

Possibilities and Pathways for Multi-benefit Managed Aquifer Recharge

Subsurface Water Storage Symposium
Denver, CO
February 22, 2024

Mike Kiparsky

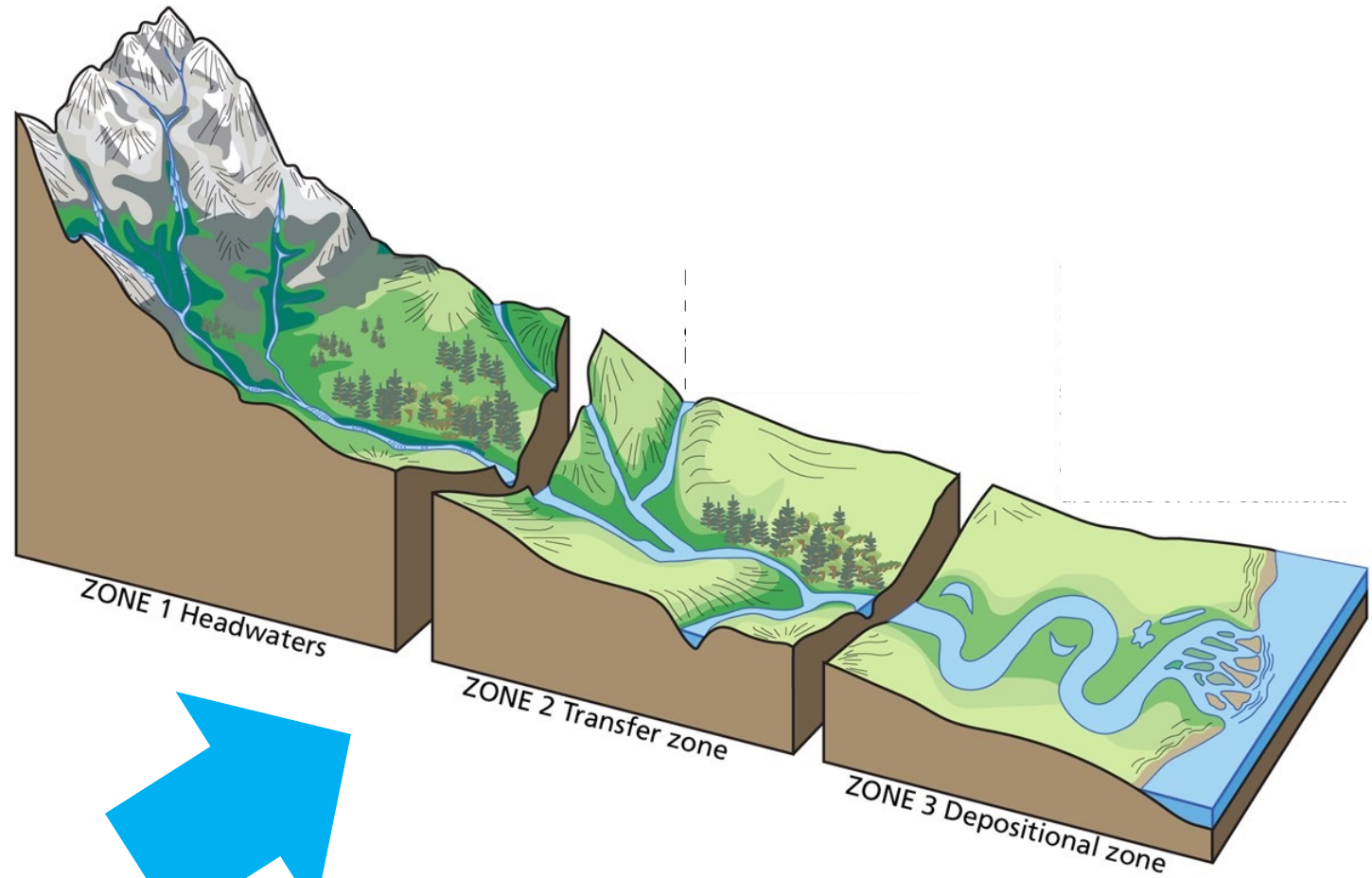
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Berkeley Law

Center for Law, Energy,
& the Environment

Subsurface storage...



...or a broader vision?



Developing a Knowledge-to-Implementation Framework for Enhanced Aquifer Recharge



Center for Law, Energy, & the Environment



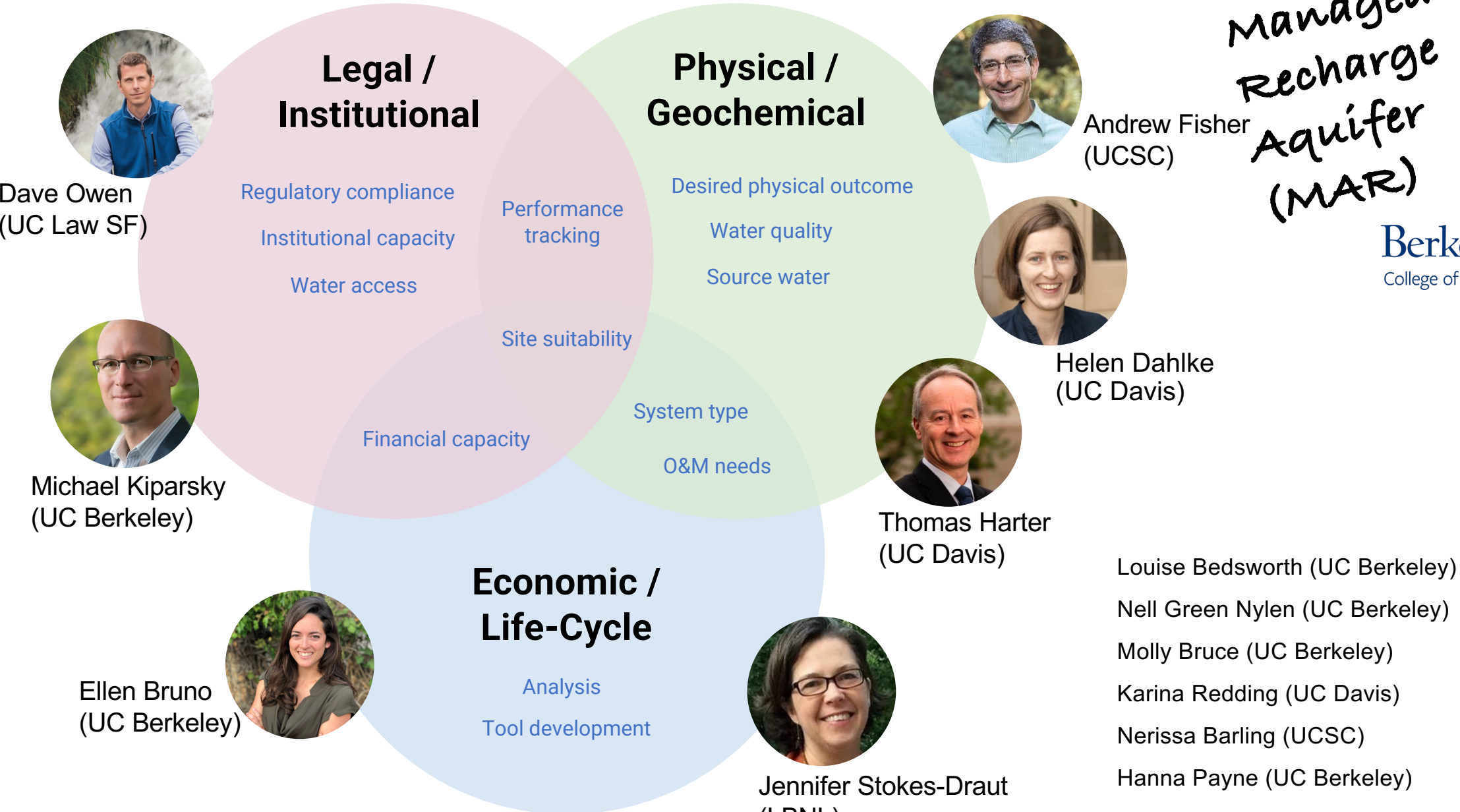
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San Francisco
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Managed Recharge Aquifer (MAR)



Dave Owen
(UC Law SF)



Andrew Fisher
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Helen Dahlke
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Jennifer Stokes-Draut
(LBNL)



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GEOCHEMICAL & PHYSICAL CONSIDERATIONS



