Staff Technical Workshop Part 2: Groundwater Assessment

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State Water Board Presenters:

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Topics Covered

- Overview of the analysis
- Data and Assumptions
- Methods and Calculations
- Results

Groundwater Use Assessment Framework

- Surface water diversions could be reduced
- If possible, water users would increase groundwater pumping to compensate for lost surface water
- For this analysis, assume water users can replace applied surface water shortage up to a maximum pumping capacity
- Maximum pumping capacity is based on the current infrastructure capacity, but in the future it may be limited by the Sustainable Groundwater Management Act (SGMA)

Suite of Models for Studying Groundwater Impacts

INPUTS

Potential UF Requirements

Change in Applied Surface Water

MODEL

Water Supply Effect (WSE)

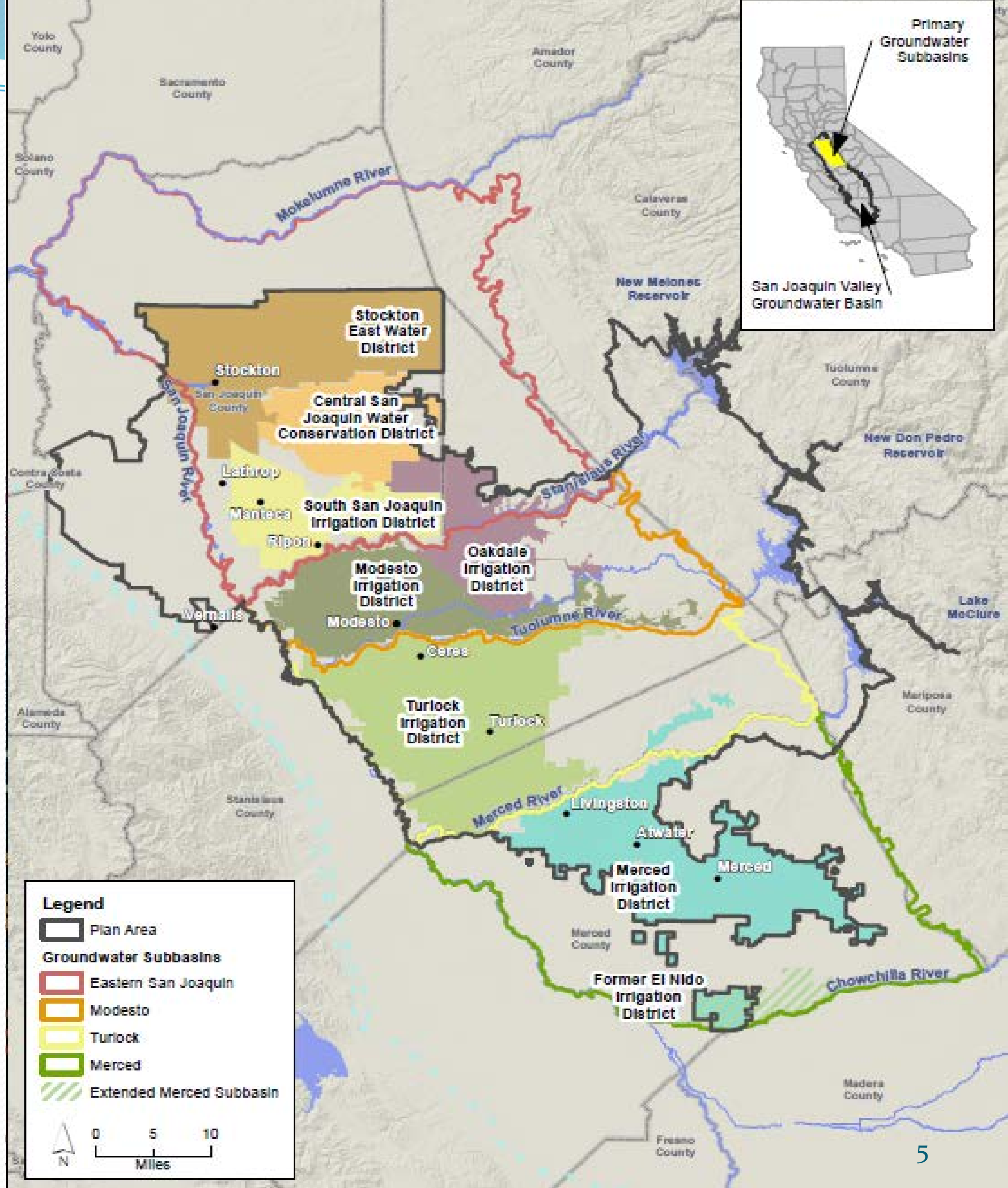
Agricultural Groundwater Use Analysis

OUTPUT

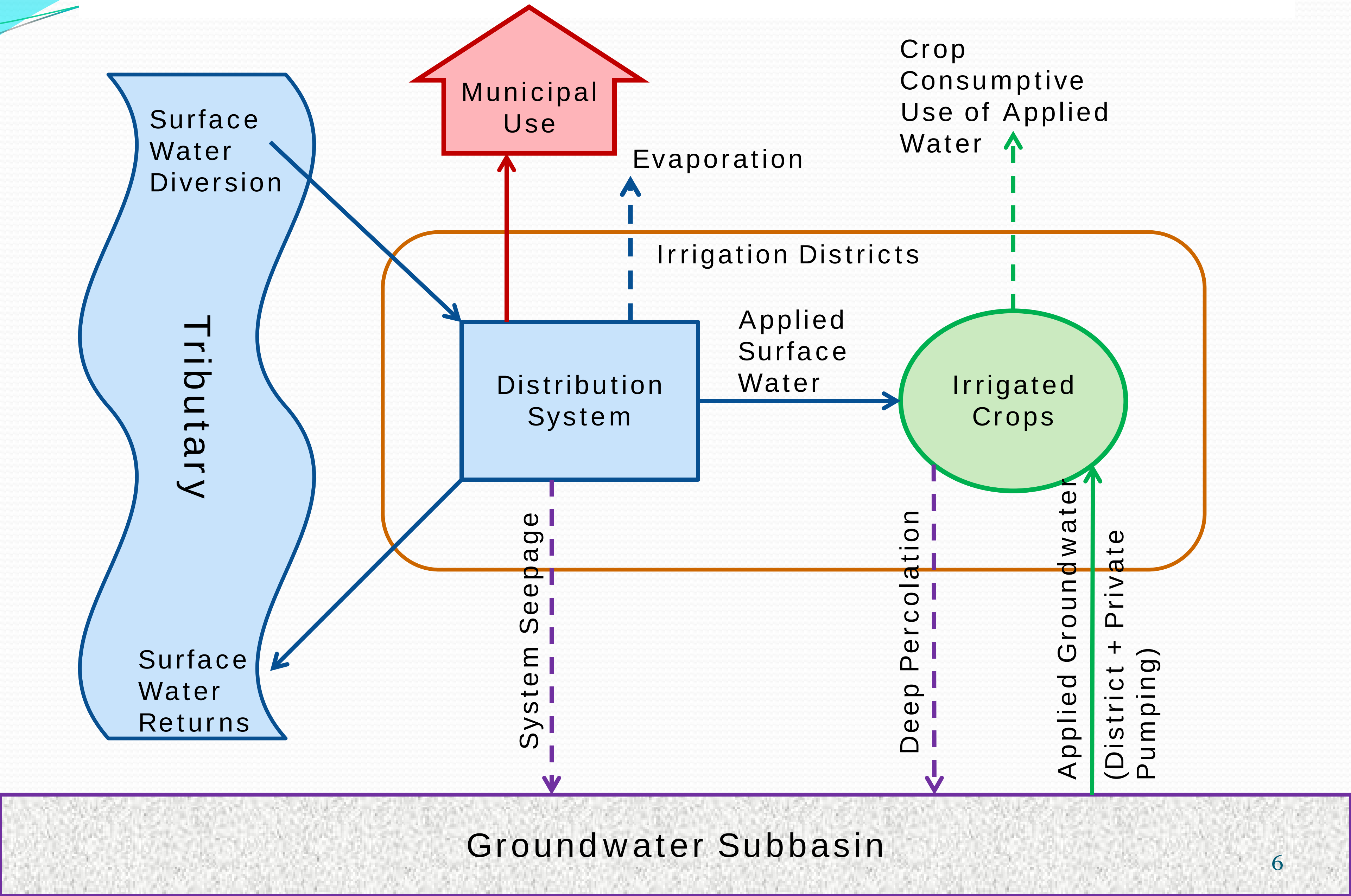
Changes in
- Surface Water Availability

Changes in
- Groundwater Pumping

