Groundwater Resources Association of California

EST. 1992

Groundwater Recharge on the Cosumnes River With Off-Season Agricultural Fields

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LARRY WALKER ASSOCIATES

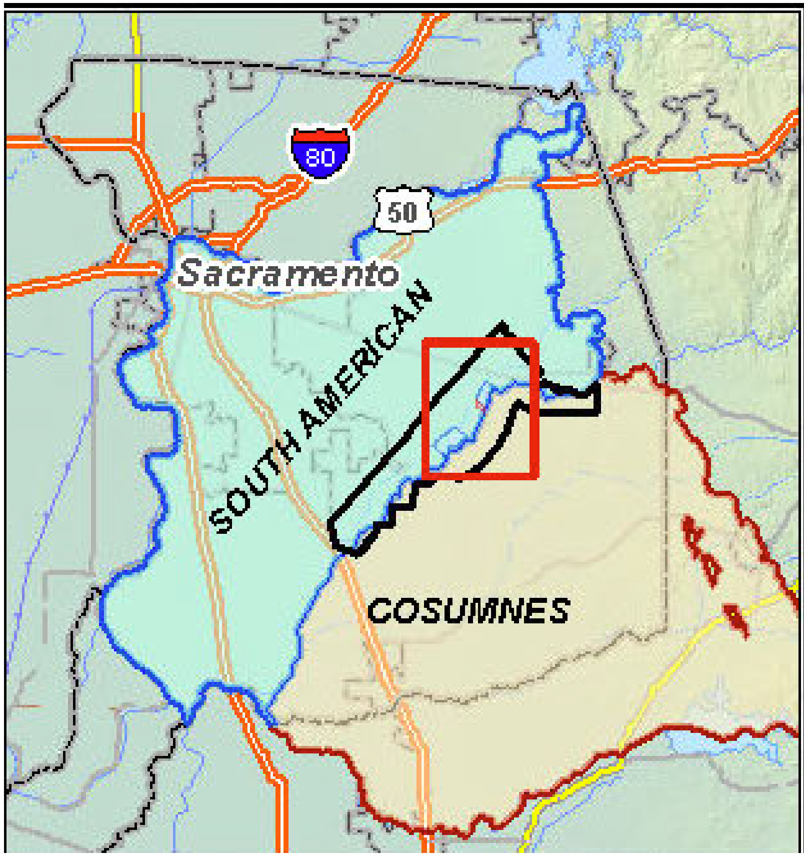
Science. Policy. Solutions.

UC DAVIS

UNIVERSITY OF CALIFORNIA

Cosumnes River Groundwater Recharge

- Integrated team, complementary skills
  - Omochumne-Hartnell Water District (OHWD)
  - Larry Walker Associates (LWA)
  - Cosumnes Coalition/TNC
  - UC Water
  - Sacramento State University
- Funded through a Prop. 84 Integrated Regional Water Management (IRWM) grant for OHWD



Comprehensive pilot study

- Irrigation design and installation
- Continuous groundwater monitoring
- ET and plant stress monitoring (UC Cooperative Extension)
- Extensive modelling

→ To understand benefits of recharge to aquifers, river, and GDEs

→ Many institutions and stakeholders involved

→ Synergistic effort

Dry Cosumnes River Bed in August, 2010

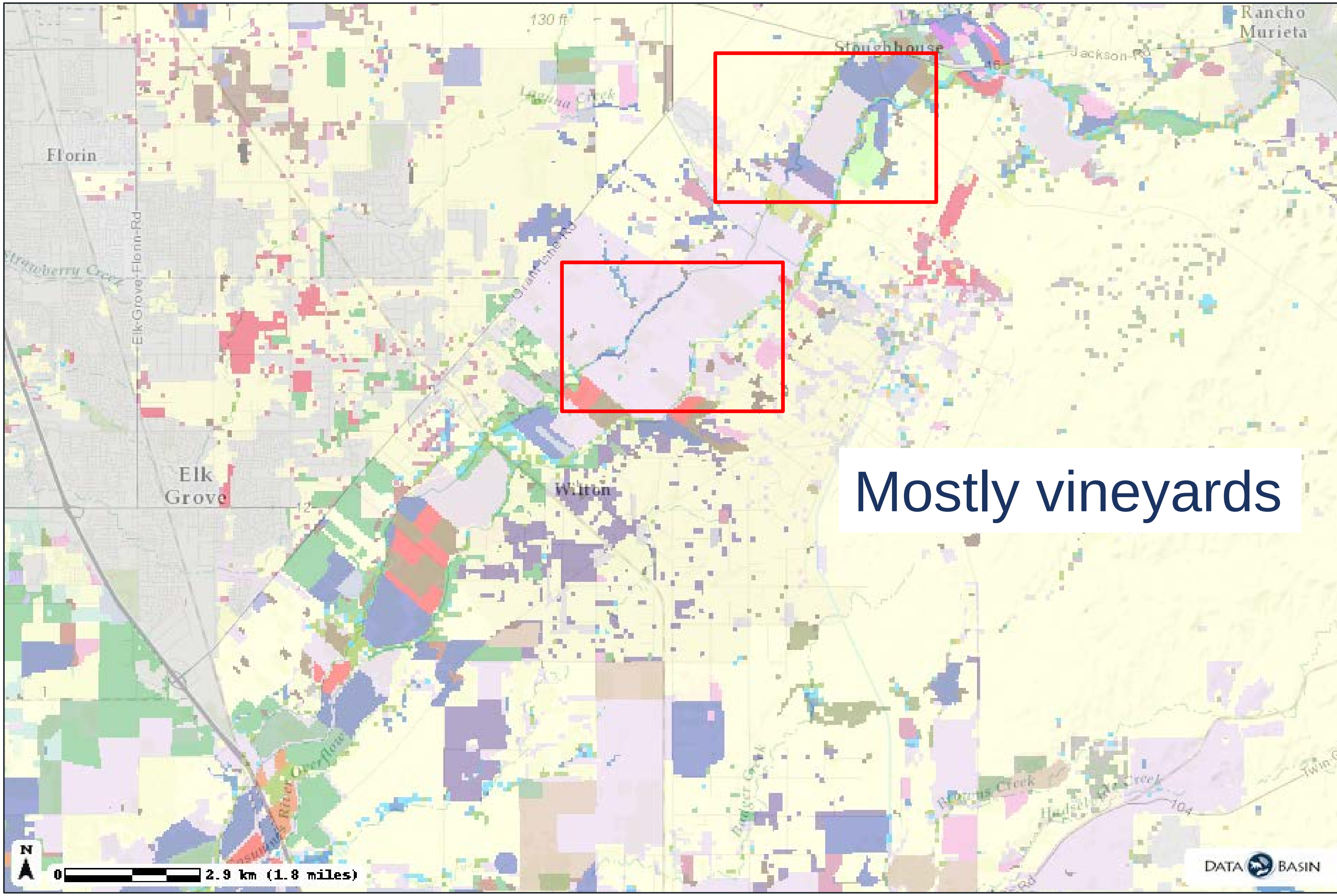
Groundwater Recharge By Flooding Agricultural Land

TABLE 1. Survey results of tree crop vulnerability to saturated conditions

Crop	Rootstock	Tolerance to saturation before budbreak	Tolerance to saturation after budbreak	Recommended N fertilizer rate
				lbs N/ac/yr
Almonds	Peach; peach x almond hybrid	1	1	250
Almonds	Plum; peach x plum hybrid	2–3	1	250
Avocados	—	0	0	150
Cherries	—	1	0	60
Citrus	—	0	0	100
Wine grapes	—	4	2	15–30
Olives	—	?	?	<100
Pears	*P. betulaefolia*	4	4	100–150
Pears	*P. communis*	4	3	100–150
Pears	*Cydonia oblonga*	3–4	2–3	100–150
Pistachios	—	?	?	200
Plums/prunes	Peach	1	1	150
Plums/prunes	Plum; peach x plum hybrid	2–3	1	150
Pomegranate	—	?	?	100
Walnuts	—	2–3	1	200

The following scores were used to estimate vulnerability: 0 - No tolerance for standing water; 1 - tolerant of standing water up to 48 hours; 2 - tolerant of standing water up to 1 week; 3 - tolerant of standing water up to 2 weeks; 4 - tolerant of standing water > 2 weeks; ? - tolerance unknown.

A.T. O'Green, et al., Soil suitability index identifies potential areas for groundwater banking on agricultural lands, California Agriculture, 2015.

