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Attorneys for Cross-Defendant
CASITAS MUNICIPAL WATER DISTRICT a California special district

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF LOS ANGELES, COMPLEX

SANTA BARBARA CHANNELKEEPER, a California non-profit corporation, Petitioner, vs. STATE WATER RESOURCES CONTROL BOARD, a California State Agency; CITY OF SAN BUENA VENTURA, a California municipal corporation, incorrectly named as CITY OF BUENA VENTURA, Respondents.	Case No. 19STCP01176 *Judge: Hon. William F. Highberger* *Dept: 10* **CASITAS MUNICIPAL WATER DISTRICT'S C.C.P § 843 REBUTTAL EXPERT WITNESS DESIGNATIONS AND DISCLOSURE; DECLARATION OF JEREMY N. JUNGREIS IN SUPPORT THEREOF**
CITY OF SAN BUENA VENTURA, a California municipal corporation, Cross-Complainant, vs. DUNCAN ABBOTT, et al., Cross-Defendant.	Date Action Filed: September 19, 2014 Phase 1 Trial Date: February 14, 2022

Pursuant to Code of Civil Procedure ("C.C.P.") Section 843, as well as the Court's July 23, and November 23, 2021 Orders,[1] Cross-Defendant Casitas Municipal Water District ("Casitas")

[1] At the Court's November 23, 2021 hearing, the Court granted Casitas' motion to designate expert witnesses in Phase 1 of the Litigation, and the Court's order of November 23

hereby discloses its retained rebuttal expert witnesses for the Phase 1 trial currently scheduled to commence on February 14, 2022. In providing this disclosure, Casitas reserves the right to ask opinion questions, or expert witness questions, of any and all witnesses who, although experts, are also percipient witnesses to issues or facts raised in this case. Subject to C.C.P Section 843, and the deadline imposed by the Court for Casitas to disclose rebuttal experts by January 7, 2022, Casitas anticipates calling the following two rebuttal experts to testify at trial:

Dr. Jim McCord, Ph.D., P.E.
Groundwater Lead /Water Resources Engineer
Lynker-Intel, LLC
5445 Conestoga Court, Suite 100
Boulder, CO 80301

Mr. Randall T. Hanson
President, One-Water Hydrologic, LLC
4559 Pescadero Avenue
San Diego, CA 92107 USA

The qualifications and expected testimony of these experts are set forth in the Rebuttal Expert Witness Reports that are being produced to all parties concurrently herewith. All of the Exhibits and References relied upon by Mr. Hanson are found in his Rebuttal Report, or at electronic links on page 21 of his Rebuttal Report. Exhibits and references relied upon by Dr. McCord are included in his Rebuttal Report and through the following link https://rutantucker.thruinc.net/Desktop/Distro/Open/031SVI8KV66.

Casitas reserves the right, per the Court's November 23, 2021 order, to call additional rebuttal or impeachment expert witnesses to provide opinion and non-opinion testimony, once all expert witnesses of all other parties have been designated.

Further, as a result of ongoing issues related to Ventura and the SWRCB's experts, and technical materials that Casitas contends were not timely disclosed per CCP § 843 (b), followed by the subsequent refusal by both Ventura and the SWRCB to agree to continue the deadline for disclosure of rebuttal opinions in order to obtain such materials, this report is limited to the

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also included authorization for Casitas to designate supplemental experts on or before December 3, 2021 and rebuttal experts before January 7, 2022. (Jungreis Decl.: ¶2, Ex. 1.)

information currently available to Dr. McCord and Mr. Hanson. Casitas maintains all rights previously reserved and subject to the Code, and the Court's direction, including the right to offer additional expert testimony based upon new information subsequently disclosed by opposing parties, if any. Casitas reserves the right to supplement this disclosure, and to designate and call at the time of trial, such other expert witnesses as may be appropriate and authorized by the Court.

Dated: January 7, 2022

Respectfully submitted

By: ______________________

Jeremy N. Jungreis
Douglas J. Dennington
Attorneys for Cross-Defendant
CASITAS MUNICIPAL WATER DISTRICT

DECLARATION OF JEREMY N. JUNGREIS

I, Jeremy N. Jungreis, declare:

1. I am a partner in the law firm of Rutan & Tucker, LLP, the attorneys of record for Cross-Defendant Casitas Municipal Water District ("Casitas"). I am licensed to practice law before all courts in the State of California. Unless otherwise stated, I have personal knowledge of the facts set forth herein and if called and sworn as a witness, could and would testify competently thereto.

2. Casitas designates as rebuttal expert witnesses at the Phase 1 trial of this matter the following retained experts: Dr. Jim McCord, Ph.D., P.E. and Mr. Randall T. Hanson. Dr. McCord's and Mr. Hanson's rebuttal designations are in addition to Casitas' prior supplemental expert designation of Dr. McCord and primary designation of Mr. Jordan Kear as an expert, all of which were authorized by the Court's order of November 23, 2021. A true and correct copy of the minute order issued by the Court after the November 23, 2021 hearing is attached hereto as Exhibit 1.

3. I am informed and believe that Dr. McCord and Mr. Hanson are both experts in hydrogeology, hydrology, and the modeling of surface and groundwater interface with extensive experience building, reviewing and commenting upon surface and groundwater models. Copies of their separate Rebuttal Reports for Phase 1 of this adjudication, which each contain their rebuttal opinions, and the bases for those opinions, are enclosed as Exhibit "2." Exhibits and supporting materials for each rebuttal report are included in electronic links provided herein.

4. Dr. McCord and Mr. Hanson have both agreed to testify at trial, and both will be sufficiently familiar with the pending action to submit to a meaningful oral deposition concerning the specific testimony, including the opinions and bases for the opinions, that they are expected to give at trial.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Dated: January 7, 2022

By: [signature]
Jeremy N. Jungreis

Exhibit "1"

EXHIBIT 1

SUPERIOR COURT OF CALIFORNIA, COUNTY OF LOS ANGELES

Civil Division

Central District, Spring Street Courthouse, Department 10

19STCP01176
SANTA BARBARA CHANNELKEEPER vs STATE WATER RESOURCES CONTROL BOARD, et al.

November 23, 2021
9:00 AM

Judge: Honorable William F. Highberger
Judicial Assistant: P. Martinez
Courtroom Assistant: R. Sanchez

CSR: Tracy Dyrness, CSR# 12323
ERM: None
Deputy Sheriff: None

APPEARANCES:

For Plaintiff(s): No Appearances

For Respondent(s): Jeremy N. Jungreis for Douglas J. Dennington; Shawn David Hagerty

NATURE OF PROCEEDINGS: Hearing on Motion - Other Late Designation of Experts; Hearing on Motion - Other Late Designation of Experts by Loa Bliss; Further Status Conference

Pursuant to Government Code sections 68086, 70044, and California Rules of Court, rule 2.956, Tracy Dyrness, CSR# 12323 , certified shorthand reporter is appointed as an official Court reporter pro tempore in these proceedings, and is ordered to comply with the terms of the Court Reporter Agreement. The Order is signed and filed this date.

The matters are called for hearing.

The parties have been previously provided with the Court's tentative ruling.

Motion of Loa Bliss, As Trustee, Etc., For Extension Of Time Re Disclosure Of Experts: Granted

After hearing oral argument, The Court rules as follows:

Motion of Casitas Municipal Water District ("Casitas MWD") Motion To Serve Untimely Expert Witness Disclosures: Granted

The deadline for presentation of Supplemental Reports by Kear and any other disclosed expert remains December 3, 2021.

The Court sets the deadline for Rebuttal Experts for January 7, 2022. The Upper Ojai Basin rebuttal expert deadline is 2/01/22.

Discovery cut-off is modified to 02/10/22.

City of Ventura is to give notice.

Order to Show Cause Re: Why The Court Shouldn't Determine Certain Watershed Boundaries According To The Terms Of Notice Of Hearing Filed By City Of Ventura is scheduled for 12/09/21 at 02:30 PM in Department 10 at Spring Street Courthouse.

Hearing on Motion for Judgment on the Pleadings (City of Ojai) is scheduled for 01/18/22 at 01:30 PM in Department 10 at Spring Street Courthouse.

City of Ventura is to file brief regarding the Antelope Evaluations case by 11/30/21.

City of Ojai is to file a response by 12/07/21.

Deadline for objections to Judicial Notice is 12/08/21.

City of Ojai to give notice.

On 12/06/21 the Court will post the structure for the 12/09/21 hearing.

City of Ventura is to give notice.

** Additional Appearances**

(telephonic)
Peter Duchesneau for Aera Energy, LLC
Gina Angiolillo for AGR Breeding, Inc.
Brian E. Moskal for Baldwin Ranch, LLC
Noah Golden-Krasner for California Department of Fish & Wildlife
Christopher Pisano for City of Buenaventura
Holly Jacobson for City of Ojai
Claude R. Baggerly for Claude R. Baggerly
Ryan Blatz for Erica J. Abrams
Laura R. Schreiner
Loa E. Bliss (Roe 27)
Neal Maguire for Rancho Matilija Mutual Water Company
Gregg Garrison for Rosanna Garrison

SUPERIOR COURT OF CALIFORNIA, COUNTY OF LOS ANGELES

Civil Division

Central District, Spring Street Courthouse, Department 10

19STCP01176
SANTA BARBARA CHANNELKEEPER vs STATE WATER RESOURCES CONTROL BOARD, et al.

November 23, 2021
9:00 AM

Judge: Honorable William F. Highberger
Judicial Assistant: P. Martinez
Courtroom Assistant: R. Sanchez

CSR: Tracy Dyrness, CSR# 12323
ERM: None
Deputy Sheriff: None

Daniel Cooper for Santa Barbara Channelkeeper
Scott Slater for Santa Barbara Channelkeeper
Adam Kear for Senior Canyon Mutual Water Company
Marc N. Melnick for State Water Resources Control Board
William Carter for The Thacher School
Nathan Metcalf for Ventura County Watershed Protection District
Jeanne M. Zolezzi for Ventura River County Water District
Brad Herrema for Wood-Claeyssens Foundation

Exhibit “2”

Prepared for: Rutan and Tucker, LLP, Counsel for Casitas Municipal Water District

Rebuttal Expert Report on the California State Water Resources Control Board's Modeling Experts:

1. Expert Report of Al Preston, PhD, PE and Gregory Schnaar, PhD, PG, 24 September 2021
2. Supplemental Expert Report of Al Preston, PhD, PE and Gregory Schnaar, PhD, PG, 03 December 2021

07 January 2021

Prepared by:

One-Water Hydrologic, LLC, San Diego, California

Lynker-Intel LLC, Boulder, Colorado and **GSI Water Solutions Inc.**, Santa Barbara, California

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Contents

Figures and Tables

No table or figures entries found, all as separate Exhibit documents.

