

Sustainable Management Criteria

- Chronic Lowering of Groundwater Levels
 - Representative monitoring networks
 - Recommended MTs and MOs
 - Groundwater dependent ecosystems and data gaps
- Interconnected Surface Water Depletions
 - Recommended representative network
 - Recommended MTs and MOs
 - Data gaps and plan to fill
- Change in Storage
 - Monitored by proxy using levels
- Seawater Intrusion
 - Not applicable to Subbasin
- Degraded Water Quality
 - Recommend new network in deep aquifer
- Inelastic Land Subsidence
 - Representative monitoring network
 - Recommended MTs and MOs

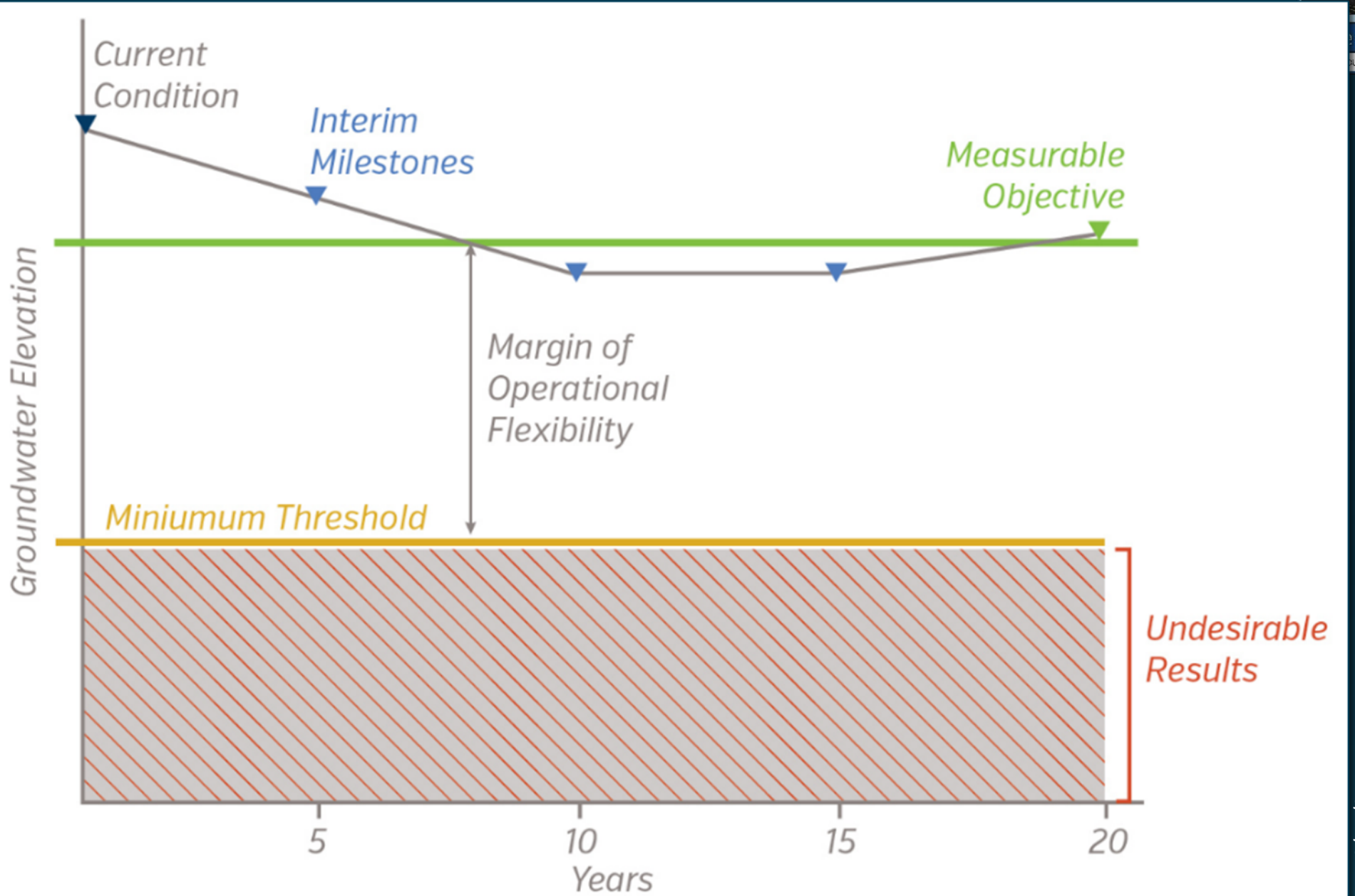
Sustainable Groundwater Management Act Terms

Acronyms

- UR = Undesirable Result
- MT = Minimum Threshold
- MO = Measurable Objective
- MoOF = Margin of Operational Flexibility
- SI = Sustainability Indicator
- bgs = below ground surface
- IM = Interim Milestone
- PMAs = Projects and Management Actions

Example:

(Current Conditions Sustainable)

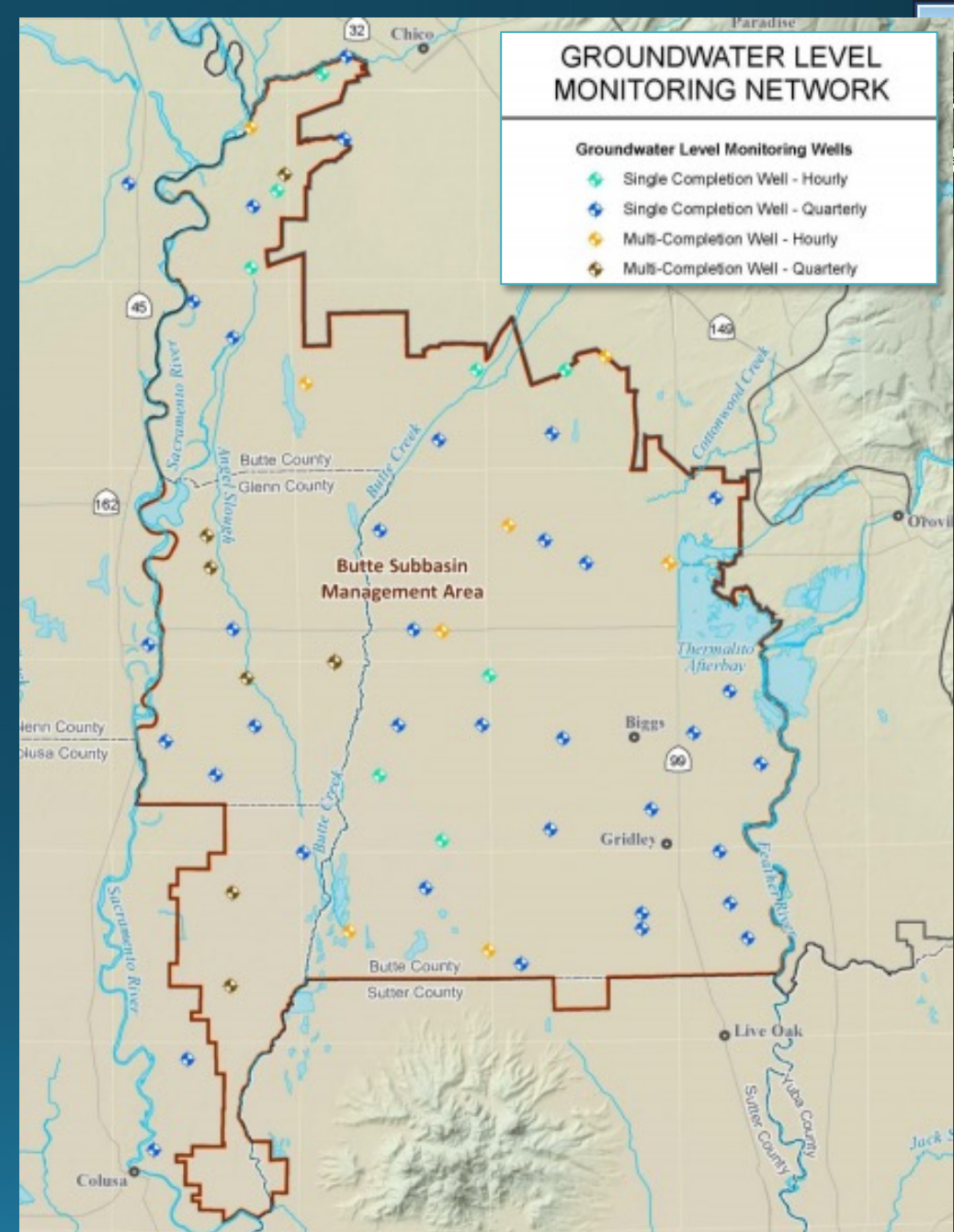


Chronic Lowering of Groundwater Levels

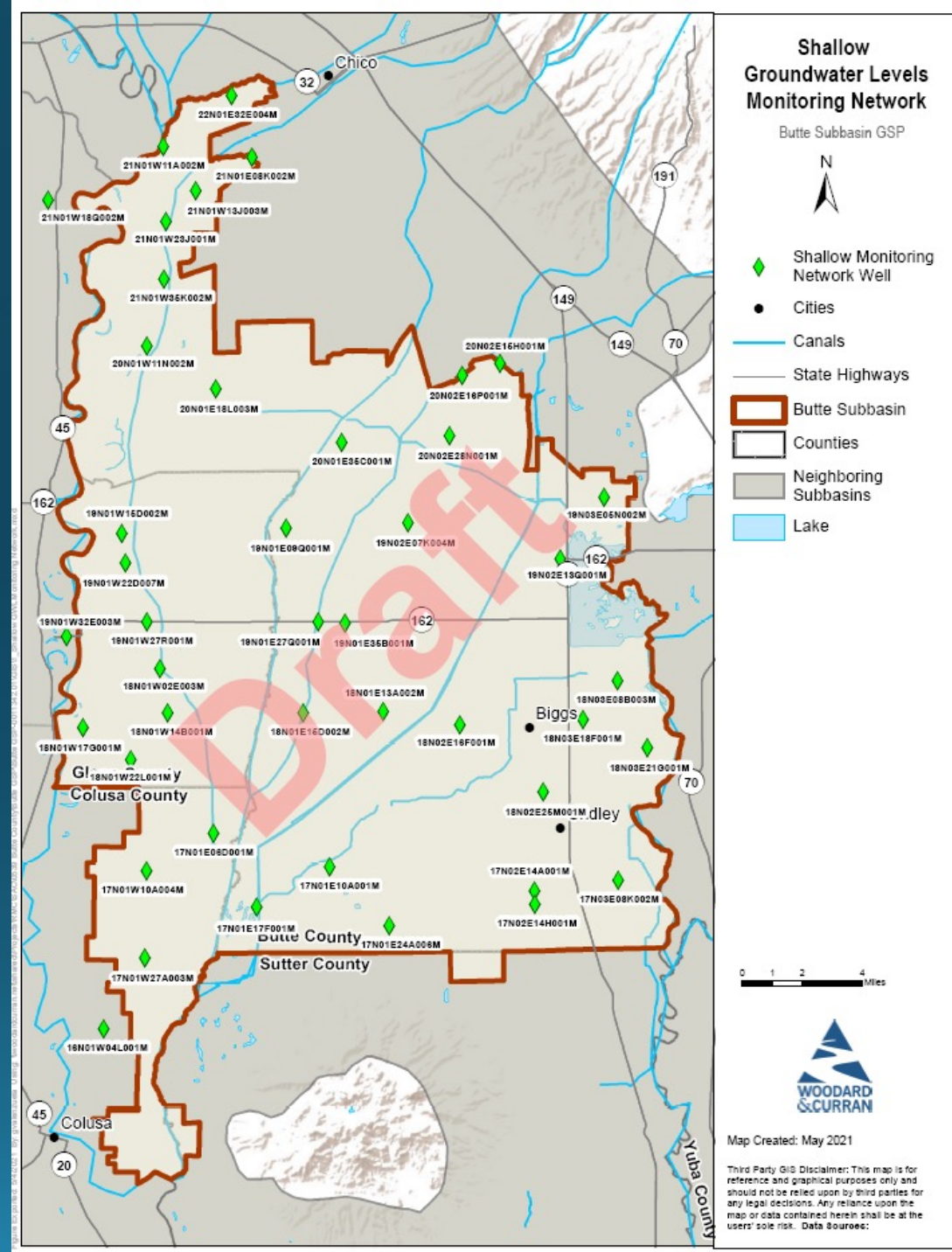
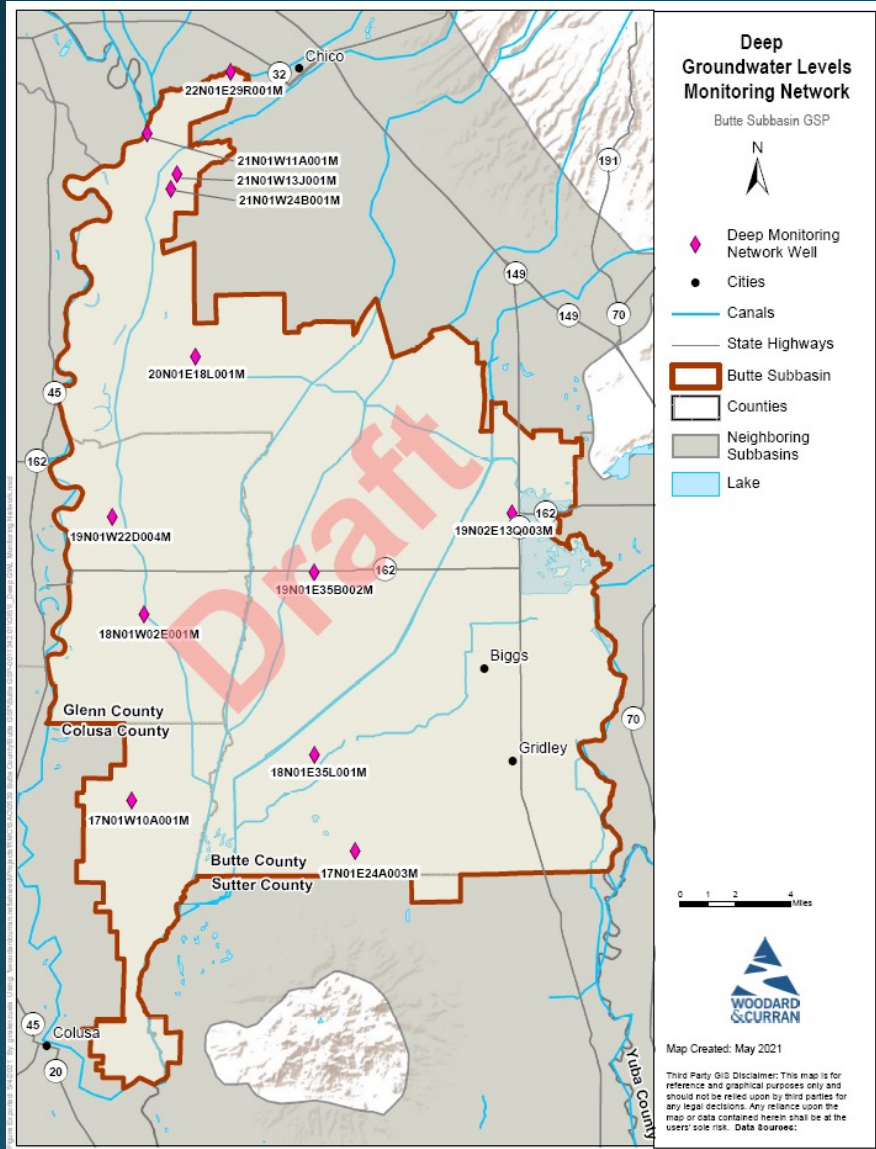
Representative Networks
Minimum Thresholds
Measurable Objectives

