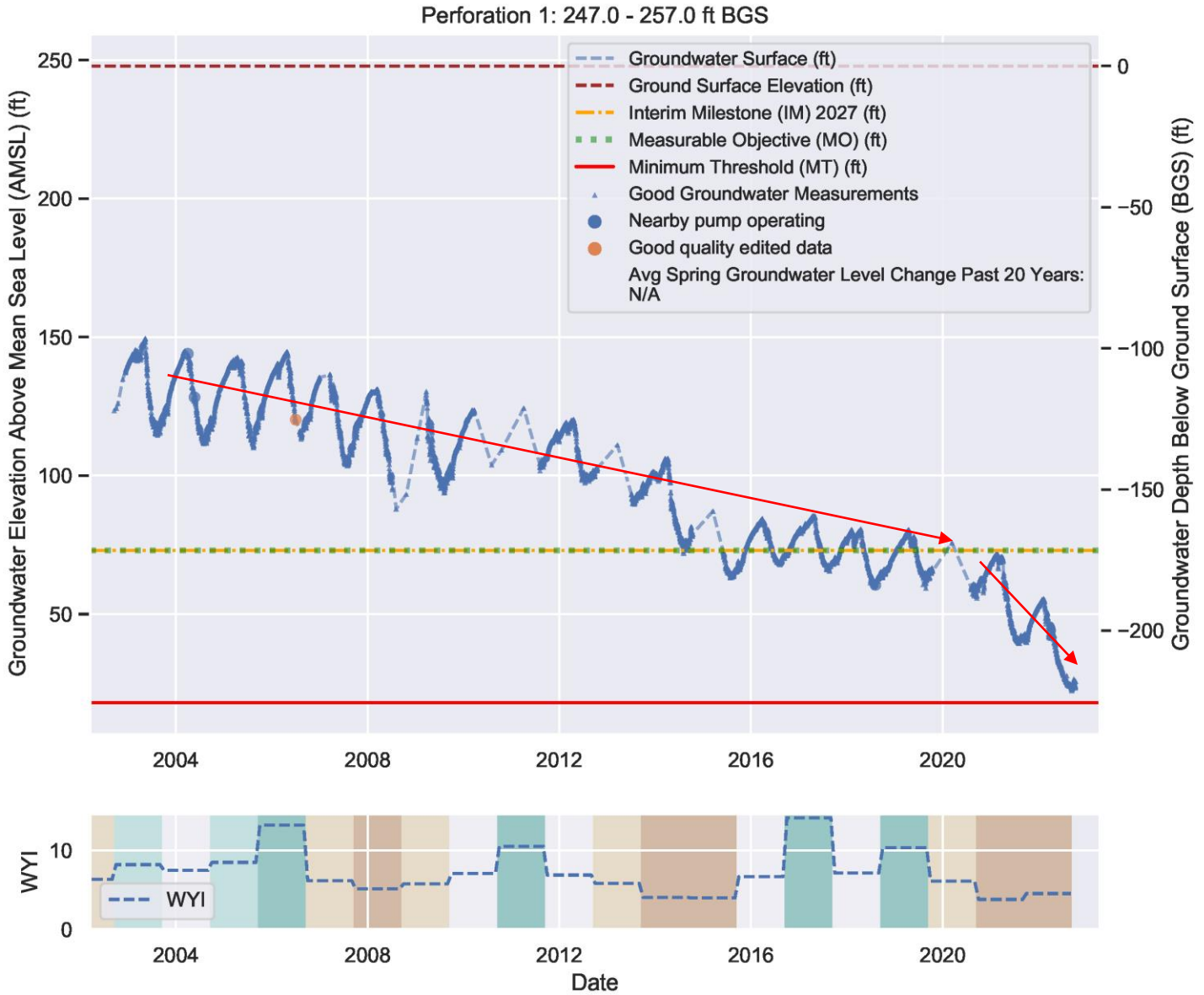
Sustainable Management Criteria:

IM (2027) = 73.0 ft AMSL
MO = 73.0 ft AMSL
MT = 18.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



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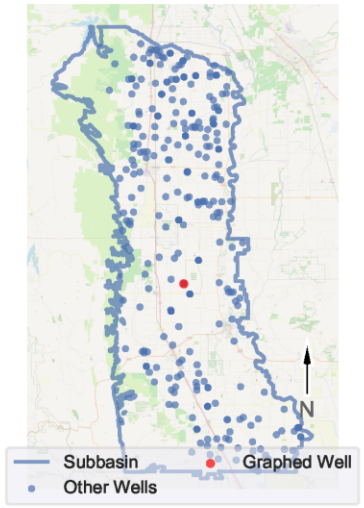
Source: WY2022 Annual Report Appendix B

COLUSA Subbasin - State Well Number (SWN): 17N02W30J002M

Well Location Map



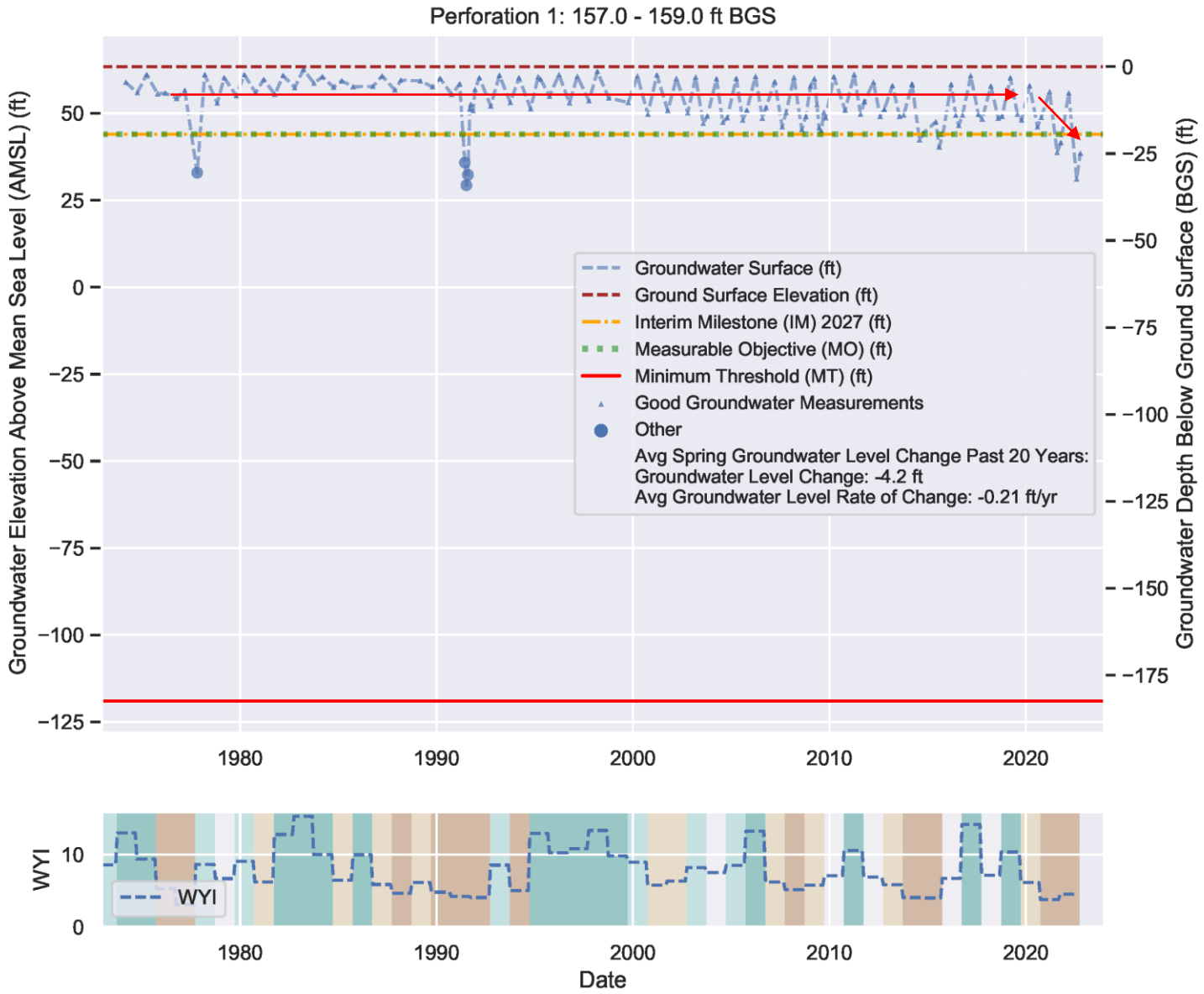
Sustainable Management Criteria:

IM (2027) = 44.0 ft AMSL
MO = 44.0 ft AMSL
MT = -119.0 ft AMSL

Minimum Threshold is the 20th Percentile of Domestic.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)



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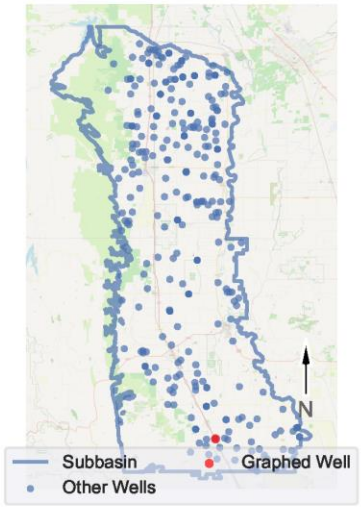
Source: WY2022 Annual Report Appendix B

COLUSA Subbasin - State Well Number (SWN): 13N02W12L001M

Well Location Map



Sustainable Management Criteria:

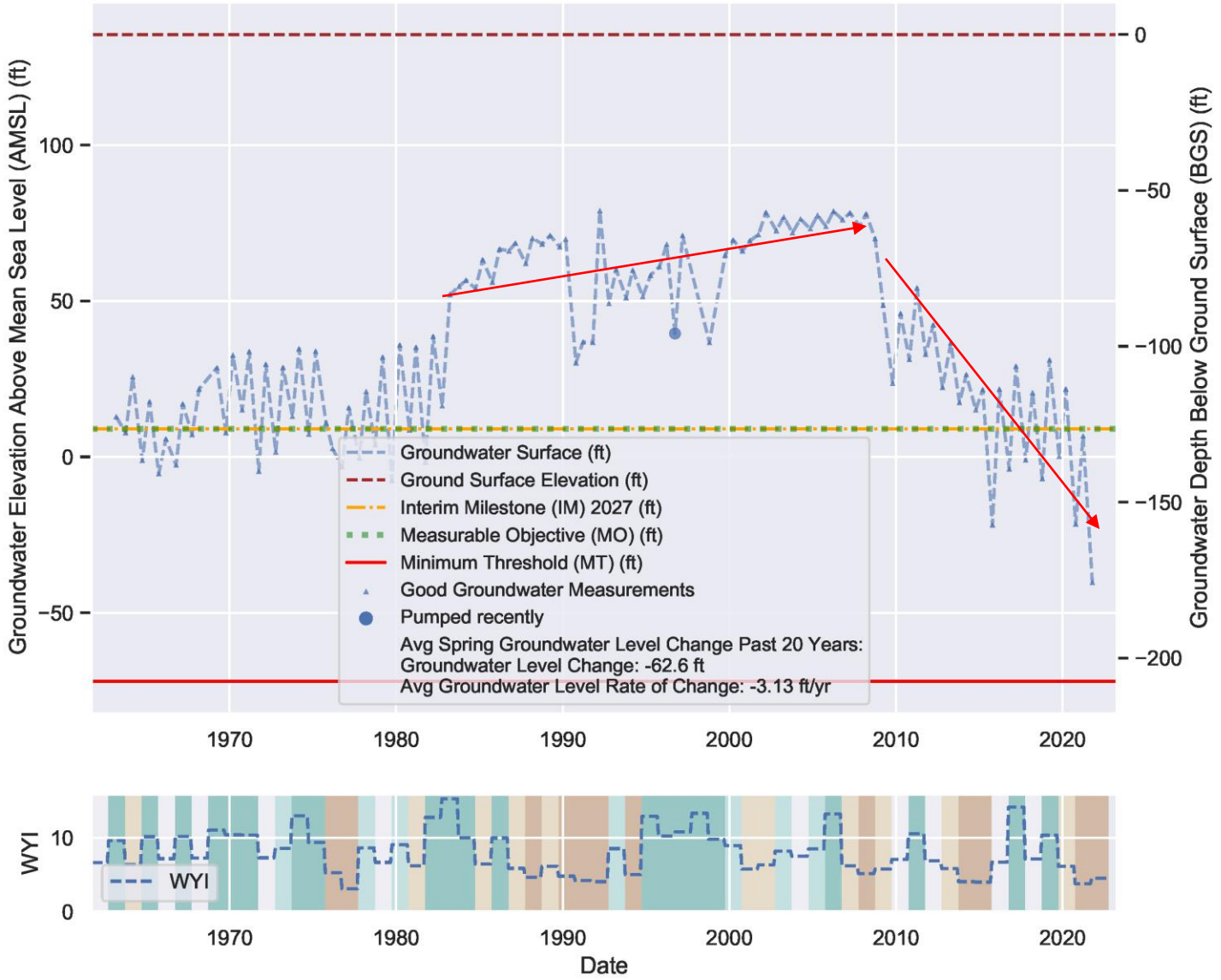
IM (2027) = 9.0 ft AMSL
MO = 9.0 ft AMSL
MT = -72.0 ft AMSL

Minimum Threshold is 50% of Range Below Historical.

Sacramento Valley Water Year Index (WYI) shown on lower right. Meaning of colors defined below.

- Wet (W)
- Above Normal (AN)
- Below Normal (BN)
- Dry (D)
- Critical (C)

Perforation data not available.



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Source: WY2022 Annual Report Appendix B

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Change in Groundwater Storage

- Groundwater Elevation from RMS Wells as a Proxy
- Thiessen Polygon Method
  - Applied a spring-to-spring change in water level within each Groundwater Elevation RMS to a Thiessen polygon surrounding the RMS.
  - Annual change in storage calculated for 1968 to 2022 for each Thiessen polygon and summed for the Subbasin.
  - Cumulative change in storage calculated Subbasin-wide for 1968 through 2022.

