7 December 2022

I. Purpose

This document describes a draft proposal to exempt Upper Feather River watershed irrigated pasture (and alfalfa; collectively referred to as irrigated pasture in this document) from the Irrigated Lands Regulatory Program (ILRP or Program), with recommendation for a potential future alternative regulatory framework. This watershed is located in portions of Plumas, Sierra, and Lassen Counties, within the Sacramento Valley Water Quality Coalition (Coalition). There are no other commercial irrigated crop types in this watershed. Staff intends to solicit public feedback on the draft regulatory recommendations.

II. Overview

Concerns have been raised about the appropriateness of including irrigated pasture in the ILRP for some time. Justification for the concerns raised include low- to zero-use of pesticides and fertilizers, permanent vegetative cover, and low economic returns coupled with continually rising compliance costs. These concerns have grown since the ILRP evolved to address nitrate groundwater impacts, further increasing Program costs to address a high priority pollutant issue that Upper Feather River irrigated pasture growers are not contributing to. Due to the low economic returns, this has unintentionally created the situation where an agricultural commodity likely impacting priority pollutant issues the least is paying the highest Program compliance costs in the context of per acre earnings.

Research findings and monitoring data indicate that ILRP high priority pollutant issues (e.g., surface water pesticides, toxicity, and groundwater nitrate) do not appear impacted by upper watershed irrigated pasture operations within the Upper Feather River watershed. Recent findings have also shown that other pollutant issues such as *E. coli* do not appear to be a significant issue associated with upper watershed irrigated pastures and can likely be addressed through an alternative regulatory framework as needed. Because much of the research information supporting this exemption proposal is specific to Upper Feather River irrigated pasture, this document is limited in scope to the approximately 70 irrigated pasture operations within this watershed.

Irrigated pastures and meadows in California provide critical forage for livestock, particularly during the summer dry season. These forage production systems are broadly comprised of native and improved perennial forage grass species, perennial clovers, and other forage legumes. Forage from these systems is most commonly harvested by grazing livestock, and in some cases is harvested via a combination of grazing and haying. Pastures can be flood or sprinkler irrigated with surface and groundwater.

III. Technical Considerations and Discussion

University of California Research

Research conducted by the University of California, Davis (UCD) indicates that irrigated pastures in the Upper Feather River watershed are of low to no risk to beneficial water uses (K.W. Tate et al., 2022; various reports). These findings are driven by the permanent vegetative soil cover, low agronomic inputs, and distance to waterways common at these operations.

First, the perennial forage species and moderate grazing intensities on Upper Feather River irrigated pasture and meadows provide for constant vegetative soil cover, which acts to protect the soil surface from erosion and creates substantial filtration capacity for sediments as well as nutrients applied to the pasture. Irrigated pastures and meadows are essentially permanent crops with stand establishment and associated cultivation occurring infrequently (>20 years) in improved species pastures and never on native species meadows.

Second, nitrogen applications are a rare practice on Upper Feather River irrigated pasture and meadows primarily due to economics – there is limited opportunity to capture production returns. Thus, these systems are commonly nitrogen deficient and external nitrogen applied to pastures via irrigation water and as atmospheric deposition is quickly taken up by forage plants, consumed by grazing livestock, and harvested as livestock products (e.g., meat, milk). UCD research consistently finds there is no excess annual nitrogen available for loss to ground water.

Third, pesticides are used as spot treatments far from surface waterways and with nearly zero potential for runoff. The management practices used by the growers coupled with the properties and low amounts of the pesticides used make transport to surface waters unlikely. Also, the actual pesticide use is far below amounts permitted by the Agricultural Commissioner/Department of Pesticide Regulation.

Finally, the irrigated pastures in the Upper Feather River Watershed are not hydrologically connected to waters of the State, precluding potential impacts from runoff. Most fields are located long distances from waterways and many also contain berms to keep water on-field. It is nearly impossible for waste runoff to reach receiving waters even if operations in this watershed used chemicals at rates that might affect beneficial uses.

At the same time, costs associated with ILRP compliance are assessed on a per-acre basis and are similar to or the same for intensely cultivated regions with high pesticide and fertilizer use and low intensity, low input regions. This puts irrigated pasture operations at an economic disadvantage for participating in the ILRP when compared to other crops. Of the agricultural sector, Upper Feather River irrigated pasture is likely impacting high priority pollution issues the least (i.e., surface water pesticides, toxicity, and groundwater nitrate) within the Coalition region, while paying high- or the highest compliance costs when considering the per acre return on yields.

Upper Feather River Production Survey Summary

UCD conducted a production survey and economic analysis for the 70 irrigated pasture and alfalfa growers in the Upper Feather River watershed and provided a summary analysis report to the Water Board in October 2022 (2022 UCD Report; see Appendix 1 for the full report). Table 1 provides some characteristics of the Upper Feather River farms from the 2022 UCD Report. This report also provides information on growers and acres that reported using 30 different management practices.

Table 1. Characteristics of Irrigated Pasture and Alfalfa Operations, Upper Feather River

Upper Feather River Watershed 2020-21 Farm Survey Summary	
Acres, Total Irrigated	30,411
Acres, Alfalfa	4,928 (16%)
Acres, Grass Pasture	25,483 (84%)
Total Number of Growers	70 [a]
Acres, sprinkler irrigated	6,026 (20%)
Acres, flood irrigated	24,385 (80%)
Acres, N application	1,331 (4.3%) [b]
Acres, field-scale pesticide use	4,782 (16%) [c]
Growers, herbicide spot treatment on weeds	18 (26%)

[a] 68 grass pasture growers and 6 alfalfa growers. Some growers produce both.

[b] Nitrogen application below crop demand. All grass pastures.

[c] All alfalfa pasture

Upper Feather River Irrigated Pasture & Alfalfa Economic Analysis

In collaboration with the Upper Feather River Watershed Group (UFRWG), UCD distributed a survey to the 70 irrigated pasture and alfalfa growers in the Upper Feather River watershed in late 2020 - early 2021. The voluntary survey was designed to obtain additional economic and operational information to accompany the Coalition-required Farm Evaluation findings. All 70 growers completed the survey. UCD prepared a summary report of the survey findings (please see Appendix 1 for the report; referred to here as the 2022 UCD Report). Table 2 below provides a summary of information from the 2022 UCD Report.

Table 2. 2020 Economic Analysis Summary (with inflation adjustments for 2022)

Primary Crop [a]	Acres	Average Yield per Acre	Average Gross Revenue per Year	Average Operating Costs per Year	Estimated Average Net Revenue per Year
Forage Harvested by Livestock	24,699	5.1 AUMs [b, c]	$176 / acre	$281 / acre	$-106 / acre
Grass Hay	784	3.1 Tons	$1,426 / acre	$474 / acre	$952 / acre
Alfalfa Hay	4,928	4.1 Tons	$1,394 / acre	$814 / acre	$580 / acre
TOTAL	30,411				

a 80% (24,699) of the total acres reporting in the survey are grazed by livestock at some time throughout the typical calendar year, for a total of 124,856 AUMs for the year. Each acre is grouped here for its primary crop type/revenue source.

b An Animal Unit Month (AUM) is a measure used to quantify the amount of forage required to support a 1,000 lb. beef cow for one month.

c UCD estimates the value at $30 per AUM in 2022 for Upper Feather River irrigated pasture.

The 2022 UCD Report also provided an analysis of ILRP compliance costs for Upper Feather River irrigated pasture growers. The report identifies an issue with the ILRP compliance costs being similar across all members of a Coalition, which they describe as subsidization by low-risk growers and crops of high-risk growers and crops. This issue is more problematic when the low-risk crop is also the lowest (or one of the lowest) earning crops, as is the case with Upper Feather River irrigated pasture in the Sacramento Valley Water Quality Coalition. This creates an unjustified inequity when growers not contributing to water quality impacts are paying a much higher percentage of net profit than those causing and contributing to the water quality impacts.

An example is provided in the 2020 Economic Analysis showing that under the current program compliance costs, a cattle producer is paying 31 times the almond grower’s regulatory costs in the Coalition when considering revenue figures. The typical cattle producer will not use pesticides or fertilizer, while the almond grower likely will do so.

Surface Water Quality Data

Surface water quality data collected in the Upper Feather River watershed shows there have not been constituents of concern measured in waterbodies downstream of farms. Water Board staff used the California Environmental Data Exchange Network (CEDEN) in June 2022 and downloaded all available pesticide and organism toxicity data for locations downstream of irrigated pasture operations in the Upper Feather River Watershed.

Water quality data collected by the Sacramento Valley Water Quality Coalition through the ILRP since 2005 has shown no exceedances of trigger limits for pesticides and organism toxicity except for toxaphene in 2011, a legacy pesticide that is no longer used. Surface water quality data collected by the Central Valley Water Board's Surface Water Ambient Monitoring Program (SWAMP) also shows there are no constituents of concern posing threats to water quality.

Groundwater Quality Data

Existing water quality data indicate that agricultural operations in the Upper Feather River Watershed are not impacting groundwater. In June 2022, Water Board staff queried Geotracker, the State Water Resource Control Board's online database housing groundwater quality data collected by all agencies, dischargers, and academia, and downloaded all available pesticide and nitrate groundwater data in the Upper Feather River Watershed.

There are two pesticides that have been detected in groundwater in the watershed - dichlorobenzene (DCB) and atrazine. DCB was detected in two separate remediation monitoring wells at a Caltrans facility in 2002 and 2008; both samples were at levels two orders of magnitude lower than the current USEPA Human Health level and were not associated with agriculture. Atrazine was measured at one non-agricultural well four times between 2010 and 2020. The highest detection was two orders of magnitude lower than the CA Primary Maximum Contaminant Limit (MCL) for drinking water.

In the last 50 years, no groundwater nitrate samples exceeding the MCL have been collected from any wells associated with agricultural operations.

Pesticide Use

Initial review of County Agricultural Commissioner Pesticide Use Reports (PUR) in the Upper Feather River watershed indicated that pesticide use might pose potential risks to beneficial water uses. Central Valley Water Board staff used the ILRP Pesticide Evaluation Protocol (PEP) analysis to identify potential pesticides of concern used on irrigated pastures in the Upper Feather River watershed along with trends of use over time. PUR data from 2010 – 2021 was used in the PEP analysis which revealed recent uses of two pesticides of concern: lambda-cyhalothrin and paraquat.

However, when Water Board staff met with growers in the Upper Feather River watershed and UCD Cooperative Extension researchers to discuss the results of the PEP analysis, it was discovered that the initial PEP analysis overestimated threats to water quality due to incorrectly reported amounts of pesticides used. The actual applications by irrigated pasture growers in the Upper Feather River watershed were significantly less than reported for lambda-cyhalothrin for two reasons. First, growers applied less than what was permitted by the Agricultural Commissioner and second, unit conversion errors were made, such as pounds being reported when in fact ounces were used. Reported amounts of paraquat used were confirmed as the actual amounts used. Overall, lambda-cyhalothrin and paraquat were used on less than 5% of the total irrigated acres in the Upper Feather River Watershed.

Upper Feather River watershed members and the Sacramento Valley Coalition invited Water Board staff and UCD/UCCE staff onto their respective properties to evaluate locations and better understand the landscape where these two pesticides were applied. The tour included discussing and viewing several management practices used to prevent pesticide transport to surface waters in the few locations close enough to a waterway for potential impacts. Tour findings revealed to Water Board staff that the risk for hydrologic transport of pesticides to surface water bodies is low to non-existent due to application and irrigation practices that growers use, field locations in relation to waterways, berms and other topographic features, and the climatic and weather conditions of the region.

Upper Feather River Case Studies

UCD researchers conducted a series of case studies at grower sites that Water Board staff visited. A total of five case studies were conducted via onsite farm visits and were designed as site specific assessments to evaluate the potential risk of hydrologic transport. Pesticide amounts, application timing, and application locations relative to hydrologic transport pathways and events were determined for all reported/permitted applications of lambda-cyhalothrin and paraquat. The structured framework was based upon the standard principles for environmental fate and transport of pollutants.

Site visits for the five case studies indicate that the farms are typical of irrigated pasture production operations across the Upper Feather River watershed and region. The weather, soils, hydrology, agronomic practices, irrigation, management practices, productivity, and economics in these Case Studies appear representative of irrigated pasture operations in the Upper Feather River watershed.

Applications of lambda-cyhalothrin on irrigated pasture (grass) were conducted in Case Studies 1 and 2 (Appendix 3). One grower applied lambda-cyhalothrin on an irrigated pasture to control a grasshopper outbreak in July 2020. Two growers applied lambda-cyhalothrin for the same purpose in May 2021. Site assessment revealed that the actual amount of pesticide applied and actual acreage sprayed was an order of magnitude less for Case Studies 1 and 2 (Table 1) than what was reported by the Agricultural Commissioner. Growers used a targeted approach by spraying dryland areas where grasshoppers were located adjacent to irrigated pasture which resulted in less pesticide being used than was reported. Transport risk of lambda-cyhalothrin to surface waters in Case Studies 1 and 2 is nonexistent due to distances from nearest surface waters, down sloping of topography from surface waters to irrigated pastures, and all tailwater being consumed by drylands on the properties.