- Groundwater Subbasin
  - Merced
  - Turlock
  - Modesto
  - Eastern San Joaquin
- Irrigation Districts:
  - Merced (MeID)
  - Turlock (TID)
  - Modesto (MoID)
  - Oakdale (OID)
  - South San Joaquin (SSJID)
  - Central San Joaquin Water Conservation District (CSJWCD)
  - Stockton East Water District (SEWD)



District Groundwater Balance

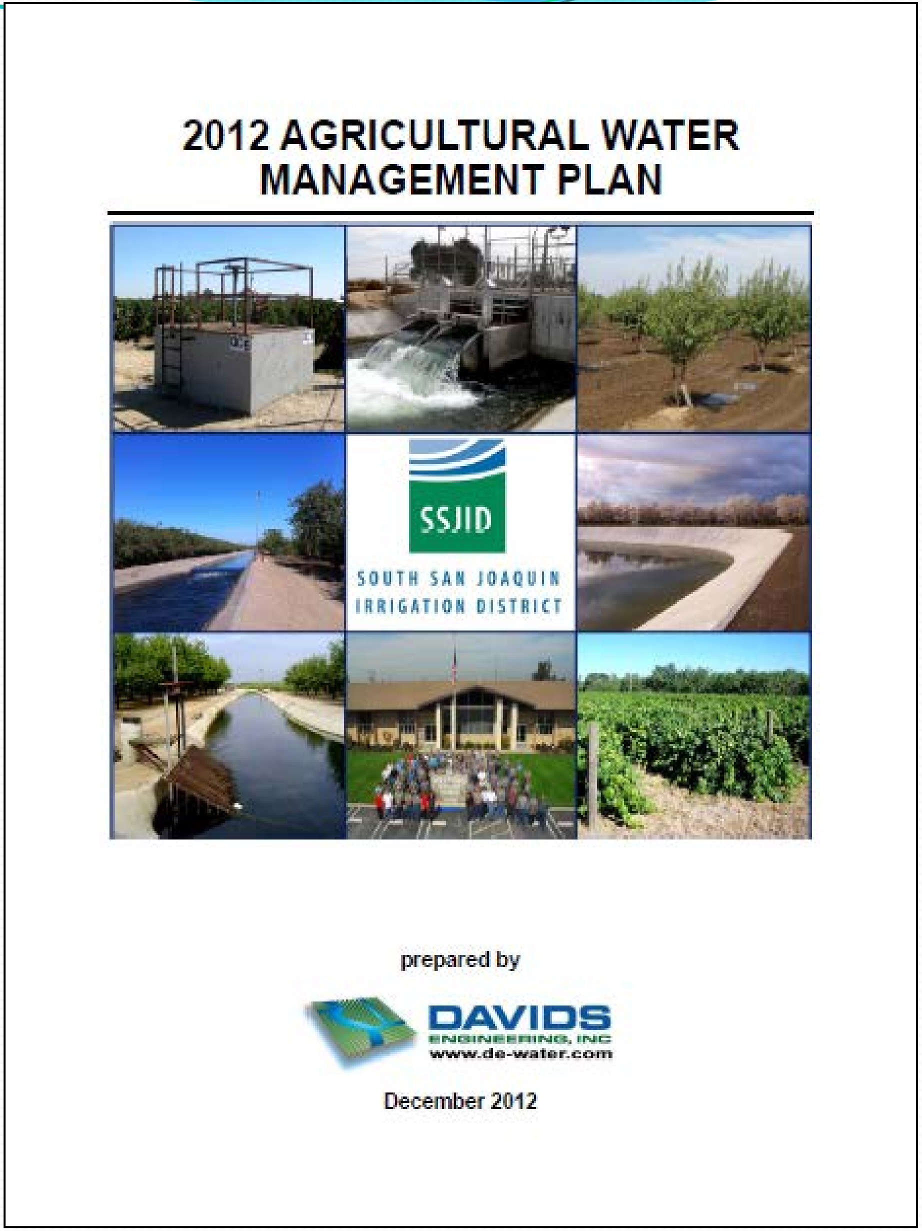


Agricultural Groundwater Use Analysis Key Assumptions

- Groundwater pumping occurs at the farm gate and is only used to satisfy crop applied water demands
- Assume districts can pump as much groundwater as needed, up to maximum pumping capacity
- For SEWD and CSJWCD only the portion of water is modeled that they contract for on the Stanislaus (totals 155 TAF), assuming both districts can fully replace any shortage with groundwater

Data Sources

- **Parameters based on district AWMPs and September 2015 information request responses**
  - District M&I deliveries
  - Seepage from regulating reservoirs
  - Minimum annual groundwater pumping
  - Maximum Groundwater Pumping capacity
  - Distributions loss factors
  - Deep percolation factors