Abbreviations and Acronyms

AF	acre-feet
AFY	acre-feet per year
cfs	cubic feet per second
CMWD	Casitas Municipal Water District
DBS&A	Daniel B. Stephens and Associates
ET	Evapotranspiration
ft amsl	feet above mean sea level
Geosyntec	Geosyntec Consultants
GSFLOW	Groundwater Surface-water Flow Model
GSI	GSI Water Solutions, Inc.
GW-SW	Groundwater-Surface Water
MF-OWHM2	MODFLOW One-Water Hydrologic Model (Version 2)
MNW	Multi-aquifer Well
MNW2	Multi-aquifer Well Package
MODFLOW-NWT	Newton Formulation for Modflow-2005
PET	Potential Evapotranspiration
POR	Period-of-Record
PRMS	Precipitation-Runoff Modeling System
SFR2	Streamflow Routing (Package version 2)
SGMA	Sustainable Groundwater Management Act
Study Plan Review	*Review of the California State Water Resources Control Board's December 2019 Final Study Plan for the Development of Groundwater-Surface Water and Nutrient Transport Models of the Ventura River Watershed*
SWRCB	State Water Resources Control Board
UF	Unimpaired Flow
USGS	United States Geological Survey
VR	Ventura River
VRW	Ventura River Watershed
VRW SW-GW Model	Ventura River Watershed Surface Water – Groundwater Model

SECTION 1: INTRODUCTION

At the request of Rutan and Tucker LLP and Casitas Municipal Water District ("Casitas" or "CMWD"), a team of water resources/hydrogeology experts[1] assembled by GSI Water Solutions, Inc. (GSI), has been closely tracking the development and application of the three-dimensional (3D) integrated hydrologic model and nutrient transport model for the Ventura River watershed. The Ventura River Watershed Groundwater-Surface Water model (VRW GW-SW model) is being developed under the auspices of the State Water Resources Control Board and Los Angeles Regional Water Quality Review Board (collectively referred to below as "Water Boards").

1.1 Overview

The expert hydrogeologic modeling team reviewing the development and application of the VRW-GW-SW model is comprised of specialists from One-Water Hydrologic LLC, Lynker-Intel LLC, and GSI. As part of this model review process, the Casitas expert team has:

- participated in the public review activities of the VRW GW-SW model, including submitting written comments on the model Study Plan (GSI et al., 2021a).
- submitted a supplemental Expert Opinion report on December 4 to the court in the proceedings of the Ventura River Basin water adjudication[2]

This report is being submitted as a Rebuttal to the original expert report submitted by the Water Boards for the water adjudication, specifically Water Board's original expert report submitted on 24 September 2021 (see Preston and Schnaar, 2021a). This rebuttal report addresses concerns with the key aspects of the original Preston and Schnaar opinion report, including:

- Uncertainties in data, models, and concepts
- Error Analysis (groundwater levels, streamflows, Casitas reservoir levels, model input parameters)
- Omissions and misinterpretations, raising counter examples or more relevant examples

It is our opinion that the treatment, or lack thereof, of these issues ultimately undermines some of the conclusions and related opinions of Preston and Schnaar, rendering them unreliable for this litigation.

1.2 Report Structure

Following this introduction, **Second 2** provides a summary of the expert qualifications and **Section 3** presents a summary of our expert rebuttal opinions. The basis for development of our opinions are presented in **Section 4.** For convenience, the layout of **Section 4** exactly follows the presentation of the model development and application as presented in Sections 2 and 3 of Preston and Schnaar (2021a), which focus on model development, calibration and application.

[1] Dr. James McCord of Lynker-Intel, Mr. Randall Hanson of One-Water Hydrologic, and Mr. Tim Thompson of GSI; CVs for the experts can be found in Exhibits folder

[2] California Superior Court, County of Los Angeles, Case no. 19STCP01176, Santa Barbara Channel Keepers v. State Water Resources Control Board and City of Buenaventura.

SECTION 2: **Qualifications of Experts**

For this rebuttal report, Dr. James T. "Jim" McCord will be the testifying expert. Dr. McCord has more than 34 years of experience in hydrology, hydrogeology, and water resource investigations, with emphasis on characterization of groundwater and surface water systems, numerical modeling of hydrologic systems, river basin planning and management, water supply and availability analysis, vadose zone hydrology, contaminant hydrology, surface water and groundwater interaction, water rights, and stochastic hydrology and geostatistics. He is a court-recognized expert in many of these topics.

Prior to embarking on his water resources consulting career nearly 25 years ago, Dr. McCord was employed as Assistant Professor of Civil Engineering and Geology at Washington State University (1988 – 1990), and Senior Member of the Technical Staff at Sandia National Laboratories (1990 – 1997), where he worked on radioactive waste management issues. Since then, Dr. McCord has been a private consultant, applying his broad expertise to help solve water resource problems for a broad range of clients, from local, state, tribal, and federal governments, to private industry (mining, oil and gas, and responsible parties in groundwater contamination cases), both in the US and internationally.

One of Dr. McCord's core skills is in groundwater flow and transport modeling. Since completing his PhD in hydrology under the mentorship of Dr. Daniel B. Stephens' 32 years ago, Dr. McCord consistently has been involved with (and most typically leading) projects that involve the development and application of groundwater models, from models related to performance assessment of radioactive waste disposal facilities back in the 1990s, to regional models for water rights proceedings in Colorado and New Mexico in the 2000s, to regional models in California, Peru, and Chile in last decade. He is currently an expert on multiple water cases across the world, and all of these involve the development and application of groundwater modeling tools or are focused on detailed critiquing of models developed by others.

Dr. McCord's CV provides details on numerous projects that he has been involved with over the past 30 years, including his expert testimony experience and partial list of publications. See attached Exhibit A for Dr. McCord's full CV.

As of the date of this report, Dr. McCord's professional fees are as follows:

- Office and Field Work, Base Rate: $220/hour
- Exhibit, Deposition, and Testimony Preparation: $275/hour
- Deposition and Trial Testimony: $330/hour

SECTION 3: SUMMARY OF REBUTTAL OPINIONS

Section 1.6 of Preston and Schnaar (2021a) presents a summary of their opinions:

> **1.6 Summary of Opinions**
>
> We have developed the following opinions in this matter:
>
> - Surface water and groundwater are connected in the Ventura River watershed
> - Most groundwater pumping causes streamflow depletion in the VRW
> - Groundwater pumping in areas distant from the Ventura River and its tributaries impacts streamflow

The bases for their opinions are presented in "Section 3 Expert Opinions" of their report. A detailed review of that "Expert Opinions" section reveals that one of the key bases for their opinions are the simulation results from the VRW GW-SW model. As noted in our supplemental expert report submitted to the court on 04 December 2021 (GSI, 2021b), serious issues with that model render it unreliable for characterization and quantification of surface water – groundwater interactions in the Ventura River watershed.

In addition, it was our conclusion in our supplemental report that in general the model shows much more hydraulic connection between the groundwater system and the surface water system than is supported by available data. Our subsequent detailed review of the Water Boards' expert reports (Preston and Schnaar, 2021a, b) and the associated model input and output files confirmed our initial concerns. We have reviewed both the released calibrated model and the model set up for "unimpaired flows." Digging into the model files further revealed particular conceptual errors, poor model fit to data, and model structure that essentially hard-wired the model to arrive a certain conclusions.

Based on our review and analyses, we have developed the following rebuttal opinions:

1. Preston and Schnarr's (2021a) Opinion 1 employs an imprecise definition of surface water – groundwater hydraulic connection and develops a quantitative measure of that definition based on model results that is biased to show a degree of hydraulic connection that may not reflect actual streamflow losses
2. Preston and Schnarr's (2021a) Opinions 2 and 3 are based on a modeling approach that is biased to compute the maximum impact of well pumping on streamflows, potentially significantly overstating expected groundwater pumping impacts on streamflow losses, and thus are not supported by the available data
3. Preston and Schnarr's assertions that most groundwater pumping in the Ventura River watershed, near and distant from the Ventura River, causes streamflow depletion in the Ventura River is questionable since it is premised on a variety of flawed assumptions not supported by data leading a biased model that appears designed to overestimate the impact of groundwater pumping on surface water in the Ventura River
4. The rebuttals to Preston and Schnarr's opinions contained in Sections 4.2 and 5.0 of this report.

Our rebuttal opinions are supported by numerous analyses of the model input files and output results, which clearly show the poor model fit to available data and a strong bias to overstating surface water – groundwater interactions and hydrologic connectivity. Evidence for this model bias includes:

- The overestimation of stream leakage related to both interlayer flows as well as unrealistic wellbore flow parameters used to represent multi-aquifer wells (MNW) in the model; these features facilitate flows across confining units and thus accommodate more losses out or the stream channel;
- The model simulated groundwater circulation pattern in the Ojai Basin is in direct conflict with multilevel groundwater piezometric head measurements (model vs South Fulton multilevel well, San Antonio spreading ground well) (Ojai Basin L1 – 2 downward flow, and upward flow from L4 – L7)
- The model hydraulic conductivities for some zones appear to be biased toward higher-than-expected values based on , which leads to higher interlayer flows and groundwater – surface water interactions;
- The model Flow – Stream Width rating curve shows a significant overestimation bias over the flow range from 2 cfs to 50 cfs,
    a. This is a flow range that encompasses approximately 86% of the daily average flow of the Ventura River and its tributaries for the model simulation period.
    b. Thus for more than 80% of the computed daily flows, the model-simulated stream channel wetted width is from two to five times wider than the field data shows, greatly overestimating anticipated water transfers between the surface water and groundwater system
- The model cannot reproduce observed low stream flows throughout most of the basin, as it appears to greatly overestimate flows in the low flow range (< 1cfs), making the model unsuitable for evaluating low flow conditions. This is especially true for the Ventura River's intermittent reach between Meiners Oaks and the confluence with San Antonio Creek

SECTION 4: Bases for Rebuttal of Preston and Schnaar

As noted previously, the layout of this section exactly follows the presentation of the model development, calibration, and application as presented in Sections 2 and 3 of Preston and Schnaar (2021a). This structure facilitates presentation of our findings in the context of countering certain statements, arguments, and findings of Preston and Schnaar.

As noted in the introduction, we have identified issues with the existing VRW SW-GW model development and application that can be grouped into three categories: (i) Uncertainties in data, models, and concepts, (ii) Error Analysis (groundwater levels, streamflows, Casitas reservoir levels), and (iii) Omissions of important data and/or information and in some cases misinterpretations, of cited work of others. In our critique that follows, we bin cited problems into one or more of these categories.

4.1 Preston and Schnaar Section 2. GSFLOW Model

This section of the describes the objectives of the model and the overall model structure.

> The overall goal of the VRW integrated surface water/groundwater model is to provide scientifically defensible, cost-effective, time-sensitive, and publicly transparent tools that can be used to support the State Board. The VRW Modeling Project Study Plan (Geosyntec and DBS&A, 2019) describes the overall project approach, modeling methodology, and code selection process. GSFLOW was selected as the code for the VRW flow model because it has the advantages of high level of credibility and transparency, online training availability, widespread use, and thorough public documentation.
>
> GSFLOW is a coupled groundwater and watershed flow model based on integration of the USGS Precipitation-Runoff Modeling System (PRMS) watershed model and MODular finite-difference ground-water FLOW model (MODFLOW). GSFLOW was developed to simulate coupled groundwater-surface water flow in one or more watersheds by simultaneously simulating flow across the land surface, within subsurface saturated and unsaturated materials, and within streams and lakes (Markstrom et al., 2008).

Interestingly, as noted in the detailed review of the model study plan (GSI et al., 2021a), the first objective listed for the model was "*Estimate existing instream flows at multiple points of interest (POI) throughout the entire Ventura River Watershed.*" This objective appears to have been dropped, perhaps because the surface water model component of the integrated model does a poor job of reproducing low flows in the Ventura River as described in the next section.

