Appendix 7A

Inventory of Projects and Management Actions Considered During GSP Development

Corning Subbasin GSP: Initial Inventory of Potential Projects and Management Actions

This document contains the following information:

Section	Description
Projects	This table lists potential projects related to groundwater and water resources management, that could be implemented in the Corning Subbasin. Projects are generally considered physical actions that require CEQA, such as recharge or surface water delivery facilities.
Management Actions	This table lists potential management actions related to groundwater and water resources management, that could be implemented in the Corning Subbasin. Management actions are policy or management tools that relate to reduced
Screening Criteria	This table lists potential screening criteria that will help us rank the projects and identify the most feasible and applicable for the GSP implementation.

Projects are grouped into preliminary categories (but not sorted in any way):

Demand Management
Flood Risk Reduction/ Enhanced Recharge
Surface Water Conveyance
Supply Augmentation

Management Actions are grouped intro preliminary categories (but not sorted in any way):

Grower Education
Supply Augmentation
Demand Management
Domestic Well Management
Policy and Ordinances
Well Data Tracking

Category	Project Type	Purpose	Description of Potential Projects(s)	Examples of Existing or Future Projects
Demand Management	Residential water use efficiency improvements	Decrease residential and commercial water demand in the Subbasin	**Examples:** Incentives for urban, residential, and commercial projects like high efficiency appliance rebates, lawn removal, low-water landscape installation, rain barrels, graywater reuse, etc.	
Demand Management	Land management for irrigation efficiency	Optimize land management to decrease the agricultural water demand in the Subbasin	**Examples**: Soil mapping to customize irrigation timing and duration. For example, the clay areas can be set to water more frequently at shorter durations while the more silty areas have longer watering durations with longer periods between watering. Soil amendments to improve moisture retention. Crop selection based on irrigation water availability.	
Flood Risk Reduction/ Enhanced Recharge	Levee setback and stream channel restoration	Prevent flooding, increase groundwater recharge, and restore more natural conditions along streams	Increase groundwater levels, provide wildlife habitat, lower water temperatures in the Sacramento River, and provide better conditions for ecosystem function.	Hamilton City levee setback and floodplain restoration on Sacramento River RCDTC side channel and habitat enhancement on Sacramento River
Flood Risk Reduction/ Enhanced Recharge	City of Corning stormwater improvements	Decrease flood risk and increase groundwater recharge	City dry wells at La Mesa Ct., Rio Bravo Ct., Rio Vista Ct., Rio Del Rey Ct., and others reportedly fail to keep up with flash flooding. Localized flooding has been reported on North Street between Edith and Toomes Avenue, on Edith Avenue between Colusa and Solano Streets, on Fig Land and Chicago between railroad tracks and West Street (including flooding from Woodson Bridge at 6th Street), Jellys Ferry Road, and Saron Fruit Colony Road.	Existing project that would need to be enhanced - plan for dry well rehabilitation
Flood Risk Reduction/ Enhanced Recharge	Runoff reduction, watershed restoration, fire restoration	Reduce amount of runoff and increase groundwater recharge; reduce potential for water quality impacts.	Restoration of watersheds burned in 2020 wildfire (and other future wildfires) and restore unused grazing land in western Subbasin	
Surface Water Conveyance	Invasive plant removal from creekbeds and irrigation conveyance canals	Improve conveyance capacity and reduce flood risk.	Many small tributaries in the watersheds have decreased conveyance, high levels of siltation, and diminished flood-carrying capacity due to invasive vegetation (arundo, tamarisk, Himalayan blackberry) overgrowth. Debris-clearing is a challenge due to environmental permitting restrictions. Cal IPC (Invasive Plant Society) identified Glenn County as one of the hardest hit Arundo/Tamarisk invasive weeds areas. Main areas include Thomes Creek and Stony Creek. Also reduces ET and allows for more water in the shallow groundwater area; restoring conditions for GDEs and native riparian species.	On an intermittent basis, State Conservation Camp crews contract with the Glenn County Public Works department to conduct hand reductions of Arundo vegetation within the Lower Stony Creek stream channel near the city of Orland as well as upstream of state and county bridges that cross the stream channel. These consist of hand cutting and burning of vegetation. City of Corning also works on maintain channels within the City.

Category	Project Type	Purpose	Description of Potential Projects(s)	Examples of Existing or Future Projects
Surface Water Conveyance	Surface water conveyance and irrigation infrastructure improvements	Allow for additional surface water use. Allow for conjunctive use groundwater management, decrease reliance on groundwater. Improve irrigation efficiency	**Examples**: Irrigation system improvements needed to utilize surface water for drip irrigation of orchards. Typical system components required for a dual source system are a surface water irrigation "turnout" or point of delivery to the field, a pipeline or ditch to convey water from the turnout to a pump station, a pump or pumps for pressurization, and filtration. Improvements in the Subbasin may include installation of regulating reservoirs, filters or treatment (for algae), and pressurize systems for drip irrigation. SCADA improvements and install VFDs on pumps to improve and maintain delivery pressures.	
Surface Water Conveyance	Increase inter-basin surface water transfers or exchanges to benefit Corning Subbasin surface water use	Increase surface water use to decrease reliance on groundwater; e.g. Utilize full TCCA allocation in wet years using groundwater recharge, groundwater banking, or conjunctive use program	Promote inter-basin transfers or exchanges with Settlement Agreement contractors (GCID, Provident, Princeton, RD108). Subsidize surface water costs to make it cheaper than groundwater, for use within Corning Subbasin. **Examples:** There are available surface water rights in the Subbasin that are not utilized. About 120,000 acre-ft of allocated water in the TCCA canal system has been available in wet years but not used (note, estimate includes land in other Subbasins).	History of transfer from settlement agreement contractors; successfully done in Corning Water District
Supply Augmentation	Groundwater recharge through: 1. Recharge through unlined canals and natural drainages 2. Dedicated recharge basin 3. ASR wells	Groundwater recharge to augment groundwater in storage for conjunctive use.	**Examples:** Recharge of groundwater with excess surface water in wet years for use in dry years. Areas identified northwest of Hamilton City and near the City of Corning have suitable surficial geology, low enough water levels to support recharge, and access to surface water. Target areas would be connected to water districts with excess water (CWD, OUWUA, TCWD) and served by water conveyance infrastructure such as OUWUA northside canal, Corning Canal, TCC, and GCID Main Canal. Could potentially use 18 new supply wells in large Eucalyptus Grove in Tehama County for ASR project if surface water can be conveyed to them. Utilize creek beds, conveyance structures such as unlined Corning Canal and laterals, agricultural fields, recharge basins, dry wells etc. to recharge groundwater with surface water flood flows. Potentially install storage reservoir to aid in capturing flood flows for recharge.	Separate projects by geography: 1. Corning area from Corning, TCC Canals 2. Capay from Stony Creek or TCC Canal 3. ASR in new supply wells drilled in old eucalyptus grove
Supply Augmentation	Recycled water program	Use treated wastewater as a resource for irrigation or recharge	Use City of Corning treated wastewater for groundwater recharge, urban, and agricultural irrigation	City of Red Bluff uses recycled water to help with irrigation along I-5.
Supply Augmentation	Well deepening or replacement program	Provide funding and resources to deepen or replace domestic or irrigation wells that go dry, replace overly shallow or inefficient irrigation wells, connect domestic properties to existing public supply systems where feasible.	Fewer shallow domestic and irrigation wells allows for deeper acceptable water levels in some parts of Subbasin. **Examples and priorities:** 1. Domestic well replacement 2. Irrigation well replacement 3. Residential property connection to public supply system.	Yuba County domestic well replacement program example.

Category	Project Type	Purpose	Description of Potential Projects(s)	Examples of Existing or Future Projects
Supply Augmentation	Import water from other Tehama County Subbasins	Use available surplus water from programs upstream of Corning Subbasin for use to recharge aquifer	**Examples:** 1. Red Bluff treated wastewater divert directly to Corning Canal (1,000 ac-ft/yr) - then could be used for recharge in the winter or directly by growers or Districts along the way 2. Trout Unlimited GW substitution transfers 3. Same project with TNC could happen on GW substitution transfers	
Supply Augmentation	Off-stream temporary storage on private lands of flood waters	Obtain surface water rights on Subbasin ephemeral streams to store winter flood flows in off-stream reservoirs/ponds to use for irrigation in the summer	This would help take more wells out of production, if the irrigation supply comes from other sources (groundwater could be emergency supply) - provides for in-lieu recharge, instead of direct recharge.	Other areas in the state already use this approach, to divert winter flows to use later (e.g. Sonoma Valley Basin)

Category	Management Actions	Purpose	Description	Examples of Existing Programs and Actions
Grower Education	Grower education and incentives to improve water use efficiency	Improve water use efficiency through better farming practices, and incentivize use of surface water over groundwater, when possible.	Teach growers the value of improved irrigation practices, such as using surface water when available, replacing inefficient wells, adding organic amendments to improve moisture retention, soil mapping for custom irrigation timing and duration. Groundwater users cooperative to coordinate pumping schedules.	Glenn County Voluntary Groundater Users Cooperative
Supply Augmentation	Incentivize growers to use full surface water allocations within Corning Subbasin Water Districts	Use all surface water available in the Subbasin before pumping groundwater for optimal water supply use	Since the 2013-2015 drought, Districts have not been able to sell all their allocated surface water to in-district growers, as growers have opted to turn to groundwater for irrigation supply due to a more reliable supply, ease of use, well investments made, and adaptability to modern irrigation infrastrucutre for tree crops. It is important to incentivize growers to use surface water when available to allow for the groundwater levels to recover in-between drought years when surface water is not available.	
Demand Management	Conversion to less water intensive crops	Reduce water use	Reduce water use while continuing to promote agriculture land use	A tiered pumping fee and allocation structure is being implemented in Salinas Valley
Demand Management	Pumping fees	Reduce groundwater pumping and fund projects and actions if pumping is not curtailed.	Tiered fee structure for groundwater extractions to incentivize reduced groundwater use, if the planned Projects and Management Actions are insufficient to reach and/or maintain sustainability	A tiered pumping fee and allocation structure is being implemented in Salinas Valley
Demand Management	Pumping restrictions	Reduce groundwater pumping	Curtailed and/or restricted groundwater extractions if the planned Projects and Management Actions are insufficient to reach and/or maintain sustainability	A tiered pumping fee and allocation structure is being implemented in Salinas Valley
Demand Management	Well metering	Better understand actual groundwater pumped in the subbasin	Metering larger agricultural wells would help better assess total pumped gorundwater in the Subbasin to evaluate against sustainable yield and better maange continued sustainability of the Subbasin.	Wells owned and operated by water districts already meter and track total well pumping
Demand Management	Water market for surface water and groundwater exchange	Efficient water resources management.	Trading mechanism for groundwater pumping credits to allow for flexibility in water use to meet demands in Subbasin but remain within overall sustainable yield. Used in conjunction with pumping restrictions. Allows for growers to acquire water needed to irrigate crops that require additional pumping than allocated amount.	
Demand Management	Land fallowing program	Reduce total irrigated land in Subbasin	Curtailed and/or restricted groundwater extractions if the planned Projects and Management Actions are insufficient to reach and/or maintain sustainability (last resort activity).	San Joaquin Valley / Tulare Basin fallowing programs

Category	Management Actions	Purpose	Description	Examples of Existing Programs and Actions
Domestic Well Management	Provide information and resources for protection of domestic wells	Reduce impacts to domestic well owners	Provide domestic well owners resources and funding for well testing, inspection, and replacement. Target well owners in locations where domestic wells are known to go dry or have water quality impacts.	
Domestic Well Management	Dry domestic well tracking system, for each county	Reduce impacts to domestic well owners	Better manage assistance to domestic well owners when water levels drop and wells go dry; identify if wells need to be replaced and provide information on well replacement	DWR dry well tracking system; initial county systems that need to be updated.
Policy and Ordinances	Land use change restrictions/management	Coordinate with counties to restrict land use changes that increase water demand in the Subbasin	Land use restrictions if the planned Projects and Management Actions are insufficient to reach and/or maintain sustainability. Primarily focused on new ag lands development, to restrict growth in areas with no surface water supply.	County general plans coordination
Policy and Ordinances	County water use ordinance	Coordinate with counties to develop policies that align with sustainable groundwater management goals	Possible ordinance include regulations and limits for groundwater use, export, and illegal diversion of surface water. Could instill additional guidelines during the well permitting process to reduce nearby competition between wells (i.e. suggestions regarding total well depth, depth of well perforations, and location of a new well relation to existing wells). Primarily for ag wells to be protective of local domestic wells near-by.	
Policy and Ordinances	Review county well permitting ordinances	Review existing ordinances and assess if additional well permitting requirements are warranted - follow updated DWR well construction recommendations (Bulletin 74).	Develop better well permitting and installation program, to help protect water quality, allow for better screening, and avoid interference or impacts on neighboring wells	
Well Data Tracking	Well registration program	Collect well locations, screening information, and pumping data for use in GSP updates.	Require well registration and pump metering to track water use.	
Well Data Tracking	Well completion database for Tehama and Glenn Counties - County well inventory (location, depth, in service or not)	Improve understanding of well distribution, construction and hydrogeology. Potentially useful for filling monitoring data gaps. Refine the location and distribution of all wells within the Tehama County portion of the Subbasin; knowing that the DWR information is not accurate and outdated	Review well completion reports and GIS data, check with well owners if data are correct. Could use similar approach to what occurred in Glenn County with County and Prop 1 grant funding. Compile information on new wells in DMS, including location, purpose, construction information, and hydrogeology. Identify abandoned wells or wells no longer in use to properly abandon.	

Potential Screening Criteria
Capital Cost
O&M Cost
Recharge Benefit (Characterize in-subbasin and outside subbasin benefits)
Other Benefit (WUE, habitat, reduced flood risk)
Potential impacts (such as environmental, or to other beneficial users)
Status of Implementation (i.e. feasibility study complete, pilot project, EIR…)
Water Source(s) and Legal Authority
Undesirable Results/Sustainability Indicators
Permitting and Regulatory Compliance
Administration logistics
Water availability
General feasibility
Public acceptance
Beneficial users that benefit from project

Appendix 7B

Framework for a Drinking Water Well Impact Mitigation Program

Framework for a Drinking Water Well Impact Mitigation Program



Written by Self-Help Enterprises, Leadership Counsel for Justice and Accountability, and the Community Water Center

Dear Reader,

This tool was developed to aid Groundwater Sustainability Agencies (GSAs) in the development and implementation of their Groundwater Sustainability Plans (GSPs). The Sustainable Groundwater Management Act (SGMA) tasks GSAs with the important responsibility of protecting our precious shared groundwater resources. As GSAs navigate these previously uncharted waters, one thing is clear: as GSAs decide how to bring their local areas into compliance with SGMA, they must do so in a way that protects drinking water resources. SGMA requires GSAs to consider all beneficial uses and users of groundwater as they create and implement GSPs, and California law lists domestic use of water as the highest priority of use. At the same time, domestic water use is at the highest risk contamination and loss of water supply. The future of families on shallow private domestic and small community water systems wells hangs in the balance as GSAs decide whether and how to protect their wells. Many families who depend on shallow domestic wells or small water systems cannot afford to deepen wells or treat their water, because they lack the economies of scale that large public water systems have for addressing impacts to water supply.

This framework provides a clear roadmap for how a GSA can best structure its data gathering, monitoring network and management actions to proactively monitor and protect drinking water wells, and mitigate impacts should they occur. We hope GSAs can use this framework as a reference when developing and implementing their GSPs.

Sincerely,



Angela Islas
Self-Help Enterprises



Amanda Monaco
Leadership Counsel for Justice and Accountability



Deborah Ores
Community Water Center

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Management Action Name: Drinking Water Well Impact Mitigation Program

Potential Implementing Organization(s): Groundwater Sustainability Agencies (GSAs) in partnership with project participants.

Purpose Statement: The purpose of this document is to be utilized by GSAs to mitigate, prevent, and address any adverse effects on drinking water wells caused by groundwater pumping volume or location, conjunctive management, or any other forms of active management as part of Groundwater Sustainability Plan (GSP) implementation. By doing so, GSAs can better achieve the goals of the Sustainable Groundwater Management Act (SGMA), avoid jeopardizing access to safe water in vulnerable communities, and also avoid violating California laws that establish a statewide Human Right to Water and that protect access to safe water. Adverse effects can include both issues with access to safe drinking water due to increased contamination, as well as issues with sustained access to water due to changes in groundwater levels.

This document provides a framework of elements to consider when GSAs are developing a drinking water well impact mitigation plan. Every community and every GSA will have to evaluate their own needs and particular considerations in order to develop a mitigation program that works best for all users. This document is broken down into the following sections:

1. Importance of Drinking Water Well Impact Mitigation Programs;
2. Framework for developing a program and key elements to consider;
3. Cost considerations for short- and long-term solutions and potential funding sources; and
4. Examples of existing Drinking Water Well Impact Mitigation Programs.



House receiving water from a temporary emergency tank due to dry groundwater well.

Section 1

Importance of a Drinking Water Well Impact Mitigation Program

How can GSP implementation impact domestic wells and small community wells?

Across the state, critically overdrafted basins have developed GSPs to manage groundwater resources sustainably under SGMA. Many GSPs have developed sustainable management criteria, including minimum thresholds (MTs) and measurable objectives (MOs), that if reached, would cause significant impacts to access to safe and affordable drinking water for vulnerable communities. GSP implementation, including management actions and projects, can either serve to protect or harm drinking water resources. For example, GSA actions that could harm drinking water include setting minimum thresholds too low, resulting in completely or partially dewatered wells. Besides the cost of deepening a well, partial or complete dewatering of a well results in the need to lower the well pump, clean the well screen more frequently, all of which leads to higher energy costs from pumping, and emotional impacts from not having access to safe water. The GSA could also develop groundwater pumping allocations, and pumping regimes or sustainable management criteria which allow for an increased movement of contaminant plumes, an increase in the concentration or release of contaminants, or an increase in salinity due to sea water intrusion in coastal wells.