Parameter Estimates

Municipal and Industrial Surface Water Deliveries

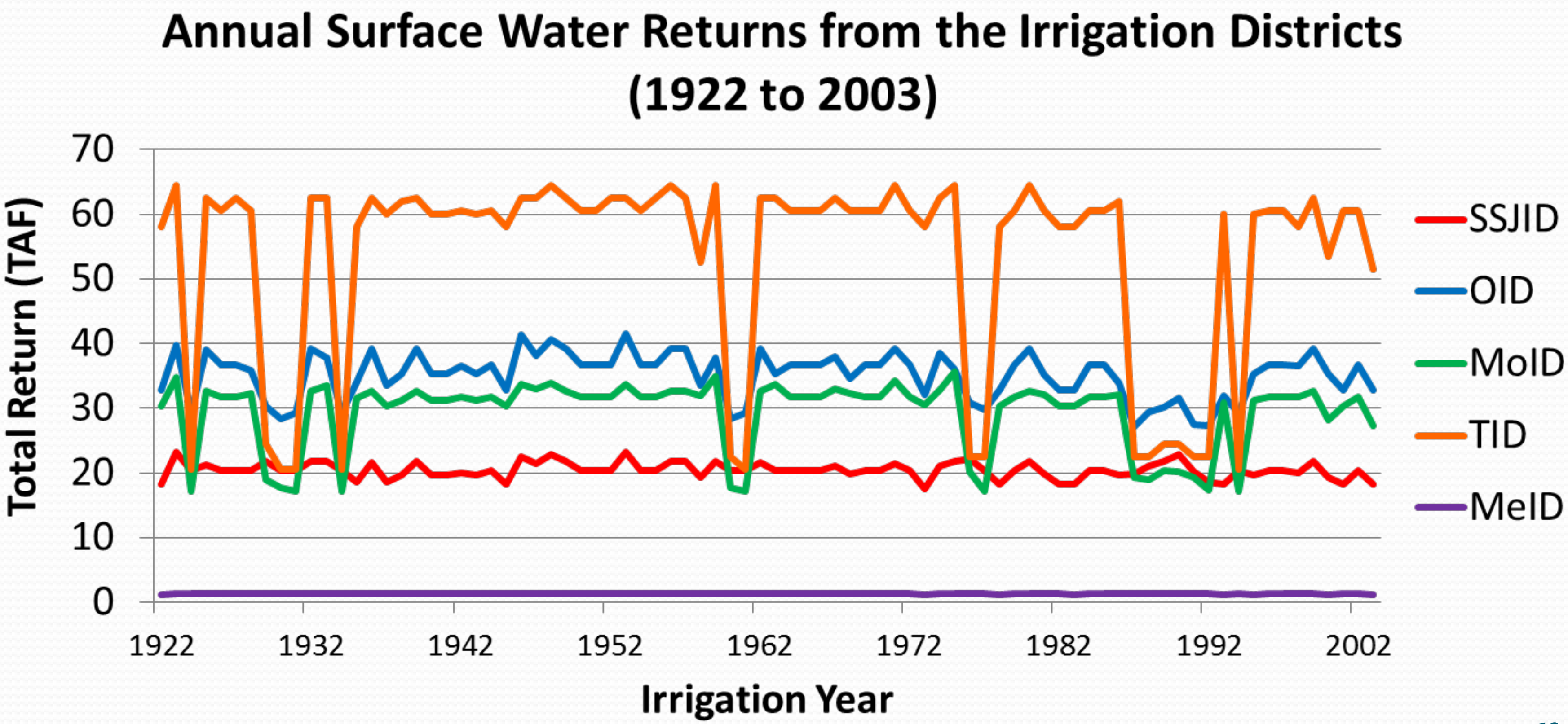
- City of Modesto Surface water deliveries from MID
  - 30 TAF/y (2012 MoID AWMP)
  - Assumed to be fully delivered each year
- SSJID deliveries to Manteca, Escalon, Lathrop, and Tracy through Degroot Water Treatment plant
  - 15.7 TAF/y (2012 SSJID AWMP)
  - Assumed to be fully delivered each year
- SEWD Municipal Deliveries
  - 10 TAF/y (2014 SEWD WMP)
  - It is assumed that any shortage is replaced with groundwater

Off-stream Reservoir Losses

- Woodward Reservoir
  - 29.5 TAF/y (2012 SSJID AWMP)
- Modesto Reservoir
  - 31.2 TAF/y (2012 MoID AWMP)
- Turlock Reservoir
  - 46.8 TAF/y (September 2015 Information request response from TID)

Surface Water Returns

- Operational spills and returns represent water diverted by the districts that returns to the river
- Estimates of spills/returns come from CALSIM II.



Merced Sphere of Influence (SOI) Demands

- Bear Creek in Merced National Wildlife Refuge (NWR)
  - Required as part of MeID FERC License for New Exchequer
  - 15 TAF/y (Merced Operations Model)
- Stevinson Entitlement
  - Adjudicated delivery to Stevinson Irrigation District
  - 24 TAF/y (Merced Operations Model)
- Former El Nido Irrigation District
  - Area South of MeID, incorporated with district in 2005
  - 13 TAF/y (Merced Operations Model)
- Other SOI demands
  - Voluntary water sales by MeID
  - 16 TAF/y (Merced Operations Model)

It is assumed that any shortage for these demands is replaced with groundwater

Distribution Loss Factors

- Distribution Loss Factors Represent Distribution Losses as a percent of surface water deliveries
- Using information from the AWMPs, the factor is calculated as:

$$\textit{Distribution Loss Factor } (DF) = \frac{\textit{Distribution Seepage} + \textit{Distribution Evaporation}}{\textit{Applied Surface Water} + \textit{Spills} \,\&\, \textit{Returns} + \textit{SOI Deliveries}}$$

	SSJID	OID	MID	TID	MeID	SEWD	CSJWCD
Distribution Loss Factor	0.17	0.29	0.05	0.08	0.32	0.08	0.31

