

FEASIBILITY STUDY | DECEMBER 2025

STORMWATER RECHARGE LOS MOLINOS SUBBASIN

PREPARED FOR

TEHAMA COUNTY FCWCD

PREPARED BY



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ATTACHMENTS

- Attachment A Technical Memorandum - Hydrologic and Hydraulic Model Approach and Evaluation for the Deer Creek Groundwater Recharge and Flood Reduction Project
- Attachment B Technical Memorandum - Hydrologic and Hydraulic Model Approach and Evaluation for the Mill Creek Groundwater Recharge and Flood Reduction Project
- Attachment C Technical Memorandum - Hydrologic and Hydraulic Model Approach and Evaluation for the Antelope Creek Groundwater Recharge and Flood Reduction Project
- Attachment D Technical Memorandum - Hydrologic and Hydraulic Model Approach and Evaluation for the Cottonwood Creek Groundwater Recharge and Flood Reduction Project

1. INTRODUCTION

The enactment of Water Code §1242.1 in 2023 provided an avenue to divert stormwater for recharge without obtaining appropriative water rights. Stormwater provides a cost-effective water source to be utilized for recharge. Stormwater diversions have the added benefit of reducing flooding from excess flows. This feasibility study summarizes four technical memorandums (TMs) (**Attachments A – D**) documenting watershed analyses conducted on four different creeks within the Los Molinos Subbasin. The TMs aimed to establish stormflow thresholds to be utilized by the County to determine diversion windows during storm events. In addition to determining flood flow threshold, the TMs also identified locations impacted by flooding that would benefit from stormwater diversions.

2. CREEKS

The creeks analyzed as part of the watershed analysis were Deer Creek, Mill Creek, Antelope Creek, and Cottonwood Creek. All four creeks are located within the Los Molinos Subbasin and experience flows high enough to allow for diversions. These creeks are depicted on Figure 1.