The following significant impacts could occur as a result of GSA policies (such as setting minimum thresholds and measurable objectives that are not protective enough of drinking water) or GSA activities (such as projects or management actions that damage water quality or allow groundwater levels to decline too far). This list is not exhaustive, merely just the most likely negative outcomes:

- Partially dry wells
- Fully dry wells
- Contaminated drinking water
- Unaffordable water rates due to the above

If GSP sustainable management criteria are developed in a way that could potentially cause significant impacts on drinking water users, the GSP must also include a robust drinking water well impact program to prevent and mitigate the drinking water impacts that occur. In some GSAs, up to 85% of domestic wells are at risk of being dewatered or partially dewatered. In these same GSAs, rural domestic and small water system demand does not contribute substantially to the overdraft conditions, yet the risks imposed on these drinking water users are overlooked and neglected, creating a disproportionate impact on already vulnerable communities.

What are the drinking water challenges facing disadvantaged communities?

Without an adequate GSP that is protective of groundwater sources near or within communities, more drinking water wells will run dry or be unable to provide safe, potable water to residents. This will further jeopardize the livelihood of California's most vulnerable communities. Vulnerable communities, including severely disadvantaged communities (SDACs), disadvantaged communities (DACs), small water systems, and domestic well owners, have limited technical, managerial, and financial capacity to respond to drinking water challenges.

Climate change further exacerbates drinking water challenges with more frequent, longer, and more severe droughts and flood periods expected. Small water systems and rural communities reliant on domestic wells are, and will continue to be, the most adversely impacted and most at risk of experiencing water shortages and/or having to rely on contaminated drinking water supplies. In order to increase water system resiliency, we must protect current water sources. Other ways to increase resilience are to secure more than one water source, assist communities with maintenance and operation costs, and ensure water affordability.

A Drinking Water Well Impact Mitigation Program is key to increasing water resilience through minimizing risks of both short-term and long-term impacts. Having adequate plans and policies to support drinking water resilience in the face of climate change is essential to reducing the amount of emergency funding needed to respond to a water shortage emergency and to prevent human health crises. A carefully designed and implemented well impact mitigation program can support efforts to ensure all communities have long-term and sustainable access to clean, safe, and affordable drinking water.

How does California law prioritize drinking water?

A GSP which lacks a mitigation program to curtail the effects of projects and management actions on the safety, quality, affordability, or availability of domestic water, goes against the intent and spirit of both SGMA and the Human Right to Water law. The Human Right to Water (AB 685) (HR2W) was signed in 2012 and added § 106.3 to the California Water Code, declaring, "the established policy of the state that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes."[1] The HR2W applies to all state agencies, requiring that they "consider this state policy when revising, adopting, or establishing policies, regulations, and grant criteria when those policies, regulations, and criteria are pertinent to the uses of water."[2] With this passage of AB 685, relevant state agencies, including the State Water Resources Control Board (SWRCB) and the Department of Water Resources (DWR), are now required to consider this state policy when revising, adopting, or establishing policies, regulations, and grant criteria that may impact the uses of water for domestic purposes. To ensure compliance with the legislature's long established position, the HR2W requires that DWR consider the effects on domestic water users when reviewing and approving GSPs.[3] DWR should continue to collaborate with the SWRCB on matters of drinking water and water quality as part of GSP review, and the SWRCB should continue to offer its expertise on these matters as part of GSP review.



Residents standing next to their new groundwater well in Monson, CA.

Further, the California legislature has recognized that water used for domestic purposes has priority over all other types of uses since 1913.[4] Reserving top priority for domestic water use was later codified in 1943, in Water Code § 106, which declares it the, "established policy of this State that the use of water for domestic purposes is the highest use of water and that the next highest use is for irrigation."[5] Further, the passage of the Safe and Affordable Drinking Water Act by Governor Newsom indicates a clear state-level commitment to providing safe and affordable drinking water to California's most vulnerable residents.[6] Poor implementation of SGMA would threaten the success of the Safe and Affordable Drinking Water Fund and would run counter to Governor Newsom's vision of providing safe water to all.

A carefully designed and implemented Drinking Water Well Impact Mitigation Program can support a statewide goal of ensuring DACs' access to clean, safe, reliable, and affordable drinking water. Including this type of program in a GSP also helps to create a groundwater management plan that understands DACs' unique social and economic vulnerabilities, is sensitive to their drinking water needs, and avoids causing a further disparate impact on low-income communities.

[1] *WAT § 106.3 (a).*
[2] *WAT § 106.3(b).*
[3] *See generally, WAT § 106.3 (b).*
[4] *California Water Commission Act of 1913 § 20.*
[5] *WAT § 106; This policy is also noted in the Legislative Counsel's Digest for AB 685.*
[6] *SB 200, Monning (2019).*

Section 2

Key Elements and a Framework for Developing a Drinking Water Well Impact Mitigation Program

1) Drinking water well monitoring network:

Many drinking water users depend on shallow domestic wells and community supply wells, which are the most vulnerable to impacts from groundwater management activities. Thus monitoring networks must be able to capture impacts to deeper public water system wells as well as shallow domestic wells.

The following approach will allow GSAs to comply with the GSP regulations and take a proactive approach to protect DACs' and domestic well owners' access to safe and affordable drinking water:

1. **Map and assess drinking water well vulnerabilities to better understand:**
   - Locations and depth of drinking water wells (both domestic and public supply well
   - Whether changes in groundwater levels and quality may be exacerbated in specific areas by pumping volume or location, conjunctive management (i.e. groundwater recharge projects), or other forms of active management as part of GSP implementation;
   - The proximity of potentially impacted wells to nearby existing public water systems; and
   - If there are areas with a high density of likely impacted wells.

The assessment should acknowledge that not all existing and utilized wells may be documented in available resources from DWR or Counties and the GSA must include a plan for filling any data gaps that may exist.

2. **Designate key monitoring wells to assess impacts to drinking water wells:**

Based on the drinking water well vulnerability assessment, identify which wells from the GSP proposed monitoring network are critical to assess impacts to drinking water wells caused by changes to groundwater levels and quality. Expand and improve the monitoring network to assess potential impacts in particular for groundwater conditions near DACs, areas with high density of private domestic wells, and water systems serving schools. The monitoring network needs to be representative of conditions in all aquifers in general, including the shallow aquifer upon which domestic wells rely. The water quality monitoring network needs to routinely monitor for all contaminants that could impact public health (not only nitrate, but also chromium-6, arsenic, 123-TCP, uranium, and DBCP). This will allow the GSA to accurately monitor for impacts on the most vulnerable beneficial users, and take a proactive approach to protect DACs' and domestic well owners' access to safe and affordable drinking water.

2) Develop an adaptive management trigger system:

Developing a protective warning system, also referred to as an adaptive management approach, can alert groundwater managers when groundwater levels and groundwater quality are dropping to a level that could potentially negatively affect drinking water users. These "triggers" are essential for groundwater management and can be adjusted to fit the needs of different management actions as well as the basin as a whole.

The trigger system should be developed in collaboration with stakeholders, in particular groups that are more susceptible to groundwater changes, and then tied back to quantifiable measures such as the GSP measurable objectives, MCLs, and numbers of partially or fully dry drinking water wells.

The table on the below provides an example of what a warning system might look like, using green, yellow, and red light indicators or triggers, and some potential corrective actions groundwater managers can take to remedy the problem. Ultimately, this approach allows for the evaluation of current conditions in order to respond accordingly to prevent or mitigate negative impacts.

Triggers	Groundwater Conditions and Impacts	Examples of Quantifiable Measures	Potential Corrective Actions
Green light	Groundwater levels and quality are stable.	Firmly in compliance with Measurable Objectives and MCLs.	No action required.
Yellow light	Groundwater levels and quality are approaching concerning levels and impacts may occur or are occurring. Some corrective actions are needed.	Groundwater levels[7]: 3% of drinking water wells have gone partially or fully dry, or 5% of drinking water wells in the GSP area are projected to go dry if current trends continue. Groundwater quality: Water quality reaches 70% of the MCL in any given monitoring well.	- Undertake an analysis to pinpoint the cause; - Undertake water quality testing for selected domestic and public supply wells; - Provide immediate support to groundwater users experiencing impacts; - Reassess pumping allocation and pumping patterns; - Consider restricting or limiting groundwater extraction near the impacted area.
Red light	Time to stop groundwater pumping and any projects or management actions which are causing dry wells. The GSA needs to mitigate as significant impacts are imminent or are occurring.	Groundwater levels: More than 7% of drinking water wells have gone dry, or 10% of drinking water wells in the GSP area are projected to go dry if current trends continue. Groundwater quality: Water quality reaches 85% of the MCL in any given monitoring well.	- Reassess pumping allocation and pumping patterns; - Consider further restricting or limiting groundwater extraction near the triggered area or reevaluating minimum thresholds or measurable objectives; - Provide interim emergency solution(s) while working with impacted groundwater users to pursue a permanent, long-term solution.

3) Drinking water well impact model:

Develop a model tied to the monitoring network and the adaptive management framework (trigger system) to evaluate groundwater levels and predict potential groundwater impacts to drinking water wells. Update the model regularly with current data, so that the model accurately predicts potential groundwater impacts to drinking water wells. The model should be used to do the following:

- Monitor and forecast changes in groundwater levels and quality;
- Monitor and forecast any localized areas for special attention and/or monitoring;
- Attempt to identify domestic wells or small public supply wells at risk of impacts;

[7] *For groundwater levels, triggers should be developed based on an estimate of potential drinking water wells being impacted across the GSA, or drinking water wells at risk of going dry if current trends continue.*

- Determine if triggers have been met based on the adaptive management framework;
- Incorporate the results above into an annual GSP progress report given to domestic well owners and community water systems.

4) Public outreach and education:

In developing a Drinking Water Well Impact Mitigation Program, GSAs should ensure that residents are aware of the benefits of such a program and how to access the program. This outreach should inform residents about the potential well impacts that could occur based on groundwater management actions, describe potential options available for well mitigation, and include information regarding whom to contact in the event that residents' wells experience negative impacts.

This outreach should take place in whatever form will be the most accessible for all stakeholder groups in the GSP area, particularly disadvantaged community residents. Outreach can be done in the form of pamphlets, mailers, additions to the public website, or radio announcements. GSAs should also conduct regular, door-to-door outreach (in partnership with other outreach experts as needed) to ensure that communities — particularly communities in areas the trigger system identifies within the yellow and red light ranges. The GSA should work with local agencies, organizations, and associations to spread materials about the program. This information should also be mentioned at regular GSA meetings for those in attendance. To ensure that this program can benefit S/DAC residents, information about the program must be disseminated widely, and such materials must be translated into all threshold languages.

5) Mitigation measures:

As soon as a GSP area experiences a yellow light trigger, the GSA should implement the steps below:

1. Third Party Determination of Causality: Work with an objective third party to establish whether the GSA's policies and actions caused the drinking water impact.

2. Change Groundwater Management Activities: Any groundwater management activities or policies that are causing drinking water impacts should be changed to avoid reaching the red light indicator.

3. Define the level of mitigation that is necessary based on a field inspection to determine static depth to groundwater levels within the impacted well. Verify well construction information and pump setting information, if possible.

4. Provide short-term drinking water supply while a permanent solution is pursued. Short-term interim solutions serve to address the immediate impacts and ensure access to water suitable for consumptive and other domestic needs, such as sanitation. Short-term emergency supplies shall be provided as soon as reasonably possible and can include bottled water, bottled water paired with tanked water, or another combination. For groundwater quality issues, bottled water may be an acceptable interim solution. However, if the issue is lack of access to water, providing bottled water is not an adequate interim solution and would require a combination of solutions as well as a long-term sustainable plan
    a. Since short-term solutions are expensive over a prolonged period of time, it is important to quickly identify potential long-term solutions. As an example, GEI's feasibility study for East Porterville at the height of the drought in 2016 estimated tank and bottled water programs cost $633,500 per month just for East Porterville, which has an estimated population of 7,331 residents.

5. Implement a long-term water supply solution:
    a. Whenever possible, the GSA(s) should facilitate connection of impacted well users to a nearby municipal water system by providing financial and technical support.
    b. Other long-term water supply solutions can include (where appropriate):
        i. In areas that are not located near a public water system that can take on additional connections, the establishment of a new small public water system may be feasible;
        ii. Providing funding to lower a well pump and/or deepen the well;
        iii. Providing an equivalent water supply from an alternate source;
        iv. Providing funding to replace the affected

well with a deeper well;

v. Providing funding to treat contaminated water;
vi. Reducing or adjusting pumping near the impacted drinking water well as necessary to avoid the impact; and/or
vii. Providing other acceptable mitigation through a collaboration with the affected drinking water well users.
viii. Note that lowering the pump and/or deepening the well will increase operational costs of the well and may require additional monitoring to ensure the well is not dewatered again. Further, these solutions may not address water quality concerns, depending upon aquifer conditions and screen depths.

A note on the prioritization of connecting impacted wells with existing nearby municipal water systems: Public water systems have an obligation to test water quality for water served, and although some public water systems have limited resources, they do have a greater ability to install treatment systems to address water quality impacts, recoup funds for litigated contamination such as 1,2,3-TCP, and apply for and receive grant funding for beneficial projects. Because of this, public water systems, including small community water systems, often provide a more reliable drinking water source than privately-owned domestic wells. It should be noted that once a resident is connected to a public water system, they are then subject to water bills that will likely be higher than the operation costs of the well.

As these long-term solutions are being developed, the community should be engaged in the process to learn about the benefits of a public water supply in terms of water reliability and water quality, and should also be informed of why water bills may be more costly. It is possible that residents may request assistance in paying monthly water bills associated with their new water connection. Water systems should work to provide affordable rate options to their ratepayers, such as through budget-based rate structures. The State Water Resources Control Board has also submitted a framework for a statewide low-income rate assistance program to the Legislature in January 2020, as required by AB 401 (Dodd, 2015), although the report has not yet been acted upon by the Legislature as of the publishing of the report.

6) Eligibility and access:

1. Eligible beneficiaries should include communities that qualify as DAC or SDAC, and households who qualify as low-income.

2. In developing a Drinking Water Well Impact Mitigation Program, a GSA should ask the following questions, and ensure that the program is easily accessible to all intended beneficiaries:
    a. What is the process for determining eligibility?
    b. Who determines if the well is eligible?
    c. What documentation does the well user need to demonstrate eligibility? Is there an unreasonable onus on the user to demonstrate past use that would constitute a barrier to access?
    d. When a well is found to have been constructed in a way that is not consistent with current regulations, is it still eligible?
    e. If a well is poorly constructed, does the program address replacing or repairing the well rather than just deepening it?

3. S/DAC residents should not be required to undertake burdensome actions or overcome other barriers to entry in order to benefit from the program. For example, residents should not be required to register before impacts occur in order to benefit from the program, and residents should not be required to prove that the GSA's activities or lack of action caused impacts. Instead, the GSA should proactively identify all well locations and information. When the GSA is notified of an impacted well, it should use the well information collected to rapidly evaluate the cause of the impact and provide adequate mitigation measures.

4. The GSA should work with local agencies and organizations to ensure that residents with impacted wells are referred quickly to the GSA for assistance.

Section 3

Costs and Potential Funding Sources

Costs are dependent on many factors including but not limited to the following:

- How protective the GSA defines its sustainability goal and related sustainability criteria;
- The number of vulnerable wells;
- The condition of the vulnerable wells;
- Proximity of vulnerable wells to existing public water systems;
- Depth of the aquifer;
- Local contractor costs; and
- Fluctuations in material costs.

For an example of the cost of several types of water supply solutions for a dry well, the San Antonio, TX, well mitigation project materials include the following average costs per well:

- Perform well diagnostics ($2,700);
- Lower pump ($4,000);
- Drill/outfit/connect replacement well ($58,000);
- Water purveyor connection ($5,000), and close existing well ($4,500).

The table below provides examples of interim and long-term solution costs based on Self-Help Enterprises' experience in providing solutions to disadvantaged communities in the San Joaquin Valley during the 2012-2014 drought. Costs are provided for illustrative purposes only and should be considered as rough estimates.

Solution	Problem	Options	General Overview of Pros and Cons	Estimate of Costs[8]
Interim Solution	Water Quality	Point-of-Use	Treats water for one tap within the household. While this option does provide safe drinking water in the home, if everything is perfect, maintenance can be inadequately carried out and assistance must be provided until a long-term solution is implemented.	- $1,000 to $4,500 per unit per home, for one year. - Costs include: initial capital costs (installation, treatment system, monitoring system) and also ongoing operation, maintenance, routine monitoring, and waste disposal costs. - Costs vary depending on the contaminant and filtration.
		Bottled water	Bottled water provides an effective and reliable source of safe drinking water and may be the only option available depending upon contaminant concentrations. However, bottled water can be expensive over a long period of time and can come with distribution challenges.	$75 per month, per house, includes delivery. Costs vary on household size.

