Memorandum #1
Identifying Benefits and Beneficiaries of Groundwater Recharge from Floodwater Diversion

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For Sustainable Conservation

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OVERVIEW

One design objective for the incentives that are developed in this study is distribute the costs of doing recharge so that they are more equitably shared by those that benefit from the action. [2] In this memo, we identify the main beneficiaries of groundwater recharge and flood risk reduction associated with a program to use floodwater releases to recharge depleted groundwater basins in California's Central Valley. One of the main purposes of compiling this beneficiary information is to inform newly created Groundwater Sustainability Agencies (GSA) of the range of beneficiaries from groundwater recharge. This information may be useful as they design ways of incentivizing groundwater recharge and financing the costs of recharge in their Groundwater Sustainability Plans.

This study explicitly considers a wide range of potential benefits and beneficiaries, including public and indirect benefits such as those to water supply, habitat, downstream communities, and transportation networks. We have employed this comprehensive approach to fully explore the effects of applying the beneficiary-pays principle to incentivizing and financing groundwater recharge. By casting a wide net for beneficiaries, we expect to maximize the number of potential beneficiary/financial mechanism combinations. Designing effective financing mechanisms based on the beneficiary pays principal translates to more capital to support groundwater recharge.

SUMMARY OF POTENTIAL BENEFICIARIES

We define *beneficiaries* as entities that generally own, use, or control assets used for specific *purposes* (i.e., *activities*) that *benefit* from groundwater recharge programs in the Central Valley

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[2] Another important objective is to attract and reward participation by growers in accepting floodwaters to percolate into aquifers. Those considerations are discussed in a separate forthcoming whitepaper.

and surrounding areas.[3] For example, downstream growers (beneficiaries) benefit in two ways: first, through recharge of their aquifers used for irrigating crops, and second, by avoiding flood damages to their fields where they grow those crops (purposes or activities) through protection provided by upstream growers that take floodwaters on their fields for groundwater recharge. We can attach monetary estimates of benefits to purposes or activities through different economic analytic methods, depending on the types of purposes. Some of these purposes are part of individual or private transactions or activities for which economic value can be readily estimated (e.g., buying and selling of agricultural products); other purposes create more broad public benefits for which a value is not easily determined because we cannot observe prices (e.g., public enjoyment of habitat and all of the various concurrent benefits from enjoying species existence).

The various benefits of an on-farm groundwater recharge program can be separated into the direct benefits of groundwater recharge, and the associated co-benefits which cover a range of benefits from flood protection, upstream discharges, and ecosystem improvement. Direct benefits of groundwater *recharge*, as identified in California's Sustainable Groundwater Management Act (SGMA) legislation, include:

> *Increasing groundwater levels, increasing groundwater storage, improving water quality, mitigating land subsidence associated with overdraft, and improvements in water supply to interconnected surface water sources*.

There are also indirect benefits of the program, associated with improved flood protection in the Central Valley and downstream, as well as upstream benefits not directly associated with groundwater. As described in the DWR's *Handbook for Assessing Value of State Flood Management Investments*,[4] categories of benefits of flood protection include:

> *inundation-reduction benefits, intensification and location benefits, agricultural flood risk management benefits, and loss-of-life benefits*.[5]

The 2013 *California Water Plan* also identifies benefits of integrated flood management to include water supply benefits, environmental benefits, water quality benefits, recreation benefits, hydropower benefits, and navigation benefits. In this analysis, we draw on all these sources to identify the set of beneficiaries in the Central Valley.[6]

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[3] Appendix A includes a glossary of key terms used in this report.

[4] California Department of Water Resources. *Handbook for Assessing Value of State Flood Management Investments*. 2014.

[5] "*Inundation reduction* benefits are reduced or modified flood damage, costs, and/or losses, to existing or future economic activity... Improved flood protection can make flood-prone land more suitable for development resulting in intensification and/or location benefits. When the land use is the same without or with a project but the intensity of land use changes, an *intensification benefit* may accrue to the project… When the land use changes between the without-project and with-project conditions because of a new economic use, a *location benefit* may accrue to the project."

[6] Appendix B describes different dimensions of measuring benefits and segmenting beneficiaries. Some of these dimensions are included in further discussion below.

We describe categories of beneficiaries in terms of their geographic location in relation to the site of potential on-farm groundwater recharge projects and the types of benefits received. As described more thoroughly below, proximity to potential project sites is important not only to better understand the relationship between flood protection and the benefits received, but also to determine the feasibility of using specific financing mechanisms.

Geographic Context and Risk Considerations

The benefits of flood protection from groundwater recharge in the Central Valley is affected by the geographic location of the beneficiary. Consequently, this analysis groups beneficiaries by region because the benefits received vary with position along the waterways.

As one example is the most commonly cited example of the benefits of groundwater recharge: neighboring agricultural operations can directly benefit through increased recharge that reduces pumping head for irrigation. The value of that benefit can be in reduced pumping costs, improved groundwater quality, or less reliance on surface water deliveries. These benefits are similar to those realized by conjunctive use projects.

As an example of indirect benefits, upstream beneficiaries such as upstream flood control agencies depend on the ability to discharge floodwater into Central Valley rivers, streams and canals to protect their areas. The value of diverting floodwaters for groundwater recharge to these beneficiaries depends on the costs of alternative floodwater control options and methods of reducing river discharges. These indirect benefits to upstream beneficiaries fundamentally differ from the more direct flood protection benefits received by agricultural operations and landowners in the Valley.

To address these important geographic distinctions, this analysis organizes beneficiaries by geographic region. We also note that Central Valley flood protection may provide benefits to state and national beneficiaries; however, analyzing the value to potential beneficiaries outside of the state is not included in the scope of this study.

This study groups beneficiaries according to the following regions:

- *Local beneficiaries* within the Central Valley include areas overlying the groundwater basin where recharge takes place,
- *Downstream beneficiaries* include growers and localities behind flood levees, instream diverters, and aquatic and terrestrial habitat,
- *Upstream beneficiaries* include dischargers upstream of recharge locations, such as hydropower generation and surface water storage reservoirs, and
- *Statewide and national beneficiaries* include maintenance and improvement of ecosystems, and regional, state and national economies that avoid damages and see increased activity.

These geographic distinctions correlate to some degree with the separations of benefits and beneficiaries by primary/secondary and direct/indirect. Local beneficiaries are more likely to receive direct and primary benefits, while those outside of the targeted aquifer are more likely to be peripheral and secondary. The category of benefits also is likely to vary.

DESCRIPTION OF BENEFICIARIES AND BENEFITS

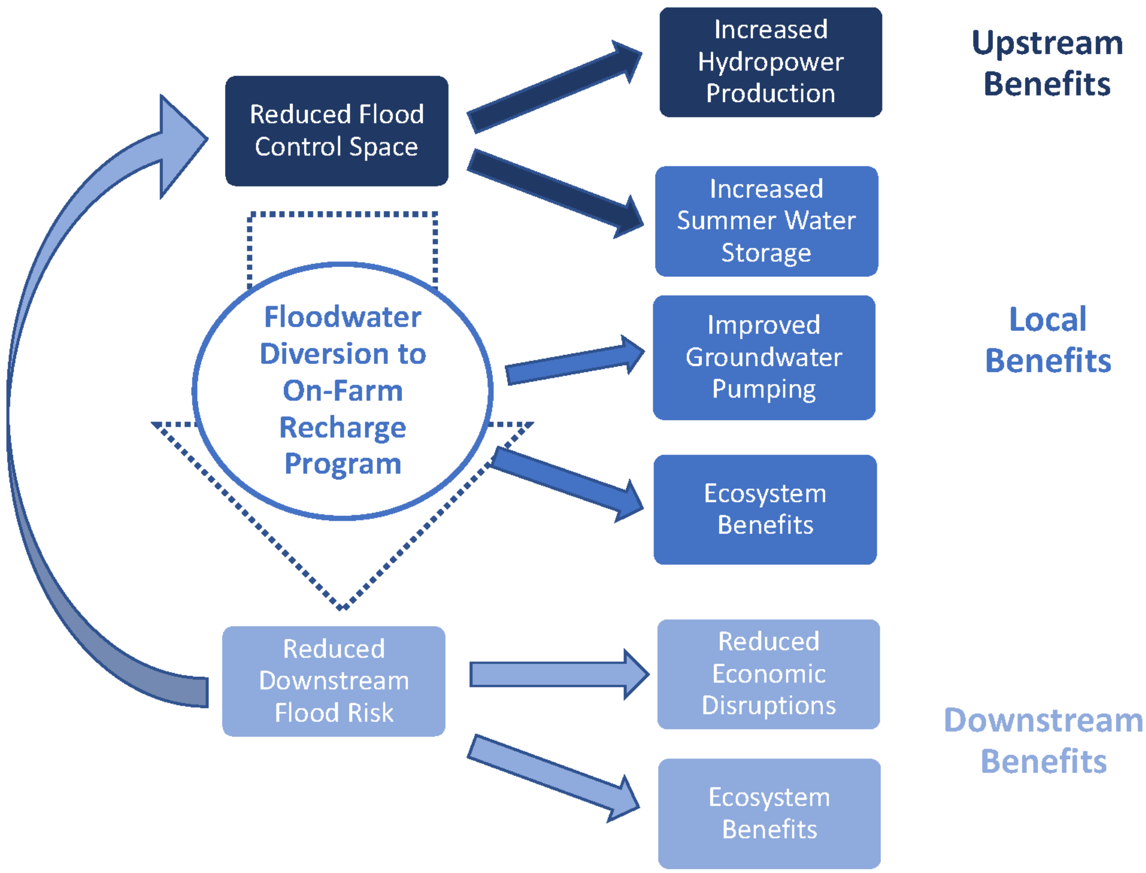
The following section gives a brief explanation of each beneficiary. Conceptually, measures of benefits are commensurate with the economic and social value of the production of goods and services, or of the assets and resources at risk to flooding. The direct benefits of groundwater recharge include increasing groundwater levels and increasing groundwater storage, improving water quality, mitigating land subsidence associated with overdraft, improved instream flows in interconnected surface water sources. Indirect benefits include annual damages avoided by improving flood control from their current level of protection to a target level of protection—both upstream and downstream, increased surface water supplies from upstream storage, and increased and higher value hydropower generation derived from greater reservoir storage. Note that several “benefits” are avoided stressors that would have been incurred by one party due to actions by another party. The most relevant example here is that upstream flood control entities often manage floods by diverting flows downstream to be managed by yet another flood control entity, thus transferring stress to the downstream party. Providing more flood management flexibility can relieve that stress, thus creating a benefit for the upstream entity.

Figure 1 illustrates some of the relationships among different benefits. The figure divides the benefits geographically, and shows where interactions occur, such as between downstream flood risk management and upstream water storage.

Direct benefits, such as improved groundwater pumping and local ecosystem benefits are the primary outcomes from on-farm recharge. Improved groundwater pumping takes place in terms of an increase in groundwater levels and available acre-feet (AF) of sustainable yield, while local ecosystem benefits are evident in the acres of land flooded under programs that provide transitional habitat birds and other species.

Other benefits are more indirectly related. For instance, floodwater diversions to an on-farm recharge program reduces downstream flood risk, measured in terms of acre-feet (AF) of water diverted or the reduction in peak streamflow downstream measured in cubic feet per second (cfs) or floodstage (in feet). In turn, reduced downstream flood risk reduces economic disruptions from flood events, as measured by a reduction in expected annual financial damages associated with the change in flood risk and the accompanying secondary economic impacts. These secondary impacts extend beyond the groundwater basin to the state economy in avoided losses. Reduced flood risk downstream also reduces the need for winter and spring flood control space in upstream reservoirs, increasing the acre-feet of storage space that can be used for other purposes. Water managers can store more water to sell to local and project water users during the dry irrigation season. Hydropower producers can increase the acre-feet of water stored for use in hydropower production, increasing total kilowatt-hours of energy production and the ability to time that generation to provide more megawatts (MW) of reliable peak capacity. Together, the increase in streamflows during the dry season can also benefit local habitat, both in terms of instream, and associated wetlands and riparian habitat. These direct and indirect relationships are summarized in Figure 1.

Fig. 1. Benefit Relationships



Estimating economic benefits is beyond the scope of the current analysis, particularly since those benefits are geographically specific. Benefits can be estimated through several different economic methods including revealed willingness to pay and stated preferences for willingness to accept. In practice, this can be difficult to estimate directly; benefits are often calculated by estimating the cost of alternatives (e.g. the cost of alternative water supplies or the cost of flood damages from incremental flood control improvements) as a proxy for the direct economic value.

Benefits can accrue across an entire district or agency service area, or to individuals. Whether growers and customers reside inside or outside of a district affects the level of benefits that those growers and customers realize. In some cases, trade-offs may arise among private short-term benefits and public sustainability benefits. These issues are often specific to situations and are not explored further here, but should be part of any consideration of an overall benefits assessment.

Table 1, below, presents our initial summary of all entities, whether private or public, that would receive benefits or services (i.e., asset protection, reduced groundwater pumping costs, ecosystem enhancements) from a groundwater recharge and flood protection program. Table 1 also identifies the primary types of benefits that accrue to each category of beneficiaries. We intend this list of beneficiaries to be comprehensive. Many of the beneficiaries receive multiple benefits, but are often a subset of a larger beneficiary group. We distinguish those beneficiaries to keep the trail of benefits clear. For example, agricultural growers may be using both groundwater and surface water, but many are using only one or the other. So, we separate growers who are using groundwater, both solely and conjunctively, from those who rely solely on surface water. The table includes the primary regional relationship within a watershed for each category of beneficiary. The table also identifies direct and primary benefits to specific beneficiaries from indirect or peripheral and secondary benefits.

Table 1. Summary of Beneficiary Categories

	Mitigated detrimental groundwater impacts					Indirect benefits						
Beneficiaries	lowering of GW levels	reduction of GW storage	degraded water quality	land subsidence	depletion of interconnected surface water	increased surface water storage/water delivery	improved surface water supply reliability	Improved soil quality and productivity	intermittent wetland habitat	improved flood control	potential increase in hydropower production	secondary economic benefits
Local Beneficiaries												
Local Agricultural Growers	X	X	X	X		X	X	X		X		x
Local Municipal Water Providers and Customers	X	X	X	X		X	X			x		x
Local Agricultural Water Providers and Grower Customers	X	X	X	X		X	X				x[a]	x
Rural Residential and Other Private Well Users	X	X	X	x						x		x
Local Ecosystem			X		X			X	X			x
Infrastructure Owners and End Users				X						X		x
Upstream Beneficiaries												
Upstream Flood Protection Agencies										X		x
Hydropower Owners and Operators											X	x
Surface Water Project Customers						X	X					x

	Mitigated detrimental groundwater impacts					Indirect benefits						
Beneficiaries	lowering of GW levels	reduction of GW storage	degraded water quality	land subsidence	depletion of interconnected surface water	increased surface water storage/water delivery	improved surface water supply reliability	Improved soil quality and productivity	intermittent wetland habitat	improved flood control	potential increase in hydropower production	secondary economic benefits
Downstream Beneficiaries												
Downstream Commercial and Residential Property Owners	X	X	X	X						X		x
Downstream Agricultural Operators	X	X	X		X	X	X			X		x
Infrastructure Owners and End Users				X						X		x
Downstream Ecosystem					X				X	X		
State Economy	X	X		X		X	X	X		X	X	X

Notes: [a] – Districts benefit from increased hydropower to the extent that they own portions of the power plants.
A large X denotes a primary or direct benefit; a small x denotes a secondary or peripheral benefit.

Local Beneficiaries

Local Agricultural Growers Relying on Own Water Supplies

Agricultural operators within the groundwater basin benefit directly from groundwater recharge. Increasing groundwater levels will reduce pumping costs for agricultural users that rely on groundwater sources exclusively or for agricultural users that supplement surface water supplies with groundwater in dry years. The program also has the potential indirect benefit of increasing surface water deliveries with increased storage behind dams upstream of the Valley. Both of these benefits have the effect of improving water supply reliability for agricultural operators.