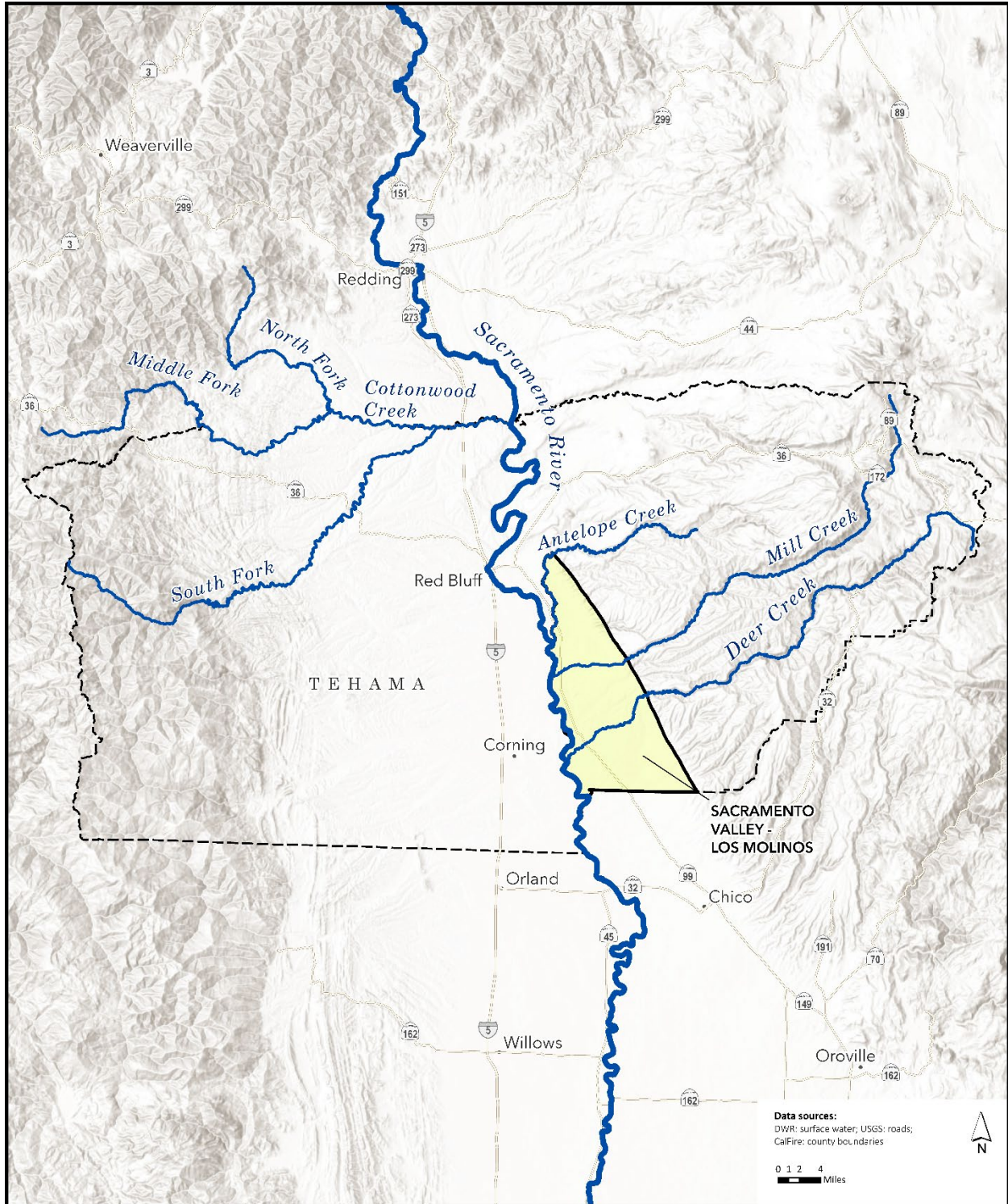


Figure 2 Location of Creeks and Sacramento River

2.1. Deer Creek

Deer Creek converges with the Sacramento River after passing through Los Molinos Subbasin. The land surrounding the creek is primarily pasture land or covered with deciduous fruit or nut crops as per the

2023 DWR land use survey. Currently, there are six claimed¹ and one licensed² water right(s) on Deer Creek within the Los Molinos Subbasin.

2.2. Mill Creek

Mill Creek converges with the Sacramento River after flowing through the center of the Los Molinos Subbasin. The land surrounding the creek is primarily used for pasture as per the 2023 DWR land use survey. Currently, there are five claimed and three licensed water rights on Mill Creek within the Los Molinos Subbasin.

2.3. Antelope Creek

Antelope Creek converges with the Sacramento River after across the northern portion of the Los Molinos Subbasin. The land surrounding the creek is primarily pasture land or covered with deciduous fruit or nut crops as per the 2023 DWR land use survey. Currently, there is one claimed water right on the Little Antelope Creek portion of Antelope Creek within the Los Molinos Subbasin.

2.4. Cottonwood Creek

Cottonwood Creek converges with the Sacramento River north of the Los Molinos Subbasin. The land surrounding the creek is primarily pasture land or covered with deciduous fruit or nut crops as per the 2023 DWR land use survey.. Currently, there are no active water rights on Cottonwood Creek within the Los Molinos Subbasin.

3. MODELS

Hydrologic and hydraulic modeling was conducted using the U.S. Army Corps of Engineers' HEC-HMS (Hydrologic Engineering Center - Hydrologic Modeling System) and HEC-RAS (Hydrologic Engineering Center - River Analysis System) software to evaluate watershed behavior, channel hydraulics, and flood response under various storm conditions. HEC-HMS provides a realistic representation of watershed behavior under both existing and modified conditions, supporting the assessment of watershed response and potential flood conditions.

HEC-HMS was used to simulate watershed hydrology by representing precipitation, infiltration, runoff generation, and flow routing to characterize how water moves across the landscape. The modeling effort focused on generating accurate flow hydrographs for specific storm events, capturing the timing and magnitude of runoff entering the stream system. These hydrographs, along with other hydrologic outputs such as runoff distributions, form the foundation for subsequent hydraulic analysis.

¹ Claimed - An active claim of water diversion and use under riparian or pre-1914 rights. May also be used to report water diversion and use while an appropriative right or registration is pending

² Licensed - Permitted Water Right has been issued a Water Right license

The hydrologic outputs from HEC-HMS were input into HEC-RAS to generate detailed hydraulic predictions. The HEC-RAS analysis is to evaluate how flow conditions generated by HEC-HMS translated into on-the-ground hydraulic impacts, particularly under different storm scenarios.

4. RESULTS

4.1. Hydrologic and Hydraulic Analysis

Using the HEC-HMS and HEC-RAS models, hydrologic and hydraulic conditions were simulated under various storm scenarios to determine diversion thresholds, assess flood impacts, and estimate recharge potential. The following sections summarize the key findings.

4.2. Diversion Thresholds and Flood Mitigation

Deer Creek

The hydrologic and hydraulic modeling established a flood diversion threshold of 13,574 cubic feet per second (cfs), corresponding to the 10-year storm event at USGS gage 11383500. This threshold was derived from a flood frequency analysis using 109 years of annual peak flow data. Flows exceeding this threshold pose significant flood risks to properties and infrastructure within the Lower Deer Creek Watershed.

Modeling results indicate that diversions at the DCID Deer Creek Diversion and Cone Kimball Dam can effectively reduce peak flows during major storm events. For a 25-year event, diverting 3,272 acre-feet (ac-ft) of water would lower water levels at the Highway 99 Bridge by approximately 1.2 feet, while a 50-year event would require 7,620 ac-ft of diversion to achieve a 2-foot reduction in water depth. These reductions significantly decrease flood hazards and demonstrate the potential of diversion operations to protect vulnerable communities during high-flow conditions.

Mill Creek

The flood diversion threshold was established at 12,222 cfs, corresponding to the 10-year storm event recorded at USGS gage 11381500. Flows exceeding this threshold pose an imminent flooding threat to properties along Mill Creek, particularly near Ellis Street. This threshold serves as a critical benchmark for initiating diversions during high-flow events to minimize flood damage.

Historical data highlight the importance of this threshold. The model predicted that an event like the 2024 flood event, which had an approximate 19-year recurrence interval, could cause significant impacts including road closures, property damage, and restricted access along the north bank of Mill Creek downstream of Highway 99.

To mitigate such risks, the study evaluated diversion strategies aimed at reducing peak flows. Lowering the 2024 flood peak of 15,400 cfs to the 10-year threshold of 12,222 cfs would require diverting approximately 3,178 cfs of water. This diversion could be achieved through coordinated operations at the Upper Diversion Dam and Ward Diversion Dam, with each facility handling half of the required volume.

Implementing this strategy would lower water levels at the Highway 99 Bridge by approximately 1.1 feet, significantly reducing flood hazards in the affected areas.

Antelope Creek

The hydrologic and hydraulic modeling established a flood diversion threshold of 5,125 cfs, corresponding to the 2-year storm event at the USGS gage. The modelling predicted that flows exceeding this threshold, such as during the November 2024 event, which had an approximate 5-year recurrence interval and a peak flow of 8,879 cfs, could cause flooding in the west floodplain of Antelope Creek downstream of Edwards Diversion Dam. The model also predicted that this event could result in road closures, property damage, and restricted access near Highway 99 and Craig Avenue.

Modeling results indicated that diversions at four proposed points could effectively reduce water levels during high-flow events. For example, during the November 2024 event, diversions would have lowered water depth at the Cone Grove Road Bridge by approximately 0.9 feet, significantly reducing flood hazards for residential properties and transportation routes.

Cottonwood Creek

The hydrologic and hydraulic modeling established a flood diversion threshold of 38,000 cfs at the CNRFC gage CWAC1, which corresponds to a 5-year flood event. This threshold was selected to reduce flooding in the High-Risk Flood-Prone Zone, where inundation is predicted to begin once flows exceed this level. The model predicted that roads and properties such as Main Street, Evergreen Road Bridge, and residences at 18700 and 18750 Evergreen Road would experience significant flood impacts when flows surpass the flood diversion threshold.

Modeling results indicated that diversions upstream of the High-Risk Flood-Prone Zone can substantially reduce flood hazards. For example, during the 2023 event, diverting 2,516 cfs from the South Fork Cottonwood Creek over a 24-hour period would have lowered water levels by approximately 0.3 foot in the flood-prone zone. This reduction would help prevent road closures and property damage, demonstrating the effectiveness of diversion operations in mitigating flood impacts during high-flow conditions.

4.3. Groundwater Recharge Potential

Deer Creek

During the February 2025 event, which had a peak flow of 17,110 cfs corresponding to a 20-year return period, diversions could have captured substantial volumes of water for recharge purposes. To infiltrate diverted volumes efficiently, suitable recharge areas near diversion dams must be identified. For example, the infiltration rate assumed in the analysis was 0.5 feet per day, which would require hundreds of acres of land to accommodate recharge during large storm events.

Mill Creek

During the 2024 event, an estimated 330 ac-ft of water could have been captured for recharge purposes. To infiltrate this volume within a single day, approximately 660 acres of land would be required, assuming a recharge rate of 0.5 feet per day.

