Appendix 8

Recharge and Extraction Methods & Measures

Contents

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Theme Subcommittee Members

The Flood-MAR Recharge and Extraction Methods & Measures Subcommittee consists of 2 co-chairs, 14 subcommittee members, and a theme coordinator. Subcommittee members are listed by name, title, and affiliation below.

Position	Name and Title	Affiliation	Email
State Co-Chair	Mark Nordberg, Senior Engineering Geologist	California Department of Water Resources (DWR)	Mark.Nordberg@water.ca.gov
Non-State Co-Chair	Jon Parker, General Manager	Kern Water Bank Authority	jparker@kwb.org
Sub-committee Member	Adam Hutchinson, Recharge Planning Manager	Orange County Water District	ahutchinson@ocwd.com
Sub-committee Member	Khalil Lezzak, Hydrogeologist	California State University, Sacramento	khalil.lezzaik@owp.csus.edu
Sub-committee Member	Craig Ulrich, Senior Scientist Engineering Associate	Lawrence Berkeley National Laboratory	CUlrich@lbl.gov
Sub-committee Member	Ate Visser, Research Scientist – Noble Gas and Isotope Hydrology	Lawrence Livermore National Laboratory	visser3@llnl.gov
Sub-committee Member	Aysha Massell, Associate Director	American Rivers	amassell@americanrivers.org
Sub-committee Member	Graham Fogg, Professor	University of California (UC), Davis	gefogg@ucdavis.edu
Sub-committee	Thomas Harter,	UC Davis	thharter@ucdavis.edu

Position	Name and Title	Affiliation	Email
Member	Professor		
Sub-Committee Member	Tara Moran, Academic Research Staff	Stanford Water in the West	tamoran@stanford.edu
Sub-committee Member	Doug Parker, Director, California Institute for Water Resources	California Institute for Water Resources	Doug.Parker@ucop.edu
Sub-Committee Member	Michael Cahn, Farm Advisor, Irrigation and Water Resources	UC Cooperative Extension, Monterey County	mdcahn@ucanr.edu
Sub-committee Member	Joseph Choperena, Senior Project Manager	Sustainable Conservatio n	jchoperena@suscon.org
Sub-committee Member	Andrew Fisher, Professor	UC Santa Cruz	afisher@ucsc.edu
Sub-committee Member	Daniel Gamon, Engineering Geologist	DWR – Divison of Integrated Regional Water Management	Daniel.Gamon@water.ca.gov
Sub-committee Member	Cordie R Qualle, Industry Faculty Fellow	California State University, Fresno	cqualle@csufresno.edu
Theme Coordinator	Francisco Flores-Lopez, Water Resources Engineer	DWR	Francisco.FloresLopez@water.ca.gov

Engagement Process

The Recharge and Extraction Methods & Measures Subcommittee's objective was threefold:

1. Identify a priority list of up to 10 data, research, and tools needs with the top three to be reported to the RAC as actions items.
2. Cost estimates to implement.
3. Define a strategy to achieve action items.

The State and non-State co-chairs were proposed by the DWR Flood-MAR team. Both co-chairs were selected based on their leadership skills and well-known expertise and experience in the corresponding fields and organizations.

The co-chairs, in collaboration with the DWR Flood-MAR team, identified a list of potential members to integrate the subcommittee. The identified candidates were academic, industry experts, practitioners, and researchers with experience and expertise on the Recharge and Extraction Methods & Measures arena. The final list of individuals who agreed to participate in the theme as subcommittee members is shown in the above table.

The subcommittee members had one meeting with the co-chairs to identify the needs' themes and organize and process the identified information. The co-chairs had, parallel to this process, several phone conversations to organize the subcommittee's contributions.

Available Research, Data, and Tools

Research Needs and Gaps

Listed below are the three main needs and gaps in research, data, and tools related to the Recharge and Extraction Methods & Measures theme. These needs and gaps were determined by the subcommittee members.

Research Needs and Gaps 1.
Compilation of existing managed aquifer recharge projects and associated data (Or the do's and don'ts of groundwater recharge).

Recharge projects have been implemented for decades and over that time a significant body of practical information has been developed. A compilation of project information into a database that can be referenced when making decisions on how to best apply water to a recharge area could be invaluable for project proponents. Most important would be the inclusion of project constraints, successes, and failures. The database will essentially be a list of "do's and don'ts" when considering recharge projects.

Research Needs and Gaps 2.
How to measure the efficiency of large- and small-scale Managed aquifer recharge projects and monitor aquifer responses.

