Ukiah Valley Basin Groundwater Sustainability Agency Technical Advisory Committee Meeting

Ukiah Valley Groundwater Sustainability Plan Development Update

May 13, 2020

Outline

- State of GSP Prior to This Meeting
- Historical Trends of Groundwater Elevation
- Integrated Model Updates and Preliminary Water Budget Discussion
- Sustainable Management Criteria
  - Surface Water Depletion (introduction)
  - Subsidence

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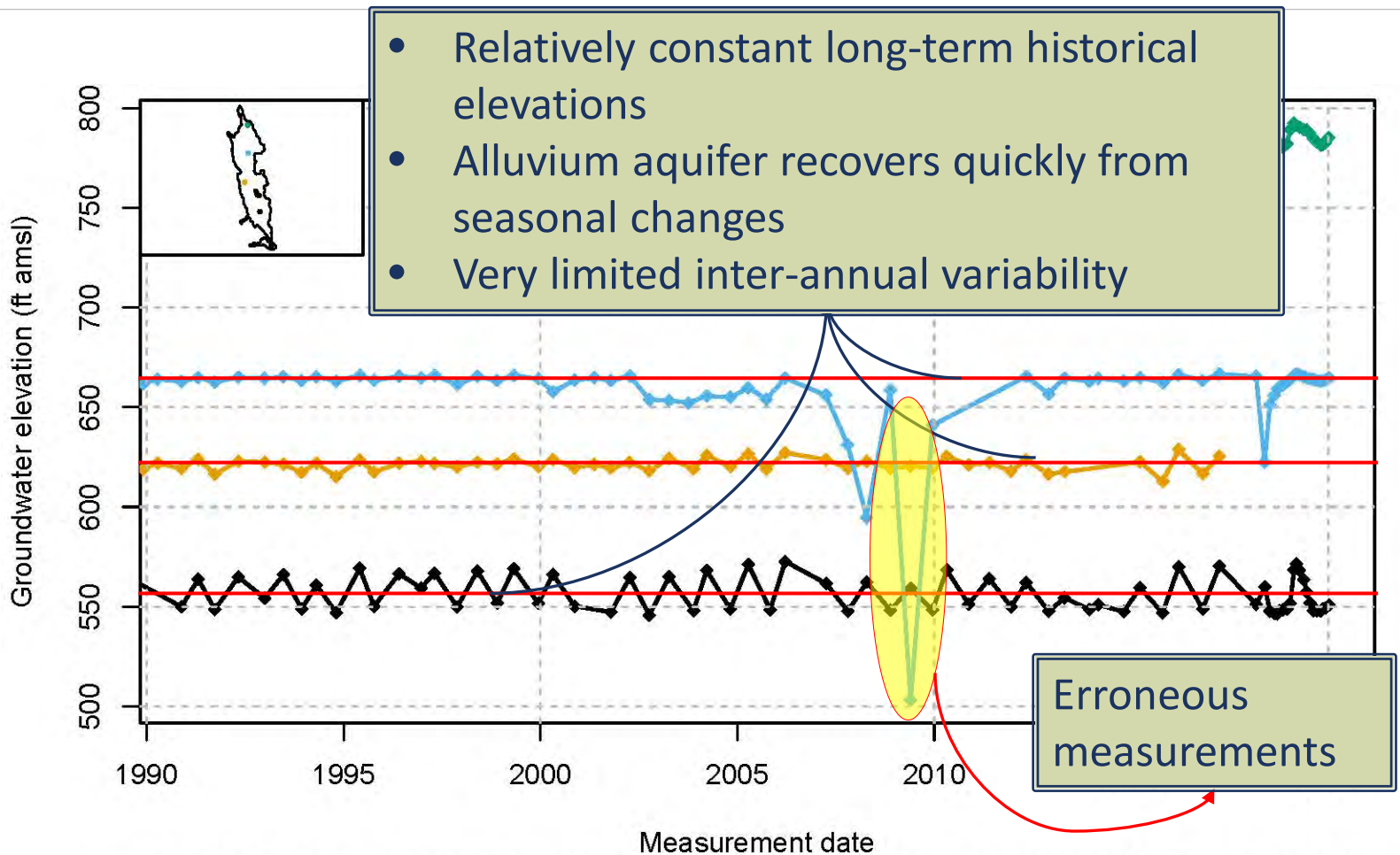 - Subsidence

State of GSP Prior to this Meeting

- Sustainable Management Criteria development for Water Quality

- Uncalibrated confined MODFLOW was presented along with calibrated PRMS and IDC

- SW/GW working group first two meetings were held

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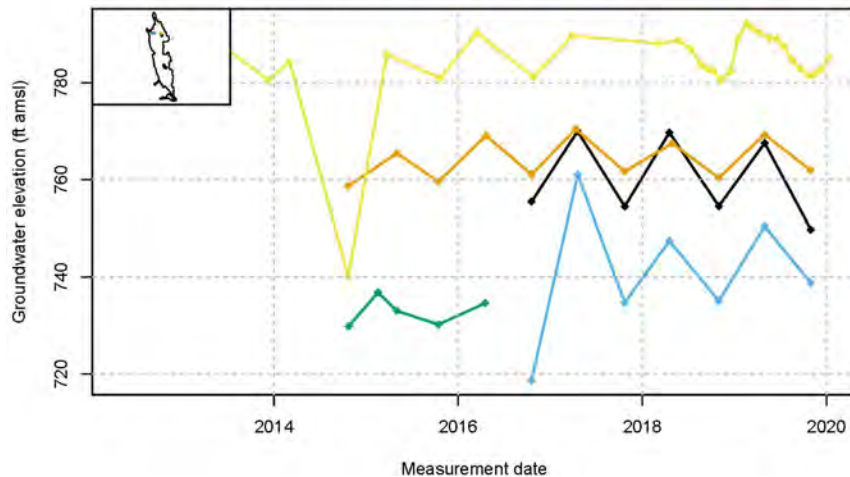# Long-term Historical Groundwater Elevations (Alluvial Aquifer)

- Relatively constant long-term historical elevations
- Alluvium aquifer recovers quickly from seasonal changes
- Very limited inter-annual variability

Erroneous measurements

Well IDs, south to north: 391096N1231677W001, 391730N1232108W001, 392358N1232020W001, 392962N1232047W001

Historical Groundwater Elevations by Region for Alluvial Aquifer

Redwood Valley
Range : 718-792 ft-MSL
Seasonal Change: ~12 ft (4-17 ft)

5 wells from total of 5 in the Ukiah Valley within the Redwood Valley

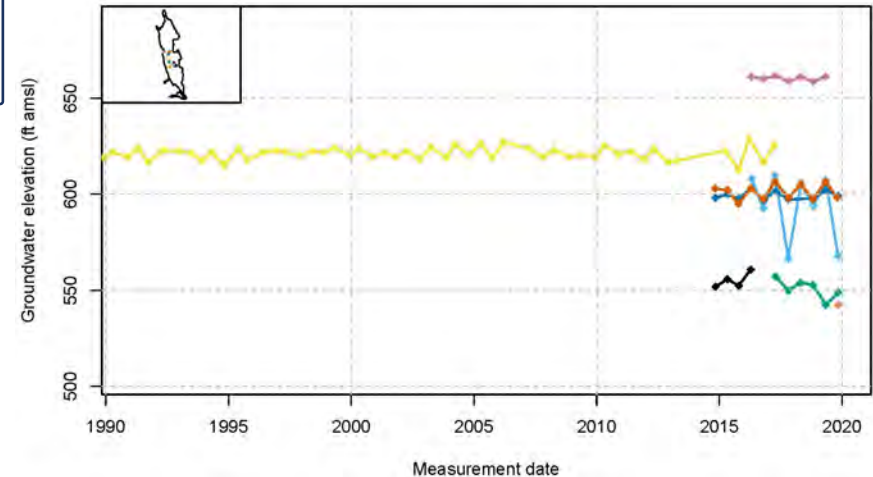8 wells from total of 10 in the Ukiah Valley within the Central Ukiah Valley
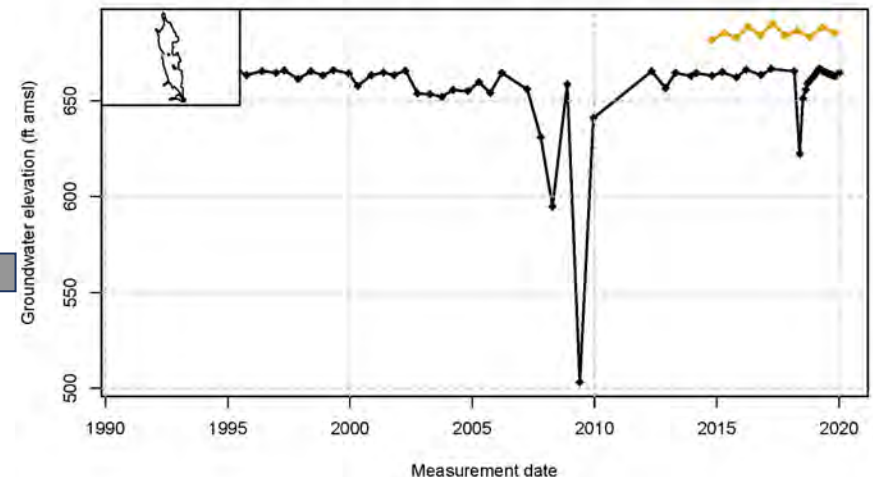
Central Ukiah Valley
Range : 542 -691 ft-MSL
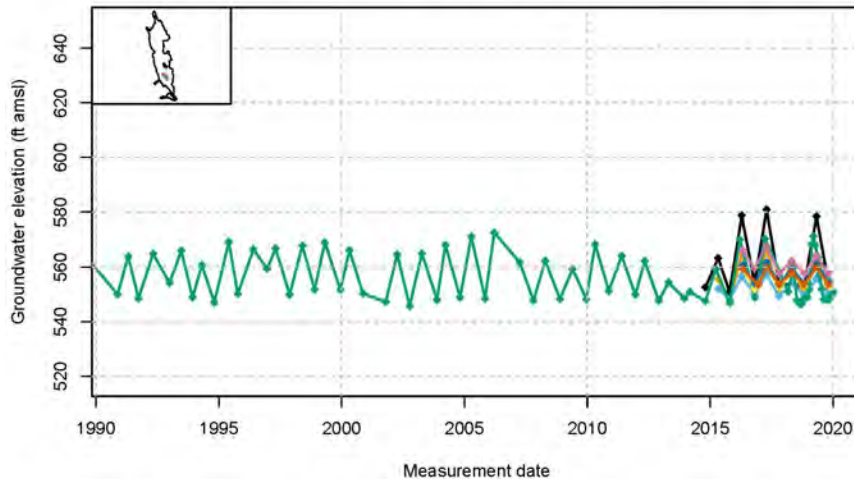Seasonal Change: ~8 ft (0-28 ft)

2 wells from total of 10 in the Ukiah Valley within the Central Ukiah Valley
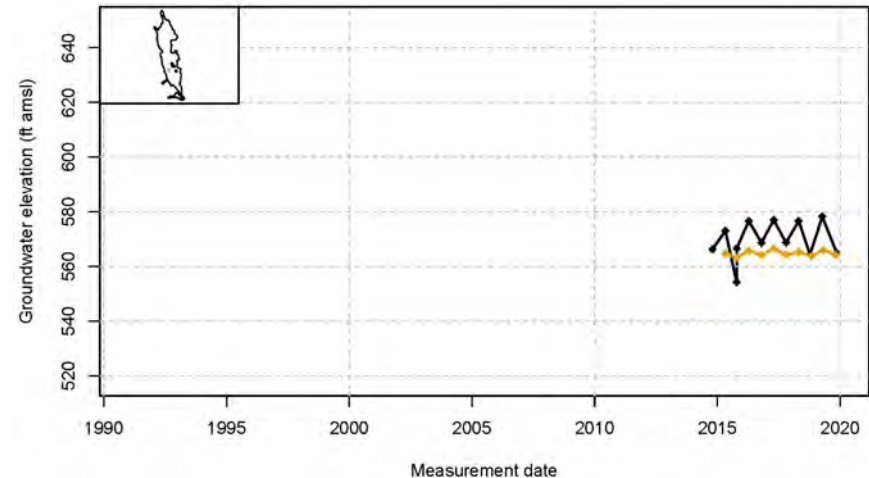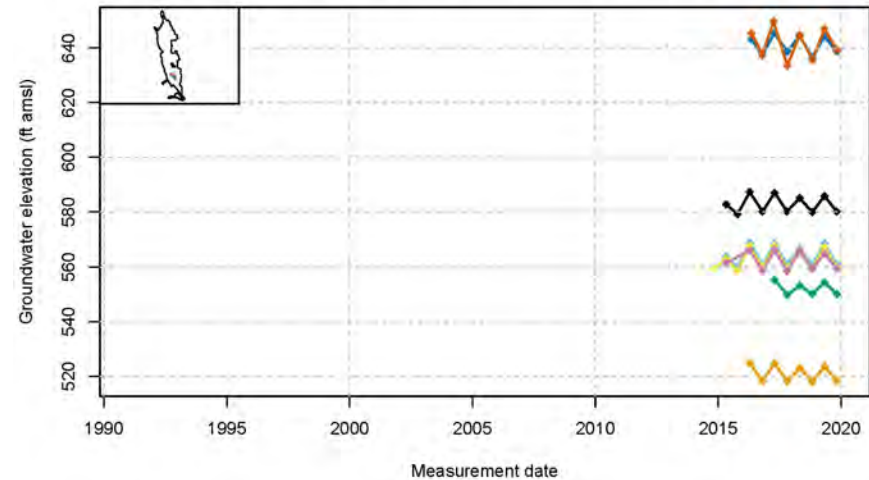
Historical Groundwater Elevations by Region for Alluvial Aquifer

Southern Ukiah Valley
Range : 518-650 ft-MSL
Seasonal Change: ~8 ft (1-16 ft)

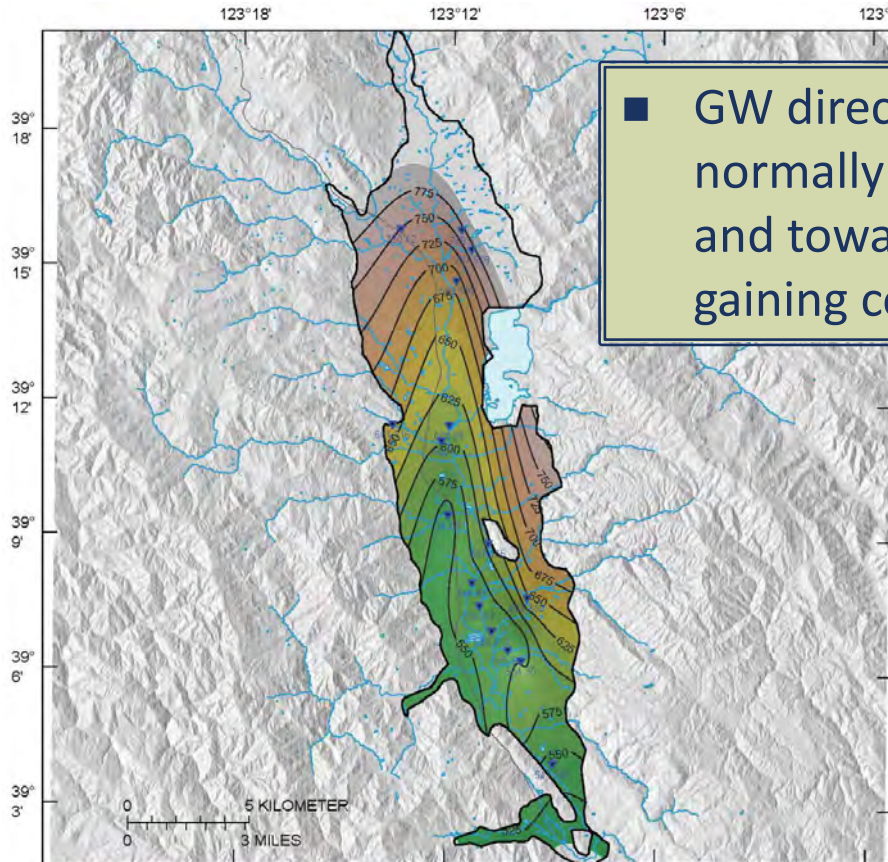8 wells from total of 18 in the Ukiah Valley within the Southern Ukiah Valley

8 wells from total of 18 in the Ukiah Valley within the Southern Ukiah Valley

Seasonal Groundwater Elevations

■ GW direction is normally southward and towards the river: gaining conditions.