Table 1. Differences in Lambda-cyhalothrin Applied vs Reported on Irrigated Pasture, Upper Feather River Watershed

	Actual active ingredient applied (lbs/acre)	Actual irrigated pasture treated (acres)	Reported/ permitted active ingredient applied (lbs/acre)	Reported/ permitted irrigated pasture treated (acres)	Actual vs reported percent difference
Case Study 1 (2020)	0.09	4	2.97	100	96.7%
Case Study 1 (2021)	0.07	3	1.98	100	96.7%
Case Study 2 (2021)	0.23	10	2.97	150	92.3%

Applications of paraquat and lambda-cyhalothrin on irrigated pasture (alfalfa) were conducted in Case Studies 3, 4, and 5 (Appendix 3). Paraquat was applied by one grower all six years since 2016 to control early spring emerging weeds. Three growers applied lambda-cyhalothrin to control alfalfa weevil and aphids during three years since 2018. The risk for transport of paraquat and lambda-cyhalothrin in these case studies was determined to be nonexistent for a variety of reasons:

- Low sprinkler irrigation used on alfalfa produces no runoff.
- Application timing of pesticides relative to snowmelt or storm events prohibits any hydrologic runoff.
- Nearest waterway to any grower is one mile.
- All fields are by berms, roads, and railroad tracks which prohibit any surface flow reaching nearby waterways and affecting beneficial uses.

In summary, some pesticides are used in the Upper Feather River Watershed, but staff finds these uses are infrequent, not widespread, are only used in small amounts as spot treatments, and are used far from receiving waters. Staff does not find evidence of a potential threat to water quality that warrants regulation under the ILRP.

E. coli Studies

Research studies have demonstrated that irrigated pasture operations do not contribute to ILRP high priority pollutants (surface water pesticides, toxicity, and groundwater nitrate). The pollutant most often associated with irrigated pasture runoff is the fecal coliform bacteria, *E. coli*. Numerous studies are available in the literature on this issue and only a few are highlighted in this document. Overall, research has found that well-managed irrigated pastures can greatly reduce livestock fecal bacterial runoff to surface waters with the use of appropriate management practices.

To examine potential *E. coli* issues in upper California watershed irrigated pastures, UC Davis and UC Cooperative Extension conducted a study[1] in the Goose Lake watershed over the four-month 2020 irrigation season at 10 flood-irrigated pastures adjacent to streams. They measured *E. coli*, nutrients, TSS, turbidity, conductivity, as well as several field parameters in the stream, both upstream and downstream of each pasture. At each sampling event, they recorded the number and type of livestock grazing, streamflow rate, and irrigation application rate. One of the study's findings reported that 80 percent of mean downstream concentrations were below 235 cfu/100 ml (ILRP *E. coli* water quality trigger limit). They also found statistical correlations between increased *E. coli* levels and increased stocking density, increased water application rates, and reduced streamflow, which showed that pasture management practices affect *E. coli* runoff levels. Studies in 2007[2] and 2008[3] found similar and related correlations between various management practices and *E. coli* runoff concentrations.

A 2019 study[4] found that controlling cattle access to streams is a critical step in reducing *E. coli* runoff. This study found that cattle-stream access management practices, including stream fencing, hardened stream crossings, and off-stream drinking water systems can reduce the overall mean fecal coliform concentrations by over 95 percent.

IV. Draft Recommendations

Since available information shows that Upper Feather River irrigated pasture operations are unlikely to cause or contribute to detrimental beneficial use impacts from prioritized agricultural pollutants, exemption from participation in the Irrigated Lands Regulatory Program is reasonable and recommended. If future information shows otherwise, these operations should be included in the ILRP again. Staff noted that operations in the watershed appear to have extremely low to no potential to discharge waste to waters of the State.

While it has been established that irrigated pastures have the potential to contribute *E. coli* in surface water runoff, the 2020 study described above did not find significant issues. Research[4] has found that proper management practice implementation can

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1 Tate, K.W., D.F. Lile, T.L. Saitone. 2022. Managing Irrigated Pastures to Mitigate Microbial Pollutant Transport to Surface Waters. See Appendix 4 for full report.

2 Knox, A.K., K.W. Tate, R.A. Dahlgren, and E.R. Atwill. 2007. Management Reduces *E. coli* in Irrigated Pasture Runoff. California Agriculture. 61:159-165. http://calag.ucanr.edu/Archive/?article=ca.v061n04p159

3 Knox, A.K, R.A. Dahlgren, K.W. Tate, and E.R. Atwill. 2008. Efficacy of Flow-Through Wetlands to Retain Nutrient, Sediment, and Microbial Pollutants. J. Environmental Quality. 37:1837-1846

4 Lewis, D.J., D. Voeller, T.L. Saitone, and K.W. Tate, 2019. Management Scale Assessment of Practices to Mitigate Cattle Microbial Water Quality Impairments of Coastal Waters. Sustainability. 11: 5516.

reduce *E. coli* runoff levels by over 95 percent. Elevated *E. coli* levels in surface water have been found to be a widespread non-point source issue throughout the Central Valley, including in the ILRP, other Water Board programs, and outside monitoring efforts. Sources of *E. coli* found in surface water also vary, which include but are not limited to grazing livestock, confined animal facilities, septic system leachate, other domesticated animals such as pets, and wild animals.

While this cross-program water quality issue is one that the Central Valley Water Board

would like to address, limited resources coupled with multiple high priority water quality pollutants has led to limited capacity for the Central Valley Water Board to address this issue so far. The Water Board (at the State and/or Regional Water Board level) should consider how best to address *E. coli* throughout the state and/or region and consider how it may fit into annual workplans.

For now, Upper Feather River irrigated pastures should be considered a low threat to water quality while the ILRP focuses on addressing those pollutants that are causing greatest impacts to beneficial uses. The Water Board may require Upper Feather River irrigated pasture operations to participate in an *E. coli* monitoring and control program if one is developed.

APPENDIX I

Upper Feather River Irrigated Pasture and Alfalfa Production

Survey Summary

Upper Feather River Irrigated Pasture and Alfalfa Production Survey Summary

Prepared by

Kenneth W. Tate[5], Tina L. Saitone[6], and Tracy K. Schohr[7]
UC Cooperative Extension and UC Davis

October 21, 2022

Background Purpose

In collaboration with the Upper Feather River Watershed Group (UFRWG) and their seventy grower members, UC Cooperative Extension (UCCE), and the Central Valley Regional Water Quality Control Board (WB) we have compiled data and information on irrigated pasture and alfalfa production in the Upper Feather River sub-watershed of the Sacramento Valley Water Quality Coalition (SVWQC). The purpose being to provide information on 1) agronomic practices such as nitrogen fertilization, pesticide use, and irrigation methods; 2) best management practice (BMP) adoption for livestock grazing, irrigation water application, tail water management, and pesticide application to protect water quality; and 3) agricultural productivity and economics. UCCE collected this information from each of the seventy growers from late 2020 until early 2021 via a written survey (*Irrigated Pasture and Alfalfa Production Survey*) developed in collaboration with WB staff. At the time the survey was completed with each grower, UCCE worked with that grower to update their Farm Evaluation and to update/complete Irrigation and Nitrogen Management Plan worksheets for each parcel with reported nitrogen application. Information from these efforts is summarized below to aid WB staff and leadership, among others, in consideration of an alternative regulatory program/strategy

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5 Professor and Cooperative Extension Specialist in Rangeland Watershed Sciences, Department of Plant Sciences, UC Davis.

6 Associate Professor of Cooperative Extension in Livestock and Rangeland Economics, Department of Agricultural and Resource Economics, UC Davis.

7 Livestock and Natural Resources Advisor, Plumas, Sierra, Butte Counties, UC Cooperative Extension.

for this sub-watershed group, similar sub-watershed groups, and/or similar commodities.

Production Practices and BMP Survey Results

Survey Response Rates. We were able to conduct a complete survey of all 70 growers and the 30,411 irrigated agricultural acres they manage and have enrolled with the SVWQC across the sub-watershed.

Table 1. Response rates for survey completion, Farm Evaluation update, and Irrigation and Nitrogen Management Plan worksheet update/completion.

	Enrolled	Surveyed	Response Rate (%)
Acres	30,411	30,411	100
Growers	70	70	100

Irrigated Pasture Production Characteristics. Irrigated pasture represents 25,483 acres (84%) of total irrigated lands across the sub-watershed (Table 2). Sixty-two growers report that they use grazing as the sole harvest technique across 24,699 acres of irrigated pasture, and 6 growers report that they use haying as the sole harvest technique for the remaining 784 acres of irrigated pasture across the sub-watershed. Ninety-six percent of irrigated pasture acres are gravity flood irrigated, with the remaining 4% irrigated via sprinkler irrigation systems.

Table 2. Characteristics of irrigated pasture operations.

Acres, irrigated pasture	25,483 (84% of total irrigated lands) [1]
Growers	68 [2]
Acres, sprinkler irrigated	1,098 (4% of irrigated pasture)
Acres, flood irrigated	24,385 (96% of irrigated pasture)

Acres, N application	1,331 [3,4] (4.3% of total irrigated lands)
Growers, N application	7
Acres, field-scale pesticide use	0
Growers, pesticide spot treatment of pests	18 (26% of irrigated pasture growers)

[1] 62 growers graze only a total of 24,699 acres of irrigated pasture, 6 growers hay only a total of 784 acres of irrigated pasture

[2] Some growers produce both irrigated pasture and alfalfa

[3] 723 acres sprinkler irrigated (54%) by 2 growers, 608 acres flood irrigated (46%) by 4 growers.

[4] Nitrogen application below crop demand for all 1,331 acres.

***Irrigated Alfalfa Production Characteristics*.** Irrigated alfalfa represents 4,928 acres (16%) of total irrigated lands across the sub-watershed (Table 3). All alfalfa growers (6) report that they use haying as the sole harvest technique for all alfalfa acres across the sub-watershed. All alfalfa acres are irrigated via low pressure sprinkler irrigation systems.

Table 3. Characteristics of alfalfa production.

Acres, alfalfa	4,928 (16% of total irrigated lands)
Growers	6 [1]
Acres, sprinkler irrigated	4,928 (100% of alfalfa acres)
Acres, flood irrigated	0
Acres, N application	0
Growers, N application	0

Acres, alfalfa	4,928 (16% of total irrigated lands)
Acres, field-scale pesticide use	4,782 (97% of alfalfa acres, 16% of total irrigated lands)
Growers, field-scale pesticide use	5 (83% of alfalfa growers)

[1] Some growers produce both alfalfa and irrigated pasture

***External Nitrogen Application*.** The majority of acres in the sub-watershed (95.7%; 29,080 acres) do not receive any external nitrogen application. Two growers reported nitrogen application to a total of 723 acres of sprinkler irrigated pasture, and 4 growers reported nitrogen application to a total of 608 acres flood irrigated pasture (Table 2). All growers applying external nitrogen report no tail water discharge from those parcels. Irrigation and Nitrogen Management Plan worksheets (i.e., nitrogen input and output budget calculation) were completed for all irrigated pasture parcels with reported nitrogen application via the UC Rangelands Irrigated Pasture Management and Planning tool developed in collaboration with the WB (http://rangelands.ucdavis.edu/ipnmp/). Nitrogen applications across all 1,331 acres of irrigated pasture were below calculated crop demand with these pastures serving as nitrogen sinks (i.e., no nitrogen available for loss to surface runoff or leachate to groundwater). No nitrogen applications were reported for alfalfa (Table 3).

***Pesticide Use*.** Eighteen (26%) irrigated pasture managers reported the use of pesticides for targeted spot treatments of pests (weeds and insects) on an as needed basis (Table 2). Zero acres of field-scale pesticide use were reported by irrigated pasture growers. Five out of the 6 alfalfa growers reported field-scale application of pesticides to 4,782 acres of alfalfa to control a mixture of weeds and insects (Table 3). Based upon these results, UCCE collaborated with the WB, UFRWG, and the Plumas and Sierra County Agricultural Commissioner to examine Pesticide Use Reports from 2016 through 2021 to determine which types of pesticides are used and on which types of lands (irrigated pasture, alfalfa, dry rangelands, etc.) in the sub-watershed. Based upon Pesticide Use Reports it was determined that paraquat dichloride and lambda-cyhalothrin – both of potential concern to the WB – were applied to less than

5% of total irrigated acres in the sub-watershed. Applications are occurring primarily on alfalfa with limited applications to irrigated pasture. During September and October of 2022, farm visits were conducted to assess the site-specific potential risk of hydrologic transport and subsequent downstream contamination of surface waters from applications of these pesticides. These assessments indicate extremely limited to no potential for hydrologic transport and downstream contamination. The full results of these case studies can be found in Appendix II.

***Irrigation Application BMPs*.** Twenty percent of total irrigated acres (6,026 acres) are reported with sprinkler irrigation systems – with no tail water runoff generation reported as an outcome/best management practice (Tables 2 and 3). Along with water quality protection concerns, persistent drought conditions and limited irrigation water supplies have driven substantial adoption of irrigation application BMPs and water conservation measures across growers and acres in the sub-watershed (Table 4).

Table 4. Irrigation application best management practices (70 growers total).

Practice	Number of Growers (%)	Acres Reported
Appropriate Application Rate	67 (96)	30,294
Soil Moisture Monitoring	65 (93)	28,545
Uniform Application	58 (83)	28,854
Visual Observation	68 (97)	30,044

***Grazing BMPs*.** Sixty-two growers report that they use grazing as the sole harvest technique across 24,699 acres of irrigated pasture (Table 2). Table 5 provides a breakdown by specific grazing best management practice for these growers. Grazing BMPs are clearly widely adopted across growers and acres, driven by synergistic water quality and productivity benefits from the practices listed in Table 5. Drought and climate change induced limits on irrigation water supplies and thus forage production make efficient grazing management to optimize forage and livestock harvest from irrigated pasture fundamentally important to agricultural sustainability in the sub-watershed.

Table 5. Grazing management best management practices (62 growers total graze irrigated pasture).