LEGAL & INSTITUTIONAL CONSIDERATIONS



COST-BENEFIT ANALYSIS (CBA) & LIFE-CYCLE ASSESSMENT

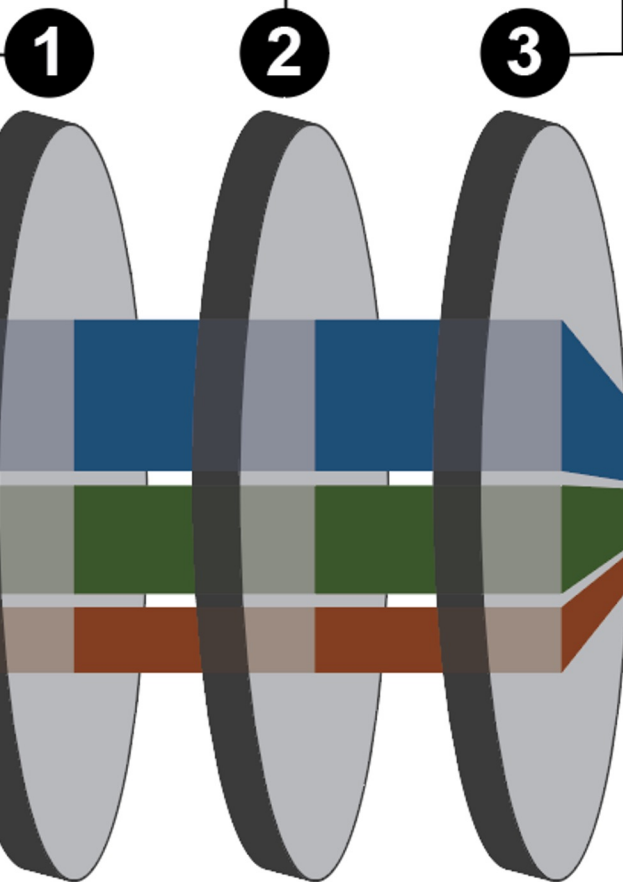


SYNTHESIS



ENGAGEMENT

NEW RESEARCH



OUTPUTS

Integrative Report
summarizing research results and interconnections

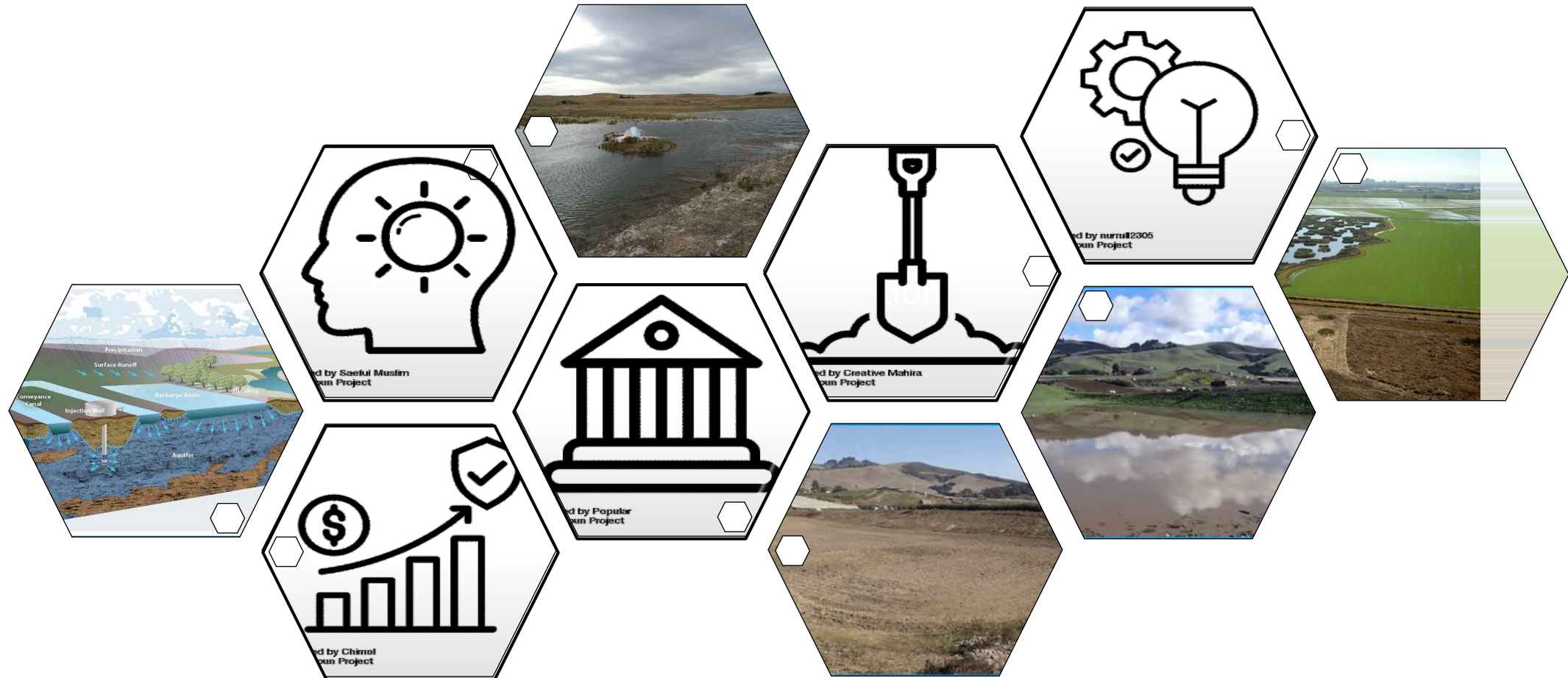
CBA Framework & Tool
enabling customizable accounting for costs and benefits across the full project lifecycle

Decision-Support Guides
to aid development and implementation of viable, safe, and cost-effective EAR projects and programs in various contexts

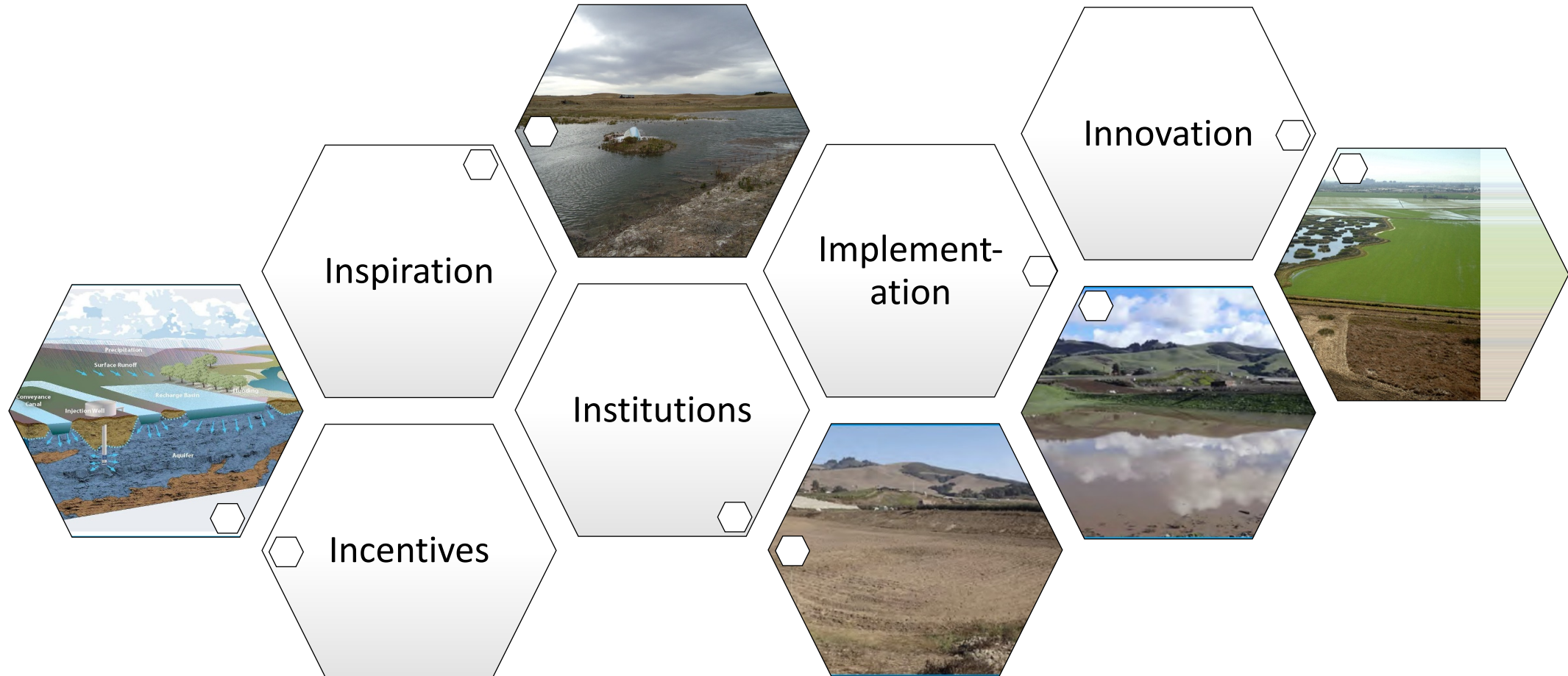
Recommendations
for improving the legal, policy, and institutional environment for EAR