Groundwater elevation in Ukiah Valley, in feet above mean sea level, for spring 2019

500   525   550   575   600   625   650   675   700   725   750   775   800

Groundwater elevation in Ukiah Valley, in feet above mean sea level, for fall 2019

500   525   550   575   600   625   650   675   700   725   750   775   800

Spring 2019

Fall 2019

Questions?

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Integrated Model Updates:

PRMS Rainfall Runoff Watershed Model

ET

Rainfall

Streamflow Routing (SFR) in the MODFLOW Groundwater Model

Watershed runoff to streams

Surface flow

IDC or GSFLOW Agriculture Model

ET

Surface and groundwater flows

Surface and groundwater flows

ET demand for crops is met by irrigation with groundwater or surface water

Surface Water and Groundwater available for Urban and Domestic Use

Surface Water and Groundwater available for Agricultural Use

Integrated Model Updates

- PRMS updates
  - PRMS updated to newer version PRMS 5.0 compatible with GSFLOW v2.0.
  - Ponds included in PRMS. SW diversions are estimated.
  - Reservoir operation methodology developed to be incorporated into the PRMS.
  - PRMS is running with GSFLOW executable.
  - PRMS 5.0 has now the capability to model stream temperature.
- IDC updates
  - IDC calculated percolation and ET are being used to adjust MODFLOW recharge and PRMS ET.
  - IDC's role will be switched to recently released Ag Package within GSFLOW and IDC will be used to form Ag Package inputs and ground truth its results.
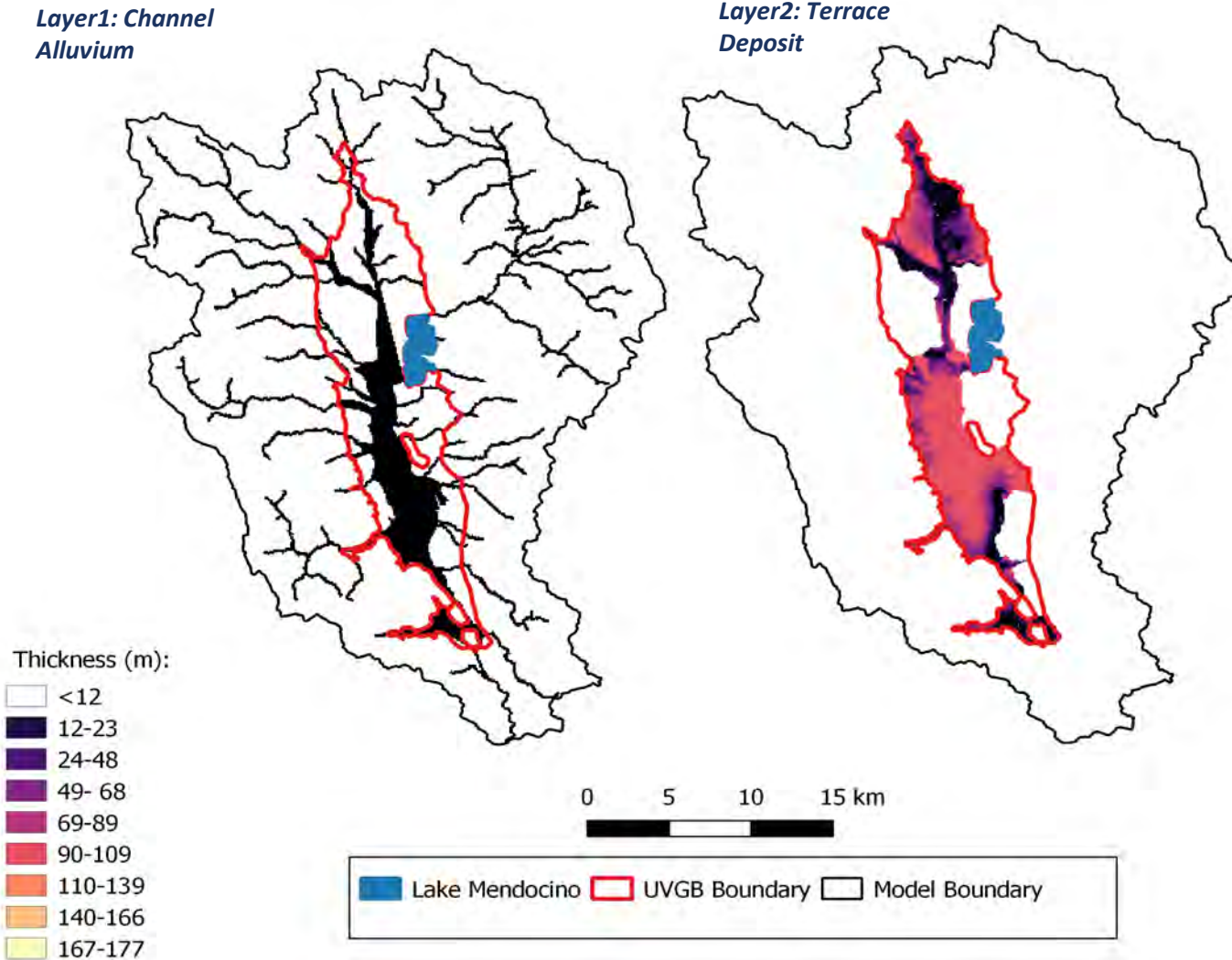
MODFLOW: Discretization

- Spatial: 100m x 100m Grid
  - Rows: 483
  - Columns: 343
  - Cells:165,669
  - Active Area: ~ 240 acres
  - Basin Area: ~ 37 acres

- Temporal:
  - From Jan 1, 1991
  - To Dec 31, 2018
  - Monthly timesteps
  - 366 timesteps

Legend

Ukiah GSA Boundary	
Upper Russian River Boundary	
Model Grid	

Model layers

- ***Layer 1:*** *Has a constant thickness of 12m (39ft)*
- ***Layer 2:*** *Has thicknesses ranging from 12 to 78m (39 to 256ft)*

Layer1: Channel Alluvium

Layer2: Terrace Deposit

Thickness (m):
- <12
- 12-23
- 24-48
- 49- 68
- 69-89
- 90-109
- 110-139
- 140-166
- 167-177

0   5   10   15 km
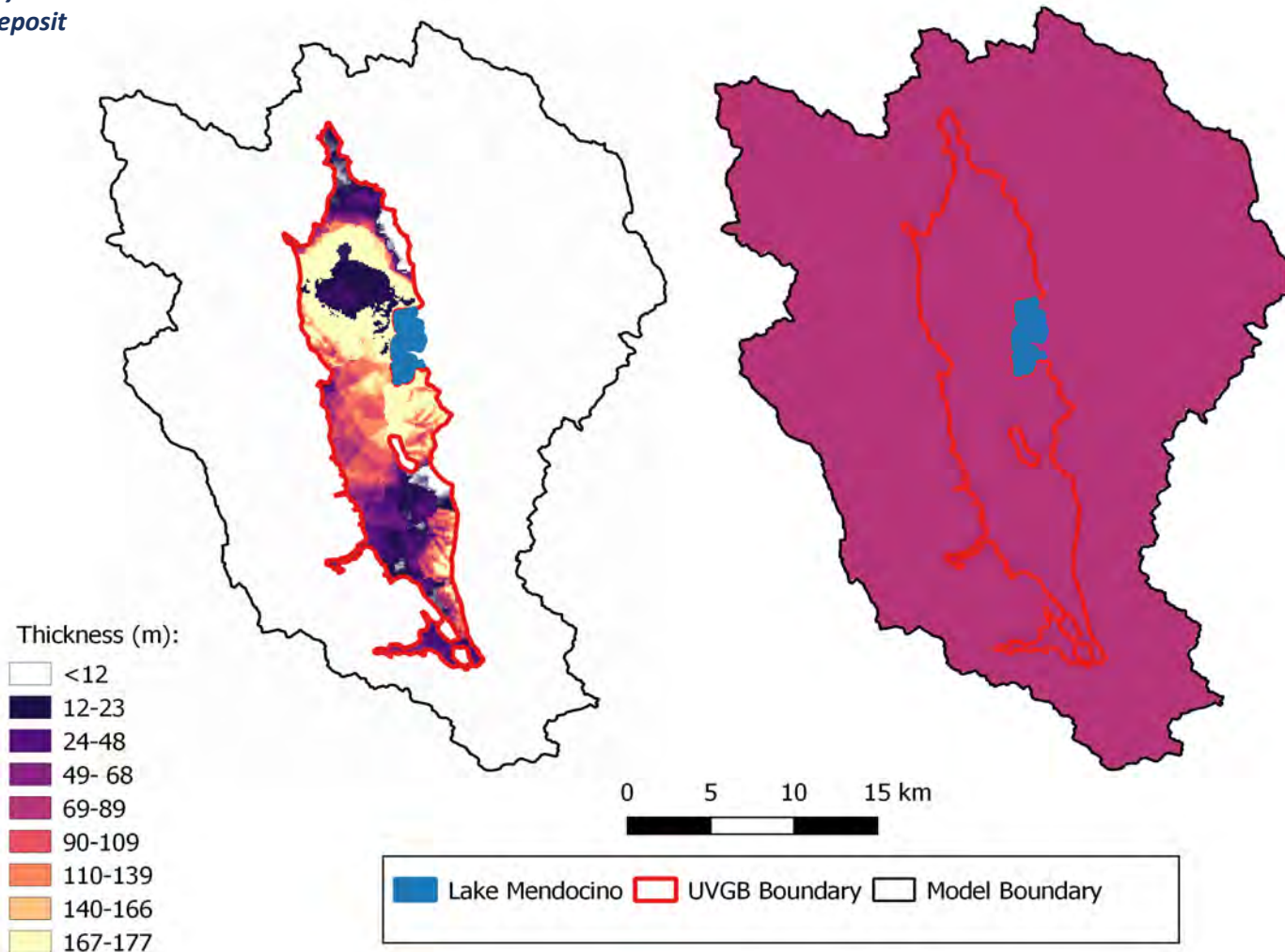
Lake Mendocino   UVGB Boundary   Model Boundary

Model layers

- *Layer 3: Has thicknesses ranging from 12 to 177m (39 to 580ft)*
- *Layer 4: Has a constant thickness of 50m (160ft)*

Layer3: Continental Deposit

Layer4: Franciscan

Thickness (m):
- <12
- 12-23
- 24-48
- 49- 68
- 69-89
- 90-109
- 110-139
- 140-166
- 167-177

0   5   10   15 km

Lake Mendocino   UVGB Boundary   Model Boundary

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Model Assumptions

Model Version	Advantages	Disadvantages
Confined Layers [1,2,3]	• *Quick Run time* • *Minimal Convergence Issues*	• *No Coupling with GSFLOW*

Model Version	Disadvantages	Advantages
Unconfined Layers [1,2,3]	• *Long Run time* • *Challenging Convergence Issues*	• *Coupling with GSFLOW* • *Add unsaturated zone flow*

Calibrate Confined Version → Use Calibrated Values → Run Unconfined Version → Couple with GSFLOW → Final Calibration

Model Hydrologic Parameters

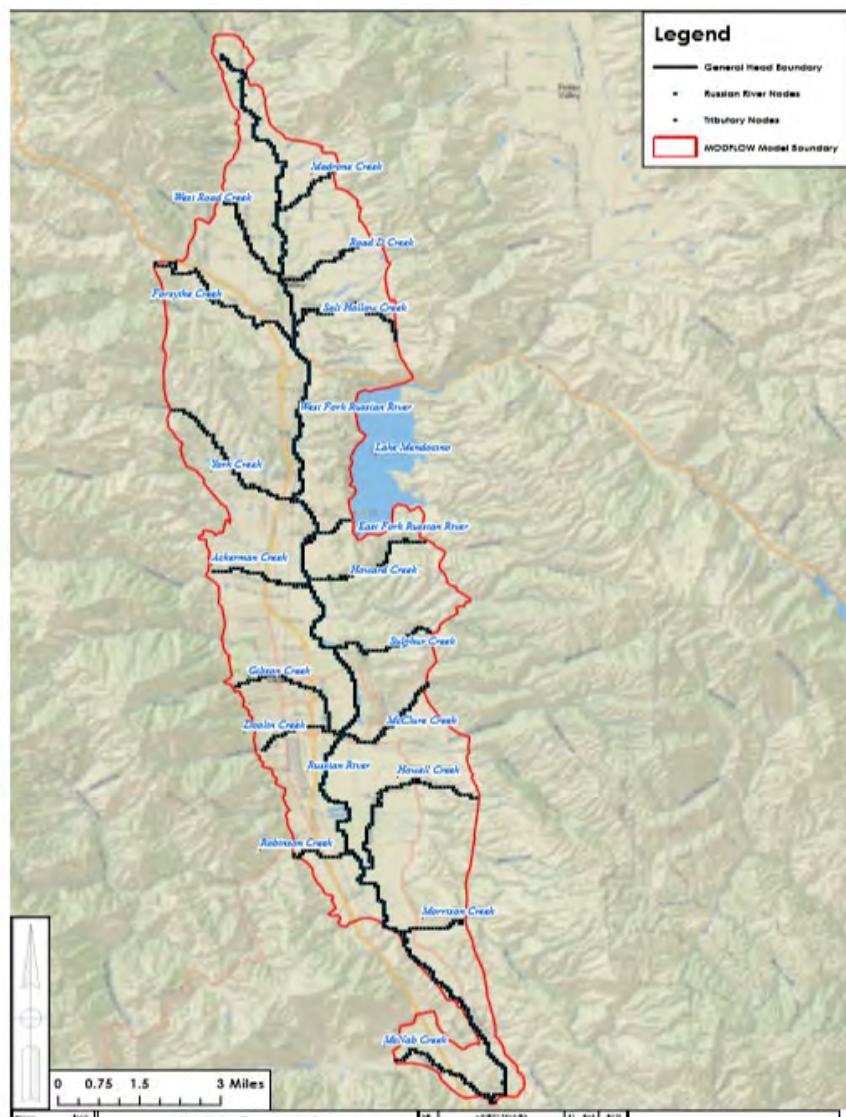*Values before calibration from the Hydrogeological Conceptual Model (HCM) and Literature.*