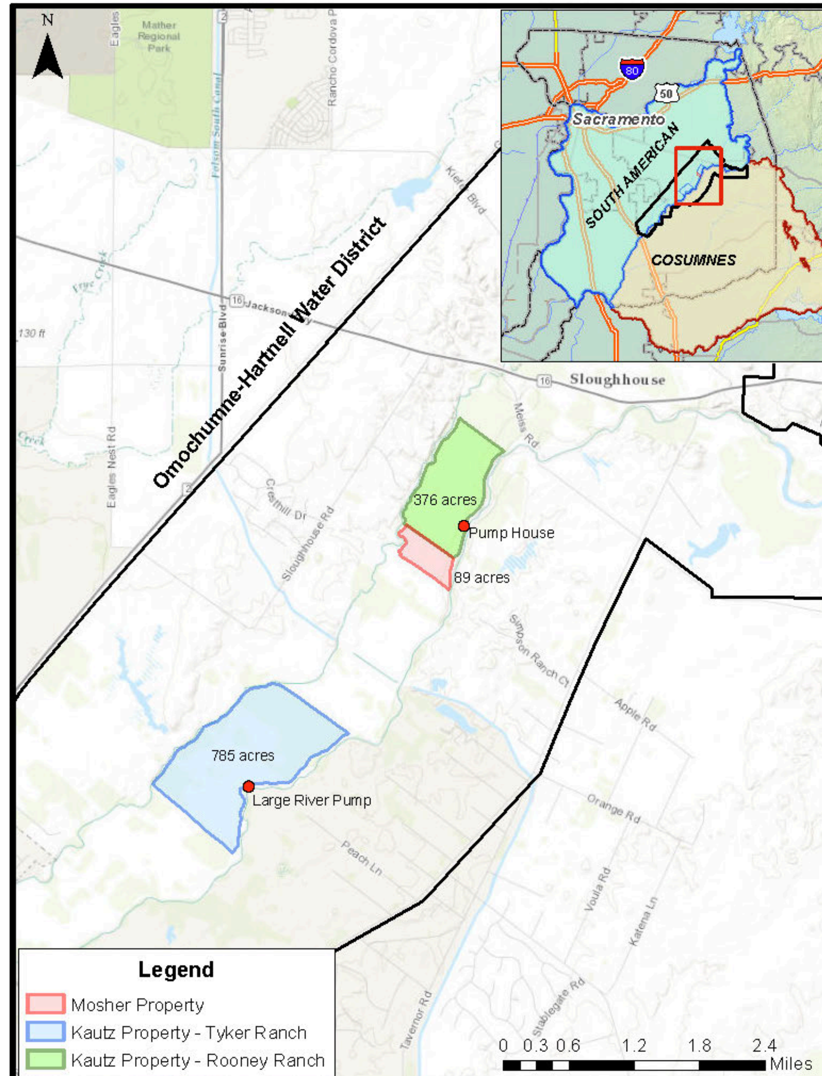


Mostly vineyards

Annual Grassland | Vineyards (includes table grapes, wine grapes, and raisins) | Tomatoes (processing) | Corn (Field and Sweet) | Safflower | Turf farms | Pasture

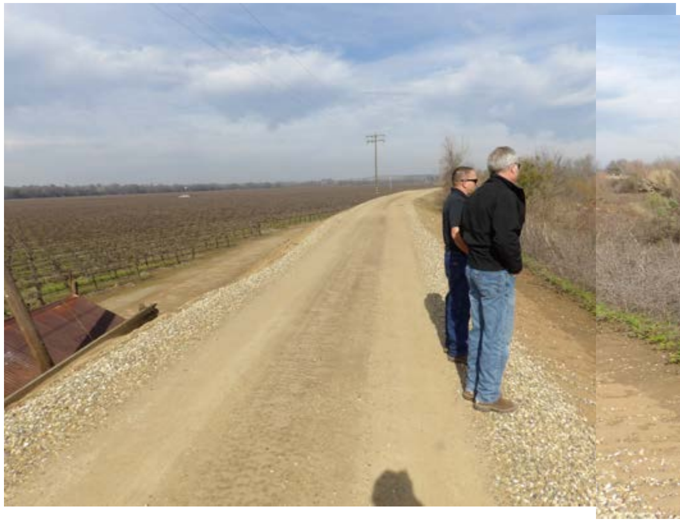
Recharge Site

- Region between Deer Creek and Cosumnes River → **ideal** for GW banking:
  - readily transmissible and low salinity soils,
  - suitable topography, and root zone residence time.
  - ag fields with good water access, crop suitability, soil permeability, and land owner interest and agreement.



Overall System Design

- 10 year period → use two existing diversions on the River to flood dormant ag fields in the off-(irrigation) season (Nov-March) when streamflow is high and excess water is available.
- **GOAL** → divert a minimum of 4,000 AF per year, but system designed to divert/recharge up to 6,000



Available Water for Diversion

- 50% of water years have enough flow in the river to allow 6,000 AF diversion
- 70% of water years would allow at least 4,000 AF diversion.

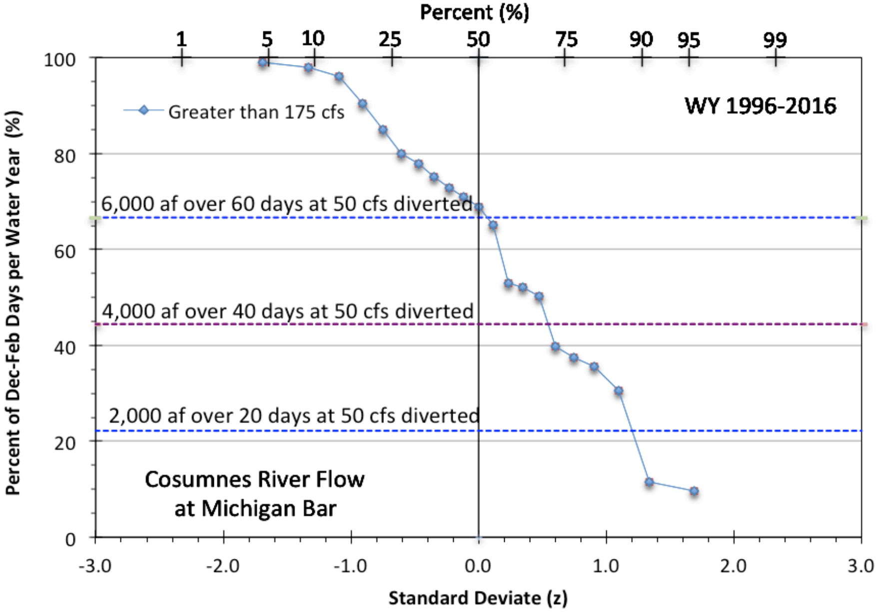


Table 1. Percent exceedance of years with the listed number of days in December through February with diversion. Volumes diverted assume 50 cfs diversion when flows at Michigan Bar exceed 175 cfs, and 7.5 cfs diversion when flows at Michigan Bar are between 75 cfs and 175 cfs.

Available Dec-Feb Days with 50 cfs of Diversion	Volume Diverted (af)	Percent Exceedance (%)	
		WY 1908-2016	WY 1996-2016
All	6,000	7	<5
60	6,000	45	52
40	4,000	67	71
20	2,000	87	88

Groundwater Monitoring

- Monitoring to show performance of the project required by the grant
- GW monitoring for quantity and for water quality, and ET and soil moisture will provide a quantitative metric of the off-season irrigation on local groundwater levels and storage
- Synergistic effort