Groundwater Levels Monitoring Network

- Refined into to a representative network for shallow and deep aquifers
- Selected 1 completion per cluster well for shallow aquifer
- Selected 1 completion per cluster well for deep aquifer



Groundwater Levels Representative Networks

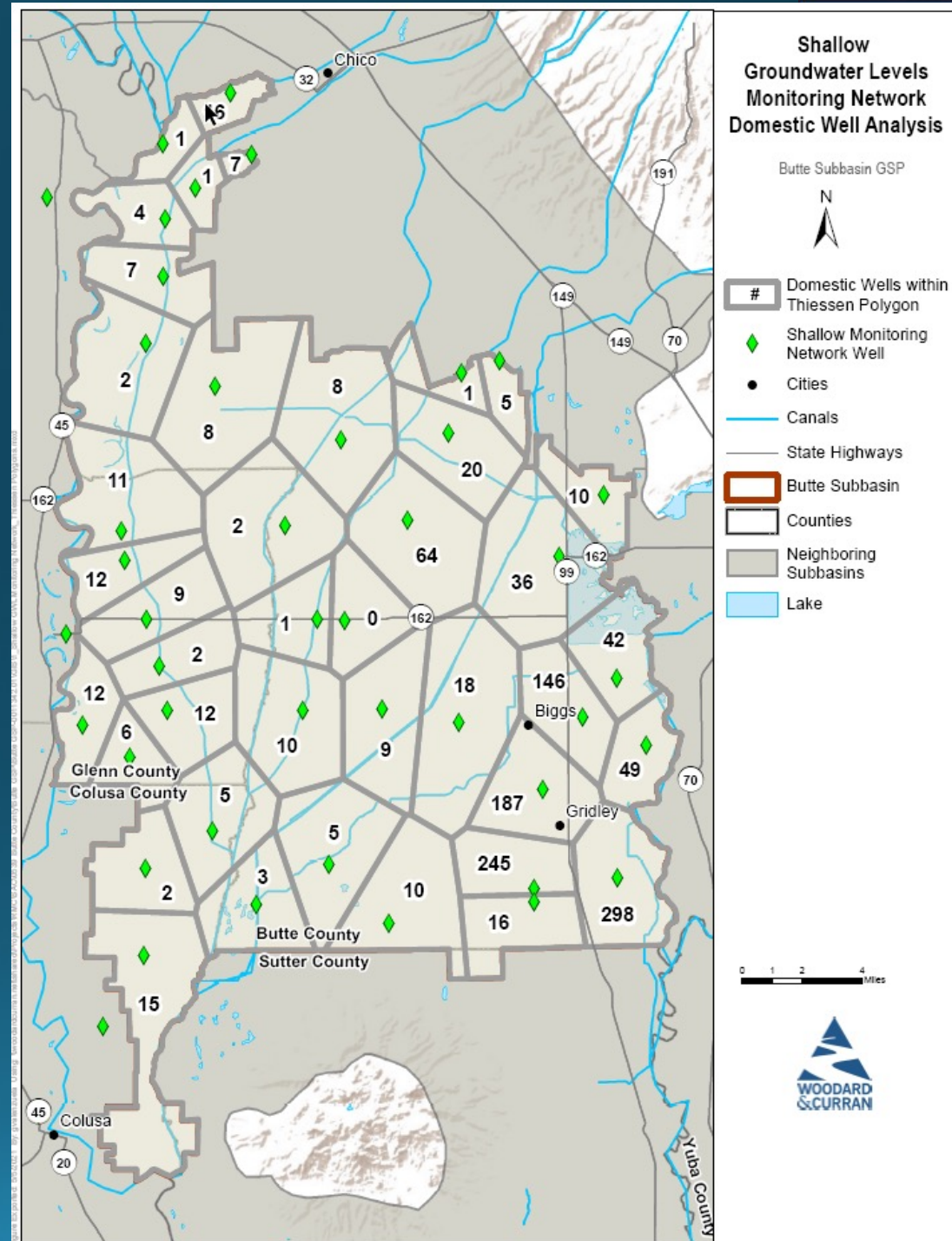
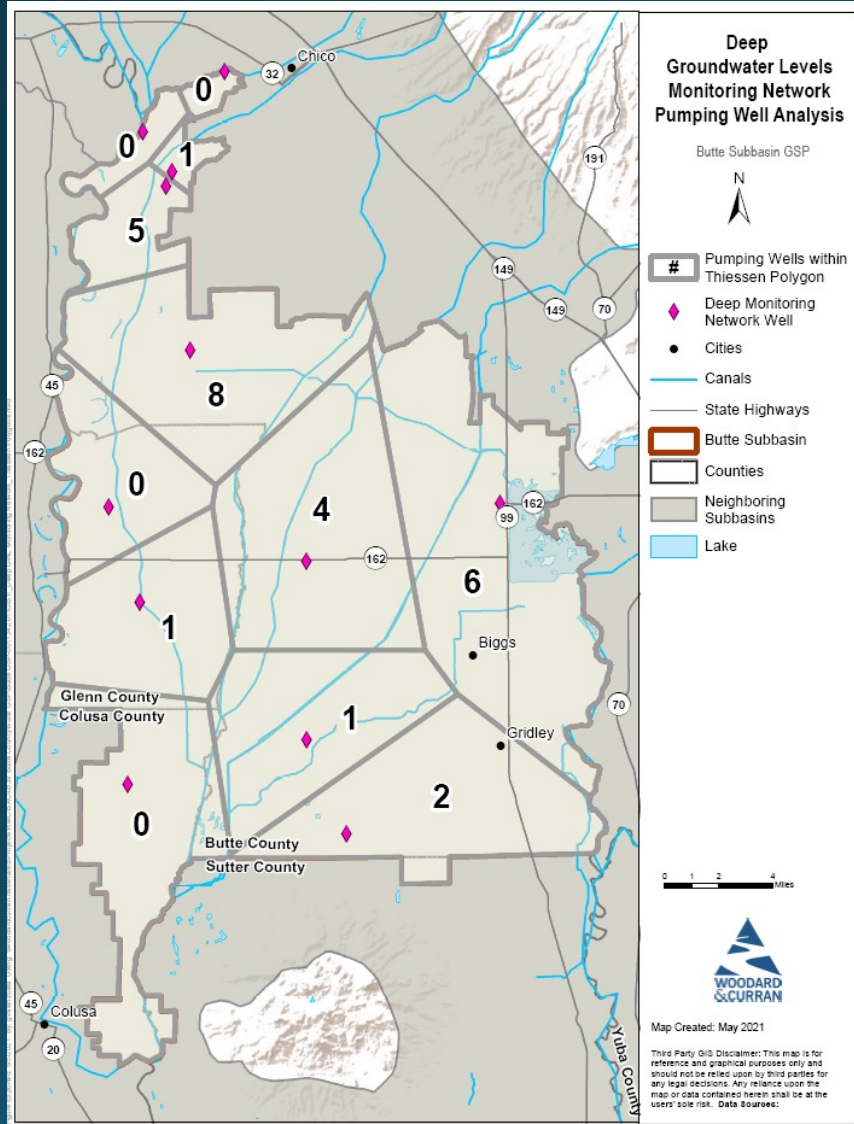


Groundwater Levels

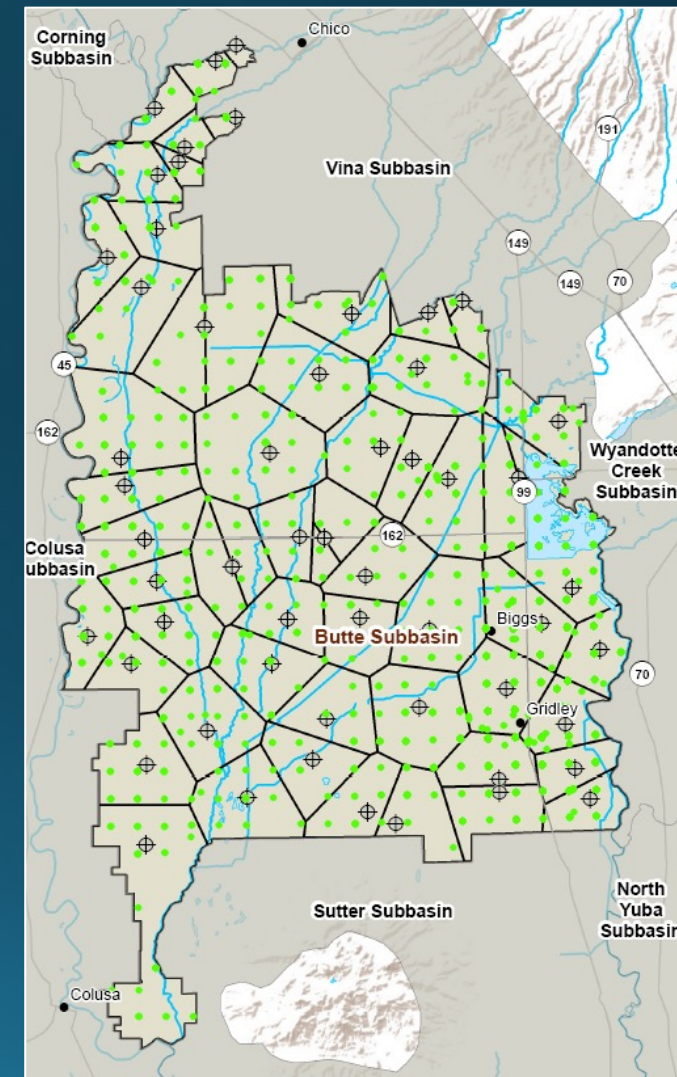
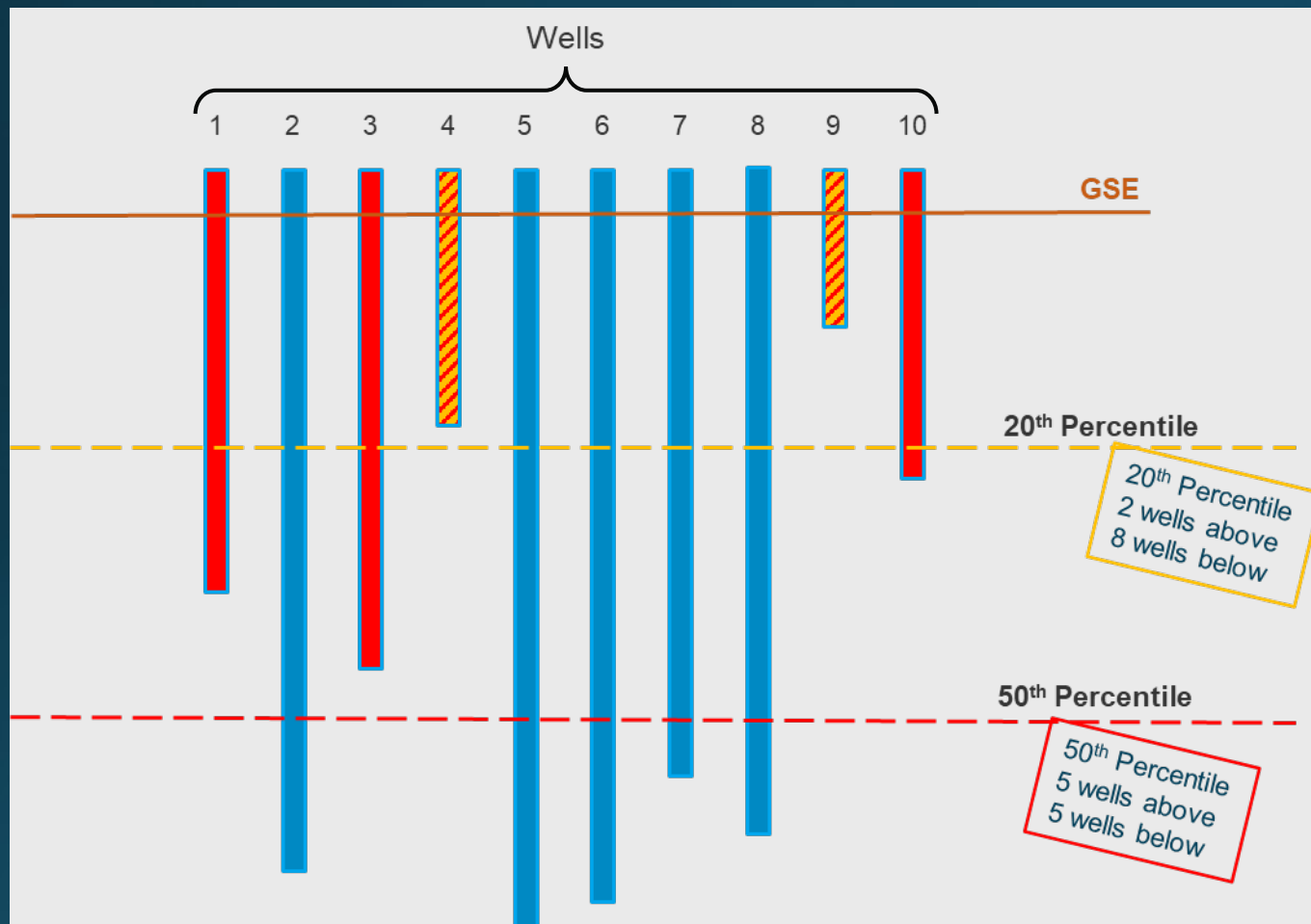
Minimum Threshold and Measurable Objective