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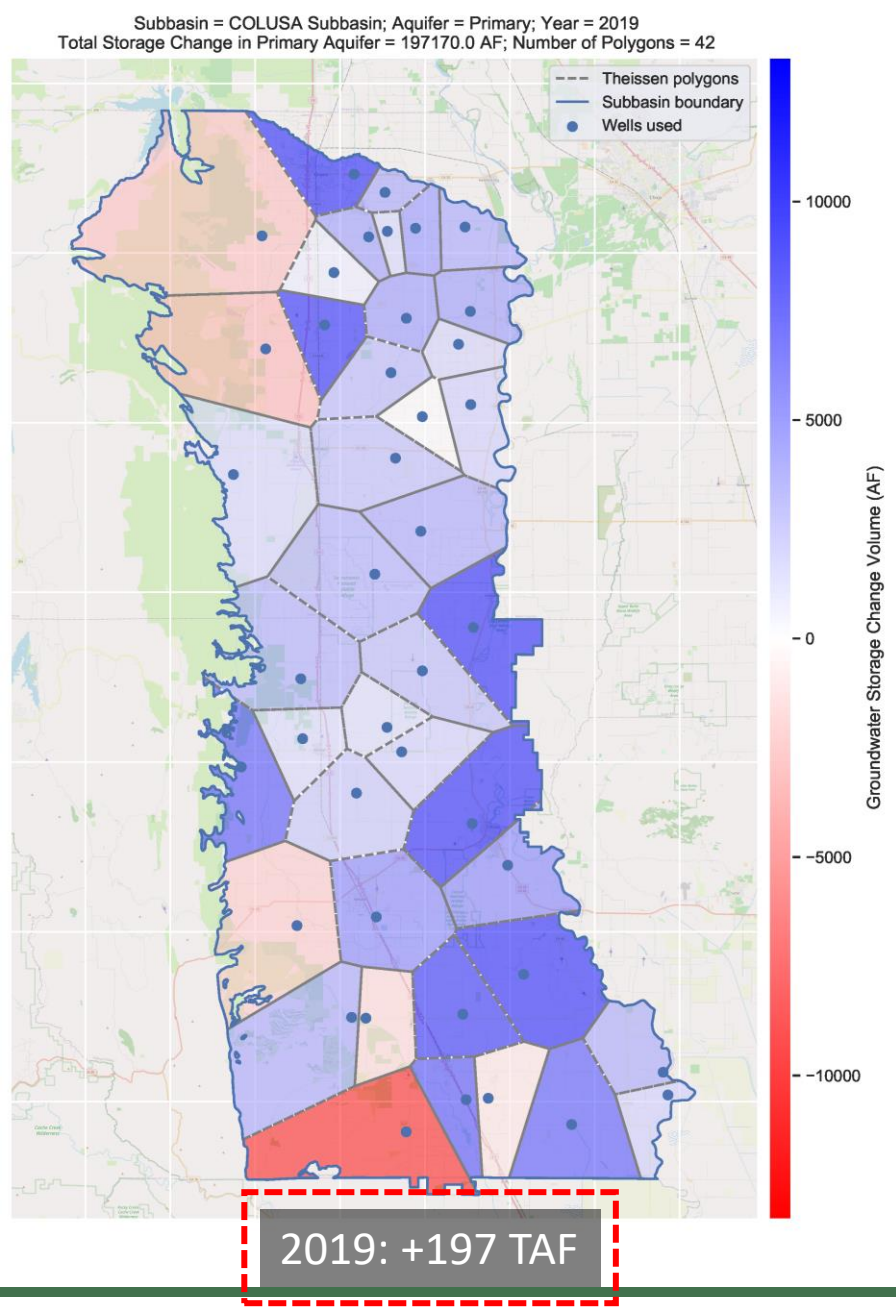
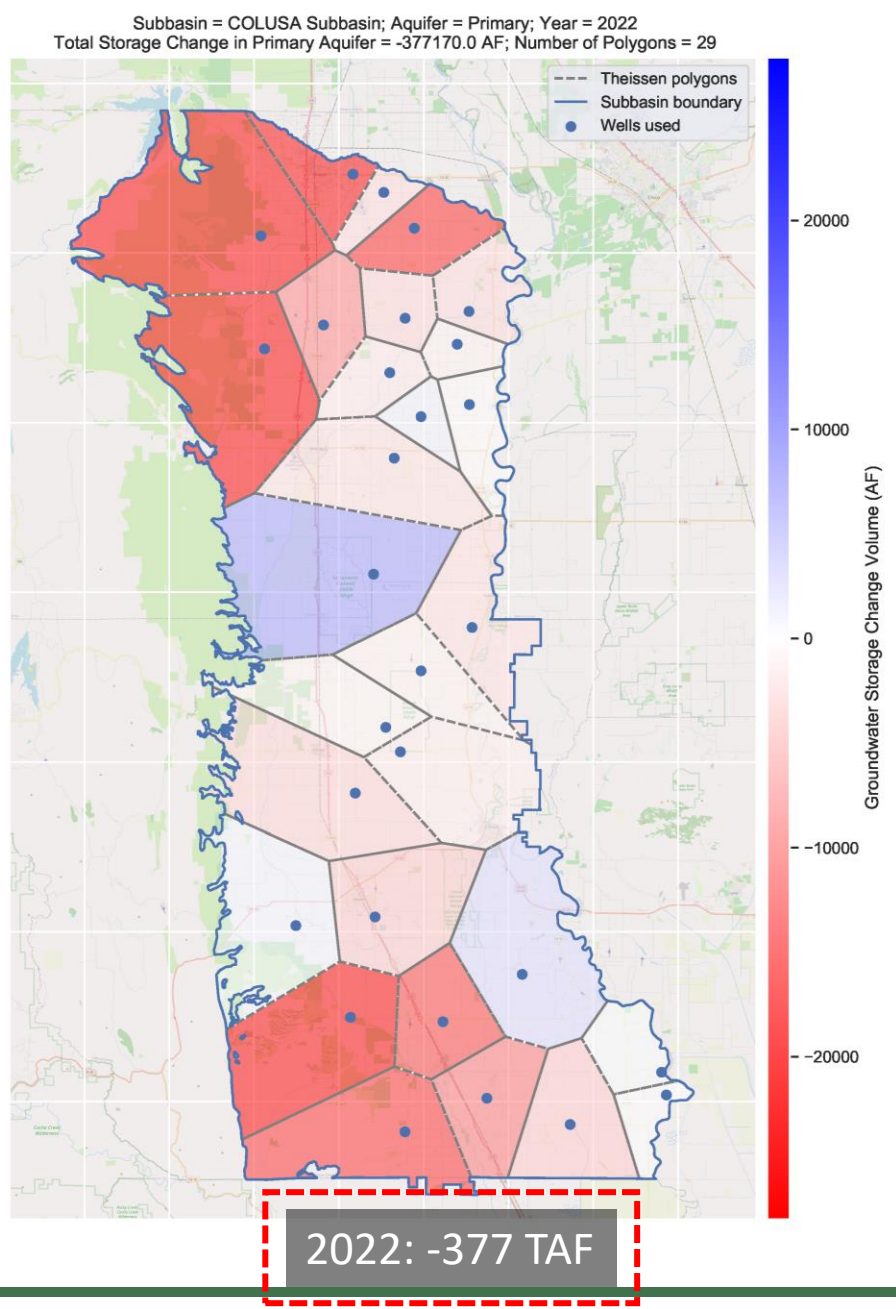


2019: +197 TAF



2022: -377 TAF

Source: WY2022 Annual Report Section 6

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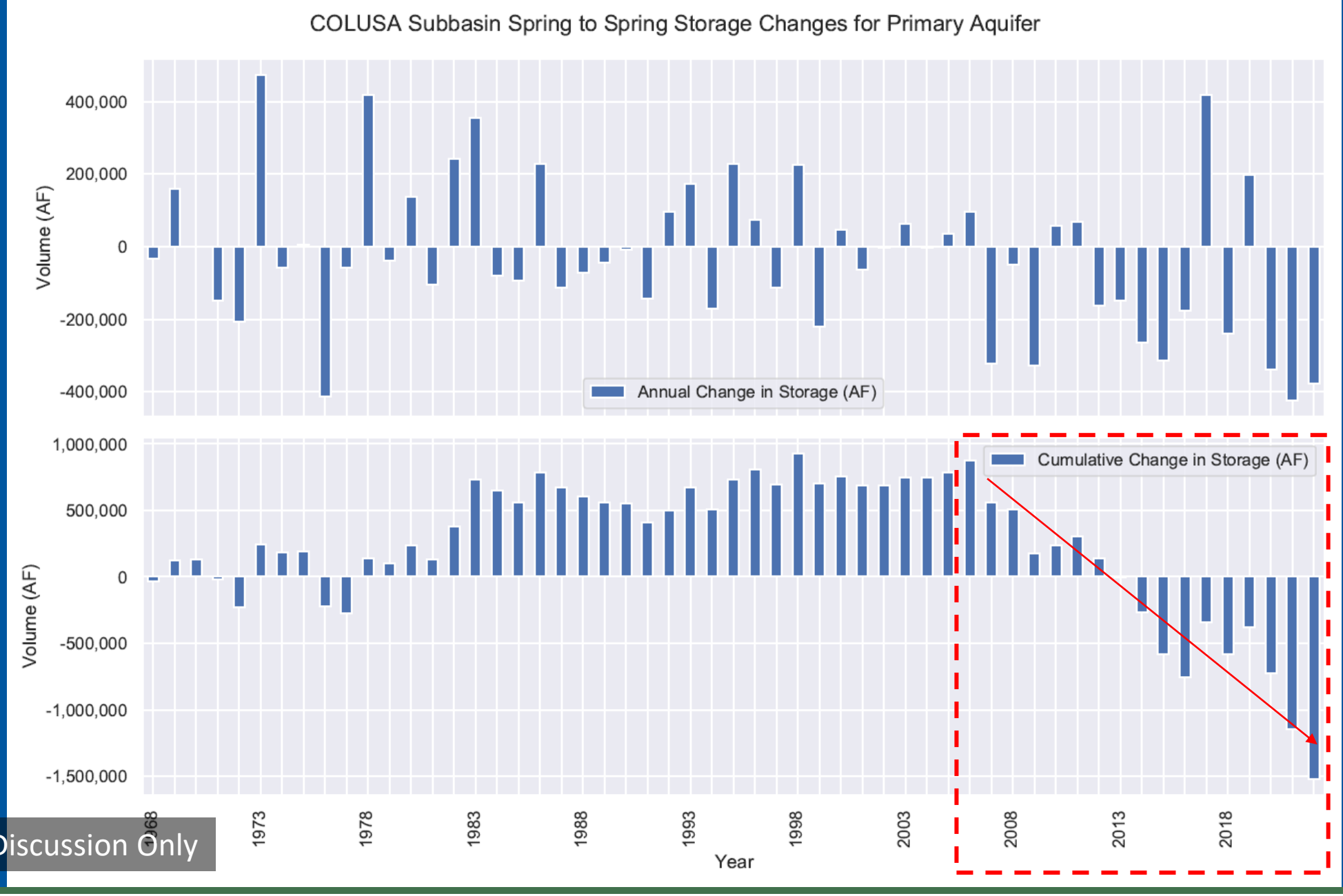

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Source: WY2022 Annual Report Section 6

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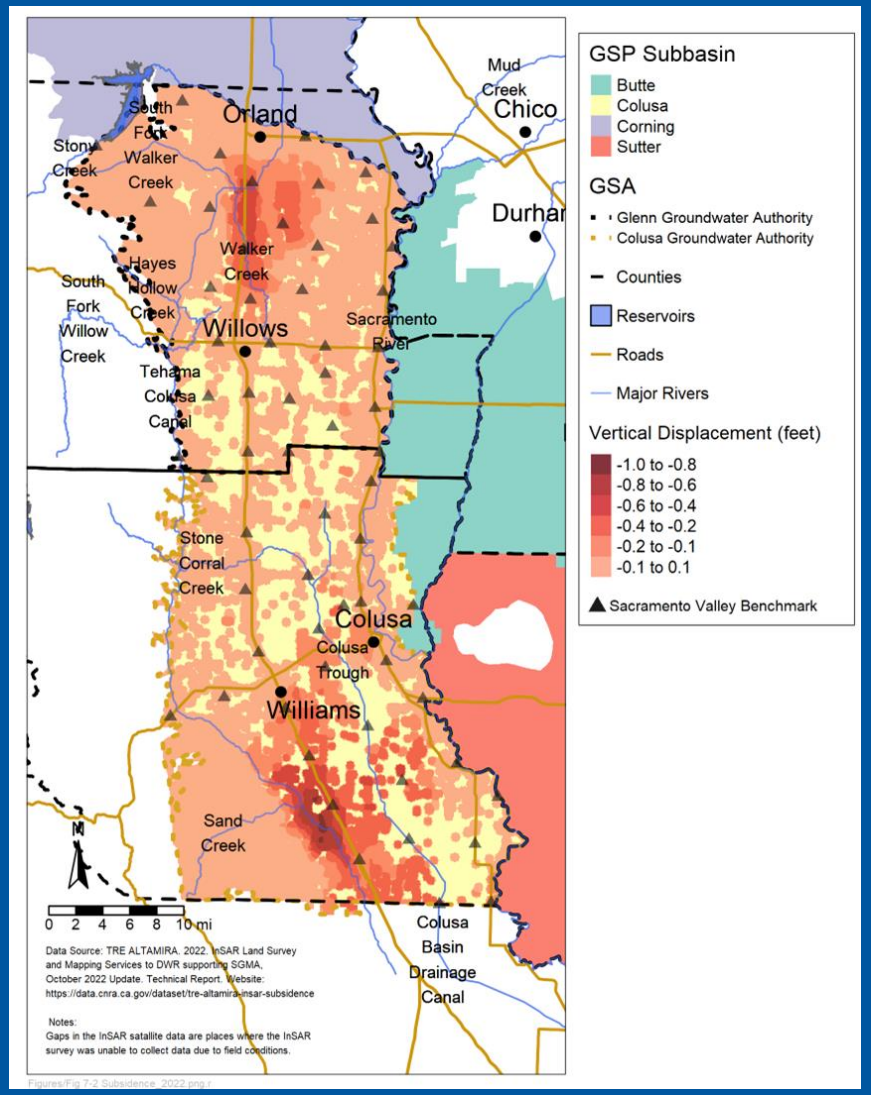
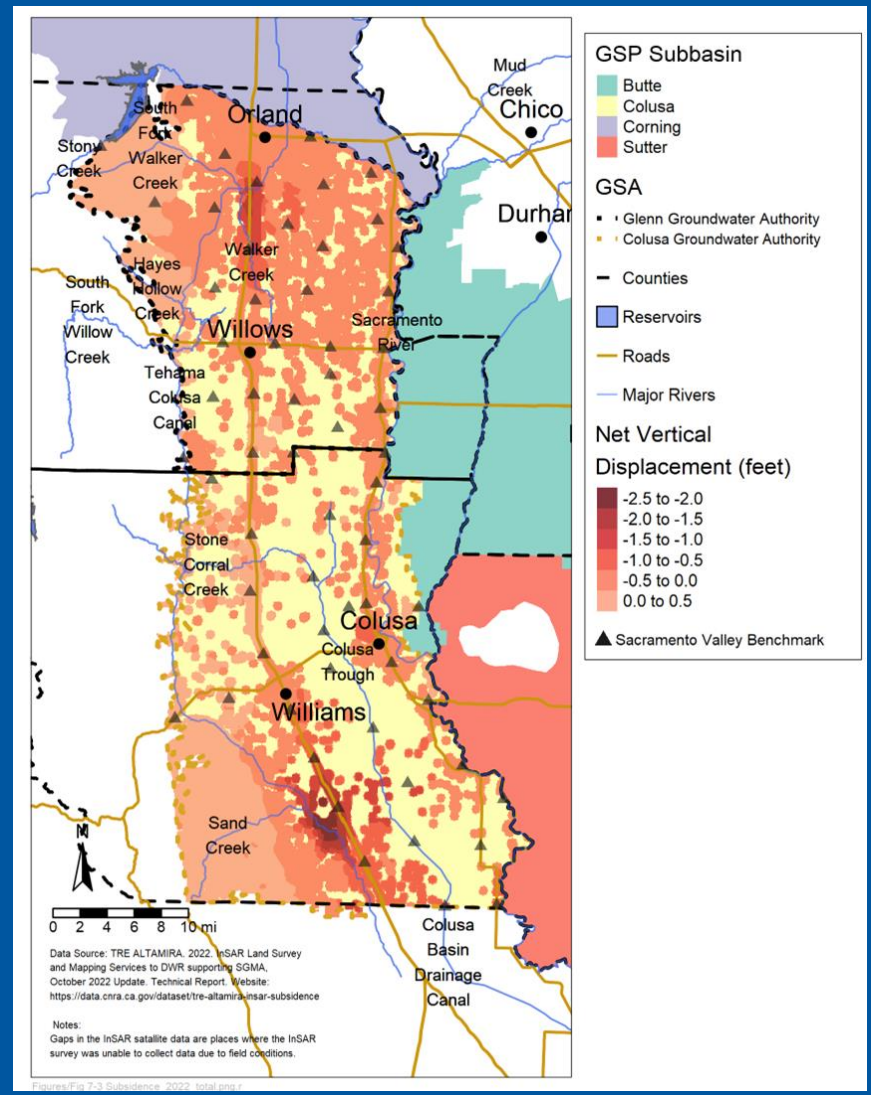
Subsidence