Additional benefits for program participants can be improved soil quality that leads to increased productivity. Using floodwaters for recharge may flush agricultural chemicals and be used to manage soil salts.

Tenants and owner-operators may realize their benefits in different ways. The degree to which benefits accrue to tenants or landowners depends on the time frame in which the benefits occur. Over the long run, landowners will gain more benefits as land values reflect improved aquifer and soil conditions. So, while both benefit from reduced pumping costs, the value of the longer-term increases in aquifer storage are more likely to accrue to land owners through increased rents.[1]

Local Agricultural Water Providers and Customer End-Users

Local agricultural water providers, such as irrigation and water storage districts, and their customers receive numerous benefits. Note that many of these end-users overlap with the local growers discussed previously, but these benefits may flow through in different paths.

Those with groundwater supplies within the target basin benefit directly from groundwater recharge. Increased groundwater levels will reduce pumping costs for local districts. In addition, improving groundwater conditions in the Central Valley will improve water supply reliability for local water agencies that currently rely on increasingly unreliable imported water supplies and overdrafted groundwater basins. Many of these providers manage conjunctive-use projects that can become more efficient as aquifer conditions improve. Using floodwater releases for groundwater recharge will also result in improved water quality in Valley aquifers that currently have a high level of nitrates and salinity due to agricultural runoff.

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[1] The literature on energy efficiency shows how improvements in the building envelope and appliances can lead to increased rents and housing values.

A separate set of benefits accrue to local water agencies that rely on surface water supplies. Groundwater recharge not only reduces pressure on surface water supplies due to increased reliability of groundwater for ag and rural pumpers,[2] in some places it also improves surface water supply reliability due to the interconnection between ground and surface water sources. For example, many growers both receive both surface water deliveries from their water purveyors and use groundwater as a back up source for dry years.[3]

Local Municipal Water Providers and Customer End-Users

Residential, commercial, and industrial water users (termed here as "municipal" water users, as distinct from agricultural water users) in the Central Valley rely on a mix of local groundwater, surface water, and imported water for their water supply. Depending on their supply mix, municipal water agencies and water users may receive multiple benefits from a groundwater recharge program akin to those listed for agricultural water agencies. These benefits have real cost savings that will be passed on from the utility to the end user. Providers that rely on groundwater will see reduced groundwater pumping costs, improved water quality, and improved supply reliability. Districts that rely on surface water may also see improved surface water reliability.

A subgroup of municipal water customers is in disadvantaged communities. These are often unincorporated towns served by community service agencies (CSAs) established by the county. These communities tend to rely heavily on aquifers that compete with agricultural operations because they cannot afford the deeper wells that larger towns and cities drill. As a result, these wells run dry more frequently and can be contaminated from agricultural and residential runoff.[4] In addition to naturally-occurring mineral elements, for over 100 years agriculture has been applying nutrients and other additives that can leach through soils into groundwater when over-applied. Despite improvements in farming practices and technologies made today, improvements in groundwater quality are difficult to detect due to the lingering effects of legacy concentrations in the soil and groundwater below.

[2] The original intent of the Central Valley Project as it was approved in 1940 was to reduce groundwater overdraft in the San Joaquin Valley. As overdraft is relieved in other ways, demand for surface supplies may be relieved as groundwater can be substituted for imported surface water. (California Department of Water Resources, "History Of The California State Water Project," http://www.water.ca.gov/swp/history.cfm.

[3] With the increased use of microdrip and subsurface irrigation systems, some growers are switching to groundwater during certain irrigation periods because groundwater tends to have less particles in it that can clog these irrigation systems.

[4] State Water Resources Control Board, "Communities that Rely on a Contaminated Groundwater Source for Drinking Water, AB 2222 Report to the Legislature," http://www.swrcb.ca.gov/gama/ab2222/docs/ab2222.pdf, January 2013.

Rural Residential and Other Private Well Users

In addition to local municipal and agricultural groundwater users, there may be other rural residential or small commercial beneficiaries that depend on private wells in the Central Valley that receive similar benefits from increased grounding groundwater levels. These individual users tend to have shallower wells connected to the aquifer being used by farm operations. Their benefits will accrue in a similar manner as the smaller CSAs.

Disadvantaged individual residents are more likely to rely on wells that are at higher risk than other municipal users, but those residents are less likely to be able to afford drilling deeper or bringing in alternative water supplies.

Local Ecosystem

The local ecosystem, composed of the physical habitat and community of related species in the Central Valley, have the potential to benefit directly from increased instream flows in places where there is interconnectedness of groundwater and surface water sources. It also benefits indirectly from an on-farm groundwater recharge program that uses on-farm flooding as the recharge mechanism. On-farm flooding provides periodic intermittent wetland habitat, particularly for migratory bird species. Further, reduced need for downstream levees can benefit the terrestrial habitat by reducing levee footprints. This enhances the ability to manage floodplains for multiple benefits including improved habitats.

Downstream Beneficiaries

Downstream Residential and Commercial Property Owners

The residential and commercial beneficiary category includes downstream Central Valley and Delta residents and local business owners who own private residential and commercial structures and property. This property would be directly damaged by flooding from floodwaters in the basin, and owners benefit from avoiding these losses through improved flood control.

Downstream Agricultural Operators

Owners of agricultural land downstream of project areas, including those in the Delta, also benefit from improved flood control in the Central Valley. This property would be directly damaged by flooding in the Central Valley, and owners benefit from avoiding these losses through improved flood control.

Infrastructure Owners and End-Users

The Central Valley and the Delta, given their location at the center of the Northern California megaregion, serve as an infrastructure hub for the movement of goods, natural resources, and people across Northern and Central California, the state, and beyond. Owners of multiple types of physical infrastructure assets benefit directly from flood protection in the Central Valley. Owners of these physical infrastructure assets and end users benefit from improved flood protection in the form of service reliability and avoided infrastructure downtime. The loss of product or service revenues is potentially a larger consequence to infrastructure owners than the direct loss of the physical infrastructure. Infrastructure in the Central Valley and downstream in the Delta include oil and gas pipelines, railroads, electricity transmission, and highways.

Downstream Ecosystem

Downstream ecosystems also benefit indirectly from flood control improvements offered by a groundwater recharge program perform many complex and interrelated functions that not only provide basic biological support but also valuable goods and services to society.[5] In the case of the Central Valley, these could include floodplain and wetlands impacts in the Sacramento-San Joaquin Delta, including flood conveyance and storage, erosion control, pollution prevention and control, fisheries, water supply, recreation, food production, education and research, historical and archaeological values, open space and aesthetic values, and habitat for waterfowl and other wildlife, including game species.

Upstream Beneficiaries

Upstream Flood Protection Agencies and Dischargers

Upstream beneficiaries include flood control agencies and protected properties along those waterways that flow to the targeted basin. Upstream flood management agencies and dischargers are able to avoid flooding downstream due to the improved flood control provided by the downstream groundwater recharge program through flood flow diversion.[6] These dischargers can avoid the cost of alternative diversion, storage, treatment and discharge methods by discharging floodwaters into public waterways. This beneficiary category includes new upstream development. Importantly, increased channel capacity through flow diversion that reduces downstream flood risk can allow flood control managers, including the Army Corps of Engineers, Central Valley Project and local dam operators to reoperate their reservoirs so as to reduce the

[5] See Chapter 4 “Ecosystem Valuation Methods” of DWR’s *Economic Analysis Guidebook* (2008) for further discussion of this issue.

[6] Downstream flood risk is the driving parameter for decisions on upstream flood control management. If the risk is reduced by diverting flows downstream, that should change the flood control parameters. Being able to flood agricultural fields is the same as an increase in the flood flow capacity of the leveed channels. This premise is the basis of the Sacramento flood control scheme with its multiple bypasses. See for example, MBK Engineers, “System Reoperation Study Forecast-Based Operations Analysis,” Draft Technical Report Prepared for the Department of Water Resources, Sacramento, California, http://www.water.ca.gov/system_reop/docs/Attachment%20A%20-%20Feb%202014%20Draft%20System%20Reoperation%20Study%20Forecast-Based%20Operations%20Analysis.pdf, February 2014.

amount of flood-control space during the winter months. This leads to increase stored water during the summer. These benefits are not often considered in past beneficiary studies of flood control or groundwater recharge projects.

Hydropower Owners, Operators and Electric Utility Customers

Many large hydropower facilities are co-located with multi-purpose flood control and water storage reservoirs. Optimizing flood control operations provides more water management flexibility to achieve multiple benefits including improved storage and hydropower generation. Increasing flood water storage space directly trades off with storage for water supplies and summertime hydropower generation. Being able to accommodate greater flood flows in the Central Valley through a groundwater recharge program reduces the need for flood storage and increases reservoir storage. That added storage can increase the power generated during the more valuable summer peak load season. That will both reduced electricity bills and emissions from other power plants that are displaced by the hydropower.[7]

Surface Water Project Customers

Customers of surface water projects in the San Joaquin Valley that are used both for surface water storage and flood control will see water supply benefits under a groundwater recharge program. This includes CVP customers, such as those on the Friant-Kern Canal, as well as those that rely on Army Corps of Engineers (US ACE) projects on the east side of the San Joaquin Valley such as Terminus Dam and Success Dam in the Tulare Basin, and local projects such as New Don Pedro Dam operated by Modesto Irrigation District and Turlock Irrigation District. Increasing flood releases as part of a groundwater recharge project increases reservoir water supply storage space. Customers of these projects that do not already fall into one of the local water supply beneficiary categories gain greater water supply reliability.[8]

Regional and State Economies

Economic impacts of a groundwater recharge program in the Central Valley can spread beyond the entities that receive direct and indirect benefits. For example, local agricultural producers that see decreased groundwater pumping costs due to a groundwater recharge program may use those savings at local agricultural equipment dealers. For indirect benefits, flooding of a single Delta island impacts not only the property owners on that island, but also business owners on neighboring islands that may depend on agricultural inputs or outputs from the flooded island. Agricultural

[7] See Appendix C, "How Hydropower Benefits from Floodwater Recharge," for more detail.

[8] Whether these customers are included in the relevant GSA will be a key distinction in determining benefits and expected contributions.

examples of who is likely to receive these benefits include equipment and fertilizer dealers for inputs, or trucking and packing houses for outputs, however, these benefits will occur throughout the local economy. Changes in local economic activity from upstream or downstream economic transactions are termed secondary impacts. The state economy is a highly-interrelated system, where impacts do not occur in isolation. This beneficiary category accounts for the owners of businesses located in the state that receive secondary benefits from improved water supply and flood protection conditions in the Central Valley

APPENDIX A BENEFICIARY ASSESSMENT TERMS AND DEFINITIONS

Relevant Terms for the Beneficiary Assessment	Definition [Source Code]
benefits	
economic benefits	Economic benefits are a measure of the willingness to pay for goods and services derived from implementation of a program or project—benefits could be measured in terms of the value added to an entity or person, or in the value of costs or damages avoided. [2, as modified]
private benefits	Benefits that accrue to identifiable subset of the community and from which individuals can be excluded. The ability to restrict benefits to those that pay enables these benefits to be funded with user money. Note that as used here, private beneficiaries would include "public" agencies that provide services to an identifiable group of users [2]
public benefits	Benefits that are shared by a wide cross-section of the community and from which individuals cannot realistically be excluded. Inability to exclude individuals means that imposing charges for access to the benefit is difficult. If 'free riders' can access the benefits without paying, there is no economic incentive for them to spend their money for these benefits. This means that if these benefits are to be created, public funding must usually be used. [2]
local benefits	For purposes of this assessment, local benefits are defined as those benefits accruing to landowners within the boundaries of the Legal Delta.
beneficiary	Any entity (individual, group, organization, agency, or community) that receives benefits or services (i.e., asset protection, protection from water supply disruption, or ecosystem enhancements) from the existing Delta levee system, or that would receive benefits or services from future investments in the Delta levee system. [1]
direct beneficiaries	Direct beneficiaries are those whose property or assets are affected in the case of avoiding or minimizing flooding [1]
indirect beneficiaries	Indirect beneficiaries are those who are affected from secondary effects of flooding, such as reduced access to shipped products if a highway is damaged. [1]
assets	
assets	For purposes of this assessment, an asset is defined as property owned by a person or group—or any item that can be considered for the common good—that is regarded as having economic value. [1]
tangible assets	Tangible assets are physical assets, such as land, vehicles, equipment, and machinery. Tangible assets are at risk of damage, either from naturally occurring incidents, or by accidents. Tangible assets, sometimes referred to as tangible fixed assets or long-lived tangible assets, are divided into three main types: property, plant, and equipment. [7, as modified]
intangible assets	Intangible assets are nonphysical. Depending on the type of entity that owns them, intangible assets may include permits, licensing agreements, and service contracts, among others. Intangible assets can add value to an entity's future worth. In some cases, intangible assets can be much more valuable than tangible assets. [7, as modified]
cost allocation	

Relevant Terms for the Beneficiary Assessment	Definition [Source Code]
cost allocation	Cost allocation refers to methods that can be used to allocate the costs of a program or project to different beneficiaries. The particular method that is used to allocate costs often depends on the data that are available because each method has different data requirements, and the allocation typically depends on the underlying assumptions on which the allocation is to be based. The method also is dependent on the legal requirements specified in particular financing mechanisms. For example, in project levees the cost allocation methodology is specified in federal and state law. For local funding, whether revenues are derived from assessments or special taxes can determine the cost allocation method which can differ from federal law. Cost allocation is the process by which financial costs of a project are distributed equitably among project purposes. A common cost-allocation method is Separable Costs-Remaining Benefits (SCRB) which distributes costs among the project purposes by identifying separate costs and allocating joint costs or joint savings in proportion to each purpose's remaining benefits.[4]
separable costs	Separable costs are project cost savings with one purpose excluded, or costs incurred for structures serving multiple (but not all) purposes. In some cases, specific and separable costs, which are costs of facilities serving only one included purpose, are the same. [6]
non-separable costs	Non-separable costs, also known as joint or residual costs, are costs of features that support all included purposes plus otherwise unallocated costs (e.g., environmental, aesthetic, and social). [6]

Notes:

[1] Delta Stewardship Council. Delta Levee Investment Strategy: Technical Memorandum 2.1: Baseline Information on Islands and Tracts, Assets, Hazards, and Beneficiaries. 2015.

[2] CALFED. CALFED Bay-Delta Program Draft Implementation Plan: Financing Plan. 2005

[3] Delta Protection Commission. Economic Sustainability Plan for the Sacramento-San Joaquin Delta. 2012

[4] Department of Water Resources. Economic Analysis Guidebook. 2008

[5] Delta Stewardship Council. The Delta Plan. 2013

[6] Delta Stewardship Council. Delta Levees Investment Strategy. Technical Memorandum 3.2: Cost Allocation Methodology. April 15, 2015.

APPENDIX B THE MANY TYPES OF BENEFICIARIES AND BENEFITS

Groundwater recharge and flood protection benefits to beneficiaries can be differentiated and categorized in many ways, depending on program purpose or the types of actions subject to a benefits analysis. We use these categories as a means to capture all of the potential beneficiaries of a program to use floodwaters in the Central Valley for groundwater recharge and their relationships. In this study, we adopt the DWR's[1] typology to characterize important categories of benefits, as follows:

- ***Direct and indirect.*** *Direct* benefits are primary benefits realized in the immediate locality of the program due to groundwater recharge. *Indirect* benefits are benefits affecting upstream or downstream areas associated with non-groundwater related benefits such as flood protection or upstream diversions. Hydropower benefits and downstream flood protection benefits are examples of indirect benefits. The benefits listed in the Sustainable Groundwater Management Act (SGMA) are direct benefits; we expand the list of indirect benefits here.
- ***Primary and secondary benefits –*** *Primary benefits* are the increased value of goods and services to beneficiaries immediately affected by a groundwater recharge or flood control project or program. Benefit categories include flood risk management, water supply, water quality, and recreation. *Secondary benefits* are the values of goods and services that subsequently accrue to other parties (beneficiaries) that interact with the primary beneficiaries. Secondary benefits can include changes in economic activity (e.g., regional or state-level jobs and income) and fiscal effects, such as taxes or other revenues, that are important to local stakeholders.[2] Secondary beneficiaries are identified in Table 1, below; otherwise, beneficiaries are considered to be primary.
- ***Private and public goods realized as benefits***[3] – "Goods" are commodities or services that can be used to satisfy human wants and that have exchange value. Characteristics of *public goods* are non-excludability (i.e., it is not possible to exclude non-payers from consuming the good) and non-rivalry in consumption (i.e., consumption of a good by one consumer does not diminish the benefit to other consumers). If a "good" does not

[1] California Department of Water Resources. *Economic Analysis Guidebook*. January 2008.