- Minimum Thresholds - Two step process:
 - Step 1: Use the shallower of 100% of range below the historical low or the shallowest 7% of nearby wells
 - Step 2: Use the deeper of step 1, or the historical low
- Measurable Objective
 - Use the average of measurements from the last 5 measured years

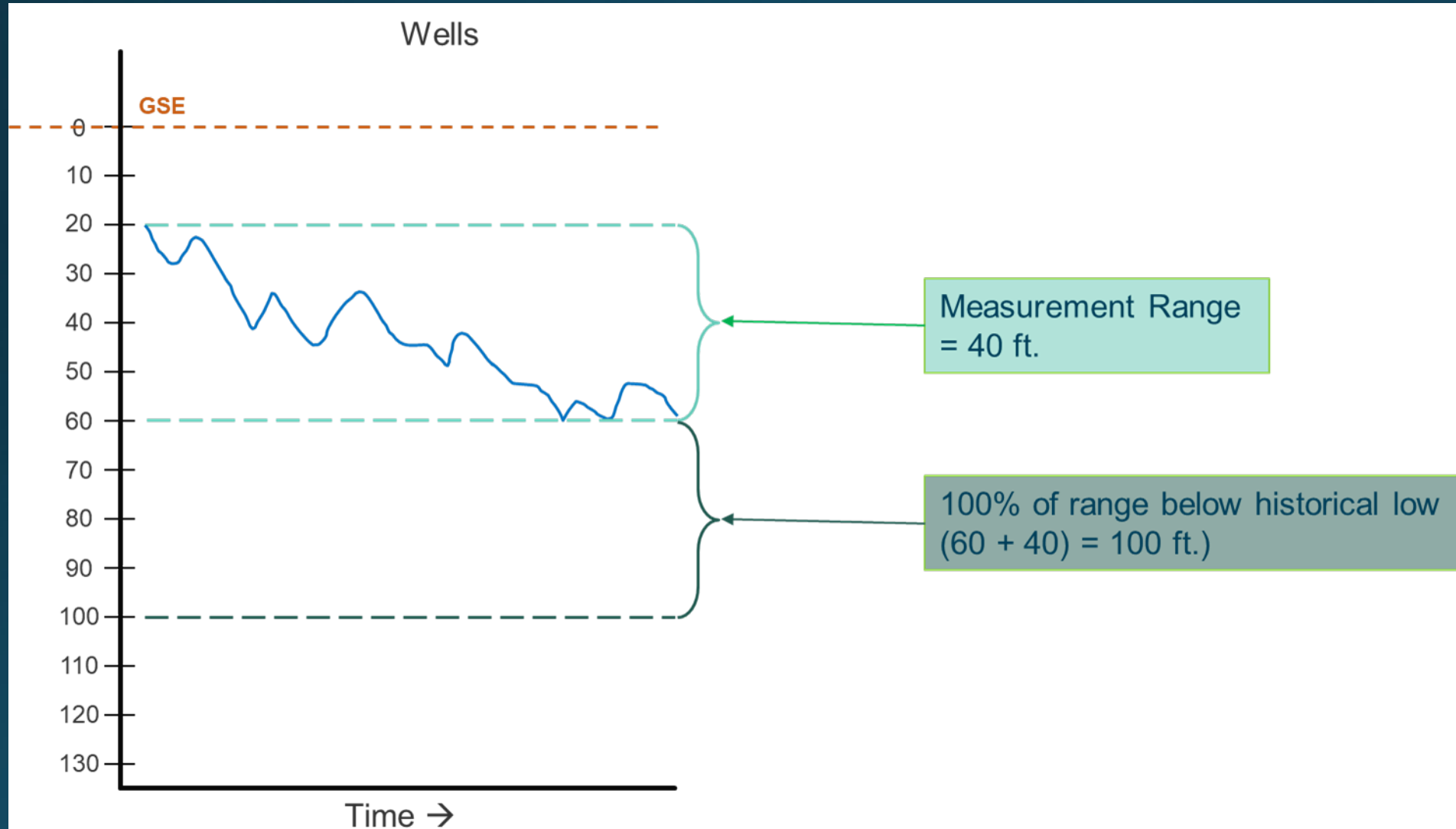
Groundwater Levels Theissen Polygons



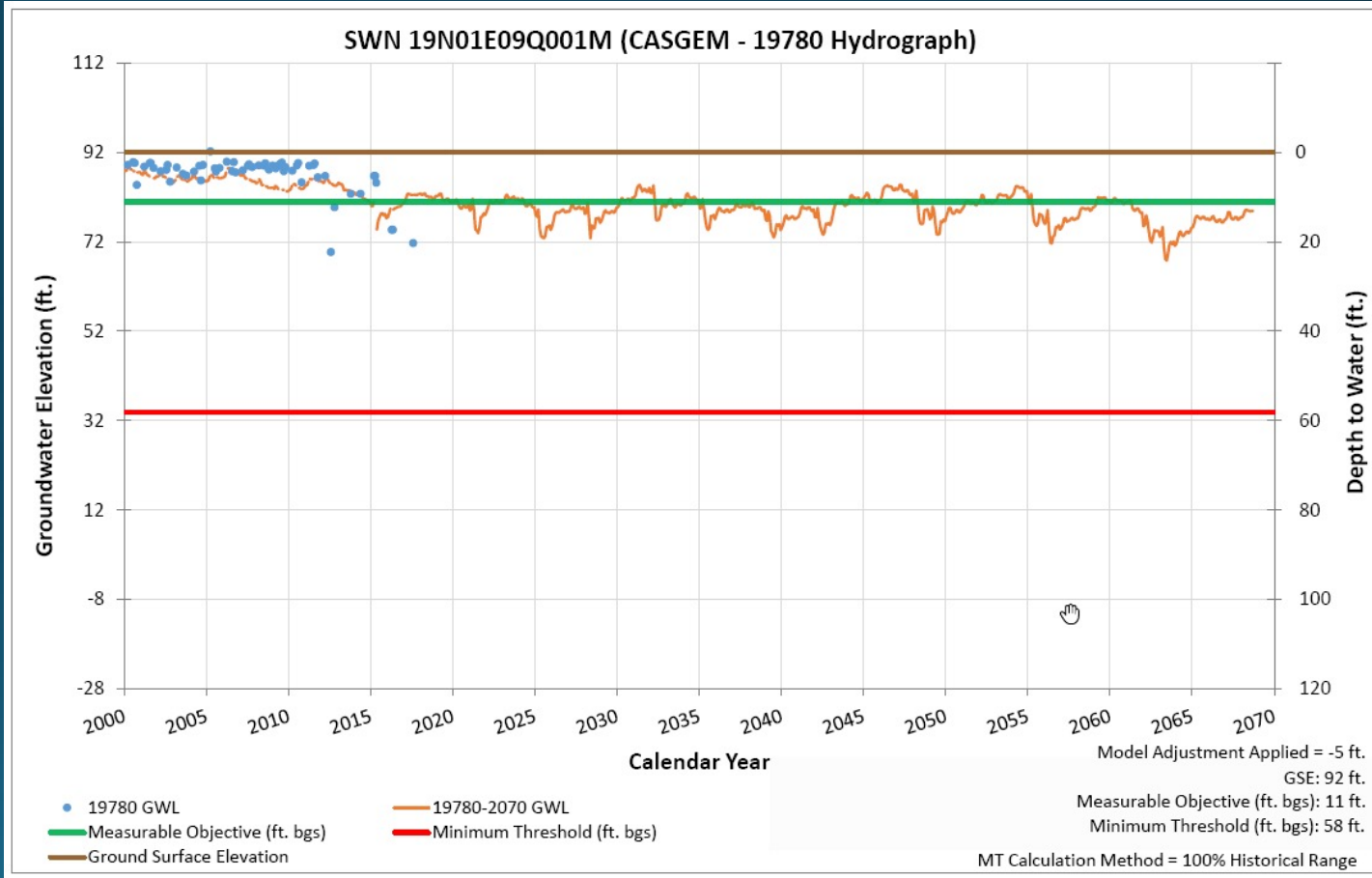
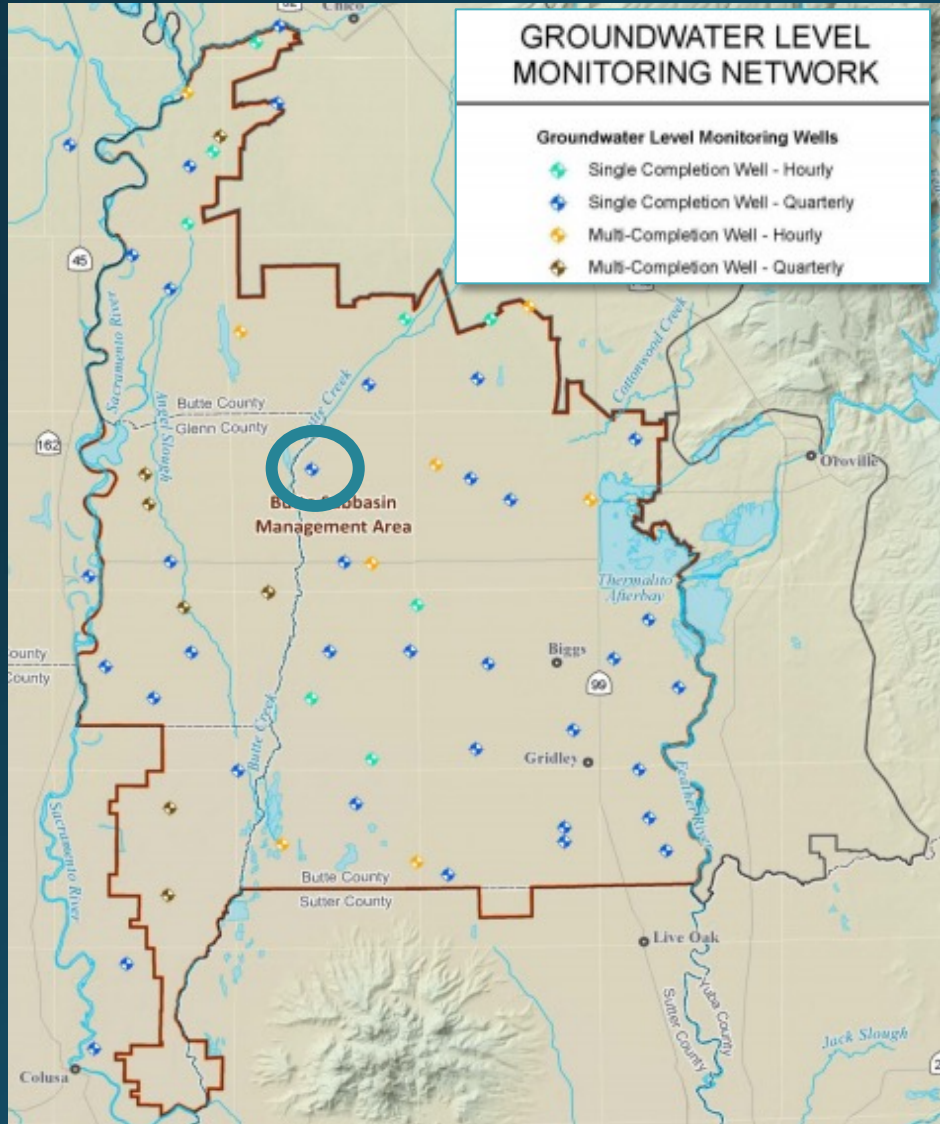
Understanding Well Depth Percentiles Groundwater Levels