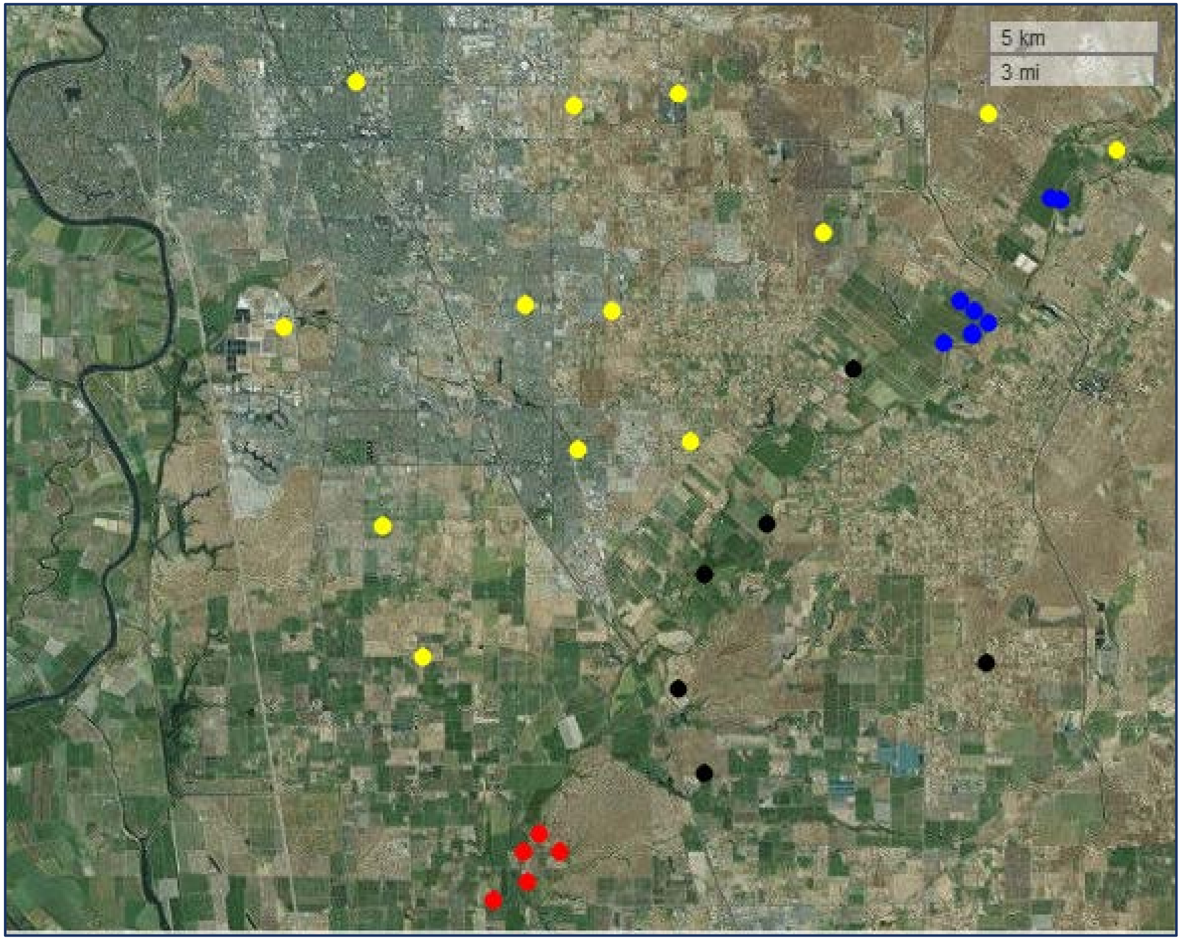
The Cosumnes Coalition

Concepts behind the UC Water Groundwater Observatory project

- Need observations to manage the GW system
- Continuous recording pressure transducers to capture relevant changes in GW levels at any time
- Telemetry-equipped GW observatory for monitoring real-time GW level fluctuations under development
- Data available in the form of well hydrographs on a web-based dashboard, but online publications details to be discussed with landowners
- Limiting factor is access to wells

Complete UC Water Monitoring Network in the basin

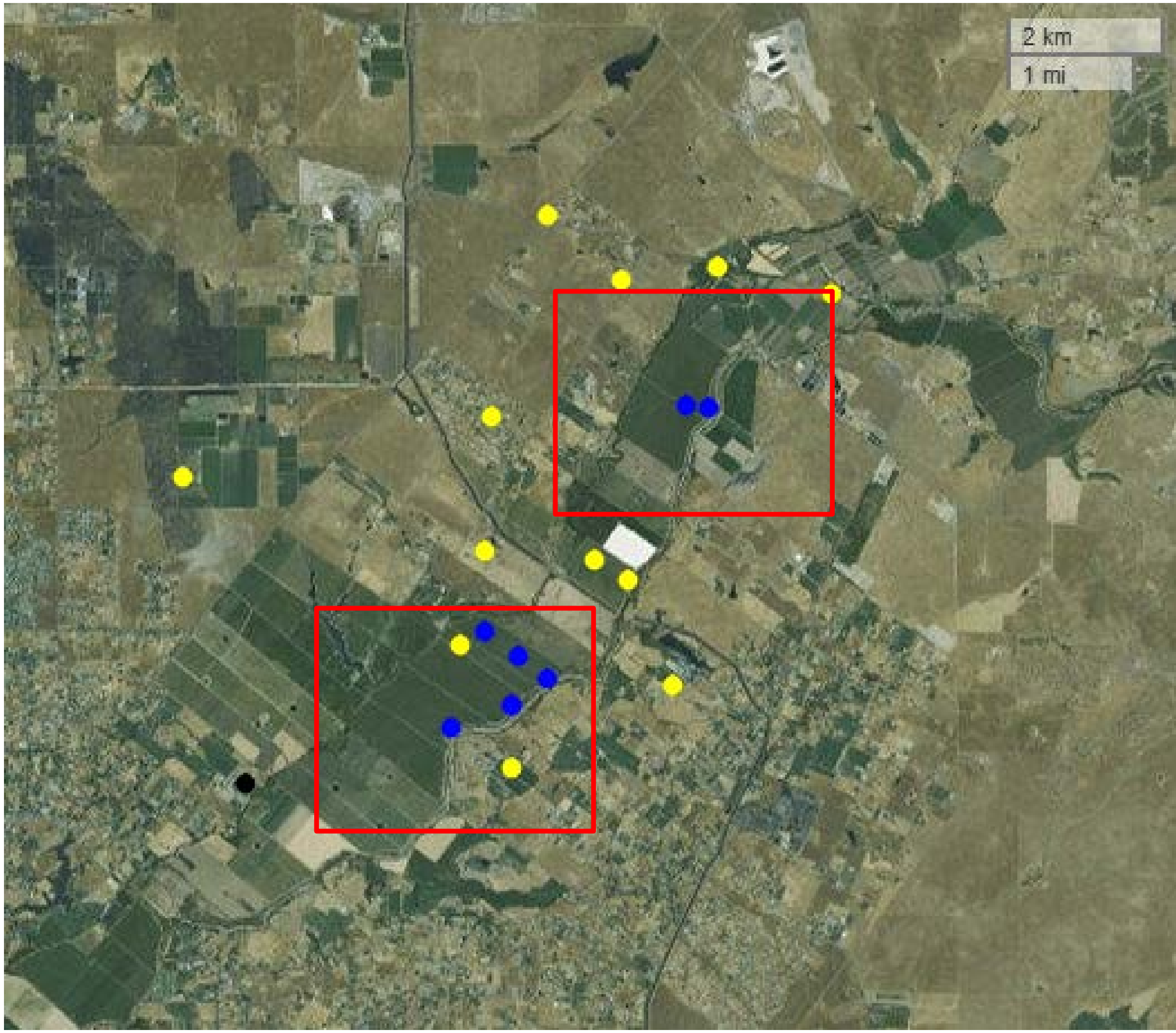
- 5 lower Cosumnes sites (Oneto-Denier field site)
- 5-10 Cosumnes corridor wells plus wells of recharge project
- 5-10 South American River Sub-basin wells



Partners: UC Water, OHWD, Cosumnes Coalition, Sacramento County

Recharge scale monitoring network

- Verified for monitoring (blue)
- Existing, but not verified (yellow)
- **4 new wells to be drilled**
- Importance of monitoring the southern side



Groundwater quality monitoring goals

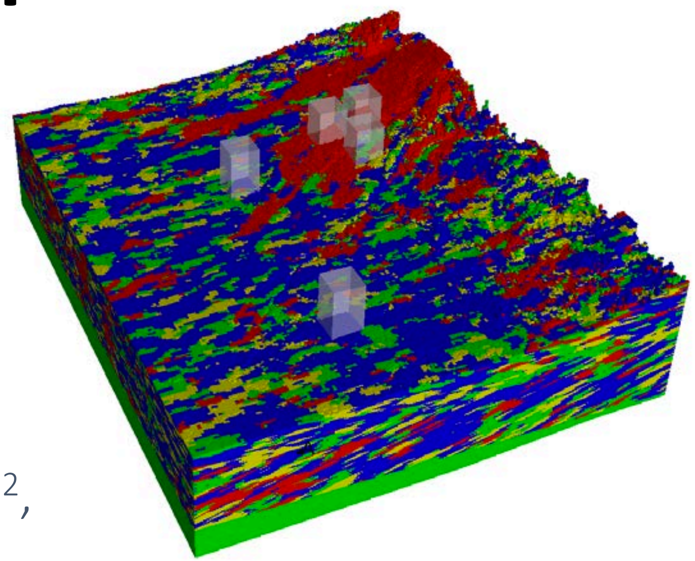
- Stable isotopes → track movement of recharged water through aquifer
- Major ion chemistry → see if reactions between recharged water and local GW could clog pore space and slow infiltration
- Trace elements, nutrients, pesticides → ensure that recharge is not degrading GW quality

SACRAMENTO
STATE

On to GW modelling

- Using advanced groundwater models to simulate aquifer heterogeneity and impact of groundwater recharge
- GW models as tools to suggest optimal recharge locations
- Future integration of extensive monitoring data into modelling → enhanced model calibration and increase model reliability (for future scenarios development)

Geologic Controls on Groundwater Recharge in the South-American Subbasin



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Take Home Messages:

Surface soils are important … but they're not the whole story!

