Highlights from Mark West Flow Study 2017-2020

INTRODUCTION

Integrated Surface and Groundwater Modeling and Flow Availability Analysis for Restoration Prioritization Planning, Upper Mark West Creek Watershed, Sonoma County, CA

Author:	O'Connor Environmental, Inc., under the direction of Coast Range Watershed Institute
For:	Sonoma Resource Conservation District
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This study was conducted to help us better understand streamflow dynamics in the Mark West Watershed, and to identify how we can improve streamflow for the benefit of fish, people, and overall ecosystem function. The study is focused on the upper 40 mi2 of the watershed in the hills above the Santa Rosa Plain. We chose this area because of its importance for endangered coho salmon ; it has been identified as a core area for protection and restoration by multiple national fisheries agencies.

We learned about the watershed and its streamflow conditions by developing a complex hydrologic model. The model was developed by incorporating existing data on topography, geology, vegetative cover, and climate, and then calibrated using real-time data collected from stream gauges and groundwater wells in the watershed. This model covered a 10-year study period (2009-2019) and provides us information on the availability of streamflow throughout the watershed and the year, how that might be impacted by climate change, and how streamflow conditions intersect with habitat conditions for fish. The model also allows us to test out different conservation project scenarios, helping us to understand what types of projects will provide the greatest benefits for streamflow and fish. Below are some highlights of what we learned.

MARK WEST WATERSHED HYDROLOGY

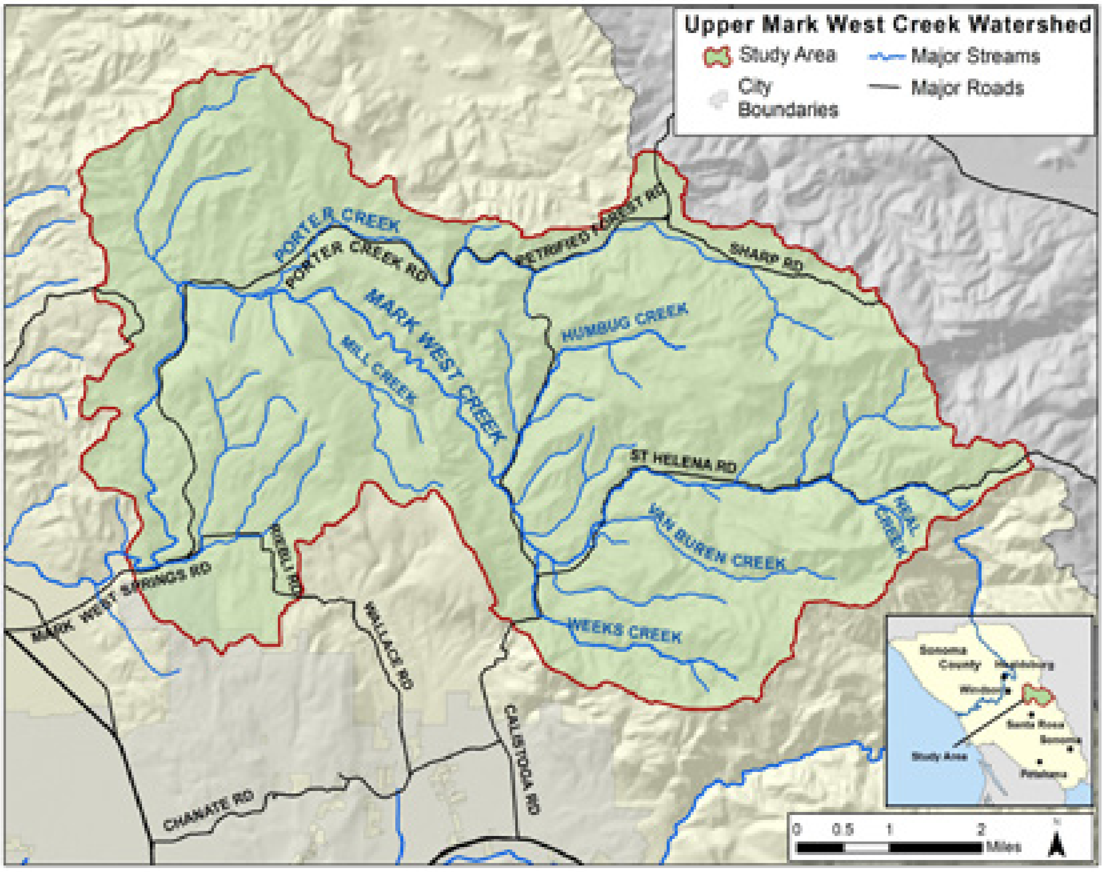
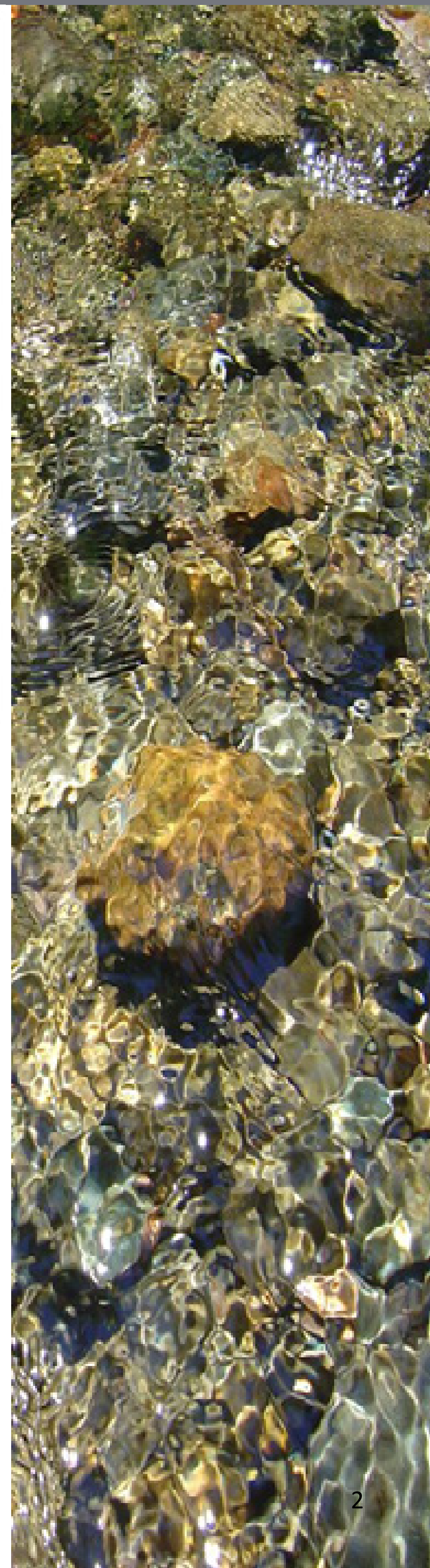