- Colusa GSP reports on Land Subsidence Since May 2017
- MT = 0.1 feet/year
- Undesirable Result = 20% or more (13 of 63) monitoring sites experience subsidence rates above the MT
- 10-15 benchmark sites near subsidence area but have not been surveyed since 2017

Interferometric Synthetic Aperture Radar (InSAR)



Annual Vertical Displacement (2022)



Net Vertical Displacement (2015 - 2022)

Source: WY2022 Annual Report Section 7

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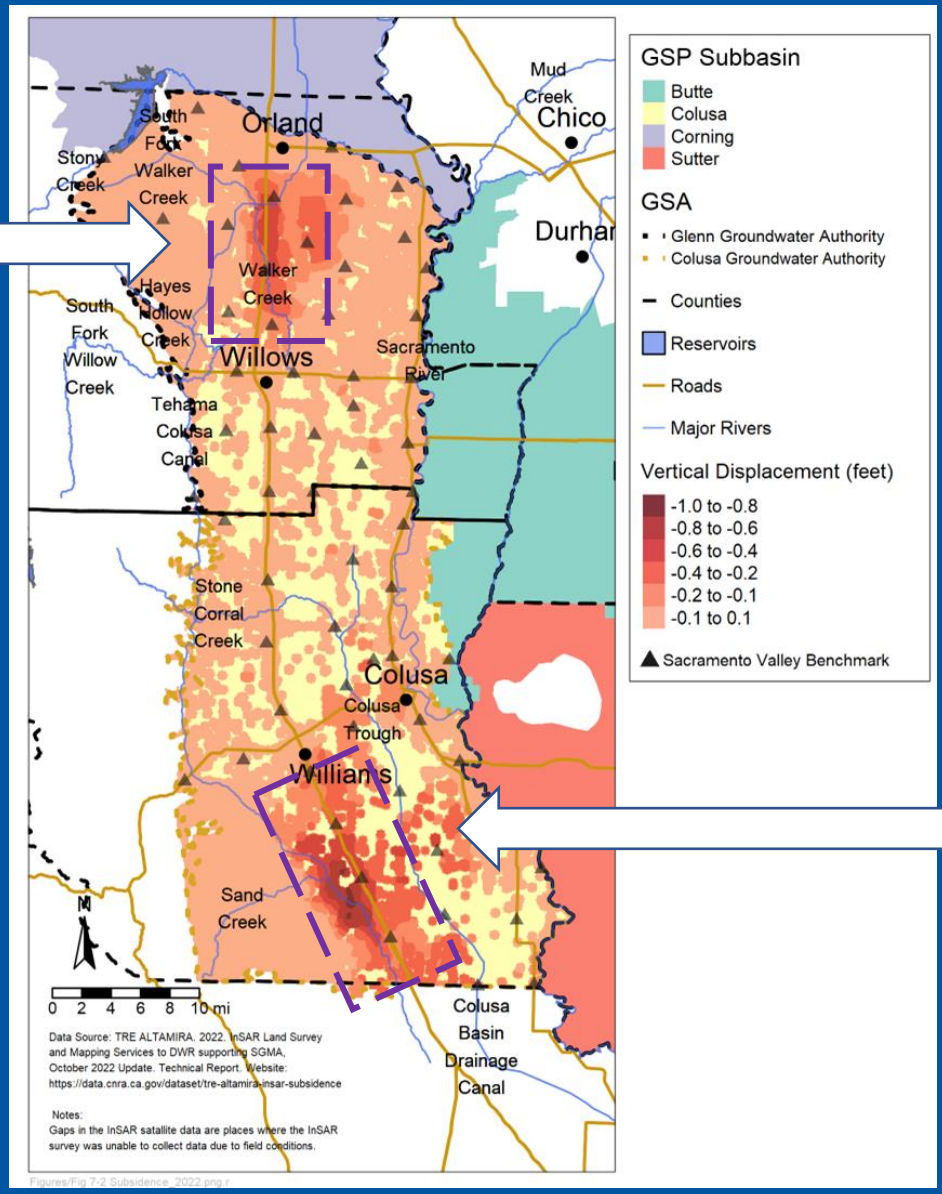
Subsidence

North of Willows/South of Orland

Max. = 0.4 feet (WY2020-WY2021)

Max. = 0.6 feet (WY2021-WY2022)



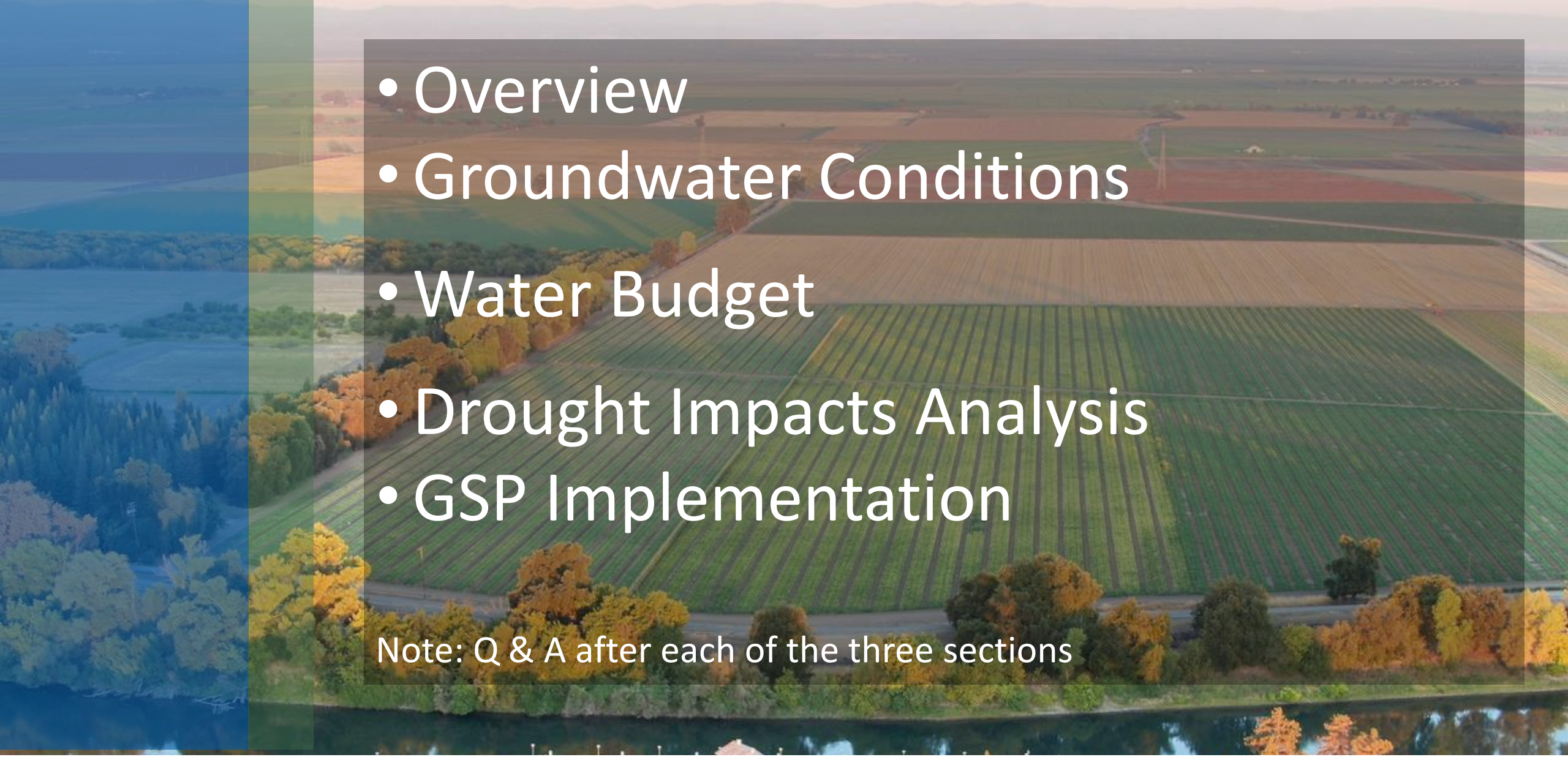
Annual Vertical Displacement (2022)

Arbuckle Area

0.4 feet to 0.8 feet

(WY2020 – WY2021 similar to WY 2021 – WY2022)

Source: WY2022 Annual Report Section 7



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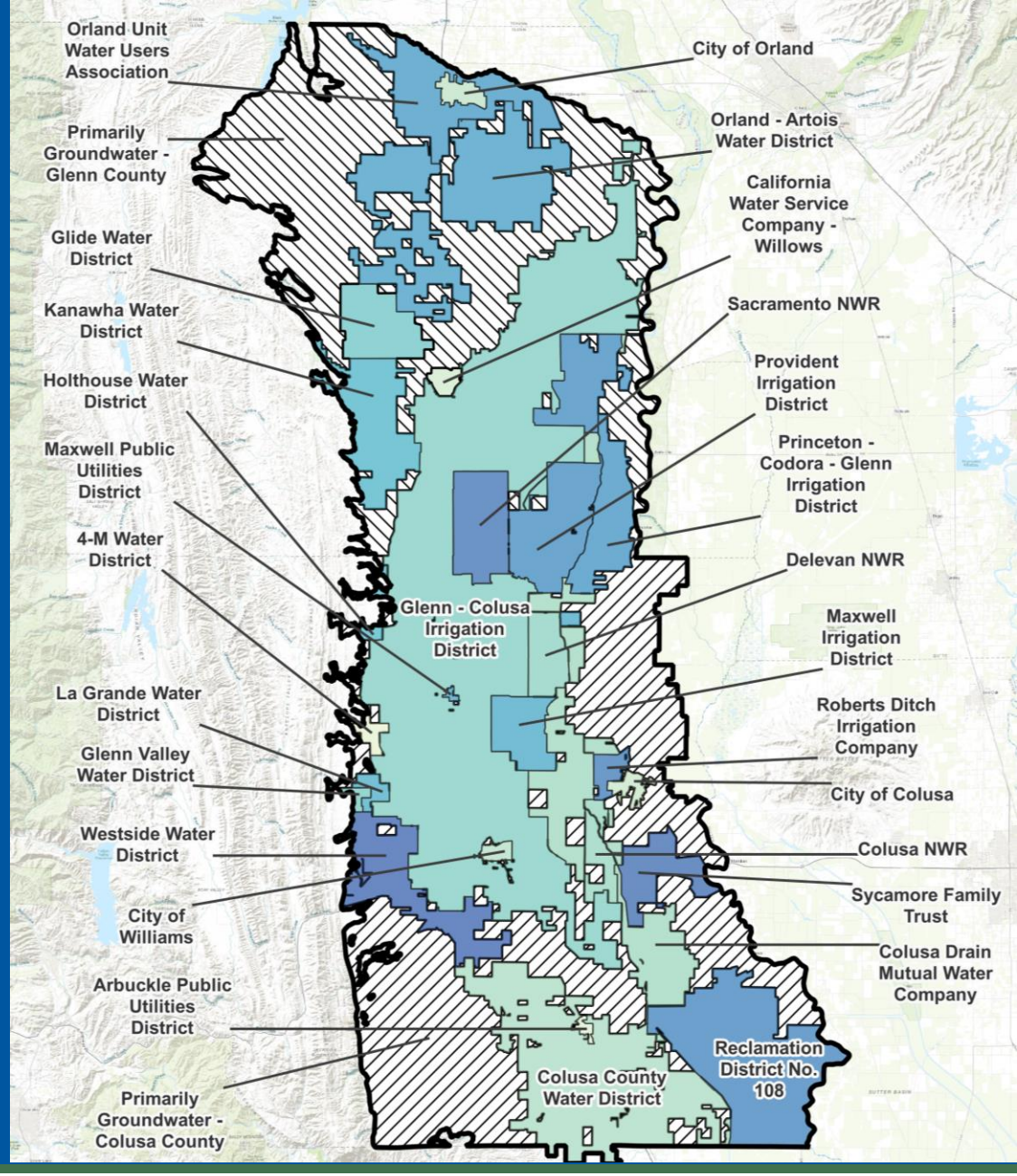
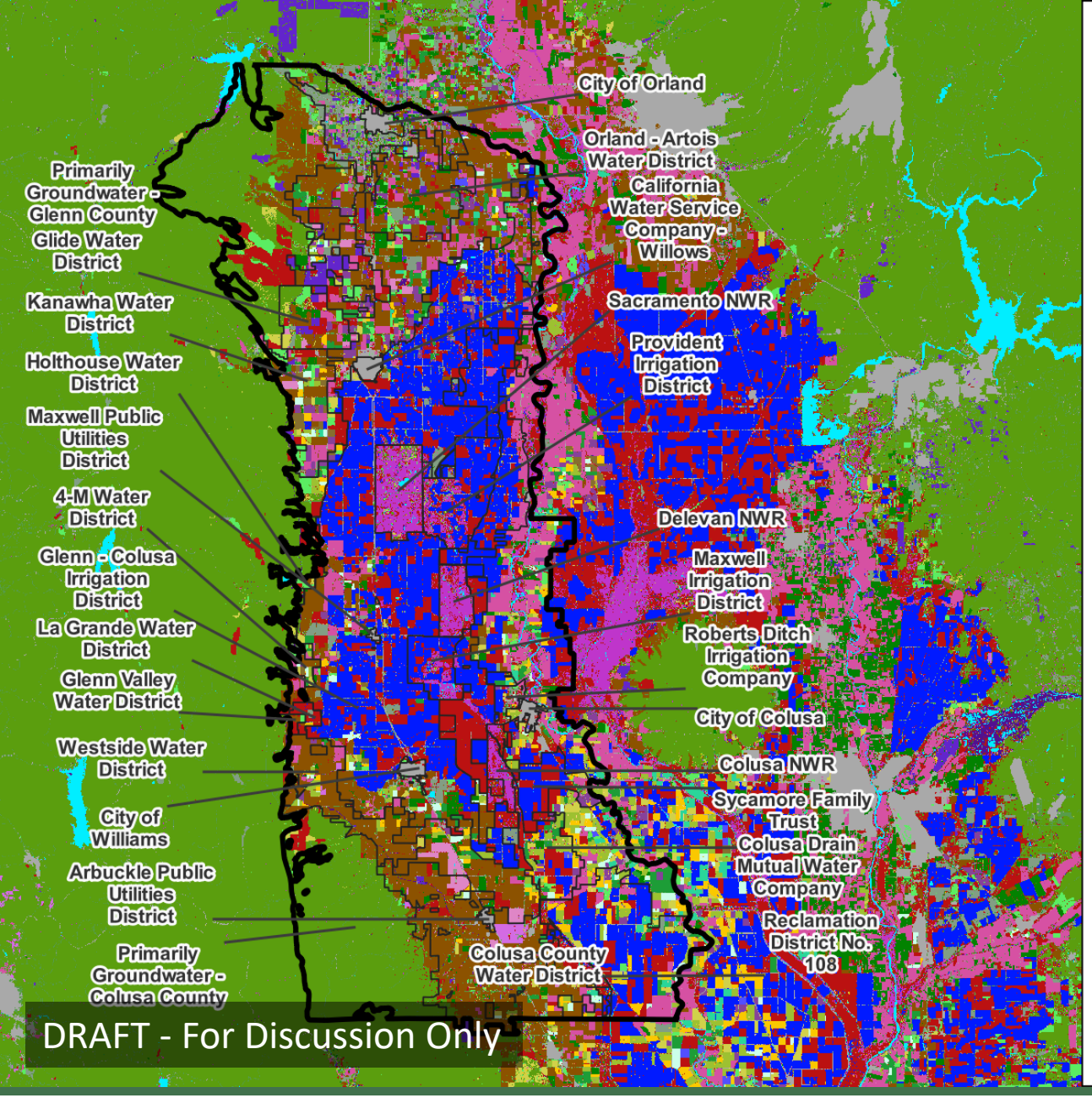
Water Budget