Large variation in recharge rates ….
controlled primarily by **geologic heterogeneity**.

Laterally-extensive silt and mud hydrofacies impede recharge
over most of the landscape.

Orders-of-magnitude greater recharge possible
over **Incised Valley Fill (IVF)** deposits, where sand and gravel hydrofacies
interconnect from land-surface to deeper aquifer system.

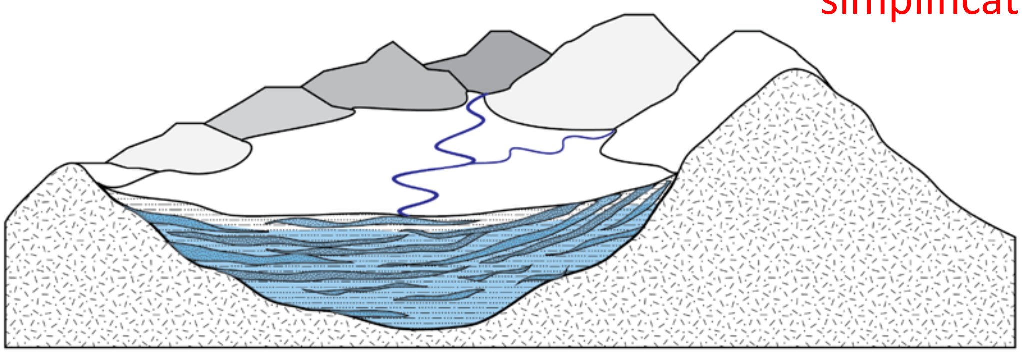
Problem: Geology controls recharge rates/extent …
… but many regional-scale GW models are not detailed enough to include these details.

Conceptualization Issue

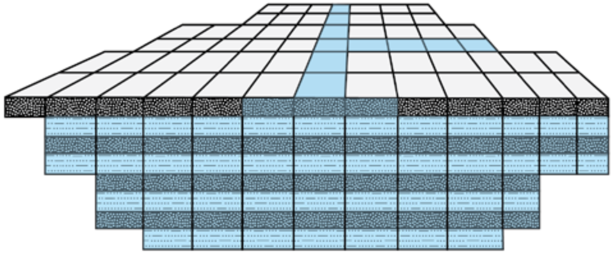
Geologic heterogeneity controls recharge …

… but is often poorly understood/represented in regional, coarse-resolution models

Typical Alluvial Aquifer System → aggregation & simplification → Typical GW Model



Complex Heterogeneity

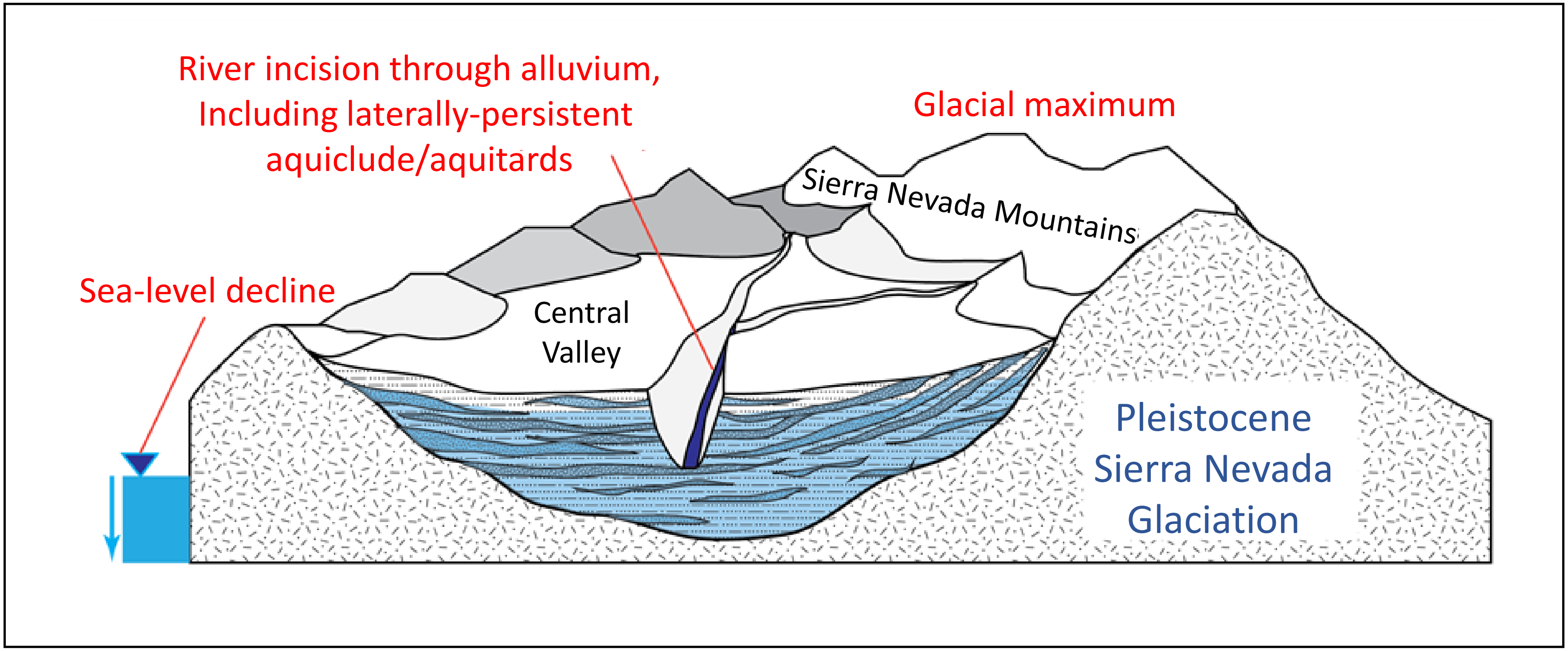


Simplified Domain

Solution: Physically-based, detailed model explicitly simulates recharge processes, & provides realistic ranges of recharge

Objective: Exploit preferential pathways (i.e., connected network of sand & gravel hydrofacies) for accelerated, high-volume recharge.

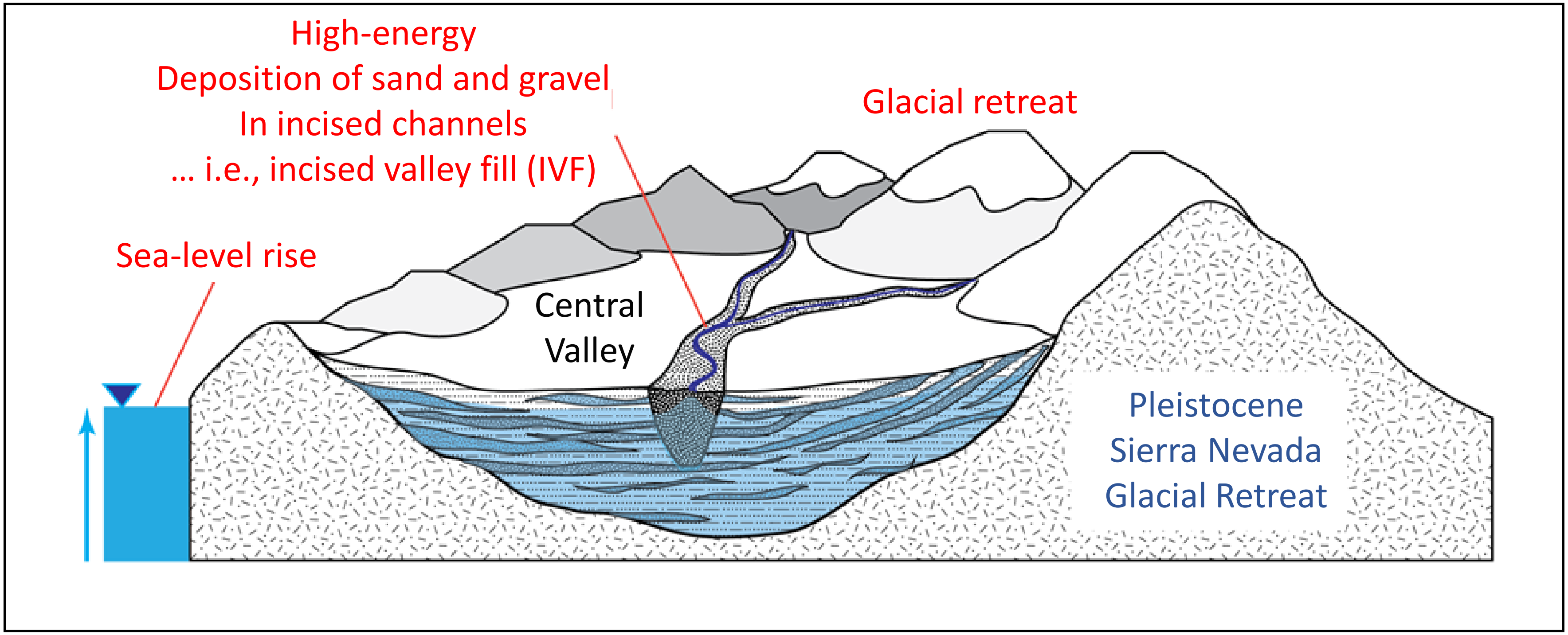
~1.8 mya – 10 kya
Glacial Maximum … River Channel Incision through Laterally-Extensive Aquitards