Practice	**Number of Respondents (%)**	**Acres Reported**
Grazing Management Plan	59 (95)	24,058
Appropriate Stocking Rate	62 (100)	24,699
Livestock Rotation	60 (97)	24,454
Pasture Rest Before Irrigation	35 (56)	15,061
Livestock Removed During Irrigation	39 (63)	16,768
Fencing to Control Access to Waterbodies	50 (81)	20,577
Defined Stream Crossings	53 (85)	22,595
Drinking Water Away from Waterbodies	39 (63)	15,907
Salt/Supplement Away from Waterbodies	60 (97)	24,549
Drag Pastures	48 (77)	18,758

Tail Water BMPs. Ninety-six percent of irrigated pasture acres (24,385 acres) are gravity flood irrigated by 64 growers (Table 2). Of the flood irrigated pasture managers, 25% report no tail water generation across 3,894 acres (Table 6). Along with water quality protection concerns, persistent drought conditions and limited irrigation water supplies have driven substantial adoption of irrigation tail water recovery and re-use BMPs across the sub-watershed (Table 6). For example, 64% of growers report that the fate of pasture tail water is as irrigation application to other pastures, and 20% report having a tail water recovery system. The implementation of pollutant filtration BMPs such as vegetated ditches/filter strips and wetlands is also robust with 95 and 69% of growers reporting, respectively.

Table 6. Tail water management best management practices (64 growers total flood irrigated pasture).

Practice	Number of Respondents (%)	Acres Reported
No Tail Water	16 (25)	3,894
Pasture is Lower Elev. than surrounding terrain	7 (11)	3,011
Tail Water goes to another agricultural user via irrigation ditch	41 (64)	17,250
Tail Water Recovery/Return System	13 (20)	8,659
Vegetated Ditch/Buffer/Strip	61 (95)	24,120
Catchment/Sediment Basin	39 (61)	15,778
Wetlands to Filter Runoff	44 (69)	19,070

Pesticide Application BMPs. Five of 6 alfalfa growers reported field-scale application of pesticides across 4,782 acres of irrigated alfalfa (Table 3). Table 7 reports pesticide application best management practices for these growers and the acres they manage. Growers report full adoption of 1 out of the 13 practices in Table 7. Please see Appendix II for additional information on pesticide application BMPs specific to growers applying paraquat dichloride and lambda-cyhalothrin.

Table 7. Pesticide application best management practices (5 alfalfa growers reporting field-scale pesticide use)

Practice	Number of Growers (%)	Acres Reported
County Applies Pesticides	5 (100)	4,782
County Permit Followed	5 (100)	4,782
Follow Label Restrictions	5 (100)	4,782
Sensitive Areas Mapped	5 (100)	4,782
Attend Trainings	5 (100)	4,782
Monitor Wind Conditions	5 (100)	4,782
Reapply Rinsate to Treated Field	5 (100)	4,782
Avoid Surface Water When Spraying	5 (100)	4,782
Use Appropriate Buffer Zones	5 (100)	4,782
Use Drift Control Agents	5 (100)	4,782
Monitor Rain Forecasts	5 (100)	4,782

Practice	Number of Growers (%)	Acres Reported
Use PCA Recommendations	5 (100)	4,782
Ag Commissioner Conducts Pretreatment Inspection	2 (40)	3,089

Economic Analysis Results

In order to ascribe economic value and assess productivity of the agricultural activities in the sub-watershed, we categorize acres according to primary commodity type (i.e., alfalfa, irrigated pasture, hay). Table 8 summarizes this categorization and acreages for the UFRW.

Table 8. Commodities, acreage, and gross revenue

Commodity	Acres	Average Yield/Acre	Average Gross Revenue/Acre
Alfalfa	4,928	4.1 Tons	$340/Ton
Hay[1]	784	3.1 Tons	$460/Ton
Irrigated Pasture	24,699	5.1 AUMs	$29.75/AUM

[1] The hay category includes grass hay and alfalfa grass hay blends.

Value of forage harvested by livestock. More than 80% of the total irrigated acres reported in the survey are irrigated pastures grazed by livestock. The economic value derived from grazing is quantified based on animal unit months (AUMs) – the amount of forage required to support one animal for one month. Across the sub-watershed, survey respondents indicate that a total of 124,856 AUMs were supported by the total irrigated pasture acres. The average length grazing season reported by survey respondents was 5.9 months per calendar year. The average AUMs supported by an acre of irrigated pasture was estimated to be 5.1.

The most recent UC Cost and Returns Study to provide the estimated economic value derived from irrigated pasture is Macon and Stewart (2020).[8] This study considers irrigated pasture in the Sierra Foothills of Northern California and estimates the value of an acre of irrigated pasture to be between $25 and $55 per AUM. Given that the irrigation and grazing season in the UFRW is shorter than that experienced in the Sierra Foothills, we would anticipate that the value of an AUM in this sub-watershed would be on the lower end of the range -- $25/AUM.

The value of an AUM is derived from the value of the calves that livestock producers are able to market for sale. In 2020 (i.e., the time of the Macon and Stewart study) national calf prices averaged $1.57/lb. In the first 7 months of 2022, national calf prices averaged $1.88/lb., a 19% increase. Given the vintage of the most recent study, it is reasonable to scale the value of the AUMs derived from irrigated pasture to reflect the increase in the value of the marketable product (i.e., calves) -- $29.75/AUM. Based on this AUM value and the average grazing season length of 5.9 months, an acre of irrigated pasture in the sub-watershed is estimated to generate an average of $175.53 per year.

However, it should be noted that these gross revenue estimates do not take into account the total operating costs associated with irrigated pasture production and management. Forero et al. (2015) quantifies the total operating costs for irrigated

[8] Macon, D. and D. Stewart. 2020. "Sample Costs to Establish, Reestablish, and Produce Irrigated Pasture in the Sierra Nevada Foothills." *University of California Agricultural and Natural Resources.* Available at: (https://coststudyfiles.ucdavis.edu/uploads/cs_public/bb/94/bb94edc2-fbfb-4be0-8853-6565b486e032/20pasturesnfhproduction.pdf).

pasture at $198/acre.[9,10] While the most recent available, the vintage of this study requires correction as well. The Bureau of Labor Statistics provides a measure of inflation specific to agricultural operations – the producer price index (PPI) for farm products. At the time of the Forero (2015) study, the average PPI for farm products for the year was 173.8. In September 2022, the PPI for farm products had escalated to 246.3, a 42% increase. Applying that percentage increase to the total operating costs for irrigated pasture from 2015 (i.e., $198/acre) yields an estimate much more relevant for 2022 -- $281.16/acre.

Value of hay harvested. A total of 784 acres of hay (e.g., grass hay, alfalfa/grass hay blends) were reported by survey respondents in the UFRW. The average yield of hay cut was 3.1 tons/acre. The United States Department of Agriculture's (USDA) California Direct Hay Report for October 14, 2022 reports that orchard grass hay (good/premium quality) in the North Inter-Mountain region of California was trading at $23.00/bale. Assuming that a bale of orchard grass weights approximately 100 lbs., a ton of hay would generate $460/ton in gross revenue. This translates to $1,426/acre in gross revenue from hay production per year. The Macon and Stewart (2020) study forecasts that the total operating costs associated with grass hay production at that time were $304/acre.[11] Adjusting this estimate for inflation results in total operating costs for an acre of hay in 2022 to be $474.24/acre.[12]

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9 Forero et al. 2015. "Sample Costs to Produce Pasture in the Sacramento Valley." *University of California Agricultural and Natural Resources*. Available at: (https://coststudyfiles.ucdavis.edu/uploads/cs_public/0e/23/0e230982-8610-42a4-8a26-32a0b10a4c5c/pasture_sv_2015.pdf).

10 Total operating costs in the study include irrigation (i.e., water delivered) and fertilizer, which are deducted from the cost presented here.

11 These total operating costs do not include cash overhead (e.g., office expenses, liability insurance) or non-cash overhead (e.g., tools, replacement parts, pipe). The cost study included irrigation costs and land lease rates, these have been removed from this figure.

12 In 2020 the PPI for farm products was 157.9. In September 2022 it was 246.3. This 56% increase was applied to the hay production total operating costs.

Value of alfalfa harvested. A total of 4,928 acres of alfalfa hay were reported by survey respondents in the UFRW. The irrigation season for alfalfa spans the months from May to September, with the average length of irrigation season being 4.5 calendar months per year. Survey responses indicated that the average yield is 4.1 tons of alfalfa per acre. The United States Department of Agriculture's (USDA) California Direct Hay Report for October 14, 2022 reports that alfalfa hay (good/premium quality) in the North Inter-Mountain region of California was trading at $340/ton. At this price, the average acre of alfalfa in the UFRW would generate $1,394 in gross revenue per year. Long et al. (2020) estimate the total operating costs associated with alfalfa production to be $522/acre in 2020.[13] Adjusting this value for inflation results in an estimate of total operating costs for 2022 of $814.32/acre.[14]

Economic implications. Although the agricultural activities conducted in the UFRW are extremely low-threat to water quality, the fees associated with compliance with the Irrigated Lands Regulatory Program (ILRP) fail to reflect this; the general fee structure is the same for more intensely cultivated crops in other regions of the Sacramento Valley Water Quality Coalition (SVWQC). One of the fundamental issues with the ILRP's compliance costs being apportioned on a per acre basis is those fees are not necessarily correlated with risk – not all acres pose equal risk to water quality. Given this structure, cross-commodity subsidization occurs with less intensive agricultural commodities, which are typically lower risk, subsidizing higher risk growers and crops.

During fiscal year 2021/22 the members of the UFRW were collectively assessed $40,395.91 by SVWQC – the sum of State Board oversight fee, SVWQC assessments, and UFRW compliance costs. During this FY, the State Board oversight fee was $1.04/acre for irrigated pasture and $1.29/acre for other agricultural commodities. Across the sub-watershed group, the total State Board oversight fee

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[13] Long et al. (2020). Sample Costs to Establish and Produce Alfalfa Hay. *University of California Agricultural and Natural Resources*. Available at: (https://coststudyfiles.ucdavis.edu/uploads/cs_public/02/ee/02ee0710-8c2c-41ea-8b25-736d1854b737/alfalfasvdraft10420.pdf).

[14] See footnote 8.

($21,544.29) accounted for 53% of UFRW's total SVWQC assessment. The remaining 47% ($18,851.62) of UFRW members' annual SVQQC assessment is associated with regional plan program management ($4,595.81), groundwater quality planning and management ($7,420.75), coalition reporting requirements ($2,640.45), and general program management costs ($4,194.61). Based on SVWQC assessments and sub-watershed costs (e.g., insurance, administration, etc.) members were assessed $1.05/acre and a $200/person membership fee.[15]

As an illustration of the economic discrepancies in revenue and ILRP assessments, compare irrigated pasture ($176/acre/year gross revenue in the UFRW) and almonds ($5,500/acre gross revenue in the Sacramento Valley in 2020). This means that a cattle producer would have to graze more than 31 acres to generate the same revenue as a single acre of almonds.[16] If each were to pay approximately the same total ILRP compliance assessment fee per acre ($1.05), the almond producer would be assessed $1.05 to earn $5,500 in revenue whereas the irrigated pasture operator would be assessed $32.55 to earn $5,500 in revenue.[17] As such, the cattle producer would pay 31 *times* the regulatory compliance costs of the almond producer in the Sacramento Valley, despite the fact that they manage an extensive, low-threat agricultural crop.

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15 The watershed group also charged members with more than 1,000 enrolled acres an additional $0.25/acre.

16 Although we present this information in terms of gross revenue herein, the results are very similar if comparisons are made based on net profit.

17 The UFRW, following years of monitoring and reporting in the ILRP, secured reduced monitoring requirements in order to remain in compliance. As such, their per acre fee assessment is often lower than other sub-watersheds without the same designation.

APPENDIX II

Upper Feather River Irrigated Pasture and Alfalfa Pesticide Transport Risk Assessment Summary

Upper Feather River Irrigated Pasture and Alfalfa Pesticide Transport Risk Assessment Summary

Prepared by

Kenneth Tate[18], Tracy Schohr[19], and Tina Saitone[20]
UC Cooperative Extension and UC Davis

November 11, 2022

Background and Purpose

During the course of evaluating the low risk to water quality status of irrigated agriculture in the Upper Feather River sub-watershed of the Sacramento Valley Water Quality Coalition (SVWQC) it was determined from pesticide use reporting 2016 through 2021 provided by the Plumas-Sierra County Agricultural Commissioner that paraquat dichloride and lambda-cyhalothrin – both of potential concern to the Central Valley Regional Water Quality Control Board (WB) and others – were applied to irrigated acres in the sub-watershed (Tables 1 and 2). Application was limited in acreage with reported paraquat dichloride applications to sprinkler irrigated alfalfa parcels representing 1.7 to 2.9% of total irrigated acres annually between 2016 and 2021 (Table 1). Lambda-cyhalothrin was reported to be applied 3 out of the 6 years in the sub-watershed primarily to sprinkler irrigated alfalfa (125 to 1,081 acres annually) with total reported applications for those 3 years across alfalfa and irrigated pasture representing 0.4 to 4.4% of total irrigated acres

[18] Professor and Cooperative Extension Specialist in Rangeland Watershed Sciences, Department of Plant Sciences, UC Davis.

[19] Livestock and Natural Resources Advisor, Plumas, Sierra, Butte Counties, UC Cooperative Extension.

[20] Associate Professor of Cooperative Extension in Livestock and Rangeland Economics, Department of Agricultural and Resource Economics, UC Davis.