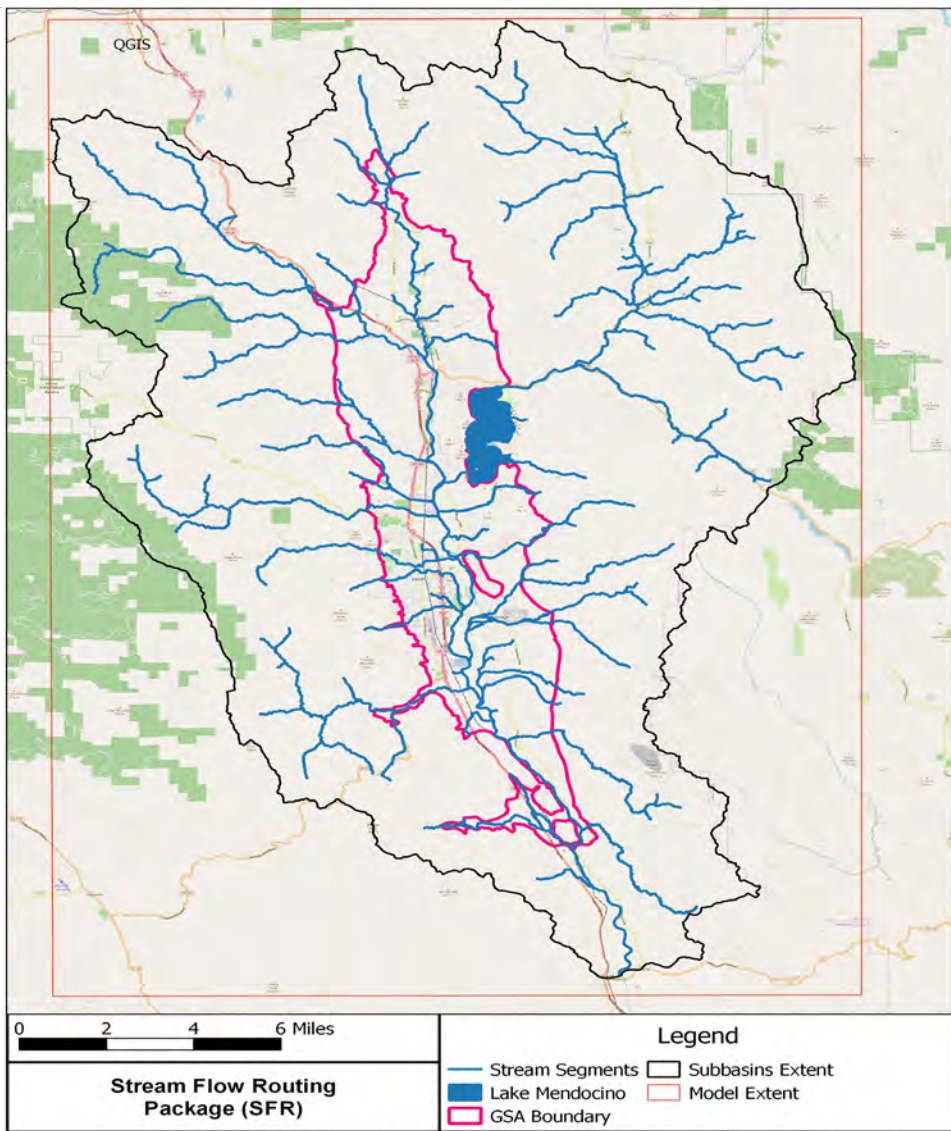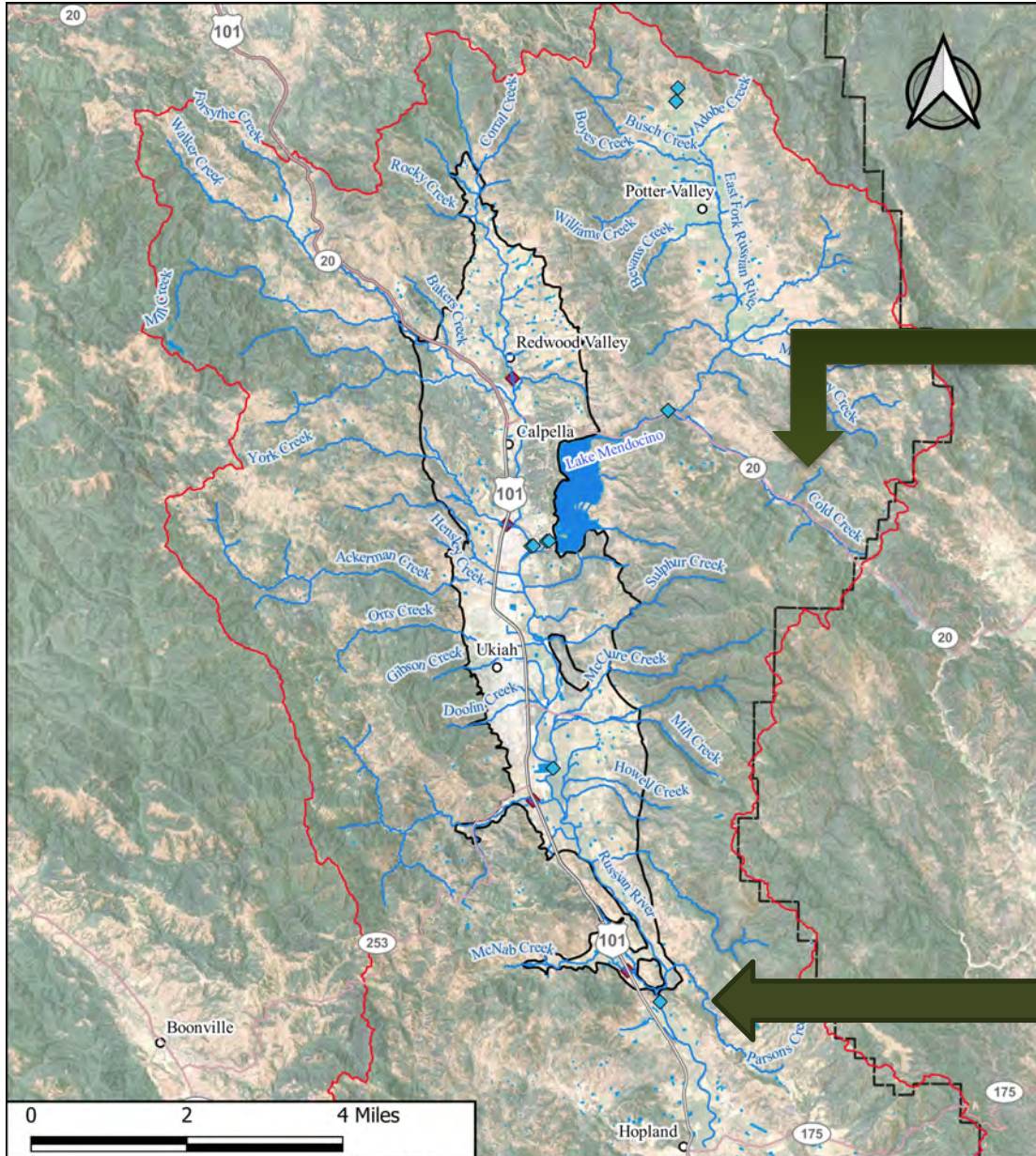| Aquifer Parameters	Parameters Ranges
Hydraulic conductivity:	
- **Layer1: Channel Alluvium**	*150 - 220 ft/day*
- **Layer2: Terrace Deposit**	*0.1 - 15 ft/day*
- **Layer3: Continental Deposit**	*0.01 - 0.51 ft/day*
- **Layer4: Franciscan**	$0.3x10^{-5} - 0.3x10^{-7}$ *ft/day*
Specific Storage	
- **Layer 1&2**	$1x10^{-5} - 1 x10^{-4}$
- **Layer 3**	$1x10^{-5} - 1 x10^{-4}$
- **Layer 4**	$1x10^{-7} - 1 x10^{-5}$
Specific Yield Layer 1&2&3	$1x10^{-2} - 5 x10^{-2}$

Stream Flow Routing (SFR) package

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Previous Modeling Effort: River Package

Current Modeling Effort : Stream Flow Routing Package (SFR).
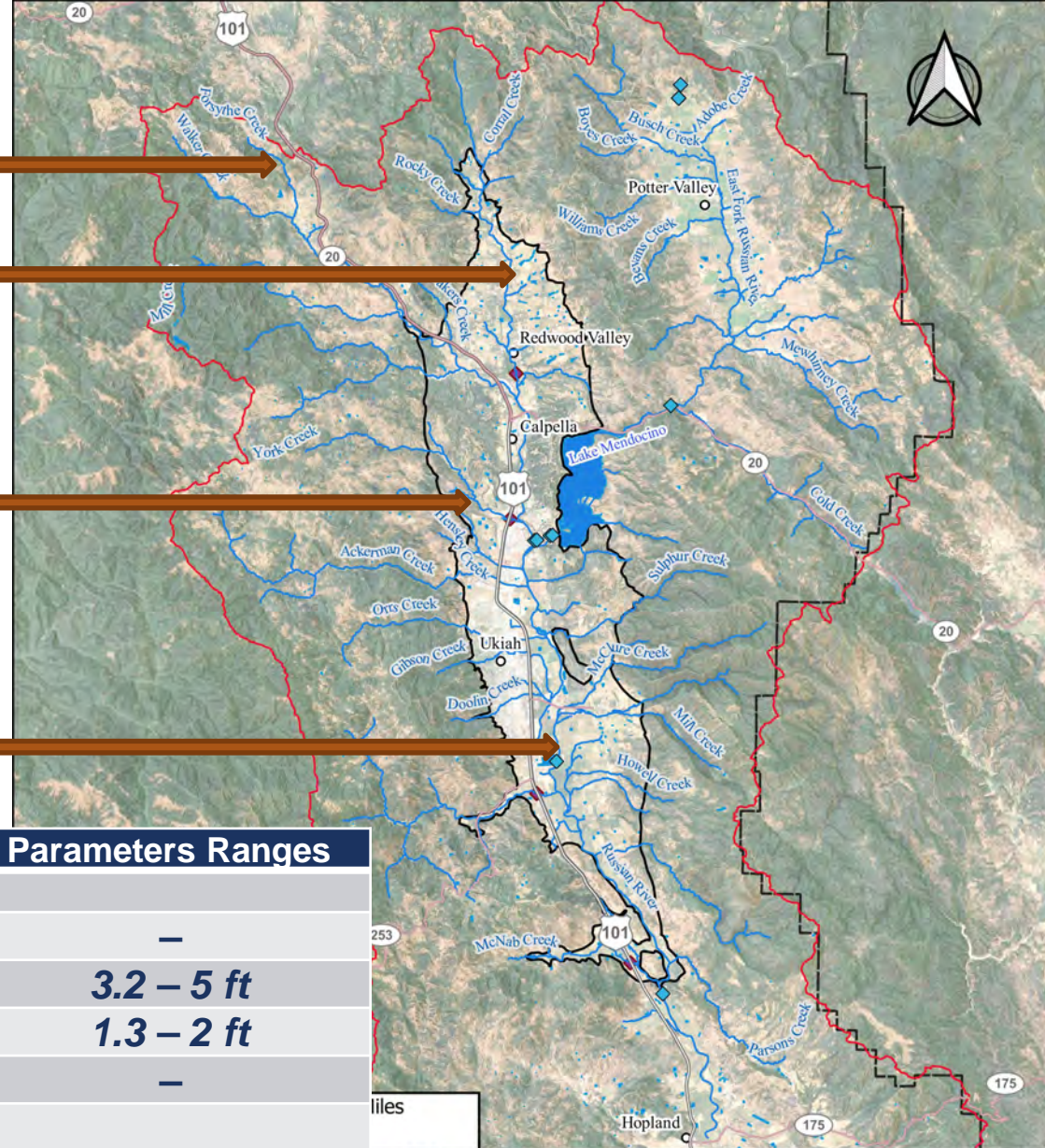
Steelhead Trout

Chinook Salmon

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Small tributaries

Natural flows of
main stem

Large tributaries

Impaired flows of
main stem

Stream Parameters	Parameters Ranges
Streambed Thickness:	
- Main stem upstream of the lake	–
- Main stem downstream of the lake	*3.2 – 5 ft*
- Large tributaries	*1.3 – 2 ft*
- Small tributaries	–
Streambed Hydraulic Conductivity	
- Main stem upstream of the lake	–
- Main stem downstream of the lake	*0.01- 0.02 ft/d*
- Large tributaries	*0.01- 0.02 ft/d*
- Small tributaries	–

Legend
County Line
UVGB
Russian River Watershed
Streams and Rivers
Water Body
Stations
USGS Streamflow Gauge
NMFS Streamflow Gauge