4.1.1 Preston and Schnaar Section 2.1 PRMS Model Description

As described above, the PRMS model was used to simulate the surface hydrologic system. Section 2.1 of Preston and Schnaar (2021a) describes model set up in terms of model domain, discretization into model grid cells, the land surface terrain modeling, spatially distributed physical and hydrologic properties of the land surface and soils, climate (precipitation and evapotranspiration, temperature, ET), vegetation cover, and man-made features that affect the surface hydrologic processes (e.g., paving to create impermeable surfaces and storm drain network). While numerous issues were raised in the initial review of the Study Plan (GSI et al., 2021a), after reviewing the model files themselves and results, several of these concerns were confirmed, including:

- Lack of treatment of stormwater drains, which can lead to significant short-circuiting of flows compared to surface runoff over natural surface.
- The treatment of spatially distributed precipitation was not explained clearly in the Webinars nor in the Preston and Schnaar expert report (2021a). The Study Plan provides a better description and refers to the Python scripts employed for precipitation extrapolation from measured stations (Gardner et al., 2018). The figure shown in the webinars and Preston and Schnaar (2021a, Fig. 2.1-3; reproduced here as **Exhibit 1**) include Thiessen polygons about each precipitation measuring station. But they provide no explanation of the significance of the Thiessen polygons nor how they are employed in extrapolating precipitation to unmeasured locations. Furthermore, the Python scripts described by Gardner et al. (2018) make no reference to the need for employing Thiessen polygons (or any other zonation technique) in the processing of precipitation data.
- As was noted in the Water Boards webinars, the treatment of the invasive species Arundo donax (common name "Giant Reed") in the model appears to have neglected the significant and ongoing Arundo eradication efforts that have been progressing in the basin for years (**Exhibit 2**). This results in an overestimation of acreage occupied by Arundo donax, especially in the later years of the simulation. On top of this, from the webinar it appears that a water duty of 24 acre-foot/acre/year (af/ac/yr)was selected for Actual ET for Arundo. A recent review article on estimates and measurements of evapotranspiration by Arundo donax (Nature Conservancy, 2019) shows a huge range, with a water duty ranging from 0.8 to 48 af/ac/year (**Exhibit 3**). However, the highest estimates were obtained using the Leaf Area Index method, which scales up fine scale porometer flux measurements by estimates of total leaf area. The six other studies employed more direct measurement methods such as lysimeter and water balance, and surface energy balance methods using satellite data. These yielded much lower values, between 0.8 and 14.8 af/ac/year, averaging 6.1 af/ac/yr. The combined impact of the overestimation Arundo donax acreage and selection of a very high water-duty for Arundo PET will result in excessive riparian ET discharges from the model domain. This in turn will strongly affect the model simulation of the surface water – groundwater interactions, casting doubt on the reliability of those estimates.
- As described by Preston and Schnaar (2021a), preliminary calibration of PRMS model hydrologic parameters was undertaken for using data from high flow period. This approach was used to take advantage of the fast model runtime for the PRMS model uncoupled from the groundwater model, facilitating rapid preliminary fit of those parameters. Final GSFLOW model calibration (including adjustments to the PRMS surface hydrology parameters) was performed with the integrated model over a broader range of flow and climatic conditions. These are discussed below for the calibration model, via analysis of model performance in simulating surface-water flows. We specifically look at hydrographs, observed minus modeled flow errors, flow frequency curves, and interactions between surface channels and groundwater.

4.1.2 Preston and Schnaar Section 2.2 MODFLOW Model Description

In this section, Preston and Schnaar describe the MODFLOW model setup. This includes showing the spatial distribution of hydrogeologic zones by layer and for numerous cross-sections, describing for the time varying stresses such as recharge and groundwater pumping, and the surface water routing and interaction with groundwater via the stream flow routing (SFR2) package.

The MODFLOW model uses the NWT version of the code (MF-NWT) with 7 layers, 365 rows and 313 columns of square cells 330 by 330 ft over 288 monthly stress periods with daily time steps. There are 6 constant head cells in layer 2 and 48 constant head cells in layer 1, located at the eastern limit of the Upper Ojai Basin portion of the model domain.

The hydraulic properties and range of values for those properties are presented in **Exhibit 4**. Based on our combined over seventy years past experience in development and application of groundwater flow and transport models, most of the values for the flow parameter used in the model are in a reasonable range. Some of the values, however, are at the limits or outside the expected reasonable range.

In the following sections, both the Calibrated and Unimpaired flow models are briefly reviewed in separate subsections that cover surface-water flows, groundwater levels, surface-water - groundwater interactions, hydrologic budgets, and Casitas Reservoir Inflows/Outflows.

4.1.2.1 Initial Conditions

One flawed item in the model setup is the assignment of initial groundwater elevations (piezometric heads) across the model domain. Groundwater elevations must be assigned for each model cell in all layers at the beginning of the model simulation, and these are referred to as "initial conditions." A well-constructed model should employ initial piezometric heads across the domain that are in "hydraulic dynamic equilibrium" based on the historical recharge and discharge conditions in the basin and the properties of the hydrogeologic media (hydraulic conductivity and storage). In most cases, the initial conditions are not the same for all layers.

In this case, Preston and Schnaar did not apply a hydraulic dynamic equilibrium initial condition for the VRW SW-GW model. Instead, they employed an ad hoc approach using two different methods for the shallow and deeper units. For the alluvial groundwater units they used interpolation of measured groundwater levels from Fall 1993, and for the underlying bedrock units they used simulated groundwater levels from the September 2005 conditions for the bedrock units. This bedrock condition was selected because Preston and Schnaar assert that September 2005 represented a "similar hydrologic time period as Fall 1993." Despite this asserted similarity, as described by Reilly and Harbaugh (2004), this approach to assignment of initial conditions automatically leads to an unquantified degree of hydraulic disequilibrium between the bedrock and alluvial units at the start of the model run (not to mention the potential disequilibrium in the upper alluvial units by their approach). This hydraulic disequilibrium will lead to a "relaxation" response by the model in the first few years of the simulation. This relaxation response is thus confounded with the model response to applied stresses (i.e., climate and groundwater pumping), especially during the first few years of the simulation. This limits the utility of the GSFLOW model as a rigorous tool for analysis of groundwater system response to changing stresses and/or management actions.

4.1.2.2 Streamflow Routing

As described by Preston and Schnaar, the GSFLOW model simulates flow in the stream channels, as well as fluxes between groundwater system and stream channels, using the MODFLOW streamflow routing (SFR2) package. They describe the SFR2 set up and associated parameterization in Webinar 1 Slide 26 (SWRCB, 2021). Problems were identified in our review of the SFR2 set up, including (1) the model's poor ability to simulate low flows, (2) the model – observed error distribution, and (3) the model's overestimation of groundwater – surface water interactions. These are discussed below in Section 4.1.3 on results with the calibration model.

4.1.3 Preston and Schnaar Section 2.3 Model Calibration and Validation

As described by Preston and Schnaar, model calibration involves iterative adjustments of various model parameters until model results match historical observations within a pre-defined tolerance. The calibrated GSFLOW model simulates both streamflows as well as groundwater levels. The following subsections discuss GSFLOW model reliability for predicting streamflows, groundwater levels, and surface water – groundwater interactions.

4.1.3.1 Preston and Schnaar Section 2.3.1 Streamflow Calibration and Validation

To evaluate performance of the GSFLOW models streamflow routing and simulation of surface water – groundwater interactions along stream channels, we performed a detailed analysis of model simulations of streamflows in the Ventura River at key points, and some of those results are presented below.

Poor Model Performance at Predicting Low Flows

Preston and Schnaar (2021a) Figures 2.3.1-10 through 2.3.1-14 show the simulated streamflow results for several points along the Ventura River. Despite the reported favorable numbers for the goodness-of-fit between of model to observed flows (Preston and Schnaar Tables 2.3.1-2 and 2.3.1-3), both the hydrographs and the flow frequency curves for all the stations below Matilija Hot Springs show that the model does not accurately simulate low flow conditions. For example, **Exhibit 5** shows the results for the Ventura River at Meiners Oaks Gage. The top two charts in **Exhibit 5** show the model appears to capture most of the wet season flow peak, however one can clearly see the poor fit of the model to the low flow conditions. The flow frequency curve at the bottom of the exhibit show that the model simulates measurable flow in the stream for the nearly 35% of the time that Ventura River is dry at that location. The cause of this extreme error is likely the model's poor performance in simulating groundwater levels in this area. In fact, this appears to be the case along most of the "intermittent reach" of the Ventura River from Meiners Oaks to its confluence with San Antonio Creek.

Preston and Schnaar (2021a) Figure 2.3.1-18 present a "Wet – Dry Map" simulated by the model compared to that type of data collected by CMWD. While the model appears to approximately mimic the wet – dry pattern observed over time, a closer look reveals that the modeled "dry reach" uses a cut-off water depth of 0.1 feet to achieve the same extent as the completely dry mapped channel. This again points to the model's overestimation in groundwater levels, and thus flows in the stream channel, especially along the intermittent reach.

It is suspected that the original model objective from the 2019 model study plan to "*Estimate existing instream flows at multiple points of interest (POI) throughout the entire Ventura River Watershed"* was dropped from the Preston and Schnaar (2021a) expert report due to this particular problem with the model (i.e., the current calibration model cannot meet that objective).

Simulated Flow Error Distribution

Exhibit 6 shows the distribution of simulated minus observed flow errors across the entire range of flows for the Ventura River at Foster Park gage VC608 (USGS 11118500). The bimodal distribution of errors suggests structural problems with the model. Likely one important contributor to this bimodal error distribution is the excessive surface water – groundwater interaction simulated by the model in the flow range from 2 to 50 cfs. This flow range encompasses approximately 86% of the model simulated daily flows for the 24-year simulation period, and as shown below the model strongly overestimate flows between the surface water and groundwater in that flow range.

Excessive Surface Water – Groundwater Transfers at Intermediate Flow Range

One key parameter that controls the surface water - groundwater interactions is the width of the stream channel as simulated by the model, with the flow rate between the surface flow in the stream channel and the underlying groundwater $Q_{sw\text{-}gw}$ computed as:

$$Q_{sw-gw} = K_{sb} * A * \frac{dH}{dZ}$$

Where K_{sb} is the streambed hydraulic conductivity, dH is the head difference between the stream channel and the groundwater, dZ is the thickness of the streambed, and A is the interface area of the wetted stream channel. The wetted area *A* is computed as wetted channel Width times length. Thus the flux per longitudinal length of stream channel is computed as $Q_{sw\text{-}gw}$ /length = K_{sb}*Width*(dH/dZ)*. In other words, flow between the surface water and groundwater through the stream bed is a linear function of stream channel wetted width.

To evaluate the model-estimated widths compared to actual data, USGS field measurements (flow and width) for the USGS gage 1118500 (VC608) was obtained and compared to the streamflow vs width as computed by the model (Exhibit 7). This chart clearly shows that the modeled channel width generally significantly overpredicts the true width in the 2 to 50 cfs flow range, which as noted above is the stream flow range for approximately 86% of the daily model time steps.

Robles Diversion Bias

Ana analysis was made to evaluate the VRW SW-GW model's ability to simulate the diversion from the river into the Casitas system at the Robles diversion. Exhibit 8 presents both the raw monthly diversion data compared to that computed by the model (8a) and the monthly diversion error and cumulative diversion error over the model simulation period (8b). This result shows that the model exhibits an underprediction bias, that averages slightly more than 1,000 af/year over the 24-year simulation period; this is evidenced by the approximately 26,000 af cumulative under diversion. This also shows that the bias is systematic, i.e., there is essentially never an over-prediction of the diversion at Robles and the errors always occur at peak flows, suggesting a systematic error in how the model treats runoff and surface water – groundwater interactions at those flows; this is also clearly demonstrated by the cumulative diversion error plot, which never shows a visible downdip in the accumulated error.[3]

4.1.3.2 Groundwater Calibration and Validation

Groundwater levels are a primary metric for the calibration of a groundwater model within GSFLOW. One can employ a variety measures from raw groundwater observations as "calibration targets," including groundwater levels, "drawdown" (difference in depth to water through time), and vertical groundwater-level differences. The VRW SW-GW model calibration only used the simple groundwater levels for assessing the measure of fit for the model calibration. For the calibration, the model developers used 53 well locations spanning 4,823 observations for model layers 1-5.