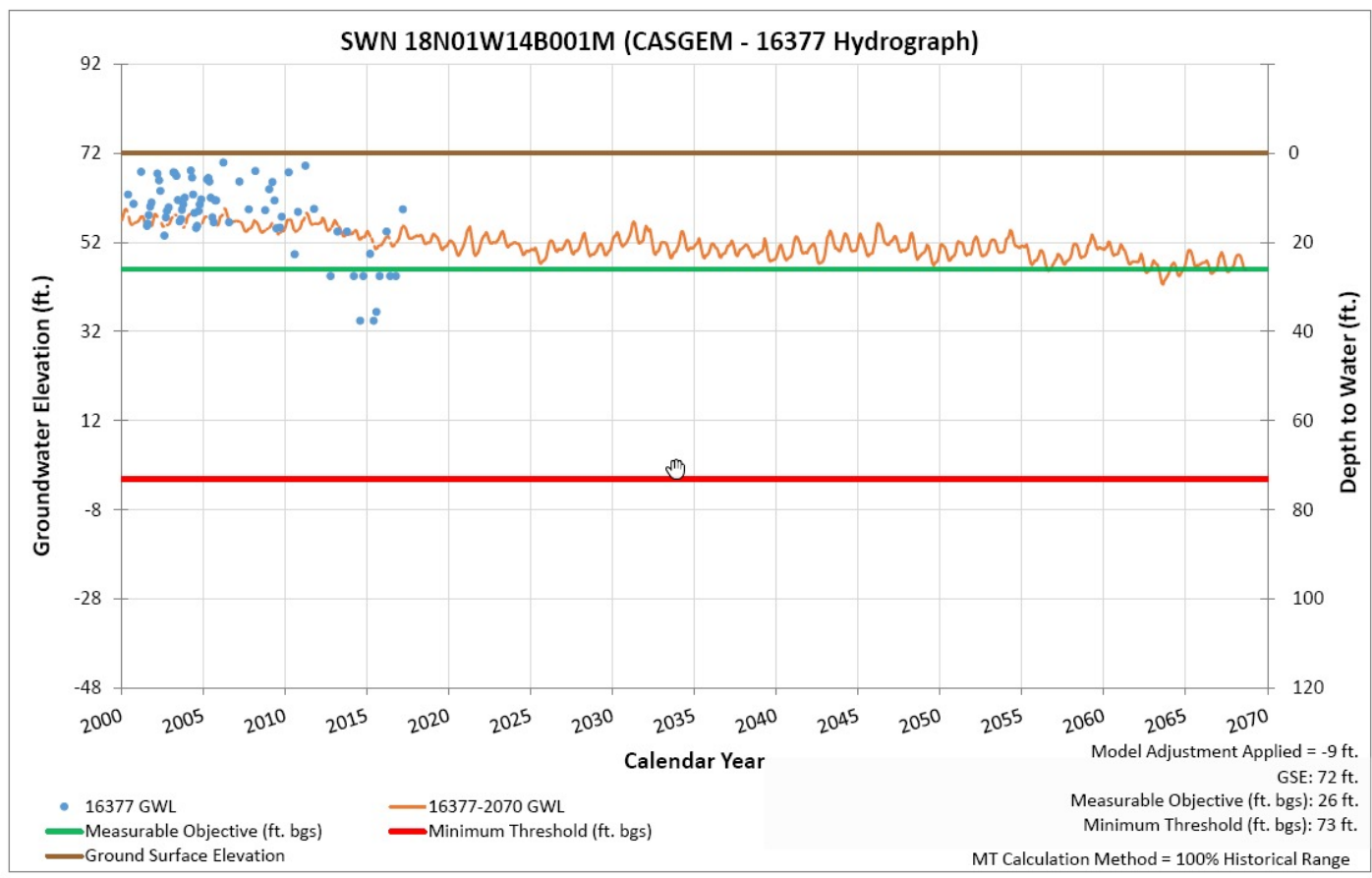
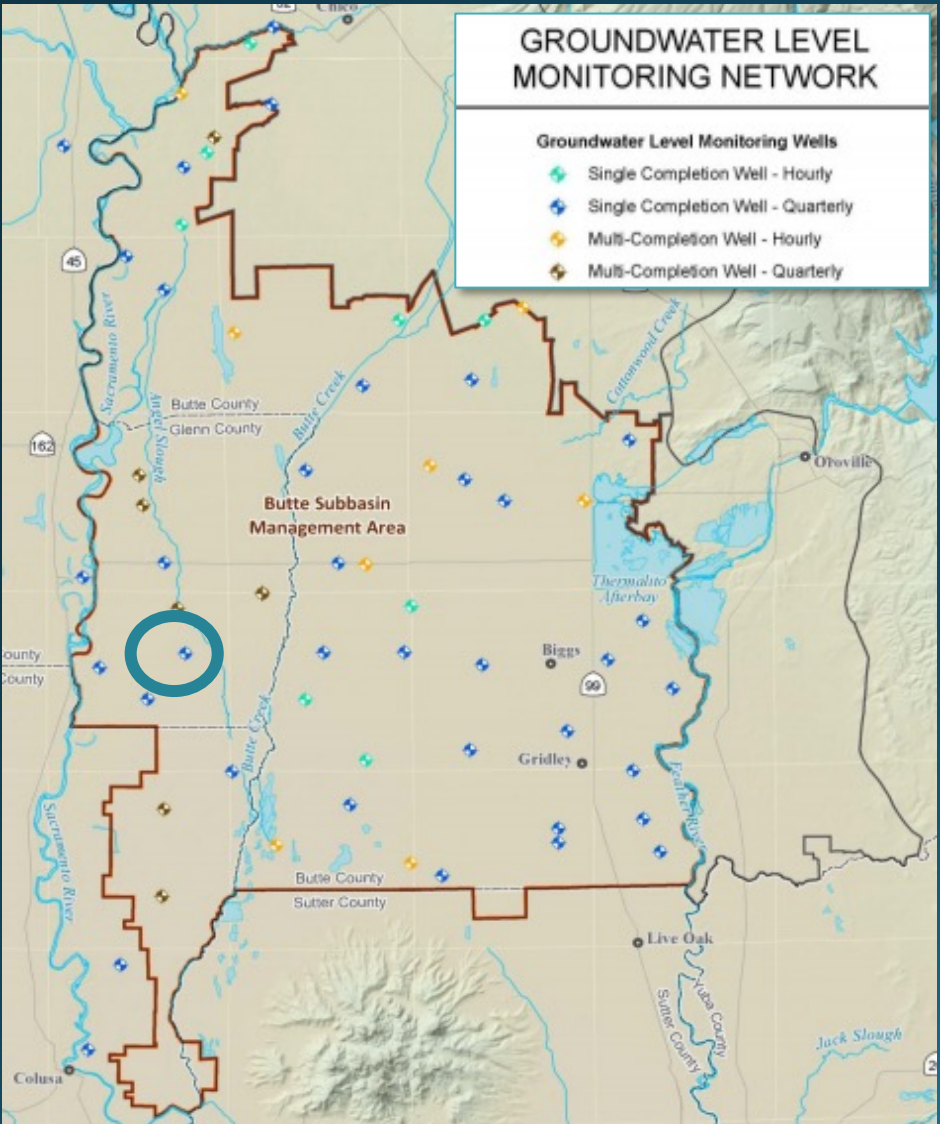
Percent of Range Groundwater Levels



Example Hydrographs and Minimum Threshold Considerations



Example Hydrographs and Minimum Threshold Considerations



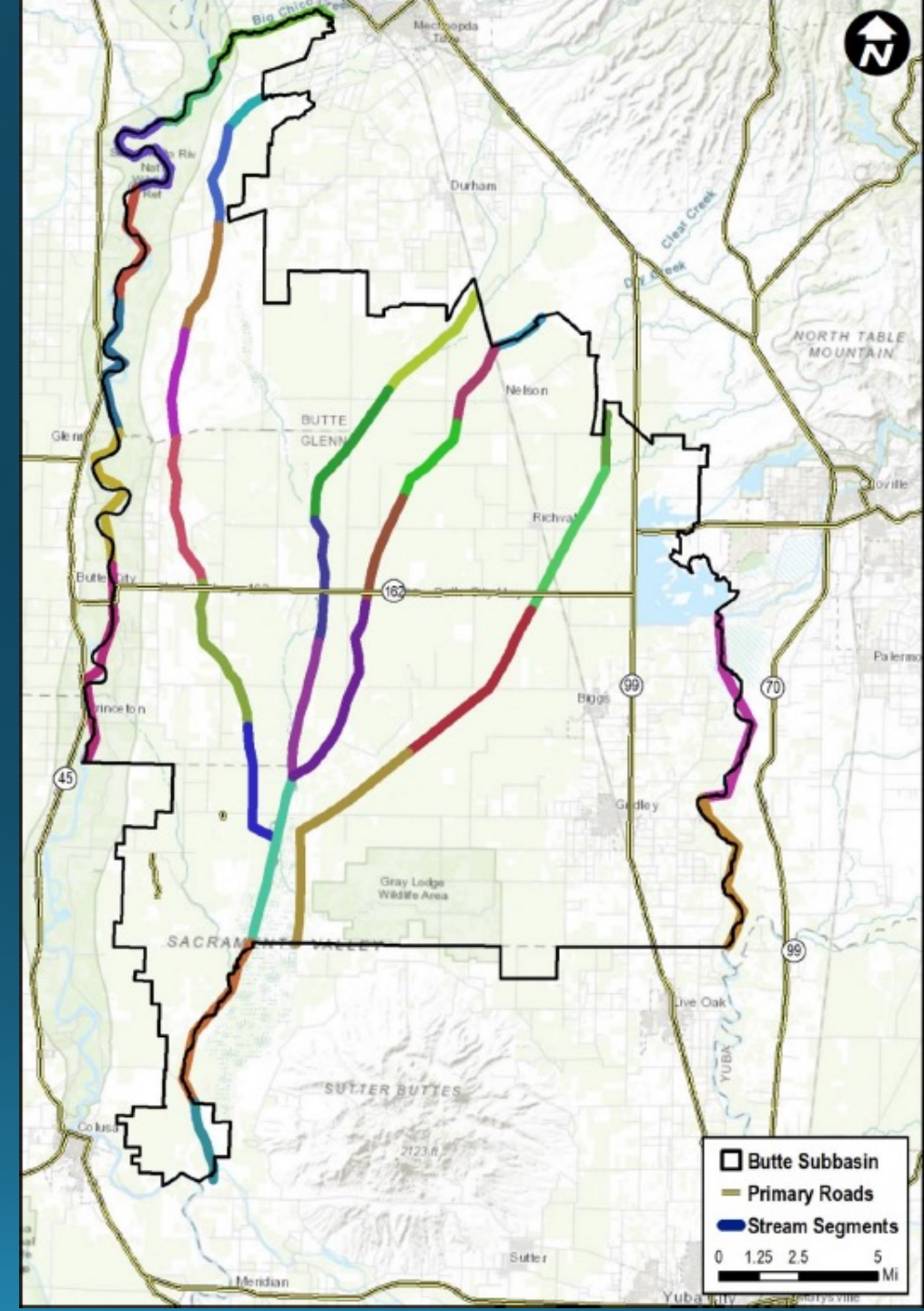
Groundwater Levels Recommendations

- Use Representative Networks for Shallow and Deep Aquifers
- Set Minimum Thresholds - Two step process:
 - Step 1: Use the shallower of 100% of range (or 20 feet, whichever is greater) below the historical low or the shallowest 7% of nearby wells
 - Step 2: Use the deeper of step 1, or the historical low + 10 feet
- Set Measurable Objectives:
 - Use the average of measurements from the last 5 measured years
- UR Detection = 25% (3 of 12 wells in deep aquifer representative monitoring wells, 11 of 41 wells in shallow aquifer representative monitoring network) fall below the minimum threshold for 24 consecutive months