Mendocino Lake Modeling

Current Model

- Specified releases from the stream gage PRMS Model
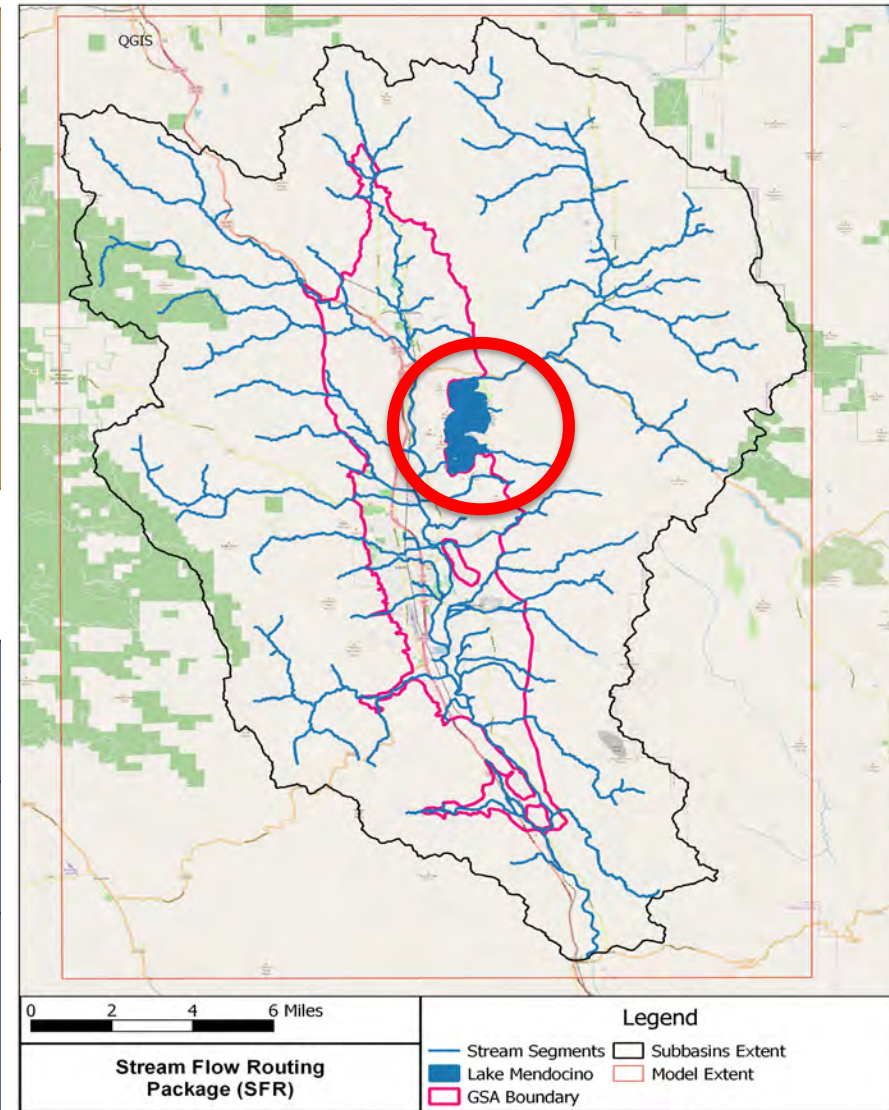 - Best way to simulate historical releases

↓

Future Model

- *Lake package in MODFLOW*

Allow to assess and simulate different management scenarios especially :
- *Reservoir operations*

Stream Flow Routing Package (SFR)

Legend
- Stream Segments
- Lake Mendocino
- GSA Boundary
- Subbasins Extent
- Model Extent

Well (WEL) package

Well Package: defines groundwater pumping rate at a specific well location.

Municipal Wells

1. Available well supply data

Name	Type	Pumping (AF/month) till December 2015
Calpella W1	MI	2.13
Ukiah WTP	MI	0
Ukiah W2	MI	0
Ukiah W3	MI	10.59
Ukiah W4	MI	0
Ukiah W7	MI	24.59
Ukiah W8	MI	8.05
Willow/Nogard W5	MI	12.35
Willow/Nogard W6	MI	12.35
Willow/Burke W7	MI	12.35
Willow/Burke W8	MI	12.35

2. Missing well supply data

Name	Type	Pumping (AF/month)
Millview W17	MI	-
Millview W12	MI	-
Millview W16	MI	-
Masonite W6	MI	-

Well (WEL) package

Agricultural Wells — Demand is currently estimated from IDC at each cell with groundwater-irrigated Agriculture

… will be migrated to *GSFLOW Ag Package* in the future

IDC Flow Components
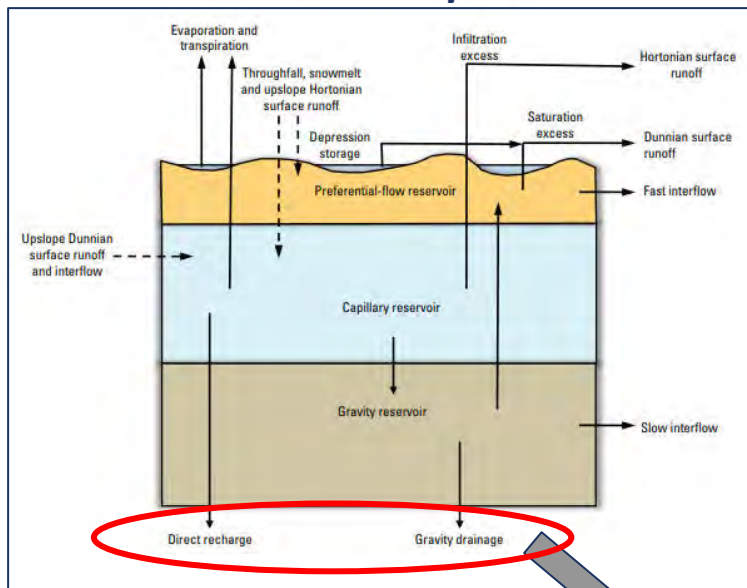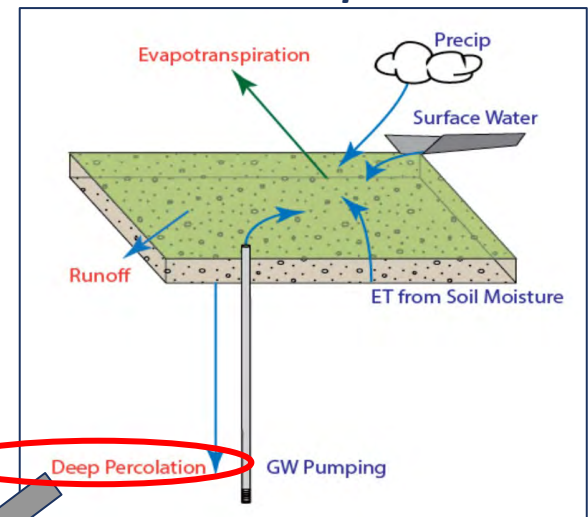

Boundary Condition for MODFLOW

Recharge package

Recharge — Currently specified using PRMS results where there is no agriculture, and with IDC where there is agriculture

… will be calculated dynamically with *GSFLOW* in the future

PRMS Flow Components

IDC Flow Components

Boundary Condition for MODFLOW

Questions?

MODFLOW Initial Calibration

Introduction to Parameters and Sensitivities

- **Parameters** are defined variables that control the flow system in a model.

  - Examples include hydrogeologic properties within the model.

- **Sensitivities** are a measurement of how important a parameter is to set of observations.

- **Observations** in groundwater models are typically hydraulic heads (water level) but including stream flow and other fluxes into or out of the system is very beneficial for a successful calibration.
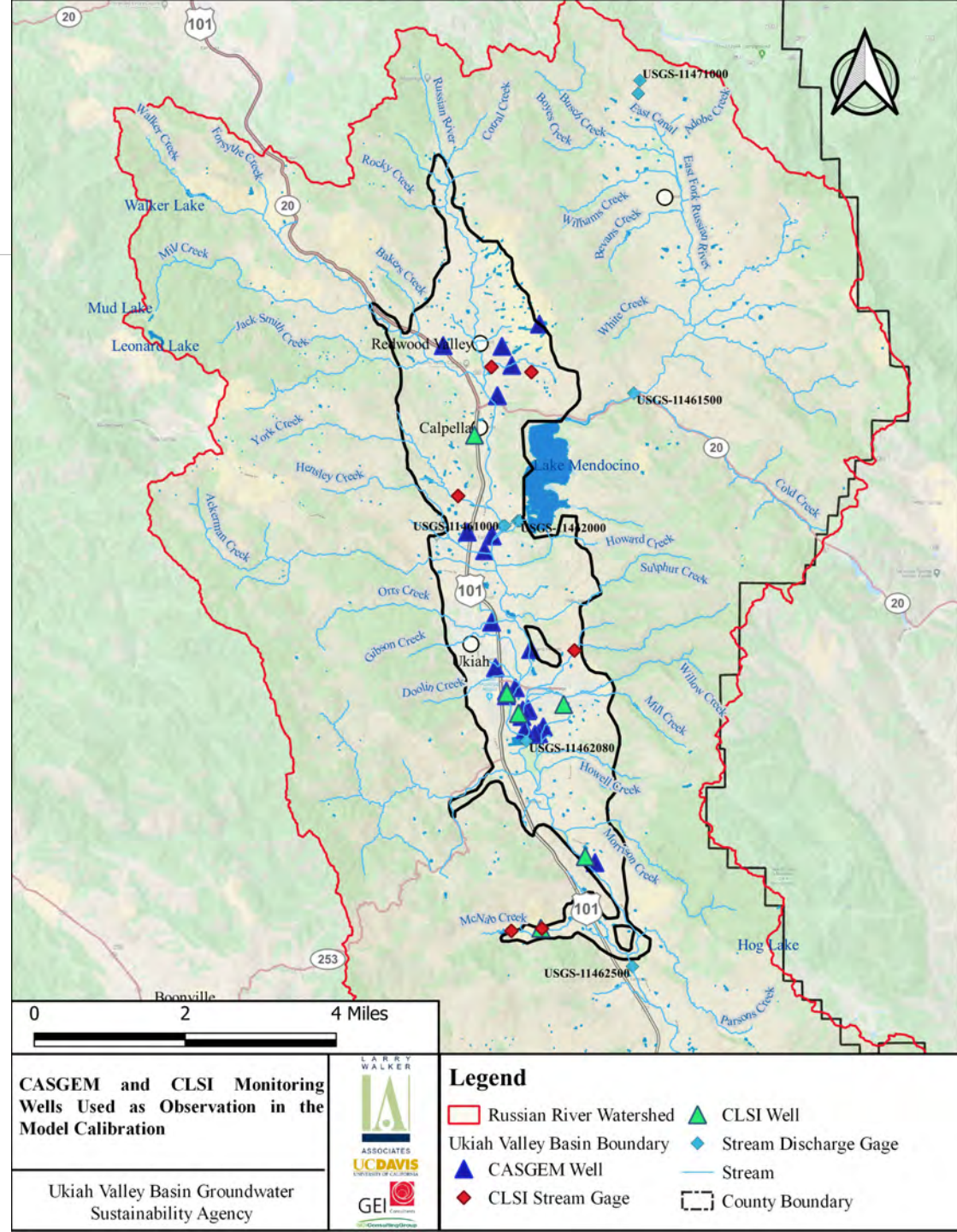
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Observations
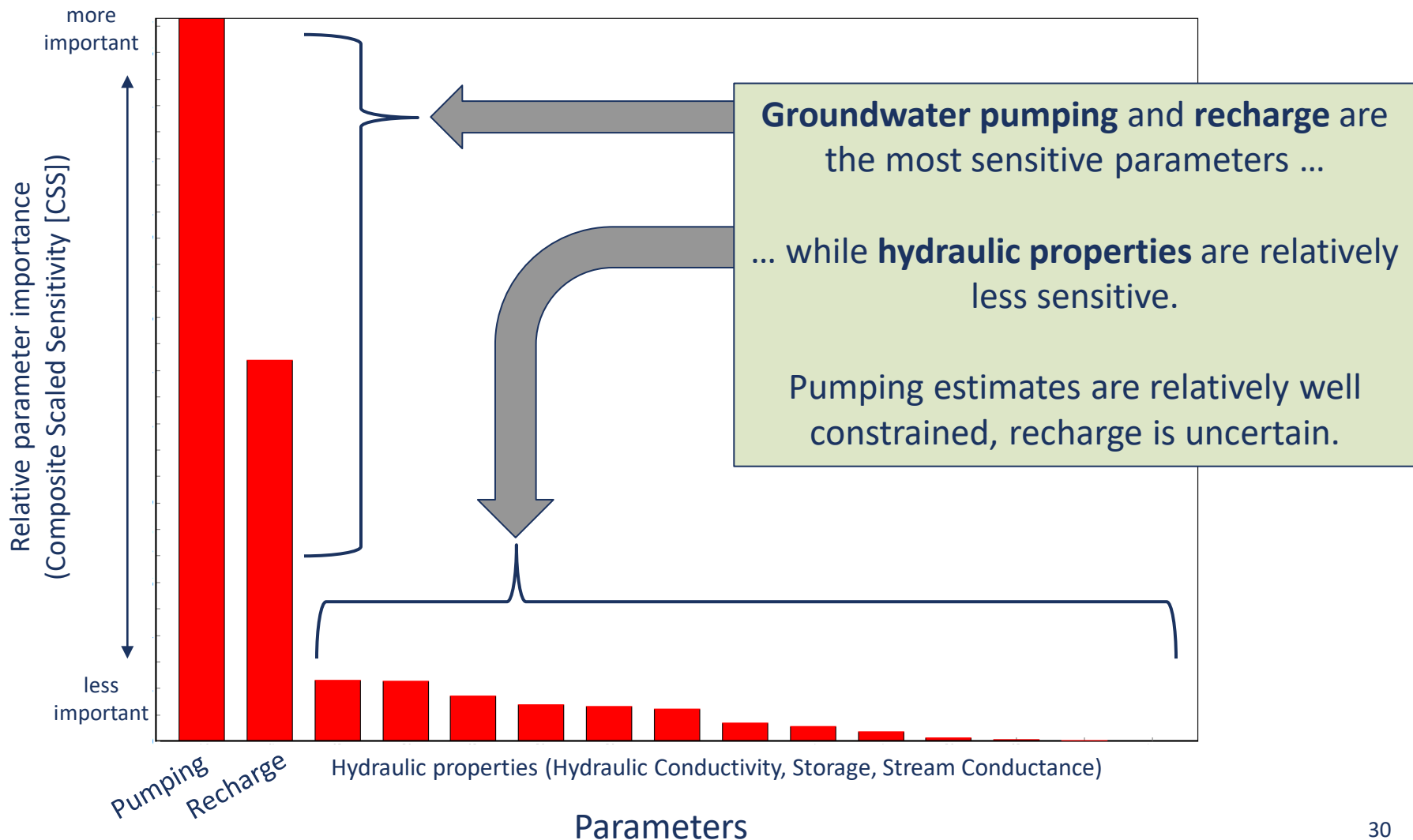
Initial sensitivity analysis and Calibration:

- 39 CASGEM wells
- 1 USGS gage (Hopland)

Subsequent Calibration:

- 39 CASGEM **+ 5 CLSI** wells
- **3 USGS + 6 CLSI** gages

CASGEM and CLSI Monitoring Wells Used as Observation in the Model Calibration

Ukiah Valley Basin Groundwater Sustainability Agency

Legend

- ▭ Russian River Watershed
- Ukiah Valley Basin Boundary
- ▲ CASGEM Well
- ◆ CLSI Stream Gage
- ▲ CLSI Well
- ◆ Stream Discharge Gage
- — Stream
- ▭ County Boundary

0   2   4 Miles

Sensitivity Results—which parameters are important?