The model goodness-of-fit statistics (Preston and Schnaar, 2021a, Table 2.3.2-1a and 2.3.2-1b) to simple groundwater levels is within the predefined calibration criteria and meet common measures for being considered an adequately calibrated model. However, two concerns are noted.

- First, there appears to be a slight bias to overpredicting groundwater levels (negative mean error). In this topographically steep terrain, higher than observed groundwater levels will intercept incised stream channels more frequently than actually would occur at lower groundwater levels, causing more interactions between the surface water channels and the underlying groundwater systems.
- Second, it appears that no effort was made to calibrate the model to observed vertical hydraulic gradients, even though there is high quality data on vertical head differences in the Ojai Basin.

The model's poor performance in reproducing these observations is described below.

[3] As part of this analysis, it was discovered that Figure 8 in GSI et al. (2021b) had a time-shift error in the plotting of the simulated Lake Casitas stage, based on the Preston and Schnaar report description that the calibration period was from 1997-2017. Making this correction confirmed Preston and Schnaar's (2021a) presentation of simulated Lake Casitas stage in their Figure 2.3.1-17.

Poor Simulation of Observed Multilevel Groundwater Levels in the Ojai Basin

As described by Kear (2021), a multi-level piezometer (groundwater level observation well) was constructed on South Fulton Street in Ojai, at a location approximately 1,700 from the San Antonio Creek stream channel deposits (**Exhibit 9**). Water levels at that well nest clearly show a consistent downward hydraulic gradient from the shallow perched aquifer down to the underlying upper aquifer and main aquifer (**Exhibit 10**). The VRW SW-GW model results were extracted for this location, and they show the opposite hydraulic gradient direction, with the highest water levels at the deepest monitoring depth. Thus the model is implying a groundwater flow pattern opposite from that which is evidenced by the water levels at the South Fulton Street well nest:

- A north-south cross-section was extracted from the model that intercepts the location where the South Fulton Street well nest is located and is shown in **Exhibit 11**. The model prediction of groundwater heads and velocity vectors is suggesting that high mountain recharge enters the Ojai Basin alluvial deposits at depth and laterally from the north.
- This implied circulation pattern continues southward to the point where the deep groundwater upwells and spills into San Antonio Creek (**Exhibit 11**).
- The fact that the best available multi-level groundwater elevation data for the basin (**Exhibit 10**) does not show the same vertical gradient in this area casts doubt on the VRW SW-GW model's computed interactions with San Antonio Creek at the south end of the Ojai Basin.

Thus the model simulated circulation pattern appears to overestimate mountain block recharge entering the basin laterally at depth and/or to underestimate the impacts of pumping at depth, or a combination of the two. Reviewing the hydrographs for each model layer at that location reveals that large fluctuations in the heads, with water levels rising to nearly the ground surface and dropping nearly 90 feet during dry periods. This does not account for the observed perched groundwater behavior.

Two other related data points cast additional doubt on the reliability of the VRW SW-GW for computing surface water -groundwater interactions in this part of the model domain. (1) The observed groundwater levels in the deeper zones tapped by the South Fulton Street piezometers are on the order of 10 feet or more lower than the San Antonio Creek channel elevation at its nearest location to the well, making it impossible for that groundwater to recharge the San Antonio Creek. (2) The model hydrogeologic profile in this vicinity, as shown in Exhibits 10 and 11, does not show the presence of a tight confining layer with perched water above and confined water below, even though this was observed during well installation (Kear, 2021).

Basin-wide Water and Local Water Budgets

The calibration model was also subject to a detailed water budget analysis. The global cumulative water budget for the entire model domain for the is shown in **Exhibit 12**, for both the Calibration and Unimpaired Flow scenario. As described below, Preston and Schnaar (2021a) define what they term an "Unimpaired Flow Scenario" (UF scenario) in which all groundwater pumping and surface water diversions are turned off. These charts show the cumulative inflows and outflows in acre-feet (af), component by component, over the 24-year simulation period. Several observations can be made from these charts:

- For the Calibration model (**Exhibit 12** upper image), one can see that the largest inflow to, and outflow from, the groundwater system is via groundwater interactions with the surface water streams
- The overall net transfer from the surface water to groundwater is roughly 50,000 af over the 24 years, so in the baseline calibration model the groundwater system is benefiting by recharge from stream flow losses on average 2,080 af/year over the simulation period

- For the UF scenario model (**Exhibit 12** bottom image), one can see that again the largest inflows and outflows from the groundwater system is via groundwater interactions with the surface water streams, but this time the magnitude of the flows are significantly larger.
  - Inflows to the groundwater from stream channel losses increase from approximately 12%
  - The outflows from the groundwater to the stream, however, increase by more than 30%, which occurs because pumping outflows from the calibration scenario have been removed

It has already been established above that the degree of surface water – groundwater interactions is excessive compared to what can be supported by available data. And these water budgets show the UF scenario exhibits even more exaggerated interactions with the groundwater system.

Another important issue to note is that the MNW2 inflows are 25% of outflows, supporting the previously stated notion that unreasonably high values were used for some of the well parameters in the used MNW package. This creates excessive interlayer flows via wellbore connection, thus accommodating more interaction between all model layers and surface stream channels.

4.1.4 Preston and Schnaar Section 2.4 Model Limitations

In this section, Preston and Schnaar provide a listing of limitation in the existing model. We agree with those stated limitations and would add the following limitations for the VRW SW-GW model as well:

- The calibration model exhibits a slight bias in overestimating groundwater levels, and this in turn impacts calculated inflows from the groundwater system to the surface streams
- The calibration model strongly overpredicts surface water - groundwater interactions most of the time due to a strong bias in the rating curve width at flow conditions less than 50 cfs
- The calibration model strongly overpredicts low flows (flows in Ventura River < 0.5 cfs), rendering it unsuitable for use as a tool for evaluating fish flows
- The calibration model does a poor job of simulating vertical hydraulic gradients in the Ojai Basin, suggesting more interaction between deep groundwater in the basin and surface flows in nearby San Antonio Creek than can be justified by available data

4.1.5 Preston and Schnaar Section 2.5 Model Pumping Scenarios

Declaring that their model provides a good representation of the integrated hydrologic system of the Ventura River Basin watershed and groundwater basins, Preston and Schnaar (2021a) then set out to apply the model for making generalized conclusions on the impacts of groundwater pumping on streamflows in the Ventura River and its tributaries. They do this by defining a series of pumping scenarios which attempt to isolate the impacts of pumping in various zones across the basin on streamflows at various locations across the basin (**Exhibit 13**).

Specifically, Preston and Schnaar (2021a) first run the UF scenario, in which all groundwater pumping and surface water diversions are turned off. Then a separate model run is performed, a model which is basically the UF scenario but with pumping in each zone added, but for only one zone at a time. Thus the results from the UF scenario become the baseline against which all other "Pumping Zone" results are compared. **Exhibit 14** shows the stream depths at VR at Foster Park computed by the UF model compared to those for the Calibration model, clearly showing the UF model simulates deeper stream flow depths than the calibration model.

We have already established that the calibration model exhibits high groundwater levels on average, and how some features of the model set up create a strong overestimation bias in flows between the surface streams and the groundwater system. **Exhibit 14** shows that the UF scenario simulates even higher water levels, potentially compounding those errors. So in essence, the new baseline for the zoned pumping analysis for streamflow impacts is a "basin full" scenario, which when combined with the stream channel width overestimation bias will naturally lead to a gross overstatement of the impacts of pumping on streamflows.

4.2 Preston and Schnaar Section 3 Expert Opinions

In this section Preston and Schnaar (2021a) attempt to support their overarching conclusions presented at the top of Section 2 above by applying the results of the various VRW SW-GW model scenarios described above, including the UF and Zoned Pumping scenarios.

1. To support their Opinion 1, Preston and Schnaar (2021a) define a direct hydraulic connection to occur between the surface water and ground water "when the groundwater elevations are equal to or higher than the streambed elevations" when actually this definition is only applicable in certain special cases and hydrogeologic conditions. Based on their definition of direct hydraulic connection, they define a measure termed the "*frequency factor* that measures the frequency (fraction of time) that groundwater levels are greater than streambed elevations." They then proceed to calculate the frequency factor at points along stream channels through the watershed, including key points such as gage locations. This analysis was undertaken for the calibration model for the 24-year baseline period.

   As shown in various analyses above, the Calibration model exhibits a bias in overestimating head, and also in not being able to reproduce intermittent conditions observed on the main streams. Thus, the results of this type of analyses using their "frequency factor" will also be biased showing higher frequency that is supported by the data.

2. To support their Opinions 2 and 3[4], Preston and Schnaar (2021a) define two new measures of the groundwater – surface water interaction and the impacts of groundwater pumping on streamflows. , what they term the "Streamflow Depletion" (without factor!) and the "Influence Fraction." These two new measures are computed using the results from the UF model and the Zoned Pumping models.

   This approach will yield unreliable results for two reasons. First, and again as demonstrated above, the UF model as a baseline represents an extreme "basin full" case, exacerbated by the various biases demonstrated for the Calibration model. The basin-full baseline approach is essentially "hardwired" to show the maximum impact of pumping on surface water bodies. This baseline compounded with these biases renders unreliable these results for developing quantitative measures of the impacts of well pumping on surface water flows in the basin. Secondly, this approach is essentially an application of a superposition modeling approach to a highly non-linear problem, which adds another layer of unquantified uncertainty atop the already highly uncertain and biased result.

One additional point related to UF and Pumping Zone model scenarios is that the results from the first several years should be neglected and considered the most unreliable of all, due to the incorrect approach to assigning initial conditions as described by Preston and Schnaar (2021a, see page 10) and discussed above in Section 4.1.2.1. For all these reasons, the modeling results employed by Preston and Schnaar to support these opinions should be considered unreliable.

