Intermittent Groundwater Recharge Strategies on Alfalfa for Sustainable Production and Water Conservation in the Central Valley of California

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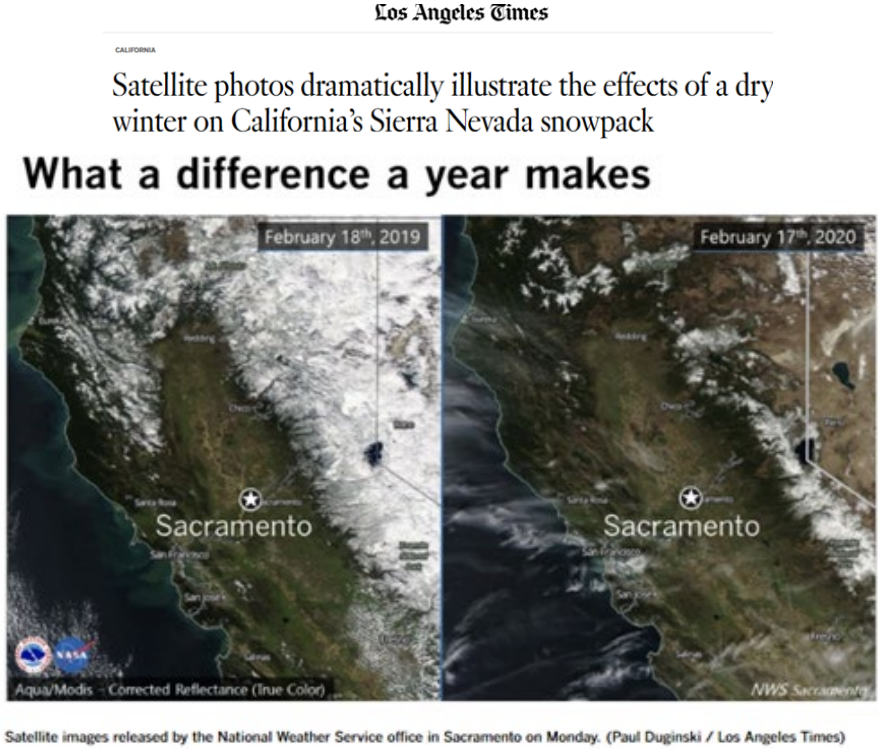
Three main sources of water that sustain California:

- Mountain snowpack
- Water stored in reservoirs (including the Colorado River Water)
- Water pumped from underground aquifers

All three sources are connected, and when the California Governor declared a drought emergency on January 17, 2014, all three had been depleted by an extended dry period.



SGMA Groundwater Management

On September 16, 2014, Governor Jerry Brown signed into law a three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA). For the first time in its history, California has a framework for sustainable, groundwater management - "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results."

SGMA requires governments and water agencies of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge. Under SGMA, these basins should reach sustainability within 20 years of implementing their sustainability plans. For critically over-drafted basins, that will be 2040. For the remaining high and medium priority basins, 2042 is the deadline.

Source: California Department of Water Resources

Intermittent Groundwater Recharge on Alfalfa

UC Kearney Agricultural Research and Extension Center, Parlier, CA

Groundwater recharge/deficit irrigation goals:

- Utilize existing alfalfa fields for groundwater recharge during the winter (January-March)
- Implement deficit irrigation after August cutting to conserve water

- Alfalfa growing season in Central Valley: March- November
- Deficit irrigation (August-November)

2019 feasibility study on selected borders, 3rd year alfalfa stand

2020, 2021, and 2022 replicated study on 12 borders (2nd and 3rd 4th year stands)

Alfalfa plots at UC Kearney Agricultural Research and Extension Center (KARE)- Parlier, CA

2022: 4th year stand

ETo: Reference evapotranspiration (in/day)

ETa: Actual crop (alfalfa) evapotranspiration (in/day or in/growing season)

Full irrigation: two irrigations/cutting

Growing Season Totals		Alfalfa ETa	ETo	Rainfall (in)
2020 (Mar 1 - Oct 31)	Deficit (August)	39.4	49.8	3.8
	Full	**40.7**	**49.8**	
2021 (Mar 1 - Sep 19)	Deficit (August)	38.3	47.1	1.6
	Full	39.4	47.1	