figure 1: Area Study



Hydrology and Streamflow

Rainfall, streamflow, and groundwater recharge in the watershed very widely from year to year, with annual precipitation ranging from 19.5 inches (2014) to 61.2 inches (2017) and streamflow depth ranging from 0.7 to 2.7 feet . In wet years, the average summer streamflow in Mark West Creek was about 0.7 cubic feet per second (cfs) downstream of Van Buren Creek and was 1.5 cfs downstream of Porter Creek, whereas in dry years these flows declined to about 0.3 and 0.7 cfs, respectively. Average summer riffle depths above 0.1-0.3 ft in most locations (0.2-0.4 ft during drought year). Salmonids require a minimum riffle depth of 0.2 ft for suitable flow conditions.

Most summer streamflow in the watershed, critical for over summer survival of juvenile coho, comes from groundwater seeps and springs. Modeling indicates that the watershed area upstream of Van Buren Creek generates 55% of the total springflow in the watershed. Groundwater recharge potential also varies widely throughout the watershed, based on factors such as soil type, topography, and rainfall patterns. The best areas for recharge include the upper Mark West Creek watershed upstream of and including the Van Buren Creek watershed, as well as the upper Humbug Creek watershed.

Existing Water Use

Total water use in the watershed was estimated to be approximately 430 ac-ft/yr. About 85% of the total use in the watershed is from groundwater with the remaining 15% coming from surface water sources. About 81% of the total surface water use comes from pond storage, 10% comes from direct stream diversions, and 9% comes from springs.

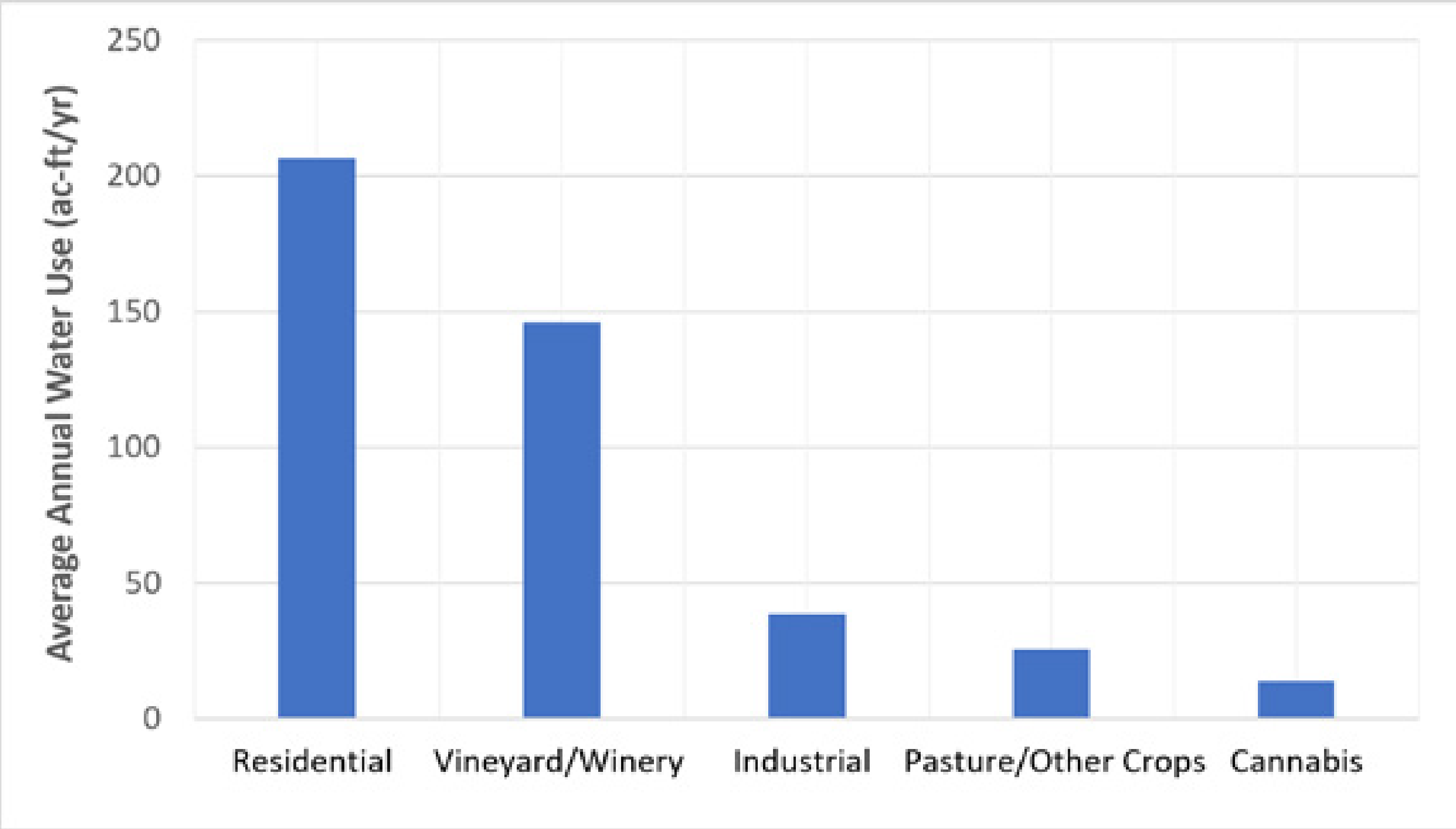


figure 2: Water use in the Mark West Creek watershed study area by major water use category