If local agencies or GSAs decide to implement a Flood-MAR program they may or may not need to measure its effectiveness with respect to aquifer replenishment or water budget accounting. Flood-MAR projects will generally benefit upper unconfined aquifers, not necessarily the deeper confined or semi-confined systems which are often the principle aquifers tapped in a groundwater basin. A small-scale Flood-MAR project may be conducted to provide local ecosystem benefits or potential recreational benefits and not need to measure or account for the volume of surface water recharged. Any effort will be for the good of the basin. However, a large-scale project, or a series of coordinated smaller projects, may desire to quantify recharge volumes from a local- or basin-wide water budget perspective and track where the recharged water travels. In this case landowners may want to receive credit or financial reimbursement for water recharged. Like the previous data gap, the "Do's and Don'ts of Groundwater Recharge", there are many examples of how existing agencies account for recharge and monitor aquifer responses. As part of this data gap we propose to compile a list of project and academic information and provide examples of how recharge accounting is conducted.

Research Needs and Gaps 3.
Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.

Floodplain inundation can be a multi-benefit approach to groundwater recharge because it could provide ecological benefits, reduce flood risk, provide reservoir operational flexibility, may not conflict with instream flow requirements, and is likely to have more water quality benefits for both surface water and groundwater than off-stream recharge locations on agricultural land. Like all potential recharge basins, the ability for floodplains to infiltrate flood water and contribute to the local aquifer is highly dependent on site-specific variables, including geologic characteristics, depth to groundwater, topography, hydrology, land use, and water quality issues. We recommend that floodplain inundation is considered along with other groundwater recharge options, both as direct recharge opportunities and in conjunction with other recharge methods. To do this we must compile available data and develop methods, analysis, and recommendations for practitioners to understand the site conditions that would make existing or potential floodplains ideal for groundwater recharge.

Prioritization Process

The theme subcommittee group was comprised of academia, industry experts, researchers, and practitioners in different fields related to the Recharge and Extraction Methods & Measures subject. Because the research, data, and tools' gaps and needs were identified in three main groups, there was not a real need to prioritize those gaps. But, the subcommittee prioritized the three gaps from Priority 1 to Priority 3 through an open and thoughtful discussion among all subcommittee members. The final priority is presented in the previous section, List of Research Needs and Gaps.

Top Three Research, Data, and Tools Actions

As part of the recommendations provided to the co-chairs during the Research Advisory Committee (RAC) meetings, the RAC coordinators suggested to present consistent levels of information for all research themes to support a coherent message throughout the R&D Plan. Another recommendation was to define the top three actions items, corresponding description, connection to Flood-MAR, and the strategy for implementation that each theme wanted to move forward in the R&D Plan.

Based on these recommendations, the lead theme consulted and had to make some adjustments to the information provided by all subcommittee members. The final top three contributions and the format of how it was submitted to the RAC committee is shown below.

Priority 1

Action: Compilation of existing managed aquifer recharge projects and associated data.

Description and Connection to Flood-MAR: Recharge and extraction projects have been underway for decades. A compilation of both the academic basics related to groundwater recharge (e.g. soil suitability) and the practical knowledge gained by those that have undertaken such projects can help guide those considering Flood-MAR.

Draft Strategy for Implementation:
Product: Develop a searchable database of existing MAR projects and key implementation and maintenance methods. Contractor to:

a) Compile and review existing guidance documents regarding groundwater recharge methods.
b) Interview/survey water districts, water managers, groundwater banks, and individual landowners with experience conducting recharge and extraction.
c) Develop database documenting existing, emerging, and promising recharge and extraction methods.
d) Some examples of recharge strategies to include in survey and database: (i) development of dedicated basins, ASR, water bank spreading ponds, private land recharge (e.g., on-farm recharge [OFR], subterranean recharge pipelines, micro basins).

Case studies to include: Information about each recharge strategy should include a cost per acre foot of water recharged. These costs will include capital expenses including requirements to legally implement (permits), ongoing operations and maintenance, and depreciation.

Successful and unsuccessful development and maintenance of these systems. Examples include:

(ii). OFR: 1. Methods used for maximum compatibility with crop production include: (a) Method, duration, volume, and seasonality of water application. e.g.: water applied via furrows; and alternate row water application, (b) Field preparation methods prior to water application.

2. Water quality considerations: (a) concentrating recharge on same cropland to minimize legacy nitrate leaching into aquifer, nutrient application method, form of fertilizer, and timing.