[2] This typology follows regional economic input-output analysis. In that framework, *direct* effects arise from immediate economic activity, *indirect* effects derive from transactions with directly-affected parties, and *induced* effects are more broad, general economy-wide impacts from changes in direct and indirect activity.

[3] The term "public" as used herein means that benefits (or costs) cannot be easily assigned to specific individuals or entities. Importantly, our use of the term does *not* refer to publicly owned enterprises such as municipal water agencies or utility districts—those are considered "private" entities because the benefits can be assigned to specific individuals who privately enjoy them. In other words, the term "public" is defined within the context of an economic understanding rather than as used in common parlance.

have both of these characteristics, it is considered a *private good*. Goods can fall across the spectrum of this definition; for example, fishing in a river can diminish the availability of the fish to others, but it can be difficult to restrict access to the fishery. This myriad of goods confers benefits on beneficiaries who use them.

- ***Tangible and intangible benefits*** – *Tangible benefits* can be quantified in monetary or other quantifiable units (such as acres of habitat improved), whereas *intangible benefits* cannot be directly expressed in quantifiable terms or metrics (for example, trauma or reduced peace of mind resulting from a flood event).

APPENDIX C: HOW HYDROPOWER BENEFITS FROM FLOODWATER RECHARGE

Many California watersheds have both large river flows and large amounts of storage, giving considerable ability to control levels of generation and water release on a seasonal as well as daily basis. Besides permitting winter-spring runoff to be stored for use in the summer, the considerable storage in various reservoirs can be used to coordinate generation with high electricity load (high market price) periods on a daily and hourly basis. During off-peak hours with low market prices, storable water flows used for hydro generation are reduced, usually to minimum levels, to preserve water for release during high load periods. When water is used to generate above minimum levels during off-peak periods, this is generally because so much water is available that the most economic option is to use some of it for generation even during off-peak hours.

Large storage reservoirs are filled and drawn down on a seasonal basis. A reservoir that supplies water directly to the conveyance facilities leading to powerhouses is called a "forebay." Many powerhouses also have "afterbay" reservoirs downstream of the tailrace. Afterbays serve to smooth out rapid changes in discharge flow and dampen surges in stream flows that could endanger people or damage environmental resources. In many cases, the afterbay of one powerhouse is also the forebay for the next powerhouse in a series of reservoirs and powerhouses along a stream.

Keeping the State's Electricity System in Balance

Operation of a large electric power grid requires several "ancillary services" from generators in addition to basic energy production. In a large interconnected system such as supplies most of California, the load is constantly changing throughout the day as loads at factories, commercial buildings, farms, and homes are turned on and off at various times. In addition, generators are coming on line, changing output and going off line at various times for various reasons. But despite the complexity of the integrated system, one simple operating rule prevails: Generation output must match the load at all times since there is no reserve storage of electricity in the system. Therefore, adjustment of the total generator output to match the load demand is a continuous process. If the system load is greater than the generation, voltage starts dropping and the system loses speed. If the generators pump more energy into the system than the loads demand, the voltage and the speed of the system will increase. These changes are normally very small for a well operated system and go unnoticed. Daily variances in system speed might put electric clocks a few seconds off at the end of the day. That error is corrected by running the system slightly faster through the night. Provision of generation capability to match system output to load is generally referred to as "ancillary services."

California Independent System Operator (CAISO) grid operations involve dispatching generation to meet loads at every point in time, taking into account the physical properties of the transmission grid. The California system accomplishes this task through two instruments. First, the CAISO directly controls substantial generation within its control area that has been placed under Automatic Generation Control (AGC) through awards in the CAISO's Regulation auctions.[4] Second, the ISO operates a real-time balancing-energy auction, which produces both dispatch instructions to change the generation levels of participating resources, and price signals to participants in the informal, price-taking real-time market.

To maintain reliable grid operations, the CAISO must (1) place sufficient (and appropriately located) generation on AGC, and (2) ensure that there is sufficient participation in the real-time markets to meet the likely contingencies. The two tasks are accomplished jointly through the operation of the CAISO's Ancillary Services (A/S) auctions.

The Ancillary Services Markets have been established by the CAISO to ensure that necessary capacity and operational flexibility are available to maintain reliability of the electric system. The PX and, for the most part, the CAISO, procure energy or ancillary services through auctions. There are five Ancillary Services Markets (both day-ahead and hour-ahead) into which energy producers may bid their generation:

- Regulation “up” — generation that is already up and running (synchronized with the power grid) and can be moved via direct electronic commands by the ISO above the unit’s scheduled output level, to keep system-wide energy supply and energy use in balance (Automatic Generation Control [AGC], or market).
- Regulation “down” — generation that is already up and running (synchronized with the power grid) and can be moved via direct electronic commands by the ISO below the unit’s scheduled output level, to keep system-wide energy supply and energy use in balance (AGC, or market).
- Spinning reserves — unloaded online generation that can be dispatched within ten minutes.
- Non-spinning reserves — unloaded offline generation that can be dispatched within ten minutes.
- Replacement reserves — generation that can begin contributing to the grid within an hour.

Utilities generally have an incentive to bid hydroelectric generation into the market in a way that results in the highest value. The characteristics of a particular facility and the amount of water available at a given time may dictate which, if any, ancillary services can be provided. The ability to provide AGC market services (regulation up/down) is subject to having the specific hardware and control systems that enable remote control of output by the CAISO.

[4] Automatic generation control allows a unit’s power level to be altered every four seconds to follow momentary changes in system load. Electricity supply and demand must be balanced every instant within narrow tolerances to prevent system collapse.

Regulation

The CAISO procures enough upward and downward Regulation to respond to real-time disturbances. Capacity selected in the two auctions (one for each direction, up and down) are paid the market-clearing price, which can vary from zone to zone. In addition, the net energy delivered from Regulation action settled at the relevant real-time ex-post price. The CAISO's initial response to a system imbalance is a balancing set of AGC signals to generators providing Regulation.

Reserves

The CAISO sets its purchases of reserves to secure sufficient real-time supplies to both meet expected loads and to provide an adequate margin for unplanned contingencies. Spinning and Non-Spinning requirements are set in accordance with the WECC Minimum Operating Reserve Criteria, to five percent of expected demand (net that met by firm imports) served by hydro resources, and seven percent of net expected demand served by non-hydro resources, or the largest single contingency. At least half of these reserves must be Spinning. Replacement reserves are purchased based on the CAISO's forecasts of unplanned outages and on the expected draw on the real-time market (taking into account the expected output of unscheduled RMR operations and other sources of uninstructed deviations).

The three A/S reserve services are arrayed in decreasing order of quality based on their technical requirements. Spinning Reserves must be provided by generators that are synchronized to the grid; a unit's Spinning Reserve capacity is limited to that which may be delivered within ten minutes of the CAISO's dispatch instruction. Non-spinning Reserves have the same delivery requirement, but need not be provided by generators that are synchronized to the grid. Replacement Reserve capacity is limited to that which may deliver energy within 60 minutes of dispatch.

Providing ancillary services requires operational flexibility and agility to respond quickly to changes in load either up or down, and to come on line and to full load in a very short time. Spinning reserve requires the capability to economically operate a unit at a very low load synchronized on the system ready to crank-up to full power in a matter of minutes. Non-spinning reserve service may require a unit to come from a cold start to full power in a matter of 10 minutes.

Hydropower Is Key to Balancing the Electricity System

Balancing generation and load is a challenge because most thermal power plants operate best at constant loads and do not respond quickly to changes in demand. To increase load, a conventional steam plant must first increase the fuel flow and the size of the fire in the furnace to make additional steam for delivery to the turbine. This takes time, especially for older steam-drum type units that have a lot of thermal inertia due to the greater mass of their components. Nuclear plants are even less responsive and are generally operated base-loaded at full capacity. Frequent changes in loads in thermal plants also increases thermal stresses in the equipment and may lead to more frequent equipment failures. Bringing a thermal plant from a cold start to full load may take several hours. Nuclear plants may take a day or more to bring to full capacity after a cold shutdown.

The new generation of combustion turbine (CT) driven thermal power plants have faster start-up and response times than conventional steam plants and may compete with hydro in the ancillary services market. However, many of these CTs are combined cycle plants coupled with steam turbines for topping cycles. The steam cycles may slow the response time of these units.

Hydroelectric resources have always provided a significant portion of the state's reserve and load-following needs. For example, up to 75 percent of the Northern California spinning reserves market is served by PG&E's hydropower assets. The current market structure also provides opportunities for hydroelectric facilities to sell products and services other than just energy. In the current market, a hydropower owner has the opportunity to bid and schedule its generation into the energy markets, then to bid and schedule any unloaded capacity into the subsequent Ancillary Services Markets and the Imbalance Energy Market run by the CAISO.

Hydro generating units are especially well suited for providing ancillary services because they can change levels of output very rapidly and move from no-load condition to full power in a matter of a very few minutes. There is no warm-up time and changes in load levels do not thermally stress components to cause equipment failures. The proven reliability of hydro assures that the ancillary service needed will be available when called for by the CAISO.

Memorandum #2
Participation Incentives for Groundwater Recharge from Floodwater Diversion

Prepared by M.Cubed[1]

For Sustainable Conservation

March 2017

PARTICIPATION INCENTIVE METHODS

This memo focuses on ways of incentivizing growers to participate in an on-farm groundwater recharge program, given the financing mechanisms outlined in the previous section. The main factors to consider in creating an effective incentive program are participant selection, price setting, and payment method. These factors are described below. In Appendix A we use this framework to examine several existing incentive programs for fostering environmental benefits.

Selection method

Unlimited Participation—In some types of environmental markets, such as those in Emission Reduction Credits, there is no limit on who participates. Participants that meet specific requirements are eligible to participate. In the context of groundwater recharge, participation will be limited by several factors, including the amount of funding available to incentivize participation, and the amount of flood water available for recharge in a given year.

Lottery—In cases where program interest is greater than available funding, a lottery method is a simple and straightforward selection method. If project benefits do not vary across applicants or if for political reasons, program operators do not want to be seen as giving preference to one applicant over another, a lottery approach could be appropriate. In the case of The Nature Conservancy's demand management pilot program on the Colorado River, a lottery system was used in the first year, as a simple, low cost, and politically neutral selection method. In that case, participants were notified that in future program rounds, the selection method may be updated to a more complex, but economically efficient process.

First-come First-served / Queuing—In a first-come first-served selection system, participants are enrolled in the program in the order they apply until the funding or available water for recharge runs out. This type of enrollment is most appropriate when the benefits offered by different participants are uniform. For example, the USDA's Conservation Reserve Program follows this method. Eligibility is limited to specific practices with large environmental benefits,

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so the program foregoes the competitive application process. Advantages of this approach are that the administrative and information costs are low. In the context of a groundwater recharge program, if eligibility can be limited to areas with specific and uniform recharge properties (e.g. certain locations in the basin, soil types, crop types) first-come first-served enrollment could be appropriate

Scored Subsidy--If however, recharge potential varies across potential participants, it will be preferable to enroll those that provide greater recharge capacity first. A scored subsidy approach to enrollment takes into consideration differentiation in the benefit from particular parcels. Scored subsidy programs use indexes or other methods to assign scores for various attributes, with the goal of identifying participants that offer the greatest level of service. For example, in a groundwater recharge program, applicants may be scored on their location in the basin, soil type and crop type to determine which parcels will yield the greatest amount of recharge per acre-foot of flood water. This assumes that the program administrator has information on the relative recharge potential from different parcels, and so has greater information requirements than a first-come first-serve program. Relative to an auction-based mechanism, a scored subsidy program has lower administrative costs and is simpler to implement.

Auction-based—In an auction based enrollment program, enrollment is based not only on the relative value that a participant provides, as in scored subsidy enrollment, but also on the price that a participant is willing to accept to enroll in the program per unit of value they provide. The costs of an auction -based system are higher, but it does allow for the most cost-effective use of program dollars.

In a reverse auction, the sellers bid what they are willing to provide the service or product, and the buyer selects the lowest qualifying bids first. The Nature Conservancy's BirdReturns program to provide temporary wetland habitat for migrating birds in California is an example of a reverse-auction program.[2] The payment to participating farmers are determined by reverse auction, where farmers submit bids of how much they would be willing to accept on a per acre basis to flood their rice fields for a 4, 6 or 8-week period. Program administrators are then able to select participants based on which fields provide the best habitat for specific species as well as bid price.

Price determination

Uniform Price--Under a uniform payment system, participants in the recharge program receive a uniform price per unit of benefit provided. In habitat conservation programs this may be on a per-acre basis. In a groundwater recharge program, the price would more likely be based on the acre-feet of water placed on a field or the amount of water likely recharged to the aquifer as a result of on-farm recharge. The main benefit of this approach is that administrative costs are low. However, the price would need to be set to incentivize sufficient interest in the

[2] Robbins, Jim, 2014. "Paying Farmers to Welcome Birds," *The New York Times,* https://www.nytimes.com/2014/04/15/science/paying-farmers-to-welcome-birds.html, April 14.

program without overpaying participants. Because of this, a uniform price scheme is not likely to procure the maximum value per dollar spent.

Pajaro Valley Water Management Agency's Net Recharge Metering program is an example of a uniform price recharge program. It offers participants a rebate on groundwater pumping fees per acre-foot of water captured as inflows from on-farm stormwater collection projects, net of the infiltration that would have occurred without the project. In a program using flood releases for on-farm recharge the price could be based on the amount of water diverted to farms. Program designers will also have to consider using a discount factor, discussed more below. In the Pajaro Valley's Net Recharge Metering program, they use a discount factor of 50% because not all water that infiltrates goes toward recharging the aquifer and not all recharge is recoverable.

Scored Subsidy—Scored subsidy-based price setting would allow some price differentiation based on recharge rates. For example, if location A results in more water recharged to aquifers compared to location B, given the same amount of water applied to fields, then it can receive a larger payment per unit of water diverted onto fields. Once again, scored subsidy programs, like uniform payment programs are likely to have lower administrative costs than auction-based mechanisms.

Reverse Auctions --Reverse auctions are an alternative to a uniform participation payment program, that promise to procure on-farm recharge opportunities at the highest return on investment. Rather than paying a uniform price to growers willing to participate in an on-farm recharge program, a reverse auction solicits bids for the lowest payment that farmers would require to participate in on-farm recharge. This gives interested participants an incentive to bid the lowest amount they are willing to accept in order to be chosen for the program, and allows program administrators to evaluate the price against the recharge benefit. This addresses the potential problem of a uniform price system setting the price too low or too high. A reverse auction can be particularly cost-effective if there is variation in benefits from different parcels. For instance, if recharge benefits vary by location in the basin, type of soil, or some other factor, program administrators can select participants based on a cost-benefit ranking or a more complex algorithm.

The Nature Conservancy's BirdReturns program is an example of a reverse auction in agri-environmental practices. In its first year, approximately 40 farmers participated, flooding approximately 10,000 acres of rise farmland. Participating in the program poses a risk for farmers, whose flooded fields may not dry out in time for planting for the following season. The reverse auction allows them to consider this risk in their bid decision and be compensated accordingly.