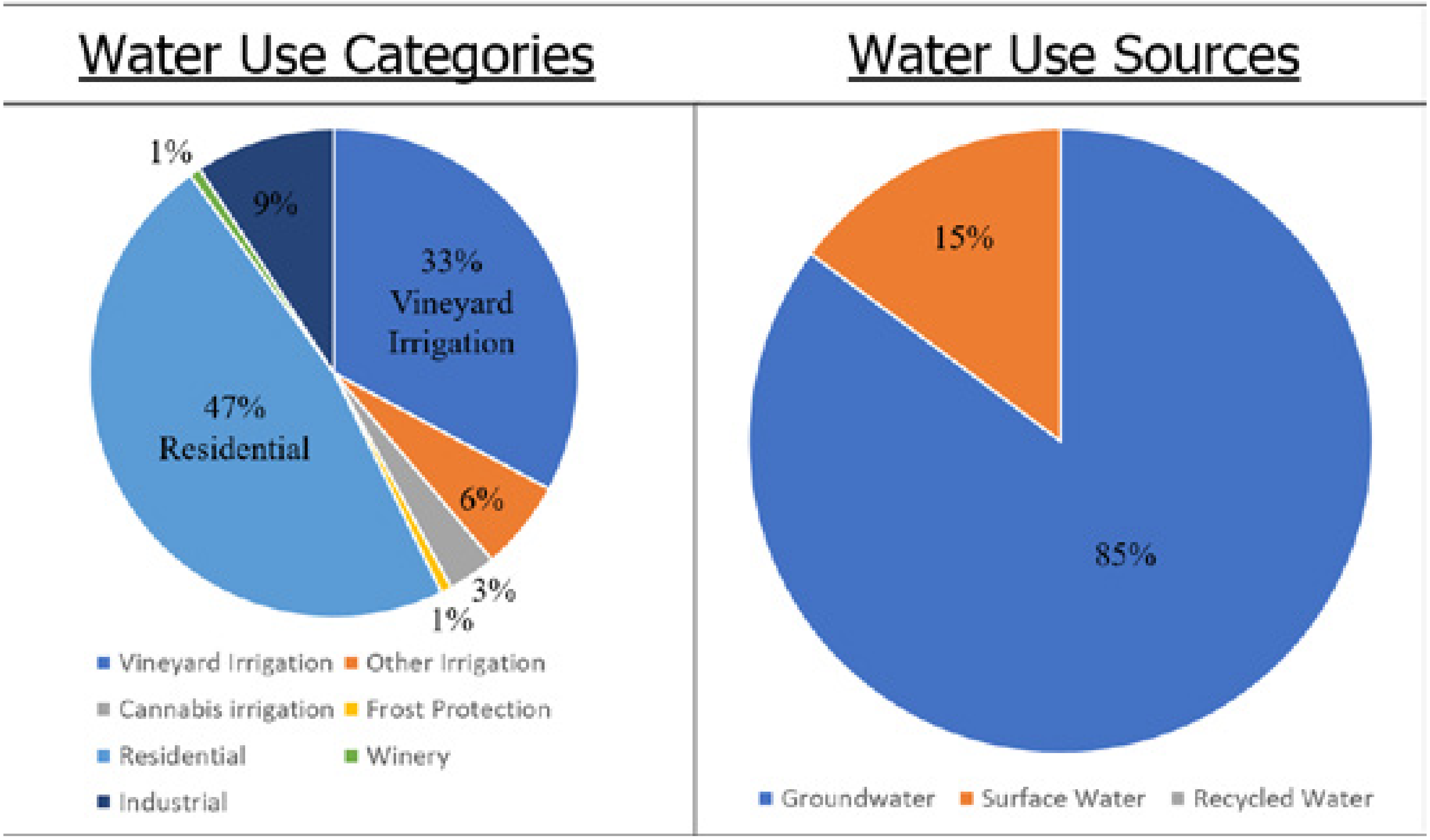


figure 3: Water use in the Mark West Creek watershed study area by major water use category and source

Looking at the watershed balance across the year, there is often enough water to meet existing human needs in an average and wet year, however in a dry year the watershed has a net deficit of water.