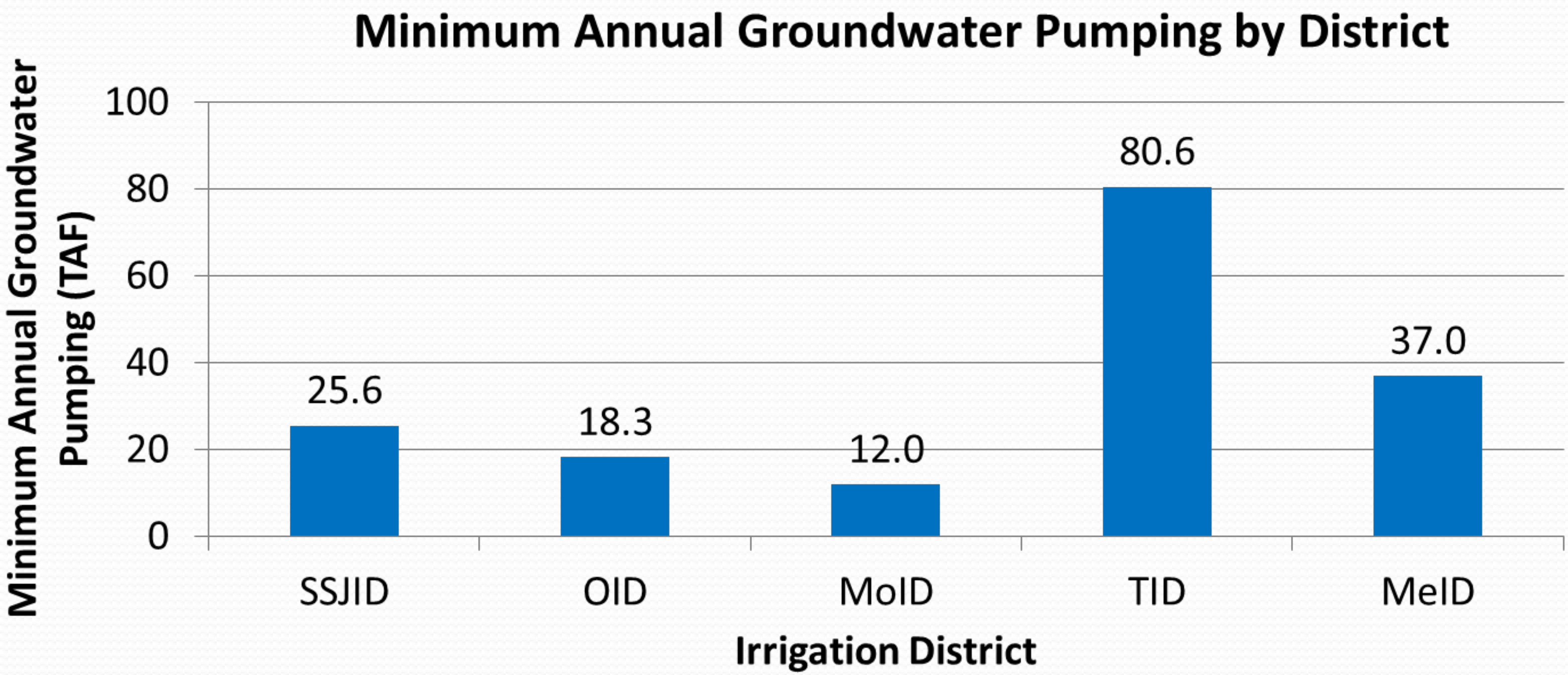
Deep Percolation Factors

- Deep Percolation Factors represent seepage of Applied Water as a percent of the crop consumptive use
- Using information from the AWMPs, the factor is calculated as:

$$\boldsymbol{Deep\ Percolation\ Factor\ (PF)} = \frac{\boldsymbol{Deep\ Percolation\ (DP)}}{\boldsymbol{Consumptive\ Use\ (CUAW)}}$$

	SSJID	OID	MID	TID	MeID	SEWD/CSJWCD
Deep Percolation Factor	0.28	0.19	0.38	0.46	0.25	0.10

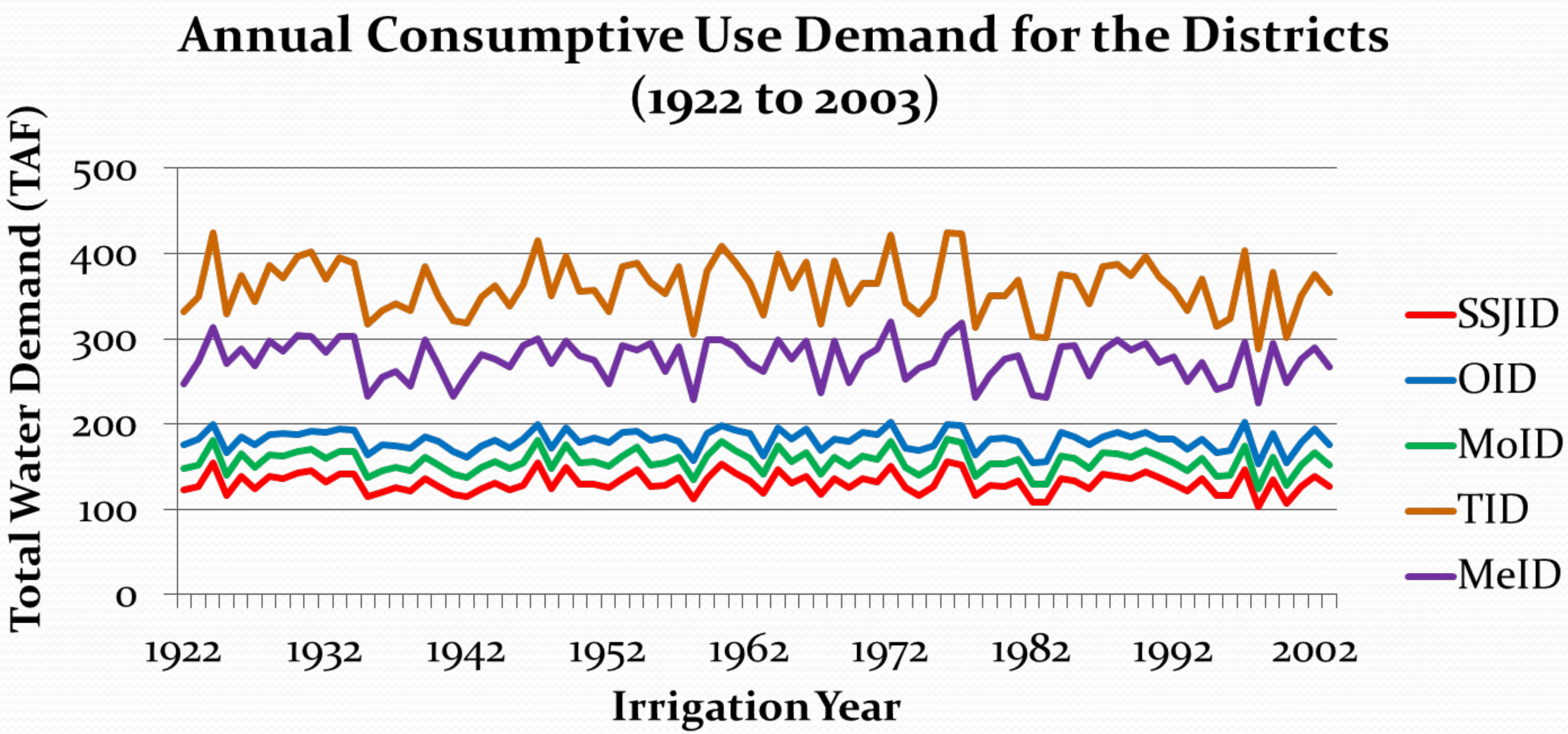
Minimum Groundwater Pumping



- SSJID, OID and MID Minimum Annual Groundwater Pumping based on 2015 Information Response Letters
- TID and MeID Minimum Annual Groundwater Pumping based on District AWMPs

Consumptive Use of Applied Water (CUAW)

- CUAW is the Portion of applied water that supports crop growth through evapotranspiration
- Estimates of CUAW Demand are based on CALSIM II.