COMMUNICATION

Pathways to Multi-benefit MAR



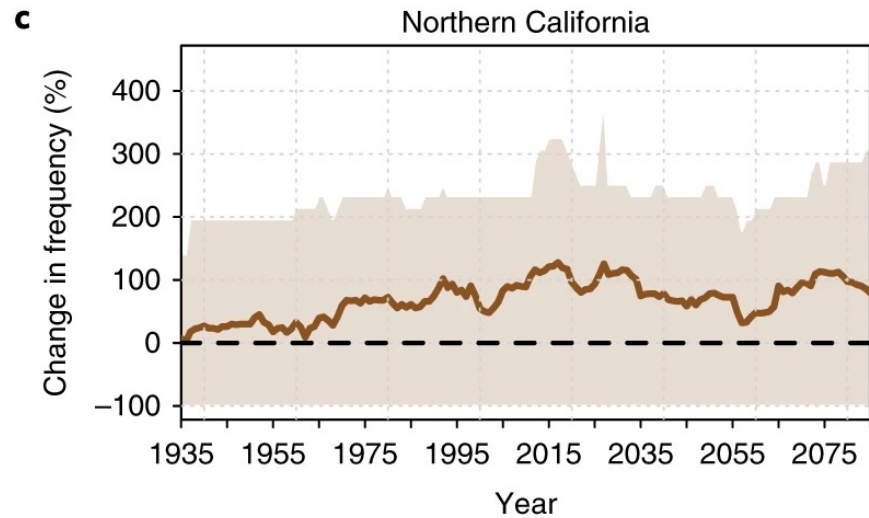
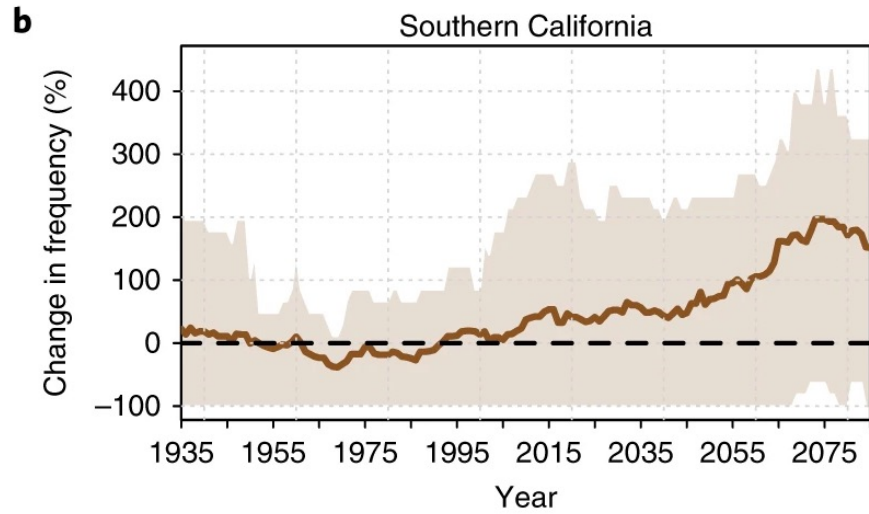
Pathways to Multi-benefit MAR



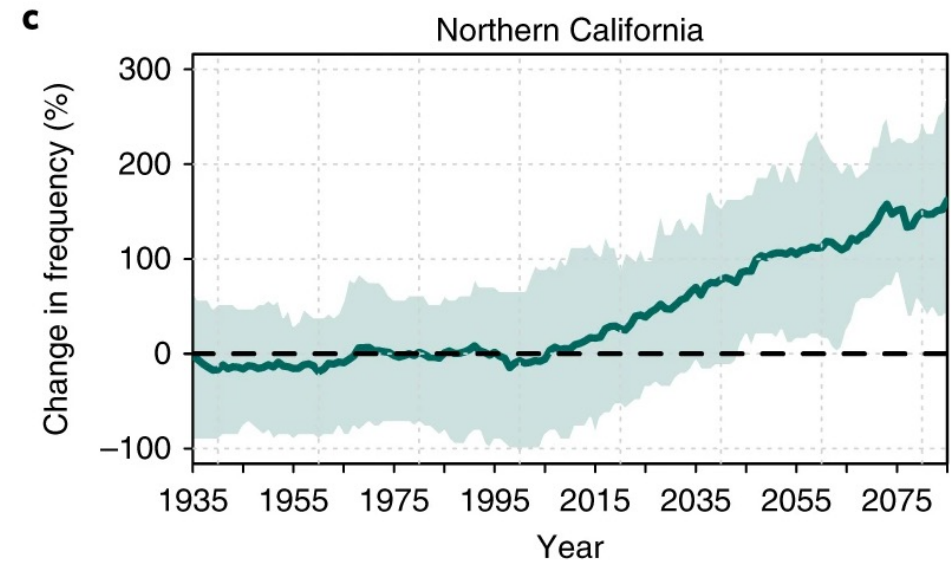
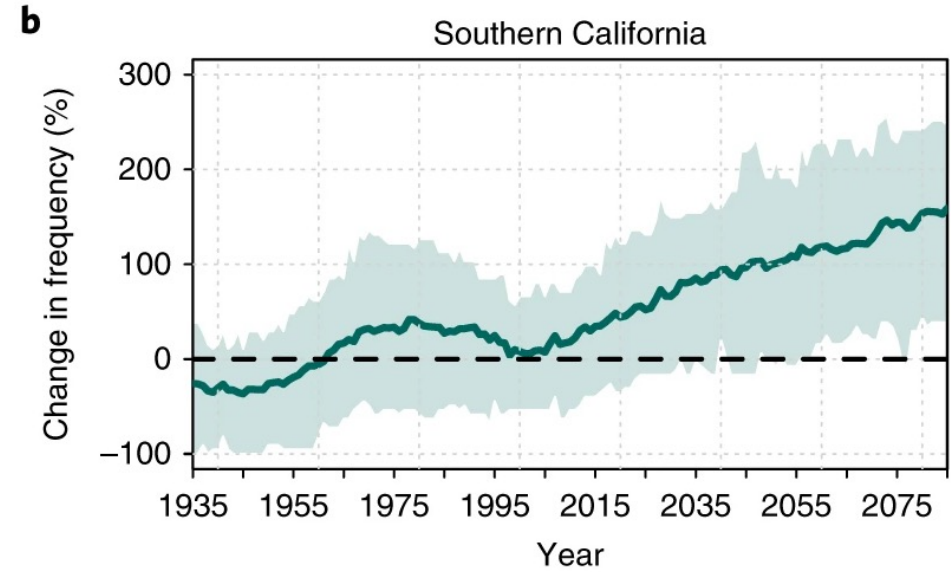
Why recharge?