- Monthly timestep
- Based on Evapotranspiration (ET) from OpenET and Precipitation from PRISM
- Results summarized by water budget region and land use classifications



Source: WY2022 Annual Report Section 2



2021 Land Use and Land Cover

0 5 10 mi

Colusa Subbasin

Cities

Land Use Land Cover

- 1-Alfalfa
- 2-Almonds
- 3-Mature Almonds
- 4-Young Almonds
- 5-Citris and Subtropical
- 6-Corn
- 7-Cotton
- 8-Cucurbits
- 9-Dry Beans
- 10-Wheat
- 11-Grain and Hay
- 12-Grapes
- 13-Grapes (Table)
- 14-Grapes (Wine)
- 15-Idle
- 16-Miscellaneous Decidious
- 17-Miscellaneous Field Crop
- 18-Miscellaneous Pasture
- 19-Miscellaneous Truck Crop
- 20-Native Vegetation
- 21-Onions and Garlic
- 22-Pistachios
- 23-Potatoes
- 24-Rice
- 25-Rice (Flooded with Decomposition)
- 26-Rice (Nonflooded with Decomposition)
- 27-Rice (No Decomposition)
- 28-Riparian Vegetation
- 29-Safflower
- 30-Semiagricultural
- 31-Sugar Beets
- 32-Sunflower
- 33-Tomatoes
- 34-Tomatoes (Fresh)
- 35-Tomatoes (Processing)
- 36-Urban
- 37-Open Urban
- 38-Walnuts
- 39-Water
- 90-Managed Recharge
- 91-Seasonal Refuge
- 92-Permanent Refuge
- 93-Managed Wetlands
- 900-Barren

Source: Land use and land cover (LULC) dataset is a combination of DWR Statewide landuse data from 2019 and USDA CropScape data from 2022. DWR 2019 is given preference over 2022 CropScape, except in the case of rice, where fallowing from CropScape is used.

Datums: NAD 1983(2011), California State Plane Zone II

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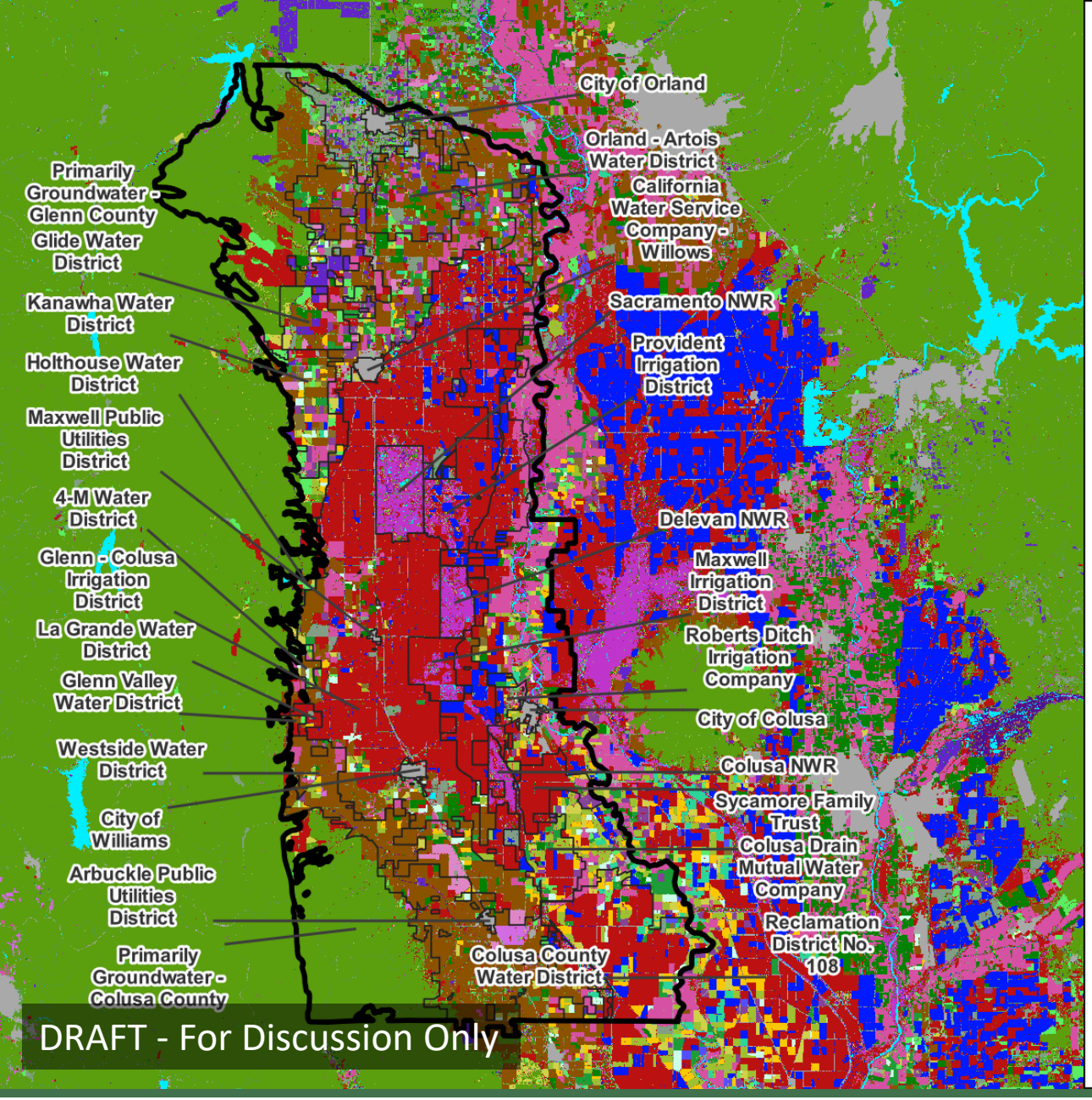

2022 Land Use and Land Cover

0 5 10 mi

Colusa Subbasin

Cities

Land Use Land Cover

- 1-Alfalfa
- 2-Almonds
- 3-Mature Almonds
- 4-Young Almonds
- 5-Citris and Subtropical
- 6-Corn
- 7-Cotton
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Datums: NAD 1983(2011), California State Plane Zone II

Water Use Sector	Groundwater Extraction, 2022 (acre-feet, rounded)	Measurement Method	Description
Agricultural	832,000	Estimate	Estimated from water budget (based on land use, ET, consumptive use fraction, and surface water supplies)
	4,480	Direct	Flowmeter records
Urban	6,000	Estimate	Estimated based on population and per capita water use requirements
	4,930	Direct	Flowmeter records
Managed Wetlands	47,000	Estimate	Estimated from water budget (based on land use, ET, consumptive use fraction, surface water supplies)
Native Vegetation	-	Estimate	No noted groundwater extraction for native vegetation, per GSP analyses
Colusa Subbasin	**Groundwater Extraction, 2022 (acre-feet, rounded)**	**Estimated Uncertainty**	**Uncertainty Source**
Total	**894,000**	**20%**	Volume-weighted combined uncertainty of water budget estimates (approximately 20%) and flowmeter records (approximately 5%)

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Source: WY2022 Annual Report Section 2

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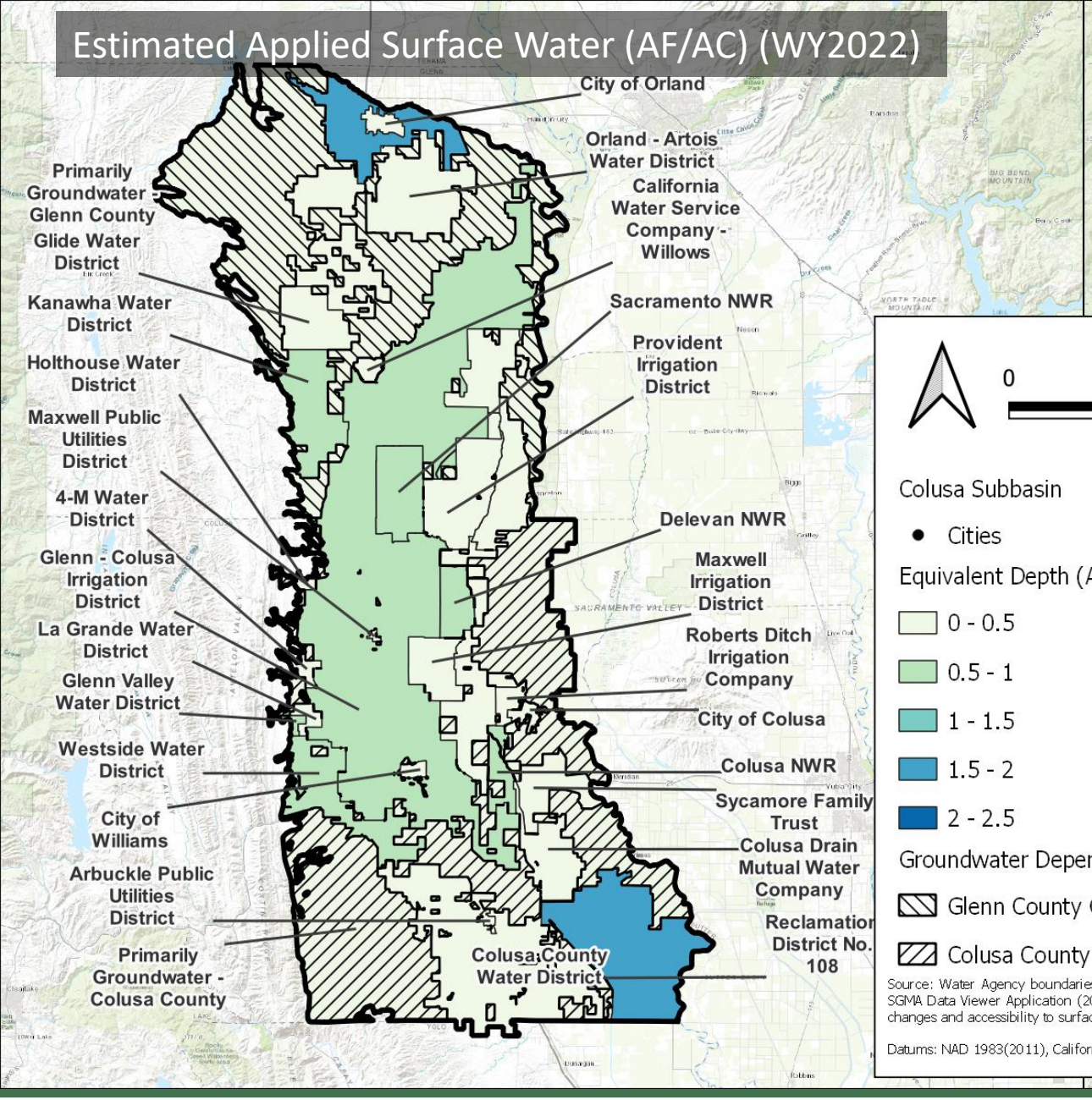
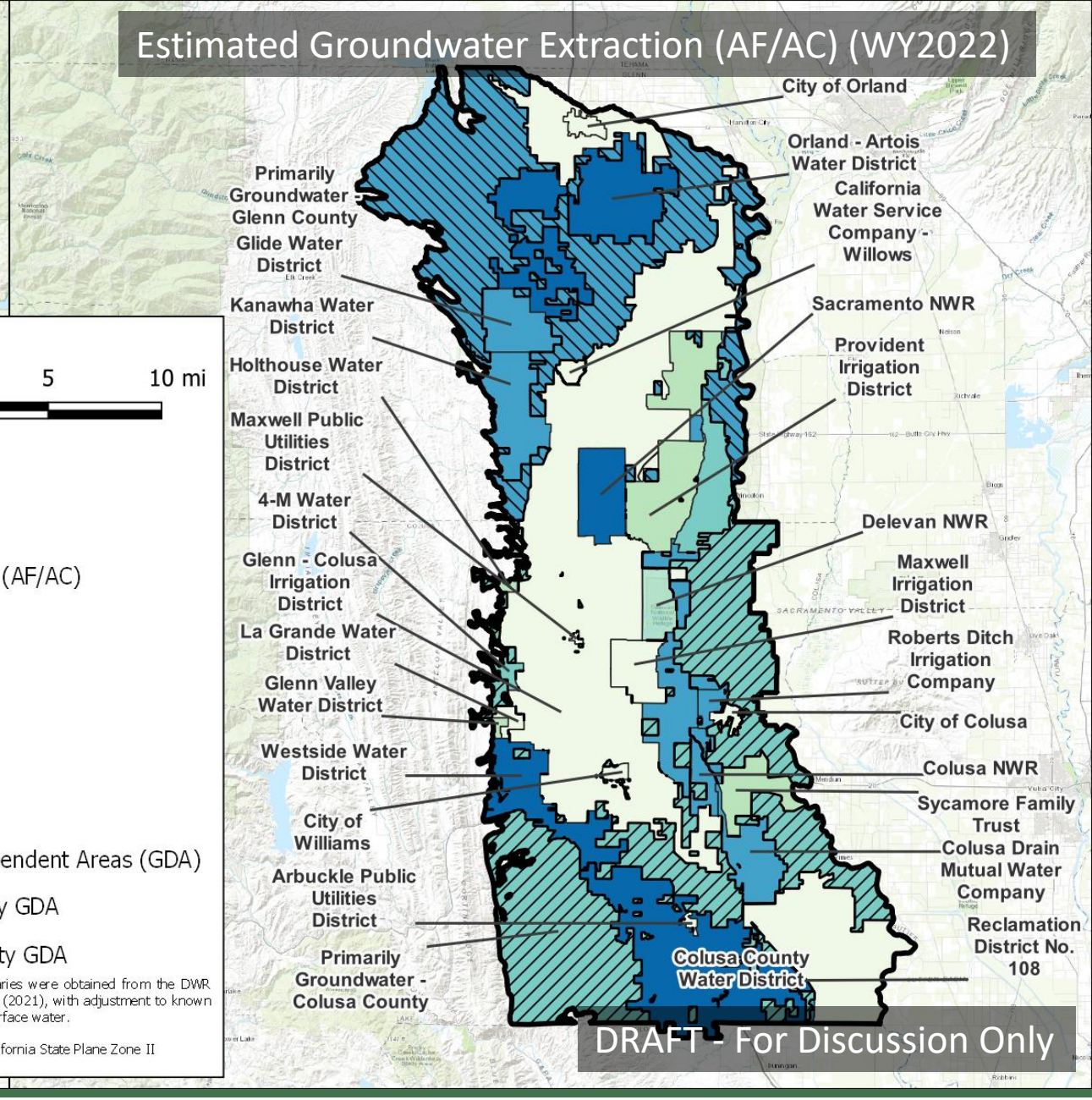
Estimated Applied Surface Water (AF/AC) (WY2022)