There is evidence that reverse-auction enrollment programs can be more cost-effective than other approaches. A modelling exercise looking at the Sun Valley Watershed in Los Angeles County found that conducting a reverse auction to implement stormwater capture Best Management Practices (BMPs), like porous pavement and infiltration pits, would be more cost effective than investing in centralized, large-scale stormwater capture.[3] That study reveals a tradeoff between optimal placement and size of the BMPs and the lower program costs of enrolling BMPs by competitive bid. There is evidence that that tradeoff nearly always favors enrollment by competitive bidding to achieve optimal cost-effectiveness.[4]

Because reverse auctions are more complex mechanisms there are more considerations to account for when structuring a successful program. First, an auction mechanism can be administratively burdensome and more costly to operate than a more straightforward uniform payment program. Additionally, generating sufficient participation in an auction is a key requirement.

However, high transaction costs on the part of applicants can reduce participation in agri-environmental reverse auction programs and result in less cost-effective auction results. According to surveys from the Tiffin River Watershed auction,[5] which held reverse auctions for Best Management Practices on agricultural lands to improve water quality in the Tiffin River and Lake Erie, three key barriers to participation were lack of knowledge about the auction (30%), perceived ineligibility to submit a bid (26%), and a lack of interest in submitting a bid (44%). Among individuals who knew about the auction and felt eligible, participants were still deterred because the auction seemed complicated (38%), they did not want to adopt any of the three eligible practices (26%), land rental agreements complicated participation (28%), and they perceived a low probability of bid acceptance (18%). Lowering perceived transaction costs and increasing interest in a reverse auction requires familiarizing potential bidders with the auction process through straightforward advertising, information sessions, and working with leaders in the community to spread the word about the program. Steps like building awareness, educating and communicating with the eligible landowners, streamlining the bidding process and reducing the time and effort required to participate will reduce perceived transaction costs and increase participation in a reverse auction, resulting in more cost-effective programs.[6]

Discount Factor—Applying a discount factor (also known as an "offset ratio" or "trading ratio") to the amount of recharge credited to participants in a groundwater recharge program can strengthen the integrity of the program or give preference to certain participants. First, a discount factor can be used to offset the uncertainty associated with groundwater recharge. For example, Pajaro Valley Water Management Agency uses a discount factor of 50% to account for the fact that not all infiltration becomes recharge and not all recharge is recoverable. The exact percentage of recoverable recharge is not known, but applying the

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[3] Baerenklau, K.A., et al. 2008. "Capturing Urban Stormwater Runoff: A Decentralized Market-Based Alternative." *Policy Matters*, Volume 2, Issue 3.

[4] Cutter, W.B., et al. 2008. "Costs and benefits of capturing urban runoff with competitive bidding for decentralized best management practices." *Water Resources Research.* http://onlinelibrary.wiley.com/doi/10.1029/2007WR006343/full

[5] Palm-Forster, L.H., et al. Too Burdensome to Bid: Transaction Costs and Pay-for-Performance Conservation. American Journal of Agricultural Economics. 98(5): 1314–1333.

[6] Whitten, S.M., A. Reeson, J. Windle, and J. Rolfe. 2013. Designing Conservation Tenders to Support Landholder Participation: A Framework and Case Study Assessment. Ecosystem Services 6: 82–92.

discount factor assures that the program makes a conservative estimate of its impact on groundwater levels. This may be particularly important if payment is made in the form of groundwater rights rather than cash or a rebate. Similar discount factors are used in groundwater banking, where a discount factor is applied to account for water losses. In criteria pollutant offset markets, a discount factor can safeguard against risk and uncertainties associated with measurement, non-additionality, and other factors, and strengthen environmental integrity. Under the Federal New Source Review, discount ratios apply to Emission Reduction Credit use in some Air Quality Management Districts and applications. For instance, in the South Coast Air Quality Management District an offset ratio of 1.2-to-1.0 applies to Emission Reduction Credit offsets.[7] Among water-based pollution abatement programs, offset and trading ratios are often greater than 1-to-1, ranging from 1.1-to-1 in Pennsylvania's Nutrient Credit Trading Program to 4-to-1 in the South Nation River Watershed Trading Program.[8]

Settlement and Payment

Cash—the most straight-forward payment method is a cash payment to farmers. This requires that the cash to support the program is already available. This kind of program may be most popular with farmers to offset the costs participating in on-farm recharge.

Fee rebate—Rather than paying cash, a recharge program could offer in cooperation with the local GSA a rebate on groundwater pumping fees, assuming that such fees are already in place. This is the approach used by the Pajaro Valley Water Management Agency in its Net Groundwater Metering program. The benefit of a rebate is that it does not require funding to be in place prior to the program, since the rebate applies to pumping fees in the following year. However, this approach may be less popular with farmers who incur real costs associated with an on-farm recharge program.

Pumping allocations or other tradeable credits—An alternative to monetary compensation for participating in a groundwater recharge program is compensating participants with additional groundwater allocations or rights. This assumes that a system of groundwater rights has already been implemented by the local GSA. On the plus side, it does not require cash on hand to fund the program, however it does require particular attention to the discount factor applied to infiltration amounts to ensure that the program maintains a net benefit to groundwater levels. Compensation in water rights will be most appropriate if there are established institutions for selling or banking these rights.

[7] SCAQMD, "Emission Reduction Credits," http://www.aqmd.gov/home/permits/emission-reduction-credits, retrieved January 2017.

[8] Fisher-Vanden, K., S. Olmstead. 2013. Moving Pollution Trading from Air to Water: Potential, Problems, and Prognosis. Journal of Economic Perspectives—Volume 27, Number 1, Winter 2013.

Other considerations in designing incentive payments for GW recharge

Two-stage enrollment—Since a groundwater recharge program using floodwater releases would only operate in wet years, a two-stage enrollment program may be appropriate. Under a two-stage process, program operators would first elicit offers and pay landowners for the option to recharge groundwater in a given timeframe. In a dry year where no floodwater releases are made, the program loses only a small amount of money. Full recharge payments only take place in the case of a wet year.

The benefit of using a two-stage enrollment structure is that potential enrollees are already lined up and ready to participate well before floodwater releases take place, smoothing the administrative process. An example of this type of program is the 1994 State Water Bank. After experimenting with water banking during statewide drought in 1991 and 1992, the California Department of Water Resources used a two-stage enrollment program in preparing for the 1994 banking program. Interested participants could purchase an option at $3.50 per AF to be exercised in March if necessary. The full offer price of $40 would then be paid only if the water purchase actually took place. In the case of the 1994 water bank, above average year runoff meant that the water bank was never implemented. In 2003, MWDSC set up a similar option program with Glenn-Colusa Irrigation District, in which a subset of the options was exercised to purchase water for transfer. Such a two-stage enrollment structure remains a promising way to secure early program participation.

Transaction costs—Transaction costs arise from the several steps involved in consummating any kind of economic transaction. This begins with the “search” process in which potential partners look scan for others who are willing to transact. Even in what appears to be one-way transactions, the parties will have costs in finding funding or developing responses to a proposed incentive. The “negotiation” process ranges from accepting a list price to participating in an auction to bargaining. The “monitoring and implementation” step can be the most costly and last for the life of good or service transacted. Transaction costs are often hidden, not showing up in the revealed price or tax for the transaction.

Transaction costs may be higher for auction programs than for simpler selection methods, but the list in Table 1 provides an example of incremental costs that accrue. For the Washington Water Trust 2015 Dungeness Dry-Year Leasing Program and Reverse Auction, described in Appendix A, it identified 14 tasks falling under three categories of transaction costs, Search, Negotiation, and Monitoring and Implementation.[9] Although the Dungeness Dry-Year Leasing Program is a reverse auction program to procure forbearance agreements from river rights holders, the transaction cost tasks are likely to be similar for a program to enroll landowners in an on-farm recharge program.

[9] Alex Bennett, Lillian Burns, Adriel Leon, Martin Merz, Patricia Song. “Factors Influencing the Expansion of Environmental Water Markets.” Bren School of Environmental Science and Management. http://www.esm.ucsb.edu/research/2016Group_Projects/documents/BrenProject_EnvMarkets_FinalReport.pdf. March, 2016.

Table 1. Example Breakdown of Transaction Costs

Transaction Cost Category	Transaction Cost Category Task	% of Total time (Washington Water Trust)
Search	Fundraising and Grand Writing	6.0%
Search	Planning and strategizing for auction	7.2%
Search	Marketing Campaign	7.2%
Search	Sent out offer forms	10.8%
Search	Landowner Outreach	10.8%
Negotiation	Process Offers Received	14.5%
Negotiation	Due diligence	10.8%
Negotiation	Draft and sign contracts	14.5%
Negotiation	Mapping for contracts	8.4%
Monitoring and Implementation	Fill out lease applications	0%
Monitoring and Implementation	Get signature on lease application	0%
Monitoring and Implementation	Visual Monitoring 3 times	8.4%
Monitoring and Implementation	Prepare invoice, issue checks	2.4%
Monitoring and Implementation	Phone call and follow-up survey to participants	2.4%

Monitoring requirements—Monitoring requirements will depend on how the program and program payments are structured, with different payment structures requiring different monitoring practices. For example, payments based on acres of fields enrolled may require on-site inspection to confirm that participants are meeting all requirements of the program. Payments linked to the amount of water diverted onto fields or the amount of water recharged may require other monitoring equipment. When designing how payments will be calculated, program operators should consider potential monitoring requirements.

Market requirements—A well-functioning market in groundwater rights or a system of banking groundwater rights may be a pre-requisite for compensating participants with payment in additional groundwater water rights. Otherwise farmers run the risk of being stranded with additional water rights that they cannot use in a given year. An outline of how to evaluate these programs is in Appendix B.

Land rental complications—Land rental complications have been cited as a reason for reduced participation in agri-environmental best practices auctions. If the decision to participate in a recharge program depends on first identifying the appropriate decision maker, and then the decision-maker coordinating with another manager, this may increase the transaction costs of participation and deter some operators from applying. Program operators should be mindful of how many parcels in the basin are rented and how this might impact participation.

APPENDIX A: EXAMPLE PROGRAMS

This section outlines several example programs that use enrollment incentives to encourage practices that result in environmental benefits. We use the framework established in the previous section to understand these programs. Table A-1 summarizes the selection, price, and payment approach used in each program.

Table A-1. Summary of enrollment programs

	Selection					Price					Payment		
	Unlimited	Lottery	First-come first-served	Scored	Auction	Uniform	Scored	Reverse Auction	Market-determined	Discount Factor	Cash / reimbursement	Fee Rebate	Water rights / tradeable credit
PVWD Net Recharge Metering				X*		X				X		X	
TNC BirdReturns					X			X			X		
Tiffin Watershed BMP Reverse Auction					X			X			X		
Washington Water Trust Reverse Auction					X			X			X		
Department of Energy and Environment Stormwater Retention Credit Trading Program	X					X			X				X
TNC Colorado River demand management program		X				X					X		
Verde River Exchange Water Offset Program	X								X		X		
Emission Reduction Credits	X					X			X				X
USDA Conservation Reserve Program--Continuous Enrollment			X				X**			X	X		

	Selection					Price					Payment		
	Unlimited	Lottery	First-come first-served	Scored	Auction	Uniform	Scored	Reverse Auction	Market-determined	Discount Factor	Cash / reimbursement	Fee Rebate	Water rights / tradeable credit
USDA Conservation Reserve Program--General Enrollment				X			X**			X	X		
Wildfire Mitigation Programs			X	X		X					X		

** For the initial pilot program, participants will be identified on an individual basis. Though not an established scoring system, this likely involves weighting a range of factors, similar to a scored subsidy.*

***rental payments do vary so they are not uniform, but they vary by county rental rates*

Pajaro Valley Net Recharge Metering Program

Pajaro Valley Water Management Agency's Net Recharge Metering[10] program is one of the few examples of a program to incentivize groundwater recharge. The program offers agricultural landowners in the valley incentives to collect stormwater runoff to recharge depleted aquifers. This kind of distributed stormwater collection is parallel to distributed generation in electricity markets. The program is starting on a pilot basis to 8 to 10 project sites that can collect at least 100 acre-feet of water per year and implementing one or two sites per year. Larger ranches have the most potential to capture large amounts of rainwater and so are being targeted for the first round of projects. Incentives are provided in the form of rebates on the participant's pumping fees in the following year (PVWMA is a special acts district formed to reduce groundwater overdraft. They charge an augmentation charge to all well users). The rebate is calculated as 50% of the augmentation charge per acre-foot of stormwater recharged on a property. They use 50% to account for the fact that not all water that infiltrates as stormwater becomes recharge and not all recharge is recoverable. The rebate provides an incentive to participate in the program even though there may be operations and maintenance costs associated with projects. A third-party certifier will assist PVWMA in identifying sites, raising funds, designing stormwater capture systems, permitting, and construction, as well as monitoring and evaluation. The rebate will apply only to additional water recharged from the project (i.e. total recharge less incidental recharge that would have

[10] http://pvwater.org/media-room/news-releases/2016/Release1601-PV%20Water%20Launches%20Landmark%20Groundwater%20Rebate%20.pdf

occurred without the project). PVWMA will publicize the program and make an annual call for statements of interest, which will be evaluated by the third-party certifier. Funding for project installation will be raised externally through grants and other means.

TNC BirdReturns Program

The Nature Conservancy's BirdReturns program uses reverse auctions to identify California farmers willing to create temporary wetland habitat by flooding their fields during February and March—the peak of bird migrations.[11] The program uses crowd-source data from birdwatchers to identify and prioritize networks of habitat needed by bird species. Participation and price are determined by reverse auction, where farmers submit bids of how much they would be willing to accept on a per acre basis to flood their rice fields for a 4, 6 or 8-week period. Program administrators were then able to select participants based on which fields provided the best habitat for specific species as well as bid price. In its first year, approximately 40 farmers participated, flooding approximately 10,000 acres of rise farmland. Participating in the program poses a risk for farmers, whose flood may not dry out in time for planting for the following season. The reverse auction allows them to consider this risk in their bid decision. Migratory bird protection can be likened to another 'crop' income, with payments to farmers made in cash.

Tiffin Watershed Water Quality BMP Program

Another example is a 2014 reverse auction in two Ohio Counties to allocate payments for applying best management practices (BMPs) to reduce agricultural phosphorus runoff in the Tiffin River Watershed. Agricultural phosphorus runoff has been identified as a primary cause of harmful algal blooms in Lake Erie. There were three eligible BMPs allowed in the auction—using cover crop, filter strips, and subsurface drainage control structures. Of approximately 1000 landowners targeted, 36 submitted bids. Bids were ranked based on the cost per pound of reducing bioavailable phosphorus. With only a small portion of farmers in the watershed submitting bits the auction did not result in the most cost-effective procurement of phosphorus reduction. Surveys conducted after the auction identified some of the primary reasons for low participation as a lack of knowledge about the BMP auction, perceived ineligibility to submit a bit, and lack of interest in submitting a bid. Among those that knew about the auction and believed they were eligible, the primary barriers were that the auction seemed complicated, they did not want to adopt any of the eligible practices, land rental agreements complicated participation, and they perceived a low probability of bid acceptance. Analyses of this program suggest that when transaction costs or perceived transaction costs of a reverse

[11] http://blog.nature.org/science/2014/08/06/birds-birdreturns-innovative-lands-conservation-science/

auction are high, a well-targeted uniform payment program may perform better in terms of cost-effectiveness.[12]

Washington Water Trust Dungeness Dry-Year Leasing Program Reverse Auction

In critically dry years, the Washington Water Trust holds a reverse auction to lease agricultural water rights to supplement instream flows in the Dungeness River. Bid invitations are sent to senior water rights holders with 10 or more acres of irrigation. Bidders must demonstrate beneficial water use in the past 5 years, and be willing to fallow at least 5 acres of irrigated land through the season. To evaluate the bids, auction managers look at the value of flow to instream habitat, seniority of rights, distance upstream from the confluence, as well as price. Bid invitations are sent out in late March, and bidders are notified of the outcome by late April. Lease payments are made at the end of the irrigation season. Program managers may hold multiple rounds open only to first-round bidders if the budget is not spent in the first round. Washington Water trust sets a reserve price that may also be adjusted in subsequent rounds.