Global weirding

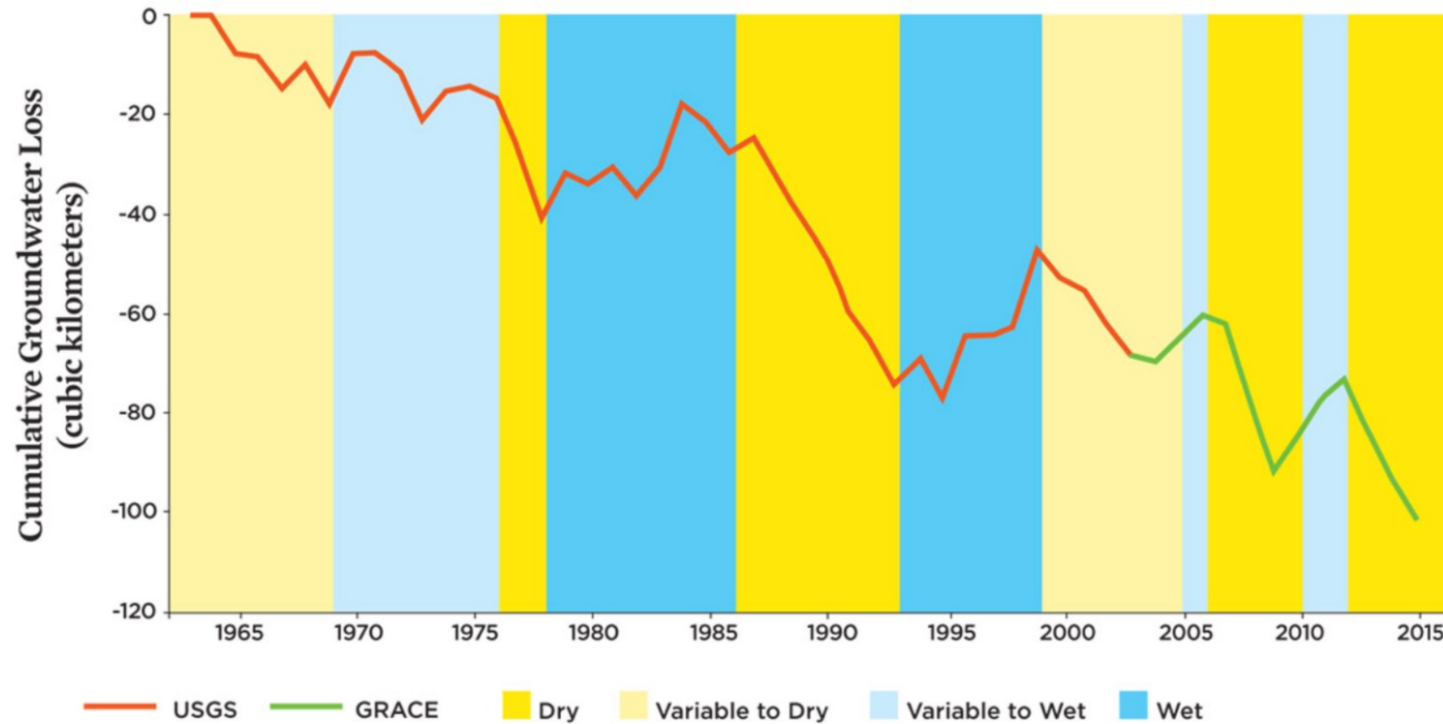


Global weirding



Visible impacts

Cumulative Groundwater Depletion in California's Central Valley



Cumulative groundwater losses in California's Central Valley aquifer since 1962. The red line shows data from groundwater model simulations calibrated by the U.S. Geological Service (USGS) from 1962 to 2003. The green line shows Gravity Recovery and Climate Experiment (GRACE) satellite-based estimates of groundwater storage losses. Background colors represent different water years.

SOURCE: ADAPTED FROM FAMILIETTI ET AL. 2014.

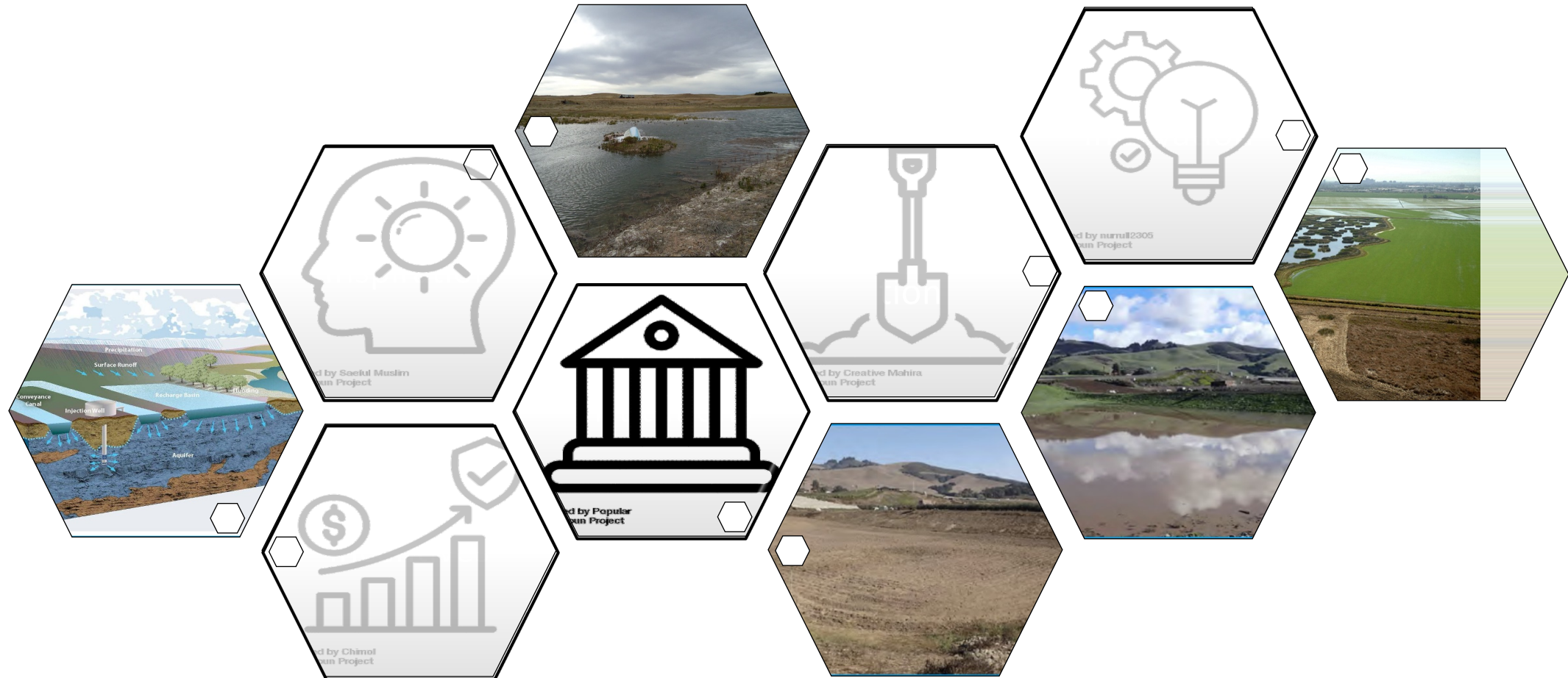
© Union of Concerned Scientists 2015; www.ucsusa.org/watersupplyshift



Why recharge?

- Increase
 - storage
 - groundwater levels
- Mitigate impacts
 - subsidence
 - seawater intrusion
 - Impacts to water quality.
 - interconnected surface waters
 - Habitat including groundwater dependent ecosystems

Institutions as a through-line



Inspiration: Heyborne Ponds Project, Ovid, CO





Unusual benefits...

Wildlife conservation

Threatened and endangered species
recovery

Recreation

Water availability for agriculture

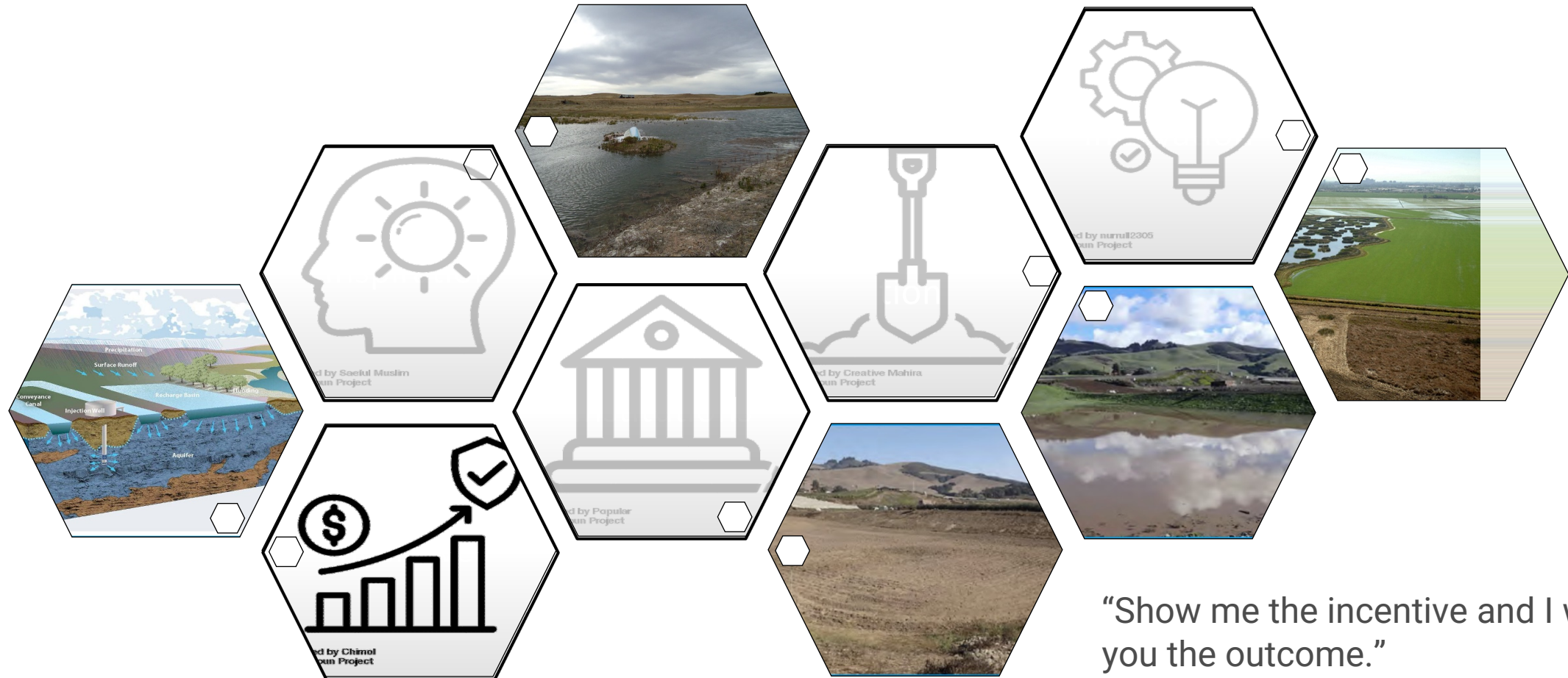


... and strange bedfellows

Ducks Unlimited
South Platte River Ranch
Lower South Platte Water Conservancy District
South Platte Water Related Activities Program, Inc