[4] Preston and Schnaar Opinion 2: Most groundwater pumping causes streamflow depletion in the VRW
Preston and Schnaar Opinion 3: Groundwater pumping in areas distant from the Ventura River and its tributaries impacts streamflows

SECTION 5: CONCLUSIONS AND SUMMARY OF OPINIONS

A detailed review of the VRW SW-GW model undertaken by Casitas' modeling experts has provided the basis for review and comment on the Preston and Schnaar expert report submitted on September 24, 2021. Based on our review and analyses, we have developed the following rebuttal opinions:

1. Preston and Schnarr's (2021a) Opinion 1 employs an imprecise definition of surface water – groundwater hydraulic connection and develops a quantitative measure of that definition based on model results that is biased to show a degree of hydraulic connection that likely overstates actual conditions
2. Preston and Schnarr's (2021a) Opinions 2 and 3 are based on a modeling approach that is biased to compute the maximum impact of well pumping on streamflows, likely significantly overstating expected pumping impacts on streamflow losses

Our rebuttal opinions are supported by numerous analyses of the model input files and output results, which clearly show the poor model fit to available data and a strong bias to overstating surface water – groundwater interactions. Evidence for this model bias includes:

- The overestimation of stream leakage related to both interlayer flows as well as unrealistic wellbore flow parameters used to represent multi-aquifer wells (MNW) in the model; these features facilitate flows across confining units and thus accommodate more interactions between the groundwater systems and the stream channels
- The model simulated groundwater circulation pattern in the Ojai Basin is in direct conflict with multilevel groundwater piezometric head measurements (model vs South Fulton multilevel well, which shows downward vertical hydraulic gradients) (VRW model Ojai Basin L1 – 2 downward flow, and upward flow from L3 – L7)
- The absence from the model stratigraphy of a verified confining layer at the south side of the Ojai Basin casts doubt on the VRW SW-GW model's computed interactions with San Antonio Creek at the south end of the Ojai Basin.
- The model hydraulic conductivities appear to be biased toward higher-than-expected values, which leads to higher interlayer flows and groundwater – surface water interactions;
- The model Flow – Stream Width rating curve shows a significant overestimation bias over the flow range from 2 cfs to 50 cfs,
    a. This is a flow range that encompasses approximately 86% of the daily flows for the model simulation period.
    b. Thus for more than 80% of the computed daily flows, the model-simulated stream channel wetted width is from two to five times wider than the field data shows, greatly enhancing water transfers between the surface water and groundwater system
- The model cannot reproduce observed low stream flows throughout most of the basin, as it appears to greatly overestimate flows in the low flow range (< 1cfs), making the model unsuitable for evaluating low flow conditions. This is especially true for the Ventura River's intermittent reach between Meiners Oaks and the confluence with San Antonio Creek

SECTION 6: REFERENCES

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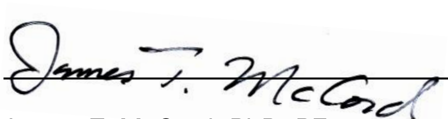
SECTION 7: AFFIRMATION OF EXPERT

I, Dr. James. T. McCord, affirm that the opinions expressed herein are mine, based on the information cited in the attached documents in the references section above and in the attached exhibits, analysis using the available data provided by the State Water Boards, and hydrogeologic brainstorming discussion among experts on the Casitas team.

Signed:



James T. McCord, PhD, PE

07 January 2021

Exhibit A - CV of Dr. James T. McCord

(beginning next page)

Jim McCord, Ph.D., P.E.

Principal Hydrogeologist / Water Resources Engineer

Lynker

Education

Ph.D., Geoscience, Dissertation in Hydrogeology, New Mexico Institute of Mining and Technology, 1989

M.S., Hydrology, New Mexico Institute of Mining and Technology, 1986

B.S., Civil Engineering, Virginia Polytechnic Institute and State University, 1981

Memberships/Affiliations

Professional Engineer (New Mexico #15568, in process for California)

Member, California Groundwater Resources Assoc.

Member, New Mexico Geological Society

Languages

English, Mother Tongue

Spanish, DELE (Diploma in Spanish as Foreign Tongue) Level 2, Fluent spoken and written

Consulting Employment History

Lynker Technologies, LLC, Principal Hydrogeologist / Water Resources Engineer, 2021 – Present

IRP Water Resources Consulting
Principal Consultant, 2020 – 2021

Geosystems Analysis, Inc.
Principal Hydrogeologist, 2018 – 2020

Amec Foster Wheeler
Principal Water Resources Engineer 2007-2018

Hydrosphere Resource Consultants, Principal Hydrologist, 1999 – 2007 (acquired by Amec)

Daniel B. Stephens & Associates, Hydrology Group Leader, 1997-1999.

Summary

Dr. McCord has more than 32 years of experience in hydrology, hydrogeology, and water resource investigations, with emphasis on characterization of groundwater and surface water systems, numerical modeling of hydrologic systems, river basin planning and management, water supply and availability analysis, vadose zone hydrology, contaminant hydrology, surface water and groundwater interaction, water rights, and stochastic hydrology and geostatistics. Prior to embarking on his water resources consulting career, Dr. McCord was employed as Assistant Professor of Civil Engineering and Geology at Washington State University (1988 – 1990) and as Senior Member of the Technical Staff at Sandia National Laboratories (1990 – 1997), where he worked on radioactive waste management issues. Over his nearly 20 years with Hydrosphere and Amec Foster Wheeler (who acquired Hydrosphere in 2007), Dr. McCord served as New Mexico manager (1999 – 2007), Water Resources Technical Director for Texas – New Mexico (2007-2011), and Water Resources Technical Director for South America (2011 – 2016). He is a recognized expert in Vadose Zone Hydrology, has authored numerous consulting reports and technical peer-reviewed papers, and co-authored the textbook, *Vadose Zone Processes* (CRC Press, 1999). Following a listing of core skills is a listing of representative projects in sustainable groundwater management and water rights* in which Dr. McCord played an important role:

Core Skills

- Hydrogeology and Vadose Zone Hydrology
- Groundwater flow and transport modeling, from site- to basin-scale
- Unsaturated flow and contaminant transport
- Groundwater recharge processes
- Surface water/groundwater interactions
- Hydrologic analyses in Water Rights
- Crop Water Use / Irrigation Hydrology
- Mine water management
- Heap leach optimization studies

Project Experience

Sustainable Water Resources Management and Water Rights

GSP Groundwater Model Development, Santa Ynez River Basin Eastern Management Area

Santa Barbara County Water Agency, California, 2020 - current

Working under subcontract to GSI Water Solutions (GSI) for Santa Barbara County Water Agency, Dr. McCord led the development of a groundwater flow model of the Santa Ynez River Basin Eastern Management Area (EMA), in support of GSI's effort to develop the Groundwater Sustainability Plan (GSP) for the EMA. The EMA has been identified as a Medium Priority basin, with the GSP to be submitted at the end of 2021. As part of this effort, Dr. McCord worked closely with the GSI team on construction of the hydrogeologic conceptual model (HCM) and a, annual timestep water budget, utilizing best available historical data and DWR requirements related to GSP development.

Development of Spatially Distributed Recharge Estimates and Surface Water-Groundwater Interactions for Aquifers in Central and West Texas.

Texas Water Development Board, 2020 - current

Teamed with WSP, LRE Water Consultants, and Dr. Raghavan Srinivasan (Texas A&M University), Dr. McCord is supporting a contract to Texas Water Development Board (TWDB) for Development of Recharge Estimates and Surface Water-Groundwater Interactions for Aquifers in Central and West Texas. The team is employing a variety of water budget and hydrologic modeling tools to obtain detailed rasterized estimates of recharge and surface water gains and losses for key stream reaches across the study area. Dr. McCord is leading the effort to evaluate the use of satellite-based tools such as GRACE and MODIS to compare to and in some cases help constrain the estimates.

Hydrology and Hydrogeology Expert Consultant, Casitas Municipal Water District

Casitas Municipal Water District, Ventura County, California, 2020 - current

For Casitas Municipal Water District (Ventura County, California), Dr. McCord is serving as a hydrogeology and hydrologic modeling expert in support of the District's TAC (Technical Advisory Committee) involvement and review of the integrated hydrologic – hydrogeologic – water quality model being developed by the State Water Boards for evaluation of fish flows for the Ventura River, review of models developed to support to GSPs in the Ojai and Upper Ventura River Subbasins, and for potential use of model in the ongoing groundwater adjudication for the basin.

Hydrology Expert, Navajo Nation, Zuni River Basin and Little Colorado River Adjudications

Navajo Nation Department of Justice, Arizona and New Mexico, 2007 - 2019

For the Navajo Nation DOJ, Dr. McCord served as the hydrology expert on two water rights adjudications (Little Colorado River Basin, Arizona, and Zuni River Basin, New Mexico). Tasks include evaluating water claims and demands (including agricultural, M&I, and domestic) by other water users in the basin, developing Navajo claims, evaluating surface water and groundwater supplies and availability in the basins, development of a three-dimensional groundwater flow model for the Zuni River Basin, evaluation and application of a unique surface water model (based on PRMS) to estimate surface water diversions - depletions associated with Hopi agricultural systems, development of expert reports, and expert testimony.

Water Supply and Water Rights Due Diligence for Vineyard Acquisition, Aconcagua River Valley, Chile

Confidential Client, California, 2018

For a confidential client, Dr. McCord led a due diligence assessment of the irrigation water supply reliability and sustainability for a 540-hectare vineyard property in the Aconcagua River Valley of Chile; currently only 105 hectares are being cultivated (1 hectare = 2.47 acres). The assessment included an evaluation of existing water rights (both surface water and groundwater) held by the farm, the historical yield of the surface rights, hydrogeologic analyses to identify preferred areas to install wells and thus perfect existing groundwater rights, and evaluation of various approaches (including groundwater banking) to increase the sustainability of the farm water supply.

GSP Groundwater Model Development, Santa Ynez River Basin Eastern Management Area

San Antonio Creek Basin Groundwater Sustainability Agency, Los Alamos, California, 2020 - current

Working under subcontract to GSI Water Solutions (GSI), Dr. McCord supported development of an annual and monthly timestep water budget tool, utilizing best available historical data and DWR requirements related to GSP development. He led the effort in bringing in gridded hydrologic data (recharge, ETo, ETa, and runoff) from the USGS Basin Characterization Model (BCM), adjusting the gridded data to honor local weather station monthly precipitation, and filtering and processing the data to develop future climate series that met SGMA requirements and incorporated climate change factors per DWR.

Groundwater Sustainability Plan Groundwater Model Development, Tulare Lake Subbasin, San Joaquin Valley

Tulare Lake Subbasin Groundwater Sustainability Agency, San Joaquin Valley, California, 2016 - 2020

Supported the development of the 3D groundwater flow model that will be used as the quantitative basis for development of a Groundwater Sustainability Plan (GSP) for the Tulare Lake subbasin in Kings County, California. The GSP for the Tulare Lake subbasin must be completed and delivered to DWR by 2020 per the requirements of the Sustainable Groundwater Management Act (SGMA). The preliminary model was delivered in March 2018, and the updated GSP model was delivered in December 2019.

Groundwater Hydrology Expert, Surface Water – Groundwater Interactions Along South Platte River

City of Boulder, South Platte Basin, Colorado, 2005-2011

Retained by the City of Boulder, CO as groundwater hydrology expert, Dr. McCord evaluated and critiqued numerous water supply augmentation plans submitted by alluvial aquifer water users / irrigators in the Lower South Platte River, Colorado. The evaluations focused on assessing the quantity and timing of depletions to South Platte flows caused by groundwater pumping. Most of the cases involved development and application of site-specific 3D numerical models of groundwater flow, and preparation of expert reports, as well as depositions and testimony in Colorado Water Court.

Hydrologic Impacts of Water Rights Acquisitions and Transfers, Middle Rio Grande Basin, New Mexico

Middle Rio Grande ESA Collaborative Program, NM ISC, 2004 - 2005

The Water Acquisition and Management Subcommittee (WAMS) of the Middle Rio Grande Endangered Species Act Collaborative Program made preliminary estimates of the volume of water required to meet the flow targets of the 2003 Biological Opinion regarding the silvery minnow. This study addresses how a water rights acquisition program in the Middle Rio Grande Basin might work, how water rights transfers might be affected, recommended terms and conditions for to be placed on transfers to avoid increased depletions in the basin, and the likely magnitude of the acquisitions.

Hydrogeology, Hydrochemistry, and Groundwater Transport Studies, Wadi Ibrahim, Saudi Arabia

Saudi Geological Survey, Mecca Valley, Saudi Arabia 2010 - 2012

On contract to the Saudi Geological Survey, Dr. McCord served as project manager and principal hydrogeologist for a study of Wadi Ibrahim hydrogeochemistry and isotope hydrology Study. Specific tasks included evaluation of aquifer hydrochemistry and geochemistry include isotope chemistry, recharge sources and rates, hydraulic properties, flow path characterization, and design and execution of single- and multi-well tracer tests for aquifer transport characteristics.