Apportioning WSE Surface Water Diversions to the Districts

Apportioning Tributary Diversions to Irrigation Districts

- Where more than one district diverts water from a tributary, it is assumed that each district will receive an equal percent of CUAW (Crop) surface water demands
  - In times of shortage, both districts receive the same shortage relative to demand
- On the Merced River, Merced ID makes 100% of the diversions, but some water is passed to its Sphere of Influence demands
- It is assumed that the two CVP contractors, SEWD and CSJWCD, only receive water from the Stanislaus after SSJID and OID diversions

Terms

- *Total Surface water available for diversion on each Tributary (T)* – $\mathbf{Div_T}$ (From WSE)
- Parameters for each District (Z):
  - *Distribution Loss factor* – $\mathbf{DF_Z}$
  - *Deep Percolation Factor* – $\mathbf{PF_Z}$
  - *Crop (CUAW) demand* – $\mathbf{C_{Dem,Z}}$
  - *Crop surface water delivery* – $\mathbf{C_{SW,Z}}$
  - *Applied water demand* – $\mathbf{AW_{Dem,Z}} = C_{Dem,Z} * (1 + PF_Z)$

"Off the Top" Demands

1) Starting with Div_T, subtract any demands that are assumed to be fully satisfied in all years (these are referred to as "Off the Top" demands)

$$Div_T \;-\sum_{\substack{For\ all\ Z\\ on\ Tributary\ T}}(Reservoir\ Losses_Z + M\&I_Z + Returns_Z \ * (1 + DF_Z))$$

$$- (SOI_{NWR} + SOI_{Stev}) * (1 + DF_Z)$$

$$= DivF_T$$

Where DivF_T = the water available to meet farm demands, or "Farm Diversion"

Farm Diversions

2) These remaining diversions are used to satisfy district crop demands, as well as the associated deep percolation and distribution losses. Therefore:

$$DivF_T = \sum_{\substack{For\ all\ Z \\ on\ Tributary\ T}} \left(C_{SW,Z} * (1 + PF_Z) * (1 + DF_Z) \right)$$

3) For the Tuolumne and Stanislaus, it is assumed that diversions are divided between the districts so that both districts meet the same percentage of crop surface water demand ($C_{SWDem,Z}$)

$$C_{SW,Z} = C_{SWDem,Z} * X_T$$

Where X_T = the % of the crop surface water demand met

Crop Surface Water Demand

4) The crop surface water demand ($C_{SWDem,Z}$) is the CUAW demand that remains after accounting for any minimum groundwater pumping in the district.

$$ASW_{Dem,Z} = AW_{Dem,Z} - MinGW_Z$$

Where $ASW_{Dem,Z}$ = the applied surface water demand

$$C_{SWDem,Z} * (1 + PF_Z) = C_{Dem,Z} * (1 + PF_Z) - MinGW_Z$$

$$C_{SWDem,Z} = C_{Dem,Z} - \frac{MinGW_Z}{1 + PF_Z}$$

% of Crop Surface Water Demand Met

5) Combining the equations, the only unknown term is X_T

$$DivF_T = \sum_{\substack{For\ all\ Z \\ on\ Tributary\ T}} \left((C_{SWdem,Z} * X_T) * (1 + PF_Z) * (1 + DF_Z) \right)$$

6) Since X_T is the same for all districts on tributary T, it can be pulled out of the summation. Rearranging the equation becomes:

$$X_T = \frac{DivF_T}{\sum \left((C_{SWdem,Z}) * (1 + PF_Z) * (1 + DF_Z) \right)}$$

7) Finally, solve for the surface water delivery for consumptive use

$$C_{SW,Z} = C_{SWDem,Z} * X_T$$

Groundwater Replacement of Surface Water Shortage

Replacement Groundwater Pumping

It is assumed that in times of surface water shortage, districts increase groundwater pumping to compensate

Increased groundwater pumping:

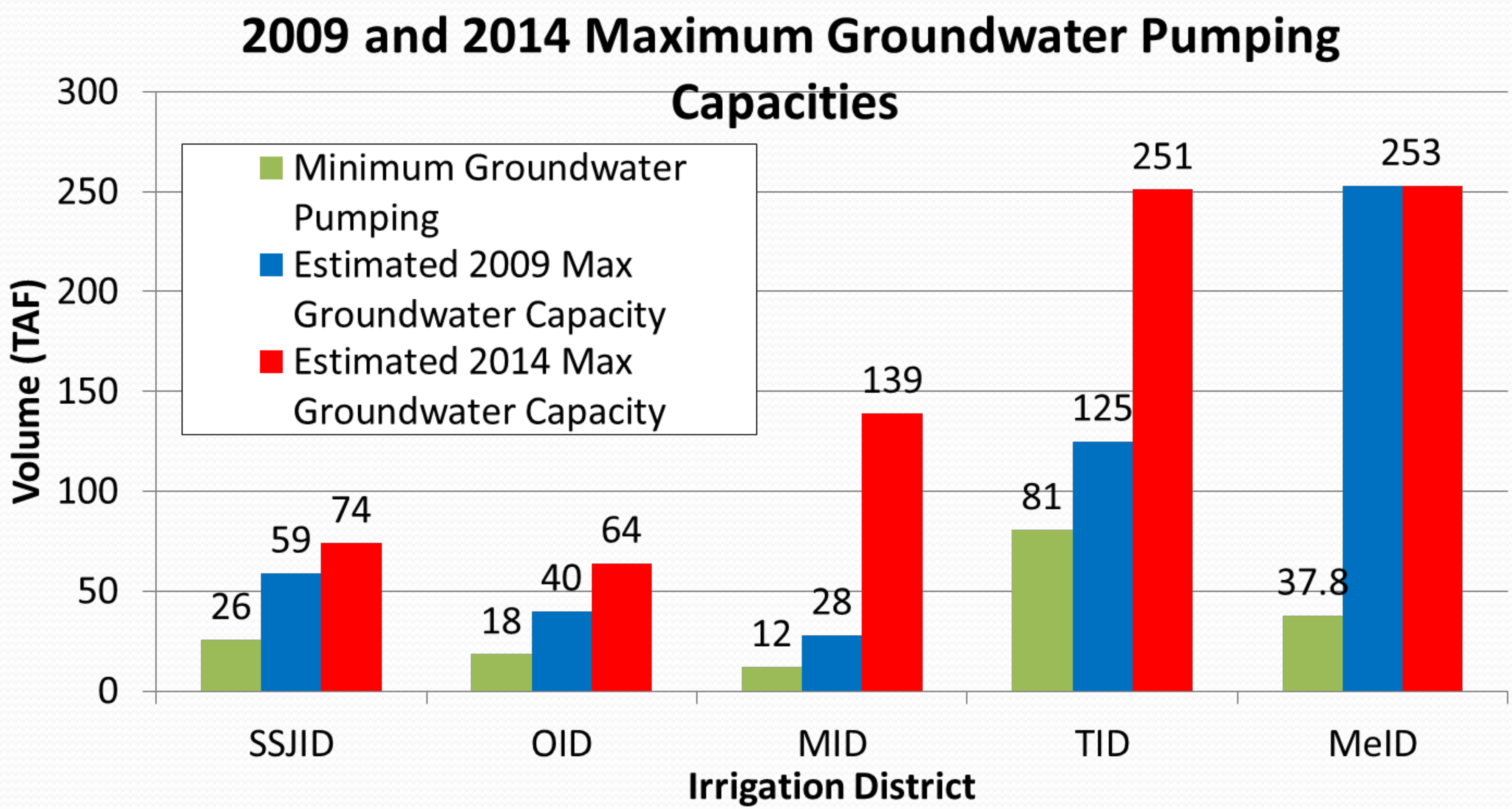
$$AddGW_D = MIN\left((AW_{Dem,Z} - ASW_Z - MinGW_Z), (MaxGW_Z - MinGW_Z)\right)$$

A high value for maximum groundwater pumping can reduce agricultural impacts, but it increases the potential for groundwater impacts.