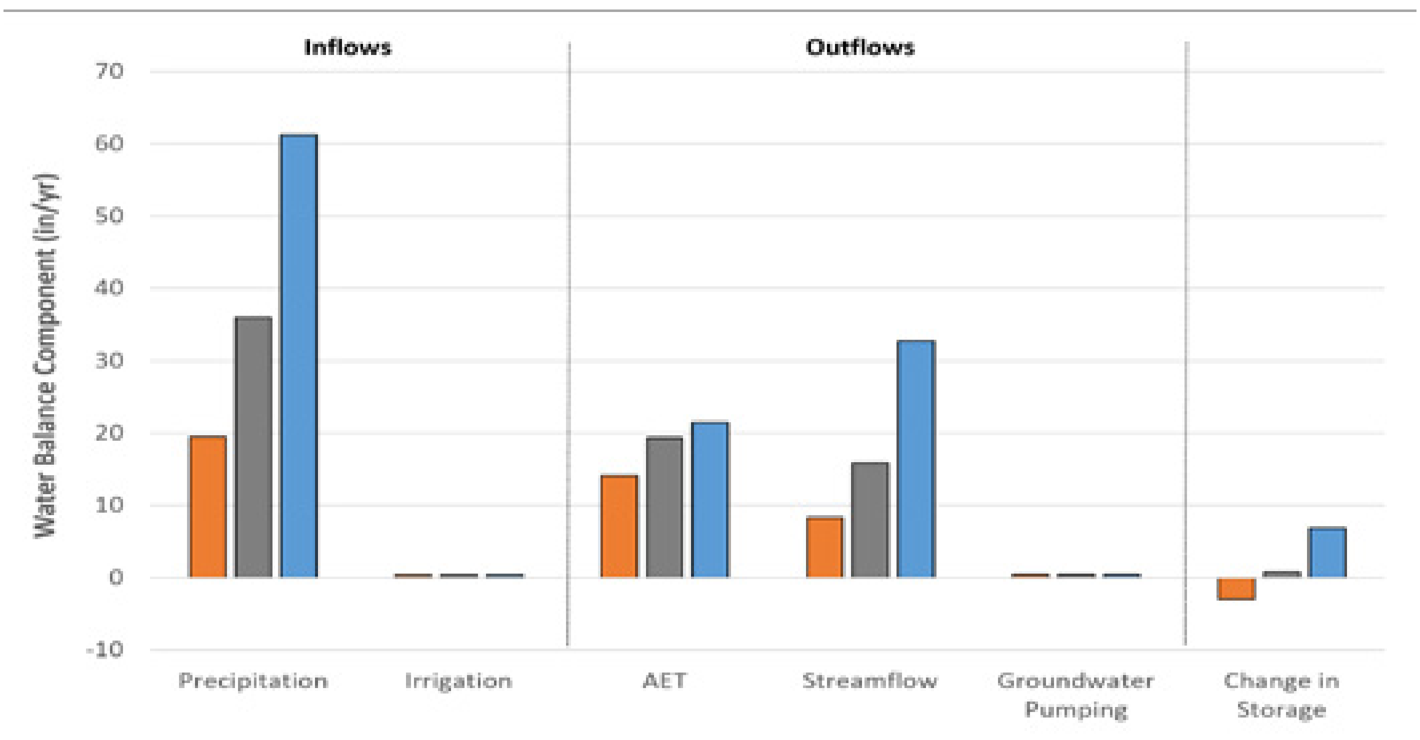


figure 4: Mean Annual Watershed Water Balance

BALANCING THE NEEDS OF FISH AND PEOPLE

Fish Habitat

Mark West Creek is a critical watershed for endangered coho salmon. Summer snorkel surveys quantified coho population for the study. In 2019, nearly all (98%) of the 734 observed coho were found in pools along Mark West Creek between Humbug Creek and Porter Creek. As mentioned above, salmonids require a minimum riffle depth of 0.2 ft for suitable flow conditions as well as deeper pools for resting areas. Temperature is critical for salmonid survival with temperatures above 18° C considered impaired and above 23° C considered lethal. **While streamflow is not the primary control water temperature, deep pools** (greater than 3.5 feet) can provide cooler refuge for fish during summer heat. **Encouraging the formation of stable deep pools and maximizing shade on the stream surface are likely the most important immediate mitigation actions.**

Most stream reaches in the watershed have both flow and temperature conditions that are considered "impaired" with regard to salmonid habitat. Based on this information, the **best areas for salmonid habitat are located within a roughly 4-mile reach of Mark West Creek between about 0.2 river miles upstream of Humbug Creek and about 2 river miles upstream of Porter Creek.**

"We will be able to make much smarter decisions about what projects can make the biggest impact the better. Projects such as protection of infiltration basins, rain water catchment, and recharge projects are expensive propositions. We want to make sure we are making the best use of these projects to make the biggest difference in the functioning of the system for all - fish and people."

- Penny Sirota, Co-Chair
Friends of the Mark West Watershed

Streamflow Enhancement Solutions

If all surface and groundwater use was ceased, modeling suggests that the mean summer streamflow would eventually increase by 6% in the high priority reach described above and 8% at the watershed outlet. Since the cessation of water use is likely unfeasible, the study looked at multiple streamflow enhancement solutions to determine the most effective measures along with predictions of climate change effects on streamflow. The solutions modeled include spring and summer flow releases from ponds, replacing surface water diversions with a well or offsetting with winter storage, managing grassland with compost application, managing forests with thinning, managing stormwater runoff with infiltration, and offsetting pumped groundwater with winter storage.

The pond release scenario generated the largest increases in summer streamflow of the stand-alone scenarios, with increases of about 13 - 14% (0.08 cfs in the high priority reach and 0.16 cfs at the watershed outlet). In the high priority reach, the next largest increases were from the forest management scenario, followed by the runoff management scenario. At the watershed outlet this order was reversed; runoff management generated about a 3% increase in summer streamflow in the high priority reach and a 10% increase at the outlet, whereas forest management generated about a 6% increase at both locations. The grassland management scenario generated the smallest increases in summer flows on the order of 2%.

Spring pond releases during drought conditions substantially increase flows in the identified high priority reach during a critical 3-week smolt outmigration period in May, extending the duration of passable conditions by approximately two weeks. The increases in flow associated with the summer pond release scenario also increased riffle depths significantly over the critical summer low flow period but the changes were not large enough to consistently maintain depths above 0.2-ft in the high priority reach.

Overall Salmonid Habitat Classification

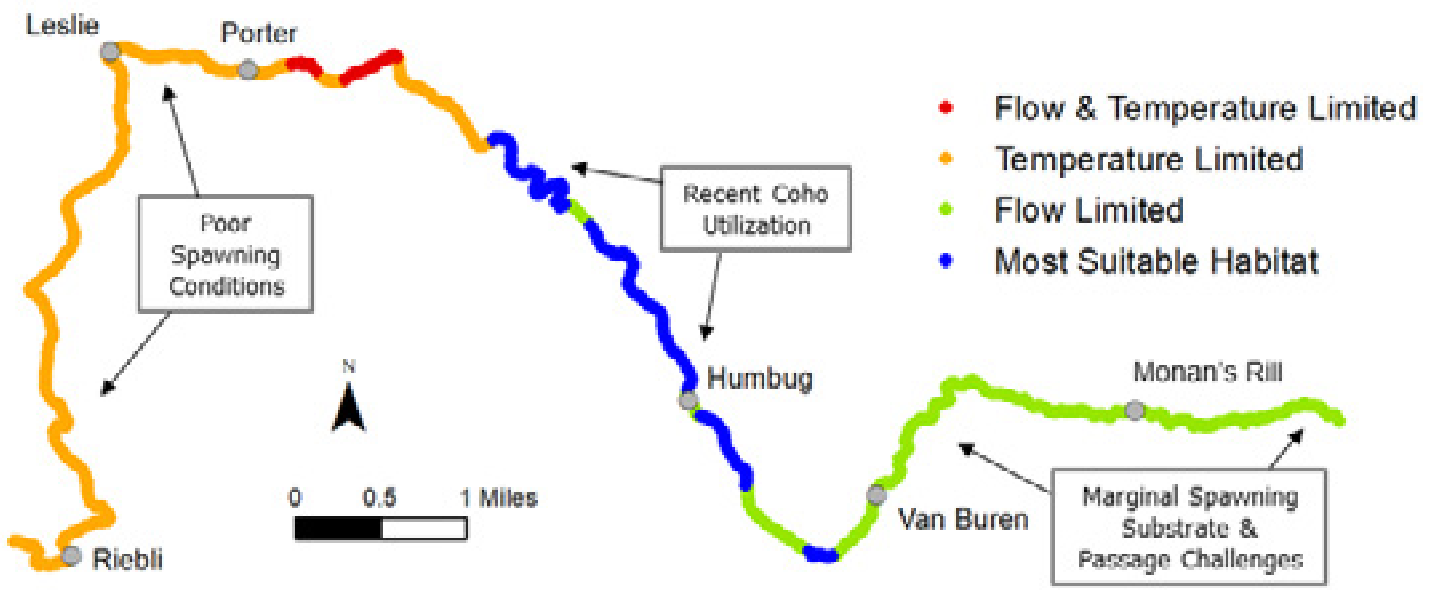


figure 5: Priority Salmonid Habitat Reach

While runoff, forest, and grassland management may not directly result in substantial streamflow improvement, these efforts have multiple benefits and are likely important strategies for managing fire risk and mitigating climate change impacts. These various benefits are in addition to the primary non-hydrologic benefits of forest and grassland management projects in reducing fuel loads and sequestering carbon respectively.