Estimated Groundwater Extraction (AF/AC) (WY2022)



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Source: WY2022 Annual Report Section 2

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Water Budget - By Water Budget Region (WY2022)

Water Budget Region	Area (AC)	Estimated Groundwater Extraction (TAF)	Estimated Groundwater Extraction (AF/AC)
Glenn - Colusa Irrigation District	156,847	22	0.1
Groundwater - Colusa County	150,199	223	1.5
Groundwater - Glenn County	129,398	217	1.7
Colusa County Water District	46,476	104	2.2
Orland - Artois Water District	37,315	86	2.3
Reclamation District No. 108	34,474	4	0.1
Colusa Drain Mutual Water Company	26,820	42	1.6
Provident Irrigation District	23,930	23	1.0
Orland Unit Water Users Association	16,359	7	0.4
Westside Water District	15,775	32	2.0
Kanawha Water District	15,313	27	1.8
Princeton - Codora - Glenn Irrigation District	11,334	16	1.4
Others	59,484	32	0.5
Totals ->	**723,725**	**837**	**1.2**

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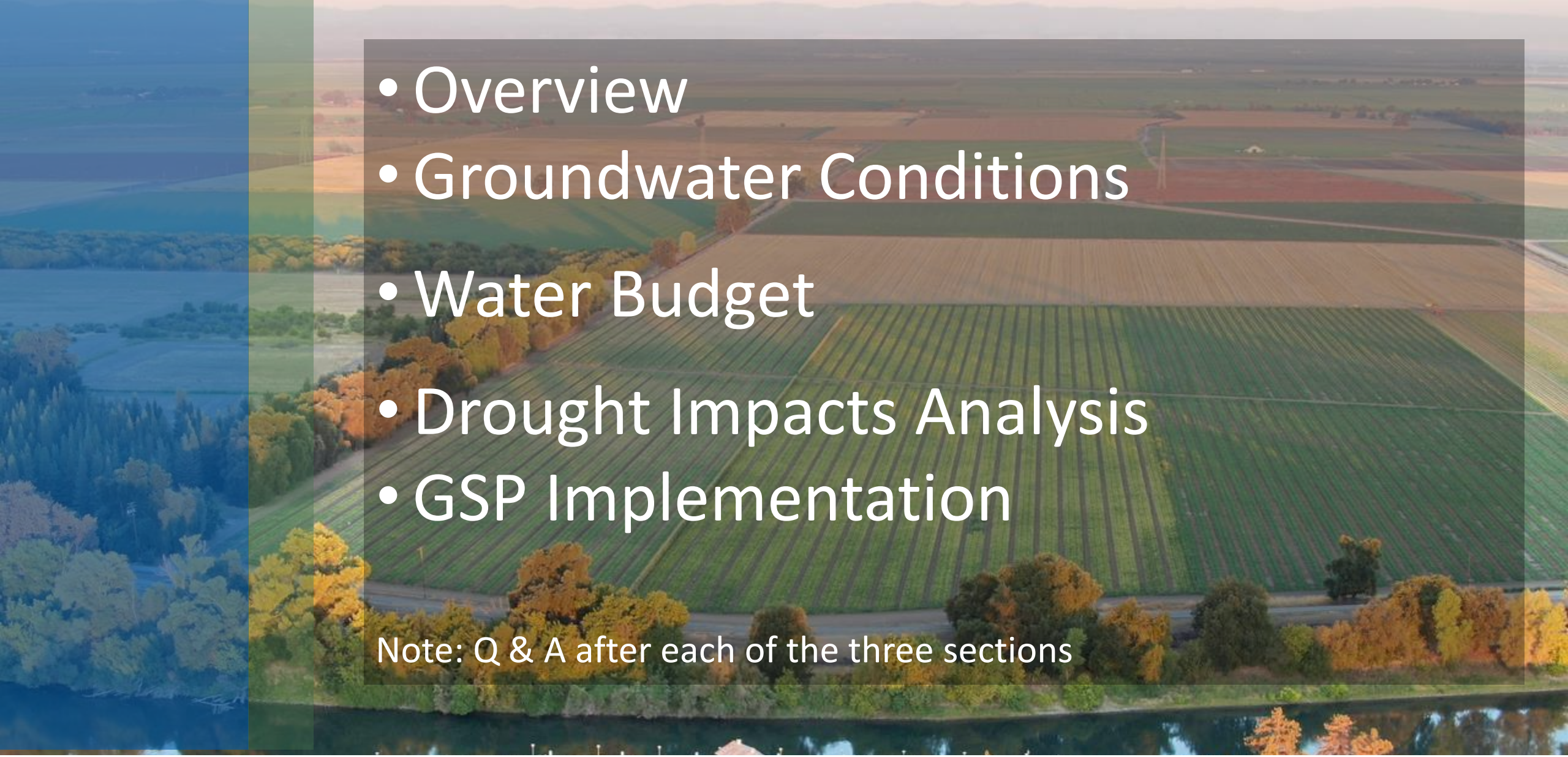
Water Budget - By Land Use (WY2022)

Land Use Classification	Area (AC)	Estimated Groundwater Extraction (TAF)	Estimated Groundwater Extraction (AF/AC)
Idle	223,136	0	0.0
Almonds	126,075	328	2.6
Native Vegetation	98,569	0	0.0
Walnuts	47,397	129	2.7
Rice	27,515	98	3.6
Riparian Vegetation	25,914	0	0.0
Urban	19,813	0	0.0
Miscellaneous Deciduous	19,430	38	2.0
Grain and Hay	15,615	30	1.9
Miscellaneous Truck Crop	13,839	31	2.2
Miscellaneous Pasture	13,321	22	1.7
Alfalfa	12,660	36	2.9
Wheat	12,137	24	2.0
Miscellaneous Field Crop	11,685	27	2.3
Others	56,621	74	1.3
Totals ->	**723,725**	**837**	**1.2**

DRAFT - For Discussion Only



- Overview
- Groundwater Conditions
- Water Budget
- Drought Impacts Analysis
- GSP Implementation

Note: Q & A after each of the three sections

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Drought Impacts Analysis

- Current Conditions
- Climate
- Streamflow
- Agricultural Acreage
- Reservoir Levels
- Vulnerable Well Analysis
- Well Completion Reports
- Drought Restrictions and Dry Wells

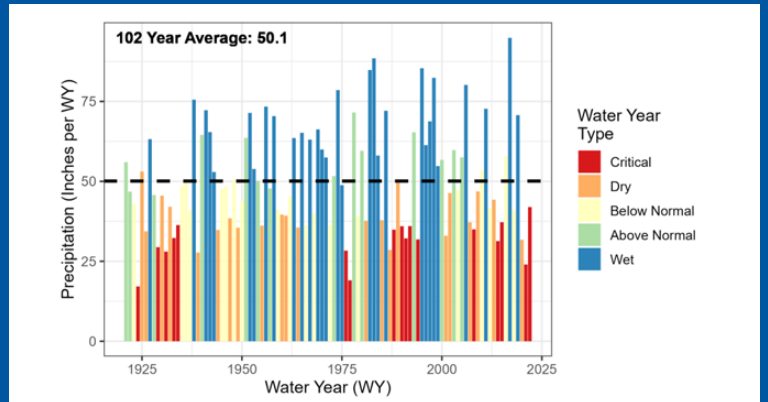


Figure 8-2. Precipitation Summary from the Northern Sierra 8 Station Index.

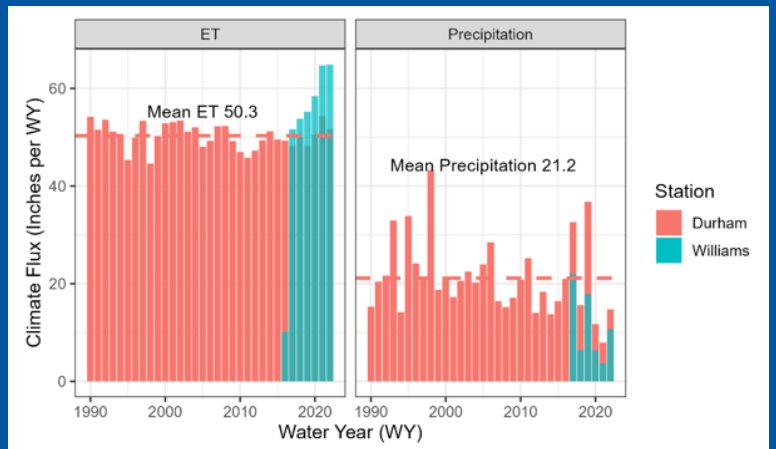
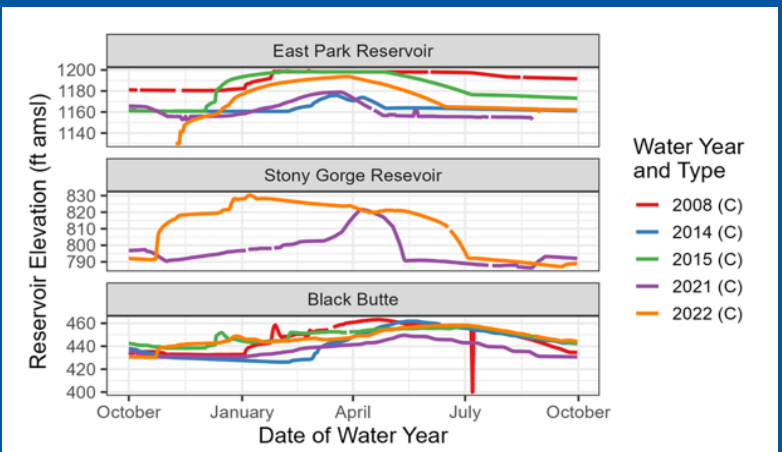


Figure 8-1. Summary of CIMIS Station Data.

Table 8-1. Mean Yearly Surface Flows of Selected Stations (mean CFS).

Station	River	2014 (C)	2015 (C)	2016 (BN)	2017 (W)	2018 (BN)	2019 (W)	2020 (D)	2021 (C)	2022 (C)
SCG	Stony Creek	--	339	441	755	137	675	666	420	17
ORD	Sacramento River	5774	7167	9715	22489	7185	16655	7081	5264	5227
COL	Sacramento River	5594	6809	9467	18024	7341	14974	7131	5170	5131
CDR	Colusa Drain	179	372	232	907	258	862	262	127	141

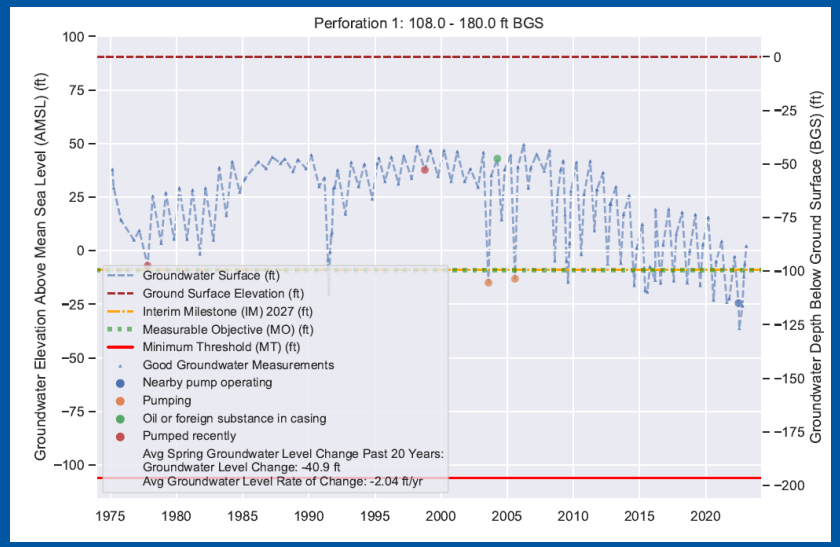
CFS = cubic feet per second
Water Year Types Classified According to the Sacramento Valley Water Year Index:
AN = Above Normal, BN = Below Normal, C = Critical, D = Dry, W = Wet

