An Integrated Program to Enhance Groundwater Supplies through Infiltration of Stormwater: Progress and Challenges in Incentivizing Sustainability

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California's GW Supplies Face a Triple Threat

- Increasing demand
- Shifting land use
- More intense rainfall

Less GW Recharge
How Severe Is California's Water Imbalance?

Water supply deficit (1995)*,#

-1.6   -5.1

Deficit = supply – demand

* Data from DWR Water Plan Updates
# Normal/Dry 160-98, based on conditions up to 1995

analysis from Beganskas and Fisher (2017)
How Severe Is California's Water Imbalance?

Water supply Projected
deficit deficit in 2020

Millions of acre-feet

-1.6 -5.1 -0.2 -2.7

Avg. normal year Avg. dry year

Deficit = supply – demand

* Data from DWR Water Plan Updates
# Normal/Dry 160-98, based on conditions up to 1995
+ Projected "future" conditions

analysis from Beganskas and Fisher (2017)
How Severe Is California's Water Imbalance?

Deficit = supply – demand

- Water supply deficit (1995)*,#
- Projected deficit in 2020 (1995)*,#
- Water supply deficit (2001–2010)*,†

- Avg. wet year
- Avg. dry year
- Avg. normal year

-1.6
-5.1
-0.2
-2.7
-8.0
-15.7

* Data from DWR Water Plan Updates
# Normal/Dry 160-98, based on conditions up to 1995
† Projected "future" conditions
‡ Normal/Dry/Wet 160-13, from 2001-10 data
**Pretty Severe!**

Water supply deficit in 2020 (1995)*,#

-1.6

Projected deficit in 2020 (1995)*,#

-0.2

Water supply deficit (2001–2010)*,#

-8.0

Groundwater deficit (2001–2010)*,#

-9.0

Deficit = supply – demand

Before recent drought

* Data from DWR Water Plan Updates
# Normal/Dry 160-98, based on conditions up to 1995
+ Projected "future" conditions
† Normal/Dry/Wet 160-13, from 2001-10 data
**Integrated Program for MAR**

- **Map** locations where enhanced recharge might be best accomplished
- **Model** availability of stormwater from hill slopes
- Design/create field projects and *measure*/validate:
  - benefits to water *supply*
  - improvements to water *quality*
- **Monetize** activities and policies that incentivize stakeholders and strengthen partnerships

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* Beganskas et al. (Wed AM)
* Gorski et al. (Wed AM)
† Pensky et al. (Wed AM)
Central Coast: heavily reliant on groundwater

GW = 83% of demand

Simultaneously a challenge and an opportunity for our region

DWR Water Plan Update 160-98
Central Coast: Virtually “off the grid” in terms of large-scale water transfers

Regional Water Transfers
at 1990 Level of Development (thousands of acre-feet per year)

Central Coast hydrologic region

* Total California Colorado River Usage was 5.2 Million Acre-Feet
** Exchange
Pajaro River and Pajaro Valley Groundwater Basins

PVGB, lower PR basin, mostly Santa Cruz and northern Monterey Counties

Primary fresh water resource is groundwater

PVWMA: Special Act district (1984)

PVWMA serves 70,000 acres, 30,000 irrigated

Major crops: Strawberries, cane berries, table crops, organic (30%)

$1B farm revenue
Overdraft is a regional challenge

**Pumping:**
~55k ac-ft/yr

**City of Watsonville:**
~7k ac-ft/yr

**Sustainable yield:**
~40k–45k ac-ft/yr
(depending on pumping distribution, time horizon, natural variability)

**Overdraft:**
~10k–15k ac-ft/yr
(depending on definition, annual conditions)

Map from PVWMA, 2012
Many forms of groundwater recharge (natural, managed)

Each form of recharge requires specific conditions, properties, design, operations – "all recharge is local"
Many forms of groundwater recharge (natural, managed)

Choices for infiltration

- Farm-field flooding
- Infiltration basin
- Flood plain reclamation

“Managed” recharge

- Well recharge

Surface recharge

- Basin/trench
- Farm field flooding
- Flood plain reoccupation
- Stream bank filtration
**Distributed Stormwater Collection – Managed Aquifer Recharge (DSC-MAR)**

Bokariza Ranch, *Project goal: ~100 ac-ft/yr*

*modified from Beganskas and Fisher (2017)*
Where to Place DSC-MAR Projects?