Replacing direct stream and spring diversions with storage and/or groundwater pumping is a viable approach for enhancing streamflow conditions but offsetting groundwater pumping with storage or shifting the timing of pumping from summer to winter is unlikely to lead to appreciable improvements in flow conditions. Of the six general strategies considered, replacement of direct diversions is the second most-effective strategy after pond releases, whereas offsetting groundwater pumping was found to be the least effective strategy. Streamflow enhancement activities should focus on upstream of Mill Creek confluence (upstream of Van Buren is highest priority)

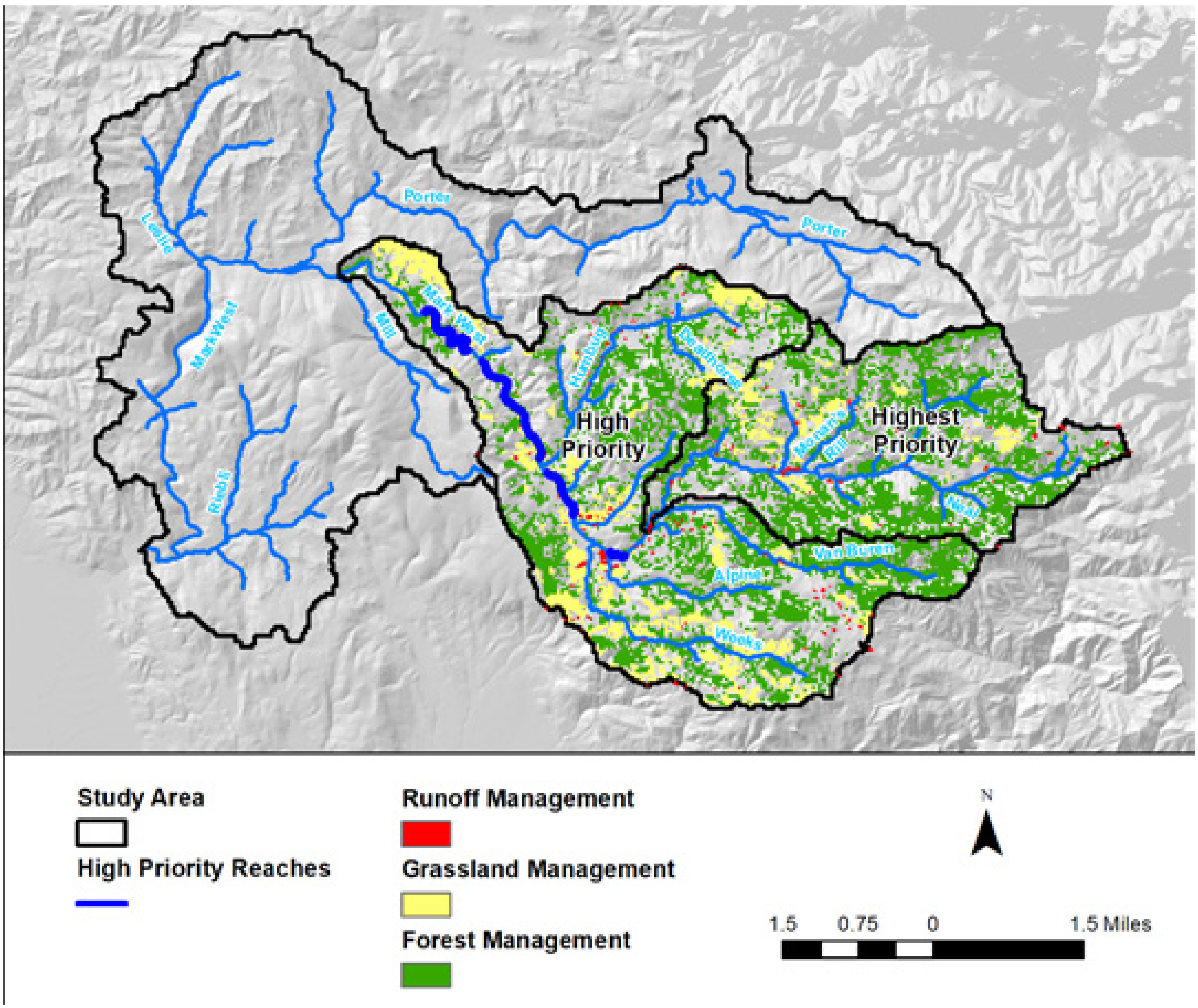


figure 6: Locations of the identified high priority reaches for habitat enhancement projects and high priority watershed areas for flow enhancement projects.