[8] *Costs are estimates based on Self-Help Enterprises' experience in providing interim and permanent solutions to disadvantaged communities in the San Joaquin Valley during the 2012-2014 drought. Costs are provided for illustrative purposes only and should be considered as rough estimates.*

Interim Solution	Access to Water	Water tank program with bottled water	Tank water can meet basic sanitation needs but should not be used to meet drinking water needs, as tank water is susceptible to bacteriological or other issues making it unsafe for consumptive purposes. Instead, the program must be paired with delivery of bottled water to meet drinking water needs.	One-time fees: - 2,600 gallon water tank and materials: approximately $2,100. - Labor and tank installation: $1,500, does not include mileage. - Electrical permit: $80, depending on the county. On-going fees: - Tank water between $500 to $900 depending on delivery charge by water hauler, per load or per hour. - For bottled water: $30 to $50 per month per house, including delivery. - Not estimated: other fees associated with ongoing maintenance of the tank, including routine cleaning. - All costs above are for one house per parcel. Costs can vary depending on conditions.	
Permanent Solution	Water Quality	Water treatment system	Technical, managerial, and financial capacity of the community should be considered when assessing water treatment options.	Costs vary depending on the technology, water contaminant(s), and number of households.	
		Alternate supply source	Options include surface water, construction of a new well, and consolidation with a nearby water system.	Costs vary depending on the desired solution, technology, and number of households.	
	Access to Water	Lowering of well pump	Least expensive long-term solution, if conditions allow. The following factors should be taken into account: lowering of a pump in the well is limited by the depth of the well, pumps near the base of the well increases energy consumption, may require more frequent screen cleaning, and water quality may be degraded due to sediments that are drawn in.	One time cost: Between $5,000 and $10,000.	
		Drill a new deeper well	A well test is necessary to assess yield capacity and water quality on deeper levels.	Private wells	$20K to $45K
				Water systems	Up to $1.5M.
		Alternative water supply source	Options include surface water or consolidation with a nearby water system. Recommend considering consolidation when households understand and agree with the advantages and disadvantages of connecting to a local water system.	Costs vary depending on the desired solution, technology, and number of households	



Resident with bottled water delivery due to dry well.

A secure and reliable funding source and mechanism for the implementation of this type of mitigation program needs to be identified in the GSP. While grant or emergency funding could potentially be available to support a mitigation program, the availability of these funds is not certain. Therefore, the GSA should plan to establish a more secure, on-going funding mechanism that accrues funds that would be available as water levels decline in the future. Funding for these types of programs should be considered as an operational cost of the GSA and funded with other ongoing costs such as administration and monitoring and therefore included in the annual budget for the GSA. The following are potential other sources of funding to consider:

- Service or land-based fee assessments using Proposition 26 or Proposition 218;
- State Water Resource Control Board programs such as Proposition 1 Groundwater Grant Program and Prop 68 Groundwater Treatment and Remediation Grant Program;
- Department of Water Resources funding programs for groundwater projects and technical assistance programs to aid SGMA implementation;
- Central Valley Basin Plan Amendment (BPA) project funding: The BPA for the regulation of salts and nitrates has been approved by the SWRCB and implementation may result in additional funding sources for nitrate contaminated aquifers. If appropriate, GSAs should consider coordinating with nitrate dischargers forming Management Zones formed to comply with the BPA in order to streamline administrative costs and leverage resources;
- United States Department of Agriculture (USDA) Rural Development Utilities funding (if available).

Note that any well mitigation projects should be coordinated with the SWRCB's Safe and Affordable Drinking Water Fund Program (which will be seeking to implement short- and long-term drinking water solutions within vulnerable communities) via the SWRCB's Division of Drinking Water. Funding from the SWRCB's Safe and Affordable Drinking Water Fund Program should not be utilized to ameliorate negative impacts to safe drinking water access in vulnerable communities that are a result of implementation of the GSPs.

Mitigation measures should not put a financial burden on S/DAC residents and communities. Where feasible, GSAs should coordinate with relevant agencies to procure funding for cost-effective and affordable solutions. GSAs should also solicit stipends and grants from agencies where there will be an added cost on residents.

Wherever consolidation is possible, the GSA should assist in pursuit of feasibility studies and assist in negotiations with public water systems. GSAs should also assist in pursuit of grants/funds to ensure that this water is affordable. This work must be initiated with community involvement, oversight, and leadership during the yellow light phase. GSAs play a unique role in regional groundwater management and the ability to convene multiple agencies to leverage multiple funding sources can support both long-term access to safe and affordable drinking water while also supporting sustainable groundwater management.

Section 4

Case Studies of Existing Mitigation Programs

It is important to note that we need not re-create the wheel when designing Drinking Water Well Impact Mitigation Programs. In fact, quite a few concepts discussed above come from existing Drinking Water Well Impact Mitigation Programs that are already part of efforts to manage groundwater resources in other areas of the state and the country. We encourage GSAs to learn from those programs and contact those agencies to find out more about how their programs are implemented.

Please visit the link below for four examples of existing Drinking Water Well Impact Mitigation Programs:

https://bit.ly/MitigationPlanCaseStudies

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Appendix 7C

Introduction and Topics for Grower Workshops

7C.1 Introduction and Topics for Grower Workshops

The following sections introduce the connections between on-farm practices and groundwater sustainability. These sections help to frame specific on-farm management actions discussed in Section 7.3 that support sustainable groundwater management, while also outlining topics for educational workshops that the GSA will implement as a management action.

The management action the GSAs plan to implement is described in Section 7.3.

Following the on-farm – groundwater management nexus overview, a more detailed discussion of the 4 management actions introduced in Section 7-3 is provided for background.

7C.2 The On-farm - Groundwater Management Nexus

Groundwater sustainability is inextricably connected to the on-farm water management decisions that growers make. The aquifers in which groundwater is stored and transmitted are dynamic systems that are directly impacted by conditions on the land surface. The water sources that growers use, the irrigation practices they apply, and the many other agronomic decisions they make can have impacts on groundwater quantity and quality.

Groundwater pumping is a major outflow from the groundwater system that is driven and controlled largely by water demand on the land surface. The depths and locations of wells affect not only how water is extracted, but also how groundwater flows throughout the rest of the aquifer. Deep percolation of irrigation water and precipitation from the surface is a significant contributor to groundwater recharge, representing more than half of total groundwater inflows to the Corning Subbasin in an average year. Like groundwater pumping, the location and timing of deep percolation impacts flows throughout the aquifer.

The on-farm – groundwater management nexus is central to achieving and maintaining groundwater sustainability, as envisioned under the Sustainable Groundwater Management Act (SGMA). Grower education on this topic presents a high-impact opportunity for promoting sustainability through better-informed, on-the-ground water management across the Corning Subbasin.

7C.2.1 Source of Water to Wells

Before development for agricultural, municipal, or domestic uses, aquifers were full and groundwater inflows (recharge) were predominantly balanced by groundwater outflows (discharge) to streams and evapotranspiration from vegetation with access to shallow groundwater or water near the land surface. Over the last 100 years, pumping has added an additional outflow from the system. Therefore, it is critical to first understand the impacts of

additional pumping on groundwater systems. When considering the role of groundwater pumping in groundwater management, it is important to recognize that:

- All water pumped from wells is balanced by some process elsewhere in the groundwater system. Groundwater pumping always reduces the volume of groundwater in storage, especially during the early stages of pumping. This reduction in volume is referred to as the cone of depression.
- As the cone of depression expands, it can eventually cause (1) an increase in recharge from streams or subsurface inflows from adjacent areas, referred to as capture (2) a decrease in discharge to nearby streams, (3) a loss of the amount of water stored in the aquifer, or a combination of these processes.
- It can sometimes take months, years, or decades for this cone of depression to reach areas of recharge and discharge.
- A new balance in the aquifer can only be reached when pumping is balanced by the sum of increased recharge and reduced discharge.

The aquifer response to pumping is ultimately influenced by where pumping occurs within the physical and structural composition of the aquifer, and where pumping occurs relative to groundwater recharge or discharge areas. Coordinated timing of pumping schedules may help to address local, short-term groundwater decline in areas where significant pumping occurs; however, aquifer responses to groundwater pumping typically occur over longer time frames and are generally impacted more by long-term trends in groundwater pumping.

All these factors are important to consider when planning for groundwater sustainability. Additional considerations about the source of water derived from wells and essential factors that govern the aquifer response to pumping are described by Theis (1940), Bredehoeft *et al.* (1982), Leake (2011), and Barlow *et al.* (2018).

7C.2.2 Capture and Sustainability

Under SGMA, GSAs must develop management actions, projects, and an implementation plan to achieve groundwater sustainability within 20 years of submitting their completed GSPs. While the precise criteria that define sustainability are described in each GSP, groundwater sustainability generally results from a long-term balance between inflows to and outflows from the groundwater system, and culminates in the absence of adverse, undesirable results of chronic groundwater level decline and groundwater storage reduction.

Achieving groundwater sustainability generally requires that rates of groundwater outflow (discharge) be decreased and/or that rates of groundwater inflow (recharge) be increased. Understanding the hydrologic capture of water in an aquifer is indelibly linked to groundwater

sustainability. In a groundwater context, hydrologic capture refers to the spatial flow of groundwater through an aquifer that is ultimately pumped from a well. Depending on the well location and characteristics, groundwater pumping may capture water recharged from irrigation, water that otherwise would have discharged to streams or groundwater dependent ecosystems, and/or water leaking from streams. Additional information about hydrologic capture is described by Theis (1940), Bredehoeft *et al*. (1982), Leake (2011), and Barlow *et al.* (2018).

7C.2.3 Importance of Surface Water for Groundwater Sustainability

Surface water availability and use also plays an important role in achieving groundwater sustainability. Using surface water for irrigation reduces groundwater pumping, providing in-lieu groundwater recharge benefits to the aquifer. Surface water also supplies direct groundwater recharge through seepage from streams, canals, and recharge ponds and through deep percolation of applied irrigation water.

7C.2.4 Essential Water Use Terminologies

This section defines and describes key terms that are used in the discussion of groundwater sustainability.

7C.2.4.1 Consumptive vs. non-consumptive use

When water is diverted or pumped to irrigate crops, not all of that water will be consumed. Some water percolates through the soil and eventually reaches the groundwater system and some water may drain or spill from fields and canals into downstream waterways.

Consumptive use refers to "that part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment" (ASCE, 2016). At the subbasin-scale, water that is consumptively used is effectively removed from the subbasin and becomes unavailable for direct or indirect reuse. The majority of consumptive use typically occurs through transpiration (T) from plants and evaporation from wet soil and open water surfaces (E), while a much smaller amount of water is typically stored in harvested crop products. For this reason, "consumptive use" is sometimes used interchangeably with the sum of evaporation and transpiration collectively referred to as evapotranspiration (ET) when discussing water and groundwater management. Consumptive use is a fundamental part of the hydrologic cycle and is a major focus in both on-farm and regional water management planning.

Non-consumptive use refers to **"**that part of water withdrawn that is not evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment" (ASCE, 2016). Non-consumptive use encompasses other water uses that do not result in water being removed from a system, allowing that water to

be reused directly or indirectly elsewhere in the system. Water that becomes deep percolation and seepage, for instance, recharges the groundwater system and is eventually available for reuse through groundwater pumping. Water that becomes return flows and spillage to downstream waterways is also eventually available for reuse by agricultural, urban, and environmental water users who draw from that water for their own supply downstream. Therefore, water that is not consumed is generally not "lost" and using such terms can be misleading.

7C.2.4.2 Beneficial vs. non-beneficial water use

Water use can be classified as beneficial if there are economic, social, or environmental benefits to how that water is used, or non-beneficial if there are no direct economic, social, or environmental benefits (ASCE, 2016). Article X, Section 2 of California's constitution mandates that the water of the State be put to beneficial use, to the fullest extent possible.

Beneficial use refers to the functional, productive purpose that water is used to support. The SGMA regulations[1] require that GSAs consider the interests of all beneficial uses and users of groundwater, including, but not limited to: agricultural users, domestic well owners, municipal well operators, public water systems, environmental users, surface water users (if there is a hydrologic connection between surface and groundwater bodies), and the specific communities within each category. Beneficial use is generally extracting water, such as pumped for domestic or irrigation supply. Sometimes groundwater use can be put to other use such as replenishing groundwater basins for later extraction or replenishing surface water bodies to restore habitat. In regard to consumptive use, beneficial use includes all water that is consumed through ET or that is incorporated into crop products. This water directly supports crop production and the economic return of the crop product.

Non-beneficial use refers to all other water that is lost without direct beneficial purpose within the system. A potential example is evaporation from canals and reservoirs, which is lost to the atmosphere and is not directly used to serve a beneficial purpose within the subbasin.

The concepts of beneficial and non-beneficial use are especially important as they relate to managing consumptive use. For example, if consumptive use needs to be reduced to achieve groundwater sustainability, attempts should be made to first reduce non-beneficial consumptive uses. The concept of water productivity can also be useful for comparing the relative magnitude of benefits across various beneficial uses. Water productivity metrics may be based on an economic indicator (e.g. net return in dollars per acre-foot of water used), a caloric product (calories of agricultural product per acre-foot of water used), or any other indicator of interest.

[1] California Water Code Section 10723.2

7C.2.4.3 Non-consumptive - Recoverable vs. non-recoverable

Non-consumptive use, or water that is diverted or pumped but not consumptively used, can often be recovered for other beneficial uses through pumping or downstream diversion. This recoverable water, or recoverable loss, includes deep percolation of irrigation water that flows past the root zone. From the perspective of groundwater sustainability, recharge water is eventually recoverable through pumping or discharge to streams and groundwater dependent ecosystems. However, some non-consumptive water use is non-recoverable for direct beneficial use within the system. Water that flows to the ocean or to saline sinks is no longer directly suitable for most beneficial purposes and is generally considered non-recoverable.

7C.2.5 Irrigation efficiency: promises and pitfalls

The concept and interpretation of irrigation efficiency depends on the spatial scale and view of what constitutes beneficial use. In common use, irrigation efficiency generally focuses on field-scale water use, relating the amount of water that is consumptively used to the amount of water that is applied through irrigation. This localized, field-scale viewpoint does not adequately account for the many other beneficial uses of water within the larger hydrologic system, or the important role of non-consumptive use at the subbasin scale. Although crops do not consume all water that is applied through irrigation, much of the remaining balance of water is still beneficially used in the larger, subbasin-scale system, as it is recycled back to the groundwater system and downstream waterways. Additional considerations on the promises, pitfalls, and paradoxes of irrigation efficiency in water management planning are described by Lankford *et al.* (2020).

Non-consumptive water uses, especially for groundwater recharge, are important components of sustainable groundwater management. The next section describes the unexpected problems and drawbacks that arise when seeking higher irrigation efficiency as a means to support groundwater sustainability. This is especially the case if groundwater sustainability requires a decrease in consumptively used water, which is often more strongly correlated with the area of land being irrigated, and not the irrigation efficiency at the field scale.

7C.2.5.1 Jevon's paradox

"Jevons' Paradox" describes a technology or policy that enhances the efficiency of using a natural resource but does not necessarily lead to less consumption of that resource. A discussion of Jevon's Paradox in relation to irrigation efficiency is described by Sears *et al.* (2018).

Technologies and policies that support adoption of higher-efficiency irrigation systems are well-intentioned, but there may be unintended consequences that impede water conservation and sustainable groundwater management. Some of these consequences directly result from irrigation efficiency improvements: applying less water to an area and reducing the gap between irrigation

and consumptive use also reduces deep percolation and seepage to the groundwater system. Other consequences may stem from behavioral responses and changes in irrigation resulting from these technologies and policies. If less water can be used to produce the same amount of a crop product, growers may be inclined to use the same amount of water and produce more. In other words, often the perception is that the water "saved" from higher irrigation efficiencies can now be used to irrigate additional land. This, compounded with the reduction in non-recoverable losses that recharge the groundwater system or support surface water bodies, can exacerbate groundwater sustainability concerns.

7C.2.5.2 Improved irrigation efficiency can make matters worse

Grower education is an important step towards enabling growers to recognize the broader impact that irrigation efficiency improvements have on groundwater sustainability.

Improvements to water use efficiency have different meanings and consequences at the different scales of irrigation efficiency described by the FAO (Brouwer *et al.*, 1989). Improving irrigation efficiency at the field scale means that irrigation more closely matches consumptive use, and that less non-consumptive use occurs. These improvements can occur through changes in grower practices and changes in irrigation methods, from lower efficiency surface irrigation that floods large areas of fields (e.g., at 60% efficiency) to higher efficiency pressurized irrigation that precisely applies water directly to plants (e.g., at 90%-95% efficiency).

At the scale of the irrigation scheme, efficiency broadens to consider conveyance efficiency and the non-consumptive water uses that occur during irrigation water distribution. At this scale, efficiencies of 60%-70% may be considered higher efficiency, while the remaining 30%-40% of water is lost to the groundwater system through seepage or to the atmosphere through evaporation.

At the subbasin scale, significant interconnections exist between on-farm water management practices and groundwater sustainability. Losses to the groundwater system that, at the field-scale, were considered to decrease efficiency are instead considered internal to the subbasin hydrologic system, and valuable components of the sustainability equation. Improving field-scale irrigation efficiency can thus reduce the amount of water that recharges the aquifer, and potentially hinder sustainability.

Misunderstanding these interconnections can lead to the assumption that increasing field-scale irrigation efficiency will reduce water use and retain this water for other beneficial uses, enhancing sustainability. However, in practice "…producers may willingly adopt more efficient systems, but may use the same amount of water either for a higher-water-use crop or put more acres into production" (ASCE, 2016), consuming more water in the end and pushing the basin farther from sustainability.

Grower education programs are valuable tools to demystify these interconnections, and to promote on-the-ground water management decisions that consider the benefits of both the consumed and non-consumed components of irrigation water. Understanding the distinction between beneficial and non-beneficial use can also help guide sustainable management decisions towards the highest return on investment with the lowest negative impacts. Additional information can be found in ASCE Manual 70 (ASCE, 2016) and Perry (2007).