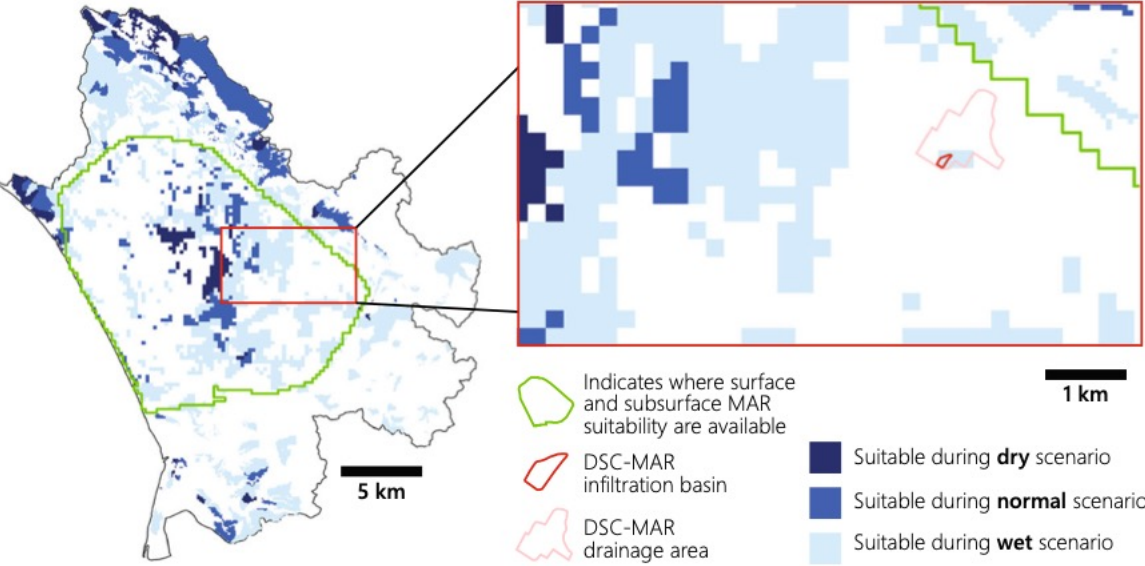
Image: Ducks Unlimited

Incentives: Recharge Net Metering (ReNeM), Pajaro Valley, CA



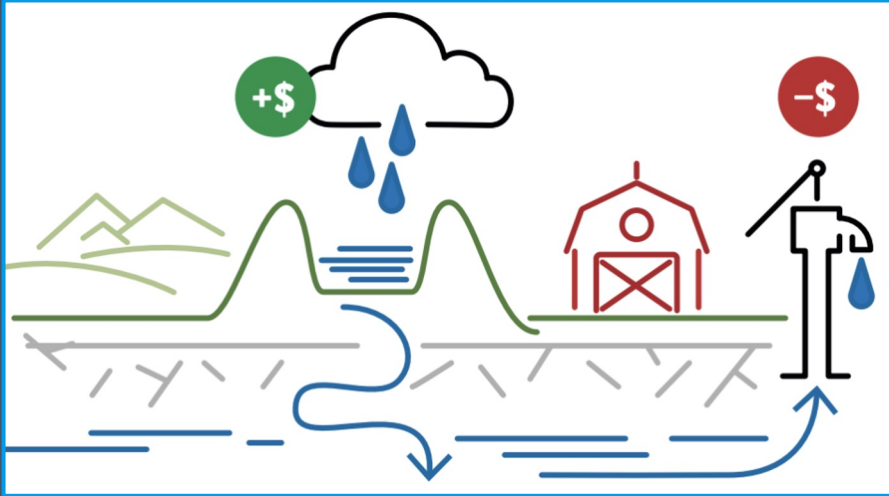
“Show me the incentive and I will show you the outcome.”
-Charlie Munger

Pajaro Valley, CA





Recharge Net Metering



Recharge Net Metering (ReNeM)

- Participants infiltrate water
- Participants receive a rebate payment
- No right to withdraw additional water
- ReNeM's benefits accrue to both participants & the groundwater basin

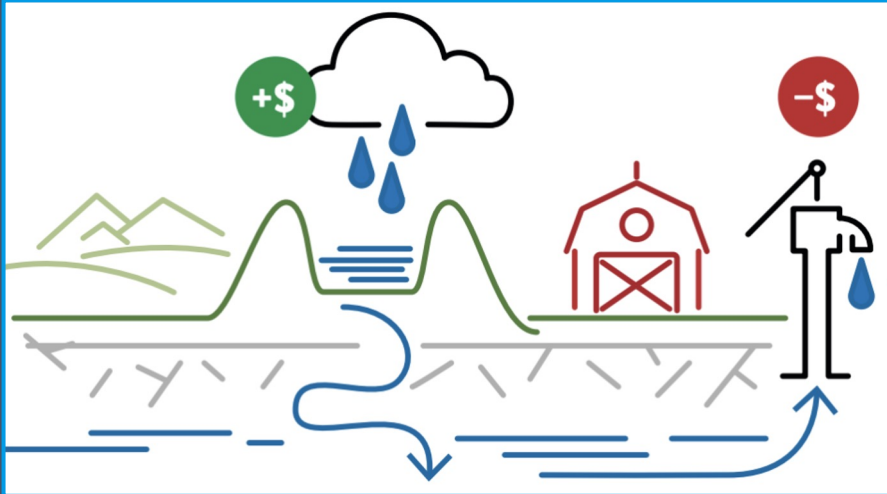
$$\text{Incentive payment} = \lambda Q_t C_t$$

Scaling factor (λ)

Net infiltration (Q_t)

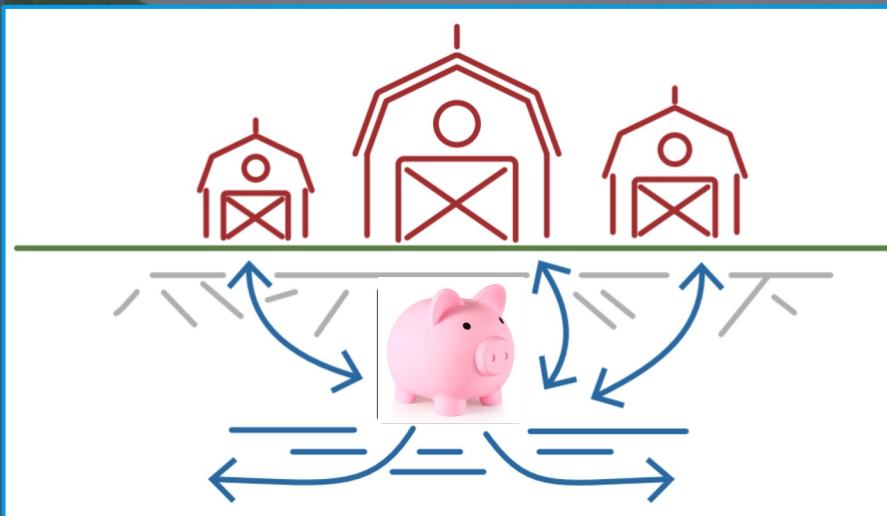
Volumetric pumping fee (C_t)

Recharge Net Metering



Recharge Net Metering (ReNeM)