Yearly Precipitation Totals (Parlier, CA)	Rainfall (in)
2011	10.42
2012	8.97
2013	3.21
2014	7.34
2015	6.85
2016	10.96
2017	10.27
2018	7.57
2019	10.56
2020	5.86
2021	9.09
Range (3.21-10.96) Avg.	9.10




Intermittent Groundwater Recharge on Alfalfa

UC Kearney Agricultural Research and Extension Center, Parlier, CA

2019 feasibility study on selected borders
3rd year alfalfa stand

2020, 2021, and 2022 replicated study on 12 borders
2nd and 3rd year alfalfa stand

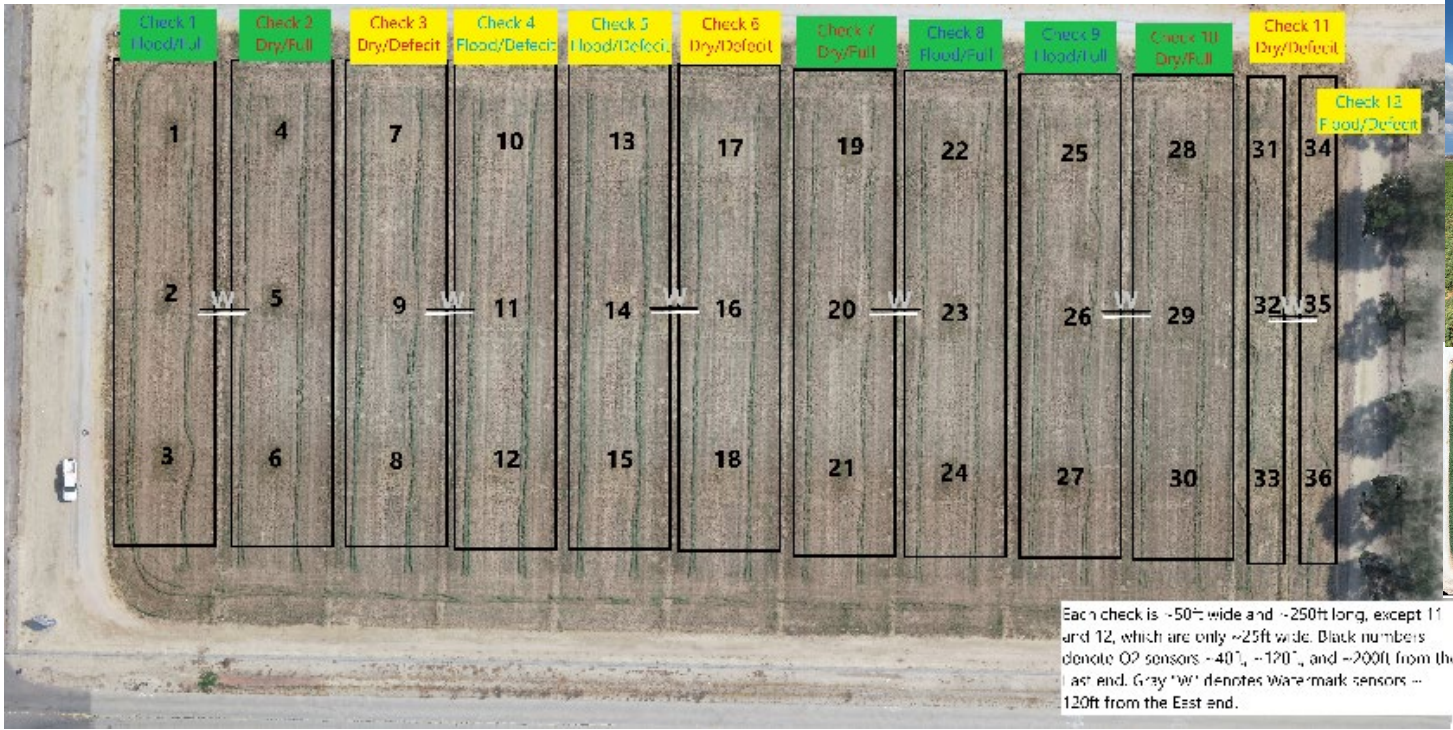
Soil: Hanford sandy loam

Drainage class: Well drained
Capacity of the most limiting layer to transmit water
K_{sat}: High (1.98 to 5.95 in/hr)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Hc	Hanford sandy loam	5.9	70.2%
Hg	Hanford sandy loam, silty substratum	1.3	15.2%
Hm	Hanford fine sandy loam	1.2	14.6%
Totals for Area of Interest		8.4	100.0%