Hydrology and Water Resources of Lower Pecos River Basin, New Mexico

New Mexico Interstate Stream Commission, 2000- 2008

Served as Project Manager and lead hydrologist for several New Mexico Interstate Stream Commission (ISC) studies related to water management issues on the lower Pecos River. Tasks included: Representing ISC on the NEPA team Hydrology Work Group for developing an EIS for re-operations of Pecos River projects; develop and apply linked surface water – groundwater hydrologic model to support adjudication settlement discussions for the lower Pecos River; analysis of seepage losses from Carlsbad Irrigation District main canal; disaggregated unidentified losses from Brantley Reservoir into three components: seepage/bank storage, submerged spring inflow, and ungaged tributary inflows.

Impacts of Coalbed Methane Development on Connected Groundwater Systems, Southern Colorado

Public Counsel of the Rockies, Huerfano and Archuleta Counties, Colorado, 2008-2011

Assessed impairment to existing water rights due to Coal-bed Methane (CBM) development in northern San Juan Basin, La Plata and Archuleta counties, and northern Raton Basin, Huerfano County, Colorado. Performed hydrogeologic evaluations and submitted expert witness documents (including affidavits in Colorado District Court, Water Division 7 and Colorado Supreme Court, Vance vs Wolfe, SEO). Included in project tasks was development of a groundwater flow model for the northern Raton Basin in Colorado and critical evaluation of groundwater models developed by energy production companies in San Juan Basin in southwest Colorado. Provided testimony in hearing before Colorado State Engineer on potential impacts of CBM development on connected surface water rights.

Isleta Pueblo Water Resources and Hydrology Expert, New Mexico

Isleta Pueblo, New Mexico, 2007 - 2011

Dr. McCord served as hydrology expert for the Pueblo of Isleta (New Mexico) addressed a variety of technical tasks including surface water and groundwater interactions in support of Rio Grande riverine habitat restoration, and evaluation of injury to Pueblo water rights due to ag to municipal transfers.

Stream – Aquifer Interactions along San Acacia – San Marcial Reach of the Middle Rio Grande

US Bureau of Reclamation, Socorro County, New Mexico, 2000-2001

Project Manager for study funded by US Bureau of Reclamation looking at surface water – groundwater interaction along the San Acacia to San Marcial Reach of Rio Grande, New Mexico. Utilizing a variety of historical data collected as early as the 1960s, Dr. McCord's analysis supported refinement of the hydrogeologic conceptual model for the reach, identified losing and gaining sub-reaches, and quantified the gains and losses (and their variability). This understanding is critical for evaluating management alternatives for this reach of the Rio Grande.

Mining Projects

Analysis of Seepage, Las Bambas Mine Waste Rock Facilities, Apurimac, Peru

Working with DHI under contract to Mining & Minerals Group (MMG), Dr. McCord is leading the effort in detailed seepage analysis. Tasks undertaken in this effort include review and compilation of waste rock materials properties, climate data analysis, and development and application of a numerical model of long-term seepage (including matrix and macropore flow) for the waste rock facility. Dr. McCord's waste rock facility seepage analyses modeling results will be used as input for the regional groundwater flow model developed in FEFLOW.

Peer Review of Hydrogeologic Flow Model, Vega Sapunta, Pampa Puno Mine, Chile

Under contract to CODELCO and working with Ausenco hydrogeologists, Dr. McCord served as senior consultant and reviewer of detailed 3D regional hydrogeologic flow model (developed in MODFLOW-USG) of the Cerro Leon and Quebrada Yocas basins that converge and feed the Vega Sapunta wetlands, a protected ecological zone. The model had been developed specific ally to evaluate impacts of well fields located upgradient of the wetlands that supply water for the Pampa Puno mine.

Analysis of Seepage, Zafranal Waste Rock and Tailings Management Facilities, Arequipa, Peru

Under contract to Teck, Dr. McCord led the effort in detailed seepage analysis. Tasks undertaken in this effort included development of a TMF conceptual model for seepage development, and development and application of a numerical model of draindown seepage from the TMF and another for long-term seepage (including matrix and macropore flow) for the waste rock facility. Dr. McCord's TMF and Waste Rock Dump modeling results were used as input for the regional model developed in FEFLOW.

Analysis of Waste Rock Seepage, Antapaccay – Tintaya Mines, Cusco, Peru

Under contract to DHI, Dr. McCord led the effort in detailed seepage analysis. Tasks undertaken in this effort included development and application of a hybrid analytical - numerical model for long-term seepage (including matrix and macropore flow) for the waste rock facility and working closely with regional modeling team (FEFLOW) to ensure consistency between the two modeling efforts.

Analysis of Seepage, Antamina Waste Rock Dump, Ancash, Peru

Working with GeoSystems Analysis scientists under contract to Antamina, Dr. McCord led the effort in detailed seepage analysis for the East Waste Rock Dump. The effort included compilation and integration of more than a decade's worth of monitoring and experimental data generated by the client since 2009, and synthesized the data to support development and application of a transient water balance model for the waste rock facility. The results of this model will be used to support mine closure engineering and water management.

Analysis of Seepage, Candelaria Mine, Chile

For an EIA in support of expansion of the Candelaria project, Dr. McCord performed detailed seepage analysis, which included development and application of a numerical model for long-term seepage for the waste rock facility. For the tailings management facility, Dr. McCord supported the FEFLOW team in the development and application of post-operations draindown modeling embedded within the regional model.

Analysis of Seepage, Drystack Tailings Facility, Rosemont Mine, Arizona

In support of mine planning for the planned Hudbay drystack tailings facility (DTF) at the Rosemont Mine in Arizona, Dr. McCord played a senior consultant role in the development of a hydrologic conceptual model for seepage development in the DTF, design and execution of a laboratory characterization program for the drystack tailing materials, analysis of geotechnical and soil-physical properties from the laboratory test results, and development and application of a numerical model of seepage and subsurface flow, with the objective to project long-term seepage rates from the facility.

Lagunas Norte Project (Barrick Gold), Water Resources Lead for Modification to EIA, Peru

Under contract to Barrick Gold, Dr. McCord led the water resources effort for the EIA study for the Lagunas Norte project expansion, and supported the mine operations team by evaluating the ability of the pit dewatering activity to provide the supply required for the mine expansion. For the water resource activity, particular tasks performed by AMEC included: compilation of historical hydrology and hydrogeology data, and development of a GoldSim water balance and water quality model, and a three-dimensional numerical model of groundwater flow for the mine area.

Stage 2 Investigation and Contaminated Groundwater Abatement Plan, Tyrone Mine, New Mexico, USA

Under contract to Freeport McMoran Tyrone mine, Dr. McCord served as a senior consultant on a Stage 2 investigation and detailed design for perched groundwater in Oak Grove Wash / Brick Kiln Gulch (OGW/BKG), which has been contaminated by acid drainage associated with the mine operations. As part of implementing these measures, site investigation and conceptual design activities in OGW/BKG had previously been completed, and the objective of this project was to conduct site investigation services to support design and construction of a keyed-in, low-permeability barrier and alluvial (perched) groundwater collection system to collect impacted water which flows to and through OGW/BKG and will accumulate up-gradient of the proposed low-permeability barrier. Data from this site investigation is beinge used to design the Stage 2 abatement measures for perched groundwater in OGW/BKG.

Fruta del Norte Project Water Resources Coordinator for Feasibility Study, Ecuador

Under contract to Lundin Gold, Dr. McCord supported the feasibility study for this gold mine, in the “ceja de selva” (edge of the jungle) in southeast Ecuador. For this project, he led the water resource studies for the project, coordinating activities among AMEC staff and subcontractors who performed the hydrogeologic and surface hydrology characterization and modeling efforts, and played a key role in development of mine water management strategies.

Pampa de Pongo Project Water Resources Lead for EIA, Peru

Under contract to Jinzhao Mining Company, AMEC performed the EIA study for the Pampa de Pongo Project, located near the coast in the Department of Arequipa in southern Peru. For this project, Dr. McCord led the water resource studies for the project, and supported the geotechnical analysis of the of pit wall stability for the feasibility study. For the water resource activity, particular tasks performed by AMEC included hydrology and hydrogeology field characterization, core drilling, and borehole hydraulic testing; site surface hydrology, meteorology, and project area water balance; and estimation of open pit water inflows using analytical and numerical models.

Analysis of Seepage, San Nicolas Waste Rock and Tailings Management Facilities, Zacatecas, Mexico

Under contract to Teck, Dr. McCord led the effort in detailed seepage analysis, which included development and application of a numerical model of draindown seepage from the TMF and another for long-term seepage (including matrix and macropore flow) for the waste rock facility. The results of these models were used as part of the upper boundary condition for the regional flow model developed in FEFLOW.

Studies and Engineering, Sustainable Management of Tailings, Minera Doña Inés de Collahuasi, Chile

Provided services in disciplines of hydrogeology and acid drainage. Preparation Analysis of Relevance and PAS 135, 137 and 155. Oversight Activities of soil sampling, QA/QC control of soil analysis, and acid mine drainage determination, updated hydrogeologic conceptual and numerical model of seepage and contaminant transport.

Analysis of Seepage and Acid Drainage, Quillayes –El Chinche Tailings Facility, Los Pelambres Mine

In support of closure planning for this tailings facility, AMEC is performing a detailed hydrogeological study, tasks have include sampling activities of tailings and water, QA/QC control of analysis of tailings and water samples, water quality assessment and geochemical modeling of water quality, installation of piezoemters, development of a hydrogeological conceptual model, and development and application of a numerical model of seepage, subsurface flow, and contaminant transport.

Antamina Mine Project Regional Hydrogeologic Integration and Hydrogeologic Geodatabase

Under contract to Antamina, Dr. McCord served as project manager for AMEC team charged with integrating all hydrogeologic data collected since site inception into an ArcGIS geodatabase, and compiling a hydrogeologic integration report, as well as developing three- and four-dimensional data visualizations. The hydrogeologic integration report involved summarizing all past work, with a particular focus on site studies undertaken since 2008, identifying important data gaps, and developing a site-wide integrated hydrogeologic conceptual model that could be used to provide a framework for interpreting existing and newly acquired site data.

La Granja Project Water Resources Lead for Prefeasibility Study, Peru

Under contract to Rio Tinto Mining Company, AMEC performed the prefeasibility study for the”starter case” for the La Granja Mine Project, located in the Department of Cajamarca in northern Peru. For this project, Dr. McCord led the water resource studies for the project, and supported the analysis of the heapleach planning task. For the water resource task, Dr. McCord coordinated activities among AMEC staff and subcontractors who performed the hydrogeologic and surface hydrology characterization and modeling efforts, and played a key role in development of mine water management strategies.

Carmen de Andacollo Project – Hydrogeologic Analyses in Support of Tailings Facility Expansion, Chile

On contract to Compania Minera TECK, AMEC is providing hydrogeological characterization and analyses in support of expansion of the mine tailing facilities. As part of this effort Dr. McCord is providing senior review and consulting to the AMEC E&I team in Santiago involved in data analysis, field characterization, and hydrogeological modeling.