(Table 2).

As one component of the low-risk status evaluation for the sub-watershed, site (farm) specific assessments (case studies) were conducted during late September and early October of 2022 to determine the potential risk of hydrologic transport and subsequent downstream contamination of surface waters from applications of paraquat dichloride and lambda-cyhalothrin occurring on these farms. A total of five case studies were conducted by UC Cooperative Extension (UCCE) via on-farm visits during which a structured assessment framework was used to determine the amount, timing, and location of pesticide applications relative to hydrologic transport events (i.e., irrigation events, storm runoff) and proximity to surface waters. The structured assessment framework was developed collaboratively by UCCE and the WB based upon standard principles of pollutant environmental fate and transport risk assessment. Collectively the 5 case studies examined all of the reported/permitted applications of paraquat dichloride and lambda-cyhalothrin in the sub-watershed from 2016 through 2021.

Table 1. Paraquat dichloride reported/permitted use in the Upper Feather River sub-watershed 2016 through 2021. No application reported/permitted on irrigated pasture was reported.

Year	**Alfalfa Acres**	**Alfalfa Active Ingredient (lbs)**	**% of Total Irrigated Acres**
2016	785	410	2.6
2017	510	146	1.7
2018	730	252	2.4
2019	790	286	2.6
2020	625	214	2.1
2021	980	322	2.9

Table 2. *Lambda-cyhalothrin reported/permitted use in the Upper Feather River sub-watershed 2016 through 2021.*

Year	Alfalfa Acres	Alfalfa Active Ingredient (lbs)	Irrigated Pasture Acres	Irrigated Pasture Active Ingredient (lbs)	% of Total Irrigated Acres
2016	0	0	0	0	0
2017	0	0	0	0	0
2018	125	2.5	0	0	0.4
2019	0	0	0	0	0
2020	555	11.3	100	2.9	2.1
2021	1,081	15.7	250	4.9	4.4

Paraquat Dichloride and Lambda-Cyhalothrin – Overview

These pesticides are of concern to the WB and others due to their potential toxicity to humans and the environment if handled and/or applied inappropriately. Both have the potential to cause acute and chronic health issues for aquatic organisms if they reach surface waters.

Paraquat dichloride (paraquat) is 1) a non-selective herbicide used for the control of broadleaf and grass weeds in agricultural and non-agricultural use settings; 2) a contact herbicide that inhibits photosynthesis, desiccating and destroying plant cell membranes within hours of application; and 3) a restricted use pesticide that can only be used by certified applicators due to "acute toxicity". Herbicide products containing paraquat are labeled with the signal word "danger" (high toxicity). In terms of environmental fate, paraquat 1) is rapidly absorbed into foliage and is rain-fast within 30 minutes of application; 2) remains in treated leaves under normal conditions; 3) is rapidly and tightly bound to soil particles; and 4) is completely inactive, biologically unavailable, and immobile in soil due to tight adsorption with no leaching potential. Unless paraquat were applied directly to surface waters (e.g., wind drift, overspray) the most likely means of transport to, and contamination of, surface waters would be mobilization and transport of paraquat bound to soil particles via soil erosion. Paraquat is also subject to moderate rates of photodegradation – it can be degraded from plant surfaces and possibly from soil surfaces to the extent of 25-50% in 3 weeks under conditions of full sunlight. The information above about paraquat is derived from the *Herbicide Handbook* (Weed Science Society of America, 14th Edition, 2014), the US Environmental Protection Agency's pesticide product labels, and the scientific literature.

Lambda-Cyhalothrin (lambda) 1) is a pyrethroid insecticide used for the control of a broad group of pests (e.g., aphids, weevils, grasshoppers, ants, termites, cockroaches, mosquitoes) in agricultural and non-agricultural (e.g., indoor/outdoor residential, commercial) use settings; 2) disrupts the nervous system of insects within minutes of contact leading to cessation of feeding, loss of muscular control, paralysis, and eventual death; 3) provides additional crop protection due to the insecticide's strong repellent effect toward insects; and 4) is a restricted use pesticide that can only be used by certified applicators due to "toxicity to fish and aquatic organisms". Insecticide products containing lambda-cyhalothrin are commonly labeled with the signal word "warning" (moderate toxicity). In terms of environmental fate, lambda 1) is rapidly and strongly adsorbed to soils and sediments; 2) is highly immobile in soil due to tight adsorption with almost no leaching potential; 3) can be subject to photodegradation with a half-life of less than 5 minutes in full sunlight; 4) can be subject to breakdown via hydrolysis in environments with pH >8; and 5) is subject to uptake from water (i.e., agricultural tailwater), adsorption, and accelerated degradation by plants in systems such as irrigated pasture, alfalfa, vegetated ditches, and wetlands. Unless lambda were applied directly to surface waters (e.g., wind drift, overspray) the most likely means of transport to, and contamination of, surface waters and sediments in surface waters would be mobilization and transport of lambda bound to soil (particularly soil organic matter) via soil erosion. The information above about lambda is derived from He, L.M., Troiano, J., Wang, A., and Goh, K.S. 2008. *Environmental Chemistry, Ecotoxicity, and Fate of Lambda-Cyhalothrin*, Reviews of Environmental Contamination and Toxicology, 195:71-91; the US Environmental Protection Agency's pesticide product labels; and the scientific literature.

Paraquat Dichloride and Lambda-Cyhalothrin – Permitted Uses in the UFRW sub-watershed

Table 1 reports the acres and pounds of active ingredient for paraquat reported/permitted by the Plumas-Sierra County Agricultural Commissioner for application in the UFRW sub-watershed from 2016 through 2021. Only one grower reported the use of paraquat on alfalfa (Case Study 4) for the purpose of controlling early spring broadleaf and grass weeds. Across all years, applications occurred between early March and mid-April (late winter depending upon annual weather conditions) subsequent to weed emergence but while alfalfa was still dormant.

Table 2 reports the acres and pounds of active ingredient for lambda reported/permitted by the Plumas-Sierra County Agricultural Commissioner for application in the UFRW sub-watershed from 2016 through 2021. Application of lambda was reported by one grower on irrigated pasture to control grasshopper outbreak in July of 2020 and by that same grower plus another grower for the same purpose in May of 2021 (Case Studies 1 and 2). Application of lambda was reported for alfalfa by one grower in late April of 2020 and 2021 for control of alfalfa weevil (Case Study 3), by one grower in June of 2018 for control of aphids (Case Study 4), and by one grower in early April of 2021 for control of alfalfa weevils and aphids (Case Study 5).

Paraquat Dichloride and Lambda-Cyhalothrin – Summary of Case Studies

Five site (farm) specific assessments (case studies) were conducted during late September and early October of 2022 to determine the potential risk of hydrologic transport and subsequent downstream contamination of surface waters from applications of paraquat dichloride and lambda-cyhalothrin. The details of each risk assessment, as well as site photographs can be found at the end of this summary.

Representativeness of the Case Study Sites. Upon site visits, it became clear that these farms are typical of irrigated pasture and alfalfa production operations across the sub-watershed and region in terms of weather, soils, hydrology, agronomic practices, irrigation, best management practice adoption, productivity and economics as described in Appendix 1X of this recommendation. These sites are also representative of potential risk of hydrologic transport and subsequent downstream contamination of surface waters from applications of pesticides broadly (i.e., paraquat and lambda as well as other pesticides of lesser environmental concern used in the sub-watershed). As a representative sub-sample of irrigated pasture and alfalfa operations, the findings below would have application broadly across these commodities throughout the sub-watershed.

Lambda-Cyhalothrin Application to Irrigated Pasture. As indicated above, application of lambda was reported by one grower on irrigated pasture to control grasshopper outbreak in July of 2020 and by two growers for the same purpose in May of 2021 (Case Studies 1 and 2). During the site assessment we found that both the actual acreage and amount of active ingredient applications were essentially an order of magnitude lower than what was reported/permitted (Table 2). In Case Study 1, the actual irrigated pasture acreage with application was 4 and 3 acres in 2020 and 2021, respectively – compared to the 100 acres permitted each year by the Agricultural Commissioner. Actual active ingredient applied was 0.09 and 0.07 pounds in 2020 and 2021, respectively – compared to the 2.97 and 1.98 pounds permitted for each year. Thus, total active ingredient applied over both years was 96.7% lower than permitted/reported in this case. The same was true for Case Study 2. In Case Study 2, the actual irrigated pasture acreage with application was 10 acres in 2021 – compared to the 150 acres permitted by the Agricultural Commissioner. Actual active ingredient applied was 0.23 pounds – compared to the 2.97 pounds permitted. Thus, total active ingredient applied was 92.3% lower than permitted/reported. In both cases, we found that lambda was actually being applied as a targeted application focused primarily on dryland areas where grasshoppers were reared immediately adjacent to irrigated pasture, and at a time when they were still too immature to take flight. In Case Study 1, 46% of the acres treated with lambda were dryland (not irrigated). In Case Study 2, 60% of the acres treated with lambda were dryland (not irrigated). Both of these cases represent targeted pesticide application, not field scale applications.

The risk of lambda transport to surface water as irrigation tailwater or storm runoff for both Case Study 1 and 2 was determined to be non-existent due to distances from surface waters, high topography between pastures and surface waters, and the fact that all irrigation is consumptively used on-ranch with no tailwater leaving the property, nor entering a surface water. Risk of direct deposition to surface waters due to drift was also determined to be non-existent due to distances from surface waters and use of best practices during pesticide application to prevent drift.

Paraquat Dichloride and Lambda-Cyhalothrin Application to Irrigated Alfalfa. As indicated above, only one grower reported the use of paraquat on alfalfa for the purpose of controlling early spring broadleaf and grass weeds all 6 years (Case Study 4). Lambda was applied to alfalfa in 3 of the 6 years to control weevils and/or aphids by 3 growers (Case Studies 3, 4, and 5). In all cases of paraquat and lambda application to alfalfa the actual acres and active ingredient applied was the same as permitted/reported by the Agricultural Commissioner (Case Study 3, 4, and 5). The risk of lambda transport to surface water as irrigation tailwater or storm runoff for both paraquat and lambda applied to alfalfa in these cases was determined to be none for a suite of reasons. First, all applications were made to low pressure sprinkler irrigated fields with no tailwater generation. Second, timing of application relative to snowmelt and possible summer storms prohibits the risk of storm runoff. Third, the nearest surface waters to any of the fields is 1 mile. Fourth, all fields have berms, railroad tracks, and/or roads which would prohibit any possibility of surface flow from the fields reaching surface waters. Risk of direct deposition to surface waters due to drift was also determined non-existent due to distances (>1 mile in all cases) from surface waters and application of best pesticide application practices to prevent drift.

Conclusions

The risk of transport to surface waters is almost nonexistent if not completely nonexistent in all cases. This assessment is based upon the 1) properties of paraquat and lambda to absorb tightly and immediately to soil particles; 2) complete vegetative soil cover at all sites preventing soil erosion and soil bound pesticide transport; 3) lack of evidence of erosion at any of the case studies; 4) lack of tailwater generation and/or lack of tailwater contribution to surface waters; 5) distances of pasture/fields to surface water; 6) temporal decoupling of the timing of application from potential hydrologic mobilization events for multiple days if not weeks – allowing pesticide absorption to soil and uptake by plants; 7) extremely low amount of active ingredient applied across all cases, and 8) implementation of irrigation application, tailwater management, and pesticide application BMPs.

APPENDIX III

Upper Feather River Irrigated Pasture Pesticide Transport Risk Assessments

Case Studies 1-5

Upper Feather River Irrigated Pasture and Alfalfa Pesticide Transport Risk Assessment

CASE STUDY #1

PESTICIDE APPLICATIONS AND PURPOSES: *what were the reported pesticide uses (2016-2021) covered by this assessment, were the actual uses different from what was permitted (a.k.a. reported), and what were the purpose for their use.*

Table 1. The pesticide uses reported (i.e., permitted) by this farm operator annually 2016 through 2021, and thus included in this case study, are summarized below.

Year	Pesticide	Meridian	Month-Day	Acres	AI* (lbs)
2020	LAMBDA-CYHALOTHRIN	32M26N10E22	7/8/2020	100	2.97
2021	LAMBDA-CYHALOTHRIN	32M26N10E22	5/3/2021	100	1.98

***AI = active ingredient**

Table 2. The pesticide uses actually implemented by this farm operator annually 2016 through 2021, if different from those reported (i.e., permitted) in Table 1. If not different, leave blank.

Year	Pesticide	Meridian	Month-Day	Acres Treated	AI** (lbs)
2020	LAMBDA-CYHALOTHRIN	32M26N10E22	7/8/2020	4 irrigated pasture 3 dry rangeland	0.09
2021	LAMBDA-CYHALOTHRIN	32M26N10E22	5/3/2021	3 irrigated pasture 3 dry rangeland	0.07

****AI = total active ingredient application to irrigated lands**

In this case, the reported use of lambda-cyhalothrin substantially exceeded the actual use in both 2020 and 2021. This pesticide was applied to non-irrigated (dry rangelands) at the upper edge of irrigated pasture. Timing and location of application was targeted to impact grasshoppers emerging from dryland rearing grounds prior to their movement into adjacent irrigated pasture. In 2020, application was made at ~0.023 lbs of active ingredient (~3 oz of product) per acre to 3 acres of non-irrigated rangeland and an adjacent 4 acres of irrigated pasture. In 2021, application was made at ~0.023 lbs of active ingredient (~3 oz of product) per acre to 3 acres of non-irrigated rangeland and to an adjacent 3 acres of irrigated pasture. The actual application of lambda-cyhalothrin to irrigated lands in this case study across both 2020 and 2021 was 0.16 lbs (Table 2), not 5 lbs as reported/permitted (Table 1).