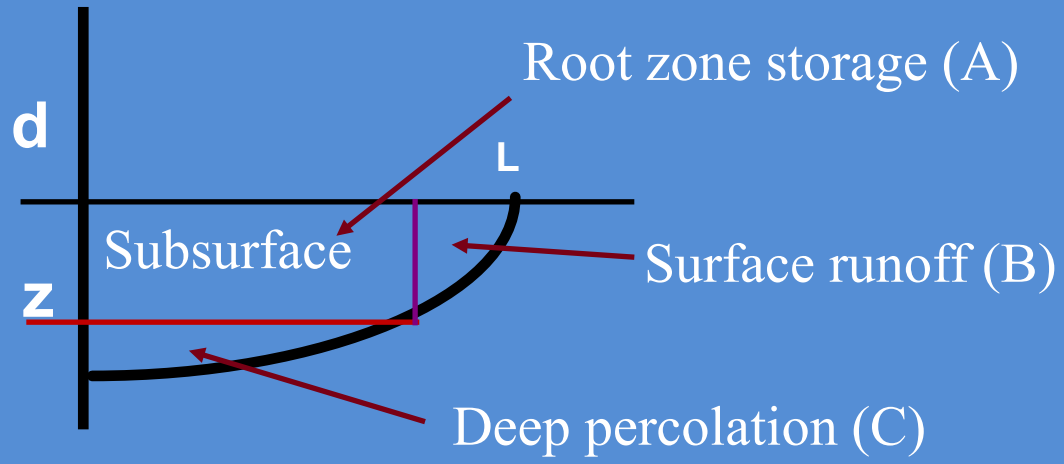
Surface Irrigation and Groundwater Recharge on alfalfa (2020, 2021 and 2022)

- Irrigation treatments during the growing season (April-November, 2019, 2020, and 2021):
  - Full irrigation and Deficit irrigation after August cutting
- GW recharge treatment: Intermittent winter flooding (1 day/week 2019 and 2020 and 2 days/week in 2021) and no flooding
- Replicated three times (yield, O_2 level in soil, moisture content, ETa, etc)



Surface Irrigation Efficiency

Applied water = Root zone storage + runoff + deep percolation



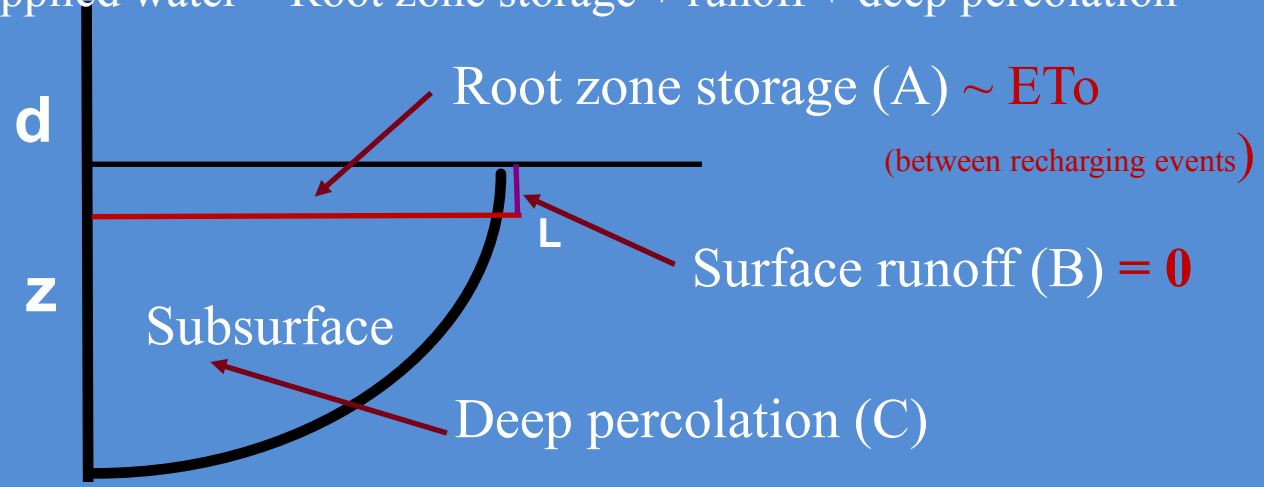
Application Efficiency (AE)= A/(A+B+C)