2009 vs 2014 GW Use Scenarios

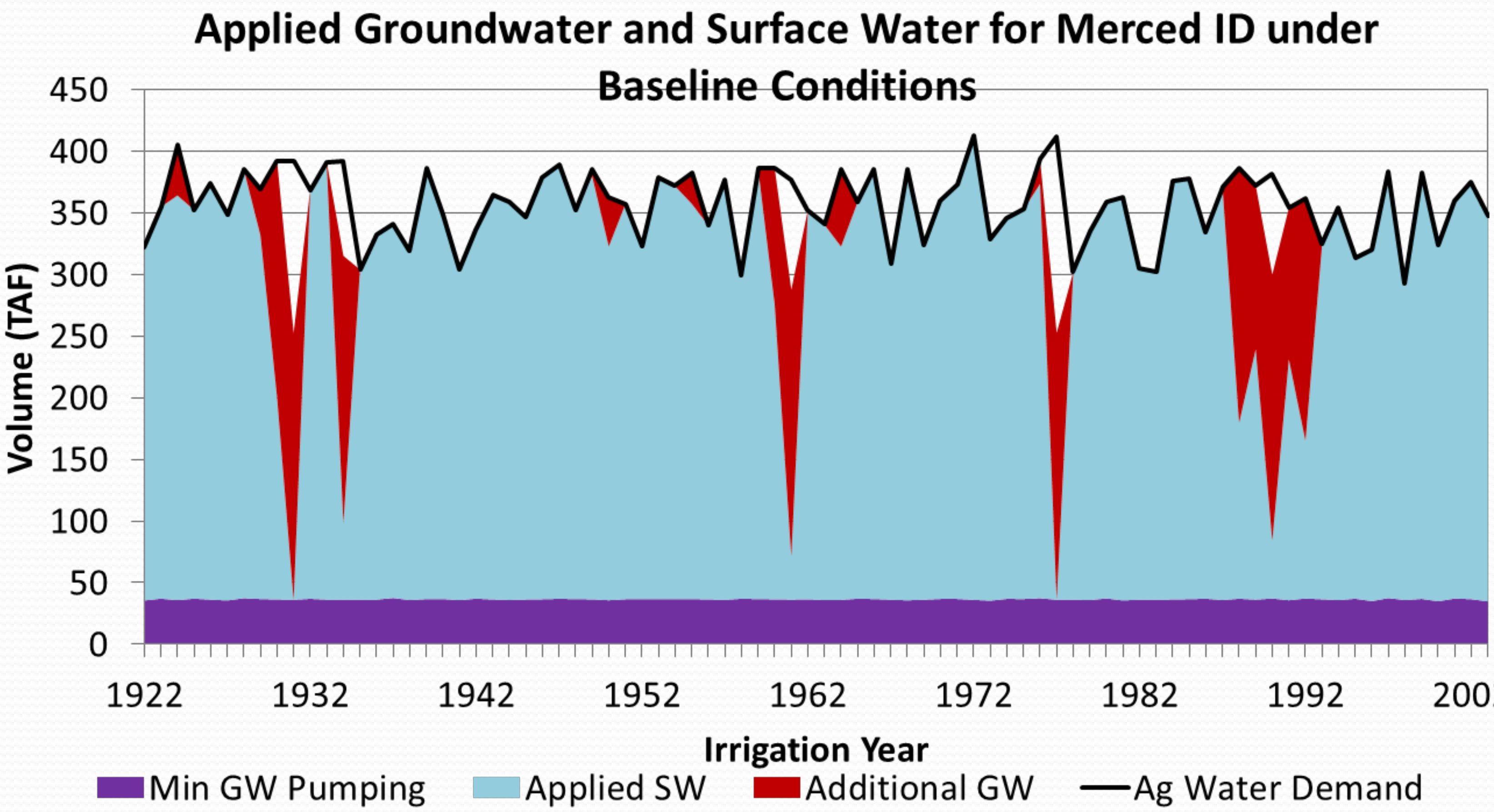
- District Groundwater pumping capacities as of 2009
  - 2009 corresponds to the initial notice of preparation of the SED
  - Irrigation District capacities based on 2012 AWMPs
  - SEWD and CSJWCD are assumed to fully replace Stanislaus river water supply
- District Groundwater pumping capacities as of 2014
  - Increase in wells drilled between 2013 and 2015
  - SSJID, OID, MID, and TID capacities based on 2015 information request response letters
- 2009 scenario used for impact determinations in SED