![Map of Santa Cruz and N. Monterey Counties](image)

Two main project components:
1. Spatial (GIS) analysis for MAR suitability
2. Runoff (PRMS) analysis for stormwater generation from hillslopes
Combining spatial data to assess MAR Suitability

- Compile, patch, reconcile, regrid, reproject datasets
- For each dataset, categorize for conditions that are more/less favorable for DSC-MAR
- Combine datasets to create maps showing composite suitability

Schematic example:

Property 1

Property 2

Combined
Suitability for Managed Aquifer Recharge based on Surface Factors

- Combine soils, bedrock info

- Additional considerations include: slope, land use, veg (discussed below)
Suitability for Managed Aquifer Recharge based on Surface+Subsurface Conditions

PVGB

Subsurface analysis:
- Transmissivity ($K \times b$)
- Vadose zone thickness
- Available storage
- Change in storage

Teo et al. (2018-in prep)
Costs to Growers/Landowners for DSC-MAR

- Land taken from production/reduced access
- Maintenance of infiltration structures (basins, dry wells)

How can participation be incentivized?
There is a Workable Example: Net Energy Metering

- generate energy locally
- account for net usage
- excess power goes on the grid for sale (and eventual use)

Net Energy Metering

Net energy metering is a type of Distributed Generation that allows customers with an eligible power generator to offset the cost of their electric usage with energy they export to the grid. A specially programmed “net meter” will be installed to measure the difference between electricity the customer purchases and exports to the grid. The methods of applying credit for exported energy vary with the program.

- Requires
  - reliable measurement and accounting
  - formula to calculate benefit/rebate
  - stakeholder and Agency trust
Example: Net Recharge Calculations

Irrigated area: 75 irrigated acres

Applied water: 2.5 ft

Annual precipitation: 1.5 ft (18 inches)

Runoff/precipitation = 0.4 (appropriate for intense events)

Options:

Drainage: 200  400  600 acres
Infiltration: 2  4  6 acres

Augmentation fee = $203/ac-ft
(outside of Delivered Water Zone)

Recharge Net Metering rebate: 50% of net infiltration
Example: Net Recharge Calculations

- Net pumping: 188 ac-ft
- Corrected for "incidental recharge"
- Net metering
- Net pumping < 0: infiltration > pumping

More collection
More infiltration

Runoff and net usage (ac-ft)

Drainage area (acres)
Example: Net Recharge Calculations

Water cost: $38k
Baseline augmentation fees
188 ac-ft pumped
Rebate
Rebate
Rebate

Fees and Savings ($/yr)

Not participating

More collection
More infiltration

Net metering

Drainage area (ac)
Recharge Net Metering (ReNeM) in the PVGB (five-year pilot program, 10/2016-9/2021)

- Goal: 1000 ac-ft/yr (8-10 field projects?)
- Third-party certifier (TPC) identifies sites, raises capital, develops engineering, plans/builds for measurement
- TPC works with landowners/tenants to validate
- TPC certifies performance, reports to agency
- Agency applies formula to calculate rebate (= credit)

Program status

- Two sites operational, another constructed, one more funded/planned for construction…
- Multiple requests for site consideration…
Recharge Net Metering (ReNeM)...
...requires three kinds of support

- **Capital costs**
  - site ID, design, engineering, installation

- **Validation**
  - measurements, sampling, certification

- **Rebates (Incentives)**
  - offset for operation and maintenance costs

In the PVGB:
Costs are competitive, program can be revenue positive
Recharge Net Metering (ReNeM)...
...is not Groundwater Banking

ReNeM:
- Incentivizes *infiltration*, not recharge, not storage
- No right to recovery, benefits accrue to basin
- Incentive is performance based, year by year
- Incentive applied as a rebate of fees

An aquifer is a bank like a colander is a bucket

Different schemes may be needed in other basins...
Challenges and Bottlenecks*

- Agreement on terms, requirements, liability, obligations.
- Between UCSC, RCD, and participants
- Between water agency, RCD and UCSC
- Multiple phases, cross referencing
- A work in progress...

*for many kinds of managed recharge
Challenges and Bottlenecks*

• Agreement on terms, requirements, liability, obligations.

• Water rights, "reasonable and beneficial," public benefit?

*for many kinds of managed recharge
Challenges and Bottlenecks*

• Agreement on terms, requirements, liability, obligations.
• Water rights, "reasonable and beneficial," public benefit?
• Accounting for benefits, services†, TBL (social, env., econ.)

Enhanced recharge →
• More supply into storage
• Dilution of salts/nutrients
• Reduce SW intrusion (coast)
• Better SW-GW connection
• Thermal regulation of streams

*for many kinds of managed recharge

† Pensky et al. (Wed AM)
Challenges and Bottlenecks*

- Agreement on terms, requirements, liability, obligations.
- Water rights, "reasonable and beneficial," public benefit?
- Accounting for benefits, services, TBL (social, env., econ.)
- Establish and apply templates, best practices

Develop tools/methods
Challenges and Bottlenecks*

• Agreement on terms, requirements, liability, obligations.
• Water rights, "reasonable and beneficial," public benefit?
• Accounting for benefits, services, TBL (social, env., econ.)
• Establish and apply templates, best practices

Misunderstandings

• Recharge ≠ storage
• Infiltration vs. recharge
• FloodMAR
• Stormwater
• Risks
Summary and Outlook

- MAR with stormwater can benefit groundwater in CA
- Find the best locations to enhance recharge
- Design systems to measure performance
- Improve water quality along with supply
- Groundwater recharge provides many benefits, justifies incentives
- MAR with stormwater can be part of a successful portfolio for sustaining groundwater