Relative parameter importance
(Composite Scaled Sensitivity [CSS])

more important

less important

Groundwater pumping and **recharge** are the most sensitive parameters …

… while **hydraulic properties** are relatively less sensitive.

Pumping estimates are relatively well constrained, recharge is uncertain.

Hydraulic properties (Hydraulic Conductivity, Storage, Stream Conductance)

Pumping   Recharge

Parameters

30

Calibration Setup—Which parameters are included?

Parameters included in the calibration:

Recharge
Horizontal hydraulic conductivity
Stream conductance
Storage properties

- Y-axis: Relative parameter importance (Composite Scaled Sensitivity [CSS]) — more important to less important
- X-axis: Parameters
- Bars: Pumping, Recharge, Hydraulic properties (Hydraulic Conductivity, Storage, Stream Conductance)

31

Initial Calibration Results—Parameter Adjustments

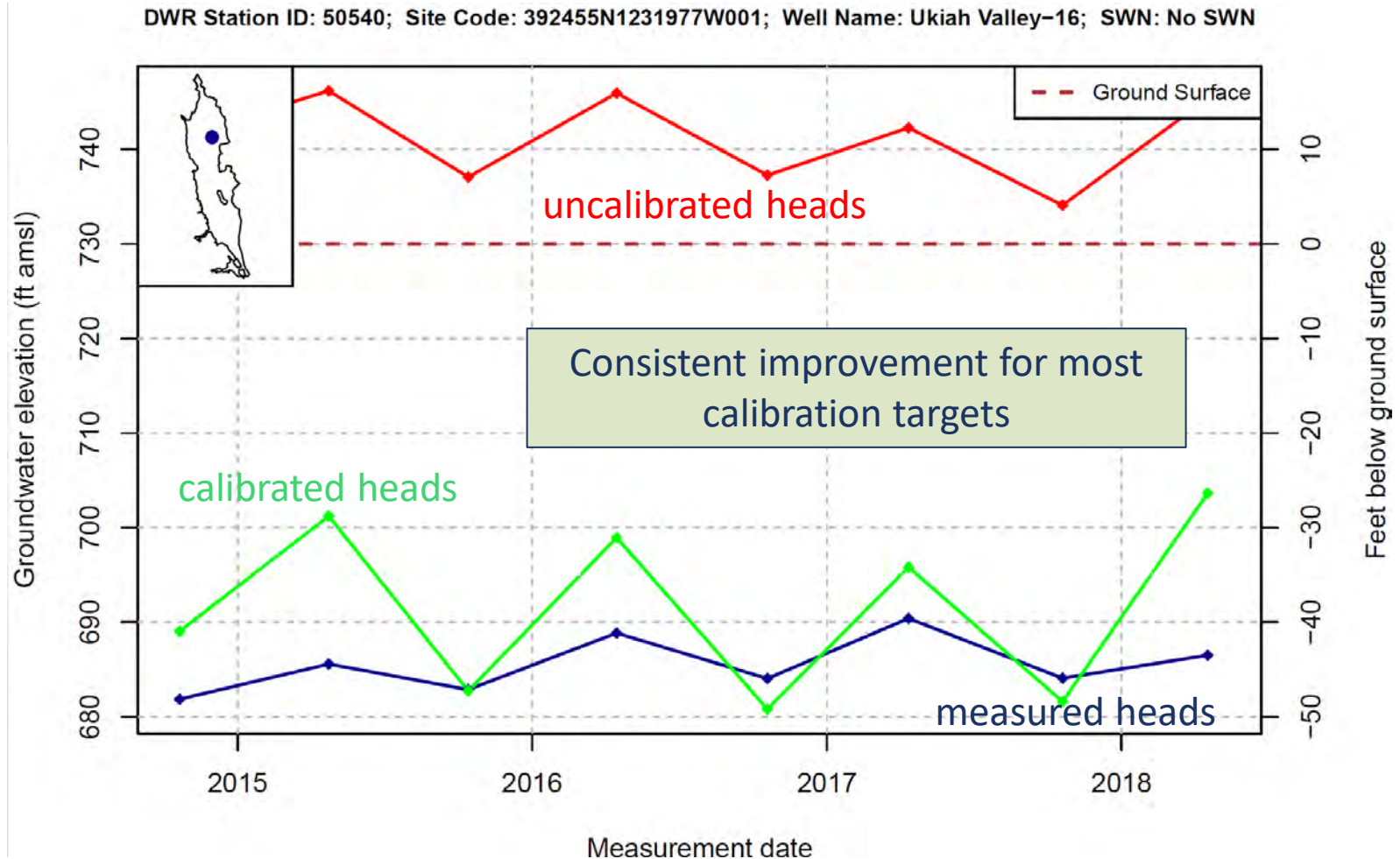|	Parameter	Initial value	Calibrated value	Change
Hydraulic Conductivity	Hk layer 1	196.8 ft/d	212.8 ft/d	Increase
	Hk layer 2	9.8 ft/d	0.96 ft/d	Decrease
	Hk layer 3	1.7ft/d	0.06 ft/d	Decrease
	Hk layer 4	3.3e-5 ft/d	3.3-5 ft/d	Not adjusted
Specific Storage	SS layer 1	1e-4	2e-5	Decrease
	SS layer 2	1e-4	2e-5	Decrease
	SS layer 3	1e-5	6e-6	Decrease
	SS layer 4	1e-7	1e-7	Not adjusted
Stream Conductance	Upland Strm Cond.	0.03 ft/d	0.01 ft/d	Decrease
	Lowland strm. Cond.	0.01 ft/d	3.1 ft/d	Increase
	Recharge adjustment factor	1.0 (unitless)	0.4 (unitless)	Decrease

Calibration Results—Groundwater Heads

Simulated vs. Observed Heads (all observation points)

Uncalibrated heads were consistently overpredicted

Initial calibration yields improvements in heads …

… by adjusting hydraulic properties and reducing recharge

- uncalibrated heads
- calibrated heads
- 1:1 line

simulated heads (ft)

observed heads (ft)

33

Calibration Results—Groundwater Heads

Simulated vs. Observed Heads (average for each observation point)

Uncalibrated RMSE = 54 ft

Calibrated RMSE = 28 ft
47% improvement … more is needed

- uncalibrated heads
- calibrated heads
- 1:1 line

Root Mean Square Error (RMSE) is a measurement of model agreement.

RMSE = 0 = perfect fit

RMSE is in units of length (i.e., ft.)

simulated heads (ft)

observed heads (ft)

34

Calibration Results—Groundwater Heads

DWR Station ID: 50371; Site Code: 391031N1231649W001; Well Name: Ukiah Valley−12a; SWN: No SWN

Uncalibrated heads were consistently overpredicted

Initial calibration yields improvements in heads

uncalibrated heads

calibrated heads

measured heads

35

Calibration Results—Groundwater Heads

DWR Station ID: 50540; Site Code: 392455N1231977W001; Well Name: Ukiah Valley−16; SWN: No SWN

uncalibrated heads

Consistent improvement for most calibration targets

calibrated heads

measured heads

Ground Surface

Groundwater elevation (ft amsl)

Feet below ground surface

Measurement date

Calibration Results—Groundwater Heads

DWR Station ID: 51453; Site Code: 392647N1232245W001; Well Name: Ukiah Valley−30; SWN: No SWN

uncalibrated heads

calibrated heads

Consistent improvement for most calibration targets

measured heads

Calibration Results—Groundwater Heads

DWR Station ID: 50339; Site Code: 391918N1232003W001; Well Name: Ukiah Valley−1; SWN: No SWN

uncalibrated heads

Some calibration targets need improvement

calibrated heads

measured heads

Calibration is an iterative process:

Additional calibration with coupled GSFLOW model will be necessary to improve results …

… to better match measured heads, streamflow, and interannual variability

38

Groundwater Model Preliminary Results

- Overprediction of heads still occurring along the river corridor

Legend

Residuals in (ft)   ● -15 - 0   ● 5 - 15   ● > 30

● < -15   ● 0 - 5   ● 15 - 30

0   2   4 miles

Residuals Map
(Simulated minus Observed)

Calibration Results - Streamflow

Streamflow at the outlet is insensitive to calibration of hydraulic properties in MODFLOW

Greater improvement will occur with integration of PRMS …

… and additional streamflow observations

Calibration Results - Streamflow

PRMS Calibrated Streamflow shows good agreement

Daily Average Streamflow (CFS), Log10 scale

Simulated (red)
Observed (blue)

New Data to be Included in Calibration Process

- CLSI data
  - 6 tributary gages
  - 5 continuous wells

- Data helps fill important data gaps

- Tributary gage data to better understand GW/SW interactions

CASGEM and CLSI Monitoring Wells Used as Observation in the Model Calibration

Ukiah Valley Basin Groundwater Sustainability Agency

Legend

- Russian River Watershed
- Ukiah Valley Basin Boundary
- CASGEM Well
- CLSI Stream Gage
- CLSI Well
- Stream Discharge Gage
- Stream
- County Boundary

42

New Data to be Included in Calibration Process

CLSI gage 14N12WC

Estimated Flow
Simulated Flow

Reasonable uncalibrated agreement for some tributary gages

New Data to be Included in Calibration Process

CLSI gage 15N12W

missing high-flow events

timing issues

Estimated Flow
Simulated Flow

Reasonable uncalibrated agreement for some tributary gages

44

New Data to be Included in Calibration Process

Stage discharge regression

Large rating curve uncertainty for CLSI gages

Estimated Flow
Simulated Flow

Poor uncalibrated agreement for some tributary gages

45

Simulated Results

Layer 1
Fall 2015

Simulated groundwater heads for layer 1 for Fall 2015

| 500 | 525 | 550 | 575 | 600 | 625 | 650 | 675 | 700 | 725 | 750 | 775 | 800 | 825 | 850 | 875 | 900 |

46

Simulated Results

Layer 1
Spring 2015

Simulated groundwater heads for layer 1 for Spring 2015

Simulated Results

Layer 2
Fall 2015

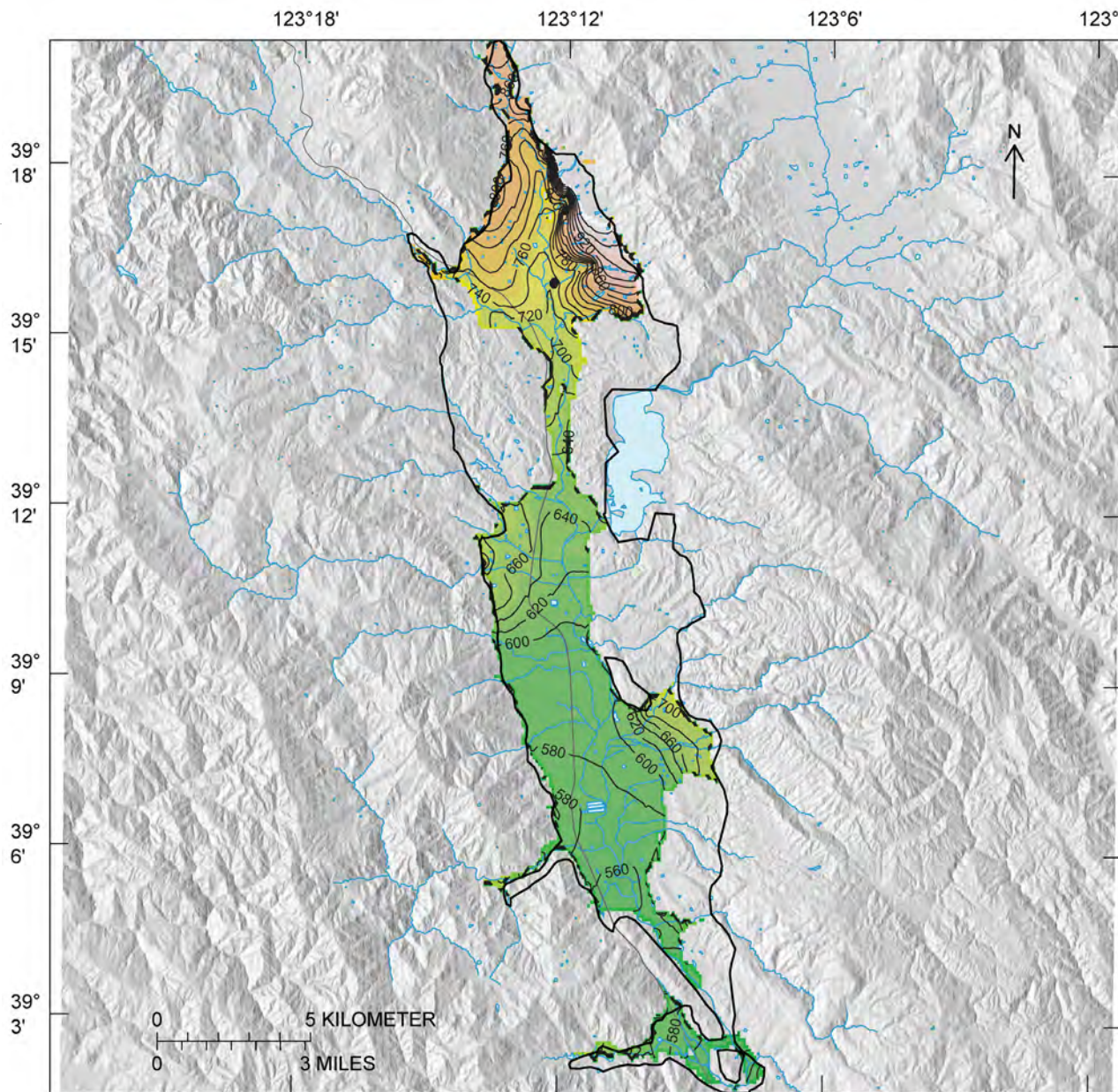Simulated groundwater heads for layer 2 for Fall 2015

Simulated groundwater heads for layer 2 for Spring 2015

Next Steps

- Transfer to GSFLOW Model
- Implement Ag package
- Final Calibration (PRMS + MODFLOW)

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Questions?