7C.2.5.3 Water quality and energy benefits

Beyond the interconnections to groundwater sustainability from a supply perspective, irrigation efficiency and on-farm water management decisions also have implications related to water quality and energy use. Improving irrigation efficiency can have a positive impact on water quality and energy use, as can water management decisions related to surface water and groundwater use.

Improving irrigation efficiency reduces the amount of water needed to irrigate a field and generally reduces runoff of nutrients and sediments, benefitting water quality in downstream waterways. Also, surface water available for irrigation in the Corning Subbasin generally has lower salinity and lower total dissolved solids (TDS) than groundwater. Using surface water for irrigation can benefit crop production and help to reduce soil salinity buildup or the need for additional water supply for leaching. Using surface irrigation methods that contribute more surface water recharge to the groundwater system also has the potential to benefit local groundwater quality in areas where high nutrient loading is not a concern.

Improving irrigation efficiency reduces the amount of water needed to irrigate a field, and as a result reduces the energy needed to supply irrigation water to that field. Choices related to water supply use can also affect the total energy use needed in irrigating a field. Groundwater pumping is energy intensive. By using surface water through gravity-fed irrigation systems, energy demands can be minimized and, in areas where surface water is offered to growers at low cost, the cost of water can also be reduced.

Further discussion on these other implications is described in Gleick *et al.* (2011).

7C.3 Descriptions of Management Action Implementation Activities

7C.3.1 Maximizing use of surface water (in-lieu recharge)

The use of surface water for irrigation whenever it is available is a crucial practice to support sustainable groundwater management. The use of surface water both offsets local groundwater demand through reduced groundwater pumping (in-lieu recharge) and increases groundwater recharge through the non-consumptive recoverable flow of deep percolation of applied surface water from the land surface to the underlying aquifer. The on-farm practices to maximize the use

of surface water include implementing a dual-source irrigation system, reducing tailwater resulting from irrigation, and other actions to promote the conjunctive management of surface water and groundwater. Specific projects related to this management actions are described in Section 7.4.

A dual-source irrigation system is capable of diverting and using surface water for irrigation when available, and using groundwater if surface water is unavailable. The benefits of this practice are that every acre-foot of surface water that is used for irrigation is an acre-foot of groundwater that remains in the aquifer (in-lieu recharge), supporting sustainable groundwater levels and maintaining groundwater storage. Additionally, the applied surface water will inevitably result in some direct groundwater recharge through deep percolation. These positive effects will initially occur in the aquifer directly beneath the grower's lands, while also influencing surrounding lands. The potential drawbacks to this system are the initial construction costs and higher maintenance costs associated with a more complex irrigation system that can draw from 2 water sources, as well as the potential for sediments and debris in surface water to obstruct irrigation systems. If the dual-source irrigation system is designed to accommodate this, surface water and groundwater could be intermixed during irrigation to mitigate these effects.

The on-farm management practice of reducing tailwater from irrigation and holding that water within the irrigated area will either increase the ET, increase the deep percolation, or some combination of the two. The practical steps taken to achieve these will vary from field to field. If there are irrigation application uniformity issues with over- and under-irrigation occurring in certain parts of the field, addressing these issues will promote tailwater reduction. Also, if there are low-lying portions of a field or border strips that are not in agricultural production, excess applied water can be directed to these areas where it can be contained by topography or the construction of low berms and allowed to infiltrate the ground and recharge the underlying groundwater system, rather than flowing off the field.

The 2 practices above are examples of conjunctive management, which recognizes that surface water and groundwater are interdependent and seeks to combine and balance the beneficial use of both water sources to promote sustainable water use while minimizing any negative economic or environmental impacts that have the potential to occur (Dudley and Fulton, 2006). Conjunctive management is often practiced on a larger scale, but it can be applied by individual growers through the practices above (and others) to maximize surface water usage when available and promote groundwater sustainability.

7C.3.2 Managing soil to improve infiltration and root zone soil moisture storage

Another on-farm practice that will promote groundwater sustainability is management of soil at the ground surface and within the root zone to improve infiltration of applied water and reduce runoff or ponding on the ground surface. This can be implemented through a variety of on-farm practices including planting cover crops or using crop rotations to increase organic matter

content in the root zone, application of manure or other organic material, limiting soil compaction by minimizing use of heavy equipment, and if there is a restrictive layer near the surface of the ground, potentially using deep ripping or tillage to improve infiltration past the restrictive layer (Sanden et al, 2016; USDA-NRCS, 2014). Improving infiltration will result in increases in direct recharge and improving soil moisture storage may increase effective precipitation and slightly reduce the required volume and frequency of irrigation.

7C.3.3 Reducing non-beneficial evapotranspiration

This section describes 2 potential methods for reducing non-beneficial ET through altering and carefully controlling the timing and volume of applied water.

7C.3.3.1 Precision irrigation scheduling

Precision irrigation scheduling has the potential to benefit both grower profits and sustainable groundwater management. Precision irrigation scheduling enables growers to accurately identify the timing and volume of irrigation water to apply to maximize crop productivity while minimizing water application. It typically requires real-time or near real-time information on soil moisture and weather conditions, and is crop dependent. When effectively implemented, precision irrigation scheduling promotes sustainable groundwater management through increased water use efficiency; water that otherwise would have been applied to the field remains in the groundwater system or is available for use elsewhere.

7C.3.3.2 Regulated deficit irrigation

Regulated deficit irrigation applies irrigation water during important drought-sensitive growth stages for a crop and reduces applied irrigation water (i.e., deficit irrigation) during other growth stages where there will be little to no effect on crop yields. This on-farm management practice needs to be prudently applied, but it has the potential to reduce applied water and associated irrigation costs while having little to no impact on crop yields. It promotes sustainable groundwater management through reduced consumptive use; water that otherwise would have been applied to the field is not consumed and remains in the groundwater system or is available for use elsewhere.

7C.3.4 Implementing a Groundwater Users Cooperative

In Glenn County, a preliminary concept was put forth to develop a voluntary local groundwater users cooperative. The purpose of this cooperative would be to coordinate agricultural pumping schedules to lessen the stress on the aquifer due to concentrated pumping in an area.

With greater cooperation and scheduling, a cooperative groundwater users program could limit the interference from one well to a neighboring well, also limiting the regional combined cone of depression created while many users are pumping a the same time.

This management action would include baseline monitoring and data collection, outreach, education, and cooperation from local landowners, as web-based mapping interface and pumping scheduling components. A discussion with the local utility companies of Time of Use may be needed. Potential areas where this approach would be beneficial include areas of concentrated agricultural activities where surface water is not available to growers. Such areas in the Corning Subbasin include the Capay region in Glenn and Tehama counties, and the northwestern portion within Tehama County near Thomes Creek, where rapid expansion of orchards is occuring.

Outreach/Education/Cooperation components would likely include:

- Public meetings
- Potential agreements to share well data
- Program registration, training and testing
- Monitoring groundwater levels within the cooperative area
- Development of feedback mechanisms for interference data
- Development of a detailed GIS-based web-application to track location of wells and when wells are operated, incorporate water level monitoring data and evaluate potential interferences

Additional details for such a cooperative would be developed during GSP implementation.

7C.4 References

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Appendix 7D

Development and Simulation of Full Allocation Scenario Management Action

MONTGOMERY & ASSOCIATES
Water Resource Consultants

Groundwater experts since 1984

TECHNICAL MEMORANDUM

DATE: April 14, 2021, revised July 22, 2021

TO: Corning Subbasin GSAs

CC: Charles Brush (Hydrolytics), Davids Engineering

FROM: Patrick Wickham (M&A) and Lisa Porta (M&A)

PROJECT: Corning Subbasin Groundwater Sustainability Plan Modeling

SUBJECT: Development of Full Allocation Scenario for Projects and Management Actions

INTRODUCTION

Surface water use in the Corning Subbasin has declined historically in response to low allocations in drought and increased grower preference for groundwater. Particularly since the 2012-2015 drought, growers have generally preferred groundwater over surface water due to the increased cost and unreliability of surface water deliveries, and the investment made in drilling new irrigation wells to satisfy unmet water demands (see Water Budget Section **4.2.5 Subbasin Water Supply Reliability)**. As indicated by declining groundwater elevations and further supported by modeled water budgets, these decreases in surface water use negatively affect the Subbasin's groundwater balance.

Approximately 40% of the Subbasin's irrigated area has access to surface water supplies, with major purveyors including Orland Unit Water Users Association (OUWUA), Corning Water District (WD), Thomes Creek WD, and Kirkwood WD. These purveyors have all experienced declining surface water use, particularly over the last ten years. If these purveyors were able to fully utilize their contracted surface water allocations in the future, it may improve the Subbasin's overall water balance and lead to recovery or stabilization in groundwater elevations. The following Full Allocation Scenario (FAS) aims to simulate effects of these districts utilizing their full surface water allocations in the future.

DEVELOPMENT OF SCENARIO

FAS development included the following steps:

- **Analysis of historical applications** to determine average monthly diversions by water year type (WYT).

- **Analysis of historical allocations** to determine average annual (WY) allocations by WYT.
- **Calculation of FAS monthly application values** for each WYT and creation of input file.

The following paragraphs describe how FAS simulated diversion inputs were developed for the following application areas:

- Corning Canal to Corning WD
- Corning Canal to Thomes Creek WD
- Tehama Colusa Canal to Kirkwood WD
- Stony Creek to Orland Unit Project

Analysis of Historical Surface Water Diversions

Historical applications present in the existing model were analyzed to determine average applications by month and WYT. Only WYs 1990 and onward were analyzed, to reflect the most recent cropping and water application patterns while retaining several instances of each WYTs to analyze. Table 1 below illustrates this using Corning Canal to Corning WD as an example, presenting the percentage of annual application volume. Most irrigation occurs in the summer, reaching a peak around July. Drier years generally have a wider spread of irrigation across the summer months as compared to normal and wet years. The same methodology was used for the other 3 districts.

Table 1. Corning Canal to Corning WD Average Monthly Diversion in Historical Model by Water Year Type, % of Annual

Month	C	D	BN	AN	W
1	3%	0%	1%	0%	0%
2	1%	0%	1%	1%	0%
3	1%	1%	1%	1%	0%
4	23%	6%	4%	3%	3%
5	10%	13%	11%	9%	10%
6	12%	18%	20%	18%	16%
7	13%	21%	22%	23%	24%
8	12%	19%	21%	21%	22%
9	9%	12%	14%	17%	15%
10	10%	7%	5%	8%	8%
11	5%	1%	1%	1%	1%
12	1%	1%	1%	0%	0%
Annual	100%	100%	100%	100%	100%

C = Critically dry, D = dry, BN = Below normal, AN = Above Normal, W = Wet

Analysis of Historical Surface Water Allocations

Historical allocations were analyzed to determine how much surface water has been available to the districts by WYT as a percentage of total allocation, reflecting how allocations are typically reduced in critically dry and dry years. Eleven years of recent data from Corning WD (Table 2) were used to develop percent surface water allocations by WYT (Table 3). It was assumed this same percent allocation is valid for all Central Valley Project (CVP) contractors within the Subbasin that receive water from the Corning Canal and the Tehama Colusa Canal. This percentage was then multiplied by the currently contracted total allocation for each district to develop an annual FAS value by WYT.

Table 2. Corning WD % Allocations by WYT

Year	WYT	% Allocation
2010	BN	100%
2011	W	100%
2012	BN	100%
2013	D	75%
2014	C	0%
2015	C	0%
2016	BN	100%
2017	W	100%
2018	BN	100%
2019	W	100%
2020	D	50%

Table 3. Average % Allocation by WYT for CVP Contractors

WYT	Average % Allocation
C	0%
D	63%
BN	100%
AN	100%
W	100%

Corning Water District

The table below illustrates this approach for Corning WD. Their current contracted allocation is 15,000 acre-feet per year (AF/yr). In critically dry years, transfers are estimated from recent historical data and added to the allocations where applicable.

The percentage allocation shown below (column three) is based on historical allocations (2010 to 2020) for Corning WD. The final column displays the annual total simulated allocation by WYT, used to create the simulated monthly timeseries for the model input.

Table 4. Historical amd Simulated Allocation by Water Year Type, Corning WD

Current Contract (AF/yr)	WYT	Average % Allocation	Estimated Transfer In (AF/yr)	Annual Simulated Allocation (AF/yr)
15,000	C	0	900	900
15,000	D	63	0	9,375
15,000	BN	100	0	15,000
15,000	AN	100	0	15,000
15,000	W	100	0	15,000

Thomes Creek Water District

For Thomes Creek WD, a current total allocation of 4,400 acre-feet per year (AF/yr) was assumed. The district had historically 6,400 AF/yr but sold 2,000 back for the environmental water account.

Table 5. Historical Allotments and Simulated Allocation by Water Year Type, Thomes Creek WD

Current Contract (AF/yr)	WYT	Average % Allocation	Estimated Transfer In (AF/yr)	Annual Simulated Allocation (AF/yr)
4,400	C	0	0	0
4,400	D	63	0	2,750
4,400	BN	100	0	4,400
4,400	AN	100	0	4,400
4,400	W	100	0	4,400

Kirkwood Water District

For Kirkwood WD, a 1,500 AF/yr total allocation was assumed. Their original allocation was 2,100 AF/yr, but they have sold some amounts to other districts. This is an estimated current allocation.

Table 6. Historical Allotments and Simulated Allocation by Water Year Type, Kirkwood WD

Current Contract (AF/yr)	WYT	Average % Allocation	Estimated Transfer In (AFY)	Annual Simulated Allocation (AFY)
1,500	C	0	0	0
1,500	D	63	0	938
1,500	BN	100	0	1,500
1,500	AN	100	0	1,500
1,500	W	100	0	1,500

Orland Project

The Orland Project is operated and maintained by the Orland Water Users' Association (OUWUA). The Orland Project water supply has not been significantly cut historically, with the exceptions of the years 1976, 1977, 2014 and 2021.

Orland's water rights allow for the diversion of 279 cubic feet per second of Stony Creek flows to a maximum of 85,000 AF annually. However, natural flows do not occur long enough during the irrigation season to provide for 85,000 AF. In addition, Orland operates two storage reservoirs, each having approximately 50,000 AF of storage.

Total annual diversions during the years 2009 through 2020 ranged from 61,042 AF (during the drought year 2014) to 94,548 AF in 2012. Diversions during 2021 will be considerably less than 2014. The area served by the north canal system typically accounts for about one 1 third to 1 half of total annual diversions.

To account for the relatively stable deliveries to the Orland Project, OUWUA percent allocation was set at 100% for all WYTs with an estimated 35,000 AF/yr for the North canal area total allocation.

Table 7. Historical Allotments and Simulated Allocation by Water Year Type, OUWUA

Current Contract (AF/yr)	WYT	Average % Allocation	Estimated Transfer In (AF/yr)	Annual Simulated Allocation (AF/yr)
35,000	C	100	0	35,000
35,000	D	100	0	35,000
35,000	BN	100	0	35,000
35,000	AN	100	0	35,000

35,000	W	100	0	35,000

Calculation of FAS Monthly Application Values

Corning Water District

Combining the monthly diversion percentages derived from historical data with the current assumed total allocations by WYT results in a FAS model input file which accounts for monthly variation, variation by WYT, and results in the maximum application of district allocations. Given the annual FAS allocation by WYT and the monthly percentage distribution of district applications, a monthly timeseries of future diversions was created for the FAS. Figure 1 shows monthly FAS application values by WYT for Corning WD. This figure details the monthly applications by WYT used to inform the FAS scenario.

Figure 2 displays this diversion timeseries as compared to historical diversions and diversions in the 'current' model simulation. Values are plotted on the historical period to allow comparison with the historical model. FAS values for Corning WD indicate greatly increased flows from the current scenario, and plot similarly to recent historical values. The following subsections display similar figures for the other districts altered in the FAS.