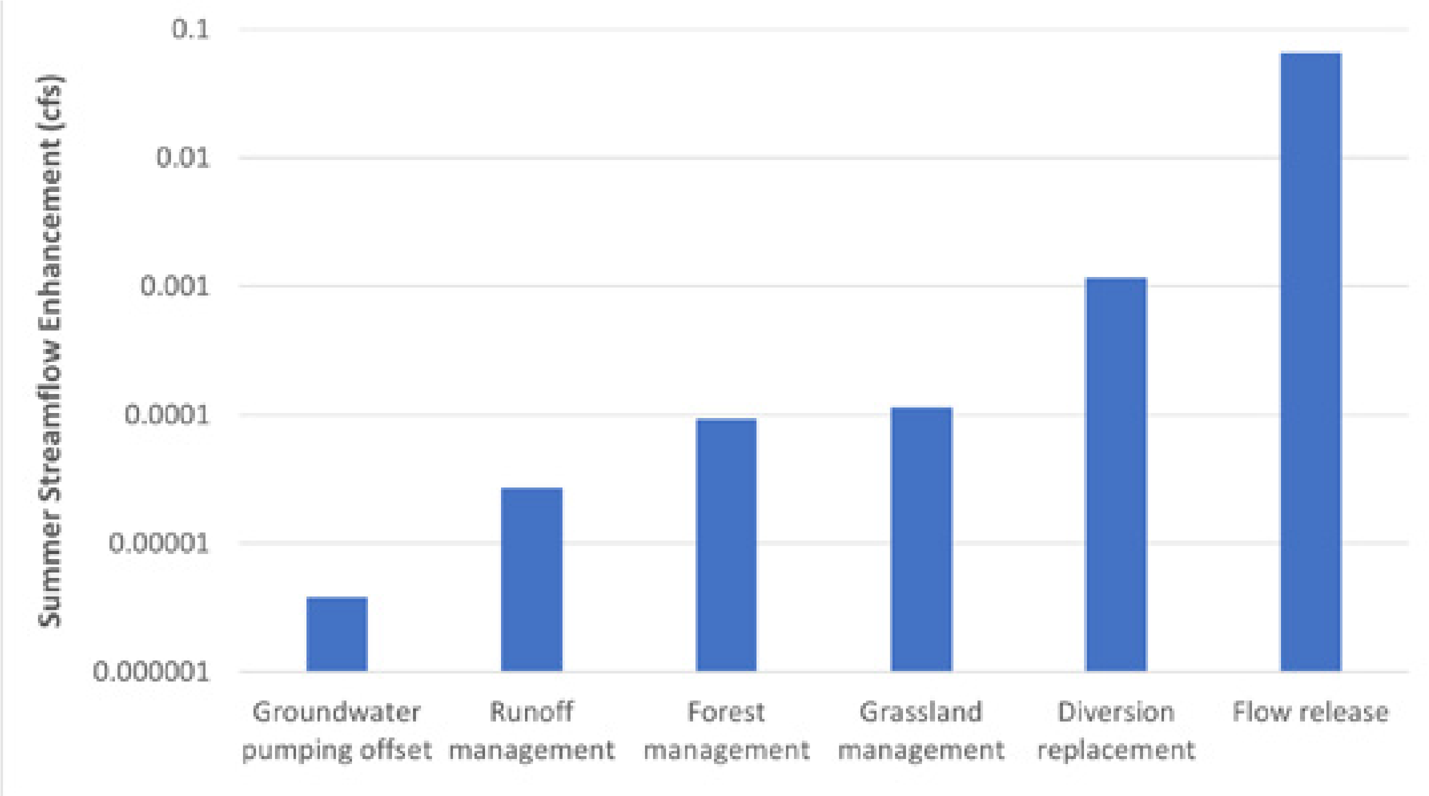


figure 7: Summary of the simulated increase in mean summer streamflow for the six primary individual flow enhancement actions represented by the model scenarios and normalized to a $25,000 average project cost.

On a cost basis, the streamflow benefits of one flow release project were found to be more than 50 times greater than an average surface water diversion replacement project and more than 500 times greater than an average grassland management project (the second and third most effective strategies).

Combined Solutions

With all of the land/water management scenarios combined (pond releases with forest, grassland and runoff management) mean summer discharges in the high priority reach increased by about 21% (0.13 cfs) and by about 28% (0.31 cfs) at the watershed outlet.

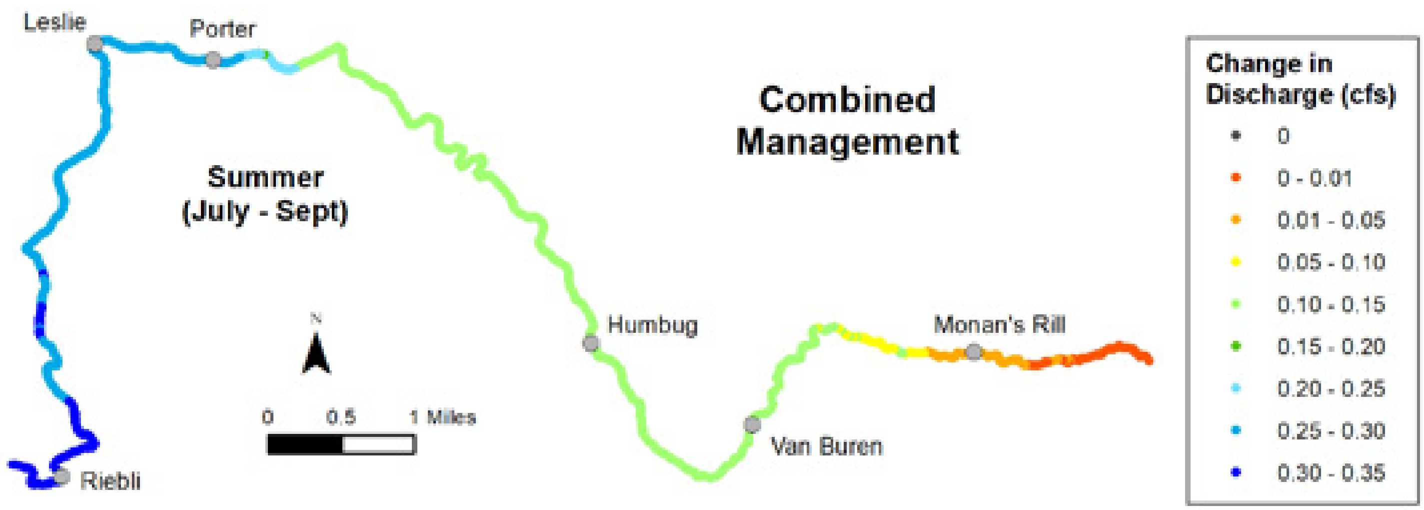


figure 8: Simulated changes to the 10-yr average mean summer streamflow for the combined management scenario (Scenario 8; note the scale in the legend is different from previous figures for other scenarios).

Climate Change

Four climate change scenarios were modeled to represent likely changes to precipitation and temperatures as predicted by available climate model data. The climate change scenarios generated a wide range of predictions with three of the four scenarios indicating decreases in summer streamflow of between 6 and 47% and one scenario indicating increases of about 15 to 19%. The mitigated scenarios indicate that **pond releases can likely offset a significant portion of the projected decreases in summer streamflow predicted by some of the models and if combined with forest, grassland, and runoff management, are likely large enough to completely offset the projected decreases.**

"My favorite aspect of this watershed is how involved and engaged the landowners are particularly the Friends of Mark West Watershed group in improving the health and resilience of their watershed."

- Kevin Cullinen, Project Manager
Sonoma Resource Conservation District

All four climate change scenarios indicate substantial decreases in springtime flows ranging from 35 - 62%. These changes greatly exceed the potential flow improvements associated with the various enhancement scenarios. Forest management generates the largest increases in mean spring discharges (~5 - 6%), and the other individual scenarios only increase spring flows by ~1 - 2%. None of the actions are capable of fully mitigating against the large decreases in springtime flows predicted by the climate scenarios. **Spring streamflow declines caused by climate change represents a dire threat to salmonids, only partial mitigation feasible is springtime pond releases, which could provide a short critical period of passable flow times to coincide with peak smolt outmigration window.**