Weissmann & Fogg (1999); Weissmann et al., (2002); Meirovitz (2010)

Objective: Exploit preferential pathways (i.e., connected network of sand & gravel hydrofacies) for accelerated, high-volume recharge.

~1.8 mya – 10 kya
Glacial Retreat … Deposition of Coarse Sand & Gravel



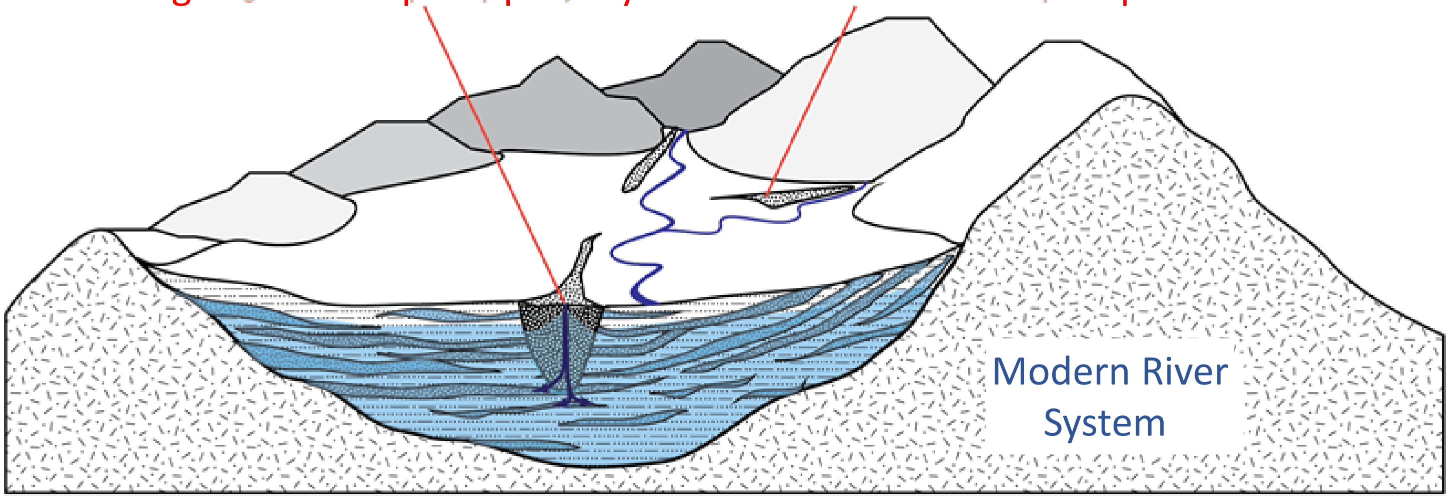
Weissmann & Fogg (1999); Weissmann et al., (2002); Meirovitz (2010)

Objective: Exploit preferential pathways (i.e., connected network of sand & gravel hydrofacies) for accelerated, high-volume recharge.

Present Day System
Outcropping Sand & Gravel … Interconnected 'Window' into Subsurface

IVF provide a high-permeability 'window' of interconnected sand and gravel for recharge to the deeper aquifer system

… But outcropping IVF only occur over small fraction of the landscape



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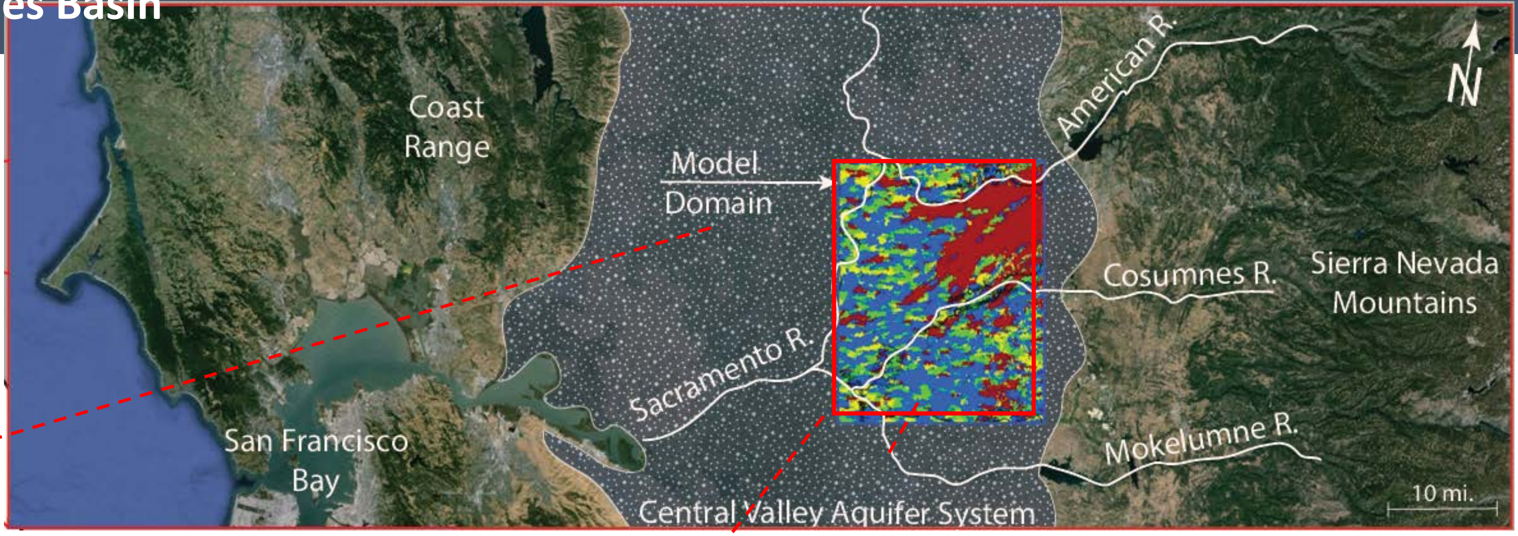
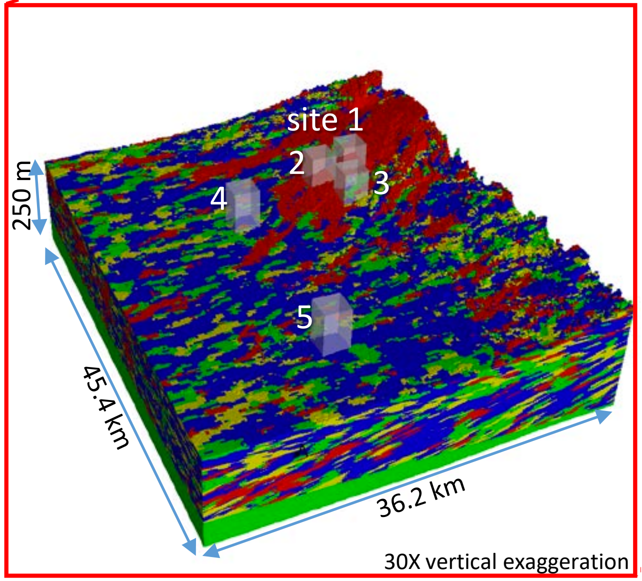
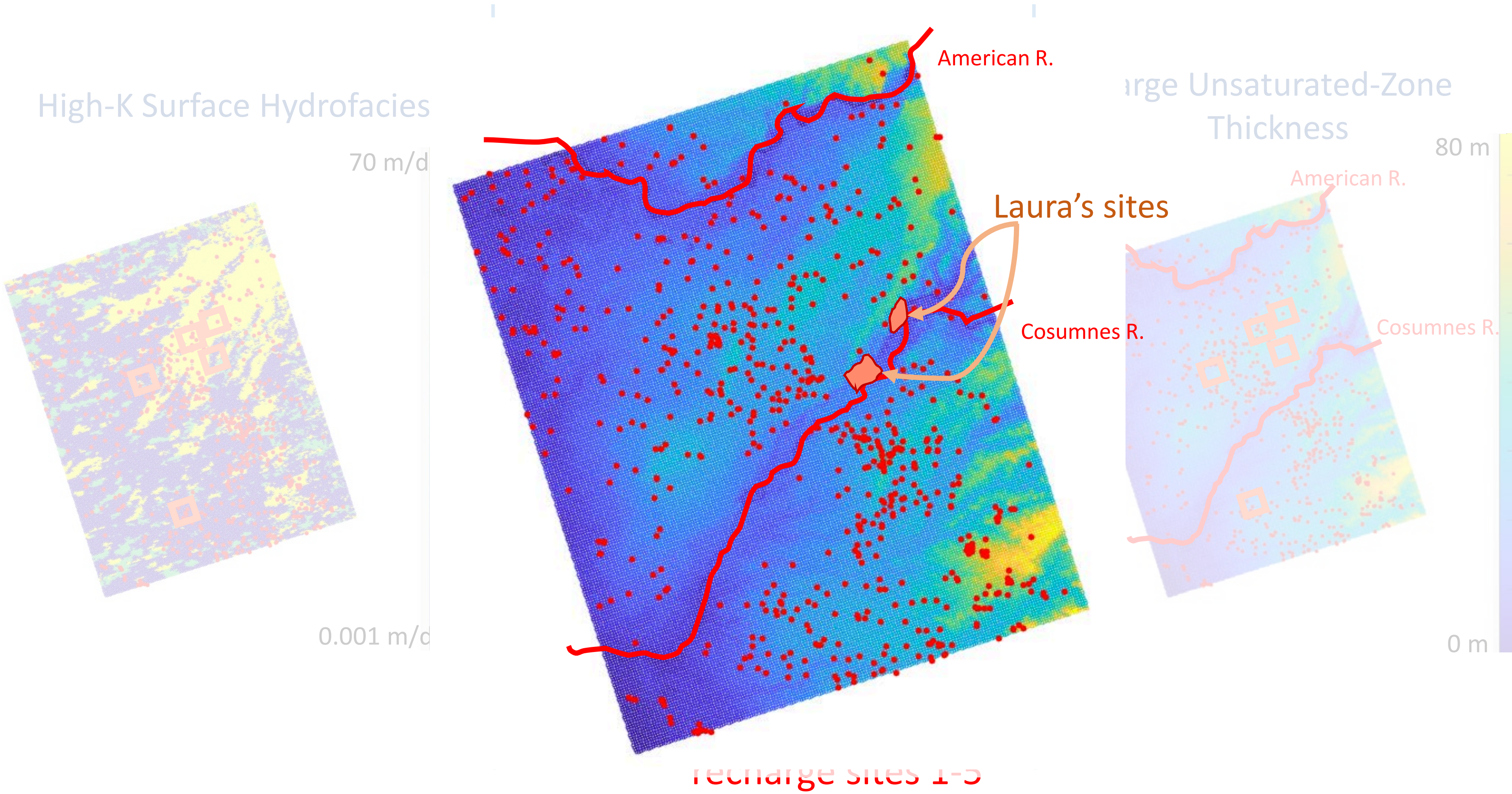
ParFlow Model
American-Cosumnes Basin