Depletions of Interconnected Surface Water Monitoring Networks Threshold Considerations

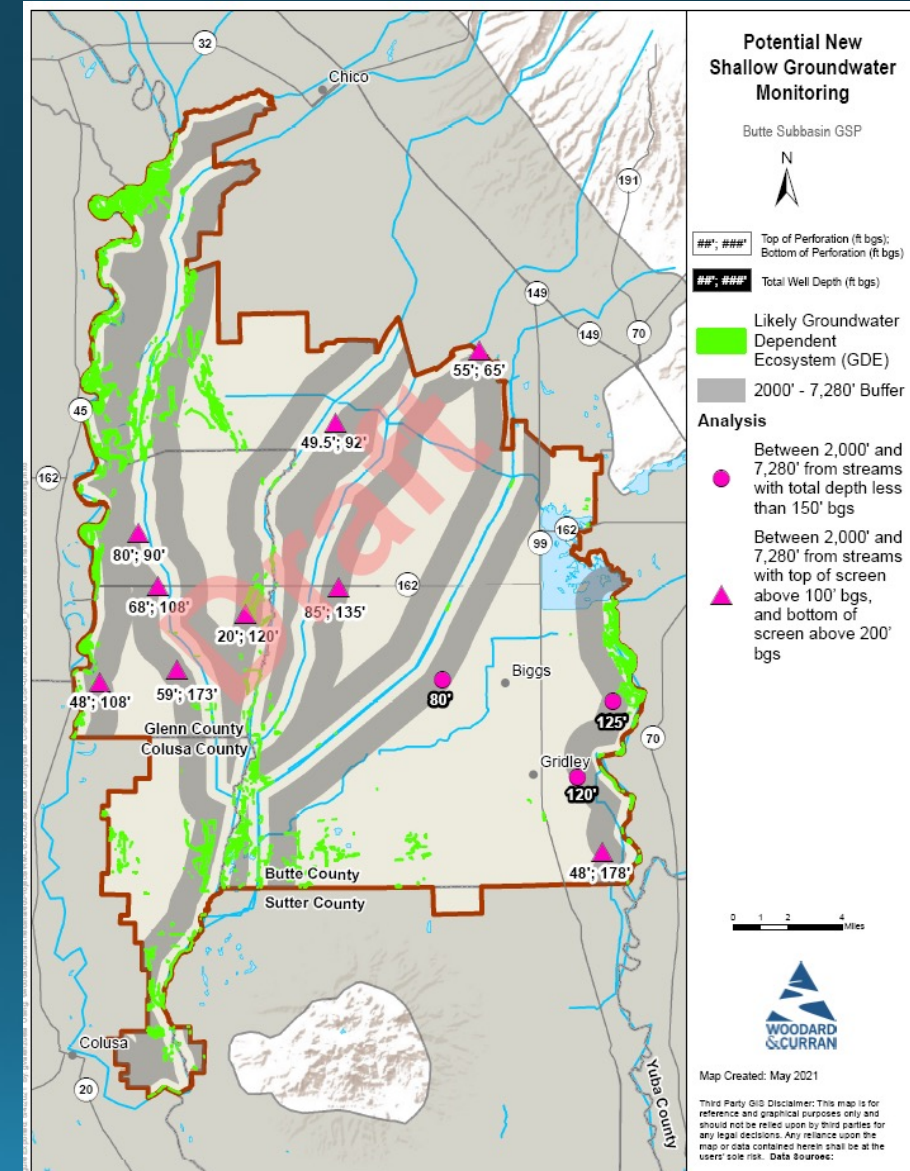
Depletions of Interconnected Surface Water Recommendations

- Focus on key water bodies:
 - Sacramento River
 - Feather River
 - Butte Creek
 - Little Dry Creek, Dry Creek, Angel Slough



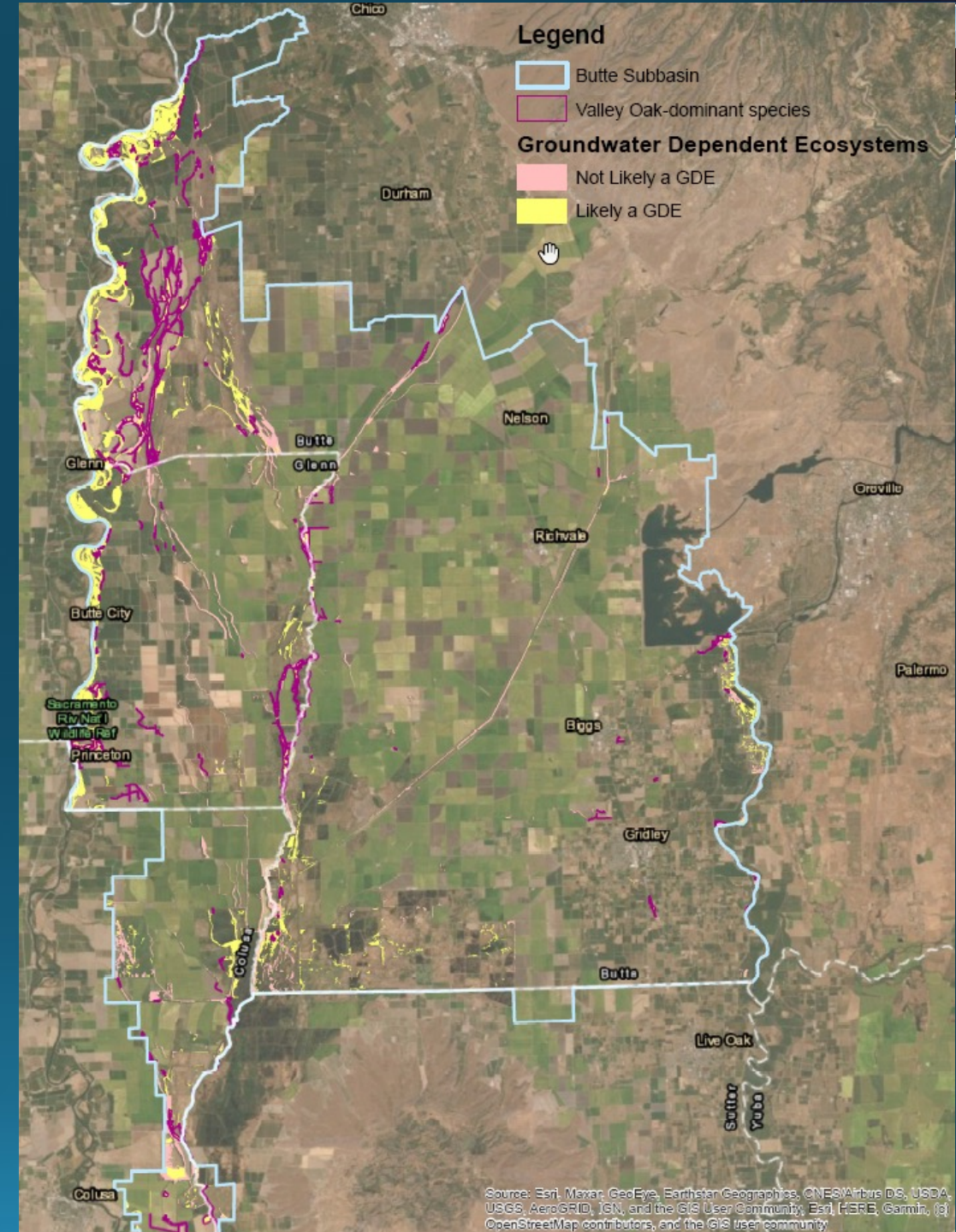
Depletions of Interconnected Surface Water

- Comparison of shallower monitoring wells, surface water proximity, and probable GDE locations



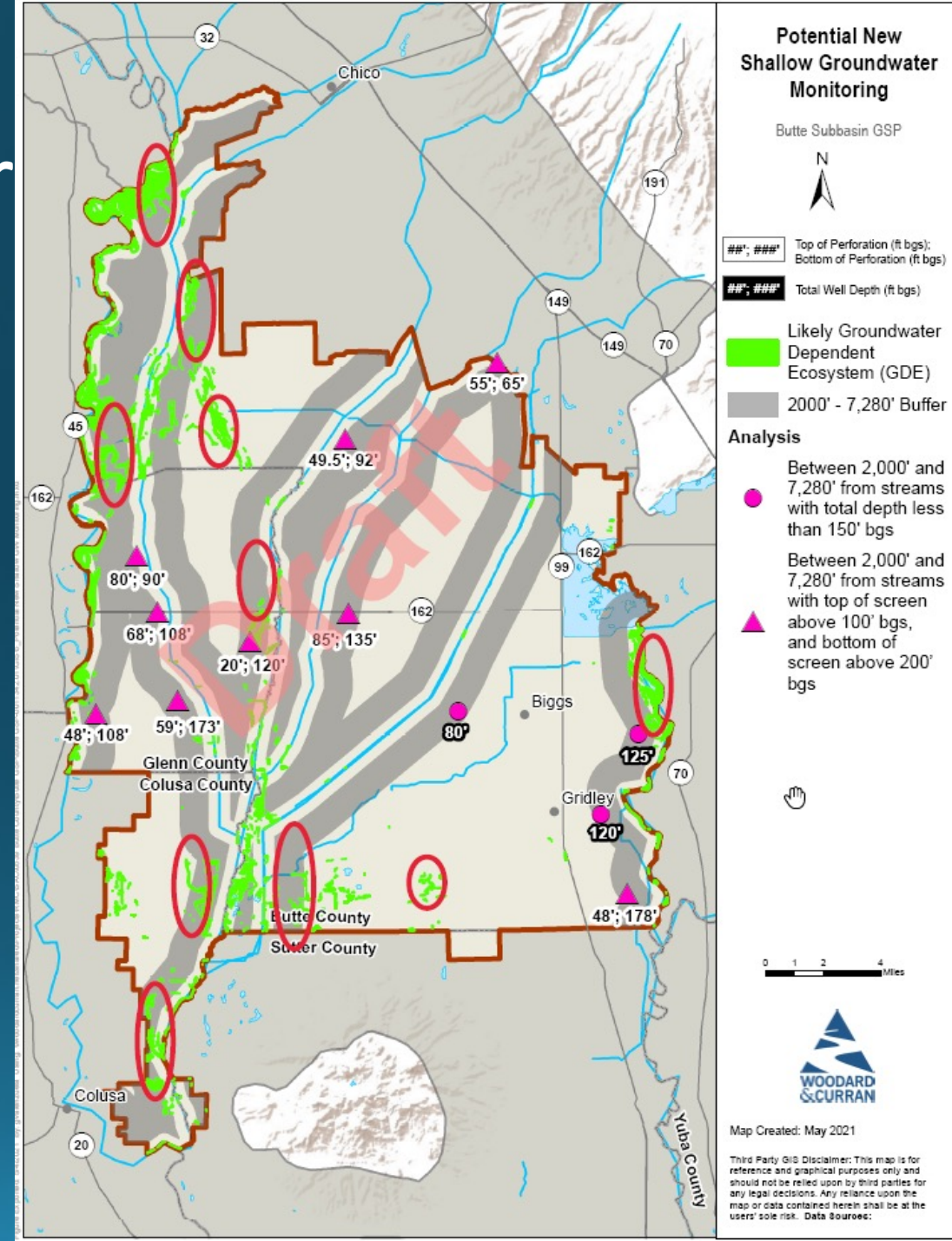
Groundwater Dependent Ecosystems

- Rooting depth of Valley Oaks = 30 feet
- Monitor with existing shallow wells near GDE locations if possible
- May use separate network of very shallow (<50 foot depth) wells, would require installation of new monitoring



GDEs and Depletions of Interconnected Surface Water

- Areas of interest for shallow monitoring that can be used for both GDEs and ISW
- 10 recommended locations
 - Shallow (35-50 foot deep), 2" diameter well, PVC casing with a 10-foot screened interval
 - Average cost to drill a new well is between \$7,000 - \$9,000
 - Total estimated cost \$80,000 to \$100,000