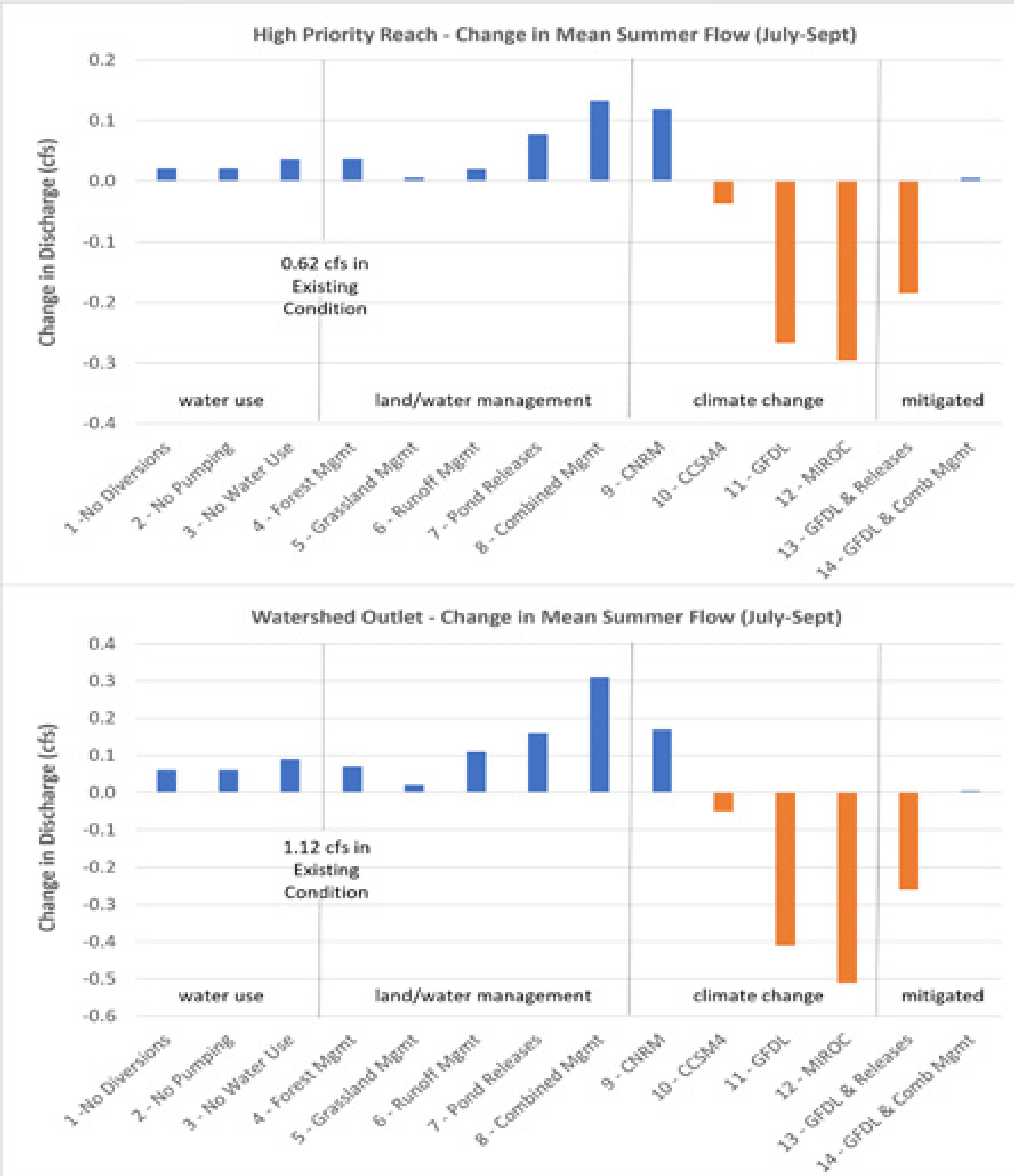
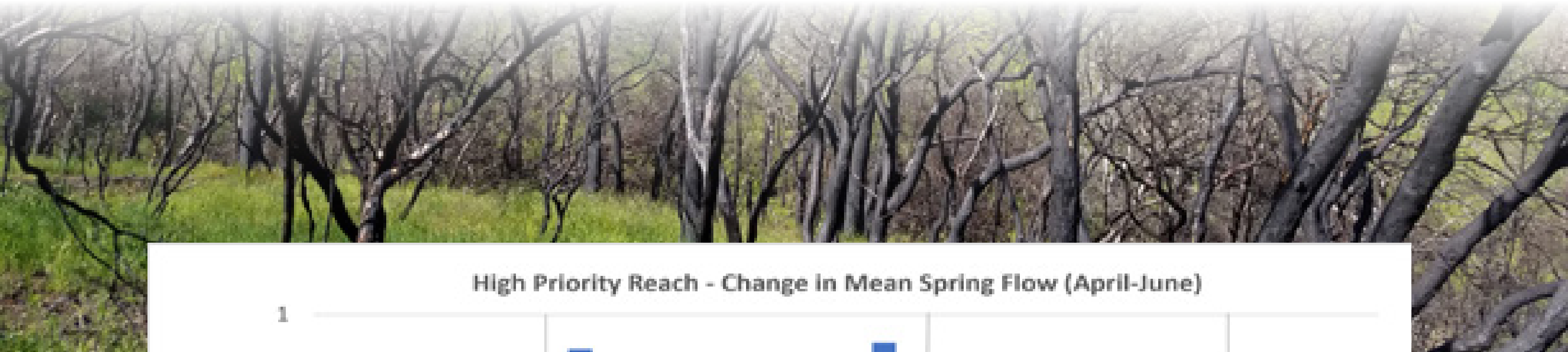


figure 9a: Summary of the simulated changes in mean summer streamflow for Scenarios 1-14 averaged over the high-priority habitat reach (top) and at the watershed outlet (bottom).