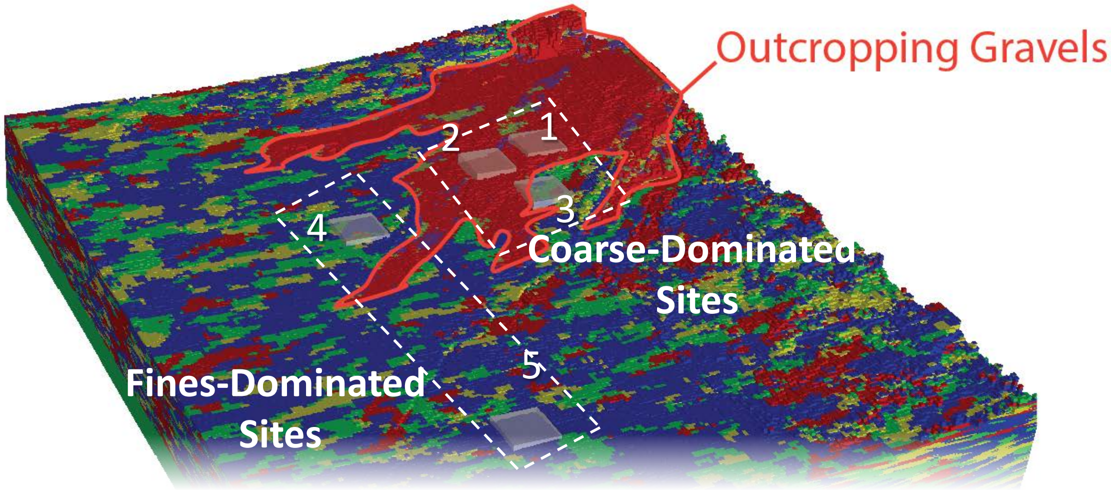


Hydrofacies	K_{sat} (m/d)	S_s (m^{-1})	Fraction of Total Vol.
Gravel	67.5	$4.0x10^{-5}$	0.23
Sand	41.2	$8.0x10^{-5}$	0.14
Muddy Sand	0.20	$1.0x10^{-4}$	0.18
Mud	0.0017	$1.0x10^{-3}$	0.45

Characteristics of a Good Recharge Site



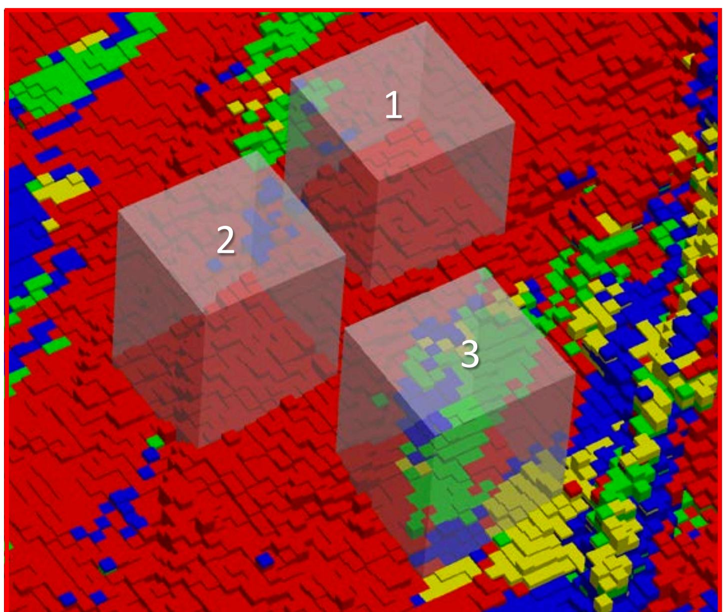
Sites are chosen to represent wide range of geologic heterogeneity