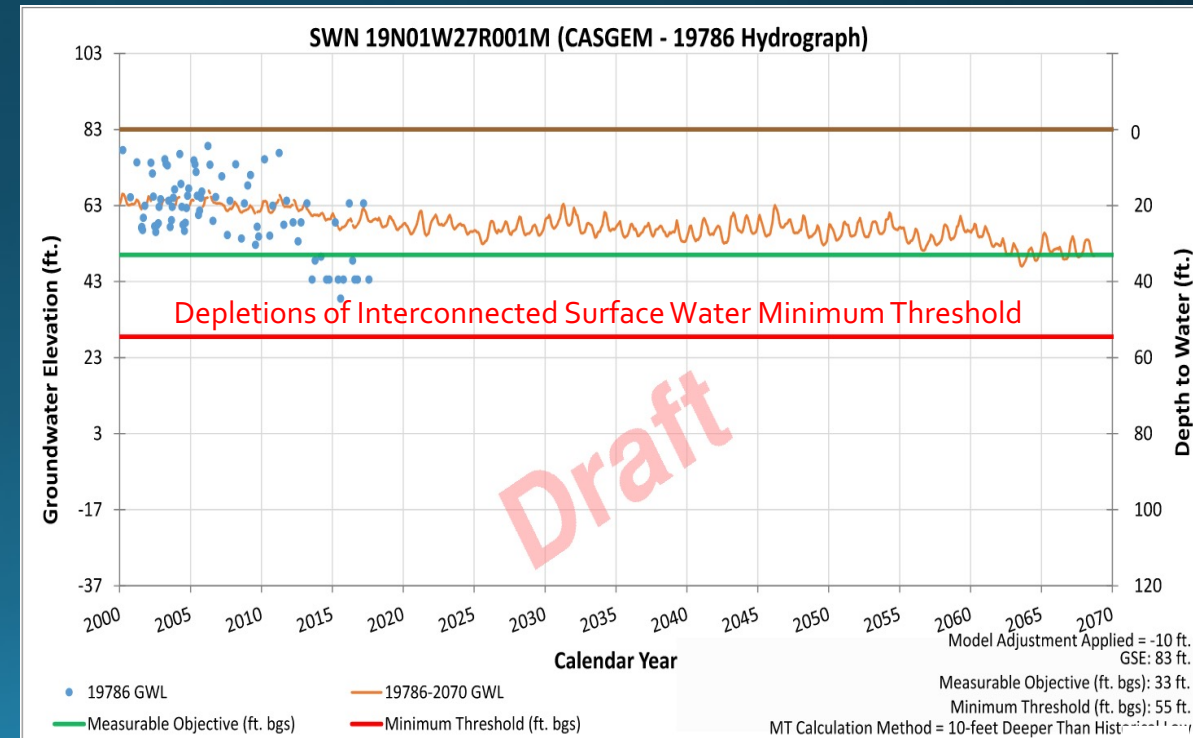
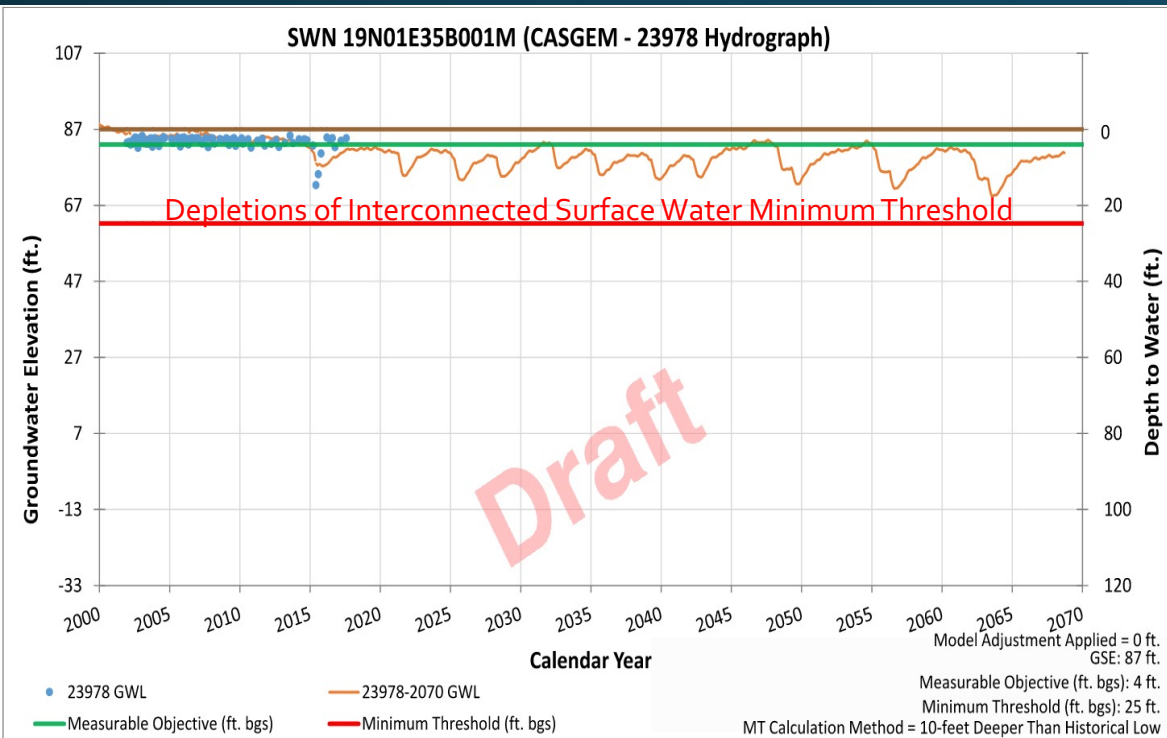


Depletions of Interconnected Surface Water Minimum Threshold and Measurable Objective

- Minimum Threshold
 - Use 10 feet deeper than 2015 low measurement
- Measurable Objective
 - Use the average of measurements from the last 5 measured years

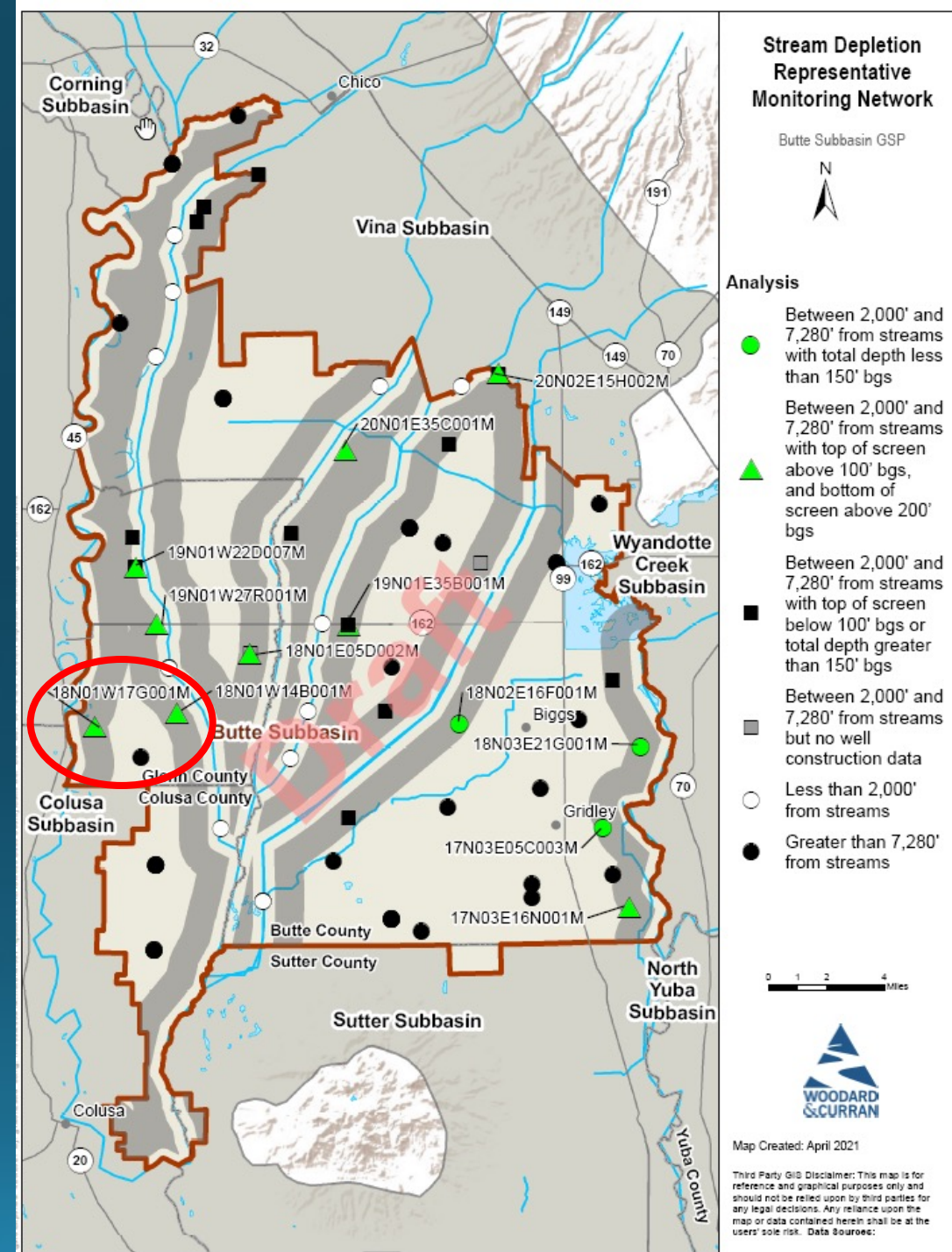
Depletions of Interconnected Surface Water

Example Minimum Thresholds and Measurable Objectives

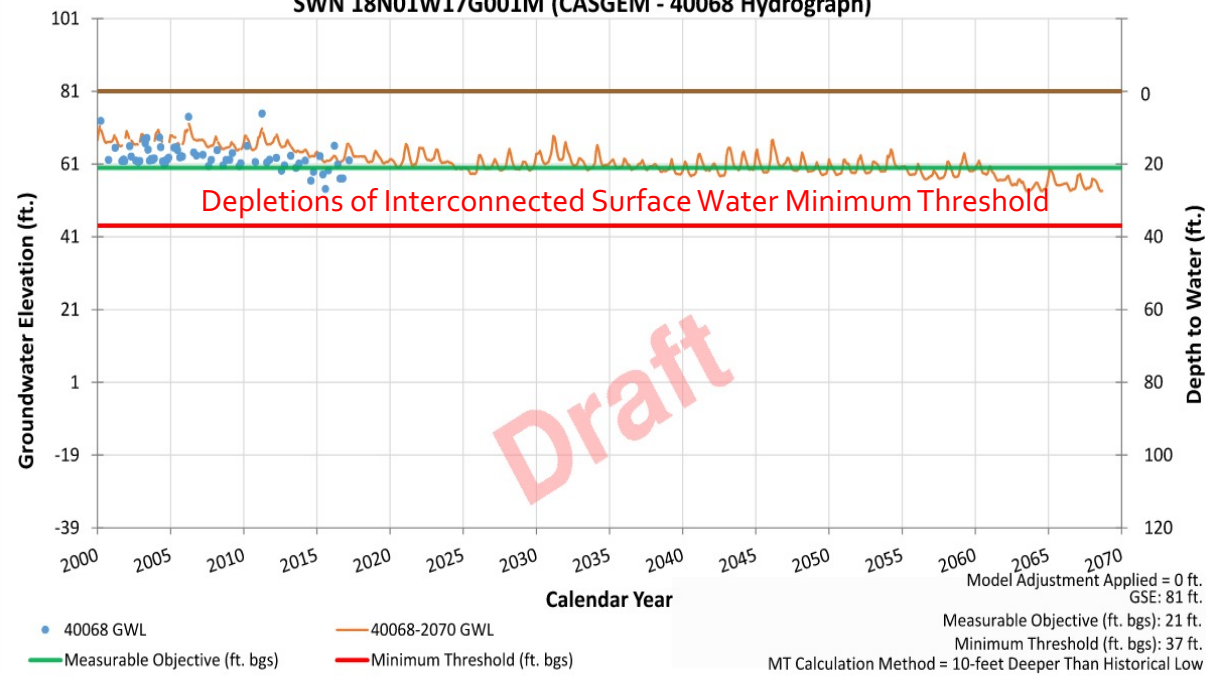


Levels and ISW Thresholds

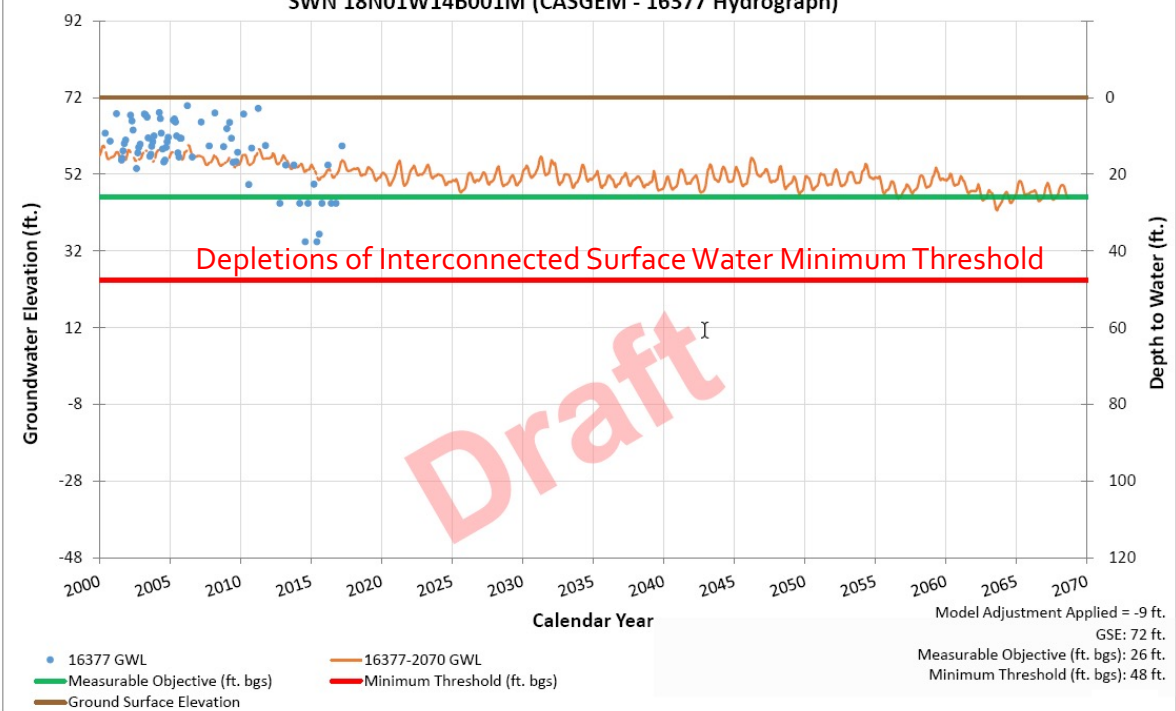
- Quick look at MTs for 3 locations
 - 18N01W17G001M (Levels and ISW)
 - 18N01W14B001 (Levels and ISW)
 - 18N01W22L001M (Levels Only)
- Shows that levels can be lower further away from water bodies and still avoid undesirable results