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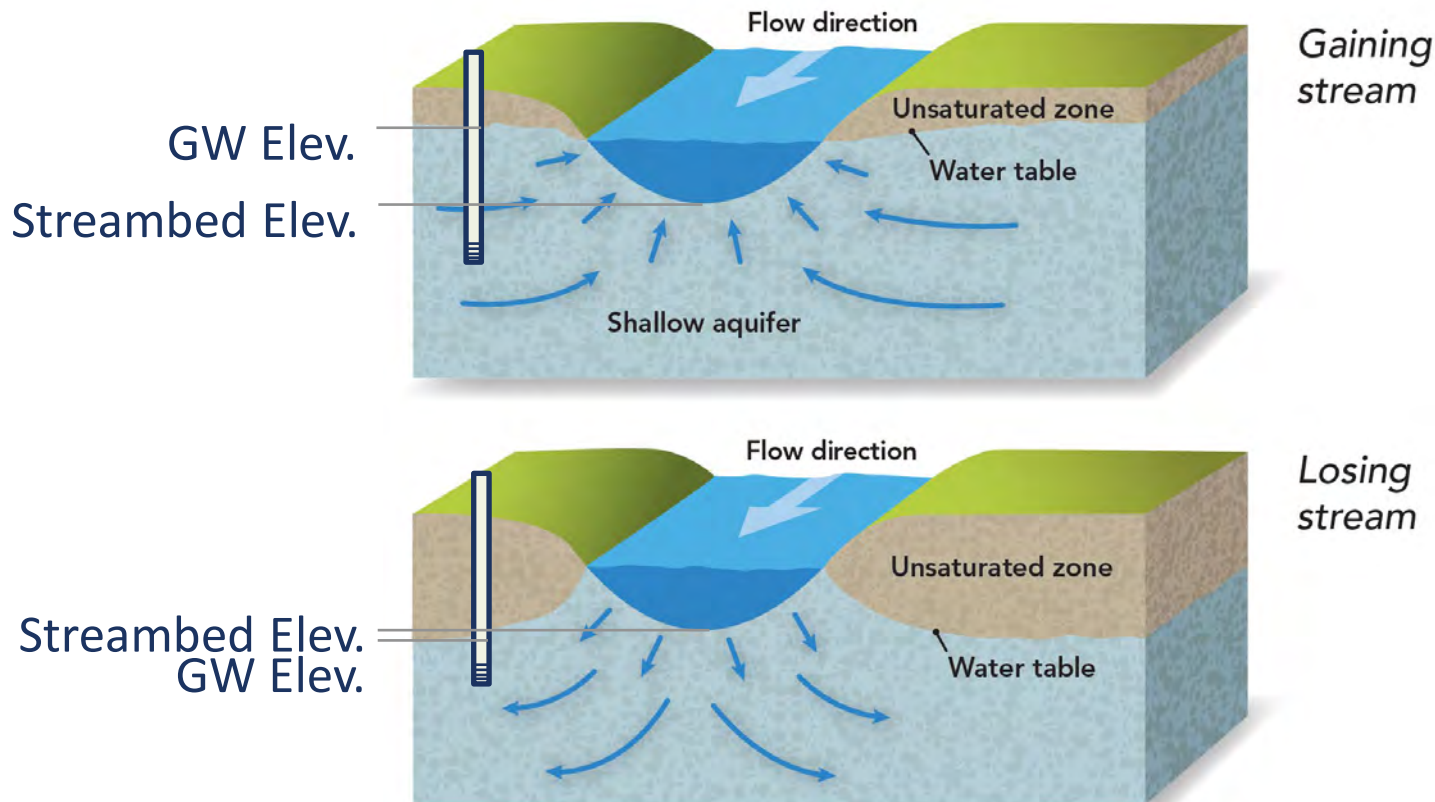 - Surface Water Depletion (introduction)
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SUSTAINABLE MANAGEMENT CRITERIA – SURFACE WATER DEPLETION

Surface Water-Groundwater Interaction SMC

- **What are surface water-groundwater interactions and why are they relevant?**
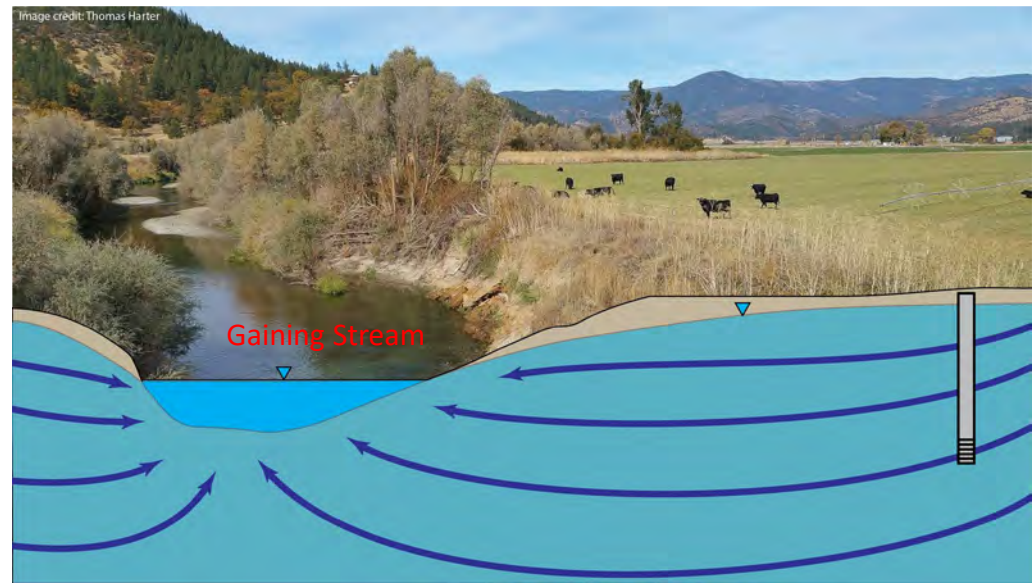
Surface Water-Groundwater Interaction SMC

How can we determine whether a stream is gaining or losing?

Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow?

- Pumping can increase infiltration of surface water to the groundwater system, or reduce exfiltration of groundwater to surface water …

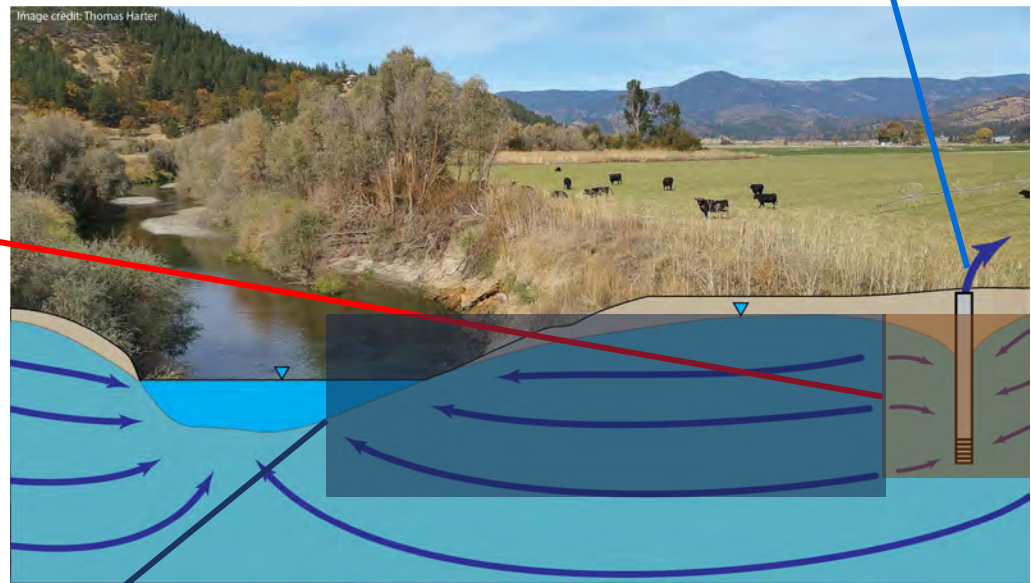- … phenomena known as "Surface Water Depletion."

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Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow?

Groundwater pumping removes water that would have otherwise discharged to the river or riparian vegetation

"Cone of depression" is initially small. Note that its extent is unrelated to impact on stream.

Pumping creates an imperceptibly small decrease in hydraulic gradient to the river … eventually resulting in reduced discharge to the river.
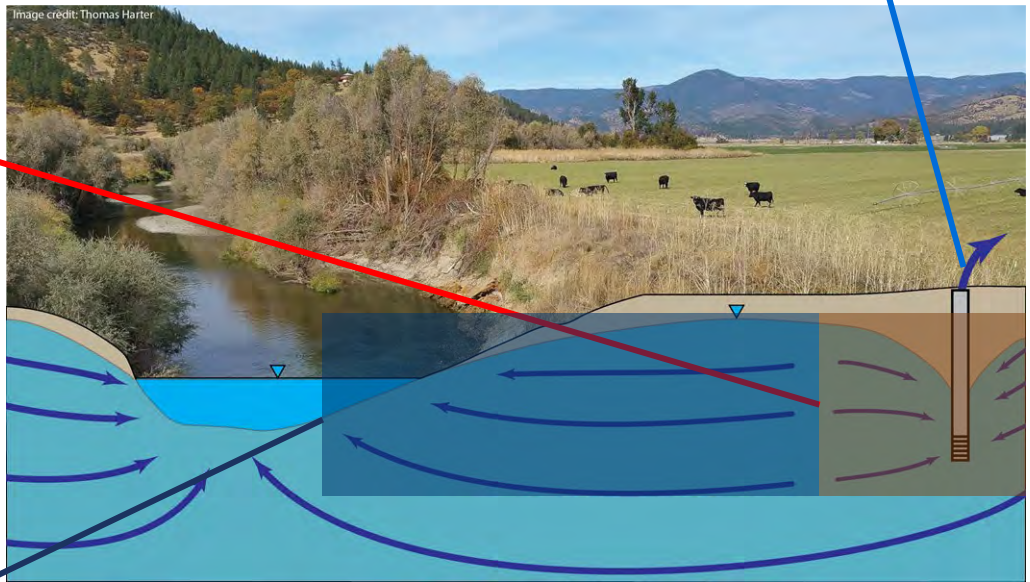
Image credit: Thomas Harter

Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow?

Groundwater pumping removes water that would have otherwise discharged to the river or riparian vegetation

Cone of depression may grow with time

Image credit: Thomas Harter

River is still gaining, but gradually less and less than before pumping initiated

More time pumping = more impact on river

Surface Water-Groundwater Interaction SMC

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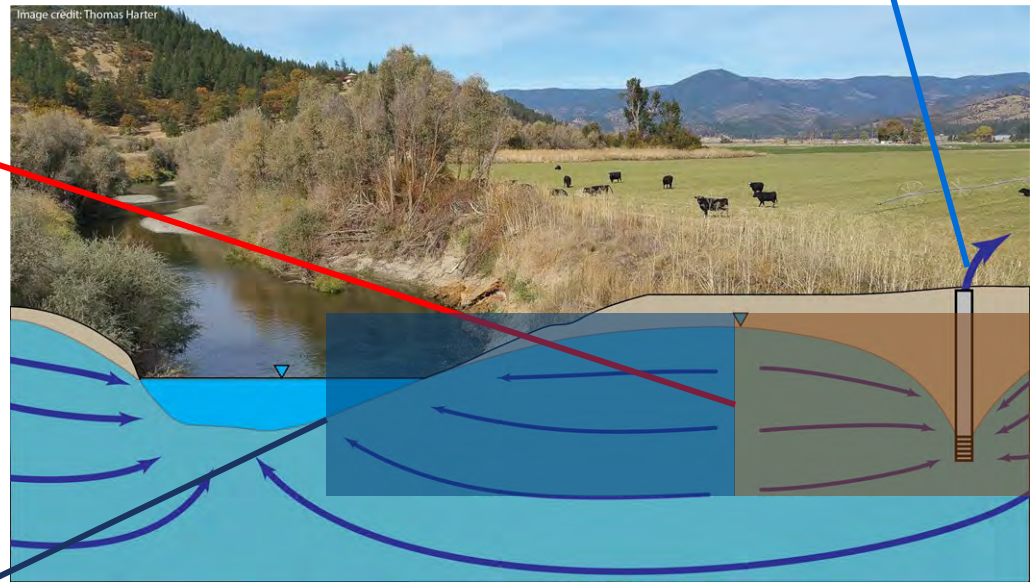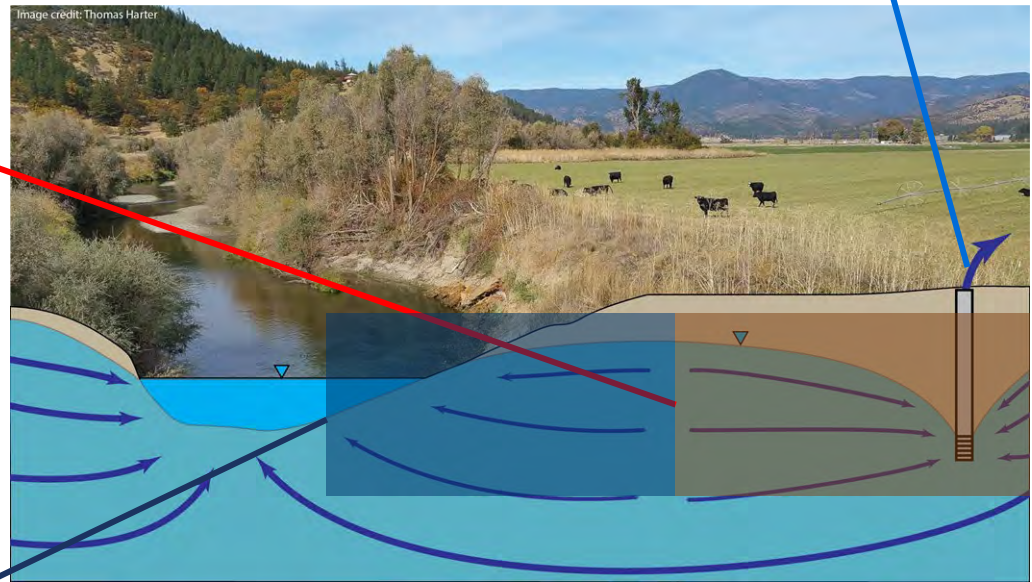
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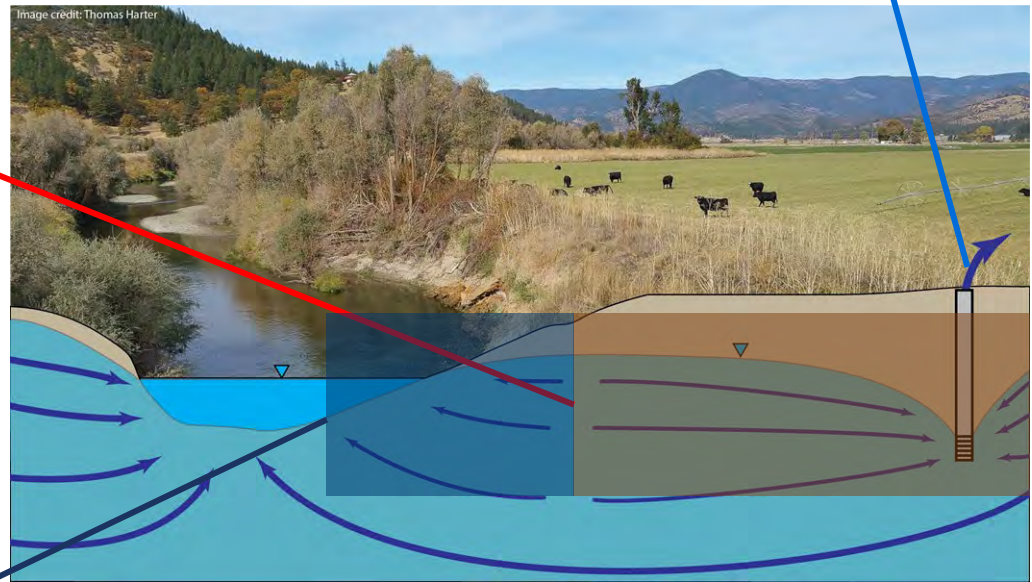
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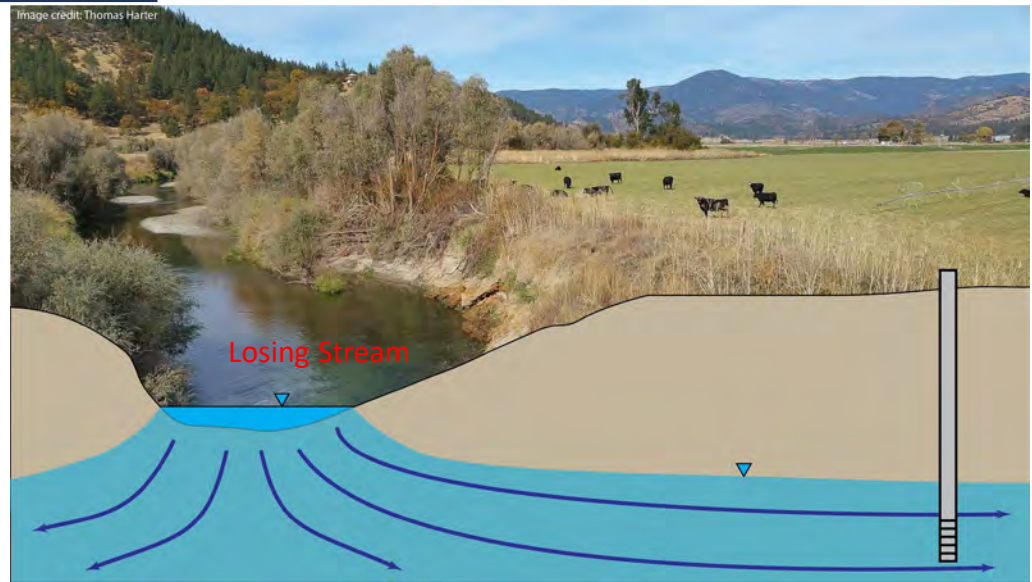