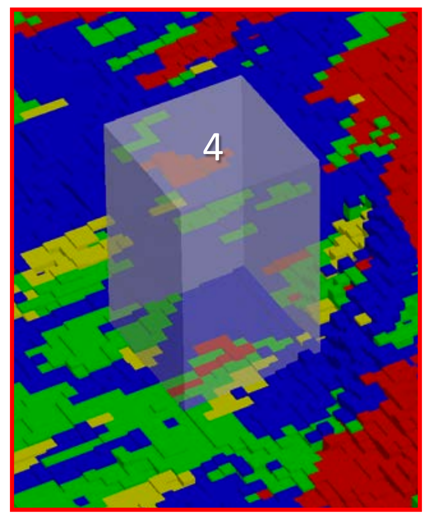
Each Site = 1420 acres

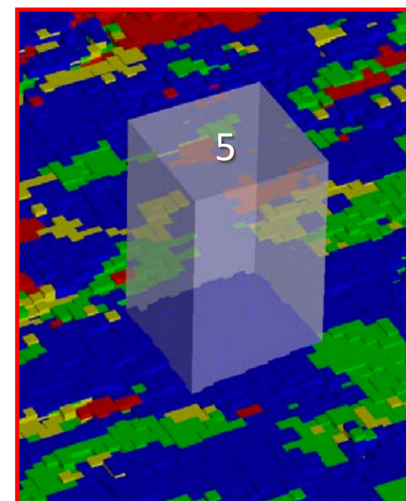
Hydrofacies:
Gravel Sand
Muddy Sand Mud

Sites 1–3: Dominated by Interconnected Sand & Gravels

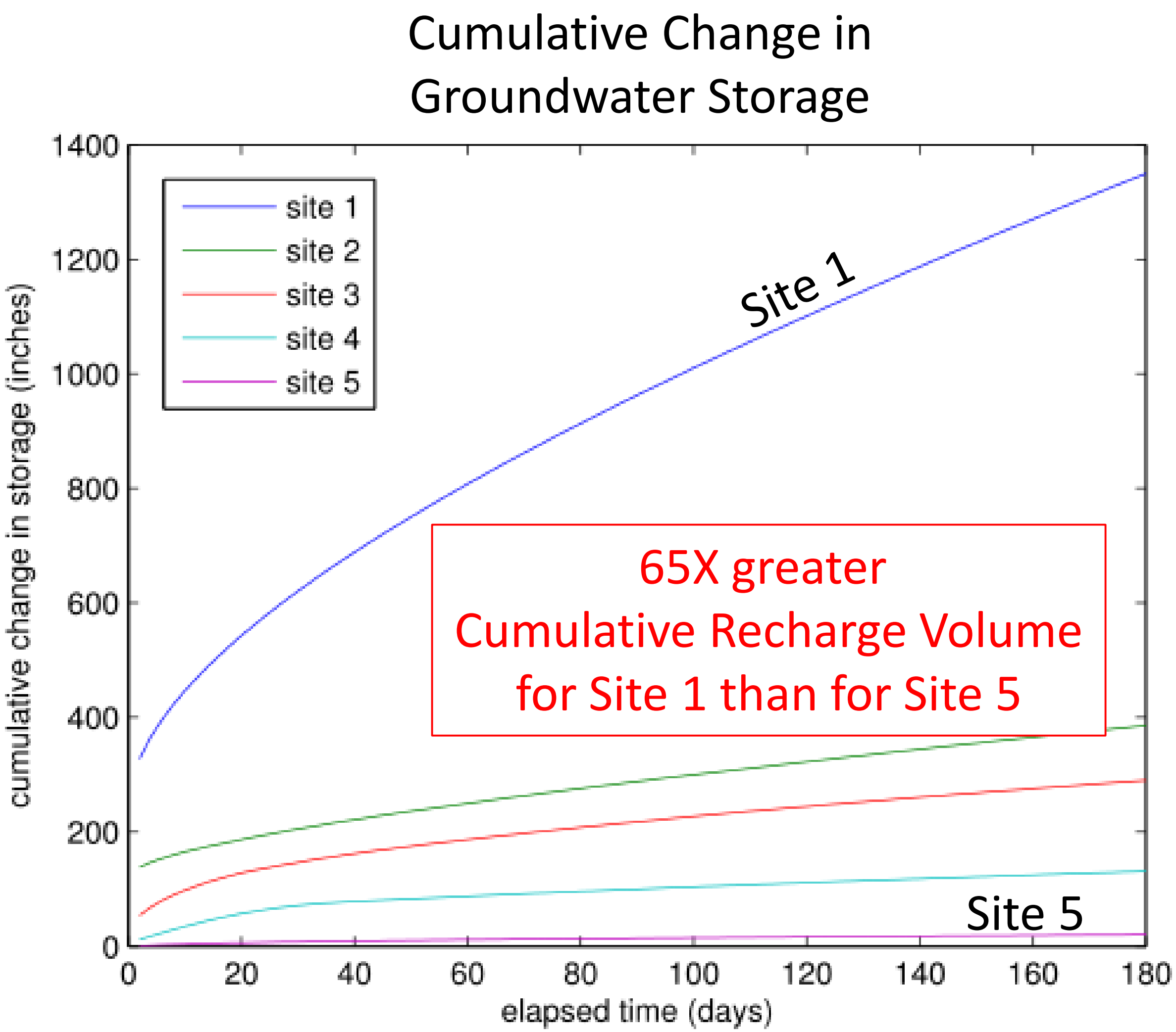


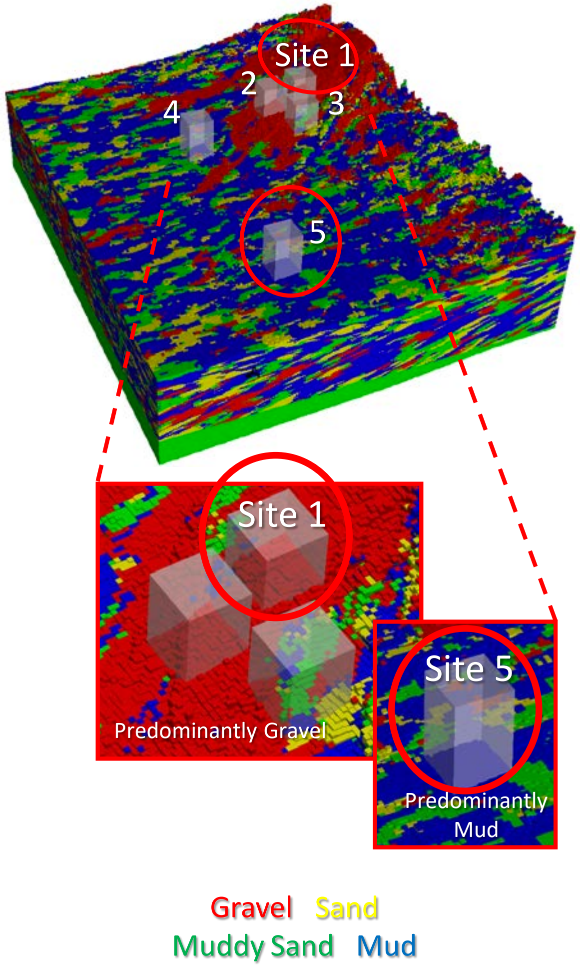
Sites 4 & 5: Dominated by Muddy Sand and Mud