(iii) Dedicated recharge basins: 1. Management; settling basins, ripping, vegetation planting, slopes, wildlife management, etc.

(iv) Water recovery methods. Final version of database to be housed at DWR to be updated and searchable by recharge type and crop by growers, GSAs, and water districts to inform project design and management.

Lead: Contract consultant or academic (possible graduate student).

Draft Costs Estimate (breakdown): This effort can start immediately. Six-month project to conduct surveys/interviews for each recharge strategy and develop searchable database.

Cost Estimate: $100,000.

Priority 2

Action: Compilation of (1) on-farm water-delivery measurement tools and methods, (2) methods of determining appropriate loss factors (e.g., Et), and, (3) recommendations regarding appropriate groundwater monitoring to determine the efficiency of managed aquifer recharge projects.

Description and Connection to Flood-MAR: The effectiveness of Flood-MAR projects is dependent on reliable and widely acceptable methods for determining the volumes of water benefitting the aquifer. This action item involves the compilation of (1) on-farm water-delivery measurement tools and methods, (2) methods of determining appropriate loss factors (e.g. et), and (3) recommendations regarding appropriate groundwater monitoring to determine the efficiency of managed aquifer recharge projects.

Draft Strategy for Implementation:

1. Compile existing documents regarding on-farm water delivery methods.
2. Compile existing guidance documents regarding the calculation of evaporative (and perhaps other) losses that would be encountered in a Flood-MAR project.
3. Develop recommendations regarding groundwater monitoring.
4. Prepare a guidance document compiling the findings.

Draft Costs Estimate (breakdown): Typical cost of a flow meter used for irrigation district or field pipelines are approximately $5,000.

Cost Estimate: $200,000.

Priority 3

Action: Establish methods and considerations by which floodplains can be used as direct recharge sites and in conjunction with other recharge methods.

Description and Connection to Flood-MAR: Floodplain inundation is a true multi-benefit approach to groundwater recharge because it provides ecological benefits, reduces flood risk, provides reservoir operations flexibility, does not conflict with instream flow requirements, and is likely to have more water quality benefits for both surface water and groundwater than off-stream recharge locations on agricultural land. Like all potential recharge basins, the ability for floodplains to infiltrate flood water and contribute to the local aquifer is highly dependent on-site specific variables, including geologic characteristics, depth to groundwater, topography, hydrology, land use and water quality issues. We recommend that floodplain inundation is considered equally with other groundwater recharge options, both as direct recharge opportunities and in conjunction with other recharge methods. To do this we must compile available data and develop methods, analysis, and recommendations for practitioners to understand the site conditions that would make existing or potential floodplains ideal for groundwater recharge.

Draft Strategy for Implementation:

1) Compile and analyze existing groundwater data related to floodplain inundation projects in the Central Valley, and potentially other analogous climates and geologies. Include analysis on both short- and long-term recharge potential of floodplain inundation. Determine gaps in knowledge and make recommendations for research.

a) Product: A paper compiling the findings.

b) Audience: government, academic, general public.

c) Lead/partners: Academic, consultant/ NGOs, DWR.

d) Timeline: 6 months

e) Cost: $50,000

2) Describe site conditions that affect groundwater recharge in floodplains, including geologic characteristics, depth to groundwater, hydrology, local topography, water quality concerns, and land use. Include a discussion on how floodplains could be used in conjunction with other recharge methods. Determine key management decisions - such as the duration, depth and timing of inundation - that affect the groundwater recharge potential of these various types of floodplain site conditions.

a) Product: A paper compiling the findings, with an accompanying decision-making tool that can be used by practitioners to determine if a site is suitable for floodplain recharge, and key management decisions that will be required for that site. b) Audience: field practitioners (planners/engineers), government, academic.

c) Lead/partners: Academic, consultant/ NGOs, DWR.

d) Schedule: 1-year

e) Cost: $100,000

3) Optional: Describe the multiple benefits associated with floodplain recharge projects, including how floodplains can be used in conjunction with basin-wide water management decisions such as dam operations and flood management. Discuss the complex landscape of permitting, environmental flows and water rights. Include policy and funding recommendations.

a) Product: A paper compiling the findings.

b) Audience: government, general public.

c) Lead/partners: Academic, consultant or NGO / DWR.

d) Schedule: 3 months

e) Cost: $50,000.

Draft Costs Estimate (breakdown): Text.

Cost Estimate: $200,000.

Next Steps (if identified by the co-chairs and/or subcommittee members)

(One paragraph narrative on the next steps to move the identified actions toward implementation.)