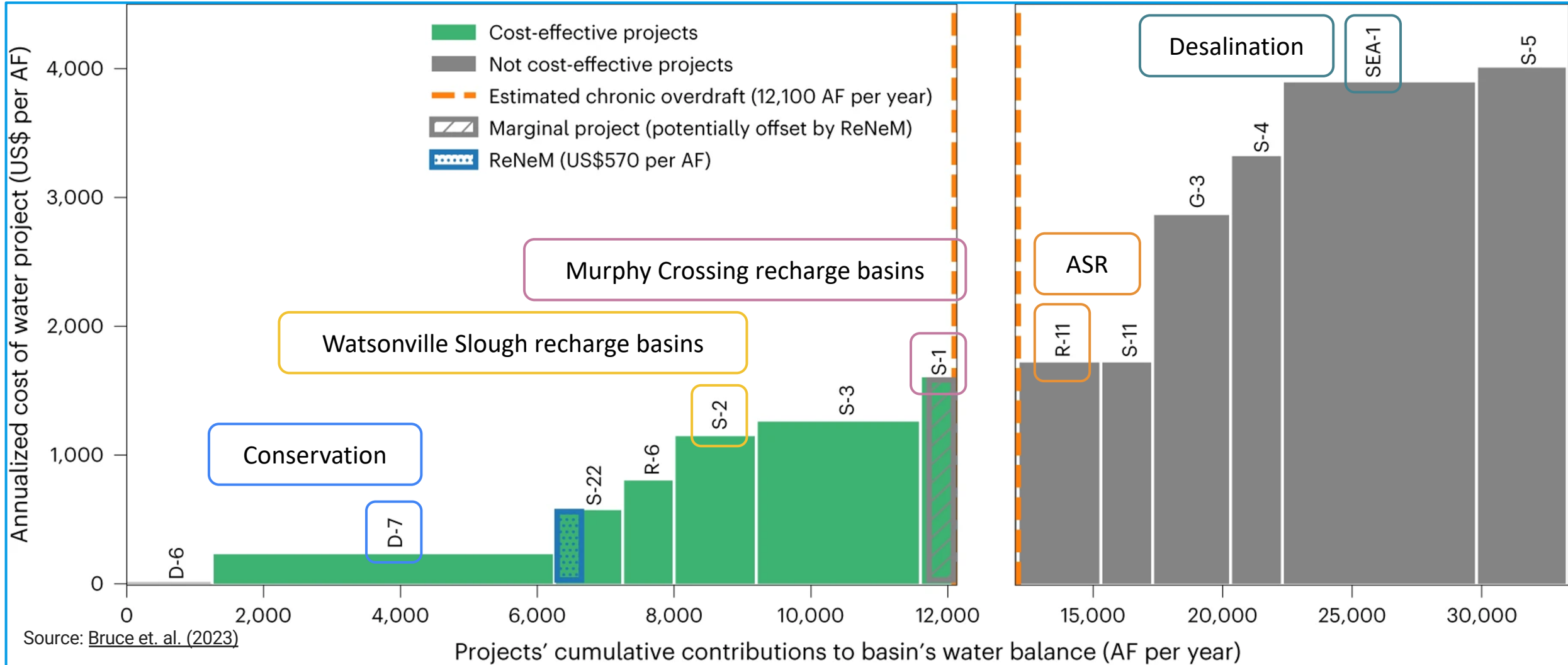
- Participants infiltrate water
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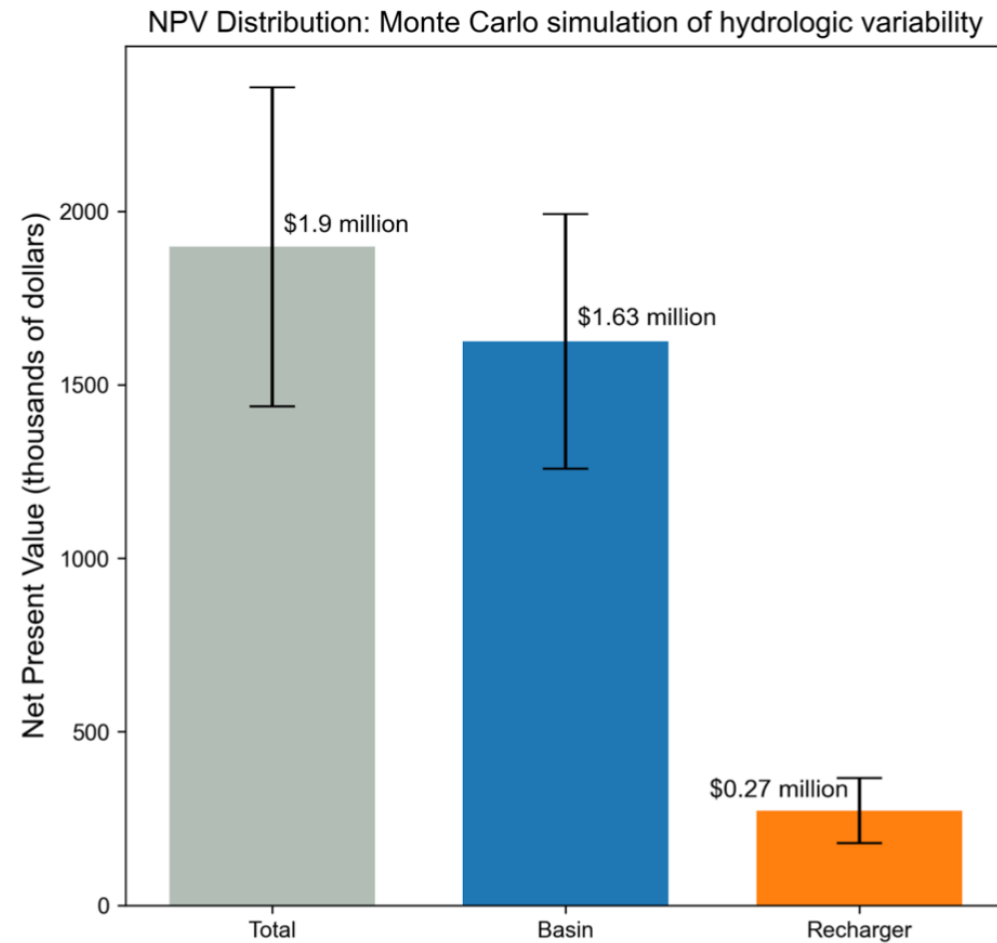
Groundwater banking

- Users “deposit” water (real or paper)
- Users receive the right to withdraw the water later
- Benefits accrue to bank users

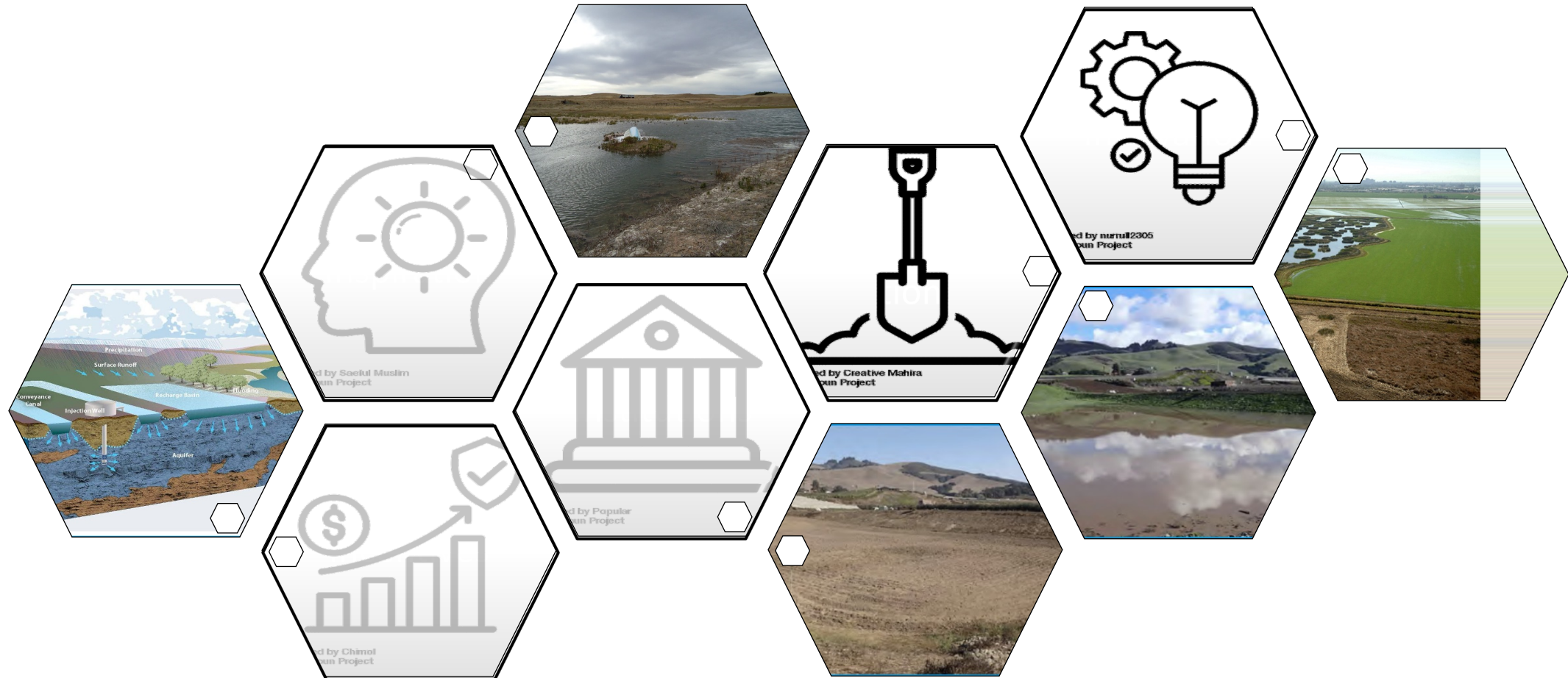
ReNeM makes economic sense...