Department of Energy and Environment (DOEE) Stormwater Retention Credit Trading Program

The District of Columbia's Stormwater Retention Credit Trading program provides incentives to install rain gardens, green roofs, and other stormwater retention infrastructure to local participants. Participants typically complete a DOEE-approved Stormwater Management Plan, and must install infrastructure following the Department's Stormwater Management Guidebook. By doing so, participants in the program generate Stormwater Retention Credits (SRC) that can be sold in an open market. Developers can purchase SRCs to meet their stormwater retention requirements. An online clearinghouse provides information on available SRCs, asking prices, final sale prices from recent transactions, and interested buyers.

The Nature Conservancy Colorado River demand management programs

The Nature Conservancy has worked in irrigation districts on the upper Colorado River and Grand Valley to implement two pilot demand management programs. The programs were implemented through local irrigation districts and designed according to local conditions. In the Grand Valley, TNC supported the Grand Valley Water Users Association to pilot a water bank program. Participants were selected by a lottery system, which was simple to implement and politically preferable for the local districts and paid a fixed price established by GCWUA early in the process. On the upper Colorado River, the program had $2 million of funding and received $7 million worth of project applications. Participants were hand-selected by the Upper Colorado River Commission to meet the first-year goal of ensuring a diversity of project types as well as

[12] https://www.econ.iastate.edu/files/events/files/palm-forsteretal-tooburdensometobid-ajae2016inpress.pdf

geographic diversity. In future program rounds the selection method may move toward a reverse auction or other selection method.

Verde River Exchange Water Offset Program

Friends of Verde River Greenway, in the Verde Valley of Arizona have initiated a pilot program to connect willing buyers and sellers of Water Offset Credits in the Verde Valley project area. Offsets can be created on an annual basis by fallowing agricultural land. Other local water users can purchase the Water Offset Credits to "offset" their own water use in the valley. Offset buyers are not entitled to additional water use as the offset credits do not represent actual water use rights. Credits are aimed at local businesses, farms, or families that are interested in supporting the effort to reduce overdraft and create more instream flows in the Verde River. Friends of Verde River Greenway is working with the Bonneville Environmental Foundation to register and track offset credits. In 2016, the program had two participants in its pilot program as buyers of offset credits.

Emissions Reductions Credits

Emissions Reduction Credits (ERCs) are issued when a source of air pollution shuts down or decreases emissions, and can be traded and banked to meet New Source Review requirements under the California Clean Air Act. New sources of emissions must offset their emissions based on set offset rations. Offset ratios range from 1.0 to 1.2, meaning that new sources must purchase 1.2 times the emission amount in ERCs. To qualify as an ERC, offsets must be surplus to any federal, state or local laws or regulations, and must be real, enforceable, quantifiable and permanent. However, since compensation for reducing emissions is in the form of a tradeable offset, there is no limit on participation, as long as the reductions meet established criteria. The price of an ERC is set by the owner and varies depending on location and pollutant. New sources of emissions may be required to obtain offsets in the form of ERCs to mitigate emissions that result after applying the best available control technology. The incentive to reduce emissions depends on the existence of healthy market and banking systems so that ERCs can be sold if not needed directly and immediately by the participant.

USDA Conservation Reserve Program—Continuous Enrollment

The USDA's Conservation Reserve Program (CRP) is a voluntary program that contracts with farmers to implement practices that yield conservation benefits. CRP contracts range from 10 to 15 years to take land out of production and establish vegetative species to control soil erosion, improve water quality and provide habitat in exchange for rental payments and cost-share assistance. Under continuous enrollment, offers to participate are automatically accepted on a first-come first-served basis as long as they meet certain eligibility requirements. Eligibility requirements include a minimum 12-month land tenure, land must be working cropland in four of the previous 6 crop years, and the land must be suitable for any of the eligible conservation practices, which include riparian buffers, filter strips, pollinator habitat, and salt tolerant vegetation, among others. The Farm Service Agency offers rental payments and cost-share assistance to participants. Rental payments are variable, based on relative productivity of the soils in each county and the average dry-land cash rent. Cost-share is also available for 50% of the cost of establishing the practice.

USDA Conservation Reserve Program—General Enrollment

Unlike continuous enrollment, general enrollment in the CRP is a competitive application process. General CRP sign-ups are not held on a fixed schedule but are announced periodically by the Secretary of Agriculture. Applicants are scored according to an Environmental Benefit Index (EBI), which takes account of soil erosion prevention, water quality improvement, wildlife benefits, air quality benefits, and cost. The FSA ranks all applicants across the country by the EBI, determines an EBI threshold and offers enrollment to all offers that scored above the threshold. Incentive payments include both rent and cost-share payments.

Wildfire mitigation incentive programs

Programs to encourage individuals to mitigate their private risk of wildfire are typically undertaken at the state, county or local level and can vary significantly. However, considering this category of incentive programs in general may be instructive to creating an incentive program for groundwater recharge. In general, these programs reimburse residents for a percentage of expenditures made to reduce their wildfire risk, up to a maximum value, typically ranging from several hundred to a couple thousand dollars. They often also provide advisory services, information, and inspections to participating residents. Interest in these programs is usually greater than available funding, so participants are selected on a first-com, first-served, or scored basis.

APPENDIX B: EVALUATING INCENTIVE MECHANISM PERFORMANCE

Different incentive mechanisms might be evaluated across a range of criteria for effectiveness and equity. Incentive goals represent what regulators, participants and interested third parties wish to achieve by adopting these mechanisms. Measures of success are the objectives an analyst can use to communicate to policymakers the goals attained by an incentive-based program. Institutional proficiency are the traits most likely to lead to a successful incentive program. This analytic framework can serve as a roadmap for an analyst in assessing these incentive proposals.

The Organisation for Economic Co-ordination and Development (OECD) proposed one set of criteria for evaluating incentive programs, such as tradeable permits or rights, in that they should achieve economic efficiency, provide effective environmental protection, be politically acceptable and supportable, provide administrative ease for the regulatory agency, and achieve equity goals.[13] The measure of an incentive program's success depends on the relationship of price or tax to marginal value of product from the resource or environmental factor measured as an input being traded, the volume of transactions, the relative price stability and spread within the program, the distributional impacts from markets' actions, and whether the stated goals by the regulatory agency were achieved. An "efficient" market achieves all beneficial transactions while reflecting all social values by internalizing the benefits and costs associated with using a resource.

[13] OECD, "Recommendation of the Council on the Use of Economic Instruments in Environmental Policy," http://acts.oecd.org/Instruments/ShowInstrumentView.aspx?InstrumentID=41&InstrumentPID=38&Lang=en, January 31, 1991.

Memorandum #3
Potential Financing Mechanisms for Groundwater Recharge from Floodwater Diversion

Prepared by M.Cubed[1]

For Sustainable Conservation

March 2017

INTRODUCTION

This memo outlines potential financing mechanisms for groundwater recharge in California's Central Valley. After a brief introduction on how current methods of funding groundwater recharge might be applied to a floodwater diversion program, the body focuses on potential financing options under the Sustainable Groundwater Management Act (SGMA), and possibilities for program beneficiaries and other non-beneficiary private interests to contribute to project financing. Table 1 provides a summary of how the beneficiary categories identified in the previous memo on Benefits and Beneficiaries correspond with potential funding sources. Appendix A provides a more exhaustive list of financing methods along with their institutional, legal, and political feasibility.

Table 1. Financing mechanisms and program beneficiaries

	Financing Mechanisms	Beneficiaries included
Local	Local Pumping Fees	Local Ag Operators, Local Municipal Water Providers, Local Agricultural Water Providers, Private Well Users
	Local Groundwater Banking and Trading	Local Ag Operators, Local Municipal Water Providers, Local Agricultural Water Providers, Private Well Users
Upstream	Water Supply Reservoirs Payment	Upstream Flood Protection Agencies, Surface Water Project Customers
	Hydropower Payment	Hydropower Owners and Operators
Downstream	Flood Protection Fees	Downstream Commercial and Residential Property Owners, Downstream Agricultural Operators, Infrastructure Owners and End Users

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	Financing Mechanisms	Beneficiaries included
	Ecosystem Payments	Downstream Ecosystem
Statewide / External	Non-Local Groundwater Banking and Trading	
	California Climate Investment Funding--SALC Program	
	Private Investment (e.g. Environmental Bonds)	

CURRENT GW RECHARGE REGULATION

Prior to SGMA, the groundwater regulations that are currently in the early stages of implementation in California, there has been little consistent oversight of groundwater resources in the state. Such use has been governed by undefined "correlative" rights and outside the jurisdiction of the State Water Resources Control Board.

However, a small percentage of groundwater basins in the state have been managed under special oversight authority—either by districts created by a special act of state legislature or in basins that have undergone adjudication. There are currently 14 Special Act Districts and 22 adjudicated basins in California[2] that have groundwater management authority. A handful of special act districts charge Groundwater Pumping Fees[3] per acre-foot of water extracted from the basin, including Coachella Valley Water District, Desert Water Agency, Orange County Water District, and Santa Clara Valley Water District. Some management entities in adjudicated basins like Chino Basin and Mojave Basin in Southern California also charge replenishment fees for groundwater extraction to fund local groundwater replenishment programs.

In addition, in a number of adjudicated basins, groundwater pumping rights are transferable and active trading takes place among water users, with the management agency responsible for maintaining the overall cap on groundwater extraction.

POTENTIAL LOCAL FUNDING MECHANISMS

This section contains a description of several funding mechanisms that have the most promise for funding groundwater recharge in the Central Valley. They are a subset of a more exhaustive list of funding mechanisms, that have been culled to include those with the most potential, based on legal, institutional, and political constraints. A full list of possible financing

[2] https://californiawaterblog.com/2014/04/03/funding-sustainable-groundwater-management-in-california/

[3] It has been an ongoing question as whether Proposition 218 applies to groundwater pumping fees. The proposition would require 2/3 voter approval. The key issue is whether pumping fees are tied to property or to the activity of pumping.

mechanisms is included in Appendix A, along with the various considerations associated with each.

Pumping Regulation under SGMA

California's Sustainable Groundwater Management Act (SGMA) created Groundwater Sustainability Agencies (GSAs) responsible for implementing sustainable groundwater management practices in their basins. SGMA was enacted in 2014 to bring groundwater basins identified as overdrafted into sustainable balances of recharge and use. Local agencies, including counties and water agencies, are given until June 30, 2017 to form GSAs. The GSAs then have until 2020 for critically overdrafted, and 2022 for other basins, to develop Groundwater Sustainability Plans (GSP) to bring each aquifer into balance over 20 years. Many solutions have been discussed, but most likely limits on pumping will be imposed in most basins.

Local Pumping Fees

It also gives these agencies the authority to impose fees on groundwater use, providing a new revenue stream to pay for groundwater recharge. Under the same legislation, GSAs have authority to impose fixed fees and fees on a per acre-foot basis, including fees based on the quantity of groundwater produced, the year in which the production of groundwater commenced, and impacts to the basin. GSAs are also authorized to collect penalties from groundwater users for over-extraction.

Existing Special Act Districts and Adjudicated Basins can serve as models for how to structure these fees based on location, type of user, and use beyond a certain allocation. Following are some examples of how districts in California currently structure fee programs to fund groundwater replenishment.

- Coachella Valley Water District (CVWD) charges a Replenishment Assessment Charge (RAC) to partially meet the cost of groundwater replenishment in its district. Because the three subbasins in the district have their own set of costs and benefits of replenishment, there are three separate RACS. In all three subbasins, the RAC applies to all private and public well owners who pump more than 25 acre-feet of water per year. In 2016 the RAC ranged from $66 per acre-foot in the East Whitewater River Subbasin, to $123.20 and 128.80 per acre-foot in the district's West Whitewater River and Mission Creek subbasins. CVWD undertakes an annual engineering analysis of groundwater to set RACs, which vary annually and have increased in recent years by 2%-30% annually in different years and subbasins.[4]

- Orange County Water District (OCWD) charges a per acre-foot Replenishment Assessment (RA) to any retail agency, farmer, business or individual that pumps groundwater in the district (though private individuals that pump less than one acre foot a year pay a flat fee instead). For the 2015-2016 water year, the RA was $322 per acre foot. OCWD also establishes a Basin Pumping Percentage (BPP), based on the portion of projected total water demands that can be met with the sustainable yield of groundwater supplies. Any party that exceeds their allocated BPP must also pay the Basin Equity Assessment designed to make the cost of pumping groundwater the same as the cost of more expensive imported water. In 2015-2016, the BEA was $587 per acre foot.[5]
- Santa Clara Valley Water District uses groundwater production charges that vary by use category and geography. Agricultural users and non-agricultural groundwater fees are different for the District's two groundwater zones. In charge zone W-2, which generally coincides with the Santa Clara Plain, groundwater charges for agricultural users are $23.59 per acre foot, while charges for non-agricultural users are $1,072 per acre foot. In charge zone W-5, which generally covers the Coyote Valley and Llagas Subbasin, groundwater charges on agricultural users are $23.59, and $393.00 on non-agricultural users.

Local Groundwater Banking and Trading

In addition, SGMA authorizes GSAs to establish rules for carrying over unused groundwater allocations from one year to the next, and voluntarily transferring allocations as long as the total extracted in any five-year period is consistent with the groundwater sustainability plan. This potential to establish tradeable groundwater use rights and water markets within the groundwater basin may provide an additional source of revenue, allow for "zero-cost" auctions in which users are compensated directly for transferring allocations, and provide a basis for incentivizing groundwater recharge.

Groundwater banking and trading also provide some flexibility in how participants in a recharge program can be compensated. If groundwater rights are tradeable, then participants do not

[4] Engineer's Report on Water Supply and Replenishment Assessment 016-2017. http://www.cvwd.org/ArchiveCenter/ViewFile/Item/505

[5] "OCWD Establishes 2015-2016 Basin Pumping Percentage and Price," *OCWD Hydrospectives*, http://newsletter.ocwd.com/2015/ReadMore_2015-07_BasinPumpingPercentageAndPrice.aspx

necessarily have to be compensated in cash, but can be compensated in groundwater rights that can subsequently be sold or traded on the market. A market in groundwater rights would relieve the groundwater agency of designing an auction mechanism for program participation. An example of a parallel program design is California's GHG allowance trading under AB 32. Under California's Cap and Trade program, entities can hold emission allowances and trade them on a secondary market to make up allowance shortfalls or profit from surpluses. Similarly groundwater users can trade rights to meet their annual water needs to profit from excess rights beyond their annual water needs.

POTENTIAL DOWNSTREAM FINANCING MECHANISMS

Downstream Flood Protection Fees

The ability to divert large quantities of water from waterways during high flow events and spread that water over large areas, safely away from downstream structures and agricultural interests has real flood risk reduction benefits. With careful analysis and valuation of these risk reduction benefits, downstream interests and flood management agencies may have an interest in contributing to such a program. A 2014 Tetra Tech, Inc. Hydraulic and Hydrology Analysis examined the downstream flood risk reduction benefits of a program to divert 150 cubic feet per second (cfs) and 500 cfs from the Kings River during flood flow conditions. The study found that at 150 cfs the project would reduce expected annual damages (EAD) by $300,000, and at 500cfs, it would reduce EAD by $800,000. In the case of the Tetra Tech project, DWR provided funding through its Flood Protection Corridor Program, which requires demonstration that the project provides sufficient flood mitigation benefits.

Ecosystem Payments

Investment in ecosystem benefits may be available from public agencies or conservation organizations. An example of this kind of investment is The Nature Conservancy's BirdReturns program, which pays farmers to flood their fields at certain times of the year to provide wetland habitat for migrating bird species. Rather than purchase conservation easements, The Nature Conservancy pays farmers to flood their rice fields temporarily, which is much less costly but provides needed habitat during periods of migration. The California Department of Fish and Wildlife is responsible for providing habitat for migrating bird species, along with non-governmental partners such as The Nature Conservancy.