Image credit: Thomas Harter

River is still gaining, but gradually less and less than before pumping initiated

More time pumping = more impact on river

Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow in a <u>losing stream</u>?

A stream segment can "gain" water and "lose" water to/from the groundwater system at different times during the year

Image credit: Thomas Harter

Losing Stream

Streams often "lose" water to the groundwater system during summer and fall months, even under natural conditions without pumping
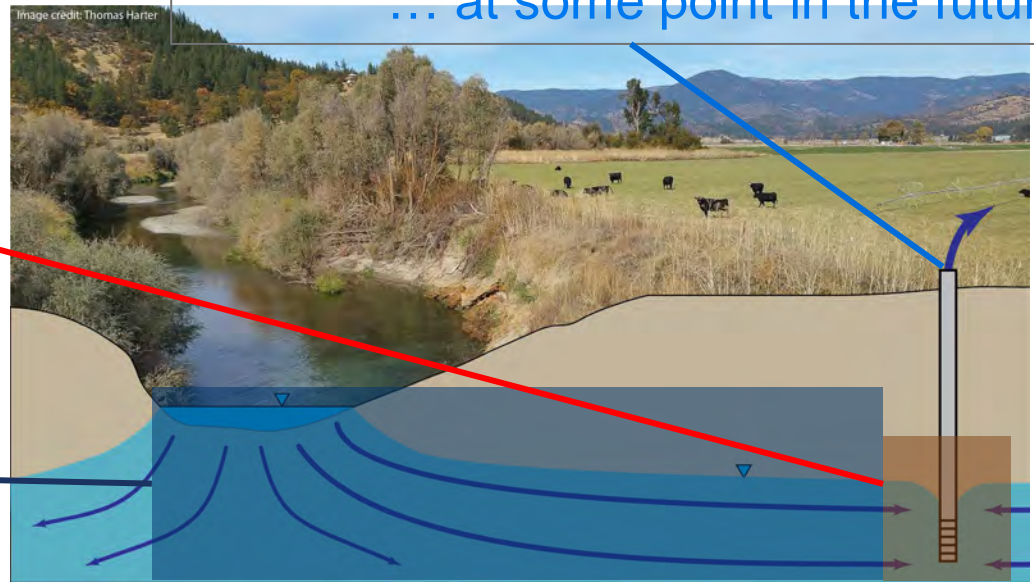
Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow in a <u>losing stream</u>?

Groundwater pumping removes water that would have otherwise discharged to the river or riparian vegetation … at some point in the future

Cone of depression may grow with time

River is still losing, and will lose more as the duration of pumping increases

Image credit: Thomas Harter

More time pumping = more impact on river

Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow in a <u>losing stream</u>?

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… at some point in the future

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More time pumping = more impact on river

Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow in a <u>losing stream</u>?

Groundwater pumping removes water that would have otherwise discharged to the river or riparian vegetation
… at some point in the future

Cone of depression may grow with time

River is still losing, and will lose more as the duration of pumping increases

Image credit: Thomas Harter
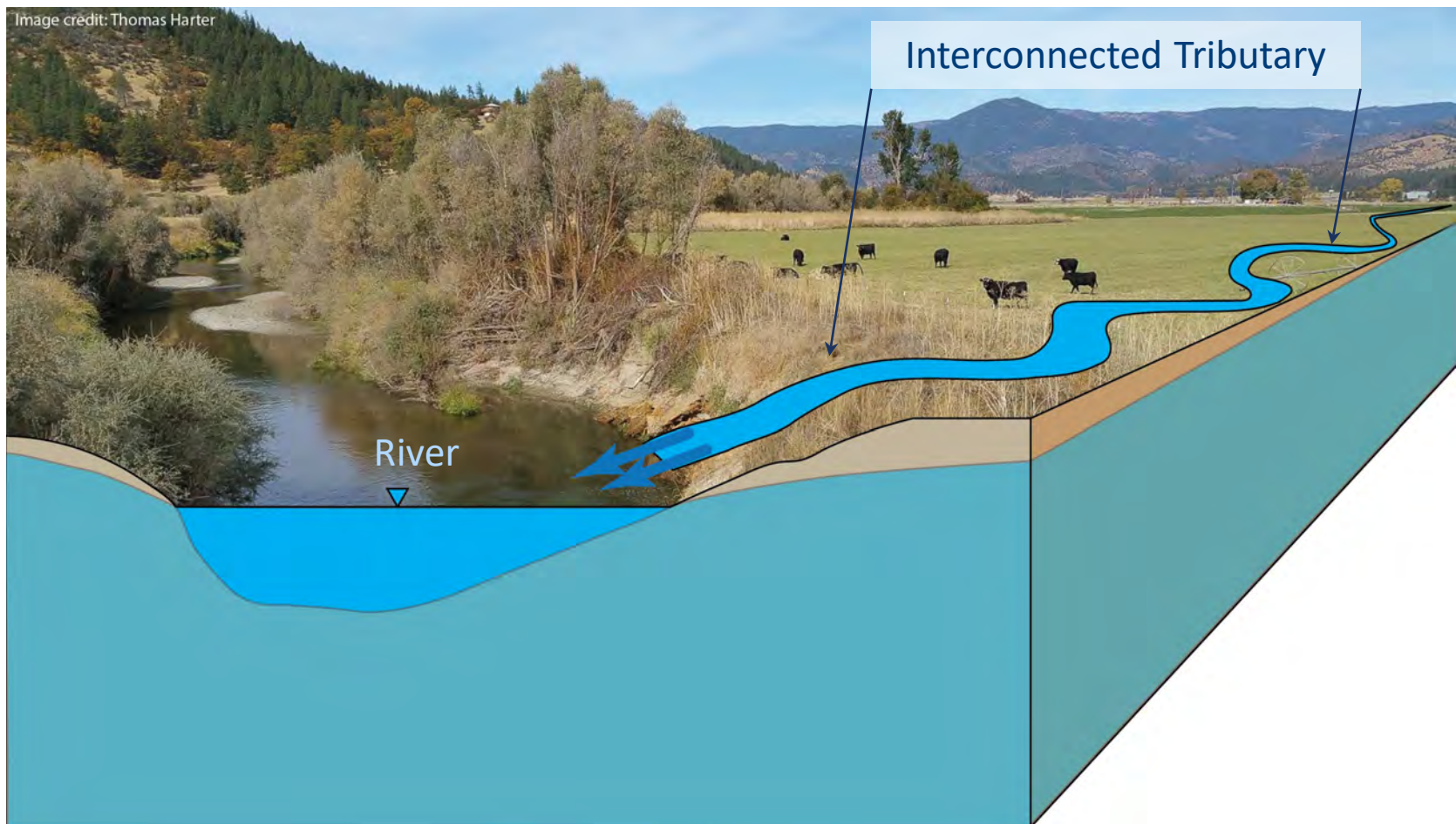
More time pumping = more impact on river

How is SW/GW interaction unique in UVBGSA? … River Incision

No incision → Elevated water table → Interconnected tributaries

Image credit: Thomas Harter

Interconnected Tributary

River

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How is SW/GW interaction unique in UVBGSA? … River Incision
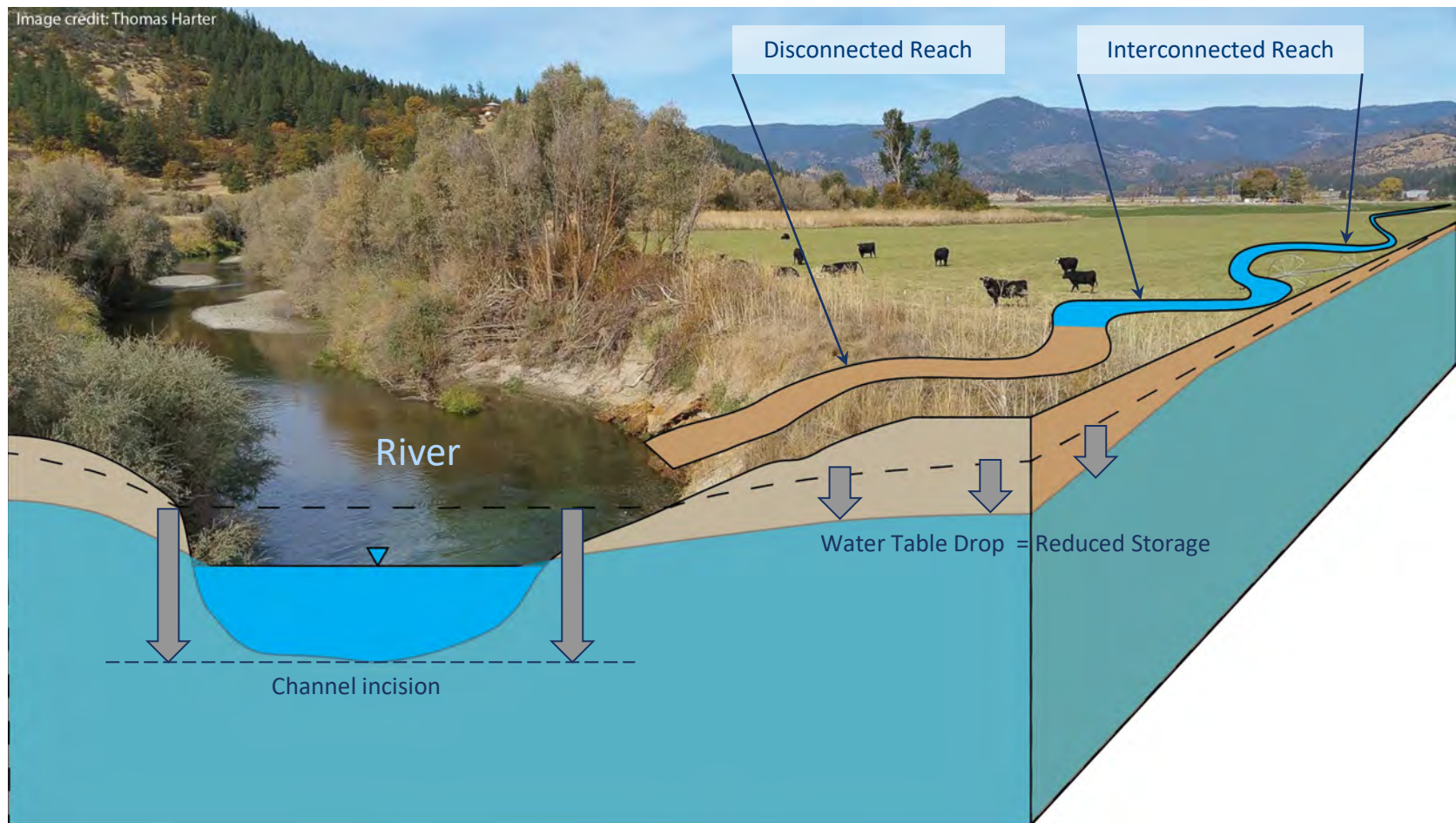
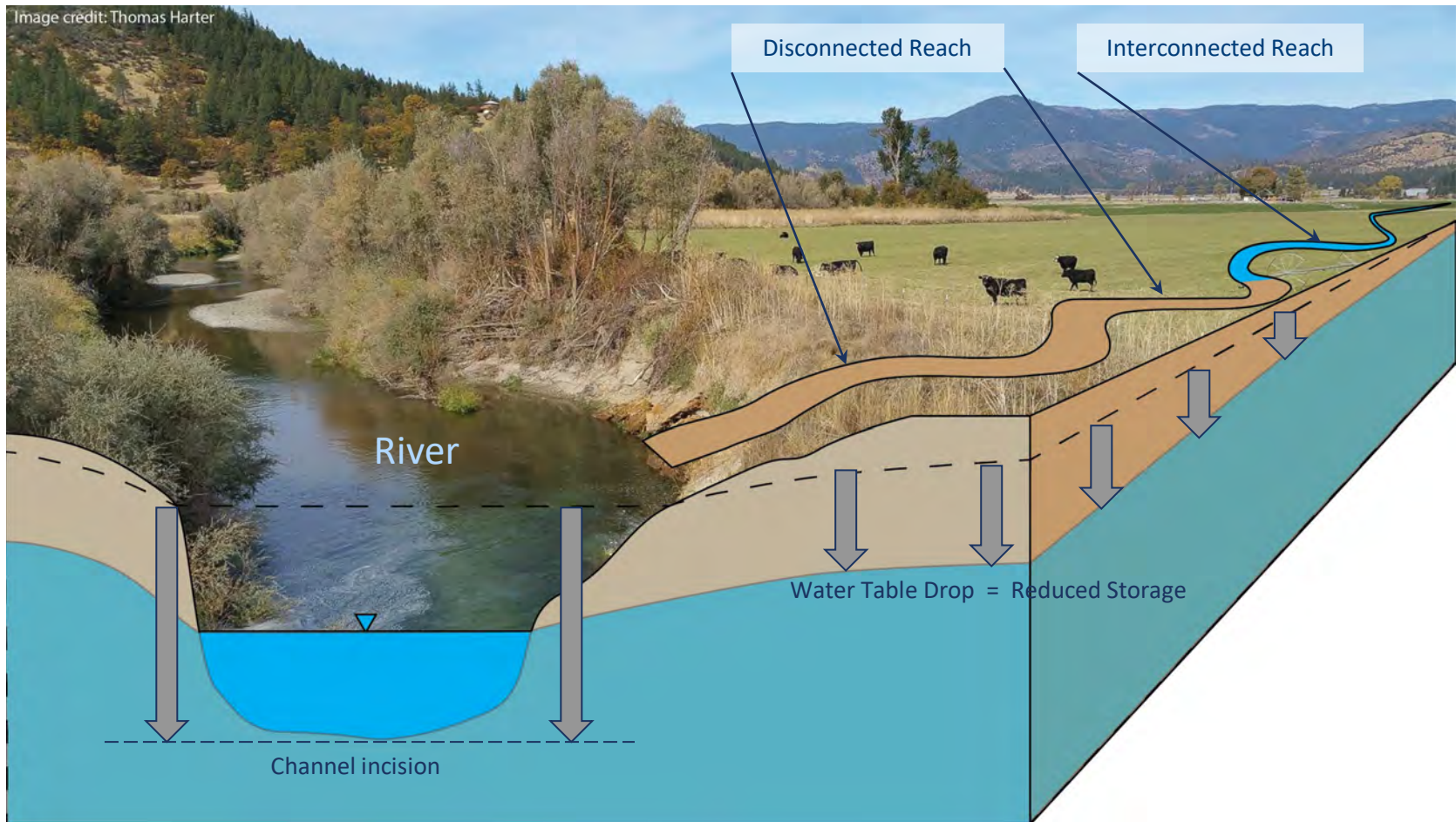Channel incision → Reduced water table depth → Disconnected tributaries