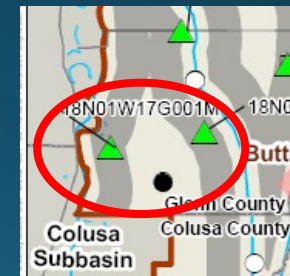
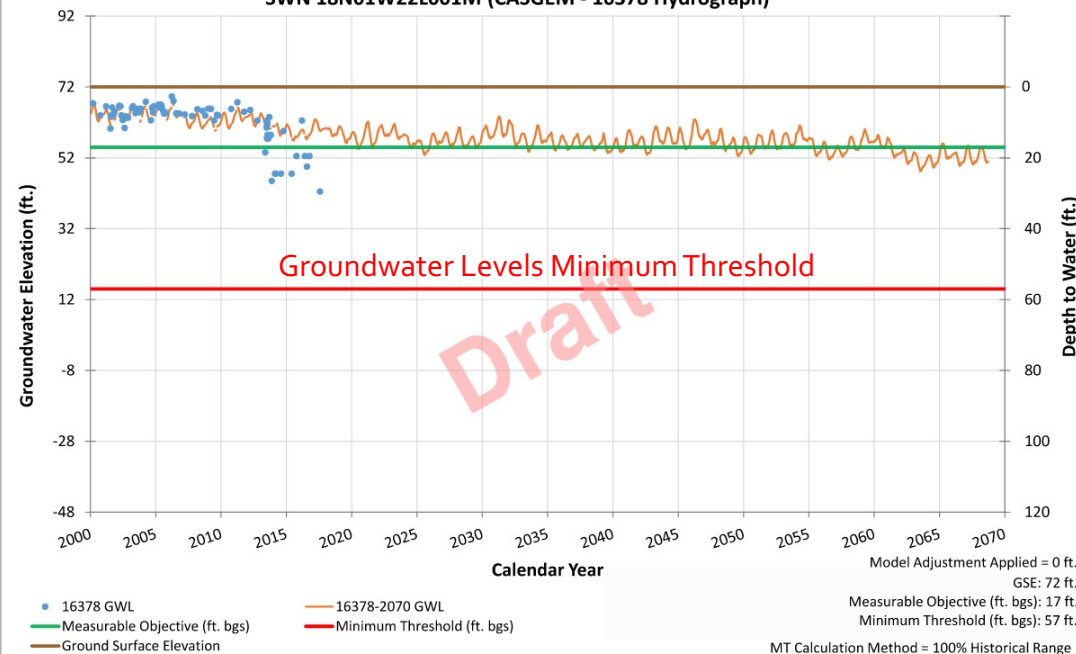
SWN 18N01W17G001M (CASGEM - 40068 Hydrograph)



SWN 18N01W14B001M (CASGEM - 16377 Hydrograph)



SWN 18N01W22L001M (CASGEM - 16378 Hydrograph)



Depletions of Interconnected Surface Water Recommendations

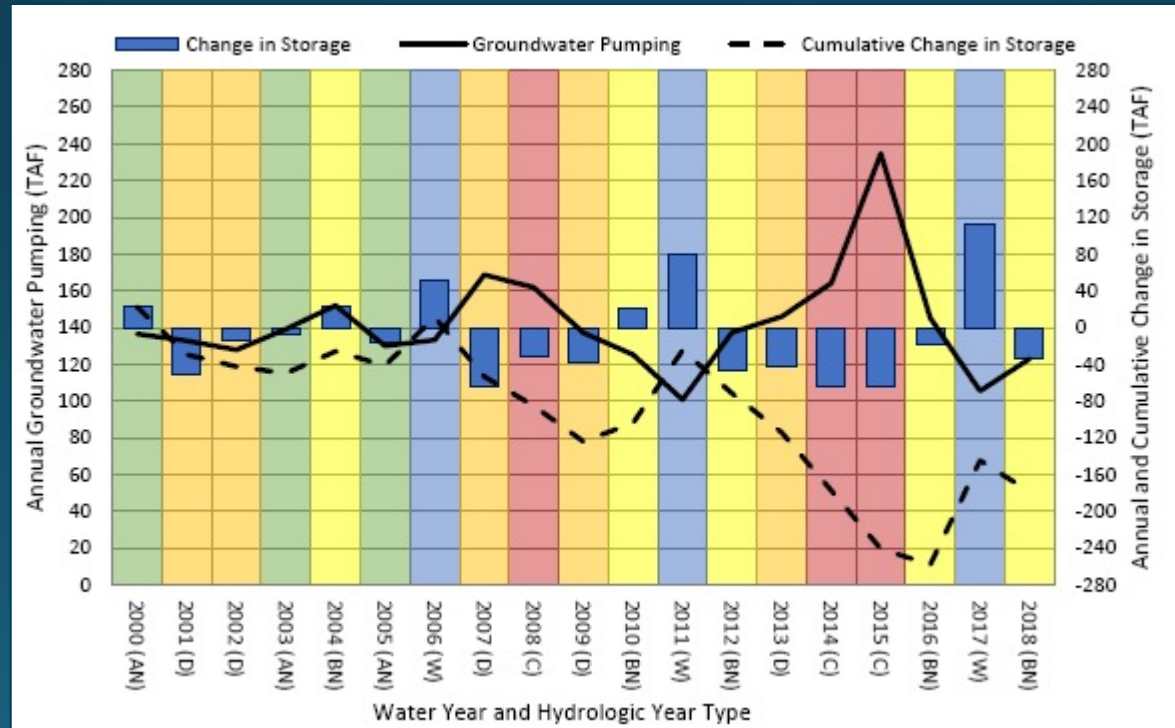
- Uses its own Representative Network and calculated thresholds
- Acknowledge data gaps
- Set Minimum Threshold
 - Use 10 feet deeper than 2015 low measurement
- Set Measurable Objective
 - Use the average of measurements from the last 5 measured years
- UR Detection = 25% (3 of 12 representative monitoring wells) fall below the minimum threshold for 24 consecutive months (same rationale as for lowering of groundwater levels)
- Fill data gaps using additional shallow wells
- Establish new GDE monitoring network with new shallow wells during GSP implementation

Reduction of Groundwater Storage

Monitor by Proxy

Reduction of Groundwater Storage

- Recommend using levels as a proxy
- Change in storage that has occurred is a small portion of available storage.
- Limiting factor to storage use is existing well infrastructure and near surface conditions, not the amount of volume storage
- Therefore: levels threshold are protective against significant and unreasonable changes in storage



Groundwater Storage Recommendation

- Monitor and Manage by Proxy Using Groundwater Levels

Seawater Intrusion

Not Applicable

Seawater Intrusion Recommendations

- Not applicable in the Butte Subbasin
- Seawater intrusion is not an applicable sustainability indicator because seawater intrusion is not present and is not likely to occur in the Butte Subbasin due to the distance between the Subbasin and the Pacific Ocean, bays, deltas, or inlets. Therefore, there is no possibility of an undesirable result due to seawater intrusion.

Degraded Groundwater Quality

Establish New Network

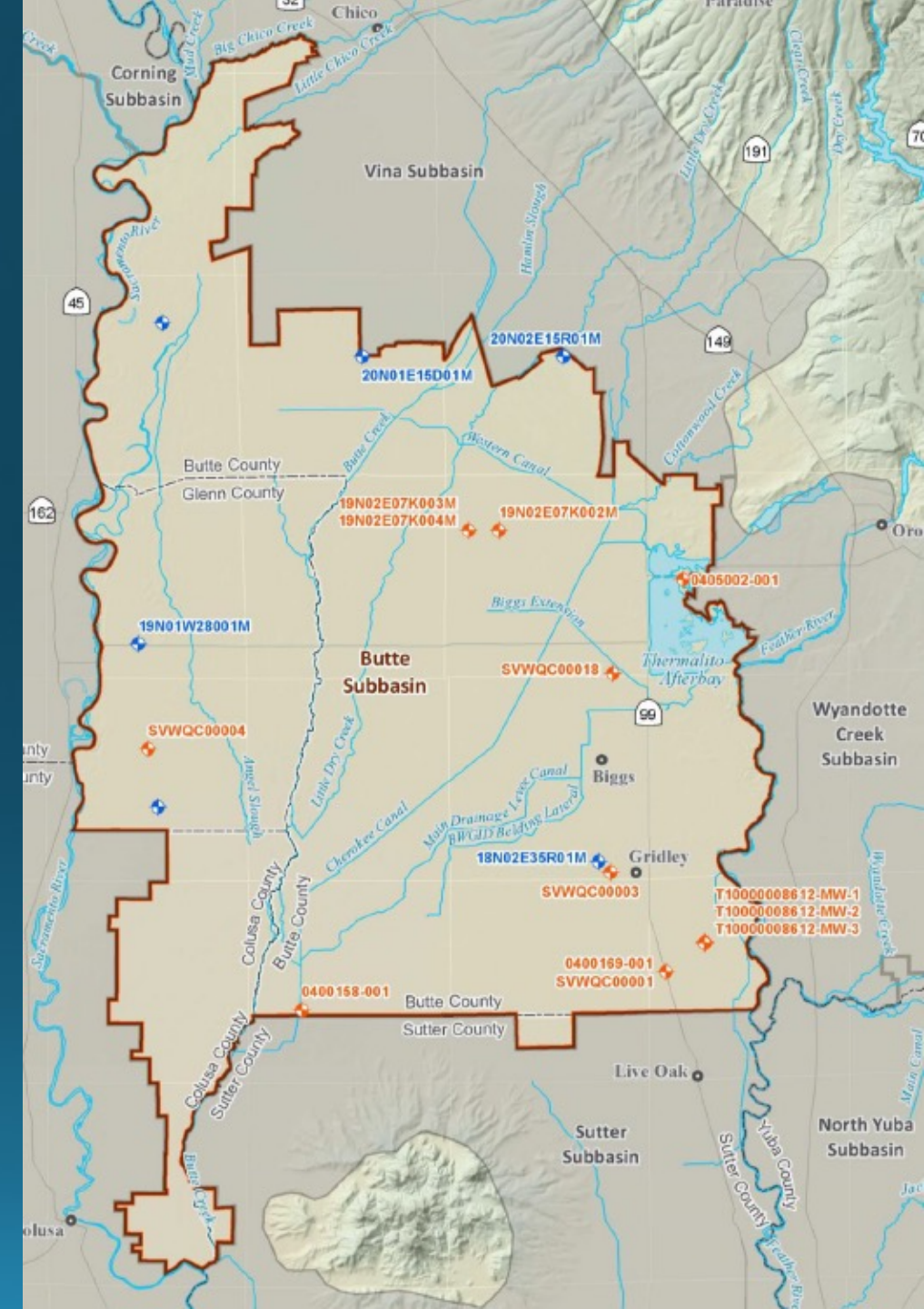
Degraded Groundwater Quality

- Key concern for Groundwater Quality in Butte Subbasin:
 - Upwelling of saline water
- Technical Team Recommendation:
 - Monitor deep aquifer
 - Establish new groundwater quality monitoring network using the deep aquifer monitoring wells used for levels