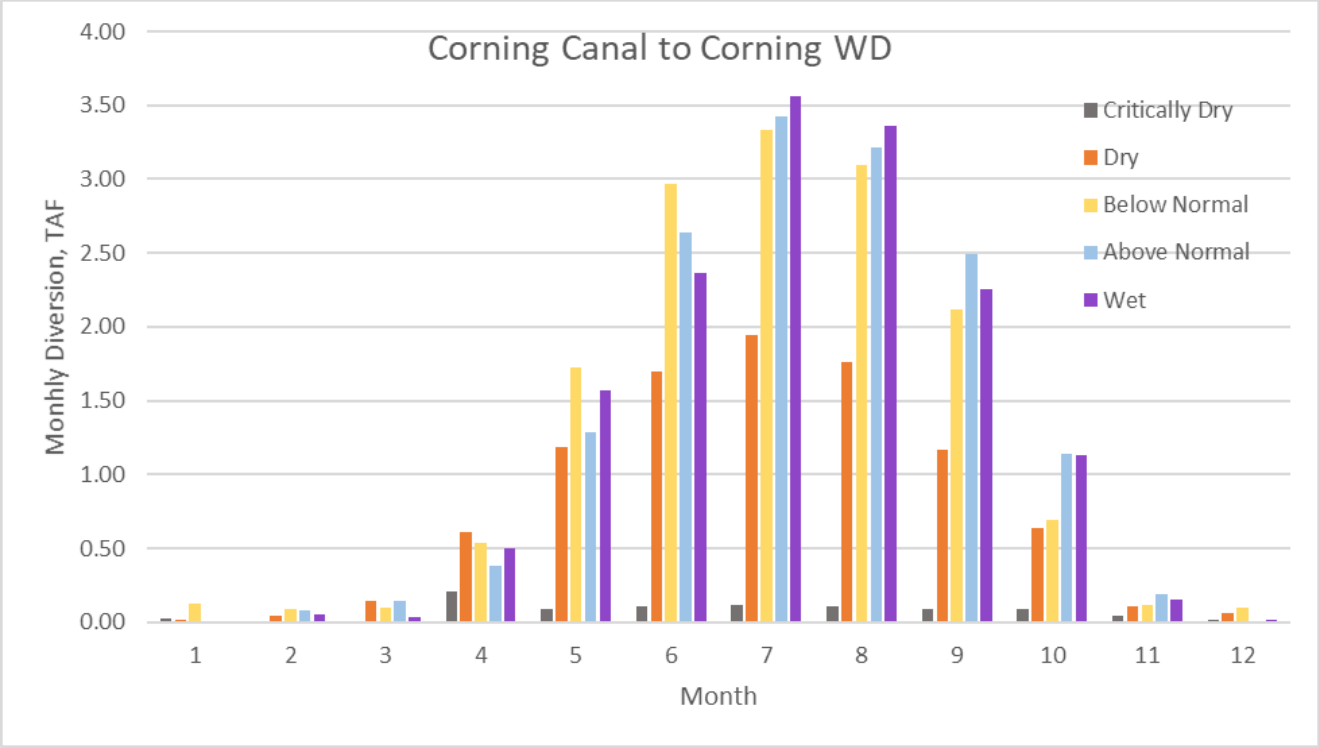


Figure 1. Corning Canal to Corning WD FAS Monthly Diversions by Water Year Type, TAF

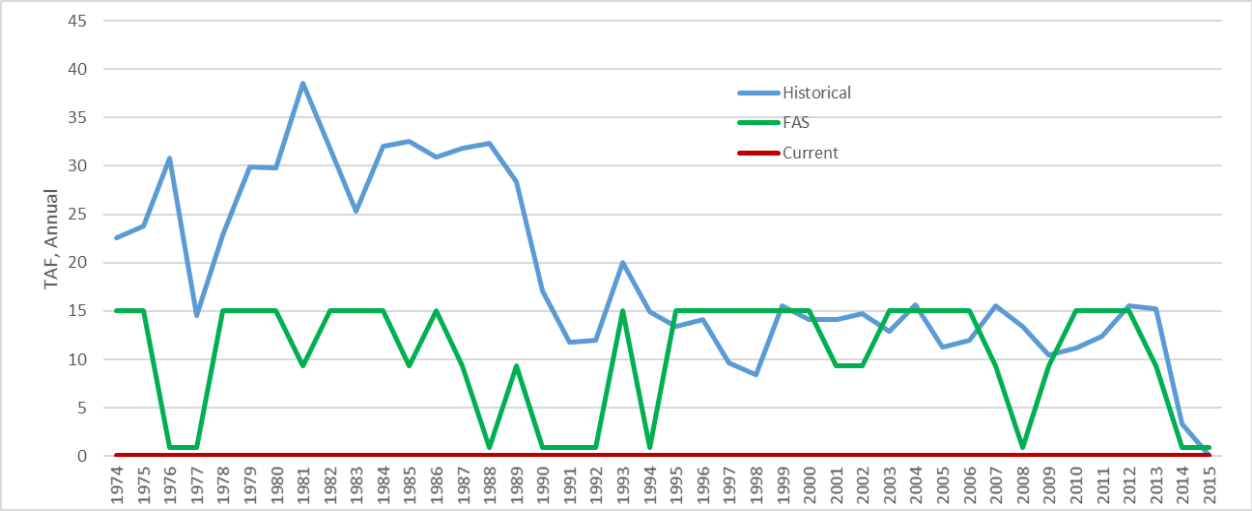


Figure 2. Historical, Current, and FAS Corning WD Simulated Diversions Timeseries

Thomes Creek Water District

The figures below display Thomes Creek WD monthly FAS application values by WYT, and the FAS annual timeseries as compared to historical and current scenarios. FAS values for Thomes Creek WD indicate greatly increased flows from the current scenario in all years but critically dry years, bringing application values in line with recent historical trends.

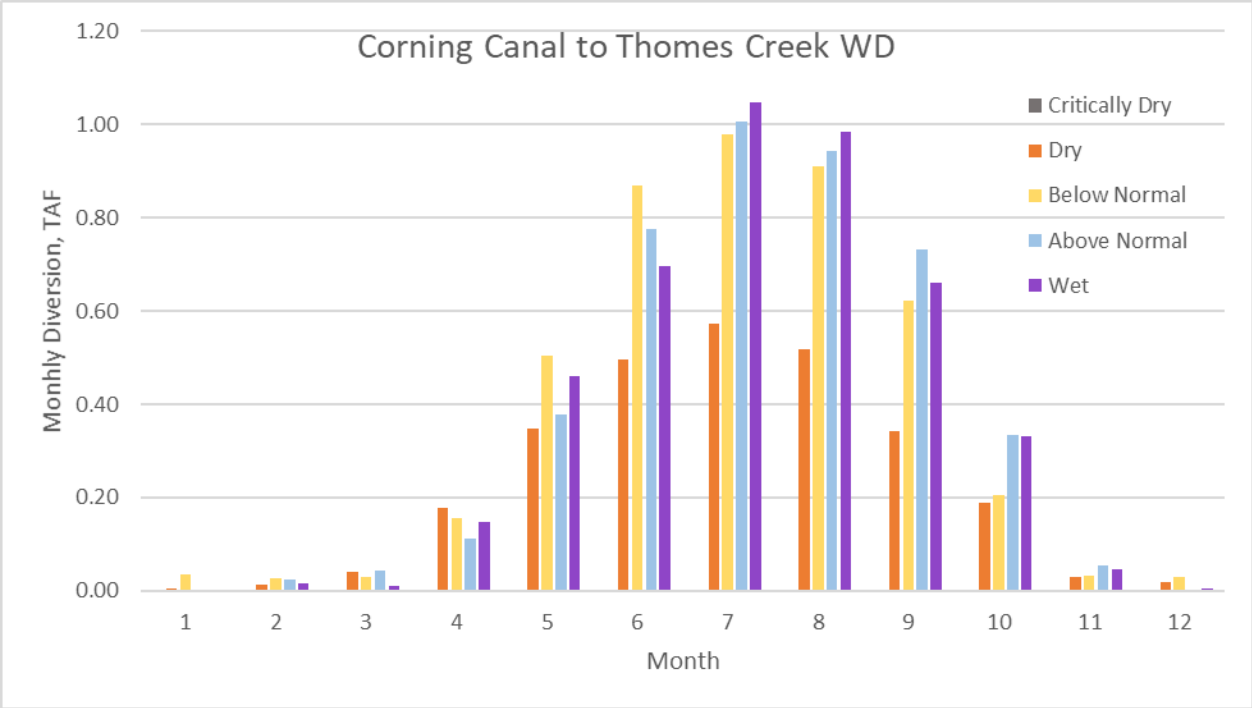


Figure 3. Corning Canal to Thomes Creek WD FAS Monthly Diversions by Water Year Type, TAF

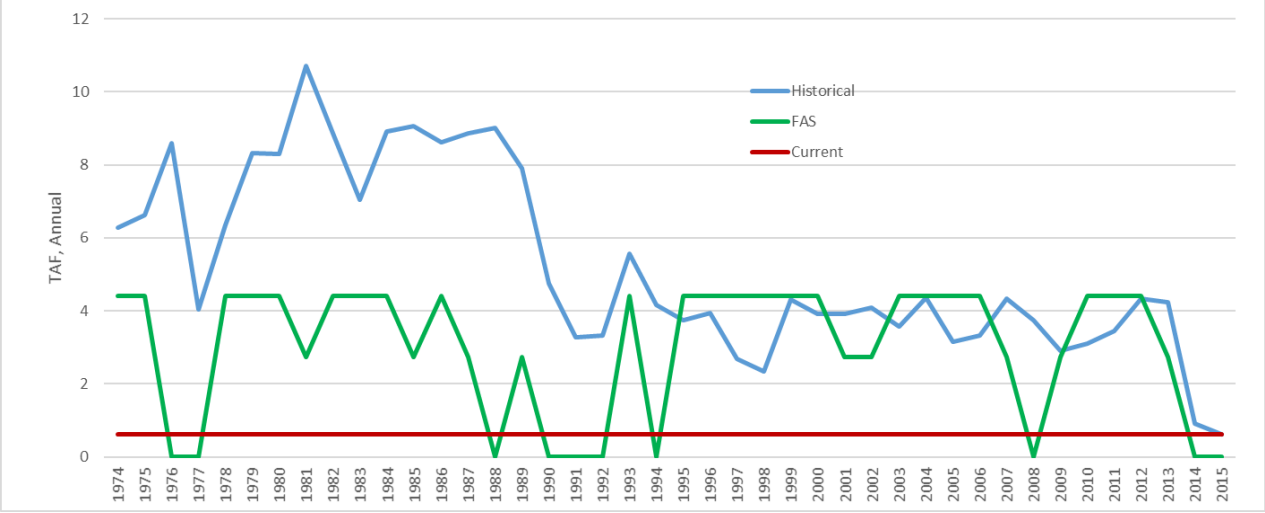


Figure 4. Historical, Current, and Corning Canal to Thomes Creek WD Simulated Diversions Timeseries

Kirkwood Water District

The figures below display Kirkwood WD monthly FAS application values by WYT, and the FAS annual timeseries as compared to historical and current scenarios. FAS values for Kirkwood WD indicate greatly increased flows from the current scenario. As compared to historical, the FAS scenario includes more than double the average available application in wet years. This indicates that Kirkwood WD potentially has more surface water allocated than is used and it could be sold to others within the Subbasin or used for groundwater recharge projects.

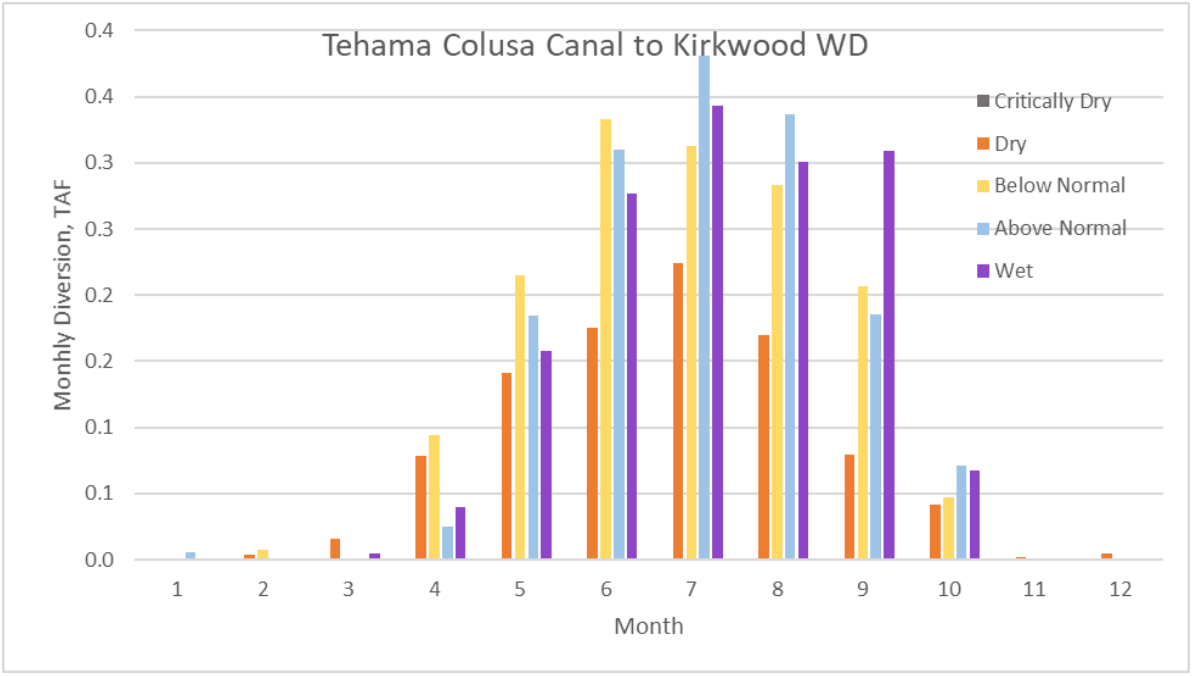


Figure 5. Tehama Colusa Canal to Kirkwood WD FAS Monthly Diversions by Water Year Type, TAF

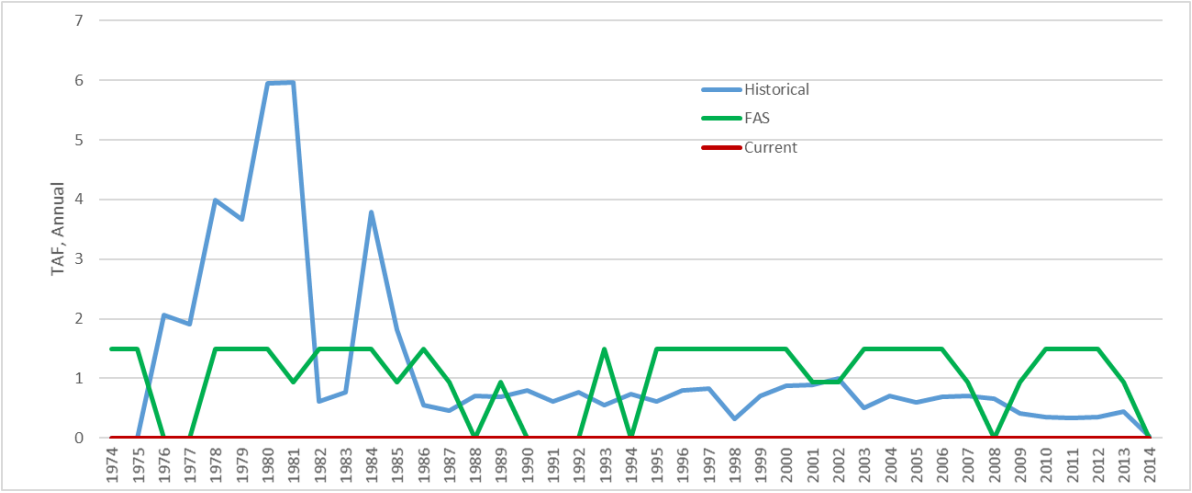


Figure 6. Historical, Current, and FAS Tehama Colusa Canal to Kirkwood WD Simulated Diversions Timeseries

Orland Project

The figures below display OUWUA monthly FAS application values by WYT, and the FAS annual timeseries as compared to historical and current scenarios. FAS values for OUWUA indicate slightly increased diversions from the current scenario. As compared to historical, the FAS scenario has roughly equivalent average annual application.

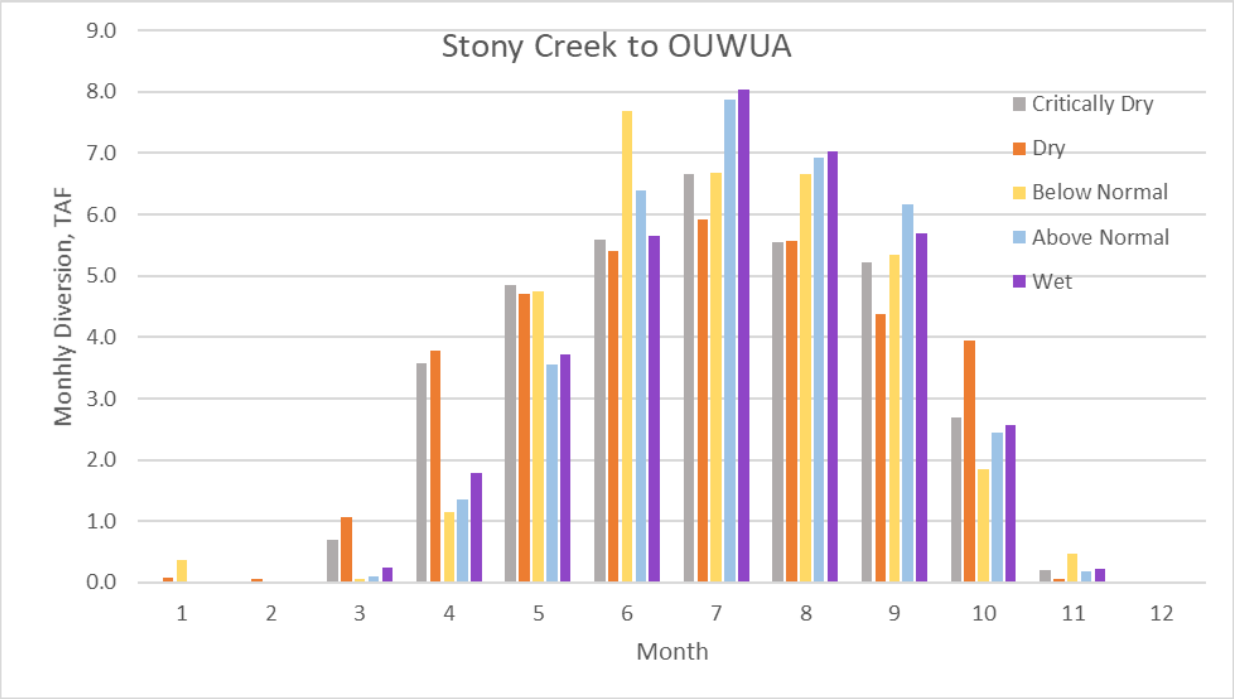


Figure 7. Stony Creek to OUWUA FAS Monthly Diversions by Water Year Type, TAF

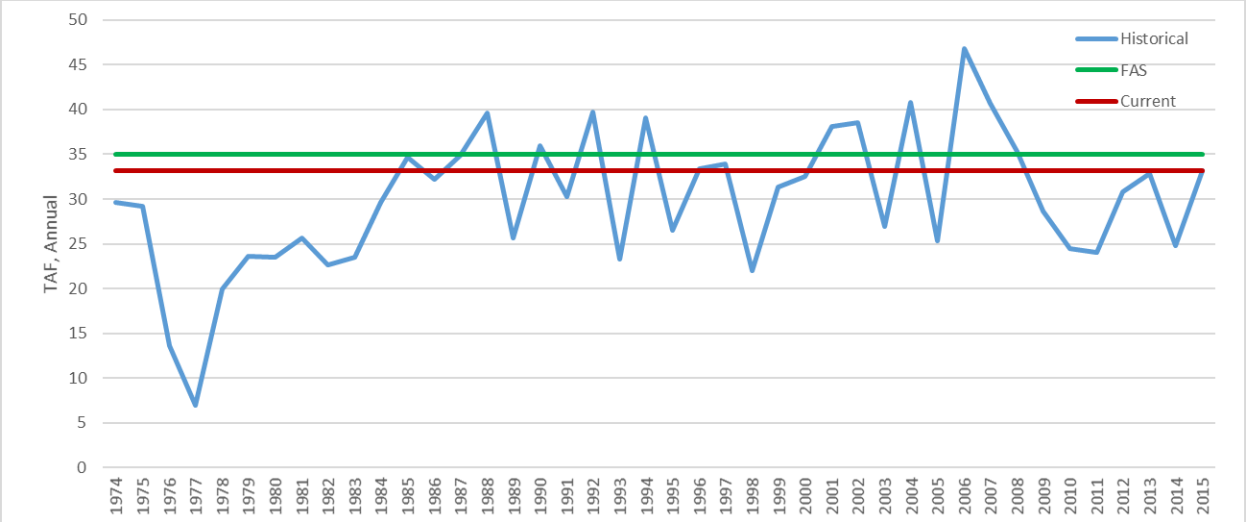


Figure 8. Historical, Current, and FAS Stony Creek to OUWUA Simulated Diversions Timeseries

RESULTS

The FAS simulation results in a 10,500 acre-foot decrease in annual groundwater pumping compared to the projected baseline scenario. This decrease in pumping produces an average of 900 acre-feet per year of additional groundwater in storage, building to an additional 42,700 acre-feet of cumulative groundwater storage after 50 years of simulation. This increase in storage results in groundwater level rises by up to 20 feet in portions of the Subbasin in Corning WD where groundwater level trends are declining since 2012. The FAS is also predicted to provide benefits to neighboring subbasins, as higher groundwater elevations in the Corning Subbasin result in less inflow from adjacent subbasins.