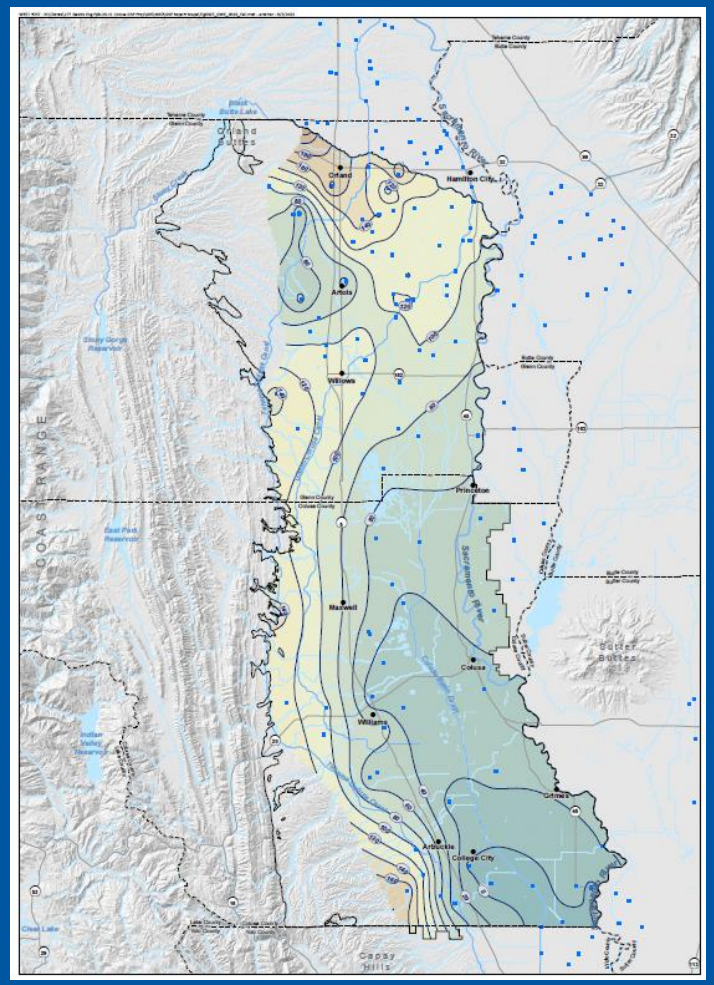


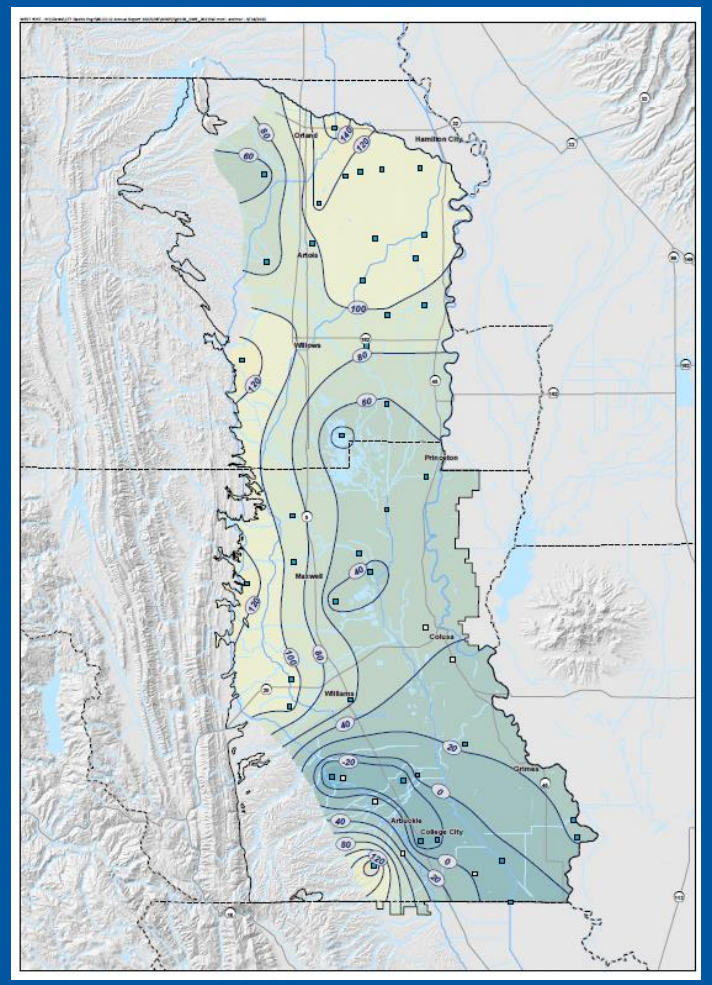
Source: WY2022 Annual Report Section 8

Drought Impacts Analysis – Vulnerable Well Analysis

- Potential Impacts to household wells
- Utilize trends in groundwater elevations (2020 – 2023 and 2021 – 2023)







Source: WY2022 Annual Report Section 8

Drought Impacts Analysis – Vulnerable Well Analysis

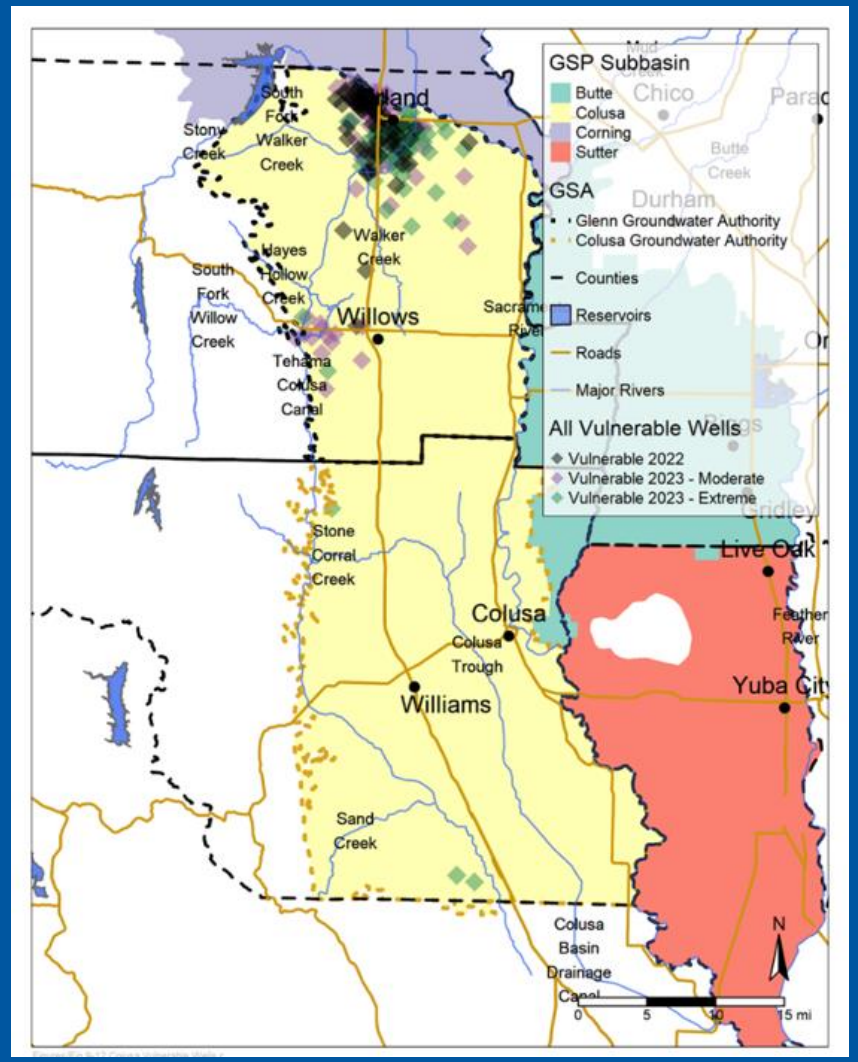


Table 8-3. Summary of Vulnerable Wells Analysis in Colusa Subbasin.

Management Area	Vulnerable in 2022	Vulnerable 2022 - Moderate	Vulnerable 2022 - Extreme
Glenn GSA	62	80	68
Colusa GSA	--	--	3

County Dry Well Records

CGA		Glenn County	
2021 = 14	**2022 = 11**	***2021 - 2022 = 284***	
Arbuckle = 9	Arbuckle = 6		
College City = 2	Colusa = 1	**2021 = 196**	**2022 = 88**
Williams = 1	Williams = 4		
Maxwell = 2			

Source: WY2022 Annual Report Section 8

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Drought Impacts Analysis – Well Completion Reports

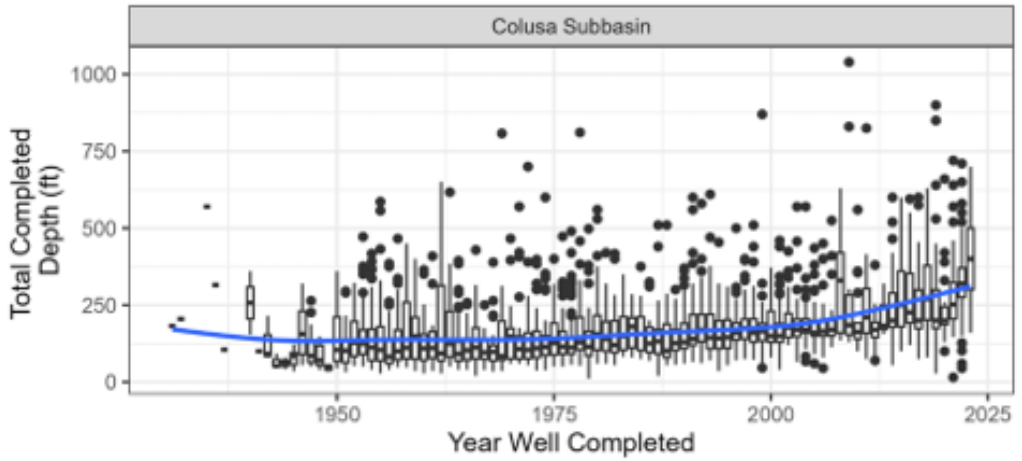


Figure 8-13. Colusa Subbasin Domestic Well Depths.

Table 8-4. Number of Well Completions in Subbasin by Sector.

Sector	2014 (C)	2015 (C)	2016 (BN)	2017 (W)	2018 (BN)	2019 (W)	2020 (D)	2021 (C)	2022 (C)	AVG
Agriculture	182	183	116	34	27	35	54	68	78	86
Domestic	45	55	43	28	29	45	33	78	89	49
Public or Industrial	0	1	5	1	2	2	2	3	4	2

Table 8-5. Median Depth of New Wells in Subbasin by Sector (feet) Over Time.

Sector	2014 (C)	2015 (C)	2016 (BN)	2017 (W)	2018 (BN)	2019 (W)	2020 (D)	2021 (C)	2022 (C)	AVG
Agriculture	1320	1413	1354	1275	1601	604	611	614	663	1051
Domestic	238	297	319	264	332	267	244	278	323	285
Public or Industrial	0	460	963	424	495	865	597	685	1388	653

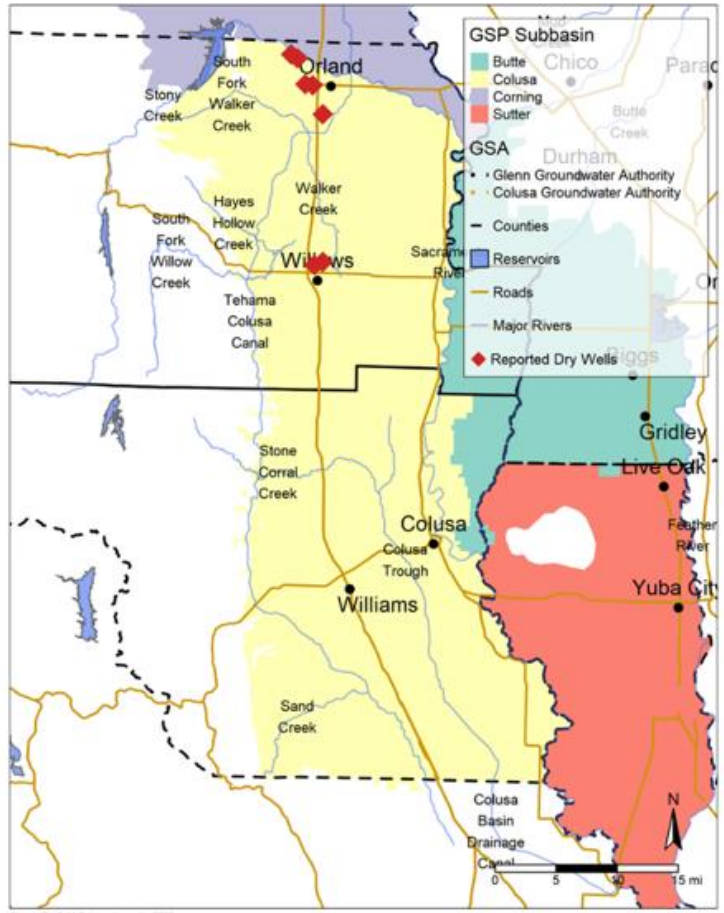
Source: WY2022 Annual Report Section 8

Drought Impacts Analysis – Dry Wells Reported to DWR

The reporting of dry or diminished capacity wells by private well owners is voluntary through the DWR Household Water Supply Shortage Reporting System (mydrywell.water.ca.gov; "Dry Well Reporting System") which has no verification or follow up conducted at the state level. The voluntary reporting form consists of 20 questions including the primary usage of well, approximate date their issue began, city, county, well depth, if the issue was resolved, and additional questions. **There were 7 reported dry or diminished wells in the Colusa Subbasin in Calendar Year 2022**

Table 8-7. Dry Wells Reported from DWR My Dry Well (updated January 6, 2023).

Management Area	2014 (C)	2015 (C)	2016 (BN)	2017 (W)	2018 (BN)	2019 (W)	2020 (D)	2021 (C)	2022 (C)
Glenn GSA	19	4	--	--	--	--	--	60	7
Colusa GSA	5	3	--	--	--	--	--	4	--



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Reported Dry Wells During Calendar Year 2022
Colusa Subbasin
Colusa Subbasin Groundwater Sustainability Plan Annual Report 2022

Source: WY2022 Annual Report Section 8

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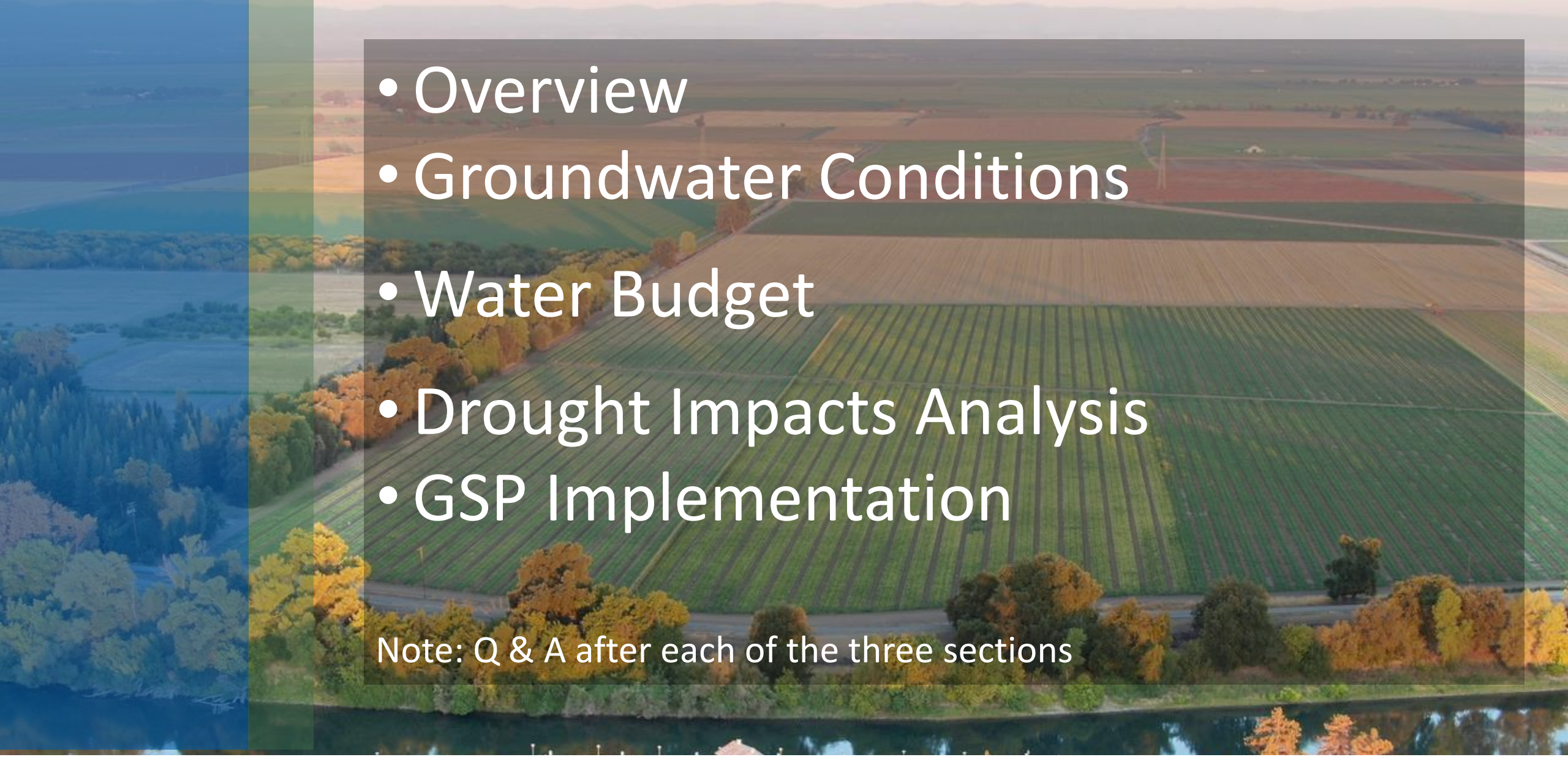