POTENTIAL UPSTREAM FINANCING MECHANISMS

Upstream Water Management

There may be some potential to raise revenue for groundwater recharge through payments from other beneficiaries of groundwater recharge. Local groundwater users will presumably already be paying fees toward groundwater recharge through the GSA, however upstream and downstream beneficiaries may be prime to contribute to groundwater recharge programs in the Central Valley.

Water Supply Reservoir Payments

The option to use flood releases to recharge groundwater can give reservoir managers more flexibility in their water storage decisions. If managers can decrease releases during a storm event, knowing that the risk of large subsequent flows can be diverted to on-farm recharge locations, they can essentially transfer the flood control responsibility from the reservoir to downstream entities, while also extending environmental benefits.[6] This allows reservoirs to reduce the amount of space reserved to capture late winter storm events. Reallocating a portion of this reservoir storage space from flood control to conservation (including hydropower, water supply, and environmental releases) means that the reservoir can generate more storage benefits, particularly in wet years.

Hydropower Payments

In particular, hydropower owners and operators may be willing to pay into a recharge program that allows for increased reservoir storage and hydropower production. The ability to store additional water for use in the summer has numerous benefits, since hydropower is an important part of the electricity grid in California. Hydropower provides flexible, dispatchable resources that helps balance out other intermittent renewable resources such as wind and solar or resources that are more difficult to ramp up to meet peaks in demand. Additional hydropower generation also replaces less efficient gas-fired facilities in the state or out-of-state coal generation with greenhouse gas (GHG)-free emissions. Hydropower also provides ancillary and emergency support services to the grid.[7] Studies modelling flood storage reductions (i.e. reallocating reservoir space from flood control storage to storage for hydropower, water supply, and environmental releases later in the year) on the Mokelumne River have found small

[6] Watts, et al. 2011. "Dam reoperation in an era of climate change." Marine and Freshwater Research 62(3): 321-327. https://www.conservationgateway.org/Documents/Watts%20et%20al%202011%20dam%20reoperation%20in%20an%20era%20of%20climate%20change_0.pdf

[7] See Memorandum 1, Appendix C for a longer discussion of the benefits to hydropower.

improvements in total economic benefit from flood storage reductions of 25% to 50%.[8] Past studies by the USACE also found that reoperation of reservoirs to reduce flood storage space was the form of reoperation with the greatest benefits, without significantly affecting existing flood protection.[9]

STATEWIDE AND EXTERNAL FINANCING MECHANISMS

This class of beneficiaries reside outside of the water basin, but have interests in developing and supporting a floodwater recharge program, either as through use of a related resource such as project water, or economic and ecosystem relationships.

Non-Local Groundwater Banking and Trading

Groundwater banking in particular has the potential to draw funding from non-local sources. Municipal and urban water agencies like San Diego County Water Authority, Metropolitan Water District of Southern California, and Santa Clara County Water Agency make large investments to ensure supply reliability in dry years. These, along with smaller municipal agencies in the Central Valley participate in Water Banking projects in Kern County, where they store supplies in wet years to call on in dry years. Similar agencies may be willing to help fund a groundwater recharge program in exchange for a portion of the groundwater rights in dry years. Currently 11 agencies in Kern County, including the Kern Water Bank and the Arvin-Edison Water Storage District provide groundwater banking either locally or to other water agencies in the Central Valley and Southern California. The oldest of these agencies, the Semitropic Water Storage District uses proceeds from its water banking activities to offset the costs of imported surface water in its service area, thereby relieving pressure on groundwater resources.

Some counties in the Central Valley are constrained by local groundwater ordinances designed to discourage their ability to export groundwater to users outside of the county. These ordinances are in place in Kern, Fresno, Madera, and San Joaquin counties and in some cases also restrict groundwater substitution transfers, and groundwater banking with non-local entities. This means that transfers of groundwater, even by displacing surface water supplies, may remain solely within local basin-level or county-level markets in many cases.

[8] Burley, N.R. 2011. https://watershed.ucdavis.edu/shed/lund/students/BurleyMSThesisSS.pdf

[9] USACE. 1988. "Opportunities for reservoir storage reallocation." Hydrologic Engineering Center, Project Report No. 11.; USACE. 1990. "Modifying reservoir operations to improve capabilities for meeting water supply needs during drought." Research Doc. No. 31 AD-A236 078.

California Climate Investment funding through the Sustainable Agricultural Lands Conservation (SALC) Program

The SALC Program is a component of the Strategic Growth Council's Affordable Housing and Sustainability Program that funds permanent conservation of agricultural land at risk of development. The SALC Program provides funding for the purchase of agricultural conservation easements and the development of agricultural land strategy plans that reduce GHG emissions through the long-term protection of agricultural lands. To qualify for funding land must be able to demonstrate a risk of conversion to residential use. $37.4 million was awarded in August 2016. Funding for the 2016/17 program is anticipated in early 2017. The program is administered by the California Department of Conservation.

Private Investment

There are examples of private entities investing in water entitlements, particularly in arid regions where fresh water for agricultural irrigation is relatively scare. Since decoupling water entitlements from land titles in 2004 and creating a more robust market to facilitate efficient water trading, Australia has seen tens of millions of dollars invested in water entitlements. Holders of water entitlements are allocated a volume of water each year, which can be sold or leased to water users. Investors expect that long-term trends in water availability and demand for the high-value produce of Australia's agricultural industry will results in long term capital growth. In recent years, several large investment funds have been established, aiming to raise hundreds of millions of dollars in water investments.[10] California water markets may need to be further developed before this kind of investment is a real possibility, however the Australian example does raise the possibility of private entities investing in on-farm recharge opportunities in exchange for proceeds from a portion of resulting groundwater rights.

Private entities have successfully invested in groundwater banks when partnered with government agencies. The Kern Water Bank initially was part of the State Water Project, but was transferred to local interests.[11] And CalPERS has joined in investing in one of several water banks in the Antelope Valley.[12] However, private investment going it alone in California have been met with significant hurdles. Cadiz, Inc. has pursued a conjunctive use agreement with

[10] http://www.blueskyfunds.com.au/blue-sky-funds/real-assets/water-entitlements/; http://www.nature.org/newsfeatures/pressreleases/investment-opportunity-helps-balance-water-needs-in-australia.xml;

[11] Lois Henry, "Water districts stuffing Kern River water in every nook and cranny they can," *Bakersfield Californian*, http://www.bakersfield.com/columnists/lois-henry-water-districts-stuffing-kern-river-water-in-every/article_74e65aee-6a36-57cf-8c7e-11e6d41cbf2e.html, March 21, 2017.

[12] Dale Kasler, "Why CalPERS is pouring millions into a Southern California water deal," *Sacramento Bee*, http://www.sacbee.com/news/state/california/water-and-drought/article138540373.html, March 15, 2017

Metropolitan Water District of Southern California (MWDSC) to store Colorado River water along MWDSC's Colorado River Aqueduct, but that effort has been ongoing for almost two decades.[13] In another example, a private company proposed to establish a groundwater bank in Madera in 1996, which prompted that county's groundwater ordinance prohibiting exports based on increased groundwater pumping as discussed above.[14]

An outside investor may be interested in participating in an internal groundwater pumping allocation program. However, no such interest has materialized in canal water delivery trading systems, such as the one used by Westlands Water District.

Environmental Bonds

Environmental Bonds are an innovative financing tool being developed by some conservation organizations. Blue Forest Conservation has developed Forest Resilience Bonds (FRB), which uses private capital to invest in forest restoration projects that make national forests more resilient to climate change impacts. Blue Forest's forest restoration projects clear forest overgrowth, creating fire suppression benefits and watershed benefits that accrue to a variety of public and private beneficiaries, including the US Forest Service, water and electric utilities, private companies, state governments, and insurance companies. Based on an evaluation of the benefits, Blue Forest contracts with participant beneficiaries to provide corresponding annual cashflows back to the bond, providing repayment to initial private investors. Blue Forest is currently developing the tool and carrying out pilots. Partnering with similar organizations that are experienced in implementing environmental bonds could provide a vehicle for funding groundwater recharge through the upstream and downstream beneficiaries.

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[13] "News: New Report Concludes Capacity Readily Available in the Colorado River Aqueduct for Conveying Cadiz Project Water," http://cadizinc.com/2015/06/23/news-new-report-concludes-capacity-readily-available-in-the-colorado-river-aqueduct-for-conveying-cadiz-project-water/, June 23, 2015; Frank Ury, "It's time to build the Cadiz Water Project," *Orange County Register*, http://www.ocregister.com/articles/water-717433-cadiz-project.html, May 31, 2016.

[14] The Natural Heritage Institute. "Designing Successful Groundwater Banking Programs in the Central Valley: Lessons from Experience." http://n-h-i.org/wp-content/uploads/2017/01/Central-Valley_Groundwater_Conj_final.pdf. 2001.

APPENDIX A: MATRIX OF POTENTIAL FINANCING MECHANISMS

	Institutional	Legal						Cost Responsibility & Limits			Stakeholder / Political Support
Funding Mechanism/Groupings	*Implementing entities with legal authority / potential capacity*	Governing statues and/or key restrictions / requirements	Governance approval	Voter composition	Vote requirement	Appeal or protest	Benefit-cost test	*Cost allocation method*	*Revenue capacity*	*Revenue-generating potential, including timing; risks*	*Potential Feasibility/Prospects for Successful Implementation*
Property-related											
Local assessment district	Local	Proposition 218	City/County/ district	Local board	Majority	Weighted by financial obligation	Only special benefits can be assessed. Costs must be reasonably related to special benefits	Benefits-based/Alternative justifiable expenditures	Status quo	Low, unlikely to generate significant new revenues	Existing reclamation districts supported, but not always well funded.
Valley-wide assessment district	Regional	Prop. 218; likely requires implementing legislation	Joint Powers Authority; special legislation	Local board	Majority vote in each jurisdiction	Weighted by financial obligation	Only special benefits can be assessed. Costs must be reasonably related to special benefits	Benefits-based/Alternative justifiable expenditures	Medium	High; five to 10 year development process	Substantial administrative, legal, and political challenges. Rejected by SF Bay Restoration Authority.
State assessment district	State	Possibly triggers Proposition 26. State-created district may be treated as a local assessment which triggers Prop 218.	California Legislature	Legislature	Likely two-thirds vote	Not unless added by statute	Charge must be reasonably related to cost	Benefits-based/Alternative justifiable expenditures	High	High; five to 10 year development process	Substantial administrative, legal, and political challenges.
Incremental tax district (e.g., Mello-Roos)	Local	Prop. 218; typically formed based on property owner consent	Local legislative body	Local voters	Two-thirds vote	No	No	Benefits-based/Alternative justifiable expenditures	Medium	High in geographic areas that are likely to experience significant development	Possible on a geographic-specific basis for new developments.

	Institutional	Legal						Cost Responsibility & Limits			Stakeholder / Political Support
Funding Mechanism/Groupings	*Implementing entities with legal authority / potential capacity*	Governing statues and/or key restrictions / requirements	Governance approval	Voter composition	Vote requirement	Appeal or protest	Benefit-cost test	*Cost allocation method*	*Revenue capacity*	*Revenue-generating potential, including timing; risks*	*Potential Feasibility/Prospects for Successful Implementation*
Parcel/assessed value tax	Local	Proposition 13	Local legislative body; voters	Local voters	Two-thirds vote	No	None	*Taxes can be established independent of cost allocation*	Medium	Medium	Requires effective ballot campaign; not beneficiary-pays based as dictated by parcel, not economic value.
Flood Prevention Fee	State or local	Requires state legislation	California Legislature	Legislature	Majority or two-thirds, depending on outcome of ongoing litigation	Yes, depending on legislation	No	Could be assessed on a per structure basis	Medium	Medium, based on Assembly Bill 29X1, Fire Prevention Fee. More likely to pay for operations and maintenance than capital expenses	Requires similar motivation as Rural Fire Prevention Fee. FPF presents precedential model passed by the Legislature.
Enhanced Infrastructure Financing District	Local	(Replacement of redevelopment districts)	Local legislative body	Local legislative body	Majority	No	No	Based on incremental property tax revenue generated	Medium	Based on incremental property tax revenue generated	Unknown
User Fees											
Water project conveyance fee;	State	Federal/State water contracts; Prop. 26	Legislature; possible contract modification	Legislature	Majority	No	Property use rates tied to fair market value	Proportionate use of facilities /Alternative justifiable expenditures	HIgh	Bay-Delta Finance Plan (2004) proposed that SWP/CVP fund 15% of flood control costs..	Similar to Bay-Delta Financing Plan user fee proposed in 2005, which identified levee financing as one component.
Groundwater pumping fee per acre-foot	GSA	Prop. 218	JPA Board	JPA Board	*To be resolved in pending court cases*	Yes	Only special benefits can be assessed. Costs must be reasonably related to special benefits	Benefits-based/Alternative justifiable expenditures	High	High	

Funding Mechanism/Groupings	Institutional	Legal						Cost Responsibility & Limits			Stakeholder / Political Support
	Implementing entities with legal authority / potential capacity	Governing statues and/or key restrictions / requirements	Governance approval	Voter composition	Vote requirement	Appeal or protest	Benefit-cost test	*Cost allocation method*	*Revenue capacity*	*Revenue-generating potential, including timing; risks*	*Potential Feasibility/Prospects for Successful Implementation*
Groundwater pumping fee per acre-foot	State	Prop. 26, Prop. 218. Matter is in active litigation around the state	California Legislature	Legislature	*To be resolved in pending court cases*	No	Charge must be reasonably related to cost	Proportionate use of facilities /Alternative justifiable expenditures	High	High	
Flood protection fee on downstream infrastructure	State	Prop. 26; requires legislation	California Legislature	Legislature	Majority	No	Charge must be reasonably related to cost	To be determined. Underwriting and allocation of risk.	Medium	Treat as flood insurance for island recovery.	Need to designate a separate agency to enforce and collect.
Impact fees											
Groundwater pumping assessment	State or GSA	Prop. 26	California Legislature	Legislature	Two-thirds	No	Charge must be reasonably related to cost	Proportionate use of facilities /Alternative justifiable expenditures	Medium	Depends on SGMA implementation and ability to measure pumping rates	
Groundwater pumping parcel tax	State or GSA	Prop. 26	California Legislature / Electorate	Legislature	Two-thirds	No	None	*Taxes can be established independent of cost allocation*	Medium	Medium. Dependent on size of parcel tax amount, and properties targeted.	Likely to be strongly opposed by agricultural stakeholders. Probably requires local approval like SF Bay Restoration Fee.
Upstream discharger fee	State or GSA	Prop. 26	California Legislature	Legislature	Majority	No	Charge must be reasonably related to cost	Benefits-based/Alternative justifiable expenditures	Low	Runoff metric basis in Alameda Co FCWCD for benefits assessment. Cost of collection could be significant	Akin to ACFCWCD fee basis. Used with property protection method in SAFCA.