Mina Huaron and Mina Morococha, Water Resources Management and Compliance with LMP and ECA Water Quality Standards

Under contract to Pan American Silver Corporation, AMEC led efforts to characterize mining project water management and discharges to evaluate current conditions and develop water management and treatment plans to ensure compliance with the new Peruvian LMP (Limitacion Maximum Permisible, basically end-of-pipe discharge) and ECA (Estandard de Calidad Ambiental, basically river standards at locations downstream from end-of-pipe discharges) for the Huaron and Morococha mines in the Peruvian Andes. Dr. McCord led the water management team, involved in analysis of existing data and development of water management models for evaluation of alternatives to ensure compliance with new standards. Treatment alternatives considered included standard mine water treatment plants, innovative water recycling and management schemes, and constructed wetlands and permeable reactive barriers.

Ollachea Mine Project Hydrology and Hydrogeology for Prefeasibility and Feasibility Studies, Peru

Under contract to IRL / Compania Minera Kuri Kullu, Dr. McCord performed project management, model development, and senior review tasks for the hydrology and hydrogeology activities for the project pre-feasibility study. Particular tasks performed by AMEC hydrology and hydrogeology team included: field characterization, core drilling, and borehole hydraulic testing; site surface hydrology, meteorology, and project area water balance; and estimation of underground mine tunnel inflows using analytical and numerical models (MODFLOW-USG).

Hydrogeological Modeling of the Limestone Quarries, Toromocho Project, Peru

As part of mine development studies for Minera Chinalco Perú S.A., AMEC constructed a groundwater flow model to evaluate likely timing that seepage from the tailings facility would begin flowing into the limestone quarry. Dr McCord served a project manager of this effort which involved staff from US and Peru office. The project was performed on a very accelerated schedule to address concerns that arose during the facility permitting process, and utilized the limited available data from the quarry area to generate a numerical model suitable for addressing questions raised by government regulators.

Quechua Mine Water Balance, Peru

For Compañía Minera Quechua performed senior review for the development of a comprehensive water balance of the Proyecto Minero Quechua mine during the operating phase. Water balances for the construction and closure phases are currently under development.

Tyrone Mine Pit Lake Model for Closure Plan, New Mexico

Senior reviewer for hydrogeology team in development of pit lake model to address a variety of issues, including estimating the post-closure recovery period of water levels in the mine pits and surrounding aquifers, and project the post-closure steady-state pit lake(s) surface elevation(s), examining the potential for pit lake outflows, and evaluating the potential interactions of pit lake(s) with other mine facilities, hydrologic features, and geologic structures.

Radionuclide Transport Modeling, Uranium Milling Facility, Western US

Groundwater expert responsible for the development and application of flow and transport models to evaluate historical radionuclide concentrations in groundwater. The results of our analysis were used for exposure assessments for off-site individuals via the drinking water and foodchain pathways as part of a toxic tort suit.

Corani Mine, Water Resources Lead for EIA, Peru

Under contract to Bear Creek Mining Company, Dr. McCord performed project management, oversaw model development, and senior review tasks for the hydrology and hydrogeology, and water resource management tasks for the project EIA study. Utilizing existing data supplemented by AMEC-collected data on site hydrology, hydrogeologic measurements and mapping, and water quality sampling team, developed linked surface water and regional groundwater models, and project area water balance to provide EIA impact analysis for water resources.

Unsaturated Flow and Transport Analysis of Heap Leach Operations

Developed a conceptual model for heterogeneous distribution of hydraulic properties within a heapleach pad for the Tyrone Mine in southwest New Mexico. Based on the conceptual model, constructed and applied a variability saturated flow and transport model to evaluate the potential for channeling and flow bypass at various surface application rates, and leaching efficiency as a function of application rates.

Environmental Contamination / Remediation Projects

Tuba City Landfill Contamination Site, Tuba City, Arizona

Under contract to the US Bureau of Indian affairs, Dr. McCord served as senior reviewer and consultant for the Tuba City Landfill Remediation Feasibility Study, AZ to develop groundwater flow and transport models to evaluate sources of uranium contamination and potential remediation alternatives.

CSX Railroad, Papa John's Stadium Contamination Plume Remediation, Louisville, Kentucky

Senior reviewer and consultant for development of models to estimate the total, mobile, and recoverable volumes and natural source zone depletion of a 20+ acre LNAPL plume in Louisville, KY. MODFLOW-SURFACT was employed to simulate reactive transport in an active water phase (both saturated and unsaturated flow) with interaction and interphase transfer with a static separate LNAPL phase. Developed remedial strategies to pinpoint locations of the project site amenable to recovery; as well as to define the areas of the site where recovery is technically impractical with use of more innovative enhanced bioremediation approaches to effective management of the LNAPL plume.

Williams Air Force Base LNAPL Plume Remediation, Arizona

Senior reviewer and consultant for development of models to estimate the natural and enhanced bioremediation depletion of a jet fuel and aviation gas release at Williams Air Force Base, AZ. The water table at this site has risen some 90 feet creating an uncharacteristically deep LNAPL residual in the site aquifers. MODFLOW-SURFACT was used to predict the fate of residual LNAPL and dissolved phase contamination following aggressive, steam-flushing recovery operations at the site.

Redlands Toxic Tort Litigation, California,

Served as methodology expert in evaluation of contaminant transport through the vadose zone. Contaminants included organic solvents disposed of from industrial and manufacturing facilities.

Rocky Mountain Arsenal, Natural Resources Damage Claim by State of Colorado

As the groundwater expert to the Colorado Office of Attorney General, Dr. McCord worked with interdisciplinary team to assess and quantify injury to groundwater resources and water supply impairment due to historical site operations at the Rocky Mountain Arsenal, CO, as part of a Natural Resources Damage Claim by the state. Tasks involved review and analysis of historical site data, as well as development and application of a regional groundwater flow model.

Spartan Site, DNAPL Contamination Plume, Albuquerque West Mesa, New Mexico

Project Manager and groundwater expert on a case which involved subsurface contamination by DNAPL at an industrial site on Albuquerque's west mesa, NM. Evaluated observed contaminant plumes (water and gas phases) for current and historical conditions in both the vadose and saturated zones. Considered impacts of municipal well pumping and a nearby irrigation ditch system on the dynamics of the fate and transport processes. Prepared expert report and was involved in technical aspects of the settlement negotiations.

Site Wide Hydrogeological Characterization Project, Sandia National Laboratories, New Mexico

Project Manager for Sandia National Laboratory (SNL) Site Wide Hydrogeologic Characterization Project. Development and testing of surface and subsurface hydrologic conceptual models for environmental restoration sites at the 200 square mile SNL region. Annual reports, regional groundwater characterization and monitoring wells, definition and characterization of representative vadose zone settings across the region, and characterization and monitoring of the site-wide surface water system.

Evaluation of Greater Confinement Disposal of Radioactive Water, Dept of Energy, Nevada

Development and application of vadose zone hydrologic models to project radionuclide migration rates associated with disposal of low-level and "orphan waste" to be disposed of in the Greater Confinement Disposal Test located on the Nevada Test Site in southern Nevada.

International Paper Groundwater Contamination Insurance Recovery

Project Manager and groundwater expert in major insurance recovery case involving five separate wood treating plant facilities across the country (LA. TX, MO, CA and WA). Development of contaminant histories based on plant records (going back to the early 20th century), site specific data and contaminant fate and transport modeling.

Waste Isolation Pilot Plant, Southeast New Mexico

Supported the development of a regional MODFLOW model used to define groundwater in the vicinity of the Waste Isolation Pilot Plant (WIPP), NM site, and application of the SECO performance assessment model to evaluate potential radionuclide releases over a 10,000-year performance period. Provided written and oral rationales for groundwater transport parameters to EPA and National Academy of Science technical review panels, and developed QA records for the WIPP license application.

Expert Witness

- 2019, General Adjudication of All Rights to Use Water in the Little Colorado River System, Civil Case No. 6417-203, Apache County Superior Court, The State Of Arizona. *Trial testimony* on behalf of the Navajo Nation, as expert in trial Phase II, Hopi Water Claims, focus on historical water resource availability, surface water modeling, and water use and depletion for agricultural and irrigation purposes. Phase II court ruling in 2019 favorable to Navajo
- 2018, General Adjudication of All Rights to Use Water in the Little Colorado River System, Civil Case No. 6417-203, Apache County Superior Court, The State Of Arizona. Filing of expert report and subsequent *deposition testimony* on contract to the Navajo Nation Department of Justice. Court-accepted expert in historical water resource availability, surface water model and water depletion analysis, and water use for agricultural irrigation purposes.
- 2012, Steadfast Insurance Company et al. vs. Terracon, Inc., et al., Colorado. Retained as plaintiffs groundwater hydrology expert, Dr. McCord served on a multidisciplinary team of hydrologists, geologists, and civil and geotechnical engineers for a large construction defects insurance recovery case. Contributed expert reports, technical exhibits to support mediation efforts, and *deposition testimony*. Case settled in August 2012 (Client: Zurich Insurance).
- 2009, Colorado State Engineer, CBM Produced Water Nontributary Rulemaking Hearing, Groundwater expert for Public Counsel of the Rockies, *testified at SEO rule-making hearing* on technical review of northern San Juan Basin groundwater model produced by CBM industry consultants (Client: Public Counsel of the Rockies).
- 2009, Isleta Pueblo vs Santa Fe Water Resource Alliance, NEW MEXICO Office of the State Engineer File No. SD-04729 & RG-74141 into SP-4842, Hearing No. 07-059. Expert reports filed and hearing testimony related to hydrologic impact of surface water transfers that moved point of diversion (and depletion) along the Rio Grande from south of Isleta Pueblo to north of Isleta Pueblo, cases settle (Client: Pueblo of Isleta).
- 2007, Vance et al vs Wolfe (Colorado State Engineer) et al. Colorado Water Court Division 7, Case No. 05CW63. Plaintiffs' hydrology expert in case to determine jurisdiction of Colorado State Engineer to adopt permitting requirements for coalbed methane wells that may be impacting plaintiffs' decreed water rights. Plaintiffs prevailed in Water Court, and case was appealed to the Colorado Supreme Court, which in 2009 affirmed the lower court ruling (see http://www.westernwaterlaw.com/articles/Vance_v_Wolfe.html).
- 2007, Sierra Club and Mineral Policy Center vs. El Paso Gold Mine, Civil Action 01-PC-2163, Federal District Court of Colorado. *Trial testimony* as groundwater flow and transport methodology expert. (Client: John Barth, Attorney-at-Law)
- 2006, Low Line Ditch Well Users, An Application For Water Rights And Approval Of Plan For Augmentation, Colorado District Court, Water Division No. 1 Case NO. 2003CW094. *Deposition testimon*y in October 2006 on impacts of groundwater pumping aspects of water rights application on senior water rights holder, case settled. (client: City of Boulder, CO; Moses, Wittemyer, Harrison, and Woodruff, P.C.)
- 2006, Dinsdale Brothers, Inc Well Users, An Application For Water Rights And Approval Of Plan For Augmentation, Colorado District Court Case Nos. 2001CW061 and 2003CW194:, Water Division No. 1. Deposition testimony in

September 2006 on impacts of groundwater pumping aspects of water rights application on senior water rights holder, case settled. (client: City of Boulder, CO; Moses, Wittemyer, Harrison, and Woodruff, P.C.)

- 2006, Allen et al. vs. Aerojet General et al., Superior Court of the State of California, County of Sacramento, Consolidated Case No. RCV 31496. *Jury trial testimony* in March 2006 regarding the evaluation of historical groundwater contamination at Aerojet Rancho Cordova Plant. Case Phase I (defendant negligence) ruled in client favor, Phase 2 (damages) settled for undisclosed sum (client: Engstrom, Lipscomb & Lack)
- 2006, Well Augmentation Subdistrict of Central Colorado Water Conservancy District, Water Rights Application and Augmentation Plan, Colorado District Court, Water Division No. 1. Deposition testimony in March 2006 on impacts of groundwater pumping aspects of water rights application on senior water rights holder, case settled. (client: City of Boulder, CO; Moses, Wittemyer, Harrison, and Woodruff, P.C.)