1) Purpose(s) for paraquat dichloride applications (leave blank if not applicable)?

2) Purpose(s) for lambda-cyhalothrin applications (leave blank if not applicable)?

Control of grasshopper infestation

APPLICATIONS RELATIVE TO SURFACE WATERS AND HYDROLOGIC TRANSPORT PATHWAYS: *how close was pesticide applied to surface waters, what is the likelihood that pesticides applied to fields/pastures could be transported in surface runoff, tailwater ditches, vegetated ditches, buffers, etc. to surface waters.*

3) Are applications made primarily to irrigated fields/pastures, to dry areas within or at the edge of fields/pastures, or a combination of the above? Please provide a brief explanation and percentages if a combination of application to dry and irrigated ground.

The applications in this case study would be best described as targeted control of emerging grasshopper populations on non-irrigated adjacent rangelands where grasshopper eggs were laid in the soil and from which juveniles (pre-flight) were emerging at the time of application. Roughly 50% of the application (area and amount) was to dry rangelands to directly target emerging grasshoppers, and the remaining 50% was applied to the edge of the adjacent irrigated pasture to deter grasshopper entry to the irrigated pasture. In this case the application was made at the top of the pasture to rangelands above (elevational) irrigation water application and to a strip about 100 feet wide across the top of the irrigated pasture.

4) What is the distance (e.g., feet, yards, miles) from the fields/pastures with application to the nearest stream or surface waters (downstream and/or adjacent)? Is it likely that pesticides from these fields/pastures could transport as surface runoff to surface waters?

The nearest downslope surface water is Wolf Creek - approximately 1 mile. Indian Creek is above (elevational) the application site about 400 yards. Due to sedimentation over time, there is a dryland berm along Indian Creek which is of higher elevation than the irrigated pasture. Irrigation water is applied to the top of the field (~400 yards from Indian Creek) and the pasture slopes away from Indian Creek. Since the pesticide application was to the top of this pasture, the entire pasture (~800 yards) served as a transport filter. Discharge from the pasture enters a downslope dryland pasture and is fully consumed. There is no potential for transport of pesticides in this case.

5) Pesticides often absorb to soil particles once applied to a field/pasture, and could be transported with soil particles if soil erosion occurs following application. Were the fields/pastures with application covered with permanent vegetation (i.e. soil surface cover, field edge buffers)? Is it likely that pesticides from this these fields/pastures could transport via soil erosion to surface waters?

The pasture has permanent vegetation with no bare ground. Soil erosion was not evident and is not likely, and given the lack of surface runoff from the field described above, the potential for sediment transport is also not likely.

6) Is there any opportunity for direct application (i.e., overspray) or indirect drift (i.e., wind) of pesticides to streams or surface waters (downstream and/or adjacent)?

There is a 400 yard buffer between the application site and the nearest surface water (Indian Creek). Best practices were employed to such that application (ground application) occurred early morning on days with no wind to ensure product impacts the pest of concern without off-site impacts.

7) Are the fields/pastures with application flood or sprinkler irrigated? If a combination, what are the acres of flood and sprinkler irrigated?

The pasture is flood irrigated via risers delivering pumped water. The pasture is laser leveled with even irrigation water application and full control of timing, distribution, and amount of irrigation.

8) During irrigation events, do the fields/pastures with application generate surface runoff (i.e., tailwater)? If so, how much tailwater is generated (as a percentage of water applied) and where does the runoff go (e.g., another field/pasture, surface water)?

The pasture generates limited tailwater. Discharge from the pasture enters a downslope dryland pasture and is fully consumed with no tailwater discharge to surface waters.

9) In general – given soil texture, climate/weather conditions, irrigation water supplies, and other site specific factors – what is the potential for runoff from the fields/pastures receiving application to impact surface waters? Please provide a brief explanation.

Non-existent because of permanent vegetated fields, limited irrigation water, laser leveled fields with uniform flow, drought and dry soil conditions during application. No tailwater contribution to surface waters. Additionally, irrigation water is pumped, and power costs are prohibitive for runoff/excess flows. Weather forecast is monitored and application occurs only if there is no rain in the forecast.

APPLICATIONS RELATIVE TO HYDROLOGIC TRANSPORT EVENTS: *when were pesticides applied to field/pastures relative to hydrologic transport events such as irrigation, and what is the likelihood that pesticides applied to fields/pastures could be transported due to proximity in time to these events.*

10) Are applications made during the spring prior to, or during summer irrigation season – or during both periods?

During summer irrigation season.

11) For applications made in the spring prior to the irrigation season, on average how many days does application occur prior to the initiation of irrigation?

Not applicable.

12) For applications made during the summer irrigation season, on average how many days does application occur prior to the subsequent irrigation event?

Applications occurs about 2 days after irrigation, once soil surface is dry enough for ground application via light weight ATV. The first irrigation following pesticide application occurs 10-14 days post application irrigation depending on soil water conditions.

13) For any applications is there potential for rainfall or snow melt runoff events to transport pesticides from the field/pasture to surface waters?

Weather forecasts are monitored so that applications are not made prior to storm events. These applications occurred during the summer drought period when rainfall is limited and dry soils have high infiltration potential.

PESTICIDE APPLICATION BEST MANAGEMENT PRACTICES: *what are the standard best practices employed to assure safe and efficient application.*

14) Please indicate which of the following best management practices employed for the specific fields/pastures assessed for paraquat dichloride and lambda-cyhalothrin applications.

Practice	**Implemented (Yes/No)**
County Applies Pesticides	No
County Permit Followed	Yes
Follow Label Restrictions	Yes
Sensitive Areas Mapped	Yes

Practice	Implemented (Yes/No)
Attend Trainings	Yes
Monitor Wind Conditions	Yes
Reapply Rinsate to Treated Field	Yes
Avoid Surface Water When Spraying	Yes
Use Appropriate Buffer Zones	Yes
Use Drift Control Agents	Yes
Monitor Rain Forecasts	Yes
Use PCA Recommendations	Yes
Ag Commissioner Conducts Pretreatment Inspection	Yes

Case Study 1 - Photos

Image 1 – Case Study 1: Bracket indicates the area where lambda-cyhalothrin was applied.

Image 2 – Case Study 1: Permanent vegetation on the irrigated pasture.

Image 3 – Case Study 1 – The arrow indicates the location of application at top of the pasture. The photo was taken from the bottom of the pasture and depicts the 800 yards of travel distance across the pasture. (taken from same location as Image 4)

Image 4 – Case Study 1: Point of tailwater discharge from the irrigated pasture with application. Any tailwater from the pasture with application is applied to the pastures below the culvert.

Image 5 – Case Study 1: The terminal pasture which receives any tailwater originating from the pasture with pesticide application – approximately 1600 yards up-slope. No tailwater is discharged from the dry pasture below the cattle in this photo.

Upper Feather River Irrigated Pasture and Alfalfa Pesticide Transport Risk Assessment

CASE STUDY #2

PESTICIDE APPLICATIONS AND PURPOSES: *what were the reported pesticide uses (2016-2021) covered by this assessment, were the actual uses different from what was permitted (a.k.a. reported), and what were the purpose for their use.*

Table 1. The pesticide uses reported (i.e., permitted) by this farm operator annually 2016 through 2021, and thus included in this case study, are summarized below.

Year	Pesticide	Meridian	Date	Acres	AI* (lbs)
2021	LAMBDA-CYHALOTHRIN	32M26N10E22	5/12/2021	150	2.97

***AI = active ingredient**

Table 2. The pesticide uses actually implemented by this farm operator annually 2016 through 2021, if different from those reported (i.e., permitted) in Table 1. If not different, leave blank.

Year	Pesticide	Meridian	Date	Acres Treated	AI** (lbs)
2021	LAMBDA-CYHALOTHRIN	32M26N10E22	5/12/2021	10 irrigated pasture 15 dry angeland	0.23

****AI = total active ingredient application to irrigated lands**

In this case, the reported use of lambda-cyhalothrin substantially exceeded the actual use. This pesticide was applied primarily to non-irrigated (dry rangelands) and along the edge of adjacent irrigated pasture. Timing and location of application was targeted to impact grasshoppers emerging from dryland rearing grounds prior to their movement into adjacent irrigated pasture. Application was made at ~0.023 lbs of active ingredient (~3 oz of product) per acre to 15 acres of non-irrigated rangeland and an adjacent 10 acres of irrigated pasture. The actual application of lambda-cyhalothrin to irrigated lands in this case study was 0.23 lbs (Table 2), not 3 lbs as reported/permitted (Table 1).

1) Purpose(s) for paraquat dichloride applications (leave blank if not applicable)?

2) Purpose(s) for lambda-cyhalothrin applications (leave blank if not applicable)?

Control of grasshopper infestation.

APPLICATIONS RELATIVE TO SURFACE WATERS AND HYDROLOGIC TRANSPORT PATHWAYS: *how close was pesticide applied to surface waters, what is the likelihood that pesticides applied to fields/pastures could be transported in surface runoff, tailwater ditches, vegetated ditches, buffers, etc. to surface waters.*

3) Are applications made primarily to irrigated fields/pastures, to dry areas within or at the edge of fields/pastures, or a combination of the above? Please provide a brief explanation and percentages if a combination of application to dry and irrigated ground.

The applications in this case study would be best described as targeted control of emerging grasshopper populations on non-irrigated adjacent rangelands where grasshopper eggs were laid in the soil and from which juveniles (pre-flight) were emerging at the time of application. Roughly 60% of the application (area and amount) was to dry rangelands to directly target emerging grasshoppers, and the remaining 40% was applied to the edge of the adjacent irrigated pasture to deter grasshopper entry to the irrigated pasture. In this case the application was made at the top of the pasture to rangelands above (elevational) irrigation water application and to a strip about 100 feet wide across the top of 3 irrigated pastures.

4) What is the distance (e.g., feet, yards, miles) from the fields/pastures with application to the nearest stream or surface waters (downstream and/or adjacent)? Is it likely that pesticides from these fields/pastures could transport as surface runoff to surface waters?

There is no downslope surface water that receives tailwater from any of the irrigated pastures on this ranch, all irrigation water is consumed on this property. Indian Creek is above (elevational) the application site about 300 yards. Due to sedimentation over time, there is a dryland berm along Indian Creek which is of higher elevation than the irrigated pasture - the pasture slopes away from Indian Creek. The final field on this property receiving irrigation application/tailwater is a hay pasture which does not generate tailwater. There is no potential for transport of pesticides in this case.

5) Pesticides often absorb to soil particles once applied to a field/pasture, and could be transported with soil particles if soil erosion occurs following application. Were the fields/pastures with application covered with permanent vegetation (i.e. soil surface cover, field edge buffers)? Is it likely that pesticides from this these fields/pastures could transport via soil erosion to surface waters?

Yes, pasture has permanent vegetation. Additionally, there is a vegetated buffer at field edge and a riparian grazing exclosure with vegetated buffer between spray application area and waterway. No, it is not likely for sediment transport due to permanent vegetation, field geography (berm that prevents flow to creek) and tailwater from irrigation ends on field of property owner. Soil erosion was not evident and is not likely, and given the lack of surface runoff from the field described above, the potential for sediment transport is also not likely.

6) Is there any opportunity for direct application (i.e., overspray) or indirect drift (i.e., wind) of pesticides to streams or surface waters (downstream and/or adjacent)?

There is a 300-yard buffer between the application site and the nearest surface water (Indian Creek). Best practices were employed to such that application (ground application) occurred early morning on days with no wind to ensure product impacts the pest of concern without off-site impacts.

7) Are the fields/pastures with application flood or sprinkler irrigated? If a combination, what are the acres of flood and sprinkler irrigated?

The pastures are flood irrigated via vegetated delivery ditches delivering gravity flow irrigation water with adequate irrigation water application and control of timing, distribution, and amount of irrigation.

8) During irrigation events, do the fields/pastures with application generate surface runoff (i.e., tailwater)? If so, how much tailwater is generated (as a percentage of water applied) and where does the runoff go (e.g., another field/pasture, surface water)?

There is no downslope surface water that receives tailwater from any of the irrigated pastures on this ranch, all irrigation water is consumed on this property. Tailwater flows from one pasture to the next, and the final pasture on this property receiving irrigation application/tailwater is a hay pasture which does not generate tailwater.

9) In general – given soil texture, climate/weather conditions, irrigation water supplies, and other site specific factors – what is the potential for runoff from the fields/pastures receiving application to impact surface waters? Please provide a brief explanation.

Non-existent. Limited irrigation water, natural sediment barrier/berm to prevent tail water irrigation from entering Indian Creek, permanent vegetated fields, drought and dry soil conditions during application. No tailwater contributions to surface waters**.**

APPLICATIONS RELATIVE TO HYDROLOGIC TRANSPORT EVENTS: *when were pesticides applied to field/pastures relative to hydrologic transport events such as irrigation, and what is the likelihood that pesticides applied to fields/pastures could be transported due to proximity in time to these events.*

10) Are applications made during the spring prior to, or during summer irrigation season – or during both periods?

During the summer irrigation season.

11) For applications made in the spring prior to the irrigation season, on average how many days does application occur prior to the initiation of irrigation?

Not applicable.

12) For applications made during the summer irrigation season, on average how many days does application occur prior to the subsequent irrigation event?

Applications occurs about a week after irrigation once soil surface is dry enough for ground application via light weight ATV. The first irrigation following pesticide application occurs 14-16 days post application irrigation depending on soil water conditions.