Funding Mechanism/Groupings	**Institutional** *Implementing entities with legal authority / potential capacity*	**Legal** Governing statues and/or key restrictions / requirements	Governance approval	Voter composition	Vote requirement	Appeal or protest	Benefit-cost test	**Cost Responsibility & Limits** *Cost allocation method*	*Revenue capacity*	*Revenue-generating potential, including timing; risks*	**Stakeholder / Political Support** *Potential Feasibility/Prospects for Successful Implementation*
Development impact fees	Local	Prop. 13	City/County	Local board	Majority	No	Nexus: must be reasonably related	Proportionate use of facilities /Alternative justifiable expenditures	Low	Low, other than geographic areas that are likely to experience significant development	Applicable on a geographic-specific basis
Habitat conservation plan (HCP)	Multi-agency	Prop. 13 applies to local impact fees	City/County	Local board	Majority	No	Nexus: must be reasonably related	Proportionate use of facilities /Alternative justifiable expenditures	Medium	Paid by water exporters mostly. Issue of whether ERP covers this already.	SWP/CVP contractors: believe already paying this cost.
Flood control plan akin to HCP (see 20 alternative)	Multi-agency	Prop. 13 applies to local impact fees	City/County	Local board	Majority	No	Charge must be reasonably related to cost	Proportionate use of facilities /Alternative justifiable expenditures	Low	Depending on development paying for flood control mitigation elsewhere in Delta	Requires identifying and quantifying specific upstream benefits.
Repeal of property tax exemption for habitat mitigation for government projects, or require in-lieu payment tied to specific benefit	State	Federal consent to pay charge, waiver of state immunity	California Legislature	Legislature	Majority	NA	None	*Taxes can be established independent of cost allocation*	Medium	May only require Legislature to fund current local assessments on CDFW land. Remove other muni exemptions.	Munis may object as being precedential for other activities. Formal requirement for in-lieu payment may be alternative.
Land trust support	Conservancy	Private action	NGO	NA	NA	NA	NA	NA	Low	Low	Required non-profit sector participation and identifying separate financing source.

	Institutional	Legal						Cost Responsibility & Limits			Stakeholder / Political Support
Funding Mechanism/Groupings	*Implementing entities with legal authority / potential capacity*	Governing statues and/or key restrictions / requirements	Governance approval	Voter composition	Vote requirement	Appeal or protest	Benefit-cost test	*Cost allocation method*	*Revenue capacity*	*Revenue-generating potential, including timing; risks*	*Potential Feasibility/Prospects for Successful Implementation*
Property covenants/set asides in exchange for investment	Private; non-governmental organization	Private action	NGO / negotiated	NA	NA	NA	NA	NA	Low	Low	Needs to be associated with water supply reliability
Levees upgrade fee	Federal; State	Requires Federal/State legislation	California Legislature	Legislature	Two-thirds	No	Charge must be reasonably related	Proportionate use of facilities /Alternative justifiable expenditures	Low	To compensate for adverse effects downstream from higher levees.	Similar to SAFCA and ACFCWCD district-based cost allocation assessments.
CATP Allowance Funds through the Sustainable Agricultural Land Conservation (SALC) Program	State	Statutory (AB 32 et al)	California Legislature	Legislature	Majority	No	[Specified in AB 32]	Not specified	Medium	Dependent on SGC action for eligibility and allocations. Allowance funds decreasing recently.	Competition with other applicants. Would need to include permanent preservation of agricultural land
Public benefits financing tools											
General Fund	State; Local	Requires legislation	California Legislature	Legislature	Majority	No	No	Separable costs / remaining benefits	High	High	
General/revenue bonds	State	Requires legislation; public vote	California Legislature / Electorate	Legislature / state voters	Majority	No	No	Separable costs / remaining benefits	High	High	Episodic issuances, usually tied to a broad range of issues.
Regional financing agency	State	Requires legislation	California Legislature	Legislature	Majority	No	No	Not specified	Medium	Medium, but requires outside contributions.	Akin to Delta Conservancy, and large scale urban flood control agencies.

	Institutional	Legal						Cost Responsibility & Limits			Stakeholder / Political Support
Funding Mechanism/Groupings	*Implementing entities with legal authority / potential capacity*	Governing statues and/or key restrictions / requirements	Governance approval	Voter composition	Vote requirement	Appeal or protest	Benefit-cost test	*Cost allocation method*	*Revenue capacity*	*Revenue-generating potential, including timing; risks*	*Potential Feasibility/Prospects for Successful Implementation*
Sales tax	State/Local	Prop. 26	Voters	State/local voters	Majority	No	None	*Taxes can be established independent of cost allocation*	High	High	Requires effective ballot campaign. Nexus tenuous.
Certificate of Participation	State/Local with private participants	Statutory	Local or State agency	Local board / State agency	Majority	No	No	Not specified	Project specific	Dependent on separate underlying financing source. Needs to be tied to specific projects, as it is leased back. Can avoid a vote on an assessment or a bond.	May have limited applications
Tax dedicated zones, with revenues redirected to Central Valley (e.g. sales; tobacco)	State	Requires legislation; Prop. 26 would apply to a new tax	California Legislature	Legislature	Two-thirds to create new tax obligation	No	No	Not specified	Low	Low	Nexus tenuous.
Agricultural property tax redirection	State	May require California Constitutional amendment	California Legislature	Legislature/ state voters	Majority	No	No	Not specified	Low	Low	Nexus tenuous.

ANALYZING COST EFFECTIVENESS FOR KINGS BASIN FLOOD FLOW RECOVERY

M.Cubed

Updated Report – March, 2016

Introduction

This report summarizes the economic modeling approach and resulting cost estimates for a set of project configurations to capture floodwater in the Kings River Basin for groundwater recharge. The cost models include all infrastructure and operating costs over the lifetime of the project, as well as probable floodwater availability to arrive at estimates of total cost, annualized total cost and total cost per expected acre-foot (AF) per year of groundwater recharge. The remainder of this report outlines specific cost assumptions used in the model and presents results across the set of project configurations for comparison.

Project configurations covered in this analysis include a dedicated recharge basin as well as multiple on-farm recharge set ups—(i) temporary infrastructure, (ii) permanent infrastructure with purchase of a new pump, and (iii) permanent using an existing surface supply or booster pump. Specific assumptions for each of these configurations are outlined in the following section.

The model was initially constructed based on assumptions made in the Summers Engineering report that booster pumps would be required to flood the entire field area. However, based on field interviews with growers Sustainable Conservation determined that pumps may not be necessary to flood the fields. This analysis therefore includes additional scenarios for the temporary and permanent infrastructure cases where no pumps are used and the fields are gravity fed.

The report first describes the underlying assumptions and data for each of the configurations evaluated. Then the costs per acre-foot recovered are calculated for each configuration. These costs are compared to assess the break-even point at which differences in flood flow probabilities favor one configuration over another. These comparisons are shown in three different ways.

Finally the cost estimates presented here are compared to a similar one prepared using data from Terranova Farms for the same configuration. That comparison shows that the Terranova costs are in fact quite comparable with those prepared in this report, ranging between $90 and $120 per acre-foot.

Based on the analysis presented here and using a common flood flow probability of 38%,[1] the cost per acre-foot recovered per year ranges from $60 to $120 per year. The range is narrow

[1] While 38% was used as a common assumption for the entire basin, flood flow availability varies considerably from the east to the west side of the basin. This parameter can be adjusted in the model to look at individual situations.

enough and the uncertainty of construction costs sufficiently large that these costs probably overlap with each other across different settings. Yet notably, the costs are fairly similar with different data sources indicating that a rough estimate of $100 per acre-foot recovered per year is a useful heuristic for planning purposes.[2]

Summary Table: Annualized Cost per Acre-Foot

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
NPV Total Cost per AF per Year	$119	$107	$99	$96	$89	$61

Model Assumptions and Data

This section explains specific parameter assumptions for each project configuration covered in this analysis. Assumptions cover the costs of constructing and operating the project, the size and operating limitations of the project, and probable floodwater flows that are likely to be available for each project.

In general, the model is constructed to allow these assumptions to be changed easily (e.g., field size, infiltration rate, flood flow probability) based on the improved estimates or changes in project design. By searching for the specific assumption outlined below in the 'Parameter Assumptions' portion of the spreadsheet model, and entering a new value in the corresponding cell, users can explore how changes to project assumptions affect overall cost estimates. For ease of use the parameter assumptions that are input directly into the model and may be adjusted are highlighted in yellow in the accompanying Excel spreadsheet. The model is not yet structured to scale infrastructure costs

On-Farm Configuration Assumptions

In the on-farm configurations, infrastructure would be put in place to implement flooding of cropland for groundwater recharge. This set of models uses criteria for typical farms in the Kings River Basin as identified in the Summers Engineering Report for Sustainable Conservation.

1. **Field size**
   Initial calculations have been carried out for the 160-acre field configuration, based on the configurations outlined in the Summers Engineering report.
2. **Desired flood depth**
   This parameter is set at 12 inches, according to the value used in the Summers Engineering Report. This value can be varied directly in the model if desired, however changes to flood depth are accompanied by changes in infrastructure and operating costs (see Table 1 of the Summers Engineering Report) that are not automatically scaled in the model. Therefore making changes to flood depth in the cost model should be done with caution.
3. **Infiltration rate**
   This parameter is set at 3 inches/acre/day but can be varied in the model if desired.
4. **Days to desired flood depth** (12 inches)

[2] See the comparison with Bachand analysis using data from Terranova Farms which arrives at costs in a similar range.

This is calculated based on the infiltration rate and pump rate. The pump rate is held constant at 4.2 inches per day, the rate that would be needed to achieve a 12 inch flood depth in 10 days under the base configuration used in the Summers Engineering Report. The model constrains the total amount of time that fields are flooded to 14 days (the time that has been determined by previous studies to have no detrimental effect on the land). Therefore the 'days to desired flood depth' value is constrained to 14 days minus 'days to drain down to desired flood depth'.

5. **Days to drain down desired flood depth** (12 inches)
   This is calculated based on the infiltration rate. For the 3 inches/acre/day scenario, it takes four days to drain down 12 inches of flood depth. This will vary with changes in the infiltration rate.
6. **Days per cycle**
   Total days per cycle are calculated as the days to desired flood depth and the days to drain down the desired flood depth. In the base case 10 days and 4 days result in a total of 14 days per cycle.
7. **Number of cycles per flood year**
   According to the Summers Engineering Report, an average of 3 cycles can be completed in years that floodwater is available.
8. **Probability of flood flows**
   The probability of flood flows being available in a given year is 38%, based on information in the Summers Engineering report that historically flood water releases on the Kings River have been made in 23 of the last 60 years. This value can be varied to reflect different hydrological data.
9. **Available flood flows per flood year**
   Flood flow assumptions are based largely on assumptions in the Summers Engineering report and are the same for both temporary and permanent configurations. Fields can be flooded up to three times per year, with an infiltration rate of 3 inches per day.[3] Total flood flow capture in years when flood water is available is then calculated as the infiltration rate (3 inches per day) times the area (160 acres), number of days of infiltration (14 days), and the number of cycles (3), or 1,680 acre-feet. With an expected flood water availability probability of 38%, this implies that such a facility would capture an average of 638 acre-feet or four acre-feet per acre over the extended period.
10. **Berm construction**
    Temporary berm construction is assumed to be necessary in both the temporary and permanent configurations and costs are based on assumptions in the Summers Engineering report. Berm construction falls under operating costs, which only take place in flood years. Berm construction cost is assumed to be $1,200. We assume that berms will be constructed from scratch at the beginning of each season when flood flows occur and that approximately one-half of berms will require reconstruction twice throughout the season (once after each of the first two cycles). To simplify these assumptions, we assume that total berm construction occurs twice.
11. **Irrigator Labor**
    These costs are based on assumptions made in the Summers Engineering report. Labor was assumed to be $15/hour (including benefits) and one man-hour of labor is required per acre. The irrigation block refers to the area within the temporary berms constructed

[3] This is equivalent to 0.25 AF per acre per day

in item 10, and is a subdivision of the 160 acre field that would have its own berm and flood water application management. Therefore 3 cycles per year for a 160 acre block amounts to $7,200.

12. **Ripping and Gypsum Costs**
Ripping and Gypsum costs were taken from assumptions made in the Summers Engineering report. These costs were estimated at $80/acre based on actual expense records from a local farm deemed to be representative and take place once per year only in flood years.
13. **Discounted Cash Flows and Net Present Value**
The net present value (NPV) of streams of future costs over 20 years are annualized to an equivalent annual payment using a discount rate of 4.4% from the 10-year average return on assets as reported by the USDA. To compute the cost per acre-foot recovered, the NPV of the annualized cost is divided by NPV of the expected annual flood flows per season, as calculated in assumption #9 above (e.g., 1,680 AF/year * 38% probability).[4]

Temporary Cost Assumptions

In the temporary on-farm configuration, pipe and pump infrastructure is rented, with no permanent construction taking place at the project site.

1. **Infrastructure Costs**
Pump and surface pipe infrastructure rental cost assumptions are taken from the Summers Engineering Report.
2. **Pump Operation**
In the temporary configuration pumps are assumed to be diesel operated. Pump fuel costs are based on current 2015 diesel cost estimates from EIA, converted from $/MMBTU to $/gallon. It is assumed under the temporary configuration that the entire field is fed by pump and that each pump can serve 40 acres, requiring 4 pumps for the entire 160-acre field. The pumps are operated a total of 120 pump-days per flood year (3 cycles * 10 days of pumping * 4 pumps). It is assumed that the pumps operate for 24 hours during the pumping periods. Assuming a 13 HP pump, a fuel consumption rate of 3.27 gal/hr. is calculated. This yields a total pumping fuel cost of $32,423 in the first year of operation.
3. **Gravity Fed**
The gravity-fed case includes all assumptions from the other temporary scenarios, but with zero pumping costs for both infrastructure and operations.
4. **Present Value Calculations**
Annualized costs are calculated by escalating current (2015) cost estimates over the 20-year period, using a cost escalation factor of 2.5% in the case of temporary infrastructure costs, and 2.6% in the case of temporary operating costs (reflecting diesel fuel prices). Escalation rates were derived as weighted averages of the subcomponents of labor, construction and energy prices.[5] The net present value of this stream of future

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[4] This is the same method used to calculate the monthly payment on a home mortgage: the NPV of a house payment divided by the NPV of the years of the term of the loan.

[5] Labor and construction escalation are based on the implied inflation rate in the U.S Treasury TIPS bonds plus 0.5% in real escalation. The diesel fuel price escalation is taken from the U.S. Energy Information Administration's 2014 *Annual Energy Outlook*.

costs is then annualized to an equivalent annual payment using a discount rate of 4.4% from the 10-year average return on assets as reported by the USDA.

Permanent Cost Assumptions

In the permanent on-farm configurations all necessary infrastructure is constructed at the project site rather than rented annually.

1. **Infrastructure Costs**
   Permanent infrastructure costs are taken from the Summers Engineering Report. For the two different permanent configurations—one with purchase of a new pump and one that makes use of an existing pump, infrastructure costs are identical for removing the existing irrigation system, furnishing and installing a 24” canal gate, furnishing and installing PVC pipe and furnishing and installing irrigation valves. However, only the configuration with a new pump purchase includes the cost of the pump, lift pump stands and F&I electrical service and control panel. Under the configuration where an existing pump is used these costs are zero.
2. **Lift Pump Power**
   The permanent configuration model assumes that half of the total acreage uses gravity-fed flood irrigation, while the other half of the total acreage will require pumping water onto the fields. The cost of operating the pump is identical between the existing pump and new pump configurations. As in the temporary cost model, pump energy is calculated as the energy to raise the total volume of water used 10 ft., where the total volume used is calculated as the infiltration rate (3 inches per acre in the base case) times the area (0.5* 160 acres), and number of days of infiltration (14 days total in the base case) over the three cycles.[6] We then apply to this total energy usage an average winter electricity rate based on current PG&E electricity rates for small agricultural users (AG-4). We calculated the winter average electricity rate[7] based on the following parameters and a 21 kW pump. We assume a 60% pump efficiency rate, which can be varied in the model.

Summer usage:	65%
Winter usage:	35%
Summer capacity factor:	45%
Winter capacity factor:	70%

3. **Gravity Fed**
   The gravity-fed case includes all assumptions from the other permanent scenarios, but with zero pumping costs for both infrastructure and operations.

[6] As noted previously, the model can vary the infiltration rate, holding period, flood depth and other parameters to arrive at different values. This analysis is based on one set of parameters provided by one study.

[7] Winter season runs from October 31 to May 1. We assume little on-farm flooding would occur in May because that would impinge on the growing season. PG&E may shorten the season to run from June 1 to September 30.

4. **Present Value Calculations**
   Annualized costs are calculated in a similar manner as temporary costs above from weighted averages, using a cost escalation factor of 2.5% and 1.9% for infrastructure costs and operating costs (reflecting electricity prices), respectively.[8] These escalation factors differ from those used in the temporary configuration because the temporary configuration operates on diesel fuel while the permanent configurations operate on electricity. The prices of these two inputs are expected to escalate at different rates.