Maximum Groundwater Pumping Capacities

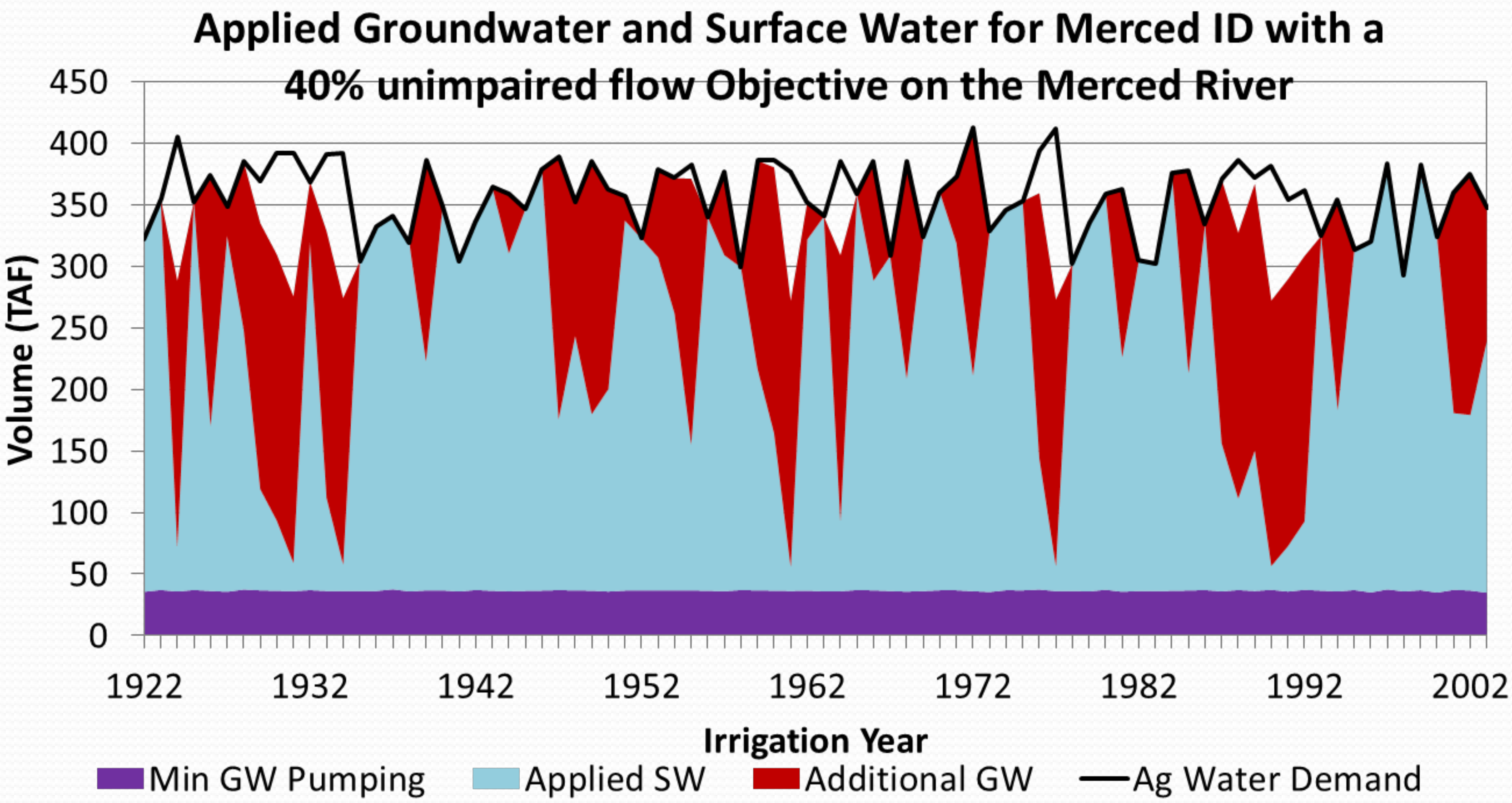


Results of the Groundwater Assessment

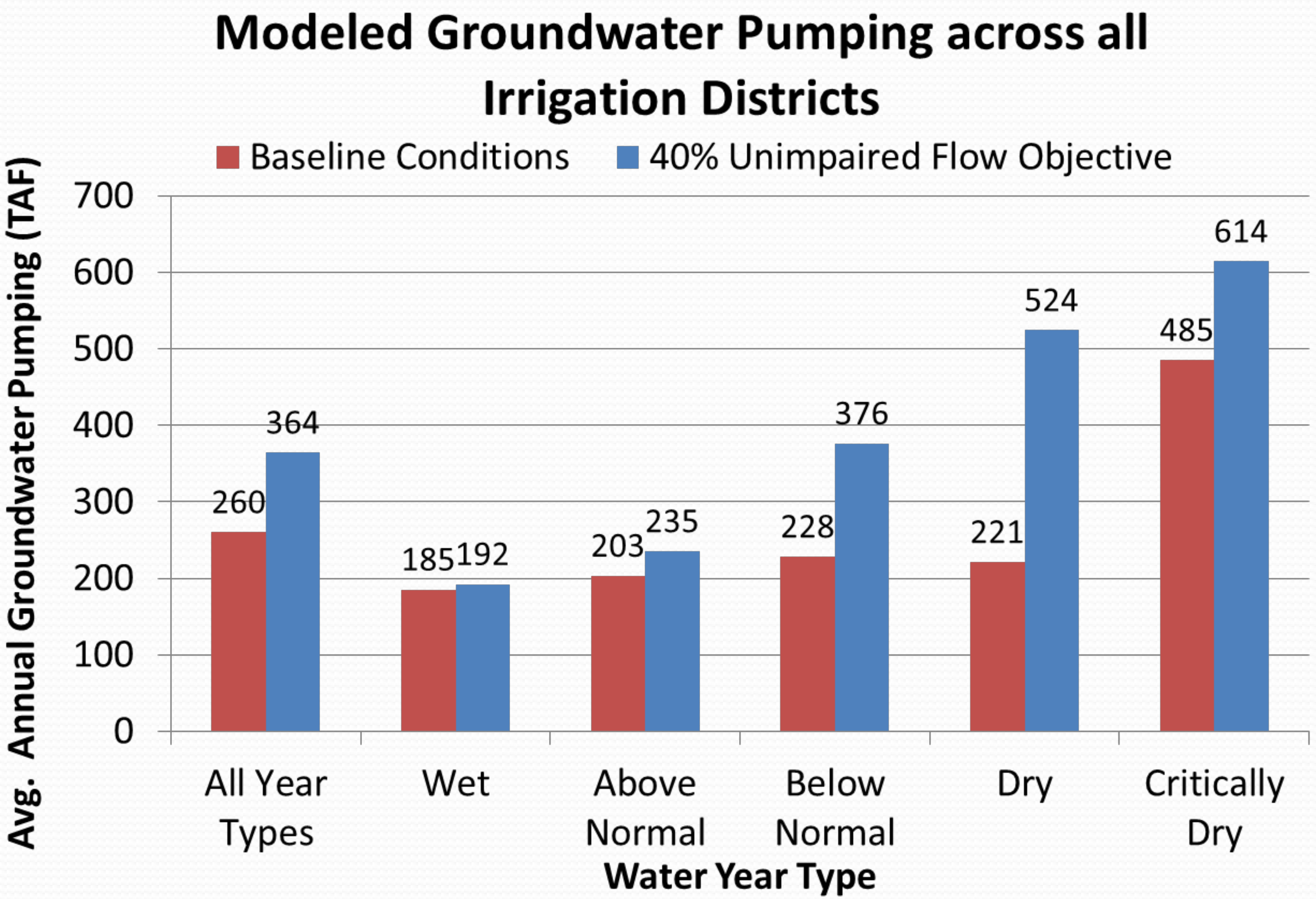
Applied Surface Water and Groundwater for Merced ID under Baseline