To achieve higher efficiency, reduce B and/or C

Intermittent Groundwater Recharge on Alfalfa

One low flow (Q) and long (T) surface irrigation event per week (Jan- April)

Applied water = Root zone storage + runoff + deep percolation



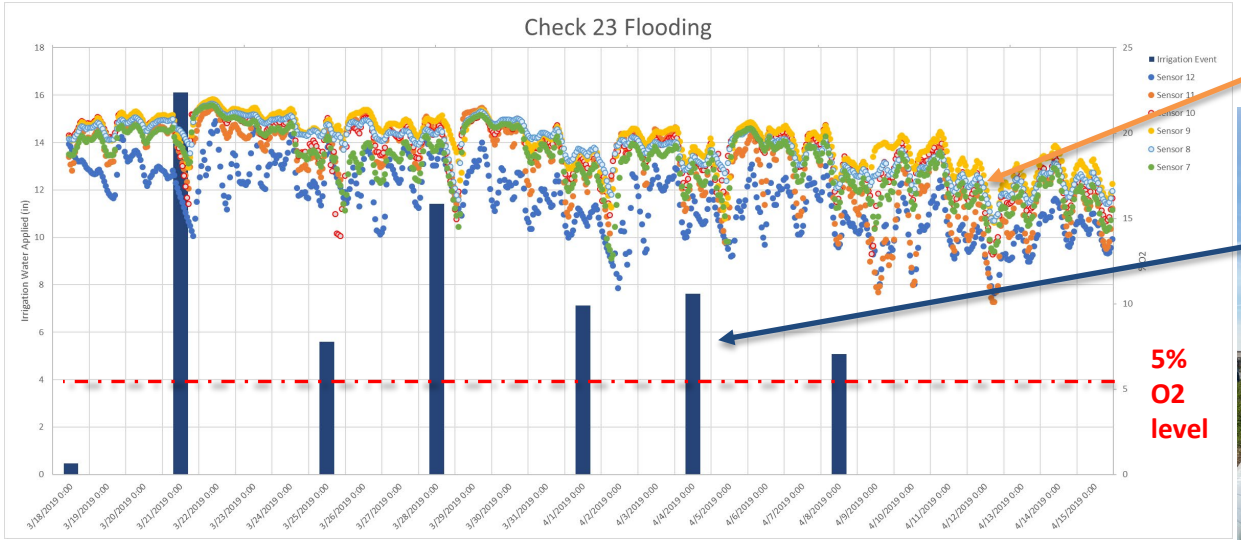
Groundwater Recharge Efficiency = C/(A+B+C)

To achieve high GW recharge efficiency, eliminate B and minimize A

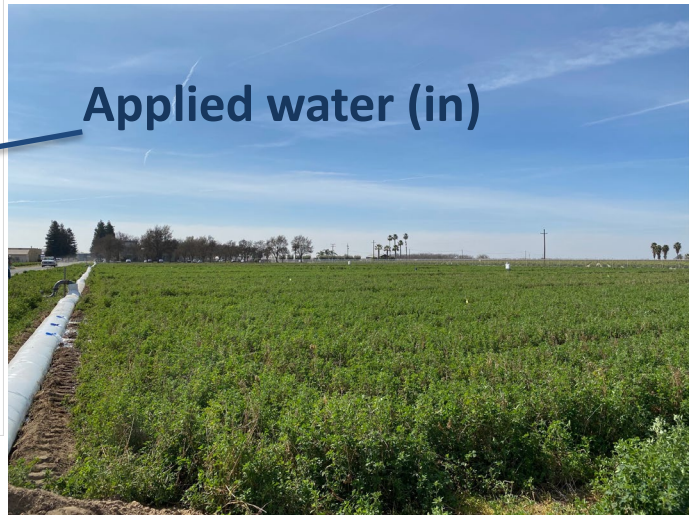
Surface Irrigation and Groundwater Recharge on alfalfa (2019- 3rd year stand)

- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 16”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- O_2 levels in rootzone above the critical 5% needed to maintain healthy root system

Data from UC Kearney Research and Extension Center (2019; **~53 inches** of recharge in 6 irrigation events, 9”/irrigation)