How is SW/GW interaction unique in UVBGSA? … River Incision

Channel incision → Reduced water table depth → Disconnected tributaries

Image credit: Thomas Harter

Disconnected Reach

Interconnected Reach

River

Water Table Drop = Reduced Storage

Channel incision

68

Questions on the physics of groundwater-surface water interaction?

How are SW/GW interactions relevant to the GSP?

- § 354.28 (c)(6) Depletions of Interconnected Surface Water.

- The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results.

How are SW/GW interactions relevant to the GSP?

- The minimum threshold for depletions of interconnected surface water shall be

  - the **rate or volume**

  - of **surface water depletions** caused by **groundwater use**

  - that has **adverse impacts on beneficial uses** of the surface water

  - and may lead to **undesirable results**

This definition will determine*

*Based on the technical team's understanding at this time.

71

How are SW/GW interactions relevant to the GSP?

- § 354.28 (c)(6) Depletions of Interconnected Surface Water. **(cont.)**

- The minimum threshold established for depletions of interconnected surface water shall be supported by the following:

  - (A) The location, quantity, and timing of depletions of interconnected surface water.

  - (B) A description of the groundwater and surface water model used to quantify surface water depletion. …

SW/GW interactions discussion topics

- Possibly tailor in-stream flow studies to local conditions
  - Correlating flow conditions with data from spawning surveys data or juvenile surveys
- Possibly define measurable objectives as functional flows, rather than constant flow rate
- Relate flow rates (at Hopland gage? elsewhere?) to tributary connectivity
  - Has this been done?
- **What does the model tell us about SW-GW interaction?**

Example using historical data from McNab Creek and adjacent monitoring well

15-minute stream gage + monitoring well head data since 2012

Example using historical data from McNab Creek and adjacent monitoring well

Stream Loss Periods

water elevation

Approximate Streambed Elev.

— streamgage
— well

2012

Flow direction

Losing stream

Unsaturated zone

Streambed Elev.
GW Elev.

Water table

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Magnitude and direction of gradient affects loss/gain volumes

Large Gradient = Greater Stream Losses

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Magnitude and direction of gradient affects loss/gain volumes

Smaller Gradient = Smaller Stream Losses

Stream Gaining/Neutral Periods

water elevation

Approximate Streambed Elev.

2012

Flow direction

GW Elev.

Streambed Elev.

Unsaturated zone

Water table

Shallow aquifer

Gaining stream

- streamgage
- well

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Magnitude and direction of gradient affects loss/gain volumes

Significant bank storage
following wet winters

streamgage
well

Approximate Streambed Elev.

Key Tasks

- Get informed on all aspects of SW beneficial uses

- Options for defining:
  - Measurable Objectives

    for stream discharge/depletion and GDEs

    "healthy" basin condition

  - Undesirable Results

    "Significant and unreasonable" depletion of surface water

  - Minimum Thresholds$\rightarrow$ avoid undesirable results
  - **What are the key questions that will help define the above?**

QUESTIONS ON SW-GW INTERACTION?

LARRY
WALKER

ASSOCIATES

Science. Policy.
Solutions.

SUSTAINABLE MANAGEMENT CRITERIA – SUBSIDENCE

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Subsidence of the land surface is an *undesirable result for SGMA*

Lowering groundwater levels

Reduction in storage

Seawater intrusion

Degraded water quality

Land subsidence

Surface water depletion

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Subsidence data available for Mendocino Co.

InSAR satellite-derived subsidence data product is the only known dataset for Mendocino Co. to use for GSPs

Figure 4: Schematic of the SAR satellites acquisition geometry. The Line of Sight (LOS) θ angle is different for each satellite track.

Data available from mid 2015-2018
Additional 2018-2019 data expected by April 2019

InSAR land surveying and mapping services in support of the DWR SGMA program
Technical Report - May 2019

Vertical Deformation Rate [inches/year]
June 2015 - May 2018

≤-2   0   ≥+2

0   200 mi

Figure 13: Vertical deformation rate map over the AOI. The sMP are colour coded according to their annual deformation rate (inches/year) within the common period (June 2015 – May 2018).

SGMA Data Viewer

Find address or place

Legends

▼ **Bulletin 118 Groundwater Basins - 2018**

☐ Bulletin 118 Groundwater Basins

▼ **TRE ALT Vertical Displacement 06/13/2015 to 06/01/2018**

- -2.75 to -2.5 (feet)
- -2.5 to -2.25 (feet)
- -2.25 to -2 (feet)
- -2 to -1.75 (feet)
- -1.75 to -1.5 (feet)
- -1.5 to -1.25 (feet)
- -1.25 to -1 (feet)
- -1 to -0.75 (feet)
- -0.75 to -0.5 (feet)
- -0.5 to -0.25 (feet)
- -0.25 to 0 (feet)
- 0 to 0.25 (feet)
- 0.25 to 0.5 (feet)

InSAR-derived and calibrated to CGPS stations across CA

Data shown are within these two color zones

Potter Valley

Redwood Valley

Lake Mendocino

Groundwater Basin: 1-52 UKIAH VALLEY

Ukiah

California Department of Water Resources. Contact: gis@water.ca.gov | USD...

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esri

DRAFT **Subsidence data for Ukiah Valley**

DWR assessed that there was no documented groundwater-extraction induced subsidence of concern

DRAFT

DRAFT Subsidence data for Ukiah Valley 2015-2018

Legends

▼ **Bulletin 118 Groundwater Ba**

☐ Bulletin 118 Groundwater

▼ **TRE ALT Vertical Displacem**

- ■ -2.75 to -2.5 (feet)
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- ■ -2.25 to -2 (feet)
- ■ -2 to -1.75 (feet)
- ■ -1.75 to -1.5 (feet)
- ■ -1.5 to -1.25 (feet)
- ■ -1.25 to -1 (feet)
- ■ -1 to -0.75 (feet)
- ■ -0.75 to -0.5 (feet)
- ■ -0.5 to -0.25 (feet)
- ■ -0.25 to 0 (feet)
- ■ 0 to 0.25 (feet)
- ■ 0.25 to 0.5 (feet)

InSAR Vertical Displacement 06/13/2015 to 06/01/2018

- ■ -0.09 ft
- ■ -0.08 ft
- ■ -0.07 ft
- ■ -0.06 ft
- ■ -0.05 ft
- ■ -0.04 ft
- ■ -0.03 ft
- ■ -0.02 ft
- ■ -0.01 ft
- ■ 0 ft or No Data Value
- ■ 0.01 ft

InSAR error from calibration and conversion is ~0.1 ft

Subsidence data for Ukiah Valley 2015-2018

Data display largely noise considering the range of both the data and the error are equivalent

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89

Questions?

Thank you!

Seasonal Change in Groundwater Elevations

2019:

Spring Head-Fall Head

- Similar pattern were shown for 2017-2019.
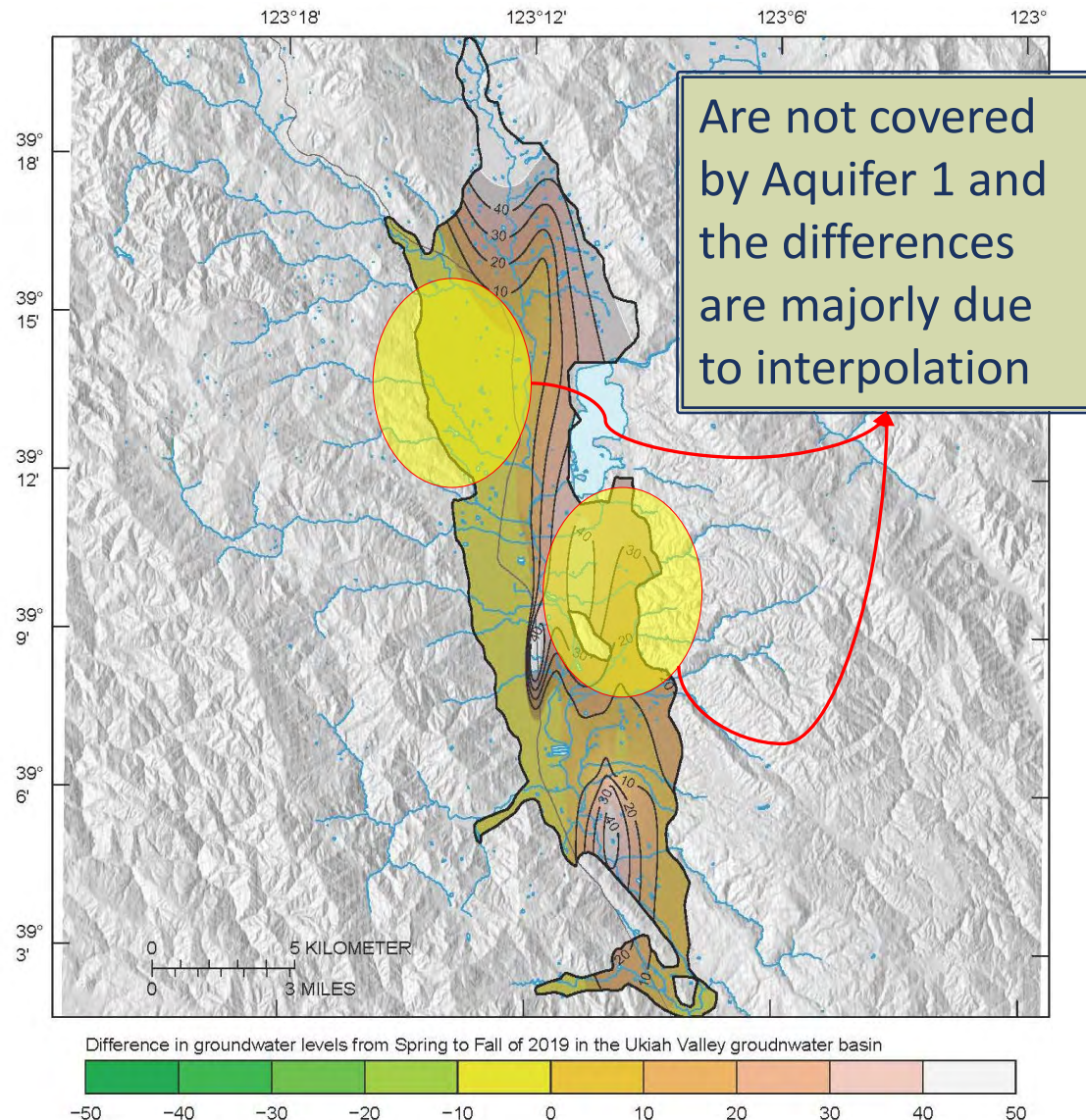- It seems west of the river and east of the river have different responses to the change in season. That may be due to the difference in land use.
- North of Redwood Valley is very dependent on climate variability.

Are not covered by Aquifer 1 and the differences are majorly due to interpolation

Difference in groundwater levels from Spring to Fall of 2019 in the Ukiah Valley groundwater basin

-50   -40   -30   -20   -10   0   10   20   30   40   50

91

Calibration Results—Water Budget

Uncalibrated Monthly Groundwater Budget for a "Typical" Water Year (GSA Area)

Legend:
- Recharge (in)
- Boundary Flows (in)
- Stream Discharge (out)
- Groundwater Pumping (out)

Y-axis: Acre-feet per monthly; +in, -out (2500, 0, -2500)

X-axis: Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep

Calibration Results—Water Budget

Calibrated Monthly Groundwater Budget for a "Typical" Water Year (GSA Area)

PLACEHOLDER FIGURE

Legend:
- Recharge (in)
- Boundary Flows (in)
- Stream Discharge (out)
- Groundwater Pumping (out)

Y-axis: Acre-feet per monthly; +in, -out
X-axis: Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep