COUNTY OF SISKIYOU

Siskiyou County Flood Control & Water Conservation District

1312 Fairlane Rd, Suite 1
Yreka, California 96097
www.co.siskiyou.ca.us

(530) 842-8005
FAX (530) 842-8013
Toll Free: 1-888-854-2000, ext. 8005

June 24, 2026

State Water Resources Control Board
Division of Water Rights
1001 I Street, 14th Floor
Sacramento, CA 95814
ScottShastaFlows@waterboards.ca.gov

Deliver via Email

Subject: Comments on Model Performance and Suitability for Intended Applications – Shasta River Model Development Report (April 2026)

Dear State Water Resources Control Board,

The Siskiyou County Flood Control and Water Conservation District (District), the Groundwater Sustainability Agency (GSA) for the Shasta Valley groundwater subbasin, appreciates the opportunity to comment and submits the below input on the Shasta River Watershed Model, as documented in the April 2026 Shasta River Model Development Report. The District's comments, with technical assistance from the GSA's SGMA technical consulting lead Larry Walker Associates (LWA), focus specifically on model performance, calibration, validation, predictive uncertainty, and the appropriateness of applying the model to future management and regulatory analyses.

Summary of Comments

The model represents a substantial technical effort and may prove to be a useful watershed-scale framework for organizing available hydrologic information. However, the calibration and validation results presented in the report do not yet demonstrate sufficient reliability during low-flow and groundwater-dominated conditions to support the management and regulatory applications proposed.

The report identifies several intended uses of the model, including unimpaired flow estimation, evaluation of groundwater pumping impacts, assessment of groundwater-surface water interactions, development of management scenarios, and support of instream flow analyses. These applications depend heavily on accurate representation of summer baseflow conditions, groundwater discharge from springs, groundwater-stream interactions, snow accumulation and melt processes, irrigation return flows, and consumptive use impacts.

The report itself acknowledges that these remain among the most difficult aspects of the modeling effort. While the model performs reasonably well at broader annual and watershed scales, uncertainty increases substantially during the very hydrologic conditions that are most relevant to environmental flow management. Consequently, model outputs should be considered preliminary and should not yet be relied upon as the primary basis for consequential management or regulatory decisions.

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1. Low-Flow Performance Remains the Principal Limitation

The most significant concern arising from the calibration and validation results is the model's performance during low-flow periods.

Throughout the report, annual and monthly performance statistics are frequently characterized as "good," "very good," or "satisfactory." While these aggregate statistics are useful indicators of watershed-scale behavior, they do not adequately characterize model performance during the periods most relevant to environmental flow management. The calibration results for the Shasta River near Yreka indicate substantial bias during dry-season conditions. During calibration, dry-season percent bias (PBIAS) reached approximately -22.7 percent, while storm-flow conditions during the dry season exceeded -30 percent bias. Validation results similarly show substantial error in the lowest flow conditions, including approximately -26 percent bias in the lowest 50 percent of dry-season flows.

These values are not insignificant when viewed within the context of summer baseflows that commonly range from tens of cubic feet per second. Under such conditions, a model bias of 20 to 30 percent can represent a large fraction of total available streamflow and can materially affect conclusions regarding habitat availability, thermal refugia, groundwater contributions, and minimum flow requirements. This concern is particularly important given that the model is being proposed for applications that are fundamentally dependent upon accurate representation of low-flow conditions. For example, instream temperature requirements depend heavily on simulated flow and how much of that flow comes from surface water versus groundwater. Model performance should therefore be evaluated primarily through the lens of those intended uses.

The overall validation statistics show improvement relative to calibration where all-conditions PBIAS dropped to -2.4 percent during validation, compared to -12.7 percent during calibration. However, this aggregate improvement obscures continued weakness in the flow regimes that matter most for environmental management. During validation, the Lowest 50 percent of Dry Season flows exhibited -26.4 PBIAS, and the Highest 10 percent of Dry Season flows exhibited +49.8 PBIAS, both corresponding to "Poor" performance by the report's own criteria. These opposing biases suggest the model is misallocating water sources within the dry season rather than simply improving in aggregate. Predictive uncertainty therefore remains greatest during the exact conditions for which the model is intended to be used.

2. Groundwater and Spring Contributions Remain Insufficiently Constrained

The report repeatedly identifies groundwater discharge and spring flow as dominant controls on summer hydrology within the Shasta River watershed. This is particularly true within the Big Springs complex and throughout portions of the lower watershed where spring-fed flows sustain streamflow during dry periods. At the same time, the report documents substantial uncertainty in the representation of these processes.

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Several spring systems exhibit significant discrepancies between observed and simulated discharge. As shown in the report's Table 6-8, multiple springs with documented flow are simulated at or near zero, including Alcove Spring (47 cubic feet per second [cfs] observed, 0.0 cfs simulated), Cold Spring (13 cfs observed, 0.0 cfs simulated), and Hidden Ranch Spring (3.6 cfs observed, 0.0 cfs simulated), while others such as Kettle Spring (7.1 cfs observed, 0.8 cfs simulated) and Little Spring (8.0 cfs observed, 0.5 cfs simulated) remain substantially underpredicted. The report attributes these discrepancies to uncertainty regarding volcanic groundwater pathways, lava tube systems, transmissivity distributions, spring locations, and groundwater routing processes. These explanations are reasonable and reflect the inherent complexity of the watershed. However, they also demonstrate that important groundwater processes remain insufficiently constrained by available data. The severity of this challenge is illustrated by the model's own development history: the report acknowledges that before coupling MODFLOW, the Big Springs Creek gage was consistently underpredicted by an order of magnitude. While the coupled model substantially improved this discrepancy, important uncertainty remains regarding groundwater flow paths, travel times, hydraulic connectivity, and the mechanisms by which groundwater contributions are translated into spring discharge and streamflow response. The uncertainty associated with groundwater contributions is further illustrated by the conceptual representation of the Big Springs complex presented in Figure 5-5. The schematic grossly oversimplifies a highly complex groundwater system and should not be interpreted as a definitive representation of groundwater flow paths from Mount Shasta to the Big Springs area. We therefore ask that the simplistic representation of the 'Estimated Lava Tube' be removed from Figure 5-5 and a more appropriate representation of the complex geology be used instead.

Existing studies indicate that major spring systems within the watershed, including Big Springs and Little Springs, likely represent distinct groundwater sources, flow paths, and residence times. While the GSA continues to collect data and refine understanding of spring sources, groundwater travel times, and the relationship between groundwater extraction and streamflow, important uncertainties remain regarding the hydrogeologic processes that sustain summer baseflows. Because these spring systems represent a critical component of watershed hydrology during ecologically sensitive low-flow periods, additional refinement of the conceptual and numerical representation of groundwater discharge should be considered an important prerequisite to expanded management and regulatory application of the model.

The challenge is not merely that spring flows are difficult to model. The challenge is that groundwater and spring discharge constitute a large portion of the water available during ecologically critical periods. When those processes remain uncertain, confidence in simulated low-flow conditions necessarily remains limited. The report appropriately identifies the need for additional refinement and additional data collection in these areas. However, those refinements should be viewed as necessary steps toward future application rather than optional improvements to an already sufficient model. More broadly, many of the hydrologic processes that dominate summer flow conditions in the Shasta River watershed remain areas of active investigation and continuing uncertainty. These include the timing and magnitude

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of spring discharge, groundwater travel times, groundwater-stream interactions, snow accumulation and melt processes, and the influence of agricultural water management on streamflow conditions. Because these processes collectively control much of the water available during ecologically sensitive low-flow periods, uncertainty in their representation limits confidence in model predictions and management applications derived from those predictions.

Similar uncertainty exists in portions of the watershed snowpack representation. Snow accumulation and snowmelt processes are important controls on recharge, groundwater inflows, and seasonal runoff timing throughout the watershed. The report relies in part on calibration to the Big Red Mountain snow monitoring station, which is located outside the Shasta River watershed, while providing relatively limited discussion of how recently installed snow monitoring stations within the watershed were incorporated into model evaluation and refinement. This does not necessarily invalidate the snow calibration effort; however, it highlights the continuing uncertainty associated with representation of high-elevation watershed processes that are important to low-flow conditions. Additional refinement and evaluation of these processes would improve confidence in model predictions used to support management and regulatory applications. This divergence between overpredicted high flows and underpredicted low flows during the dry season documented in the validation results has direct implications for groundwater-surface water interaction analyses and the reliability of simulated baseflow contributions within this section of the watershed.

3. Consumptive Use and Water Management Assumptions Introduce Significant Uncertainty

The model incorporates a broad suite of water management activities, including irrigation demand, groundwater pumping, canal leakage, reservoir operations, diversions, and return flows that are primary controls on summer low-flow hydrology. The report acknowledges uncertainty in many of these inputs as these processes are represented using generalized assumptions, estimated operational rules, or incomplete datasets, yet the implications of these uncertainties are not fully evaluated in the documentation.