Large Range of Responses Across Sites





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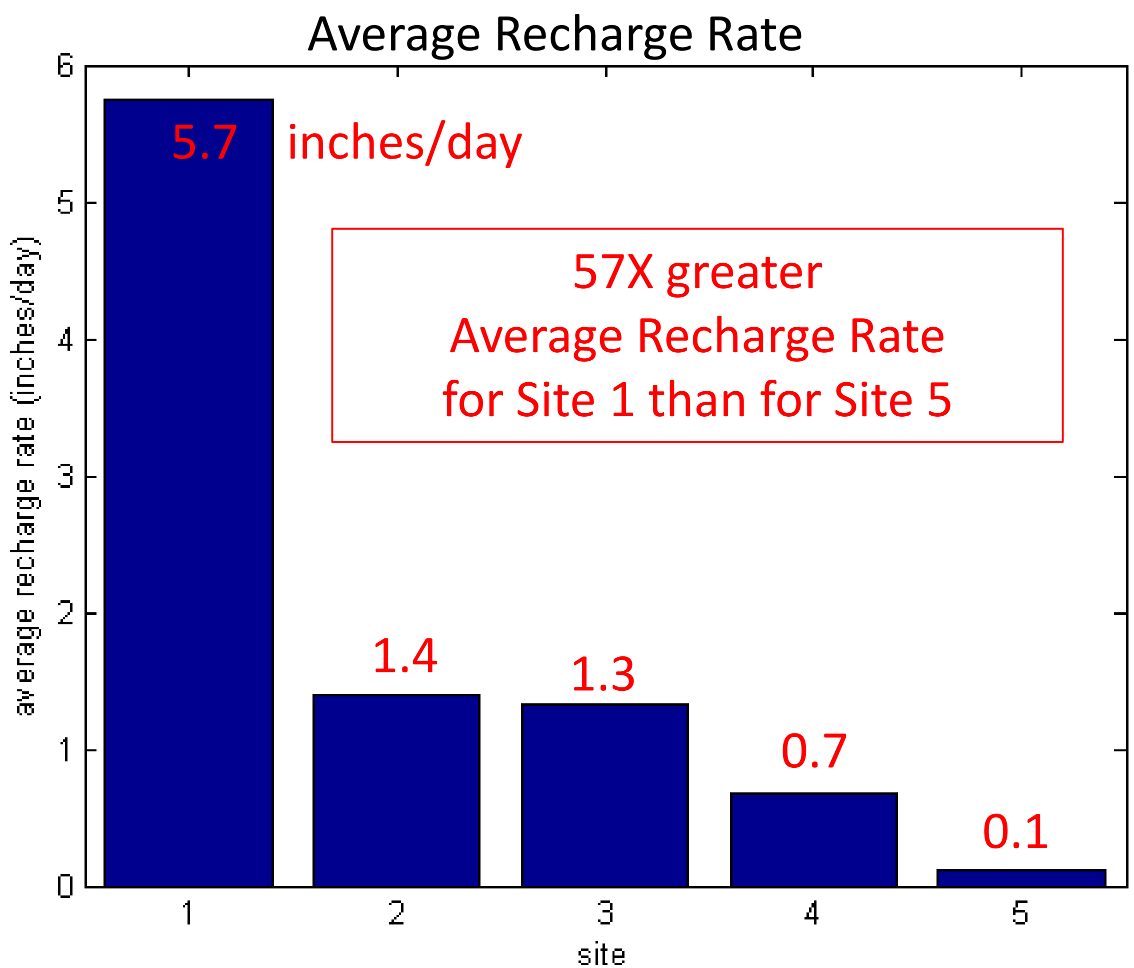
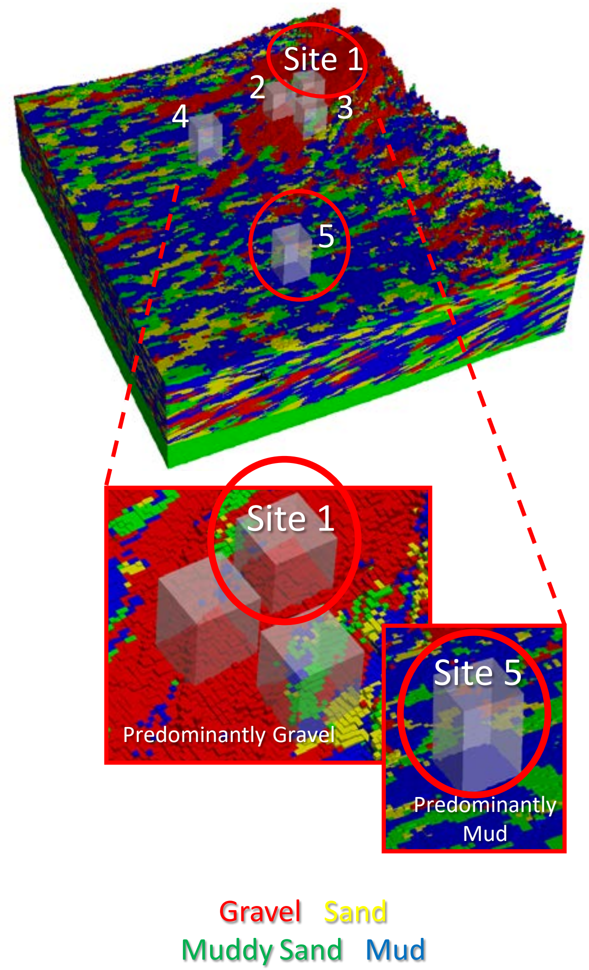
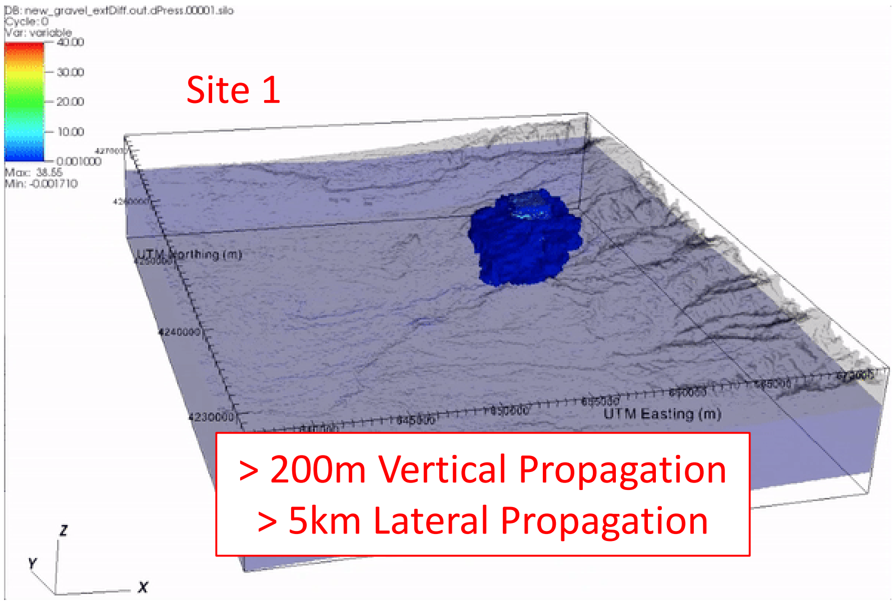
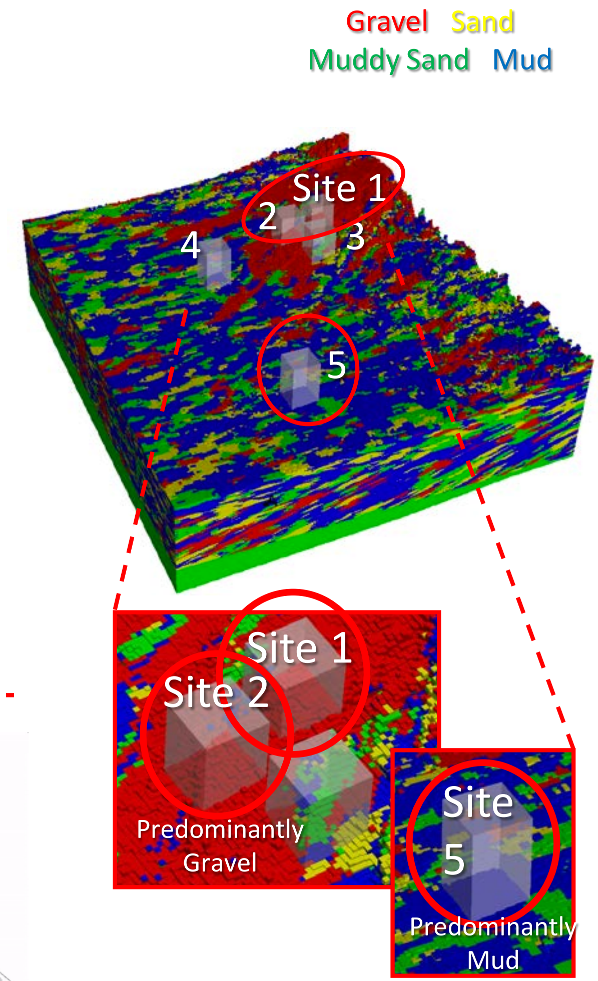
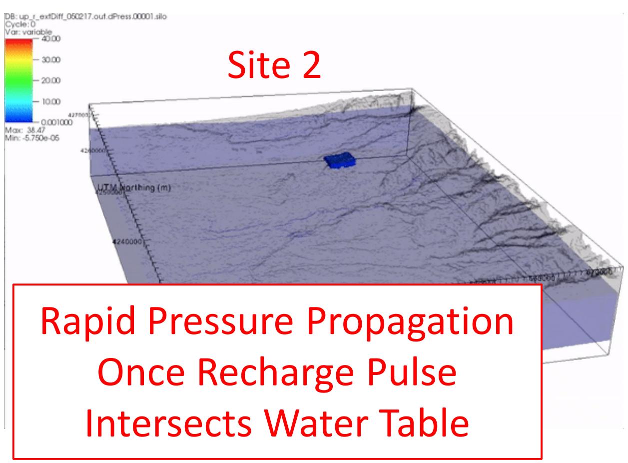


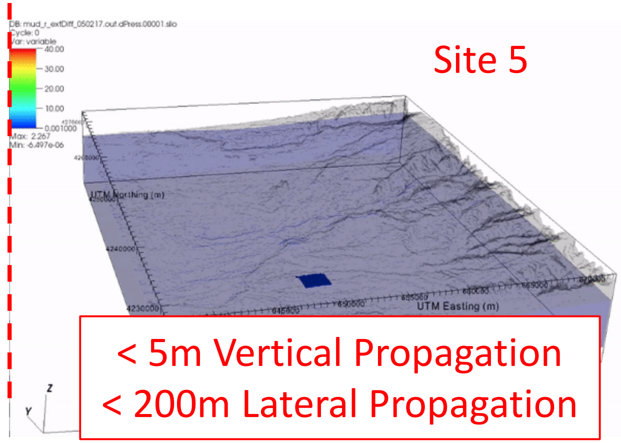


Pressure Perturbation Animations (0–180 days)









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Questions?

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