$\%O_2$ level



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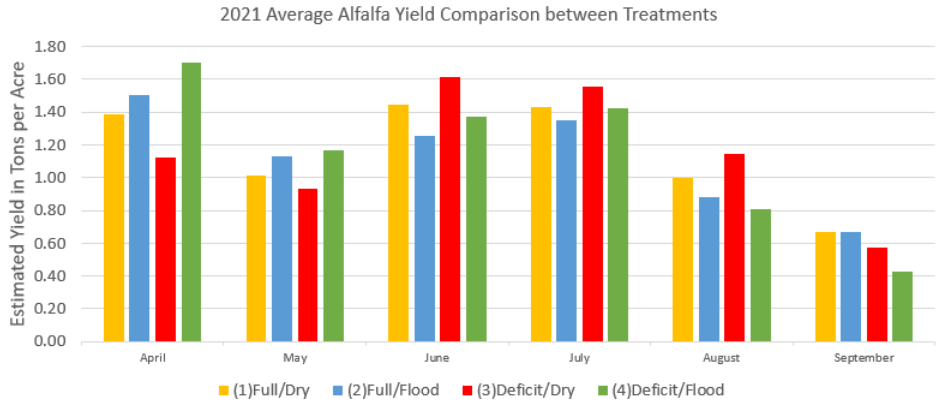
Surface Irrigation and Groundwater Recharge on alfalfa (2021- 3rd2nd year stand)