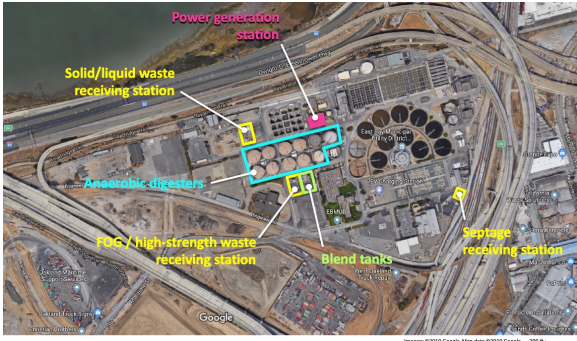
...and is win-win



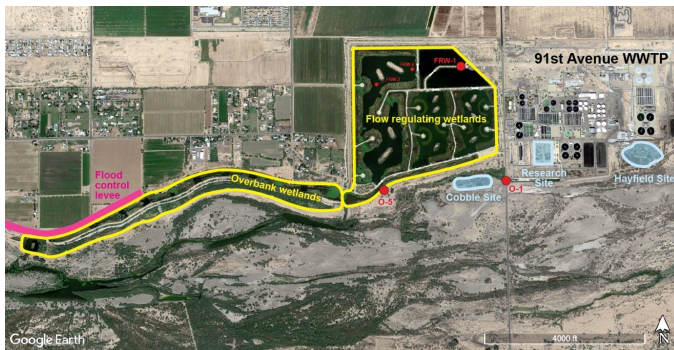
Innovation and implementation



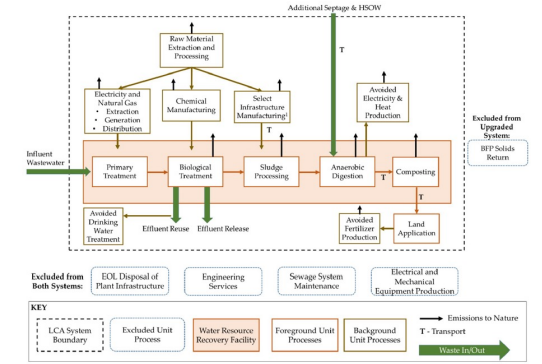
Innovation case studies



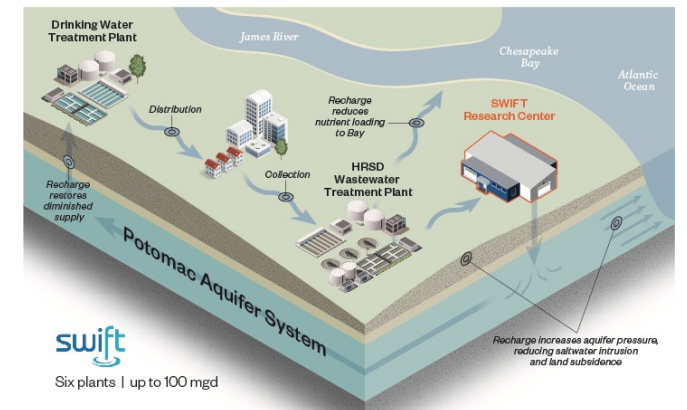
Resource recovery



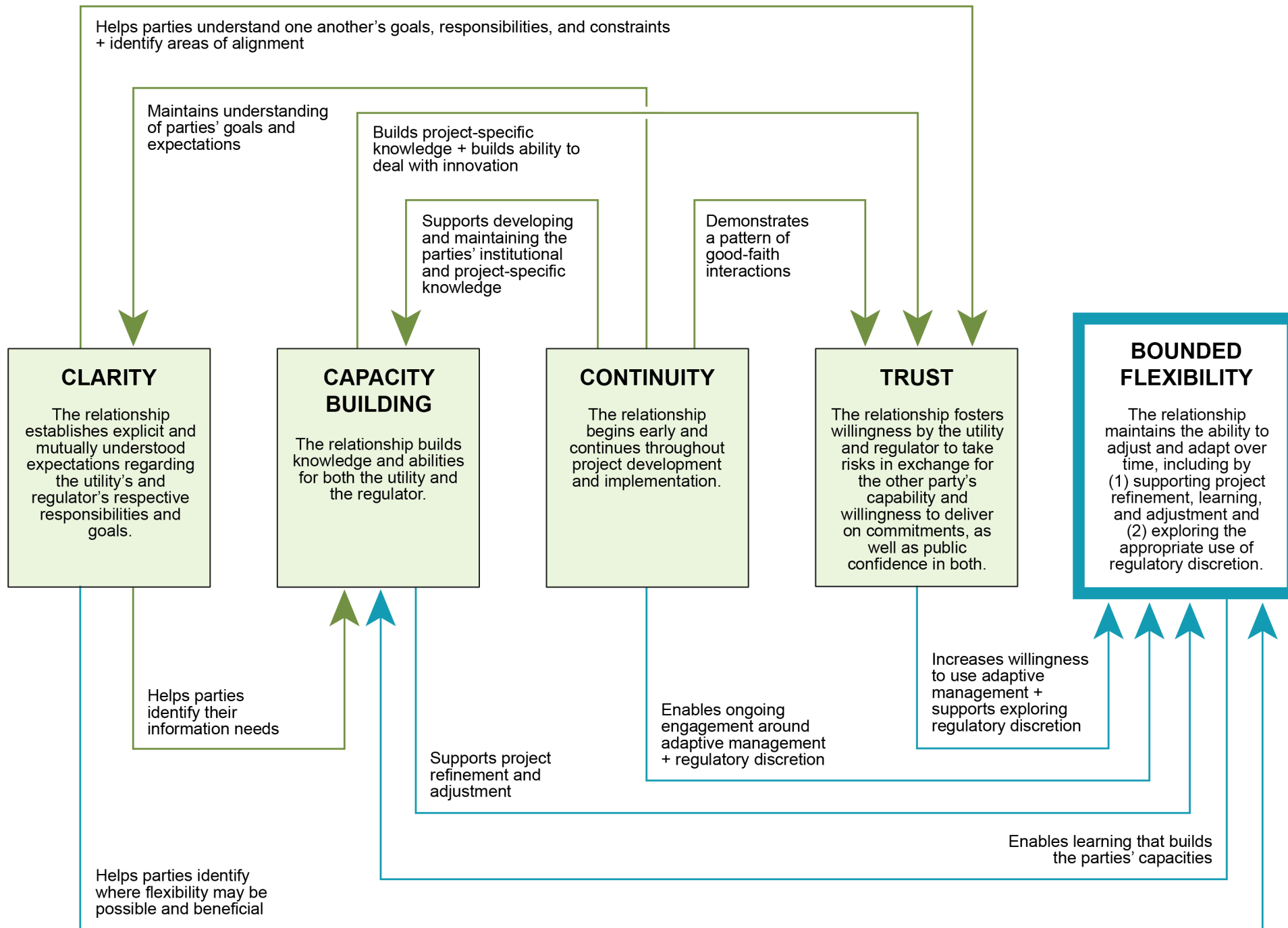
Large scale constructed treatment wetlands