Antelope Creek

An estimated volume 3,587 ac-ft of water could have been diverted during the November 2024 event for recharge purposes. To infiltrate this volume within a single day, approximately 7,174 acres of land would be required, assuming a recharge rate of 0.5 feet per day. Larger storm events would yield even greater recharge opportunities; for instance, a 10-year event would provide 7,182 ac-ft, requiring 14,364 acres, while a 50-year event could generate 16,834 ac-ft, requiring 33,668 acres.

Cottonwood Creek

During the 2023 event, diverting 1,066 ac-ft of water could have been diverted for recharge. This volume would require approximately 2,132 acres of recharge area, assuming an infiltration rate of 0.5 foot per day. Larger storm events would provide even greater recharge opportunities.

4.4. Water Availability for Recharge

Deer Creek

Annual water availability for recharge was assessed using two operational approaches. Method 2 (Threat of Flood Conditions) estimated an average annual recharge volume of 481 ac-ft, reflecting the limited frequency of flood conditions, which occur in approximately 11% of years. In contrast, Method 1 (90th Percentile/20 Percent Method) yielded a much higher estimate of 10,889 ac-ft, with water available for diversion in 95% of years.

Mill Creek

Annual water availability for recharge was assessed using two methods. Under Method 2 (Threat of Flood Conditions), the average annual recharge volume was estimated at 178 ac-ft, with flood conditions occurring in only 11% of years. Conversely, Method 1 (90th Percentile/20 Percent) yielded a much higher estimate of 7,345 ac-ft, with water available for diversion in 95% of years..

Antelope Creek

Annual water availability for recharge was assessed using the 90th Percentile/20 Percent Method (Method 1), which estimated annual recharge volumes ranging from 369 to 13,416 ac-ft, with an average of 4,877 ac-ft. Historical data indicate that diversion opportunities would occur in approximately 95% of years, making this approach highly reliable for long-term water management.

Cottonwood Creek

Under Method 2 (Threat of Flood Conditions), the average annual recharge volume was estimated at 224 ac-ft, reflecting the limited frequency of flood conditions. In contrast, Method 1 (90th Percentile/20 Percent) yielded a much higher estimate of 15,000 ac-ft, with water available for diversion in approximately 95% of years.

5. SUMMARY TABLES

The following tables present a consolidated view of the key findings from the hydrologic and hydraulic analyses. Table 1 summarizes the diversion thresholds and associated return periods for each creek, while Table 2 compares annual groundwater recharge volumes estimated using two operational approaches: Method 1 (90th Percentile/20 Percent) and Method 2 (Threat of Flood Conditions). These tables provide a quick reference for evaluating flood mitigation and recharge potential across the study area.

Table 1 Summary of Diversion Thresholds by Creek

| Creek | Diversion Threshold (cfs) | Return Period |
|------------------|---------------------------|---------------|
| Deer Creek | 13,574 | 10-year event |
| Mill Creek | 12,222 | 10-year event |
| Antelope Creek | 5,125 | 2-year event |
| Cottonwood Creek | 38,000 | 5-year event |

Table 2 Annual Water Availability for Recharge

| Creek | Method 1 (90th Percentile/20%) | Method 2 (Threat of Flood Conditions) |
|------------------|---|---------------------------------------|
| Deer Creek | 10,889 ac-ft | 481 ac-ft |
| Mill Creek | 7,345 ac-ft | 178 ac-ft |
| Antelope Creek | Avg. 4,877 ac-ft (range: 369–13,416) | N/A |
| Cottonwood Creek | 15,000 ac-ft | 224 ac-ft |

6. CONCLUSION

The results of this analysis demonstrate that establishing a diversion threshold of 13,574 cfs for Deer Creek, 12,222 cfs for Mill Creek, 5,125 cfs for Antelope Creek and 38,000 cfs for Cottonwood Creek could substantially reduce flood risks in the Los Molinos Subbasin. Furthermore, utilizing diverted floodwaters for groundwater recharge offers a dual benefit: mitigating flood hazards while enhancing regional water supply reliability.

To advance this work, this study recommends conducting land suitability analyses for recharge areas near potential diversion points, evaluating additional upstream diversion points, improving gage data, assessing local runoff not mitigated by channel diversions, and creating a flood diversion plan for operational planning. These measures will support the development of ranked alternatives for flood mitigation and groundwater recharge, ensuring a resilient and sustainable water management approach for Tehama County.