13) For any applications is there potential for rainfall or snow melt runoff events to transport pesticides from the field/pasture to surface waters?

Weather forecasts are monitored so that applications are not made prior to storm events. These applications occurred during the summer drought period when rainfall is limited and dry soils have high infiltration potential.

PESTICIDE APPLICATION BEST MANAGEMENT PRACTICES: *what are the standard best practices employed to assure safe and efficient application.*

14) Please indicate which of the following best management practices employed for the specific fields/pastures assessed for paraquat dichloride and lambda-cyhalothrin applications.

Practice	**Implemented (Yes/No)**
County Applies Pesticides	No
County Permit Followed	Yes
Follow Label Restrictions	Yes
Sensitive Areas Mapped	Yes
Attend Trainings	Yes
Monitor Wind Conditions	Yes
Reapply Rinsate to Treated Field	Yes

Practice	Implemented (Yes/No)
Avoid Surface Water When Spraying	Yes
Use Appropriate Buffer Zones	Yes
Use Drift Control Agents	Yes
Monitor Rain Forecasts	Yes
Use PCA Recommendations	Yes
Ag Commissioner Conducts Pretreatment Inspection	Yes

Case Study 2 - Photos

Image 1 – Case Study 2: Area where lambda-cyhalothrin was applied. Dry, upland area with elevated berm and vegetated buffer ~300 yard from Indian Creek.

Image 2 – Case Study 2: Irrigated pasture with permanent vegetation.

Image 3 – Case Study 2: Vegetated irrigation ditch.

Image 4 – Case Study 2: The final field on this property receiving irrigation application/tailwater is a hay pasture which does not generate tailwater.

Upper Feather River Irrigated Pasture and Alfalfa Pesticide Transport Risk Assessment

CASE STUDY #3

PESTICIDE APPLICATIONS AND PURPOSES: *what were the reported pesticide uses (2016-2021) covered by this assessment, were the actual uses different from what was permitted (a.k.a. reported), and what were the purpose for their use.*

Table 1. The pesticide uses reported (i.e., permitted) and actually implemented by this farm operator annually 2016 through 2021, and thus included in this case study, are summarized below.

Year	Pesticide	Meridian	Date	Acres	AI* (lbs)
2020	LAMBDA-CYHALOTHRIN	32M23N15E27	4/22/2020	180	2.6
2020	LAMBDA-CYHALOTHRIN	32M23N15E20	4/23/2020	135	2.0
2020	LAMBDA-CYHALOTHRIN	32M23N15E29	4/24/2020	120	1.0
2020	LAMBDA-CYHALOTHRIN	32M23N15E29	4/25/2020	120	1.8
2021	LAMBDA-CYHALOTHRIN	32M23N15E29	4/17/2021	126	1.5
2021	LAMBDA-CYHALOTHRIN	32M23N15E29	4/20/2021	164	1.5
2021	LAMBDA-CYHALOTHRIN	32M23N15E30	4/22/2021	175	2.0
2021	LAMBDA-CYHALOTHRIN	32M23N15E27	4/23/2021	191	2.3
2021	LAMBDA-CYHALOTHRIN	32M23N15E20	4/30/2021	135	1.6
2021	LAMBDA-CYHALOTHRIN	32M23N15E21	5/1/2021	120	1.5

***AI = active ingredient**

1) Purpose(s) for paraquat dichloride applications (leave blank if not applicable)?

2) Purpose(s) for lambda-cyhalothrin applications (leave blank if not applicable)?

Control alfalfa weevil.

APPLICATIONS RELATIVE TO SURFACE WATERS AND HYDROLOGIC TRANSPORT PATHWAYS: *how close was pesticide applied to surface waters, what is the likelihood that pesticides applied to fields/pastures could be transported in surface runoff, tailwater ditches, vegetated ditches, buffers, etc. to surface waters.*

3) Are applications made primarily to irrigated fields/pastures, to dry areas within or at the edge of fields/pastures, or a combination of the above? Please provide a brief explanation and percentages if a combination of application to dry and irrigated ground.

All applications were directly to sprinkler irrigated alfalfa fields.

4) What is the distance (e.g., feet, yards, miles) from the fields/pastures with application to the nearest stream or surface water (downstream and/or adjacent)? Is it likely that pesticides from these fields/pastures could transport as surface runoff to surface waters?

Little Last Chance Creek is ~ 1.5 miles from the application sites, and the Middle Fork Feather River is ~3 miles from the application sites. Topography and barriers such as railroad tracks and roads prohibit hydrologic connection to both surface waters. There is no potential for pesticides applied to these fields to transport as surface runoff due to topography and barriers, distance, and low flow sprinkler irrigation which does not generate surface runoff.

5) Pesticides often absorb to soil particles once applied to a field/pasture, and could be transported with soil particles if soil erosion occurs following application. Were the fields/pastures with application covered with permanent vegetation (i.e. soil surface cover, field edge buffers)? Is it likely that pesticides from this these fields/pastures could transport via soil erosion to surface waters?

The alfalfa fields have permanent vegetation with no bare ground. Soil erosion was not evident and is not likely, and given the lack of surface runoff from the field described above, the potential for sediment transport is also not likely. Also, there are permanent vegetated buffers around the edges of the field.

6) Is there any opportunity for direct application (i.e., overspray) or indirect drift (i.e., wind) of pesticides to streams or surface waters (downstream and/or adjacent)?

There is no potential for direct application or indirect of pesticides to enter surface waters. The applicated fields are at least 1.5 miles from the nearest surface waters. Best practices were employed to such that application occurred on days with no wind to ensure product impacts the pests/weeds of concern without off-site impacts.

7) Are the fields/pastures with application flood or sprinkler irrigated? If a combination, what are the acres of flood and sprinkler irrigated?

Low flow sprinkler irrigation.

8) During irrigation events, do the fields/pastures with application generate surface runoff (i.e., tailwater)? If so, how much tailwater is generated (as a percentage of water applied) and where does the runoff go (e.g., another field/pasture, surface water)?

No tailwater/surface runoff is generated from these fields under sprinkler irrigation.

9) In general – given soil texture, climate/weather conditions, irrigation water supplies, and other site-specific factors – what is the potential for runoff from the fields/pastures receiving application to impact surface waters? Please provide a brief explanation.

None for fields with application. All fields are in permanent vegetation on sprinkler systems, it is costly to pump water to irrigate so only apply what the crop needs. No tailwater generated from fields. Additionally, soils in the region are dry during irrigation season. There are buffers that are not farmed (or sprayed) covered with native permanent vegetation edge the fields. The pesticide applications are prior to irrigation when soil is dry, to prevent soil damage.

APPLICATIONS RELATIVE TO HYDROLOGIC TRANSPORT EVENTS: *when were pesticides applied to field/pastures relative to hydrologic transport events such as irrigation, and what is the likelihood that pesticides applied to fields/pastures could be transported due to proximity in time to these events.*

10) Are applications made during the spring prior to, or during summer irrigation season – or during both periods?

Spring prior to irrigation.

11) For applications made in the spring prior to the irrigation season, on average how many days does application occur prior to the initiation of irrigation?

At least 4 days prior to irrigation, and greater if there are cool weather conditions. Irrigation post application is delayed as long as possible to insure pesticides have maximum possible time to impact the target pests.

12) For applications made during the summer irrigation season, on average how many days does application occur prior to the subsequent irrigation event?

Not applicable.

13) For any applications is there potential for rainfall or snow melt runoff events to transport pesticides from the field/pasture to surface waters?

Weather forecasts are monitored so that applications are not made prior to storm events. These applications occurred during the spring period following snowmelt and relatively dry soils at the time have high infiltration potential.

PESTICIDE APPLICATION BEST MANAGEMENT PRACTICES: *what are the standard best practices employed to assure safe and efficient application.*

14) Please indicate which of the following best management practices employed for the specific fields/pastures assessed for paraquat dichloride and lambda-cyhalothrin applications.

Practice	Implemented (Yes/No)
County Applies Pesticides	No
County Permit Followed	Yes
Follow Label Restrictions	Yes
Sensitive Areas Mapped	Yes
Attend Trainings	Yes
Monitor Wind Conditions	Yes
Reapply Rinsate to Treated Field	Yes
Avoid Surface Water When Spraying	Yes
Use Appropriate Buffer Zones	Yes
Use Drift Control Agents	Yes
Monitor Rain Forecasts	Yes
Use PCA Recommendations	Yes
Ag Commissioner Conducts Pretreatment Inspection	Yes

Case Study 3 - Photos

Image 1 – Case Study 3: Vegetated buffer around alfalfa field with sprinkler pivot irrigation.

Image 2 – Case Study 3: Edge of field buffer on wheel line irrigated field.


Image 3 – Case Study 3: Alfalfa field with permanent vegetation cover.


Image 4 – Case Study 3: Edge of field buffer and road barrier to transport.


Image 5 - Site 3: Another example of extensive filed edge buffers on sprinkler irrigated fields that is representative of the watershed.

Upper Feather River Irrigated Pasture and Alfalfa Pesticide Transport Risk Assessment

CASE STUDY #4

PESTICIDE APPLICATIONS AND PURPOSES: *what were the reported pesticide uses (2016-2021) covered by this assessment, were the actual uses different from what was permitted (a.k.a. reported), and what were the purpose for their use.*

Table 1. The pesticide uses reported (i.e., permitted) and actually implemented by this farm operator annually 2016 through 2021, and thus included in this case study, are summarized below.

Year	Pesticide	Meridian	Date	Acres	AI* (lbs)
2016	PARAQUAT DICHLORIDE	32M22N15E04	3/21/2016	140	73.1
2016	PARAQUAT DICHLORIDE	32M22N15E03	3/22/2016	140	73.1
2016	PARAQUAT DICHLORIDE	32M22N15E04	3/23/2016	140	73.1
2016	PARAQUAT DICHLORIDE	32M22N15E14	3/24/2016	125	65.3
2016	PARAQUAT DICHLORIDE	32M22N15E10	3/25/2016	110	57.4
2016	PARAQUAT DICHLORIDE	32M22N15E04	3/27/2016	130	67.8
2017	PARAQUAT DICHLORIDE	32M22N15E10	4/3/2017	150	20.8
2017	PARAQUAT DICHLORIDE	32M22N15E10	4/3/2017	60	20.8
2017	PARAQUAT DICHLORIDE	32M22N15E14	4/4/2017	130	44.7
2017	PARAQUAT DICHLORIDE	32M22N15E04	4/5/2017	130	45.1

Year	Pesticide	Meridian	Date	Acres	AI* (lbs)
2017	PARAQUAT DICHLORIDE	32M22N15E10	4/5/2017	40	14.1
2018	PARAQUAT DICHLORIDE	32M22N15E10	3/30/2018	120	40.6
2018	PARAQUAT DICHLORIDE	32M22N15E04	4/2/2018	120	41.7
2018	PARAQUAT DICHLORIDE	32M22N15E10	4/3/2018	135	46.7
2018	PARAQUAT DICHLORIDE	32M22N15E10	4/4/2018	170	56.9
2018	PARAQUAT DICHLORIDE	32M22N15E10	4/4/2018	65	22.9
2018	PARAQUAT DICHLORIDE	32M22N15E14	4/6/2018	60	22.9
2018	PARAQUAT DICHLORIDE	32M22N15E03	4/9/2018	60	20.3
2018	LAMBDA-CYHALOTHRIN	32M22N15E04	6/1/2018	125	3.9
2019	PARAQUAT DICHLORIDE	32M22N15E10	4/3/2019	60	21.7
2019	PARAQUAT DICHLORIDE	32M22N15E11	4/4/2019	15	5.4
2019	PARAQUAT DICHLORIDE	32M22N15E10	4/4/2019	180	65.2
2019	PARAQUAT DICHLORIDE	32M22N15E14	4/5/2019	120	43.4
2019	PARAQUAT DICHLORIDE	32M22N15E03	4/5/2019	120	43.4
2019	PARAQUAT DICHLORIDE	32M22N15E04	4/10/2019	110	39.8

Year	Pesticide	Meridian	Date	Acres	AI* (lbs)
2019	PARAQUAT DICHLORIDE	32M22N15E14	4/12/2019	60	21.7
2019	PARAQUAT DICHLORIDE	32M22N15E10	4/13/2019	125	45.2
2020	PARAQUAT DICHLORIDE	32M22N15E10	4/4/2020	125	42.6
2020	PARAQUAT DICHLORIDE	32M22N15E04	4/5/2020	125	42.6
2020	PARAQUAT DICHLORIDE	32M22N15E04	4/11/2020	125	42.6
2020	PARAQUAT DICHLORIDE	32M22N15E10	4/21/2020	190	65.2
2020	PARAQUAT DICHLORIDE	32M22N15E14	4/21/2020	60	20.7
2021	PARAQUAT DICHLORIDE	32M22N15E10	3/5/2021	65	18.1
2021	PARAQUAT DICHLORIDE	32M22N15E10	3/5/2021	85	25.3
2021	PARAQUAT DICHLORIDE	32M22N15E04	3/6/2021	130	36.2
2021	PARAQUAT DICHLORIDE	32M22N15E03	3/25/2021	130	43.4
2021	PARAQUAT DICHLORIDE	32M22N15E04	3/25/2021	125	43.4
2021	PARAQUAT DICHLORIDE	32M22N15E10	3/25/2021	60	21.7
2021	PARAQUAT DICHLORIDE	32M22N15E10	3/26/2021	135	45.2
2021	PARAQUAT DICHLORIDE	32M22N15E04	3/27/2021	125	45.2
2021	PARAQUAT DICHLORIDE	32M22N15E14	3/28/2021	125	43.4

***AI = active ingredient**

1) Purpose(s) for <u>paraquat</u> dichloride applications (leave blank if not applicable)?

Control of Spring weeds.

2) Purpose(s) for <u>lambda-cyhalothrin</u> applications (leave blank if not applicable)?

Control of aphids.

<u>APPLICATIONS RELATIVE TO SURFACE WATERS AND HYDROLOGIC TRANSPORT PATHWAYS:</u> *<u>how close was pesticide applied to surface waters, what is the likelihood that pesticides applied to fields/pastures could be transported in surface runoff, tailwater ditches, vegetated ditches, buffers, etc. to surface waters.</u>*

3) Are applications made primarily to irrigated fields/pastures, to dry areas within or at the edge of fields/pastures, or a combination of the above? Please provide a brief explanation and percentages if a combination of application to dry and irrigated ground.

All applications were directly to sprinkler irrigated alfalfa fields.

4) What is the distance (e.g., feet, yards, miles) from the fields/pastures with application to the nearest stream or surface water (downstream and/or adjacent)? Is it likely that pesticides from these fields/pastures could transport as surface runoff to surface waters?

Little Last Chance Creek is ~0.75 mile from the application sites, and the Middle Fork Feather River is ~1 mile from the application sites. Topography and barriers such as railroad tracks and roads prohibit hydrologic connection to both surface waters. There is no potential for pesticides applied to these fields to transport as surface runoff due to topography and barriers, distance, and low flow sprinkler irrigation which does not generate surface runoff.

5) Pesticides often absorb to soil particles once applied to a field/pasture, and could be transported with soil particles if soil erosion occurs following application. Were the fields/pastures with application covered with permanent vegetation (i.e., soil surface cover, field edge buffers)? Is it likely that pesticides from this these fields/pastures could transport via soil erosion to surface waters?

The alfalfa fields have permanent vegetation with no bare ground. Soil erosion was not evident and is not likely, and given the lack of surface runoff from the field described above, the potential for sediment transport is also not likely. Also, there are permanent vegetated buffers around the edges of the field.

6) Is there any opportunity for direct application (i.e., overspray) or indirect drift (i.e., wind) of pesticides to streams or surface waters (downstream and/or adjacent)?

There is no potential for direct application or indirect of pesticides to enter surface waters. The applicated fields are at least 1.5 miles from the nearest surface waters. Best practices were employed to such that application occurred on days with no wind to ensure product impacts the pests/weeds of concern without off-site impacts.

7) Are the fields/pastures with application flood or sprinkler irrigated? If a combination, what are the acres of flood and sprinkler irrigated?

Low flow sprinkler irrigation.

8) During irrigation events, do the fields/pastures with application generate surface runoff (i.e., tailwater)? If so, how much tailwater is generated (as a percentage of water applied) and where does the runoff go (e.g., another field/pasture, surface water)?

No tailwater/surface runoff is generated from these fields under sprinkler irrigation.

9) In general – given soil texture, climate/weather conditions, irrigation water supplies, and other site-specific factors – what is the potential for runoff from the fields/pastures receiving application to impact surface waters? Please provide a brief explanation.

None for fields with application. All fields are in permanent vegetation on sprinkler systems, it is costly to pump water to irrigate so only apply what the crop needs. No tailwater generated from fields. There are buffers that are not farmed (or sprayed) covered with native permanent vegetation edge the fields. The pesticide applications are prior to irrigation when soil is dry, to prevent soil damage. Weather forecast is monitored and application occurs only if there is no rain in the forecast.

APPLICATIONS RELATIVE TO HYDROLOGIC TRANSPORT EVENTS: *when were pesticides applied to field/pastures relative to hydrologic transport events such as irrigation, and what is the likelihood that pesticides applied to fields/pastures could be transported due to proximity in time to these events.*

10) Are applications made during the spring prior to, or during summer irrigation season – or during both periods?

LAMBDA-CYHALOTHRIN – during the irrigation season
PARAQUAT DICHLORIDE – prior to the irrigation season

11) For applications made in the spring prior to the irrigation season, on average how many days does application occur prior to the initiation of irrigation?

At least 7 days prior to irrigation, and greater if there are cool weather conditions. Irrigation post application is delayed as long as possible to insure pesticides have maximum possible time to impact the target pests.

12) For applications made during the summer irrigation season, on average how many days does application occur prior to the subsequent irrigation event?

One week prior to next irrigation event. The field is irrigated, then 2-3 days post-irrigation the pesticide is applied once soil conditions allow wheeled vehicle application, then the field is irrigated no sooner than 7 days post application.

13) For any applications is there potential for rainfall or snow melt runoff events to transport pesticides from the field/pasture to surface waters?

Weather forecasts are monitored so that applications are not made prior to storm events. These applications occurred during the spring and summer periods following snowmelt and relatively dry soils at the time have high infiltration potential.

PESTICIDE APPLICATION BEST MANAGEMENT PRACTICES: *what are the standard best practices employed to assure safe and efficient application.*

14) Please indicate which of the following best management practices employed for the specific fields/pastures assessed for paraquat dichloride and lambda-cyhalothrin applications.

Practice	**Implemented (Yes/No)**
County Applies Pesticides	No
County Permit Followed	Yes
Follow Label Restrictions	Yes
Sensitive Areas Mapped	Yes
Attend Trainings	Yes
Monitor Wind Conditions	Yes
Reapply Rinsate to Treated Field	Yes
Avoid Surface Water When Spraying	Yes
Use Appropriate Buffer Zones	Yes
Use Drift Control Agents	Yes
Monitor Rain Forecasts	Yes
Use PCA Recommendations	Yes

Practice	Implemented (Yes/No)
Ag Commissioner Conducts Pretreatment Inspection	Yes

Case Study 4 - Photos

Image 1 – Case Study 4: Edge of field vegetated buffers for alfalfa field with sprinkler pivot irrigation.


Image 2 – Case Study 4: Edge of field buffer on alfalfa field with sprinkler pivot irrigation.


Image 3 – Case Study 4: Edge of field buffer on alfalfa field with sprinkler wheel line irrigation.

Image 4 – Case Study 4: Permanent vegetation in alfalfa field with low flow sprinkler pivot with no-end sprinklers.

Image 5 – Case Study 4: Closest waterway from pivots is ~0.75 mile.

Upper Feather River Irrigated Pasture and Alfalfa Pesticide Transport Risk Assessment

CASE STUDY #5

PESTICIDE APPLICATIONS AND PURPOSES: *what were the reported pesticide uses (2016-2021) covered by this assessment, were the actual uses different from what was permitted (a.k.a. reported), and what were the purpose for their use.*

Table 1. The pesticide uses reported (i.e., permitted) actually implemented by this farm operator annually 2016 through 2021, and thus included in this case study, are summarized below.

Year	Pesticide	Meridian	Date	Acres	AI* (lbs)
2021	LAMBDA-CYHALOTHRIN	46M21N15E12	4/2/2021	110	3.4
2021	LAMBDA-CYHALOTHRIN	46M21N16E06	4/2/2021	60	1.8

***AI = active ingredient**

1) Purpose(s) for paraquat dichloride applications (leave blank if not applicable)?

2) Purpose(s) for lambda-cyhalothrin applications (leave blank if not applicable)?

Control alfalfa weevils and aphids.

APPLICATIONS RELATIVE TO SURFACE WATERS AND HYDROLOGIC TRANSPORT PATHWAYS: *how close was pesticide applied to surface waters, what is the likelihood that pesticides applied to fields/pastures could be transported in surface runoff, tailwater ditches, vegetated ditches, buffers, etc. to surface waters.*

3) Are applications made primarily to irrigated fields/pastures, to dry areas within or at the edge of fields/pastures, or a combination of the above? Please provide a brief explanation and percentages if a combination of application to dry and irrigated ground.

All applications were directly to sprinkler irrigated alfalfa fields.

4) What is the distance (e.g., feet, yards, miles) from the fields/pastures with application to the nearest stream or surface water (downstream and/or adjacent)? Is it likely that pesticides from these fields/pastures could transport as surface runoff to surface waters?

The nearest surface water is Smithneck Creek which is ~1 mile from fields with application. There is an ephemeral storm drain ~100 yards adjacent to one field which flows to a dry pasture and terminates without connection to a surface water. During 2019-2021 there has been no flow in the storm drain. There is no potential for pesticide from the fields to transport as surface runoff due to distance and topography between fields and Smithneck Creek, edge of field vegetated buffers, and no tailwater from the fields due to low flow sprinkler irrigation.

5) Pesticides often absorb to soil particles once applied to a field/pasture, and could be transported with soil particles if soil erosion occurs following application. Were the fields/pastures with application covered with permanent vegetation (i.e. soil surface cover, field edge buffers)? Is it likely that pesticides from this these fields/pastures could transport via soil erosion to surface waters?

The alfalfa fields have permanent vegetation with no bare ground. Soil erosion was not evident and is not likely, and given the lack of surface runoff from the field described above, the potential for sediment transport is also not likely. Also, there are permanent vegetated buffers around the edges of the field.

6) Is there any opportunity for direct application (i.e., overspray) or indirect drift (i.e., wind) of pesticides to streams or surface waters (downstream and/or adjacent)?

There is no potential for direct application or indirect of pesticides to enter surface waters. The applicated fields are ~1 mile from the nearest surface waters. Best practices were employed to such that application occurred on days with no wind to ensure product impacts the pests/weeds of concern without off-site impacts.

7) Are the fields/pastures with application flood or sprinkler irrigated? If a combination, what are the acres of flood and sprinkler irrigated?

Low flow sprinkler irrigation.

8) During irrigation events, do the fields/pastures with application generate surface runoff (i.e., tailwater)? If so, how much tailwater is generated (as a percentage of water applied) and where does the runoff go (e.g., another field/pasture, distance to surface water)?

No tailwater/surface runoff is generated from these fields under sprinkler irrigation.

9) In general – given soil texture, climate/weather conditions, irrigation water supplies, and other site specific factors – what is the potential for runoff from the fields/pastures receiving application to impact surface waters? Please provide a brief explanation.

None for fields with application. All fields are in permanent vegetation on sprinkler systems, it is costly to pump water to irrigate so only apply what the crop needs. No tailwater generated from fields. There are buffers that are not farmed (or sprayed) covered with native permanent vegetation edge the fields. The pesticide applications are prior to irrigation when soil is dry, to prevent soil damage. Weather forecast is monitored and application occurs only if there is no rain in the forecast.

APPLICATIONS RELATIVE TO HYDROLOGIC TRANSPORT EVENTS: *when were pesticides applied to field/pastures relative to hydrologic transport events such as irrigation, and what is the likelihood that pesticides applied to fields/pastures could be transported due to proximity in time to these events.*

10) Are applications made during the spring prior to, or during summer irrigation season – or during both periods?

Spring prior to irrigation.

11) For applications made in the spring prior to the irrigation season, on average how many days does application occur prior to the initiation of irrigation?

Usually a month prior to irrigation.

12) For applications made during the summer irrigation season, on average how many days does application occur prior to the subsequent irrigation event?

Not applicable

13) For any applications is there potential for rainfall or snow melt runoff events to transport pesticides from the field/pasture to surface waters?

Weather forecasts are monitored so that applications are not made prior to storm events. These applications occurred during the spring and summer periods following snowmelt and relatively dry soils at the time have high infiltration potential.

PESTICIDE APPLICATION BEST MANAGEMENT PRACTICES: *what are the standard best practices employed to assure safe and efficient application.*

14) Please indicate which of the following best management practices employed for the specific fields/pastures assessed for paraquat dichloride and lambda-cyhalothrin applications.

Practice	Implemented (Yes/No)
County Applies Pesticides	No
County Permit Followed	Yes
Follow Label Restrictions	Yes

Practice	Implemented (Yes/No)
Sensitive Areas Mapped	Yes
Attend Trainings	Yes
Monitor Wind Conditions	Yes
Reapply Rinsate to Treated Field	Yes
Avoid Surface Water When Spraying	Yes
Use Appropriate Buffer Zones	Yes
Use Drift Control Agents	Yes
Monitor Rain Forecasts	Yes
Use PCA Recommendations	Yes
Ag Commissioner Conducts Pretreatment Inspection	Yes

Case Study 5 - Site Photos

Image 1 – Case Study 5: Vegetated edge of field buffer.


Image 2 – Case Study 5: Wheel line irrigated field with permanent native vegetation
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Image 3 – Case Study 5: Wheel line alfalfa field with permanent vegetated buffer.

Image 4 – Case Study 5: Field edge vegetative buffers on sprinkler irrigated fields.

APPENDIX IV

Tate, K.W., D.F. Lile, T.L. Saitone. Managing Irrigated Pastures to Mitigate Microbial Pollutant Transport to Surface Waters

Managing Irrigated Pastures to Mitigate Microbial Pollutant Transport to Surface Waters

Prepared by

Kenneth W. Tate[21], David F. Lile[22], and Tina L. Saitone[23]

UC Davis and UC Cooperative Extension

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Background and Purpose

In response to concerns over potential microbial pollution of surface waters from flood irrigated pasture systems across northern and central California UC Rangelands has completed a series of studies to examine the effectiveness of 1) vegetative filters (e.g., wetlands and buffer strips); 2) pasture grazing management; and 3) irrigation management to mitigate waterborne transport of microbial pollutant to surface waters. This document briefly summarizes these findings in the context of documenting low threat conditions to water quality – as indicated by *Escherichia coli* (*E. coli*) concentrations – associated with irrigated pasture systems with appropriate best management practices

[21] Professor and Cooperative Extension Specialist in Rangeland Watershed Sciences, Dept. of Plant Sciences, University of California, Davis. Email: kwtate@ucdavis.edu

[22] Cooperative Extension Advisor in Natural Resource and Livestock, University of California, Lassen County. Email: dflile@ucdavis.edu

[23] Professor of Cooperative Extension Specialist in Livestock and Rangeland Economics, Dept. of Agricultural and Resource Economics, University of California, Davis. Email: saitone@primal.ucdavis.edu.

(BMPs). This information will aid water board staff and leadership, among others, in consideration of an alternative regulatory program/strategy for the Upper Feather River Sub-watershed group and similar sub-watershed groups. This same information was utilized by water board staff and leadership during consideration of an exemption for the Goose Lake sub-watershed group from the Irrigated Lands Regulatory Program, and this information is equally relevant to the Upper Feather River sub-watershed. Studies included in the summary are 1) an observational study of water quality immediately upstream and downstream of irrigated pastures on 10 upper watershed ranches in Modoc and Lassen Counties – including ranches in the Upper Feather River watershed (Tate et al. In Preparation[24]); 2) a study of water quality from foothill pastures treated with a gradient of grazing and irrigation intensities and timings (Knox et al. 2007[25]); and 3) a study of the efficacy of small wetlands to filter pollutants in irrigated pasture tail-water (Knox et al. 2008[26]).

Research Results

***1) On-Ranch Irrigated Pasture Water Quality Survey*.** The research paper for this study is currently in preparation for publication, thus we provide a bit more detail on scope and methods here than in the following two published studies. We conducted bi-

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24 Tate, K.W., D.F. Lile, T.L. Saitone. In prep. Mitigating Water Quality Impacts from Grazed Irrigated Pastures.

25 Knox, A.K., K.W. Tate, R.A. Dahlgren, and E.R. Atwill. 2007. Management Reduces E. coli in Irrigated Pasture Runoff. California Agriculture. 61:159-165. http://calag.ucanr.edu/Archive/?article=ca.v061n04p159

26 Knox, A.K, R.A. Dahlgren, K.W. Tate, and E.R. Atwill. 2008. Efficacy of Flow-Through Wetlands to Retain Nutrient, Sediment, and Microbial Pollutants. J. Environmental Quality. 37:1837-1846.

weekly stream water quality sampling immediately upstream and downstream of 10 irrigated pastures for the entire course of the irrigation season. Irrigation season ranged from April through July across the study sites, typical of these types of systems in the region. Study sites enrolled in the survey were single pasture systems immediately adjacent to a stream reach. Each pasture was flood irrigated from an in-stream diversion immediately upstream of the pasture, with tail-water from the pasture returning directly to the stream reach via numerous return points and as diffuse sheet flow (Figure 1). The downstream sample site was located immediately downstream of the last observed tail-water return from the pasture. *E. coli* concentrations (colony forming units per 100 milliliters (cfu/100 ml)) for all samples were determined via direct membrane filtration and incubation on a selective agar (Derose et al. 2020[27]). Triplicate samples were collected and analyzed at each sample event and each sample site (n = 20), generating 428 samples in total across all 10 pastures. Although not reported here, we also determined nutrient concentrations (total N, NO_3-N, NH_4-N, total P, PO_4-P, dissolved organic carbon), total suspended solid concentrations, turbidity, conductivity, pH, temperature, and dissolved oxygen concentrations for each sample. At each sample event on we recorded the number and type of livestock grazing the pasture, streamflow rate at each sample location, and rate of irrigation water application.

Figure 1. An example study site sample schematic with stream, in-stream irrigation diversions, irrigated pastures, tail-water returns, and sample collection sites.

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[27] Derose, K.L., L.M. Roche, D.F. Lile, D.J. Eastburn, and K.W. Tate. 2020. Microbial Water Quality Conditions Associated with Livestock Grazing, Recreation, and Rural Residences in Mixed Use Landscapes. Sustainability. (https://www.mdpi.com/2071-1050/12/12/5207)

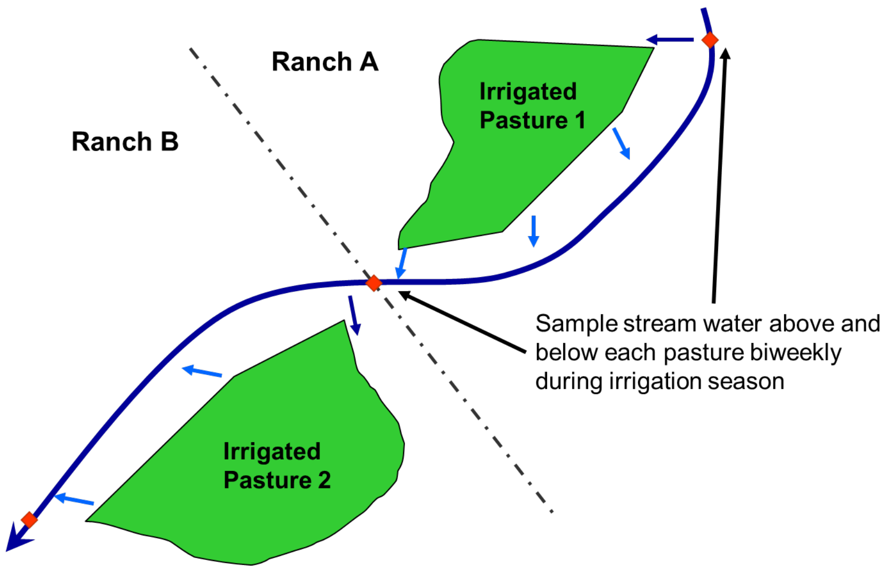

Table 1 reports mean *E. coli* concentrations (cfu/100 ml) observed over the irrigation season upstream and downstream of each irrigated pasture enrolled in the study, as well as the mean difference (change) in concentration downstream compared to upstream of each pasture (mean downstream concentration minus mean upstream concentration) – quantifying the impact of each pasture on in-stream microbial water quality. Eighty percent of mean downstream *E. coli* concentrations were below 235 cfu/100ml (current Irrigated Lands Regulatory Program microbial water quality objective), compared to 60% of upstream mean concentrations. Thirty percent (Steams 1, 9, 10) of pastures resulted in reduced downstream concentrations, forty percent (Streams 2, 3, 4, 6) resulted in a slight increase in concentrations (<20 cfu/100ml), and thirty percent (Streams 5, 7, 8) resulted in a substantial increase in concentrations. These results demonstrate substantial variation in site-specific impacts to in-stream microbial water quality, and substantial potential for pasture management of improve or have limited negative impacts on microbial water quality.

Table 1. Mean *E. coli* concentrations (cfu/100 ml) and one standard error of the mean observed over the irrigation season upstream and downstream of each irrigated pasture enrolled in the study. Mean difference (change) in concentration calculated as mean downstream concentration minus mean upstream concentration. A negative mean difference indicates reduced *E. coli*, a positive mean difference indicates increased *E. coli*, a difference near zero indicates no change.

Stream	Mean *E. coli* (1 standard error) as cfu/100ml		
	Upstream	**Downstream**	**Mean Difference**
1	357 (159)	123 (36)	-233
2	85 (33)	96 (14)	11
3	9 (3)	18 (4)	9
4	12 (4)	24 (6)	12
5	98 (28)	186 (62)	88
6	111 (17)	131 (13)	20
7	52 (17)	1117 (373)	1064
8	1074 (380)	1304 (244)	230
9	1171 (446)	135 (21)	-1036
10	363 (101)	180 (36)	-183

We are conducting statistical analysis to understand how site-specific grazing and irrigation management was associated with the range of downstream impacts reported in Table 1. Specifically, we have conducted preliminary linear mixed effects regression analysis to examine relationships between stocking density as animal units/hectare, irrigation application rate as millimeters of water applied per hectare per day, and downstream *E. coli* concentrations for each sample day. We are finding positive increases in downstream concentrations associated with increased stocking density ($P<0.001$), increased irrigation water application rates ($P=0.015$), and reduced streamflow (P=0.001). Preliminary analysis also indicates these factors are interacting. For example, downstream concentrations are higher under circumstances of relatively high stocking rate (fecal loading), irrigation application rate (hydrologic transport), and low flow conditions in the stream receiving pasture tail-water. We are currently analyzing relationships between grazing management, irrigation management and differences in observed upstream and downstream concentrations (actual water quality impact).

***2) Grazing and Irrigation Intensities and Timing*.** We conducted a study of foothill flood irrigated pastures under which we manipulated the 1) timing of livestock grazing relative to the timing of regular irrigation events; and 2) rate of irrigation application and thus tail-water to examine relationships between these practices and *E. coli* concentrations in pasture tail-water (Knox et al. 2007). This is published research, and the reader is directed to the paper for full methods and findings. We found that *E. coli* concentrations in tail-water directly from the pasture were highest when cattle were actively grazing during an irrigation event with high tail-water runoff rates. *E. coli* concentrations in tail-water were significantly reduced with increasing rest time between grazing and irrigation. However, the relationship was not linear, and *E. coli* reductions became smaller with each additional day of rest. For example, the *E. coli* concentration was 23% lower after 9 days of rest than after 1 day of rest, but only 2% lower after each additional day of rest after that. This reduction was likely due to two primary processes: (1) as cattle fecal pats age, the microbial pollutants in them naturally die off, and (2) as the pats dry, they develop shells that trap the bacteria inside. We also found that as irrigation tail-water runoff rates increased, *E. coli* concentrations increased in tail-water. This relationship can be attributed to the fact that higher runoff rates increase the tail-water's capacity for pollutant mobilization and transport.

3) Wetlands to Filter Pollutants in Irrigated Pasture Tail-water. In conjunction with the study reported in Knox et al. 2007) we also examined the capacity for small wetlands to serve as vegetative buffers to filter *E. coli* from flood irrigated pasture tail-water (Knox et al. 2008). This is published research, and the reader is directed to the paper for full methods and findings. On average, we found that a functioning wetland reduced *E. coli* load in tail-water by 68%. However, we found that that as tail-water runoff rate increased, the wetland was less effective at filtering *E. coli* and reducing concentrations in tail-water to the point that at high runoff rates the filtration capacity of the wetland was overcome. The increase in instantaneous tail-water runoff rate corresponded with a decrease in hydraulic residence time, which also likely reduced the amount of time for wetland processes that reduce *E. coli* concentrations, such as exposure to solar ultraviolet radiation and predation by other microbes. These results agree with research we have conducted across various grazing lands scenarios demonstrating the high filtration capacity of pastures and rangelands for waterborne microbial pollutants (Atwill et al. 2002[28]; Atwill et al. 2006[29]; Tate et al. 2006[30]).

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[28] Atwill ER, Hou L, Karle BM, et al. Transport of *Cryptosporidium parvum* oocysts through vegetated buffer strips and estimated filtration efficiency. Appl Env Microbiol. 2002. 68:5517-27.

[29] Atwill ER, Tate KW, Pereira MGC, et al. Efficacy of natural grass buffers for removal of *Cryptosporidium parvum* in rangeland runoff. J Food Protect. 2006. 69:177-84.

[30] Tate KW, Atwill ER, Bartolome JW, Nader GA. Significant *E. coli* attenuation by vegetative buffers on annual grasslands. J Env Qual. 2006. 35:795-805. https://doi.org/10.2134/jeq2005.0141

Irrigated Pasture as a Microbial Water Quality Threat

Source identification and mitigation of microbial pollutant sources in mixed-use watersheds is an issue spanning the globe. Livestock agriculture, septic systems, wastewater treatment systems, and recreation are documented, potential anthropogenic sources of microbial pollutants. Studies also document the potential for microbial pollutant contributions from environmental sources such as wildlife, soil, and streambed sediments. Not surprisingly, studies often report detection of microbial pollutants from multiple sources, with the relative magnitude of contributions from sources varying over space and time due to watershed specific conditions. Thus, exceedances of *E. coli* in surface waters across California is an issue much broader than irrigated pasture. In fact, it is broader than the scope of the Irrigated Lands Regulatory program and agricultural land uses.

In our survey of 10 upper watershed irrigated pasture systems we found that while management decisions resulted in microbial water quality pollution at 3 sites, there were an equal number of instances where microbial water quality was improved due to pastures filtering polluted irrigation water. We found an approximately equal number of pastures associated with minor *E. coli* increases (<20 cfu/100ml). Based upon the studies detailed above, we can characterize irrigated pasture conditions that lead to microbial water quality impacts as having one or more of the following traits:

- Excessive irrigation application and tail-water runoff rates
- Excessive livestock densities for long periods, limited rest or rotation of livestock
- Frequently grazed by livestock during irrigation events

- Discharge into low flow streams

We have found the following best management practices managers employ to create low threat conditions on irrigated pasture – these practices are all also associated with improved agricultural productivity and profit:

- Irrigate based on soil-plant water demand at application rates appropriate for soil infiltration capacity to reduce tail-water runoff rates and volumes
- Moderate livestock densities with rest and rotation during the irrigation season
- Rotate grazing and irrigation timing to allow rest before irrigation when and where possible
- Filter tail-water using vegetative buffer strips, vegetated ditches, hay pastures, and wetlands when and where possible.

The management challenges and opportunities are different on each pasture and ranching operation. There is no single best management practice, stocking density, or irrigation application rate. The pasture manager can reduce water quality impacts by implementing one or more of these management options. The key is to make the effort to moderate stock density, runoff, and timing of grazing relative to irrigation whenever and wherever practically possible. Properly managed irrigated pastures pose low threat to microbial water quality.