Dedicated Basin Configuration Assumptions

The dedicated basin configuration consists of permanent construction of a groundwater recharge basin for the sole purpose of recharging excess floodwaters. Once again the model is constructed to allow assumptions to be changed easily (e.g., field size, infiltration rate, flood flow probability, etc.). The model is not yet structured to scale infrastructure costs.

1. **Basin Size**
   This analysis relies on two projects. The first is the recently completed Laguna Irrigation District Groundwater Recharge Project 168. The gross site acreage used is 52 acres, and the basin floor acreage used for actual recharge activity is 41 acres. The second is the Tulare Irrigation District's Swall Basin. The footprint is 135 acres but the recharge portion was not provided. The costs per acre are close for these projects ($132 for TID and $146 for LID), so the average of these costs are used here to compare to the other configurations..
2. **Flood Flow Probability and Availability Assumptions**
   Flood flow assumptions are based largely on the project description document for LID; we did not have similar parameters for TID so we assumed similar conditions. According to the study by Provost and Pritchard, in wet years floodwater is available 121 days on average. Based on the same study, floodwater is available in 35% of years based on historical data from 1954 to 2011. However, for ease of comparison the initial model uses a 38% probability of flood flows according to the assumptions for the on-farm configuration. Note that this probability can be varied in the model.
   An infiltration rate of 18 inches per acre per day is identified in the project description. In order to be conservative and based on advice from Sustainable Conservation, we use an infiltration rate of 6 inches per acre per day[9], which is based on average percolation rates for Fresno Irrigation District basin projects. Total flood flows are then calculated as 6 inches per day infiltration rate * 41 acres basin floor * 121 days, or 2,481 AF per flood year. Based on a 38% chance of any given year being a wet year, this yields expected flood flows per year of 951 AF.
3. **Construction Costs**
   Construction Costs are actual costs provided for each project. Where unit costs are appropriate and available from the engineering report, these are included in the cost estimation model and can be varied in the model as necessary.
4. **Operating Costs**

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[8] Labor and construction escalation are based on the implied inflation rate in the U.S Treasury TIPS bonds plus 0.5% in real escalation. The electricity rate forecast is taken from the California Energy Commission's *California Energy Demand 2014-2024*.

[9] This is equivalent to 0.5 AF/acre/day.

Operating costs are based on historical basin operation costs in Laguna Irrigation District and applied to the TID basin as well. Operating costs include mechanical weed control, chemical weed control, earthwork, and operations. Historical costs across six basins and gross basin acreage were used to calculate an average historical cost per acre. For all cost categories except for operations, all six basins were used to calculate average costs. However, for operations, costs vary significantly depending on whether the basin is operated annually as a regulation basin (based on average 90 day water run) or used only during excess water events (based on 30 days average). Operating costs used in the model are the average across those basins used only during excess water events as these are more similar to the way the Laguna ID basin would be operated.

5. **Gross Site Acreage**
   Operating costs are calculated on a per acre basis, using gross site acreage as opposed to basin floor acreage. Note that the distinction between gross and basin floor acreage was not available for the TID project.
6. **Discounted Cash flows and Net Present Value**
   The net present value of streams of future costs over 20 years are annualized to an equivalent annual payment using a discount rate of 4.4% from the 10-year average return on assets as reported by the USDA. To compute the cost per acre-foot recovered, the NPV of annualized total cost is divided by the NPV of expected annual flood flows per season, as calculated in assumption #2 above (i.e., 2,481 AF/ flood year * 38% probability).

Cost Calculations

Total costs across all six configurations: (1) Dedicated basin, (2) Permanent with purchase of a new pump, (3) Permanent with use of an existing pump, (4) Permanent gravity fed, (5) Temporary pump rental, and (6) Temporary gravity fed are calculated both as the NPV of the total stream of costs over the 20-year period, taking into consideration how costs are likely to escalate over time, as well as the equivalent annualized cost. Both of these calculations are presented in Table 1 below. Total costs range from $540,000 in the temporary configuration with gravity-fed flooding to $1.5 million in the dedicated basin configuration. These are equivalent to a range in annualized costs from $39,000 under the gravity-fed temporary configuration to $113,000 under the dedicated basin configuration.

Table 1. Total Cost and per Acre-Foot Cost Calculations

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
NPV Total Cost	$1,545,000	$944,000	$871,000	$850,000	$784,000	$540,000
Annualized Cost	$113,000	$69,000	$64,000	$62,000	$57,000	$39,000
Annualized Cost per AF	$119	$107	$99	$96	$89	$61

Annualized present value per acre-foot cost estimates range from $61 for the temporary, gravity-fed configuration to $119 for the average of the dedicated basin configurations. The estimates for the other permanent and temporary configurations are in the middle of the range from $89 and $107.[10] An important observation is that this range is sufficiently narrow that one

[10] Per acre-foot cost estimates can be calculated in two different ways, which result in equivalent values. One is by dividing the total annualized cost by the annual probability-weighted calculation of flood flows ((a) 1680 acre-feet multiplied by 38% probability of

option does not dominate over the others in all situations. These relative costs will change with differing circumstances.

Total costs presented in Table 1 are calculated as the sum of infrastructure construction costs and operating costs. A breakdown of infrastructure and operating costs that make up the total costs presented above is shown in Table 2.

Infrastructure costs are upfront construction costs. Calculations of NPV and annualized payments take into consideration financing this cost of construction over the 20-year period. Operating costs take place only in years when flood flows actually become available. Therefore the initial annual operating costs are calculated as probability-weighted costs or the expected value of costs based on a 38% chance of flooding in a given year. That probability-weighted initial cost is then escalated over the 20-year period according to the assumptions listed above to arrive at the NPV and annualized total operating costs.

Infrastructure costs range from $398,000 to $1,426,000 for the temporary configuration and the dedicated basin configuration, respectively. Permanent on-farm configurations have infrastructure costs in the middle of this range at $781,000 for the permanent configuration with a new pump and $708,000 for the permanent configuration with an existing pump. These are equivalent to an annualized cost of $57,000 and $52,000 for the permanent configurations with and without an additional pump. For the temporary and dedicated basin configurations, annualized infrastructure costs are $29,000 and $124,000 respectively. Operating costs are actually higher in the temporary configuration because we assume that the rented pump runs on diesel, which is more expensive to operate than electric pumps under the permanent configurations and that four pumps will be needed to cover the 160-acre field. Permanent configurations have the same operating costs since we assume that costs of operation are the same whether a new pump or an existing pump is used to move water onto the field. The dedicated basin configuration has the lowest operating costs. Operating cost estimates therefore range from nearly $120,000 in the dedicated basin configuration to nearly $386,000 in the temporary configuration. These are equivalent to annualized costs of nearly $9,000 in the dedicated basin configuration and over $28,000 in the temporary configuration.

flooding in a given year or 644 acre-feet in the permanent and temporary scenarios; (b) 2481 acre-feet multiplied by 38% probability of flooding in a given year or 951 acre-feet in the dedicated basin scenario). The other is by dividing the NPV of total costs by the NPV of total flood flows over the lifetime of the project. The NPV of the flood flows calculation assumes that water stored in the current year is more “valuable” than water stored in the future and discounts those future flows. This is based on the premise that dollars do not have real value on their own—they represent value embedded in other things such as labor, land and water, so each of those should be discounted in the same fashion. The two approaches yield equivalent estimates of total cost per AF of water recharge.

Table 2. Total Infrastructure and Operating Costs

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
Infrastructure Cost--NPV Total Cost	$1,426,000	$781,000	$708,000	$708,000	$398,000	$398,000
Infrastructure Cost--Annualized Total Cost	$104,000	$57,000	$52,000	$52,000	$29,000	$29,000
Operating Cost--NPV Total Cost	$120,000	$163,000	$163,000	$142,000	$386,000	$142,000
Operating Cost--Annualized Total Cost	$9,000	$12,000	$12,000	$10,000	$28,000	$10,000

Cost estimates vary somewhat from those made in the original Summers Engineering report. The individual components of temporary infrastructure cost estimates are the same as those in the report, however, applying a 38% chance of flooding in any given year rather than the simplified 33% used in the report and taking the annualized cost of the NPV result in a final estimate that is higher. Temporary operating costs are lower than those estimated in the original report, mainly because the original report overestimates fuel costs by double counting pump-days of operation. In the permanent configuration with a new pump, infrastructure and operating costs are close to those estimated in the original report. The main differences arise from our estimation of lift pump power costs based on EIA fuel price forecasts and our methodology for annualizing total costs based on NPV. Total annualized costs are higher than those estimated in the original Summers Engineering report, $72,000, but only by about $3,000 or about 4.2%.

Break-even Comparisons among Flow Recovery Configurations

The model allows users to vary the probability of flood occurrence to explore the effect on total costs across the various recharge project configurations. Being able to compare cost-effectiveness across flood flow probabilities is important because those probabilities can vary within a basin. Those probabilities vary naturally due to differing watershed topographies and stream capacities. They also vary as acreage moves further up the canal system away from the mainstem. And even taking action to divert floodflows can affect the probability of such flows further downstream and down the canals. In fact, that change in probabilities is one of the ancillary benefits to downstream communities and property owners.

The break-even analysis identifies at which point in a probability distribution one retention strategy is cost-effective over another. The costs shown here are only examples, and these should be tailored to specific settings in each case.

Holding the flood probability for the dedicated basin constant at 38% (based on the historical average of floods occurring in 23 of the last 60 years), we can determine what flood probabilities would be necessary in the on-farm configurations so that on-farm recharge is at least as cost-effective as recharge in the dedicated basin.

At a flood probability of 38.3%, Annualized Cost/AF of recharge water in the dedicated basin is $119. The permanent on-farm configurations are less than or equal to (i.e. more affordable than) this cost across all probabilities. For the temporary on-farm configuration, because there is no permanent infrastructure, costs are incurred only in years when floodwater is available. At these probabilities, total cost/AF is equal across the configurations at $88/AF. If flood probability rises above 52%, temporary on-farm capture becomes more expensive than the dedicated basin scenario. The cost of the dedicated basin falls to $88 as well at that point.

Table 3. Break-even point with dedicated basin as specified flood probability

	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
Probability of flood flows fall below:	100%	100%	99%	52%	77%

This result implies that even when dedicated basins might take a large proportion of available flood flows which then lowers the probable availability of flows to on-farm operations, the on-farm configurations may still have similar costs per acre-foot. A water management agency can develop a portfolio of flow recovery strategies using this approach.

Similarly, we can obtain the flood probabilities that would be necessary for each of the configurations to be cost-competitive with the lowest cost temporary configuration. At a flood probability of 73% the permanent configuration with an existing pump and the temporary configuration with gravity-fed flooding have the same annualized cost per acre-foot at $60. At a flood probability of at least 82%, the permanent configuration with a new pump and the temporary on-farm configuration have the same total cost per acre-foot. The dedicated basin configuration would have to have a flood probability of at least 77% in order to reach a total cost of $60/AF.

Table 4. Break-even point with temporary configuration

	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental
Flood flow probability must be at least	77%	82%	73%	70%	N/A

The probability of flood occurrence is likely to vary in different locations. The cost model therefore allows users to explore changes in cost with different flood frequencies. Tables 5 and 6 display the total costs and annualized costs per acre-foot of recharge across the four different recharge project configurations for different flood frequency probabilities ranging from 25% to 45%.

Configurations exhibit lowest costs at higher flood frequencies. For the dedicated basin configuration, costs per acre-foot range from $101 to $181 over the flood frequencies from 25% to 45%. For the permanent configuration, costs range from $94 to $154 with a new pump, and from $87 to $142 with an existing pump. With gravity-fed flooding in the permanent configuration, costs range from $84 to $139. For the temporary configuration, the costs remain constant at $89 per acre-foot with pump rental and $61 per acre-foot with gravity-fed flooding, across the varying flood frequencies.

Table 5. NPV Total Costs at varying flood frequencies

Flood Frequency	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
25%	$1,535,000	$888,000	$815,000	$801,000	$512,000	$352,000
30%	$1,539,000	$908,000	$835,000	$819,000	$614,000	$422,000
35%	$1,543,000	$930,000	$857,000	$839,000	$717,000	$494,000
40%	$1,546,000	$951,000	$877,000	$855,000	$818,000	$562,000
45%	$1,550,000	$972,000	$899,000	$875,000	$920,000	$634,000

Table 6. NPV Total Costs per AF at varying flood frequencies

Flood Frequency	Dedicated Basin	Permanent with New Pump	Permanent with Existing Pump	Permanent Gravity Fed	Temporary Pump Rental	Temporary Gravity Fed
25%	$181	$154	$142	$139	$89	$61
30%	$151	$132	$121	$119	$89	$61
35%	$130	$115	$106	$104	$89	$61
40%	$114	$103	$95	$93	$89	$61
45%	$101	$94	$87	$84	$89	$61

Comparison of M.Cubed/Summers and Bachand/Terranova Results

We compare Bachand's estimate with M.Cubed's temporary configuration, the most comparable one, since the Terranova pilot project was renting diesel equipment temporarily only in flood years. For the temporary structure configuration, M.Cubed estimated a long-run cost of $89/AF, where Bachand estimated a first-year cost of $38/AF. These estimates are highlighted in red below to show the starting points of the analyses.

Between the two projects' costs in a single flood year are comparable, but Terranova used 1,000 acres and recovered 3,100 AF of recharge, whereas the Summers estimate used 160 acres and 1,680 AF of recharge. Terranova shows a recovery of 3.1 AF/acre while Summers shows 10.5 AF/acre.

- If M.Cubed used Bachand's first-year methodology the result would be $68/AF. Beyond that, our cost escalation and annualization methodology increases our cost estimates a bit more to $89/AF.
- If Bachand used M.Cubed's annualized costs, the cost would be $118/AF.

M.Cubed/Summers Data	Method			Bachand/Terranova Data	Method	
Description	**M.Cubed**	**Bachand**			**M.Cubed**	**Bachand**
				One-time infrastructure costs	$28,780	$28,780
Surface pipe	$35,000	$35,000		Conveyance (weirs, irrigation pipe system)	$6,969	$6,969
Lift pumps (4 engines)	$24,000	$24,000		Pump rental (3 engines)	$25,479	$25,479
Total Infrastructure Cost per Flood Year	$59,000	$59,000		**Total Infrastructure Cost per Flood Year**	$32,448	$32,448
Annualized Infrastructure Costs	$29,070			**Annualized Infrastructure Costs**	$42,110	
Build temporary berms 2 times per year	$2,400	$2,400		Labor (land prep, management)	$18,545	$18,545
Diesel fuel for pump operation	$32,423	$32,423		Diesel	$29,986	$29,986
Irrigator labor	$7,200	$7,200		Contracted Services	$1,500	$1,500
				Other operating (taxes, ins., admin)	$6,491	$6,491
Annual ripping or gypsum application	$12,800	$12,800				
Total Annual First-Year Operating Cost per Flood year		$54,823		**Total Annual First-Year Operating Cost per Flood year**		$56,522
Annualized Operating Costs	$28,160			**Annualized Operating Costs**	$10,466	
Total Cost In A Single Flood Year		$113,823		**Total Cost In A Single Flood Year**		$117,750
Annualized Total Cost Frequency Weighted	$57,230			Annualized Total Cost Frequency Weighted	$52,576	
Acre-Feet Per Flood Year	1680	1680		Acre-Feet Per Flood Year	3116	3116
Infiltration Rate (Feet/Day)	0.25	0.25		Infiltration Rate	0.35	0.35
Frequency	38%	38%		Frequency	14%	14%
Cost/AF In A Single Flood Year	$34	**$68**		Cost/AF In A Single Flood Year	$17	***$38***
Cost/AF Adjusted For Flood Frequency	***$89***	$177		**Cost/AF Adjusted For Flood Frequency**	**$118**	$265