CLIMATE CHANGE SCENARIOS



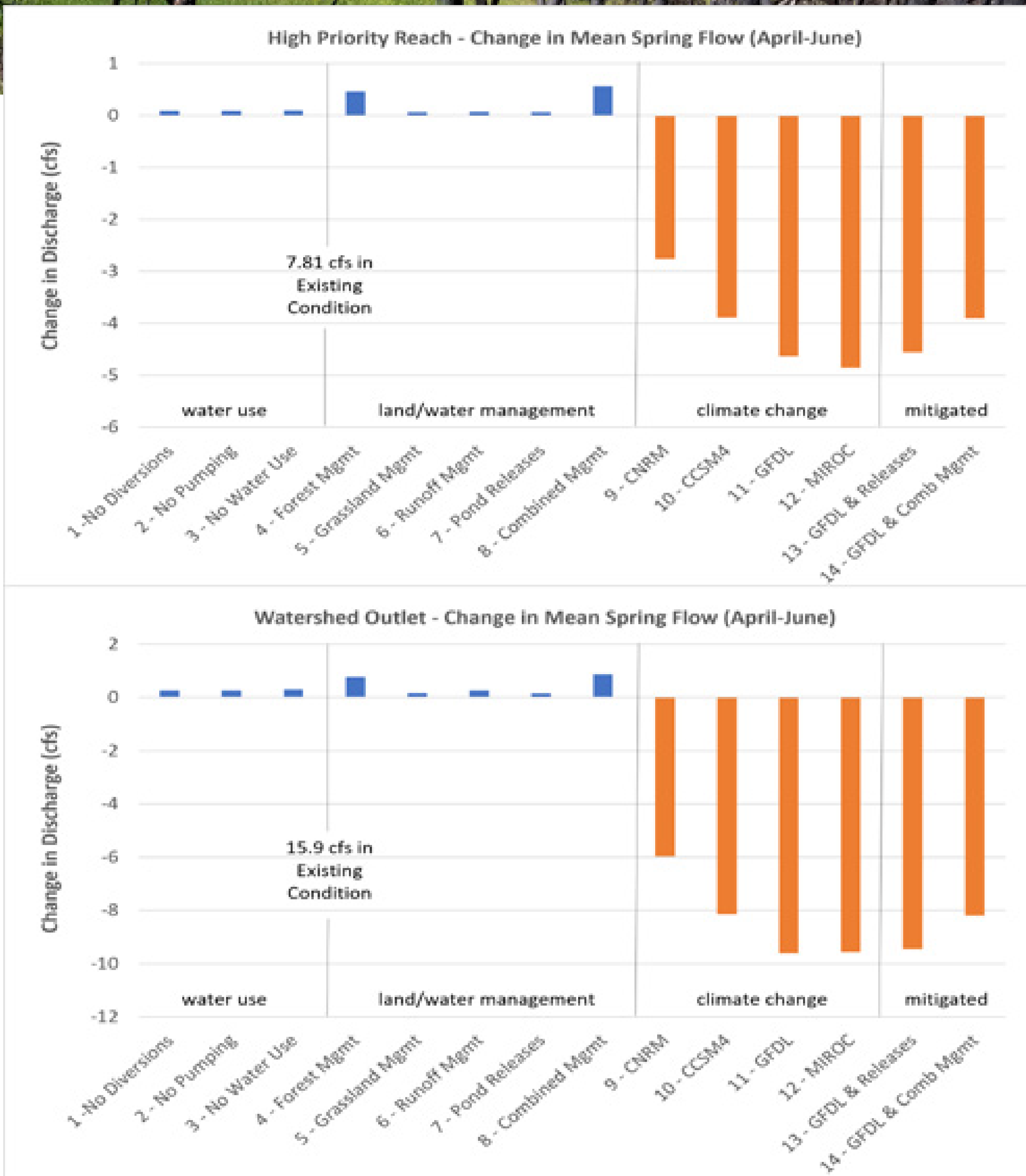


figure 9b: Summary of the simulated changes in mean springtime streamflow for Scenarios 1-14 averaged over the high-priority habitat reach (top) and at the watershed outlet (bottom).

FLOW STUDY CONCLUSION

Key Findings

- Summer streamflow mostly caused by spring discharge, concentrated upstream of Van Burren Creek.
- Streamflow is not the primary control on temperature and encouraging formation of stable deep pools and maximizing shade on the stream surface are likely the most important immediate mitigation actions.
- Releasing water from existing ponds in the watershed shows the largest potential increases in average summer streamflow, with increases of about 13-14%. Pond releases could also be timed to occur over a 3-week period in spring to improve conditions for outmigrating fish, extending the period when fish are able to pass through by two weeks.
- Replacing a surface water diversion with a well is the second most effective solution for increasing streamflow
- Runoff, forest, and grassland management have multiple benefits and are likely important strategies for managing fire risk and mitigating climate change impacts in addition to streamflow improvement.
- Streamflow enhancement activities should focus on upstream of Mill Creek confluence (upstream of Van Buren is highest priority)
- Summer streamflow declines caused by climate change can be mitigated with a combined solution strategy
- Spring streamflow declines caused by climate change represents a dire threat to salmonids, only partial mitigation feasible is springtime pond releases, which could provide a period of passable flow times to coincide with peak outmigration window

"Cumulative long-term effect of groundwater use on surface flows appears to develop over a period of decades and although there is some evidence that wells proximate to streams have somewhat greater influence on surface flows, cumulative watershed-wide groundwater withdrawals ultimately cause streamflow depletion and short-term reductions in groundwater use are not likely to generate comparable short-term increases in streamflow."

-Matt O'Connor, PhD, CEG
President, O'Connor Environmental, Inc.

Future Studies and On-the-Ground Project Implementation

- **Installation of large wood to encourage formation and protection of existing deep pools as in-stream large wood (logs and trees) densities are low in Mark West Creek**
- **Conduct planning study for the upper watershed to identify parcels most suitable for grassland, forest, and runoff management projects and that these projects be implemented where feasible.**
- **Conduct landowner outreach on pond flow release and surface diversion replacement and/or offset**
- **Post fire flow modeling – Mark West Watershed has experienced fires in 2017, 2019, and 2020, burning 73% of the watershed; this is a unique opportunity to model post-fire impacts on streamflow hydrology**
- **Finalize Concept Designs – CRWI and SRCD staff in partnership with Pepperwood Preserve and Sonoma County Regional Parks staff identified five streamflow enhancement conceptual projects to be considered for future development and implementation. These included:**

    1. Mark West Regional Park headquarters facilities - runoff collection and infiltration from roofs & hardscape; based on the preliminary park master plan.
    2. Mark West Regional Park tributaries - infiltration enhancement in existing fan-like terrace and floodplain from the north facing slope opposite park headquarters.
    3. Pepperwood Preserve - organic enrichment of grassland soils and broad enhancement of soil hydrologic characteristics with compost treatment.
    4. Pepperwood Preserve – creating a reservoir at lip of homestead meadow for recharge enhancement.
    5. Mark West Regional Park and/or Pepperwood Preserve - Ephemeral/intermittent channel manipulation to enhance recharge (e.g. treating an incised channel with something like check dams to increase the duration of saturation and/or raising channel bed so that available existing alluvial terraces or floodplains can receive and infiltrate more water that would otherwise runoff as stormflow). This could conceivably be implemented on either property. Opportunities exist at Pepperwood but potentially more potential for flow enhancement for salmonids at Mark West Regional Park.

Thank you to the landowners and our dedicated partners for your support and investment in this important study in the Mark West Creek Watershed.