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Note: Q & A after each of the three sections

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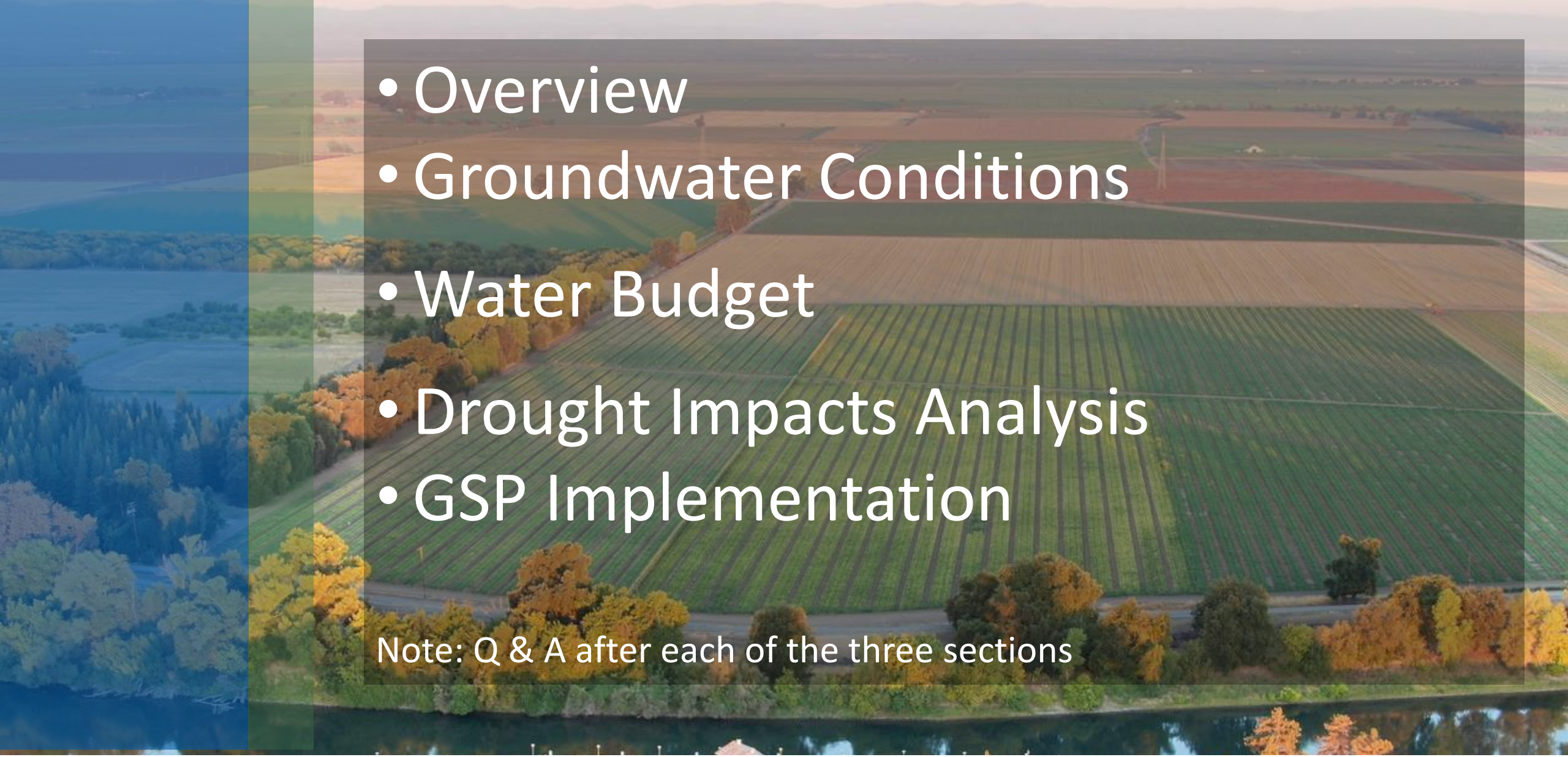
GSP Implementation

- Updates discussed in the DRAFT Annual Report (Section 7)
- Highlights in 2022:
  - Submitted SGMA Implementation Round 2 grant application in December 2022
  - Funding and Financing Plan efforts
  - Progress noted for seven projects and management actions, 8,400 AF of benefits
  - Development of new projects and management actions since GSP development:
    - GGA Recharge Project
    - Spring Valley Recharge Project
    - Others refined in the Round 2 grant application

Source: WY2022 Annual Report Section 7



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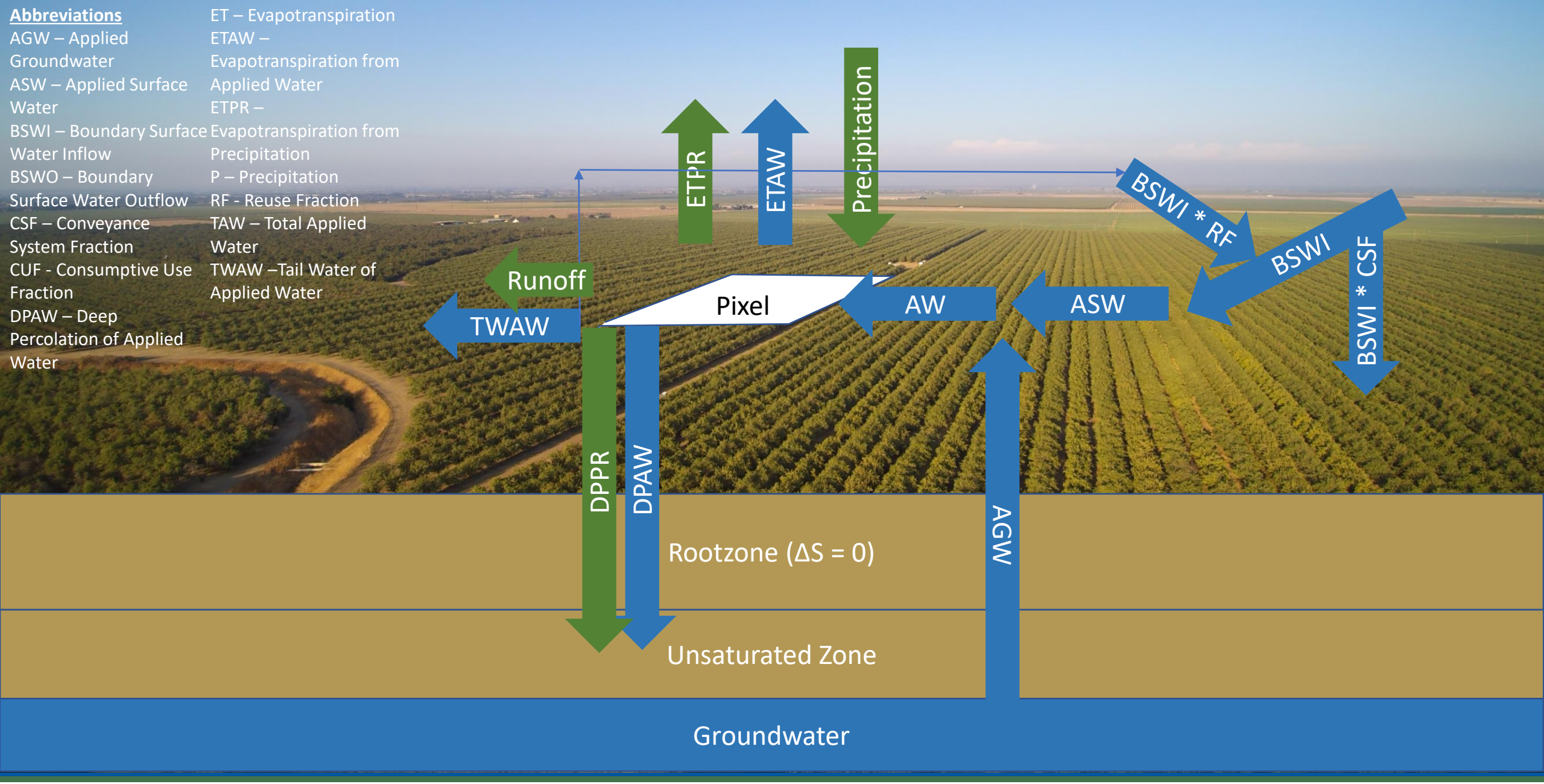
Abbreviations

AGW – Applied Groundwater
ASW – Applied Surface Water
BSWI – Boundary Surface Water Inflow
BSWO – Boundary Surface Water Outflow
CSF – Conveyance System Fraction
CUF - Consumptive Use Fraction
DPAW – Deep Percolation of Applied Water
ET – Evapotranspiration
ETAW – Evapotranspiration from Applied Water
ETPR – Evapotranspiration from Precipitation
P – Precipitation
RF - Reuse Fraction
TAW – Total Applied Water
TWAW –Tail Water of Applied Water



Abbreviations

AGW – Applied Groundwater
ASW – Applied Surface Water
AW – Total Applied Water
BSWI – Boundary Surface Water Inflow
BSWO – Boundary Surface Water Outflow
CSF – Conveyance System Fraction
CUF - Consumptive Use Fraction
DPAW – Deep Percolation of Applied Water
ET – Evapotranspiration
ETAW – Evapotranspiration from Applied Water
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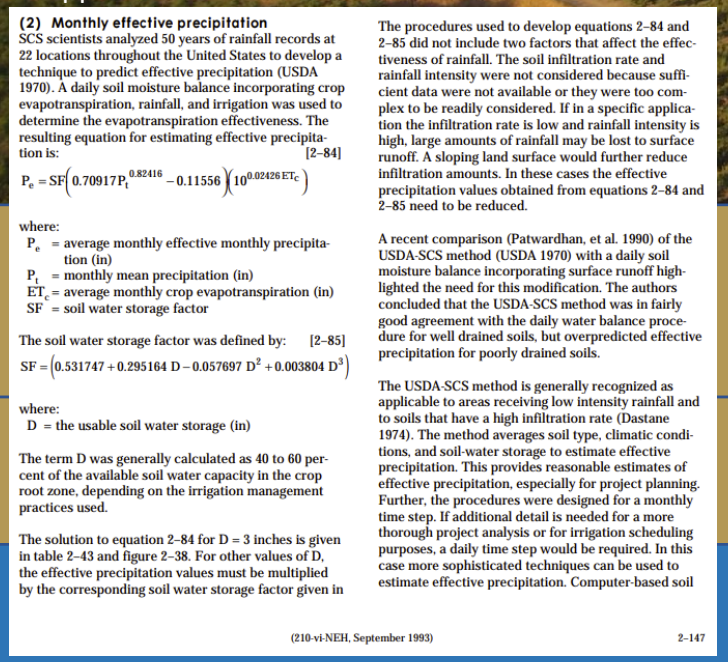
P – Precipitation
RF - Reuse Fraction
TWAW –Tail Water of Applied Water



(2) Monthly effective precipitation

SCS scientists analyzed 50 years of rainfall records at 22 locations throughout the United States to develop a technique to predict effective precipitation (USDA 1970). A daily soil moisture balance incorporating crop evapotranspiration, rainfall, and irrigation was used to determine the evapotranspiration effectiveness. The resulting equation for estimating effective precipitation is: [2–84]

$$P_e = SF\left(0.70917 P_t^{0.82416} - 0.11556\right)\left(10^{0.02426\,ET_c}\right)$$

where:
P_e = average monthly effective monthly precipitation (in)
P_t = monthly mean precipitation (in)
ET_c = average monthly crop evapotranspiration (in)
SF = soil water storage factor

The soil water storage factor was defined by: [2–85]

$$SF = \left(0.531747 + 0.295164\,D - 0.057697\,D^2 + 0.003804\,D^3\right)$$

where:
D = the usable soil water storage (in)

The term D was generally calculated as 40 to 60 percent of the available soil water capacity in the crop root zone, depending on the irrigation management practices used.