This uncertainty is understandable given the complexity of the watershed and limitations of available data. Nevertheless, it creates an important limitation on model interpretation. Because the model is frequently evaluated against observed streamflow records that already reflect the combined influence of these water management activities, uncertainty associated with consumptive use representation is embedded within both the calibration process and subsequent model predictions. As a result, model limitations and uncertainty propagate from the baseline conditions into the scenario analysis, making it difficult to assess with confidence how those limitations and uncertainties may impact management decisions.

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4. Unimpaired Flow Estimates Inherit Existing Model Uncertainty

One of the primary applications of the model is estimation of unimpaired flow conditions. The report describes unimpaired flow simulations as the removal of diversions, pumping, storage, and other anthropogenic influences from the calibrated baseline model. However, unimpaired flow estimates are not independent of uncertainty in the baseline model. Rather, they inherit uncertainty associated with every major process represented within the simulation framework.

Uncertainty in groundwater contributions, spring discharge, pumping impacts, irrigation demand, return flows, diversion operations, recharge estimates, and stream-aquifer interactions all propagate into unimpaired flow estimates. Accordingly, unimpaired flow predictions should be interpreted as scenario-based estimates rather than definitive representations of natural hydrologic conditions. The uncertainty associated with these estimates should be explicitly communicated whenever the model is used to support environmental flow recommendations, management evaluations, or regulatory analyses.

5. Additional Refinement Should Precede Expanded Regulatory Application

The report appropriately identifies a number of areas where future refinement would improve model reliability, including:

- Expanded groundwater monitoring;
- Improved spring characterization;
- Refined pumping estimates;
- Improved diversion representation;
- Updated irrigation information;
- Additional calibration focused on low-flow conditions;
- Improved representation of upland hydrologic inputs, including snow accumulation and snowmelt processes; and
- Improved characterization of agricultural consumptive use and irrigation-related water management.

These recommendations are well founded. However, the report often transitions directly from discussing model limitations to discussing future management applications. In practice, there should be an intermediate step in which the most significant uncertainties are addressed and reduced before the model is relied upon for consequential management or regulatory decisions.

The current model provides a useful framework for identifying data gaps and organizing watershed information. At present, that may be its most valuable contribution. The model should continue to evolve through targeted data collection, refinement of conceptual understanding, and focused calibration efforts aimed at improving representation of low-flow and groundwater-driven processes.

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Recommendations

Based on the findings presented in the report, the following recommendations are offered:

1. The current model should not be relied upon as the primary basis for consequential regulatory or management decisions involving instream flow requirements, unimpaired flow determination, groundwater pumping impacts, or curtailment evaluations. In particular, the unimpaired flow estimates presented in Section 7 of the report should not be used in regulatory proceedings until the uncertainty bounds on those estimates have been explicitly quantified and disclosed, given that they inherit the full uncertainty of the baseline model's groundwater, spring discharge, and consumptive use representations.
2. Future model development should prioritize improving representation of low-flow conditions, groundwater-stream interaction, spring discharge, and consumptive use impacts.
3. Additional field data collection should be undertaken to better constrain groundwater contributions, spring flows, groundwater travel times, high-elevation hydrologic processes, pumping distributions, diversion operations, irrigation return flows, and agricultural consumptive use estimates.
4. Future scenario analyses should explicitly characterize uncertainty associated with model predictions rather than presenting results as deterministic outcomes.
5. Any application of the model for management or regulatory purposes should clearly disclose the limitations identified in the calibration and validation analyses.

Closing

The Shasta River Watershed Model represents a significant investment of technical effort and provides an important foundation for continued watershed analysis. However, the current calibration and validation results do not yet demonstrate sufficient reliability during the hydrologic conditions most relevant to the model's intended applications.

The model should therefore be viewed as a developing planning and analysis tool rather than a fully validated decision-support framework. Continued refinement, additional data collection, and focused improvement of low-flow and groundwater process representation are necessary prerequisites before the model is relied upon for management or regulatory decision-making.

Thank you for the opportunity to provide these comments. Please do not hesitate to contact us at mparker@co.siskiyou.ca.us for further discussion.

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Sincerely,

Signed by:
Ray Haupt
CA2D9FF2102C42E...

Ray A. Haupt

Chair, Siskiyou County Flood Control and Water Conservation District