Groundwater Elevation Benefits by Water Year Type

Figure 9 and Figure 10 display the simulated change in September groundwater elevations with FAS implementation, by comparing FAS results to the 2070 projected baseline. Increases in groundwater elevation in a wet year following 26 years of simulation, shown on Figure 9, result in up to 20 feet of groundwater level increase as compared to baseline. Benefits are centered around the Subbasin's CVP contractors, who have experienced the larger decreases in recent surface water use as compared to OUWUA. Groundwater level increases of at least 1 to 5 feet spread across most of the Subbasin, and north into southern Red Bluff Subbasin.

Increases in groundwater elevation in a dry year following 42 years of model simulation, shown on Figure 10, present up to 10 feet of groundwater level increase as compared to baseline. Elevations are increased by 5 to 10 feet in the central-western portions of the Subbasin near the CVP contractors, and 1 to 5 feet across the majority of the Subbasin stretching into northern Colusa Subbasin and southern Red Bluff Subbasin. While the previous figure illustrates maximum benefits predicted by the scenario, this figure helps illustrate minimum benefits by displaying a dry year when less surface water is applied. Therefore, any observed benefits occur due to residual effects of increased surface water application in previous normal and wet years. In this way, Figure 10 illustrates how long-term benefits of increased surface water applications persist even in dry years. In-lieu groundwater recharge in wetter years when surface water is readily available to CVP contractors provides for additional groundwater availability to pump in dry years when there is no surface water is available.

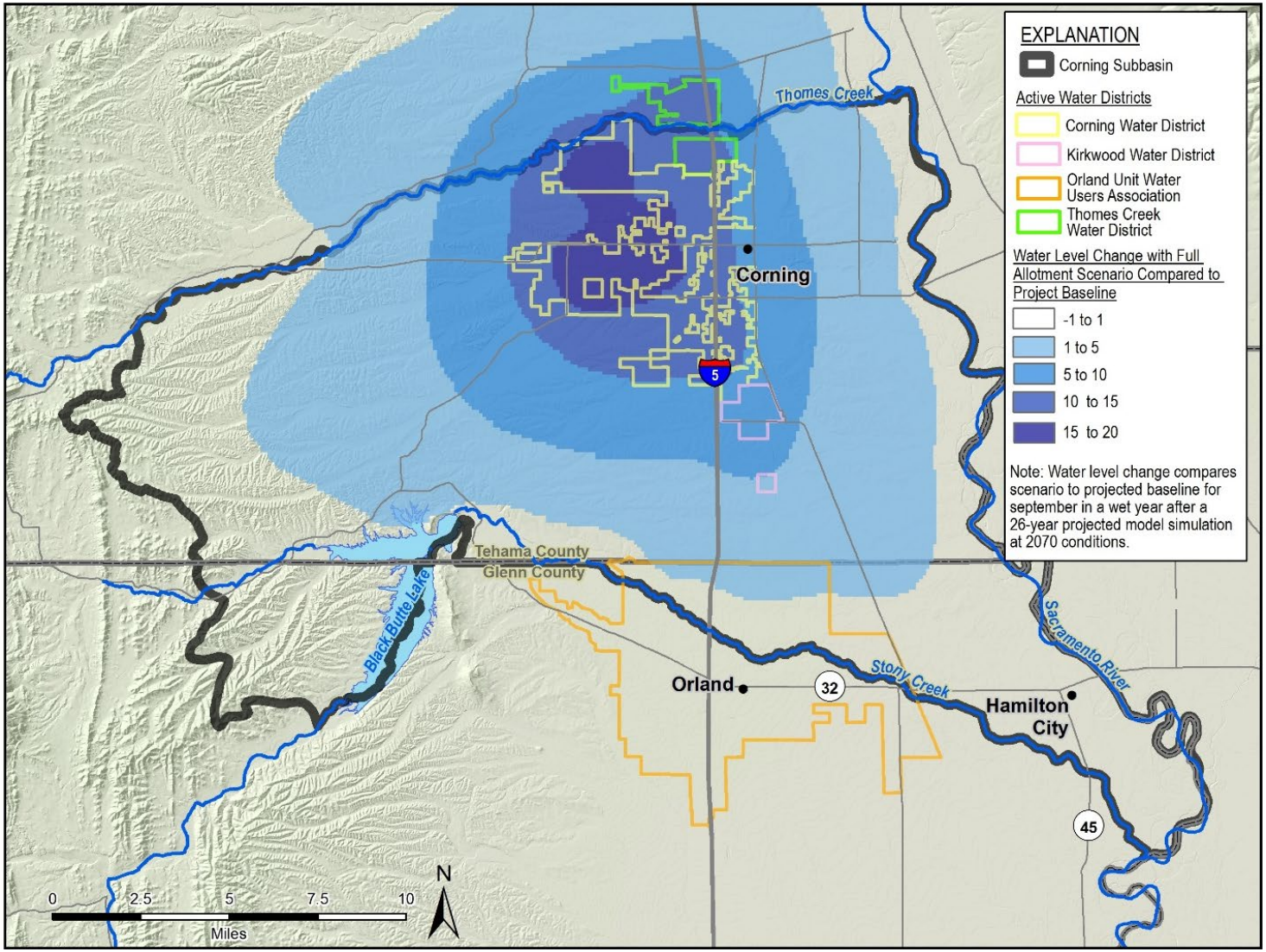


Figure 9. Simulated Groundwater Elevation Benefit from Full Allocation Scenario in a Wet Year Following 26 Years of Model Simulation

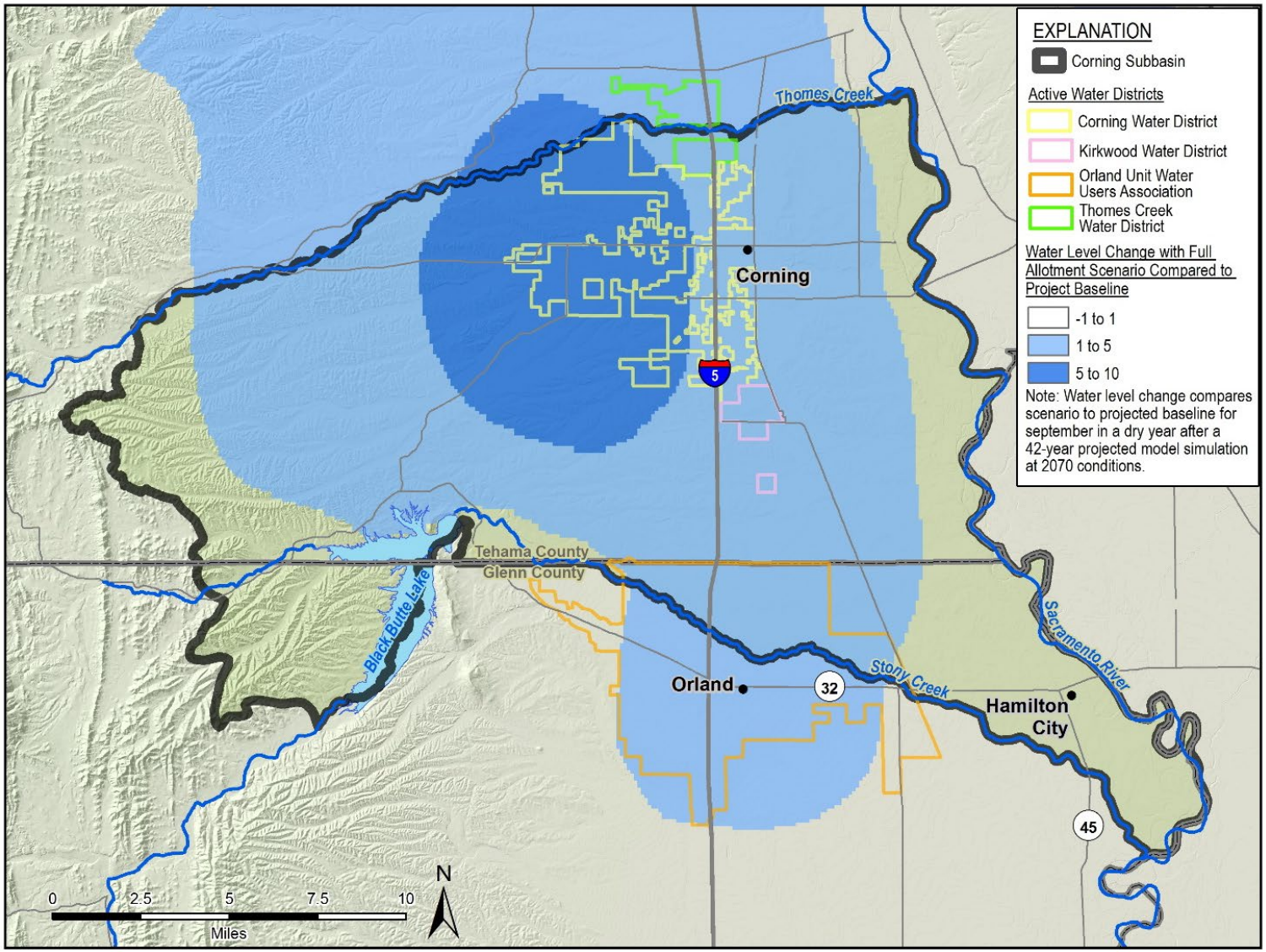


Figure 10. Simulated Groundwater Elevation Benefit from Full Allocation Scenario in a Dry Year Following 42 Years of Model Simulation

Groundwater Elevation Benefits Over Time

Figure 11 and Figure 12 display simulated benefits from the FAS as compared to the projected baseline shown as a difference in groundwater elevation over time at one well, for the entire projected simulation timeframe. Values greater than zero indicate an increase in groundwater elevations as compared to baseline. These figures are not intended to provide estimation of increases in groundwater elevation at a specific point in the future, but rather to illustrate potential increases in groundwater elevation between the projected baseline simulation and a scenario that simulates full utilization of surface water allocations. To illustrate these changes, 1 well within the Corning WD and 1 well within the OUWUA area are used, as shown below.

Figure 11, which displays simulated benefit for well 24N03W17M001M in the Corning WD area, illustrates groundwater elevation increases in the area which is expected to receive the most benefit. Groundwater elevations are predicted to increase up to approximately 20 feet; elevations are notably increased during wet and very wet years. While benefits are relatively lower in dry years, residual increases in groundwater elevation of at least 4 feet persist. These illustrate how utilizing full surface water allocations would increase operational flexibility.

Figure 12, which displays simulated groundwater elevation increases from baseline for well 22N03W01R001M in the OUWUA area, illustrates groundwater elevation increases in a portion of the Subbasin expected to receive less benefit. As compared to baseline, groundwater elevations are still generally increased by roughly 2 to 4 feet. In some of the wet years elevations are slightly decreased from baseline, a result of taking more water from Stony Creek and therefore reducing downstream streambed recharge to groundwater.

Future changes in groundwater elevation will be monitored using the networks described in Section 5 of this GSP. Direct correlations between increased surface water applications and changes in groundwater elevations may be difficult to quantify due to implementation of concurrent management actions and projects in the Subbasin.

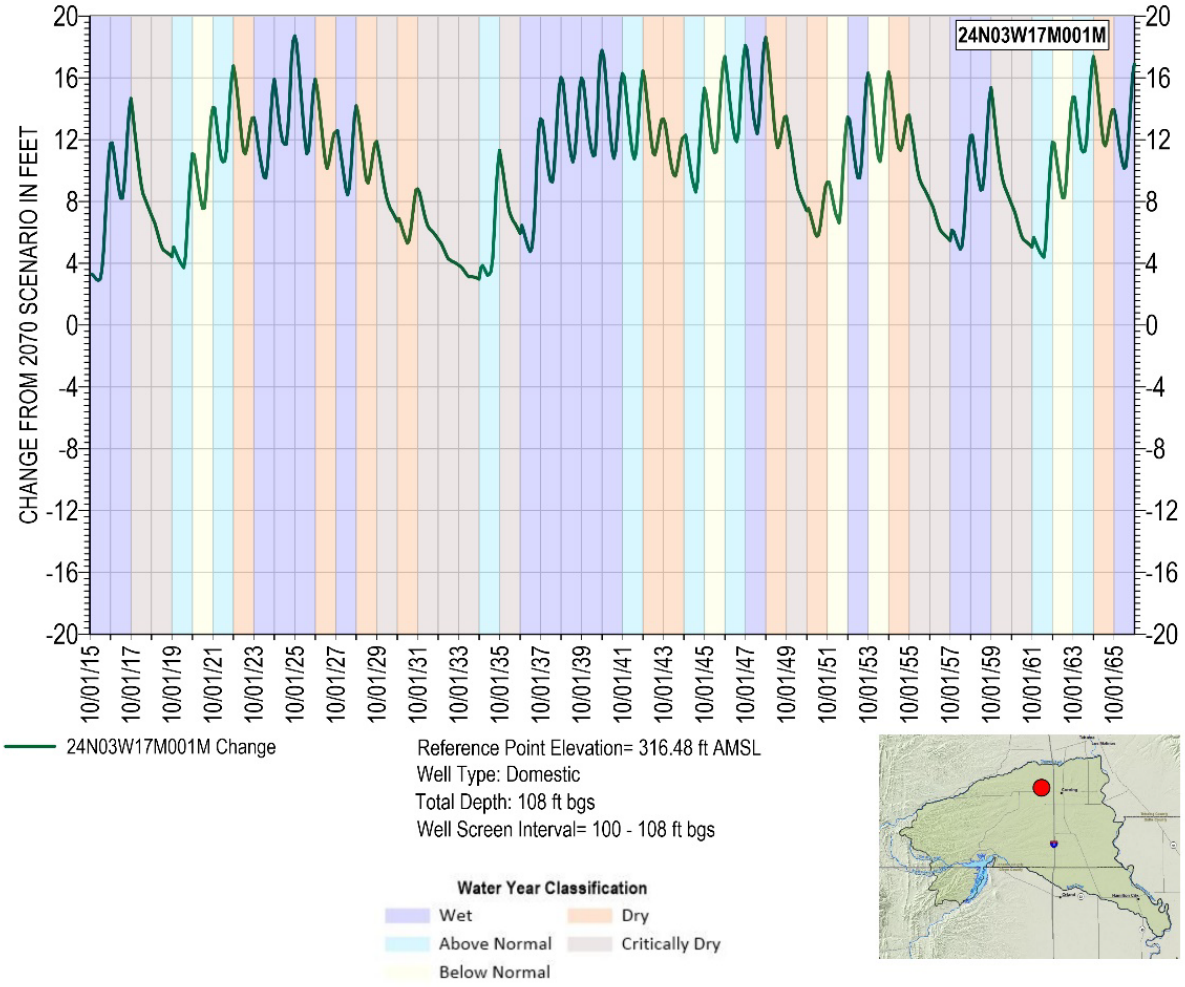


Figure 11. Simulated Groundwater Elevation Change from Full Allotment Scenario within Corning WD Area