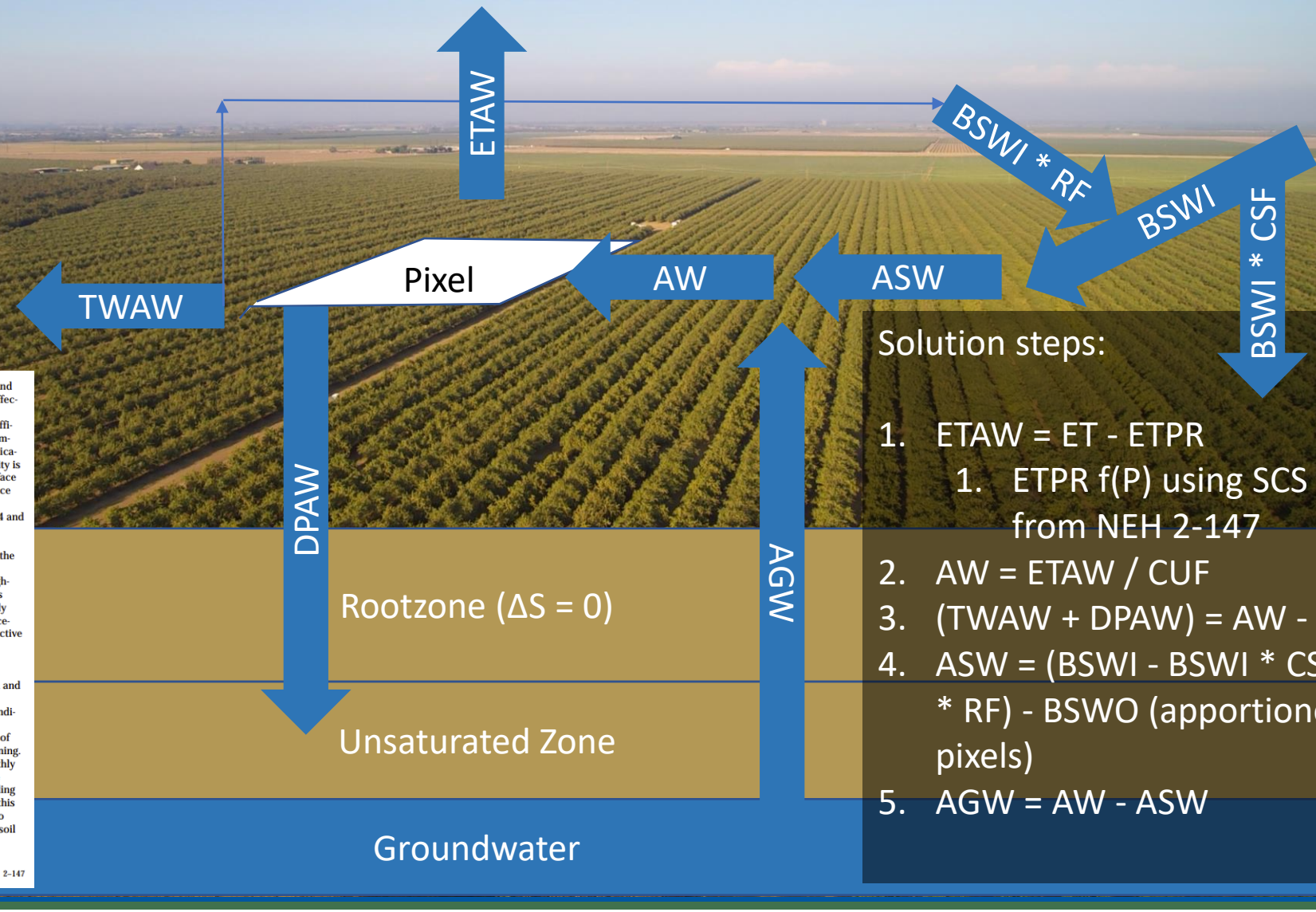
The solution to equation 2–84 for D = 3 inches is given in table 2–43 and figure 2–38. For other values of D, the effective precipitation values must be multiplied by the corresponding soil water storage factor given in

The procedures used to develop equations 2–84 and 2–85 did not include two factors that affect the effectiveness of rainfall. The soil infiltration rate and rainfall intensity were not considered because sufficient data were not available or they were too complex to be readily considered. If in a specific application the infiltration rate is low and rainfall intensity is high, large amounts of rainfall may be lost to surface runoff. A sloping land surface would further reduce infiltration amounts. In these cases the effective precipitation values obtained from equations 2–84 and 2–85 need to be reduced.

A recent comparison (Patwardhan, et al. 1990) of the USDA-SCS method (USDA 1970) with a daily soil moisture balance incorporating surface runoff highlighted the need for this modification. The authors concluded that the USDA-SCS method was in fairly good agreement with the daily water balance procedure for well drained soils, but overpredicted effective precipitation for poorly drained soils.

The USDA-SCS method is generally recognized as applicable to areas receiving low intensity rainfall and to soils that have a high infiltration rate (Dastane 1974). The method averages soil type, climatic conditions, and soil-water storage to estimate effective precipitation. This provides reasonable estimates of effective precipitation, especially for project planning. Further, the procedures were designed for a monthly time step. If additional detail is needed for a more thorough project analysis or for irrigation scheduling purposes, a daily time step would be required. In this case more sophisticated techniques can be used to estimate effective precipitation. Computer-based soil

(210-vi-NEH, September 1993) 2–147

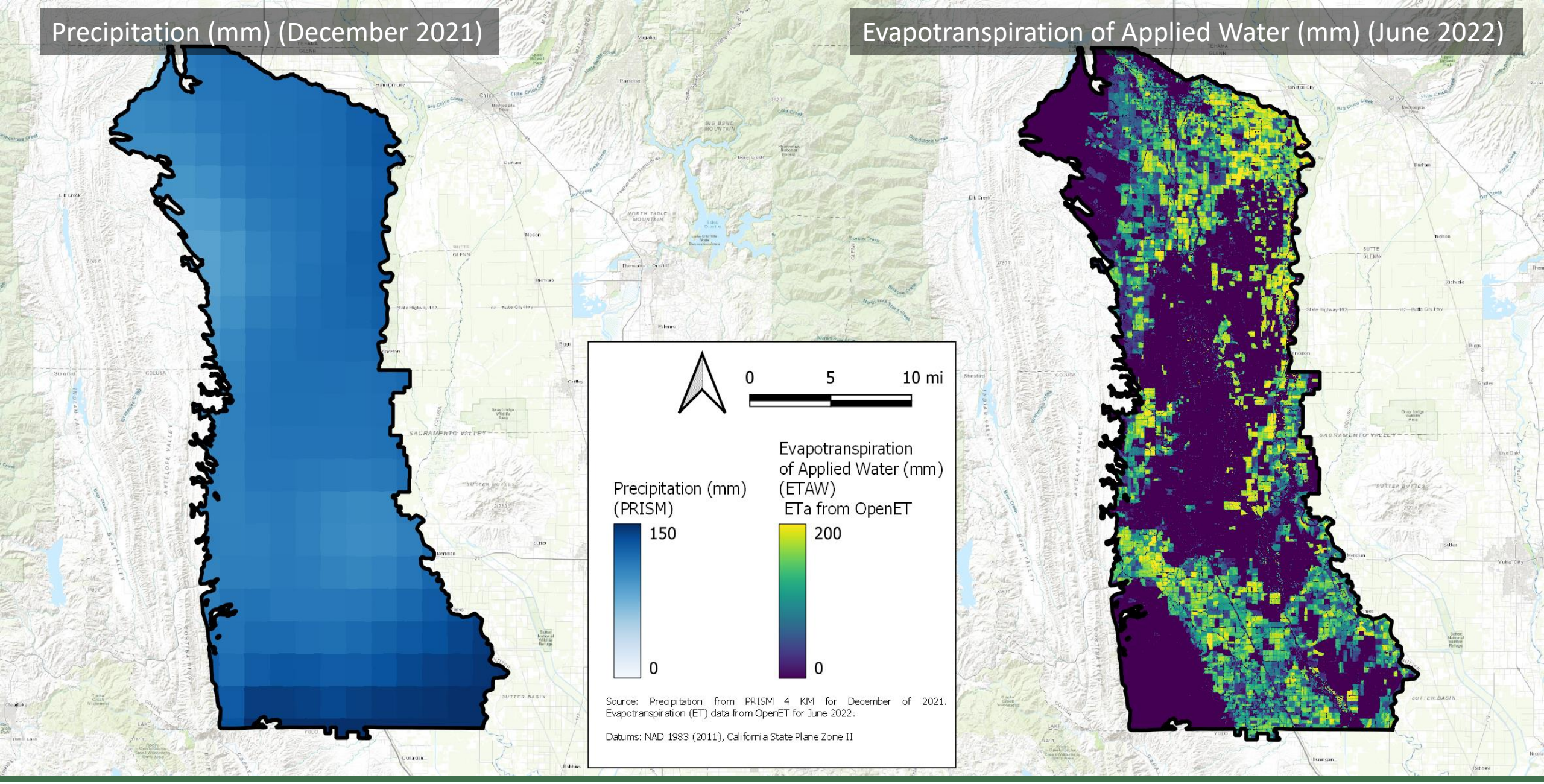


Solution steps:

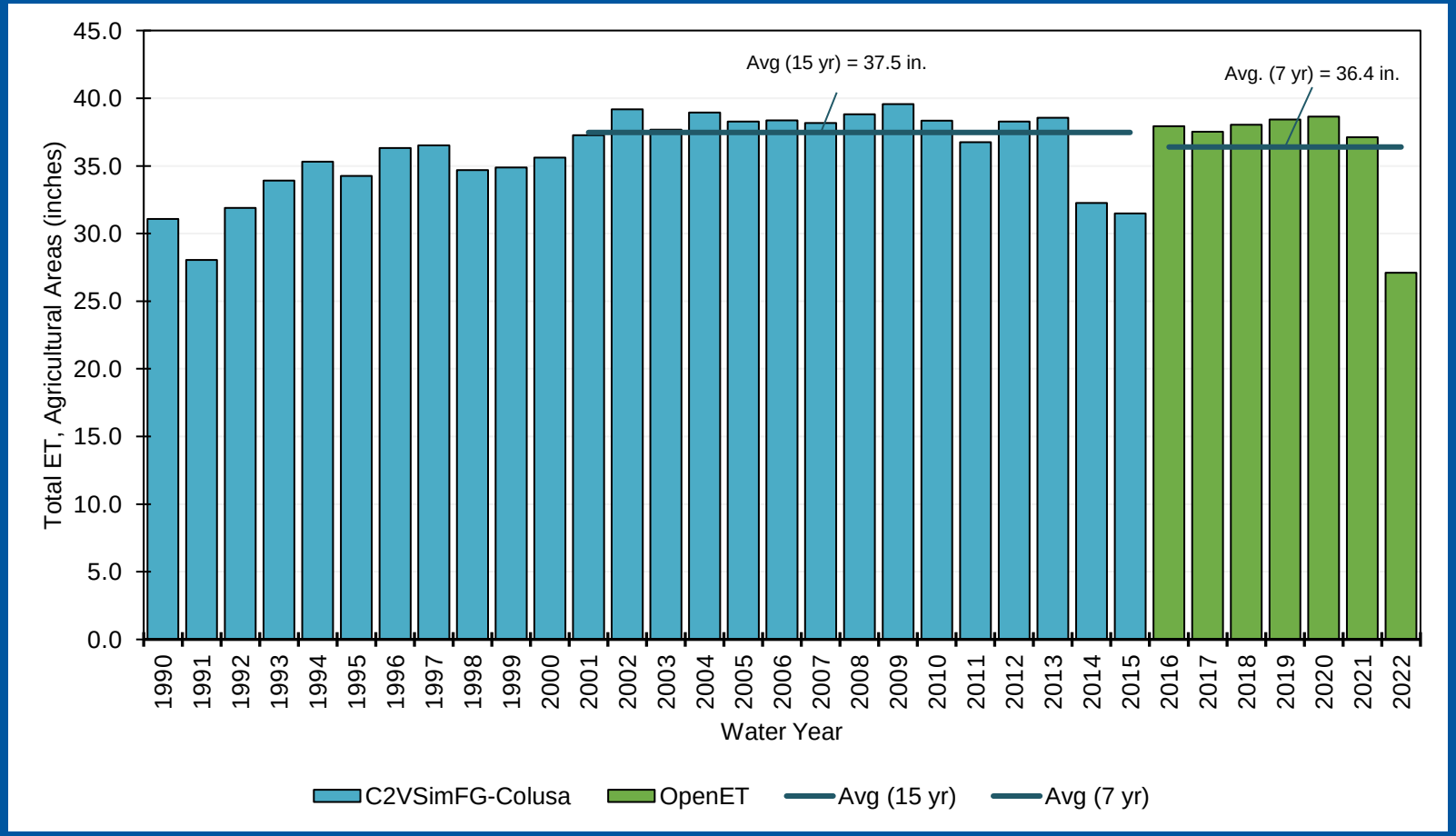
1. ETAW = ET - ETPR
   1. ETPR f(P) using SCS method from NEH 2-147
2. AW = ETAW / CUF
3. (TWAW + DPAW) = AW - ETAW
4. ASW = (BSWI - BSWI * CSF + BSWI * RF) - BSWO (apportioned to pixels)
5. AGW = AW - ASW

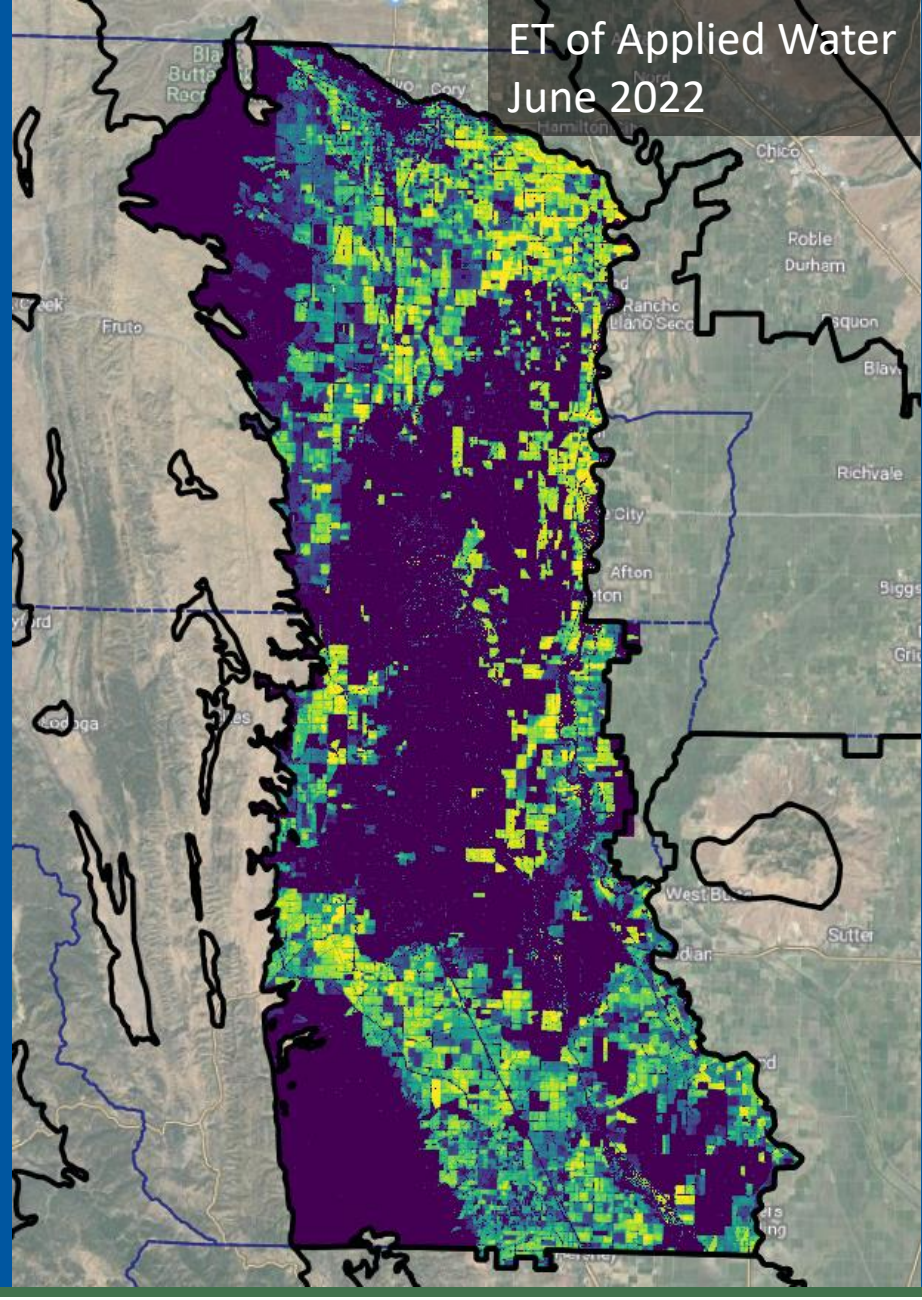
Precipitation (mm) (December 2021)

Evapotranspiration of Applied Water (mm) (June 2022)



OpenET to C2VSimFG-Colusa Comparison





Source: WY2022 Annual Report Section 2

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