Groundwater Quality

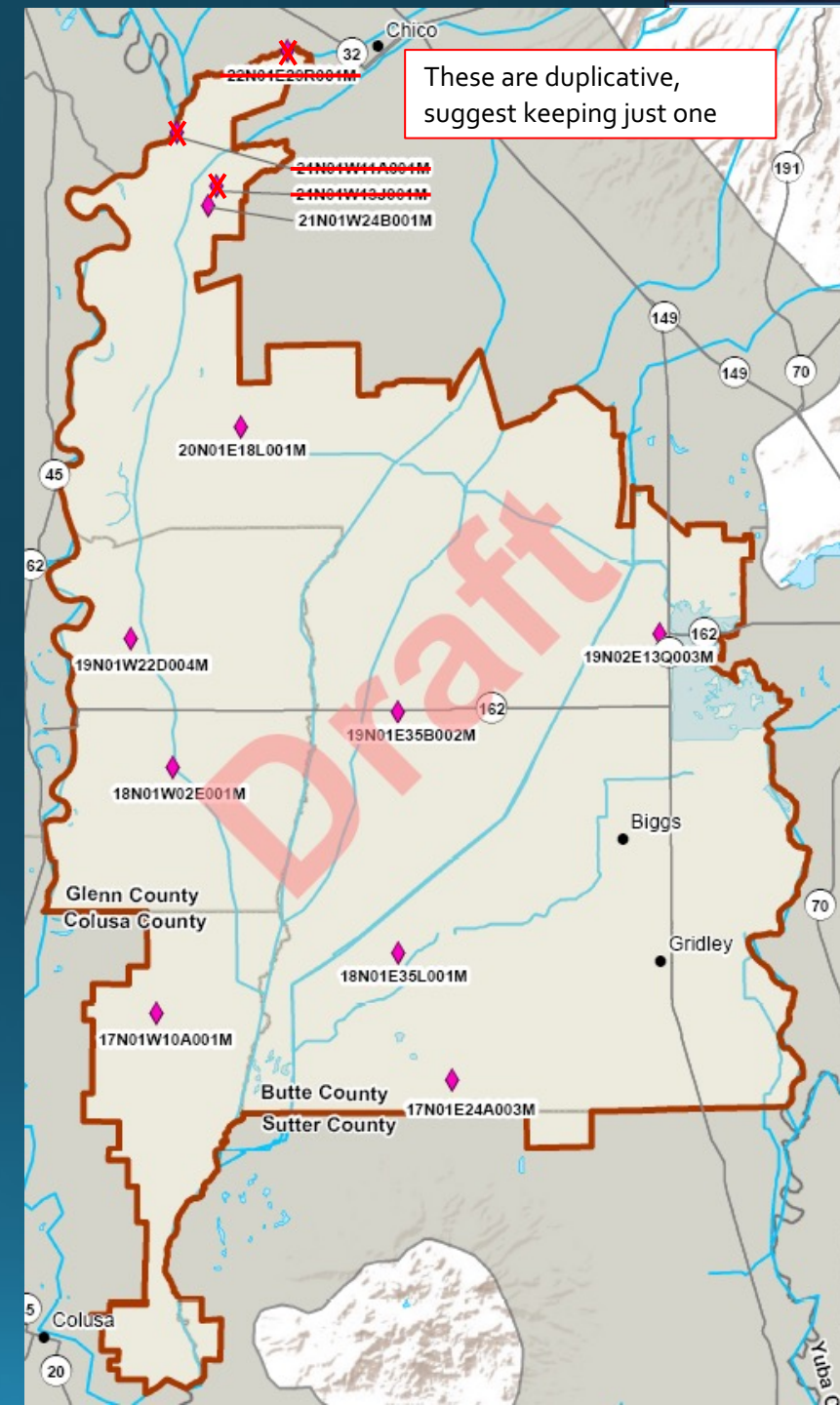
Existing Monitoring

- No existing monitoring is deep enough to monitor the deep aquifer
 - Average depth 166 feet bgs
 - Deepest depth 600 feet bgs
- GAMA network sites (orange) have 1 to 3 measurements (inadequate to set thresholds)
- Butte Subbasin Network sites (blue) do not have well construction



Groundwater Quality New Monitoring Network

- Use deep aquifer levels network
- Collect readings with sensor probes or special sampling technology to avoid purging the wells to reduce monitoring cost



Groundwater Quality Recommendations

- Set MT at higher concentration of:
 - 900 $\mu\text{s}/\text{cm}$ (more stringent than long term drinking water MCL)
 - Historical high measured at that location
- Set Measurable Objective at:
 - 700 $\mu\text{s}/\text{cm}$ for agricultural use (Basin management program value)
- UR Detection = 25% (3 of 9 representative monitoring wells) exceed the minimum threshold for 24 consecutive months

Groundwater Quality Recommendations

- Establish new groundwater quality monitoring network using deep aquifer network wells during GSP implementation
- Monitor using non-purging methodology
- Revise thresholds at 5-year update using measurements collected from adoption to update
- Consider drinking water MCLs and agricultural requirements to set thresholds

Inelastic Land Subsidence

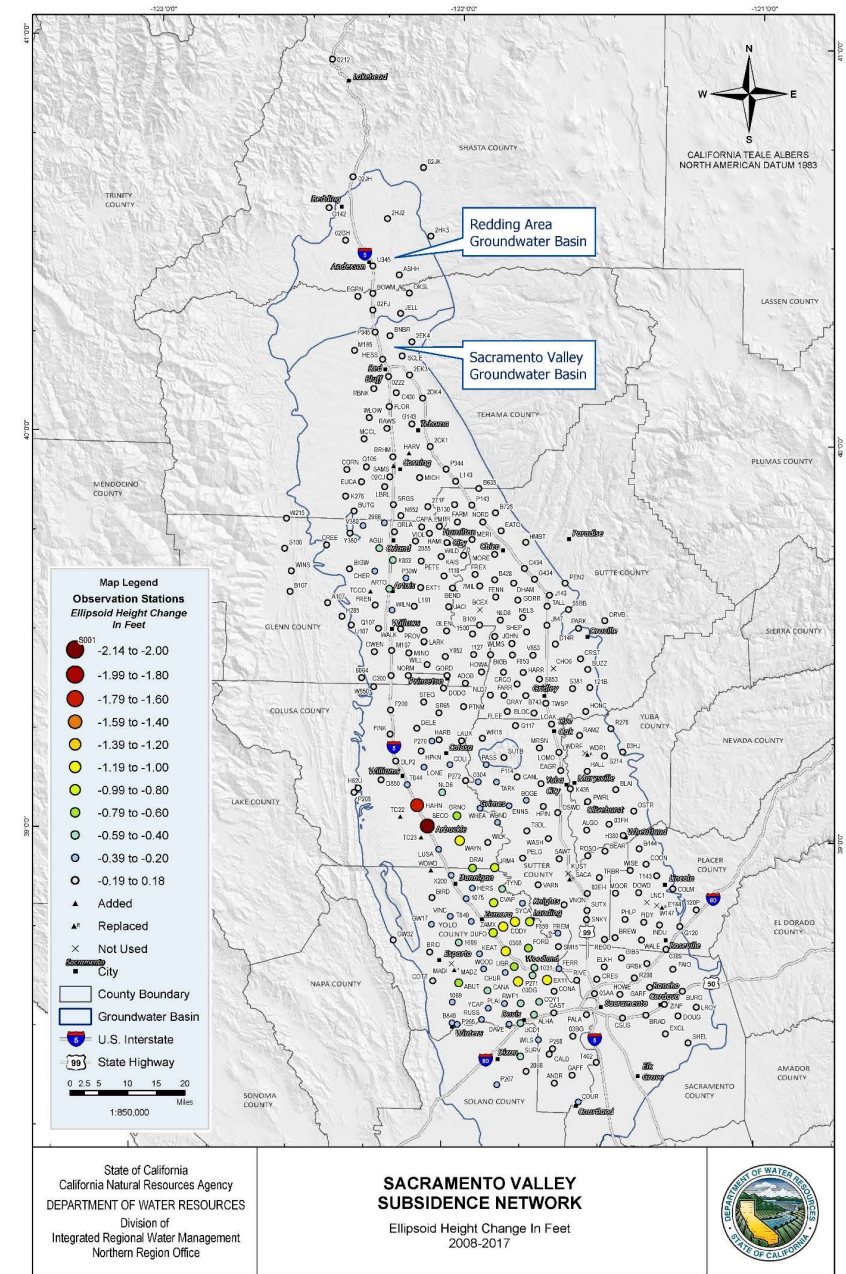
Representative Networks

Minimum Thresholds

Measurable Objectives

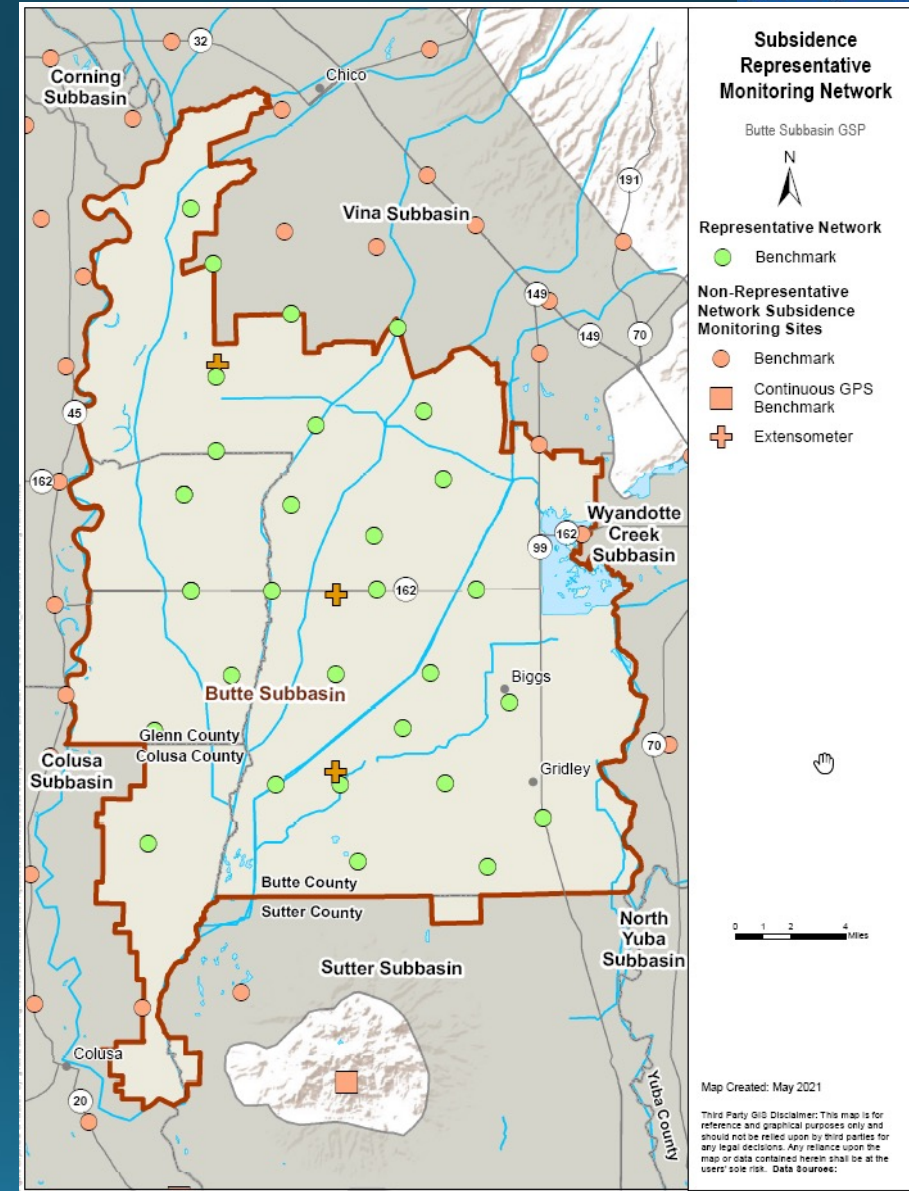
Subsidence Representative Network

- Establish representative network
 - Use DWR's Sacramento Valley GPS Subsidence Network
 - Use monitoring locations within Butte Subbasin



Subsidence

- Historical subsidence is small
 - Less than 0.0325 feet per 5 years
- Recommend continued use of the DWR Sacramento Valley Subsidence Network
- Set MT at: 0.5 feet per 5 years (Consistent with Yuba GSP)
- Set MO at: 0.25 feet per 5 years (Consistent with Yuba GSP)



Subsidence Recommendations

- Acknowledge that subsidence is not occurring in the Butte Subbasin
- Use DWR's Sacramento Valley GPS Subsidence Network for representative network
- Set MT at: 0.5 feet per 5 years
- Set MO at: 0.25 feet per 5 years
- UR Detection at: 25% of monitoring points fall below the MT*
 - *Note the UR does not have "for 24 consecutive months" because it is over a 5-year period. Review InSAR data annually to ensure subsidence does not become a concern

Summary of SMCs

SMC	MT	MO	Identification of UR
Groundwater Levels	Step 1 - Shallower of: <ul style="list-style-type: none"> • 100% of range below the historical low (or 20 feet, whichever is greater) • Shallowest 7% of nearby wells Step 2 - Deeper of: <ul style="list-style-type: none"> • Step 1 • Historical low+ 10 feet 	Average of last 5 measured years	25% of representative network exceed MT for 24 consecutive months
Interconnected Surface Water	2015 Low + 10 feet deeper	Average of last 5 measured years	25% of representative network exceed MT for 24 consecutive months
Groundwater Storage	GWLs as proxy	GWLs as proxy	GWLs as proxy
Seawater Intrusion	N/A	N/A	N/A
Groundwater Quality	Higher of: <ul style="list-style-type: none"> • 900 $\mu\text{s}/\text{cm}$ • Historical high 	700 $\mu\text{s}/\text{cm}$	25% of representative network exceed MT for 24 consecutive months
Subsidence	0.5 ft per 5 yrs	0.25 ft per 5 yrs	25% of representative network exceed MT