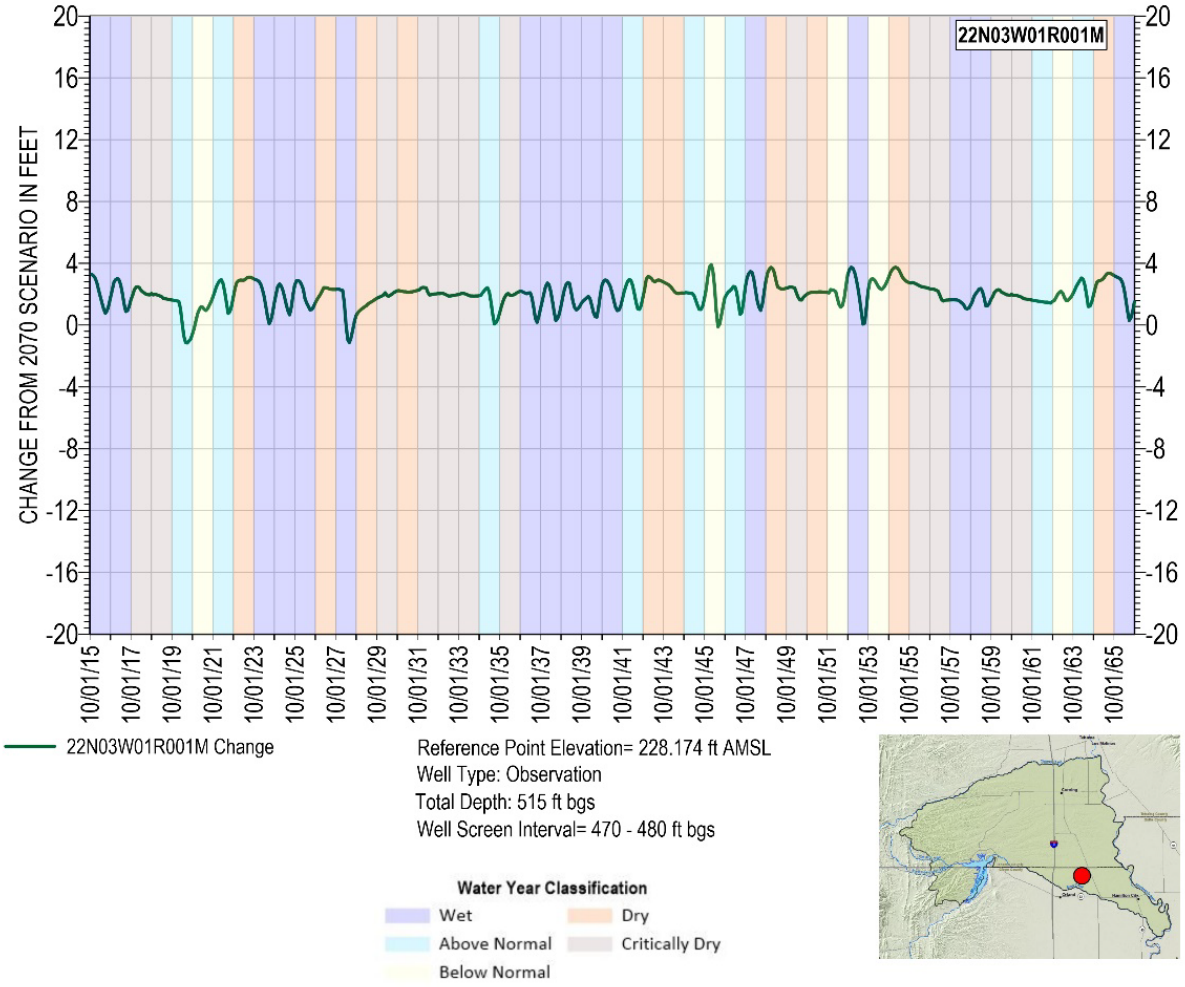


Figure 12. Simulated Groundwater Elevation Change from Full Allotment Scenario Within OUWUA Area

Appendix 7E

Potential Sources of Surface Water Available for Projects

7E. POTENTIAL SOURCES OF SURFACE WATER AVAILABLE FOR PROJECTS

Increasing surface water use would help achieve sustainability in the Subbasin by decreasing reliance on groundwater. Most of the projects and some of the management actions described in Section 7 are focused on increasing the use of surface water supplies. Increasing surface water use is most easily done through existing surface water rights and contracts. Most of the permitted, unused surface water currently available to growers in the Subbasin is through existing CVP contracts, as described in Section 7.3.2.4. Stony Creek is adjudicated by federal decree (*United States of America v H.C. Angle et al*[1]*)* and consequently Stony Creek and its tributaries are fully appropriated.

Developing new supplies or water rights is more difficult and would take longer than using existing permitted supplies, as it would require additional regulatory compliance and water may not be available when needed most in the dry irrigation season. Any modification to the existing CVP contracts or any transfer of CVP water between CVP contractors would likely be completed under the USBR Accelerated Water Transfer Program and subject to USBR approval. Surface water from the streams in the Subbasin is available seasonally, pending water rights applications. Purchases of excess river flows by CVP contractors could be completed under Section 215 of the Reclamation Reform Act. Similarly, new water rights can be acquired by water districts or individuals in the wet season through the State Water Resources Control Board (SWRCB) Division of Water Rights. Additional information on the potentially available water sources in the Subbasin is included below.

7E.1 CVP Contract Water

Most of the surface water available to growers in the Subbasin are through CVP contracts as well as other federal contract water. This section describes some of the regulatory background and legal framework to transfer CVP water for beneficial use.

7E.1.1 Background

The Central Valley Improvement Act of 1992 (CVPIA) enabled federal water contractors to transfer all or part of their contract amount to any other California water user, including State or Federal Agency or Indian Tribe. For certain regions, including the Sacramento Valley, the USBR currently has in place an Accelerated Water Transfer Program which enables the transfer and exchange of up to 500,000 acre-feet of project water under previously completed environmental documentation. Water transfers are regulated by either USBR (CVP), DWR (State Water Project (SWP), or the SWRCB.

[1] https://casetext.com/case/united-states-v-angle-6

Water transfers or exchanges between CVP contractors are not regulated by the State Water Resources Control Board unless the point of diversion, purpose of use, or place of use under CVP's water right will change to complete the transfer. Thus, CVP transfers only need review and approval from the USBR.

Water transfers from CVP to SWP contractors require the approval of both state and federal agencies, and also the SWRCB if the place of use is outside the transferor's service area.

7E.1.2 Reclamation Reform Act Section 215 Water Supplies

Section 215 of the Reclamation Reform Act (RRA) allows for excess and unstorable winter/ spring flows to be purchased by water districts through USBR. Section 215 is described by USBR as a "Public Law [that] authorizes the Bureau of Reclamation (Reclamation) to provide temporary water service contracts (Section 215 contracts) of one year or less for water supplies that are not storable for project purposes or are infrequent and otherwise unmanaged flood flows of short duration". The determination of excess flow is made by the USBR Central Valley Office (CVO) based on a variety of factors including, but not limited to, water temperature, minimum flows, Delta X-2 salinity conditions, and tributary inflows. This decision is made reactively, not predictively, and so contracts must be in place and water meters operational ahead of time. In some years, Section 215 water is available only for a short period (such as several days). Additionally, the timing of water availability corresponds with winter storms or snowpack melt and thus is typically available outside the typical irrigation season. However, to the extent these conditions occur during the irrigation season, water districts could maximize Section 215 water use for in-lieu recharge projects.

Most Sacramento Valley CVP contractors have a provision that entitles them to Section 215 water under their annual contracts. Prior to the implementation of SGMA, there were many years without a demand for this water. During Dry and Critical years, the demand is higher, but there is little water available. During wet years, there is availability, but generally no demand. Typically, Section 215 water was purchased in average, below normal, or above normal years, and not in dry or critically dry years.

Currently, if a water district has a contract for Section 215 water in place, the District will make inquiries to USBR regarding availability. USBR asks the CVO for their determination, and if they estimate availability USBR authorizes the district to divert the water. The districts are required to read their meters (typically at TCC turnouts) before and after Section 215 deliveries begin, to fully account for the diversion.

7E.2 Unappropriated Streams

There are seasonally unappropriated stream systems in the Corning Subbasin that could be used as water supply for irrigation or for groundwater recharge projects. Information related to stream appropriation in the Subbasin is available through the SWRCB water rights permitting office.

Adopted in 1998 by the SWRCB, Water Right Order 98-08 identifies Fully Appropriated Stream Systems (FASS) in California based on prior determinations that no water from these systems remains available for appropriation during certain months. The SWRCB does not accept applications for new water rights in an FASS unless the designation allows new applications under certain conditions, though parties can petition to revise an FASS declaration prior to applying for a new water right.

The SWRCB developed an interactive GIS web-application map for easy visualization of fully appropriated streams throughout the state. The FASS reaches shown on Figure 7-3 provide general reference of critical reaches of FASS in and around the Corning subbasin. That an area does not contain an FASS does not indicate the availability of water, only that the area was not included in Water Right Order 98-08. For example, most of the reaches in the Sacramento Valley are only fully appropriated during the summer irrigation season, and other months during the year might still have available water for diversion Stony Creek and its tributaries are the only fully appropriated stream system in the Subbasin.

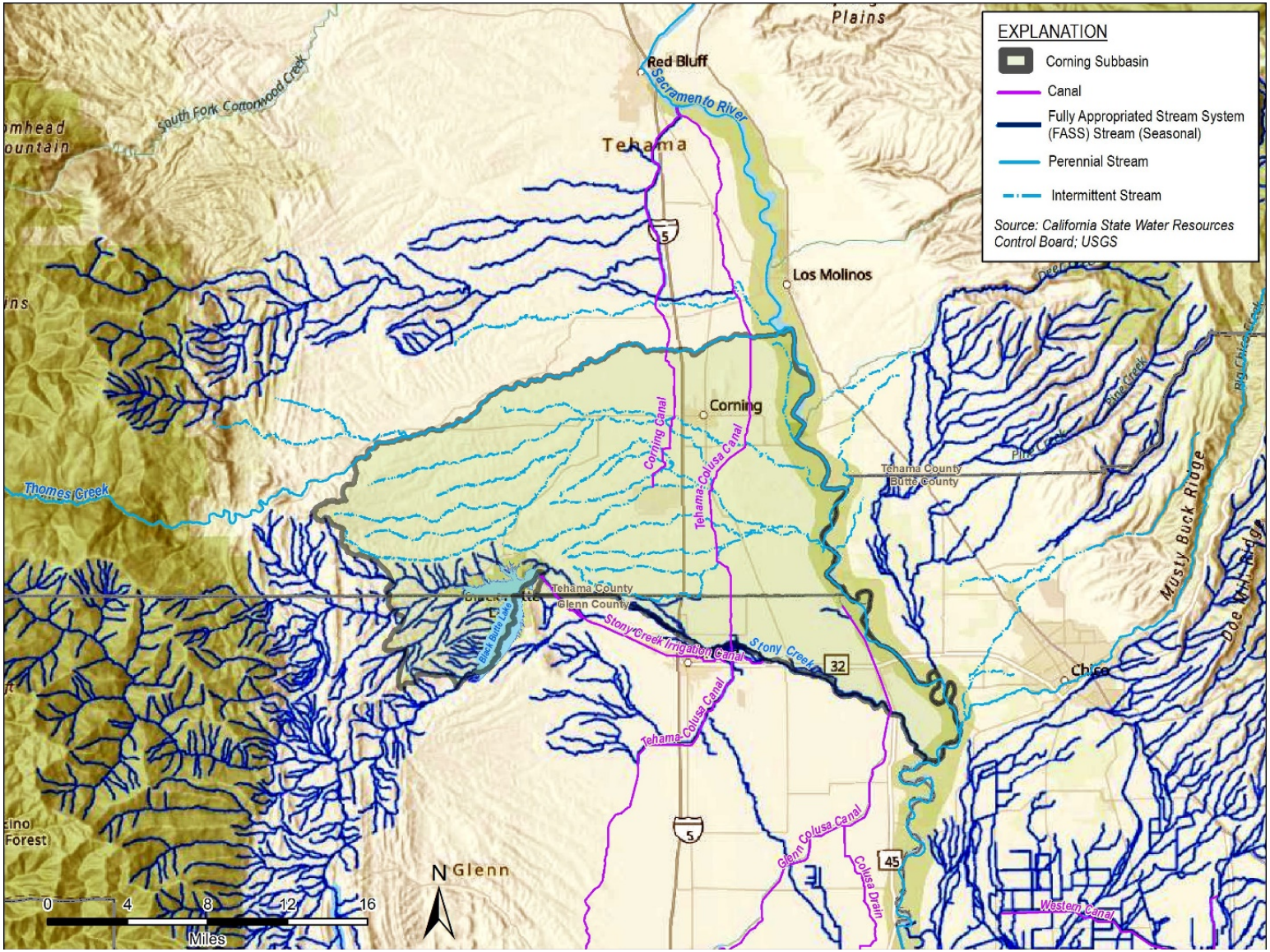


Figure 7E-1. FASS Streams Mapped in and around the Corning Subbasin (Source: SWRCB)

Table 7-2 includes the FASS and critical reaches that flow in or near the Corning subbasin. FASS declarations encompass all upstream sources; therefore, all stream systems in the Corning subbasin that are hydraulically continuous tributaries of the Sacramento River, for example, are considered fully appropriated from June 15 to August 31.

Table 7-1. FASS in and around the Corning Subbasin

FASS	Season	Critical Reach
Sacramento-San Joaquin Delta	6/15 – 8/31	From the Delta upstream
Stony Creek Stream System	4/11 – 11/30	From the confluence of Stony Creek with the Sacramento River upstream
Unnamed Drain	4/1 – 9/30	From the junction of the unnamed drain and the Glenn Colusa Canal (in southeastern part of Corning subbasin) – shown on map

Source: SWRCB, 1998

The GSAs or other responsible agency would likely need to apply for a new appropriative water right permit through the SWRCB Division of Water Rights to obtain water from seasonally appropriated streams for irrigation or groundwater recharge projects. There are temporary and streamlined permits available for pilot projects. A new water right permit would require an analysis of stream discharge to determine the potential volume, reliability, and impact of diversion for this project. This appropriative water right permit application must show proof of several conditions:

1. Unappropriated winter and spring flows on the stream occur at greater than the 90th percentile of daily discharge measurements for the historical stream record
2. Total project diversions equal to or less than 20 percent of the total flow in the stream will not cause unreasonable impacts on fish and wildlife in the
3. That the diverted water for groundwater recharge will be put to beneficial use such as groundwater pumping

7E.3 References

State Water Resources Control Board (SWRCB), 1998. Water Right Order 98-08.

Appendix 7F

OUWUA Infrastructure Improvements for In-Lieu Recharge – Additional Details

7F OUWUA INFRASTRUCTURE IMPROVEMENTS FOR IN-LIEU RECHARGE

7F.1 Background

The Orland Unit Water Users Association (OUWUA or Association) is fortunate to have a reliable surface water supply from Stony Creek, but its conveyance and distribution facilities are approaching obsolescence. For example, the distribution system is capable of operating only on a rotation schedule, which is generally adequate for forage crop production, but not for production of high value crops and adoption of modern irrigation systems. Therefore, surface water utilization is gradually decreasing in favor of groundwater for irrigation purposes. This, coupled with relatively low pumping cost due to shallow groundwater, has led many growers to transition from surface water to groundwater as land is converted to orchards, orchards are replanted, or during years of reduced surface water availability. Maintaining a substantial base of surface water users is dependent on the Association's ability to transition from the existing rotation delivery service to a more flexible, responsive water delivery service. Such an improvement in water delivery would allow OUWUA to better provide for the irrigation needs of its members, increase the efficiency with which it uses its water supplies, and provide in-lieu recharge benefit.

7F.2 Prior Completed Work

The broadly defined objectives of the project are developed in large part based on past work that the OUWUA has completed or been involved in. This prior work has informed OUWUA's initiation of modernization and formed the essential building blocks and prioritization of activities of the Program as illustrated by the brief summaries below:

- **2003 CALFED Modernization (Planning Study)** – The OUWUA investigated modernizing its existing distribution system in order to enhance conservation. Three estimates of the volume of water that could be conserved were 40,100 acre-feet per year (AF/yr), 25,400 AF/yr, and 14,400 AF/yr, depending on the size of the investment in infrastructure. The range of capital investments for the 3 alternatives are $221,640,000, $53,499,000, and $18,489,000, respectively.
- **2003, 2006 Stony Creek Fan Report** – OUWUA engaged with Glenn Colusa Irrigation District (GCID), Orland-Artois Water District (OAWD), the Bureau of Reclamation (USBR; Reclamation), the California Department of Water Resources (DWR), and other parties to explore regional aquifer systems to better define the physical and operational characteristics of those systems, and to better understand the potential effects of ongoing and potential future groundwater development for regional benefit.
- **2005 ITRC Orland Unit Water Users' Association Modernization Plan and Specifications**

- **Orland Project Regulating Reservoir and Associated Canal Improvements (Completed)** – OUWUA completed the planning, design, and construction of a 49.5 acre-foot regulating reservoir in their Southside service area to reduce spillage and provide increased delivery flexibility. This was completed in 2013.
- **2016 ITRC Rapid Appraisal Report** – The Cal Poly Irrigation Training and Research Center conducted a site visit and interview with OUWUA staff and provided recommendations for infrastructure and management improvements.
- **Northside Phase 1 Modernization (Completed) -** The first phase of modernization included the replacement of 12 existing check structures with long-crested weirs, replacement of 8 lateral heading structures with new concrete structures and automated flow control gates, upgraded flow measurement, real-time data access through SCADA, and remote operation of the Northside diversion. This was completed in 2018.
- **Northside Phase II Modernization (Conceptual) –** The second phase of the Northside modernization project has been conceptualized by Davids Engineering and OUWUA staff and includes the construction of a 30-50 acre-foot regulating reservoir on the Lateral 130 system and associated canal improvement to provide enhanced spill routing, measurement, and management. The Phase II components would also increase the benefits realized by the Phase I improvements. OUWUA has conducted flow monitoring in their canals from 2018-2021 to inform a future design process.
- **On-Canal Pump Turnout Policy** – In response to increasing demand for more flexible delivery to accommodate drip-micro irrigation systems, OUWUA has developed a policy to enable water users to pump directly from the canal and a streamlined water ordering protocol in certain cases.
- **Lateral Pipeline Conversion in Urban Areas (On-Going)** – In 1990, the OUWUA and USBR agreed with the City of Orland to place its open-ditch irrigation system facilities into buried pipelines within the City of Orland. Undergrounding is being accomplished as land development occurs or as determined by OUWUA's Board of Directors.
- **2017 Agricultural Water Management Plan (AWMP)** – OUWUA prepared the AWMP in accordance with the requirements of the Water Conservation Act of 2009, also known as Senate Bill x7-7 (SBx7-7). In developing the Plan, OUWUA devoted considerable effort to evaluating its water management practices and to developing a program aimed at sustaining sound water management practices where they are already in place and identifying opportunities to implement improved practices that are found to be locally cost effective.