Deficit irrigation on selected borders after Aug. 2021 cuttings

Flooding events on selected borders

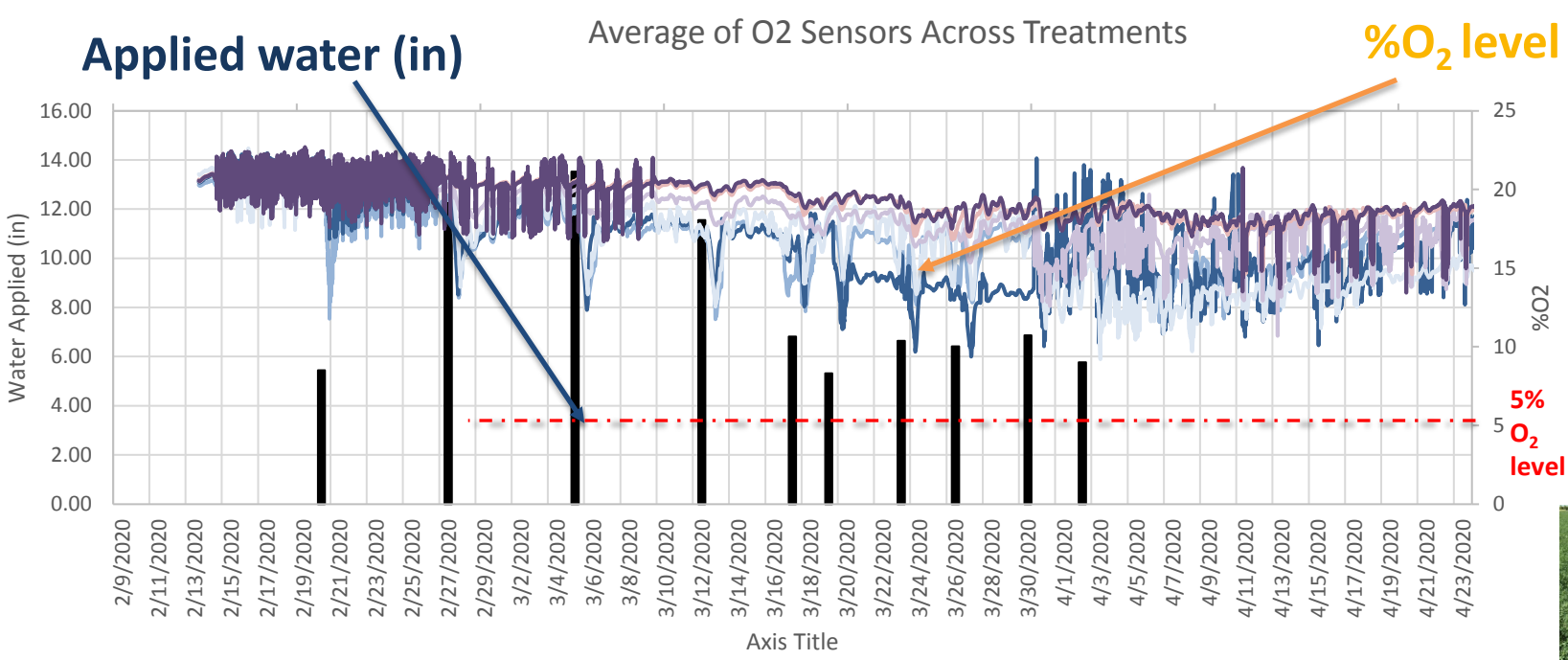


Here is an example of utilizing existing surface irrigation for GW recharge, work that Khaled is doing at Kearney Ag Center. Existing surface irrigation systems could be used on alfalfa to recharge ground water during the winter and early spring months. In the graph we are looking at weekly applied water that could be recharged to GW and at the same time monitoring O2 level in the root zone so we don't have saturated conditions for long time that may impact alfalfa growth. Here ger is using intermittent recharge practices, applying water continuously for up to up to one day per week. As you can see O2 levels are good and way above the 5% critical level that impact roots.

Surface Irrigation and Groundwater Recharge on alfalfa (2020- 2nd year stand)

- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 13”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- O_2 levels in rootzone above the critical 5% needed to maintain healthy root system

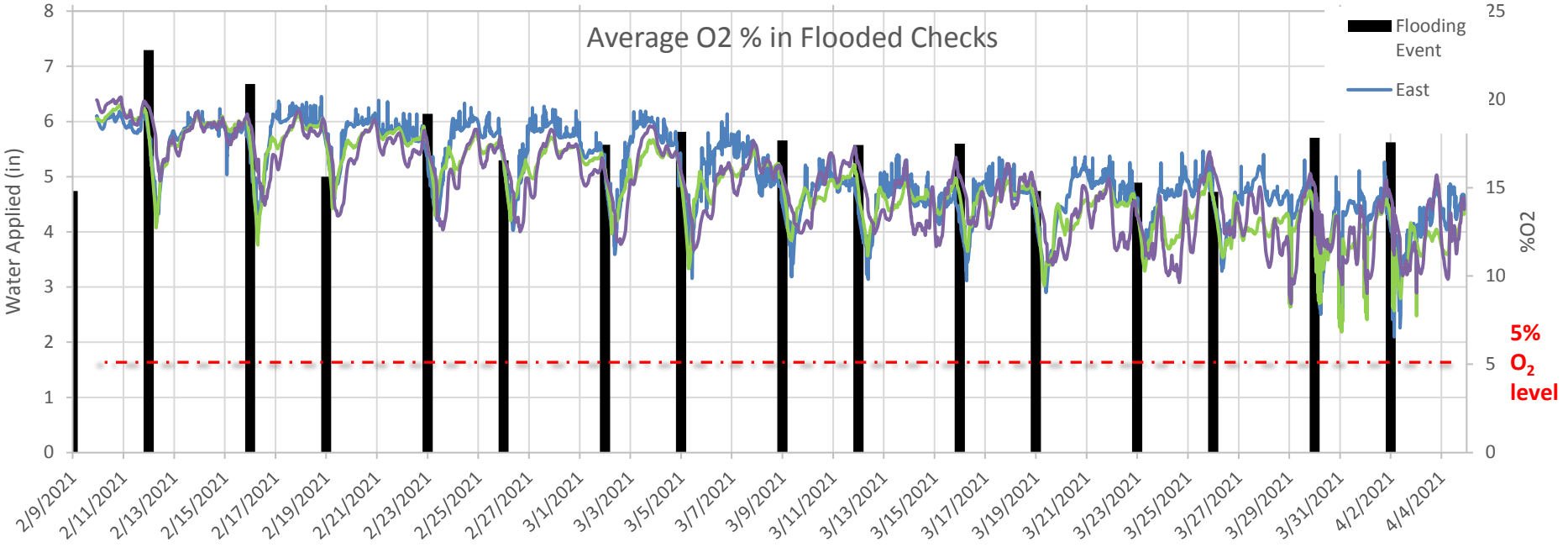
Data from UC Kearney Research and Extension Center (2020; **~80 inches** of recharge in 10 irrigation events, ~8”/week)



Surface Irrigation and Groundwater Recharge on alfalfa (2021)

- Utilization of existing surface irrigation systems on alfalfa for GW recharge.
- Up to 7”/week recharge with intermittent flooding with no significant impact on alfalfa yield
- Data from UC Kearney Research and Extension Center:

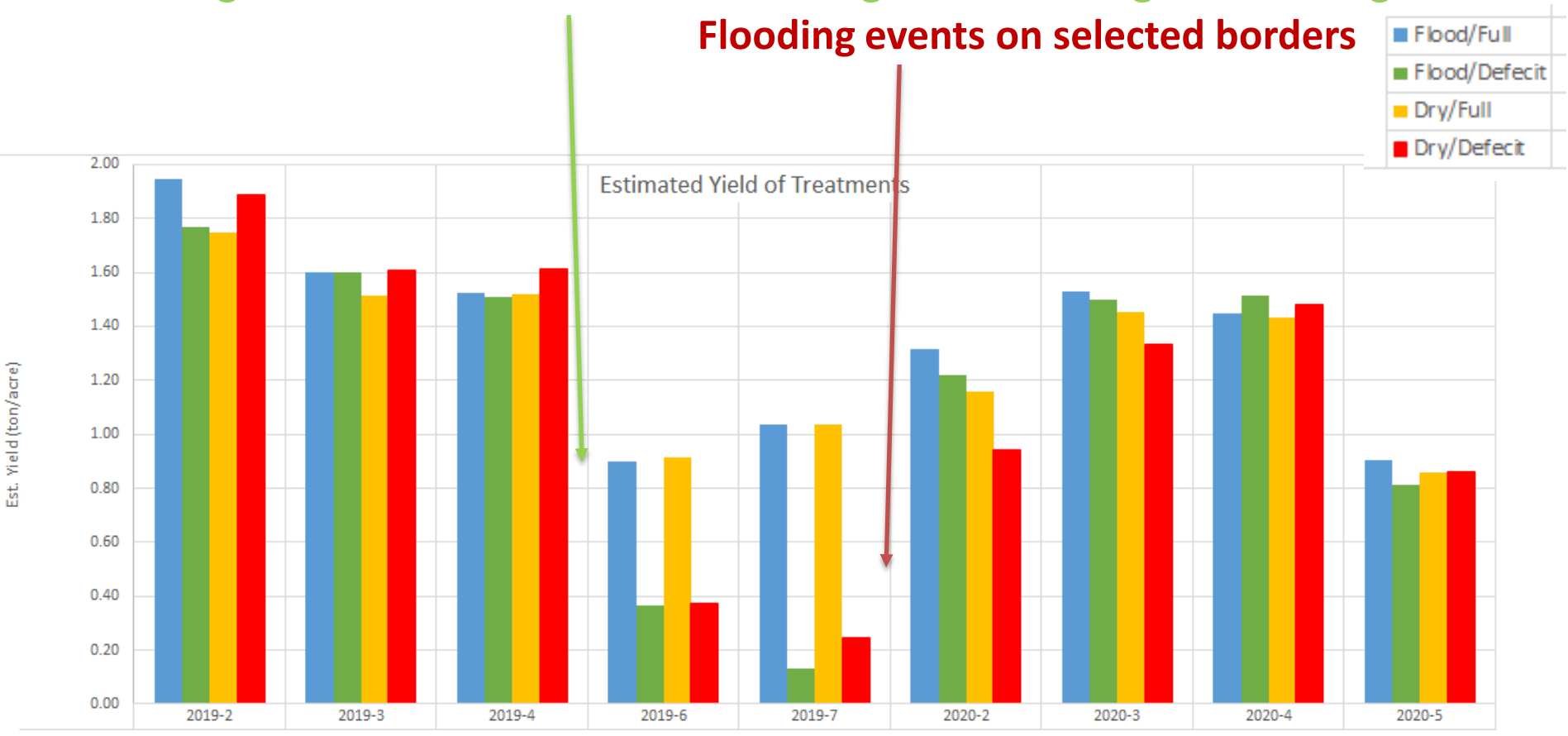
2021; **~89 inches** of recharge in 16 irrigation events over a 7.5 week period (~12”/week)



Surface Irrigation and Groundwater Recharge on alfalfa (2020- 2nd year stand)