Applied Surface Water and Groundwater for Merced ID under the 40% Alternative

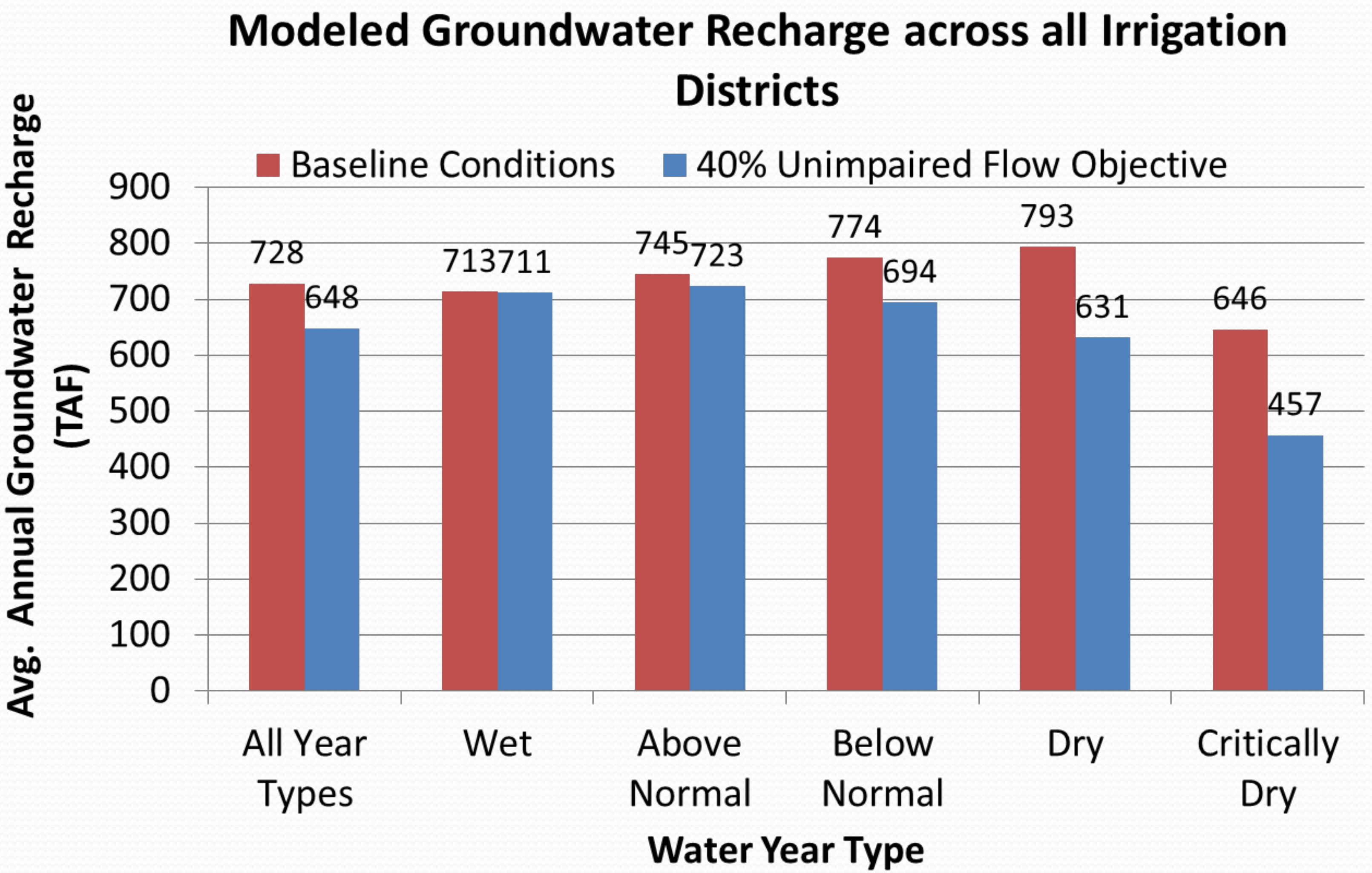


Average Annual Groundwater Pumping

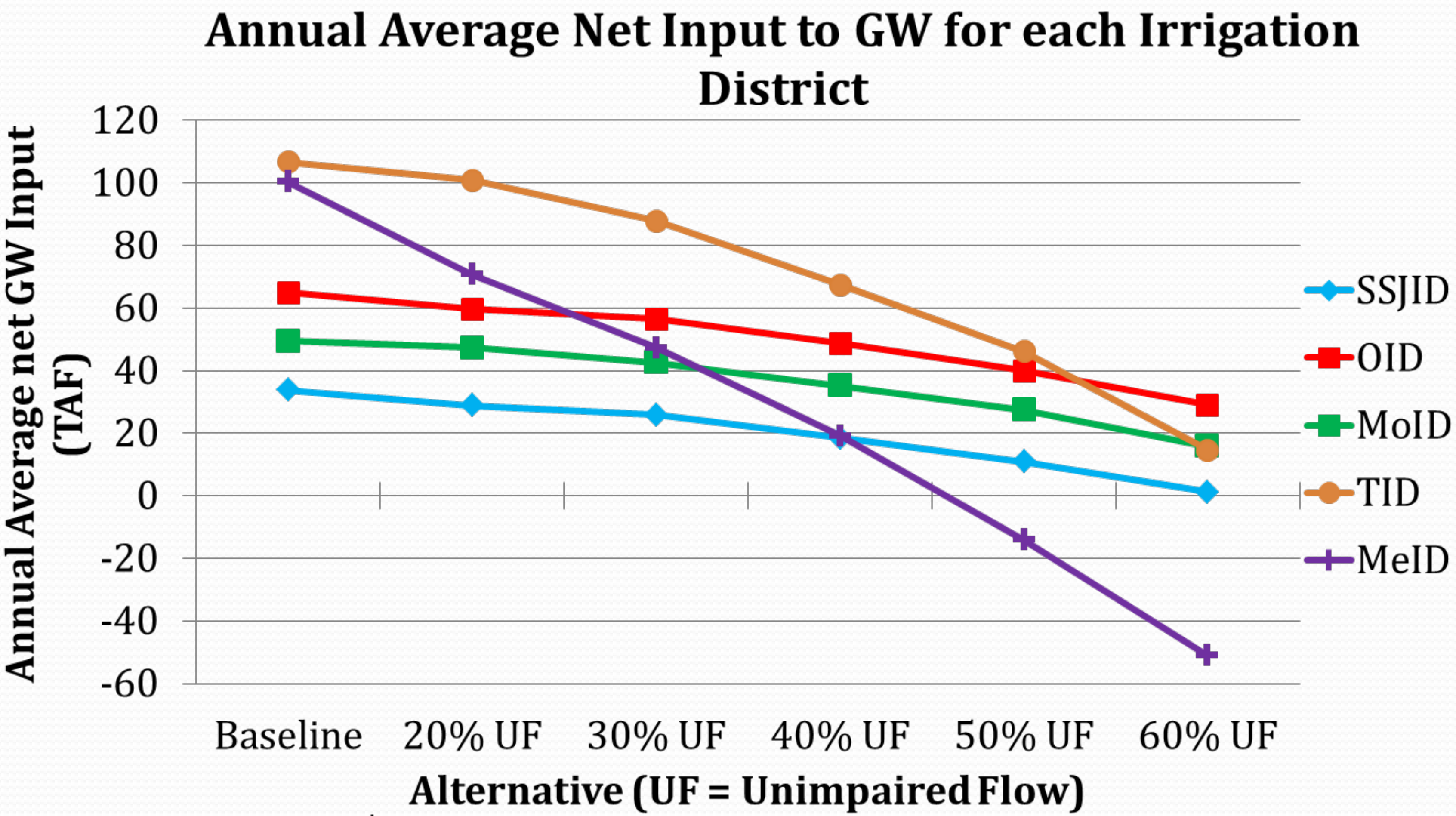


Estimated 2009 Plan Area Maximum Groundwater Pumping Capacity = 626 TAF/y

Average Annual Groundwater Recharge



GW Net Input within Irrigation Districts



Positive Input = Net GW recharge

Further Information

- More information on these topics can be found in the following chapters and appendices of the SED:
  - Chapter 9, *Groundwater Resources*
  - Appendix G, *Agricultural Economic Effects of the Lower San Joaquin River Flow Alternatives: Methodology and Modeling Results*
- These chapters, as well as the Groundwater and Surface Water Use Analysis spreadsheet, can be found at:

http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2016_sed/index.shtml.