7F.3 Project Overview

The OUWUA Infrastructure Improvements for In-Lieu Recharge project goal is to modernize infrastructure and adds management tools necessary to support and promote expanded surface

water use for irrigation in-lieu of groundwater pumping. The project incentivizes existing surface water users to continue using surface water for modern pressurized irrigation systems. The goal of the project is to maximize the use of surface water on lands within the OUWUA service area and potentially on neighboring lands within the context of strategic annexations.

The In-Lieu Recharge project would be planned, designed, and implemented over time per a strategic phasing plan. The modernization project for this Subbasin is focused on OUWUA's Northside service area and is guided by 4 broad objectives:

1. Maintain and enhance the reliability and utilization of the surface water supply to promote long-term sustainability of and access to groundwater for agriculture production, domestic, and urban uses in dry years.
2. Modernize infrastructure that has reached the end of its useful life, become obsolete, or does not support current and future water management initiatives.
3. Expand data collection and data management within OUWUA to support modernization, planning, and water management best practices.
4. Increase knowledge of OUWUA water users and staff and support initiatives (by OUWUA and others) regarding conjunctive use, groundwater conditions, water use efficiency, and best management practices.

7F.4 OUWUA Modernization Project

The project is formulated around 6 focus areas or project concepts that would improve OUWUA's ability to increase delivery flexibility with the objective of increasing in-lieu recharge. These are listed below and described in subsequent sections:

1. Northside Phase II Modernization Project
2. Lateral Pipeline Conversions
3. Data Collection and Management
4. Tehama Colusa Canal Interties (contingent on satisfactory agreements)
5. Potential Land Annexations (subject to OUWUA's total acreage limitations)
6. Grower Outreach and Education

7F.4.1 Construction Activities and Requirements

General pre-construction and construction activities include initial feasibility assessment, design, permitting, environmental review, earthwork, construction of civil works, and installation and integration of mechanical systems. Details on construction activities, schedule, and project costs will be developed as part of the final project design for each project. OUWUA does not

anticipate that construction will be required for all elements of the Program, particularly those focused on improved data management, water monitoring and measurement, training, outreach, or education. Project concepts, and any associated construction activities or requirements that have been developed by OUWUA at varying planning levels, are described in more detail below. General project costs are provided as a lump sum in Section 7.4.1 of the GSP. More specific and updated costs will be developed early during project planning phases during GSP implementation.

7F.4.1.1 Northside Phase II Modernization Project

The Northside Distribution System Improvement Project would combine a regulating reservoir with improvements to lateral headings and the Northside main canal (Laterals 100 and 130) shown on Figure 1. The improvements would pass flow adjustments from the lateral headings to regulating reservoirs. Phase I (completed 2018) completed improvements in the upper portion of the distribution system. Phase II would expand upon these improvements by continuing the structural improvements downstream on Lateral 130, the backbone of the system designed to collect flow mismatches and automatically pass these mismatches to the regulating reservoir. This will include new long-crested weirs to pass flow changes downstream while maintaining upstream water control at each bifurcation and at any existing, intermediate check structure. At each bifurcation, one leg will have a long-crested weir and the other will have flow control with measurement. Four lateral headings (L131, L134, L135, and L150) will be improved with a flow control gate to provide automated flow control and integrate with the Association's existing SCADA system. Approximately 33 water level control sites will be replaced with either a single or double bay long-crested weir or a flap gate. Long-crested weirs will be installed at all water level control sites on Lateral 130 to minimize significant head fluctuations in the upstream pool due to the higher flow rates passing through the canal system to the reservoir.

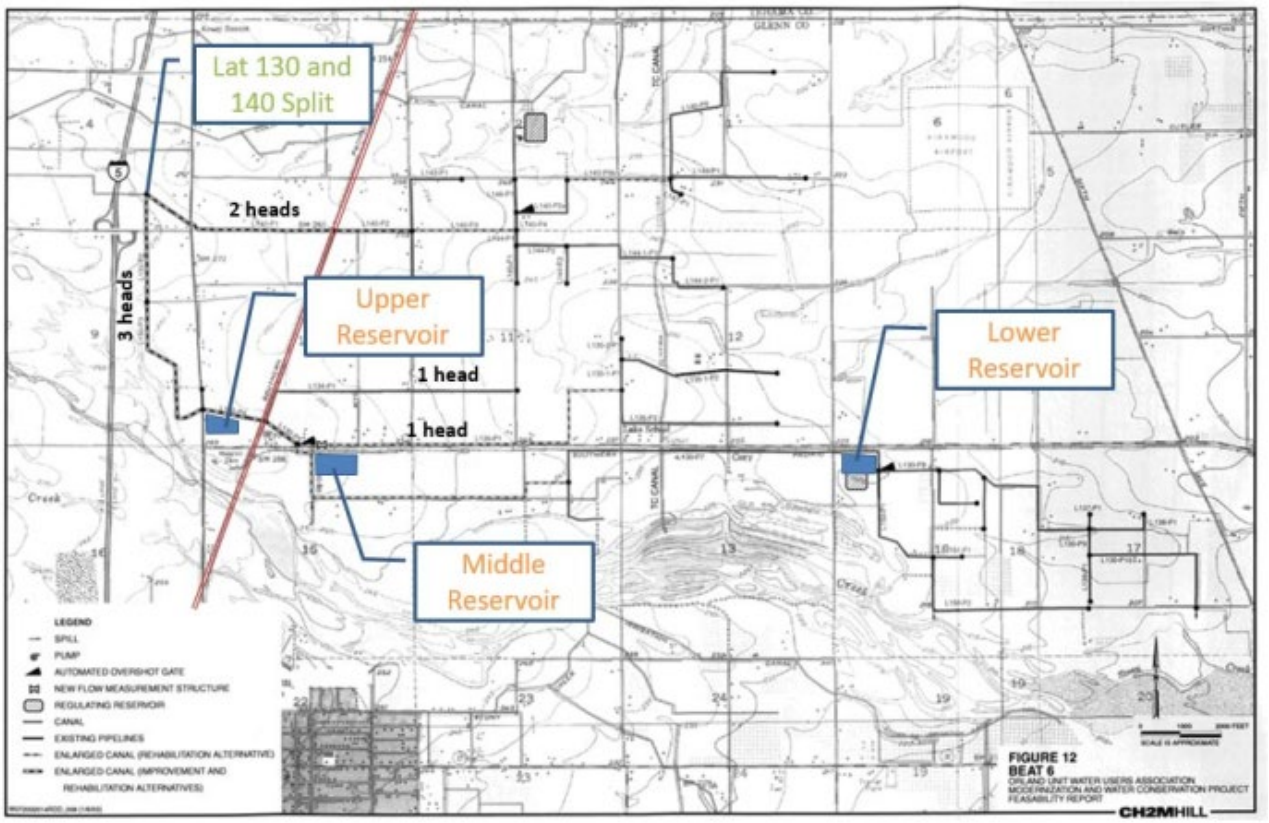


Figure 1. Northside Phase II Modernization.

Regulating reservoirs are an important part of OUWUA's modernization plans in that they minimize system spillage while enabling system operators to provide additional delivery flexibility to growers and help the Association accomplish its conjunctive water management goals, through which local and regional water supply reliability may be improved.

A feasibility investigation completed in 2003 (CH2M HILL, 2003) identified 3 potential sites for a reservoir (Figure 1) and concluded that constructing a 35-acre-foot regulating reservoir in close proximately to where Laterals 134 and 135 branch off Lateral 130 (i.e., the 'upper' location) would provide the most benefit. Additionally, the historical water demands downstream of this point are sufficient to utilize the water that is re-regulated by the reservoir. Additional site inspections and investigations are required before a final site is selected.

Construction activities would include the excavation of existing site soils and the placement, compaction, and shaping to create the regulating reservoir. This work would be completed using heavy earth moving equipment. Inlet and outlet work would require placement of structural concrete, piping, gates, and instrumentation. Construction of in-canal structures would require the removal of existing concrete lining, excavation, concrete placement, and installation of gates and instrumentation.

7F.4.1.2 Lateral Pipeline Conversions

OUWUA delivers water on a rotational basis whereby each water user receives water on a set interval, typically 12 to 14 days, that varies by water availability. Water is rotated between lateral and sublateral canals as needed to meet the demand and some laterals with limited demand will be 'wet' for only a few days and 'dry' the remainder of the rotation period. This means that water users must take water when it's their turn and water is present in the canal. This arrangement is typically equitable and delivers a reliable flow rate but has limited flexibility to deliver outside of the rotation schedule or deliver small flow rates for long durations, which is typical of orchard crops using pressurized irrigation systems. Converting certain lateral canals to closed, gravity pressurized pipelines that can be left charged would enable increased flexibility and reduced operations cost and effort to accommodate this flexibility. Candidate laterals have not been identified and would require topographic survey and assessment of demands to size pipelines. Priority laterals would be those branching from main canals with sufficient elevation difference and serving a high proportion of orchard crops with drip-micro irrigation systems. It is estimated that approximately 15,000 to 25,000 linear feet of pipeline would be necessary to convert priority candidate laterals. Additional planning is required to confirm.

Construction activities would be determined based upon the final designs but would likely include the demolition and removal of existing concrete lining and canal structures, excavation of pipeline trenches, installation of pipelines, assembly and installation of farm turnouts, installation of mechanical equipment and flow meters, and burial of infrastructure.

7F.4.1.3 Data Collection and Management

This project would include the expansion of the OUWUA's existing SCADA system with additional monitoring locations to inform operations and to maximize the benefits of the modernized infrastructure. Key control sites, such as lateral headings and tail-end spill sites, are priority candidates for telemetry installations and improved flow measurement. Additionally, enhanced delivery flow measurement and management of delivery records would be beneficial to overall water use efficiency and in-lieu recharge goals. Construction activities required to implement additional water monitoring sites would vary by site, but likely include the installation of a Remote Terminal Unit (RTU) that would enable remote communication of collected parameters to the OUWUA office. RTU installation may require the installation of a vertical mast pole to support hardware and communication antenna. Additional construction activities would vary by the type of site (i.e., flow measurement, level measurement, control, or other).

7F.4.1.4 TCC Interties

This project would formulate and effectuate an agreement between OUWUA, the Tehama-Colusa Canal Authority (TCCA), and the USBR to allow the Association to utilize the Tehama-Colusa Canal (TCC) as an intertie conveyance between its Northside laterals and also to

its Southside service area. This would enable surpluses to be discharged to the TCC and either conveyed to other lateral systems or exchanged as credit to meet demands elsewhere in the OUWUA. The TCC connection could also facilitate future water transfers to other CVP contractors. The TCC currently crosses 6 Northside laterals or sublaterals and could provide additional flexibility that is necessary to support in-lieu recharge.

Each lateral or sublateral connection to the TCC would require infrastructure to enable discharges and offtakes to/from the TCC. Discharge could likely be accomplished using gravity, but offtakes would require pumps. Additional water control and measurement equipment would be required to maximize the benefit of the intertie and connections. Construction of these facilities would require earthmoving, concrete, and mechanical and electrical systems. Construction within TCCA/USBR right-of-way and modification of these facilities would require federal approval.

OUWUA is currently in discussion with USBR to take title of the Orland Project facilities and allow for revenue generation through the transfer and sale of surplus water. OUWUA has 2 existing TCC intertie sites available to transfer any surplus water to TCCA to reduce their Sacramento River diversions at Red Bluff or provide for regional conjunctive use objectives.

7F.4.1.5 Potential Land Annexations

This project would consider existing or future annexations and consider opportunities to expand surface water delivery service to areas that currently rely on groundwater. OUWUA has adopted a policy regarding the land annexation application process for areas outside its boundaries. OUWUA has recently (in 2012 and 2013) received and accepted applications for annexation of approximately 593 acres into the service area, thus increasing the use of surface water and increasing in-lieu recharge. The process involved in annexing land is somewhat new and time consuming. The USBR limits OUWUA to a total area of 21,000 acres. There are several additional landowners that are interested in annexation should capacity become available. Construction activities for land annexations would vary by project and are not known at this time.

7F.4.1.6 Grower Outreach and Education

Educating existing water users and growers on the Associations modernization initiatives and delivery service offerings is essential to encouraging conjunctive use. Outreach and education would be conducted by OUWUA with support from local agencies and technical consultants. Research, education, and outreach with growers on the following topics: on-farm - groundwater management nexus, essential water “use” terms, the promises and pitfalls of irrigation efficiency; and on-farm practices for sustainable groundwater management. No construction activities are expected for this project element. Additional details on such a grower education program are provided in Management Action 2 and in Appendix 7C.

7F.4.2 Implementation

Per the OUWUA's 2017 Agricultural Water Management Plan (AWMP), the primary source of the Orland Project's water is direct diversions from and storage of Stony Creek water (Davids Engineering, 2017). The Project utilizes its pre-1914 water rights to store a maximum of 51,000 AF at East Park Reservoir alone and to divert no more than 279 cubic feet per second (CFS) daily during the irrigation season—not to exceed 85,050 acre-feet annually – from Stony Creek. The Orland Project also utilizes post-1914 water rights that consist of 50,200 acre-feet stored at Stony Gorge Reservoir. The Association does not produce groundwater as a source of irrigation supply, though some lands within the service area utilize private groundwater wells some of the time. The Association does not receive any other water supplies. With the exception of water stored in Stony Gorge Reservoir, Stony Creek and its tributaries are adjudicated under what is known as the "Angle Decree." Stored water in Stony Gorge reservoir is under the authority of the State Water Resources Control Board. Title to all Orland Project water is held by the United States as administered by the Bureau of Reclamation.

7F.4.3 Conditions or Constraints on Implementation

A planning study and preliminary design phases would be required to refine the defined projects, project features, costs, and benefit. Implementation would be contingent upon this planning stage, and also on final permits and environmental approvals. Additionally, if the costs and benefits do not make the project practical for immediate implementation to address current groundwater sustainability challenges, the project may still potentially be implemented in the future if the conditions of the subbasin change such that the benefits outweigh the cost. The project may also be initially implemented on a smaller scale and expanded over time.

OUWUA currently participates or initiates discussions with the Army Corps of Engineers, the USBR, the City of Santa Clara (who owns and operates the Stony Gorge Dam hydroelectric powerhouse) and other agencies to evaluate policies that affect OUWUA's flexibility in delivering and storing water and that could affect the implementation of this project. OUWUA actively evaluates the effect of Reclamation policies and operational practices on Association operations and seeks policy changes to alleviate water supply and flexibility constraints.

It is likely that funding will be a challenge. The transfer and sale of surplus water supply would generate revenue that could be applied to implementation. However, OUWUA does not have a policy for transferring water into or outside the Orland Project because title to the water rights is held in the name of the United States and under the direction of the U.S. Bureau of Reclamation and therefore any proceeds would accrue to Reclamation rather than OUWUA. OUWUA is considering taking title to the Orland Project and is negotiating with Reclamation. Part of these negotiations include OUWUA having the ability to transfer water. Such action, however, will require Congressional authorization.

7F.4.4 Project Permitting

The project would require environmental clearance at the Federal level (NEPA) and at the state level (CEQA). The following permitting agencies would be involved in project implementation: USBR, USACE, CDFW, USFWS, TCCA, SWRCB, RWQCB, and Glenn County. OUWUA would be the project owner.

7F.4.5 Project Operations and Monitoring

This project incorporates additional water monitoring sites (flow and level) that will be integrated into the OUWUA's existing Supervisory Control and Data Acquisition (SCADA) system. Field operators will have access to these data through remote laptops, tablets, or cell phones, and office staff will have access to the main base station. Additionally, delivery data management will be enhanced to support and streamline the OUWUA's ability to administratively support the additional delivery flexibility afforded by the modernized infrastructure and field tools.

OUWUA would be responsible for all project operations within their boundaries and associated with their water rights. Coordination with TCCA, USACE, or USBR may be required for reservoir reoperation, water transfers, conveyance of non-project water by Federal facilities, or during construction. The Program would be operated based upon available supply and in response to irrigation demands. To the extent possible, modernization projects would be operated to maximize flexibility of delivery service while minimizing spillage. Monitoring and assessing performance would be accomplished by frequent analysis of data from the constructed monitoring sites to inform day-to-day operations. Collected data would also be aggregated over time and evaluated to identify trends or to assess the performance of operating decisions or conditions.

7F.5 References

CH2M Hill, 2003. OUWUA Distribution System Modernization and Water Conservation Project. A CALFED Agricultural Conservation Program Grant Study, Prepared for: Orland Unit Water Users Association. January.

Davids Engineering, 2017. Orland Unit Water Users' Association. 2017 Agricultural Water Management Plan.