Deficit irrigation on selected borders after Aug. 2019 and Aug 2020 cuttings

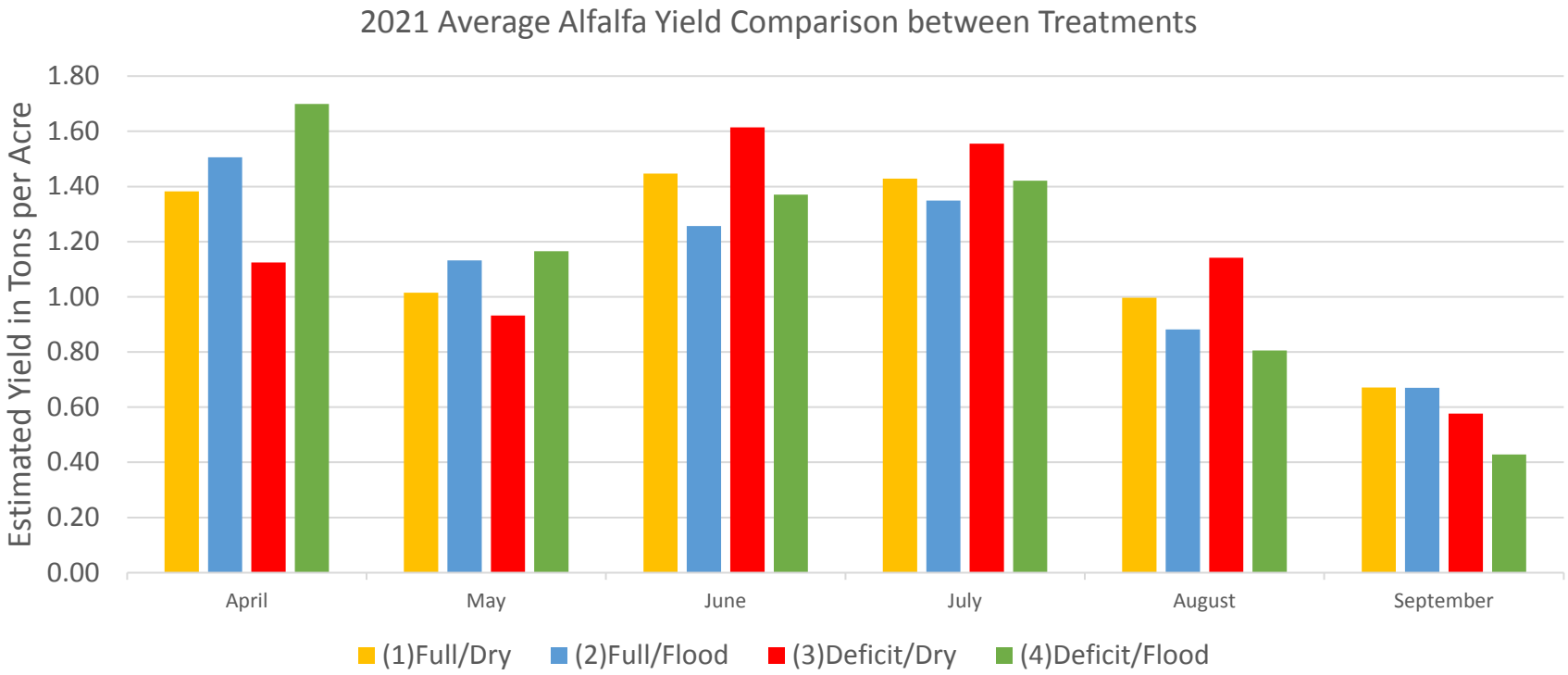
Flooding events on selected borders



Surface Irrigation and Groundwater Recharge on alfalfa (2021- 3rd year stand)

Deficit irrigation on selected borders after Aug. 2021 cuttings

Flooding events on selected borders



Summary

Practical options for groundwater recharge (alfalfa)

- Deficit irrigation on alfalfa could be used to address water shortages (Water transfer, drought, SGMA, etc) with minimal impact on alfalfa stand (KARE)

- Great potential for utilizing existing surface irrigation infrastructure for groundwater recharge (to address SGMA)

- Alfalfa fields with the proper soil type (medium to high infiltration rates) are ideal locations for GW recharge in California (less potential issues with nitrate leaching as compared to other crops)

- Very little modification is needed to the existing surface irrigation system and no need for dual irrigation systems (for irrigation and surface system for GW recharge)

- Modernization of irrigation districts or flood water delivery to farms is needed (SSJID- Pressurized, Turlock ID- Active control, Oakdale ID- Storage and automated control, CVWD- GW recharge)

Thank You