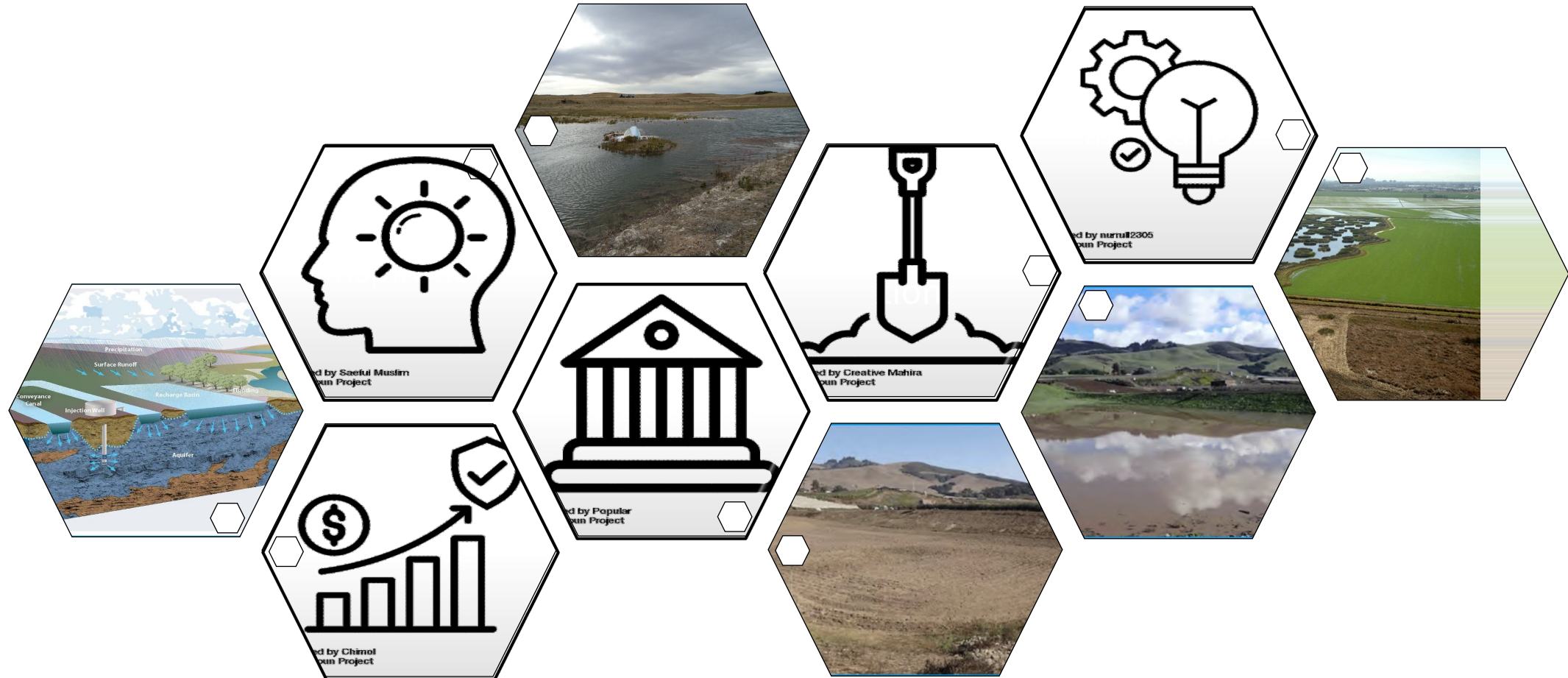
Attempted resource recovery and integrated management



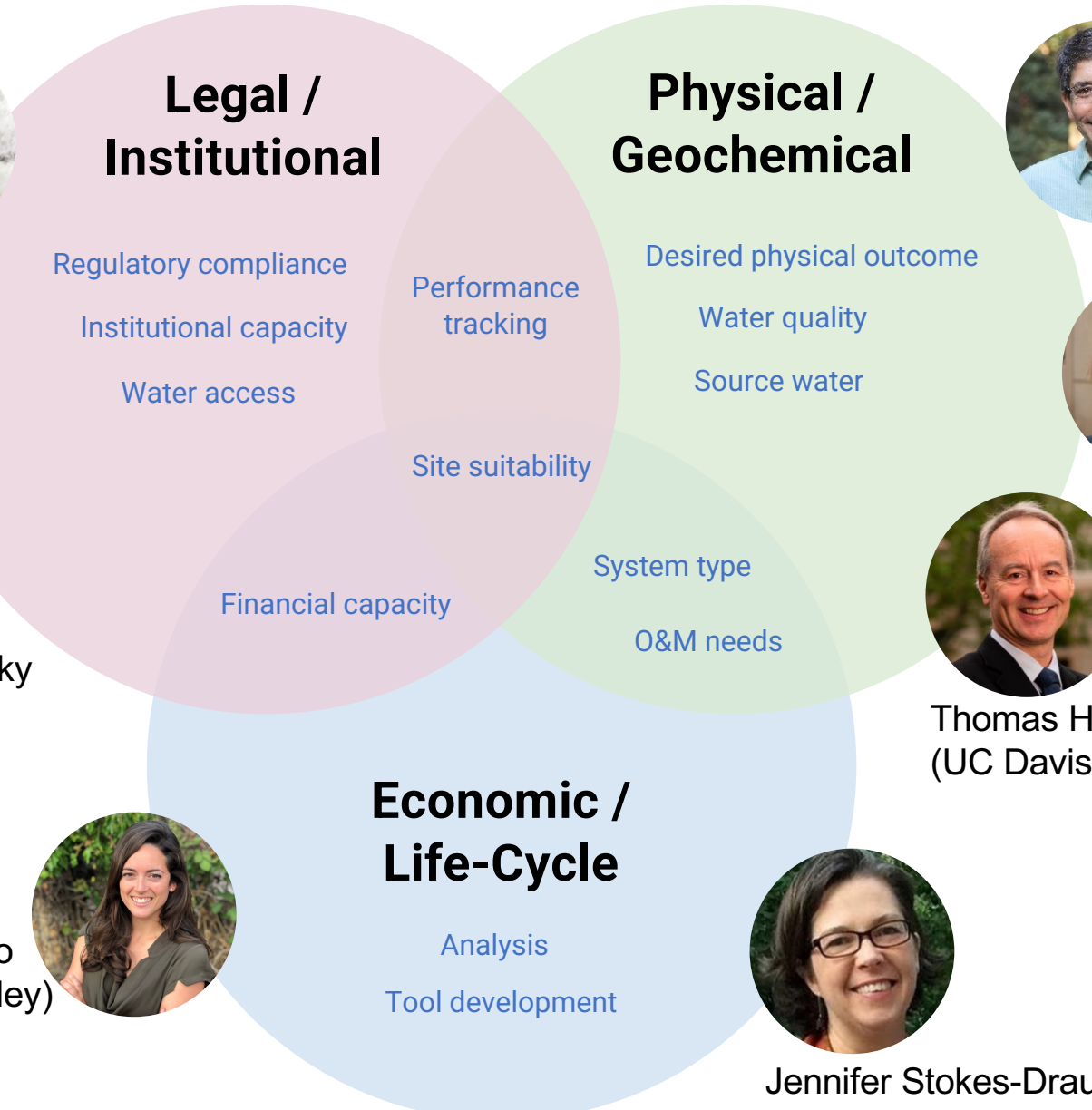
Indirect potable reuse via recharge



Conclusions



Developing a Knowledge-to-Implementation Framework for Enhanced Aquifer Recharge



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Much appreciation

- Amazing Collaborators

- Andy Fisher, Helen Dahlke, Thomas Harter, Dave Owen, Ellen Bruno, Jenn Stokes-Draut, Louise Bedsworth, Nell Green Nysten, Molly Bruce, Karina Redding, Nerissa Barling, Hanna Payne, Anita Milman, John Tracy, Luke Sherman, David Sedlak, and many more...

- Generous funders

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- Contact

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Further Reading

- *N Green Nysten. 2021. Surface Water Quality Regulation as a Driver for Groundwater Recharge: The Case of Virginia's Sustainable Water Initiative for Tomorrow Case Studies in the Environment 5 (1), 1124592*
- *Michael Kiparsky, Kathleen Miller, Phoebe Goulden, Anita Milman, and Dave Owen. 2021. Groundwater Recharge for a Regional Water Bank: Kern Water Bank, Kern County, California. Case Studies in the Environment 5(1):1223400. <https://doi.org/10.1525/cse.2021.1223400>*
- *Kathleen Miller, Andrew T. Fisher, and Michael Kiparsky. Incentivizing Groundwater Recharge in the Pajaro Valley Through Recharge Net Metering (ReNeM). Case Studies in the Environment 5(1): 1222393. <https://doi.org/10.1525/cse.2021.1222393>*
- *Kiparsky, M, AT Fisher. WM Hanemann, J Bowie, R Kantor, C Coburn, and B Lockwood. 2018. Recharge Net Metering to Enhance Groundwater Sustainability. Center for Law, Energy & the Environment, UC Berkeley School of Law, Berkeley, CA. 4 pp. doi.org/10.15779/J2792D*
- *Molly Bruce, Luke Sherman, Ellen Bruno, Andrew T. Fisher, and Michael Kiparsky. 2023. Recharge Net Metering (ReNeM) is a novel, cost-effective management strategy to incentivize groundwater recharge. Nature Water 1(855–863). <https://doi.org/10.1038/s44221-023-00141-1>.*
- *Nell Green Nysten, Michael Kiparsky, and Anita Milman. 2022. Cultivating effective utility-regulator relationships around innovation: Lessons from four case studies in the U.S. municipal wastewater sector. PLOS Water 1(8): e0000031. <https://doi.org/10.1371/journal.pwat.0000031>*
- *Sarah Beganskas, Kyle S Young, Andrew T Fisher, Ryan Harmon, Sacha Lozano. 2019. Runoff modeling of a coastal basin to assess variations in response to shifting climate and land use: implications for managed recharge. Water Resources Management. <https://doi.org/10.1007/s11269-019-2197-4>*
- *Milman et al. 2021. Groundwater Recharge to Support Wildlife and Water Users: The Heyborne Ponds Project, Sedgwick County, Colorado. Case Studies in the Environment. DOI: <https://doi.org/10.1525/cse.2021.1235924>.*

Thank you