Reports & Publications

Textbooks

Selker, J.S., C.K. Keller, and J.T. McCord, 1999. Vadose Zone Processes, Lewis / CRC Press, Boca Raton, FLA, 339 pp.

McCord, J.T., and J.S. Selker, 2003. Transport Phenomena and Vulnerability of the Unsaturated Zone, in Encyclopedia of Life Support Systems, UNESCO, www.eolss.net.

Refereed Journal Articles

McCord, J.T., C.A. Gotway, and S.H. Conrad. 1997. Impact of geological heterogeneities on recharge estimation using environmental tracers. Water Resources Research, 33(6):1229-1240.

Goodrich, M.T. and J.T. McCord. 1995. Quantification of uncertainty in exposure assessments of hazardous waste sites. Ground Water, 33(5):727-732.

Eaton, R.R. and J.T. McCord. 1995. Monte Carlo stochastic analysis of effective conductivities for unsaturated flow. Transport in Porous Media, 18(3).

McCord, J.T. 1991. On the application of second-type boundaries in modeling unsaturated flow. Water Resources Research, 27(12):3257-3260.

McCord, J.T., J.L. Wilson, and D.B. Stephens. 1991. The importance of hysteresis and state-dependent anisotropy in modeling flow through variably saturated soils. Water Resources Research, 27(7):1501-1518.

McCord, J.T., D.B. Stephens, and J.L. Wilson. 1991. Toward validating macroscopic state-dependent anisotropy in unsaturated soils: Field experiments and modeling considerations. Journal of Contaminant Hydrology, 7:145-175.

McCord, J.T. and D.B. Stephens. 1988. Comment on `Effective and relative permeabilities of anisotropic porous media' by Jacob Bear, Carol Braester, and Pascal Menier. Transport in Porous Media, 3:207-210.

McCord, J.T. and D.B. Stephens. 1987. Comment on `Effect of ground-water recharge on configuration of the water table beneath sand dunes and on seepage in lakes in the Sandhills of Nebraska, USA' by Thomas C. Winter. Journal of Hydrology, 95:365-367.

McCord, J.T. and D.B. Stephens. 1987. Lateral moisture flow beneath a sandy hillslope without an apparent impeding layer. Hydrological Processes, 1(3):225-238.

Conference and Symposia Proceedings

McCord, J.T., S. Sigstedt, S. Gangopadhyay, and R. Uribe, 2018. Stream Depletion Factors, Unit Response Functions, and streambed properties for modeling lagged river depletions due to well pumping, Western Groundwater Summit, Groundwater Resources Association of California, September 2018.

McCord, J.T., and S. Gangopadhyay, 2016. Stochastic numerical analysis of up-scaled aquifer and streambed properties for modeling lagged river depletions due to well pumping, Geological Society of America Annual Meeting, 25-28 Sept 2016, Denver, CO.

McCord, J.T., D.B. Stephens, and T.C. Jim Yeh, 2016. Moisture dependent anisotropy in unsaturated flow: theory and application, Geological Society of America Annual Meeting, 25-28 Sept 2016, Denver, CO.

McCord, J.T., J.A. Clark, N. Starr, R. McGregor, and N. Mandic, 2010. Applied Telescopic Mesh Refinement in Groundwater Modeling: Three Case Studies, NGWA National Groundwater Modeling Summit, Denver, CO, April 11-15.

Gangopadhyay, S., J.T. McCord, and S. Musleh, 2007. A Combined Stochastic-Deterministic Approach to Estimating Effective Streambed and Aquifer Properties and Lagged River Depletions due to Alluvial Well Pumping, Symposium on River, Floodplain, and Terrace Hydrology, New Mexico State University, Las Cruces, NM, Feb 28 – Mar 1, 2007.

Carron, J.C., J.T. McCord, A. Elhassan, P. Barroll, T. Stockton, and M. Rocha, 2006. Pecos River Decision Support System: Tools for Managing Conjunctive Use of Surface and Groundwater Resources, US Committee on Irrigation and Drainage Water Management Conference, October 25-28, Boise, Idaho.

Hall, L.M., J.T. McCord, and J.L. Smith, 2006. Pumping Tests Designed for Investigating Surface Water – Groundwater Interactions Along the Lower South Platte River, Northeast Colorado, NM Water Research Symposium, New Mexico Water Resources Research Institute, August 15, 2006.

Dr. McCord has more than 75 additional conference presentations and publications on a range of water resource topics dating back to 1985, and a list of those can be provided upon request.

Prepared for: Rutan and Tucker, LLP, Counsel for Casitas Municipal Water District

Rebuttal Expert Report on the City of San Buenaventura Modeling Experts:

1. Expert Report of Claire Archer, PhD, 23 August 2021

07 January 2021

Prepared by:

One-Water Hydrologic, LLC, San Diego, California

Lynker-Intel LLC, Boulder, Colorado and **GSI Water Solutions Inc.**, Santa Barbara, California

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Abbreviations and Acronyms

AF	acre-feet
AFY	acre-feet per year
cfs	cubic feet per second
CMWD	Casitas Municipal Water District
DWR	California Department of Water Resources
ET	Evapotranspiration
GHB	General-Head Boundary Package
GSI	GSI Water Solutions, Inc.
GW-SW	Groundwater-Surface Water
IHM	Integrated Hydrologic Model
HFB	Horizontal flow barrier
MNW2	Multi-aquifer (Well Package)
MODFLOW-OWHM1	One-Water Hydrologic Flow Model version 1 of Modflow-2005
PRMS	Precipitation-Runoff Modeling System
SFR2	Streamflow Routing (Package version 2)
VRW	Ventura River Watershed
WY	Water Year

SECTION 1: INTRODUCTION

At the request of Rutan and Tucker LLP and Casitas Municipal Water District ("Casitas" or "CMWD"), a team of water resources/hydrogeology experts[1] assembled by GSI Water Solutions, Inc. (GSI), has been closely tracking the development and application of the three-dimensional (3D) integrated hydrologic models (IHM) for the Ventura River watershed. The additional Ventura River Watershed Groundwater-Surface Water Model (VRW OWHM-PRMS Model) was developed under the auspices of the for the City of San Buenaventura by Cardno in support of their adjudication of the Ventura River watershed.

1.1 Overview

The expert hydrogeologic modeling team reviewing the development and application of the VRW-SW-GW model is comprised of specialists from One-Water Hydrologic LLC, Lynker-Intel LLC, and GSI. As part of this model review process, the Casitas expert team has:

- Reviewed this new and additional IHM and compared it with the SWRCB model, as well as selected data and conceptual features

This report is being submitted as a Rebuttal to the original expert report submitted by the City of San Buena Ventura for the water adjudication, specifically Claire Archer's original expert report submitted on August 31 2021.. This rebuttal report addresses the following aspects of the Archer opinion reports:

- Uncertainties in data, models, and concepts
- Error Analysis (groundwater levels, streamflows,)
- Omissions and misrepresentations, raising counter examples or more relevant examples

It is our opinion that the treatment, or lack thereof, of these issues ultimately undermines some of their conclusions and related opinions presented by Archer for the City of San Buenaventura. While we did not suggest alternate ways of model analysis, or alternate ways to provide a more credible model, some of these issues will be addressed in our summary.

1.2 Report Structure

Following this introduction, Section 2 presents a summary of our expert rebuttal opinions. The basis for development of our rebuttal opinions are presented in Section 5 with the review of the model. Section 6 provides selected issues with expert opinion document from Dr. Archer which focuses on model development, calibration and application and all related examples used to support opinions of Dr. Archer (Cardno, 2021b).

[1] The CVs for the team of experts involved in the preparation are included in the exhibits.

SECTION 2: SUMMARY OF OPINIONS

Based on the detailed review effort as introduced above, the Casitas hydrogeologic modeling expert team has developed the following overarching opinion:

- The Cardno Ventura River Basin Integrated Watershed model has a number of outstanding issues and uncertainties that render the current model unsuitable for use in quantification of surface water – groundwater interactions, which renders the opinions of Dr. Archer in her report of August 31, 2021 uncertain and of questionable validity.

This overarching opinion is supported via observations from our current review and related results and conclusions drawn by Cardno (2021b), specifically:

1. Based on selected hydrologic properties and flow features, this 1-layer model appears to be “too leaky.” Thus the model appears to overestimate the effect of groundwater pumpage on the exchange between surface-water and groundwater flow systems.
2. The apparent overestimation of stream leakage may be related to potentially unrealistic streambed attributes used to drive groundwater-surface-water interactions; The consequence of this is that the model cannot reliably estimate low-flow conditions and may also overestimate infiltration of surface water as groundwater recharge at larger flow conditions.
3. The model does not include the two reservoirs simulated as lakes or off-grid reservoir operations nor related reservoir deliveries as water supply except for simulation of “external water” for irrigation, and these estimates of external water delivered from the Ventura River may be substantially overestimated. The consequence of this is that conjunctive use and surface-water deliveries are not reliably represented and are not predictive of impacts on downstream surface water resources.
4. This model does not employ HFB (Horizontal Flow Boundary) package nor any other special treatment for simulating any other geological structures except for the Foster Park subsurface dam. This omission may undermine Dr. Archer‘s assertion that there is large scale surface-water-groundwater connectivity.

Additionally, rebuttals to specific opinions provided in Dr. Archer’s rebuttal report (Cardno, 2021b) are included in Section 5 of this rebuttal report.

SECTION 3: Review of Model Development Plan

Ordinarily model development would include a plan for developing a conceptual model and related tools and data that will be used to develop a numerical model to assist with the analysis of the use and movement of water that includes climate, groundwater, surface-water, and the landscape. To the best of our knowledge, this document and process never occurred for this model as it did for the California State Water Resource Control Board (SWRCB) model development. In addition to the best of our knowledge, there was never the creation of a Technical Advisory Committee (TAC) of experts to provide input and oversight during model development or any webinars reviewing the development or results of the models or any training on how to use or maintain this model.

Finally, there were significant constraints established through the court stipulation on how the information that was shared could be used or distributed. This made it difficult to assess the information that was provided. Finally, there were selected items that we didn't receive, including the PRMS model and any input that was used to develop this model outside of selected spreadsheets for input attributes for both models, the MF-OWHM1 code, and any tools used to develop the input or for analysis for the model results.

SECTION 4: Acquisition, Review, and Testing of Archer Model Files

As noted previously, the layout of this section exactly follows the presentation of the four subregions of the Ventura Watershed model development, and related field and model hydrologic analysis and conclusions as presented by Dr. Archer in Cardno (2021b). This structure facilitates presentation of our findings in the context of countering certain statements, arguments, and findings of Archer.

As noted in the introduction, we have identified issues with the existing VRW OWHM-PRMS model (herein referred to as the "Archer Model") development and application that can be grouped into three categories: (i) Uncertainties or potential errors in models and concepts, (ii) Model Error Analysis (groundwater levels, streamflows), and (iii) Omissions of important data and/or information and in some cases misinterpretations, of cited work of others. In our critique that follows, we grouped cited problems into one or more of these categories.

4.1 OWHM-PRMS Model

Four subregions of the Ventura Watershed include: Upper Ventura River Valley Groundwater Basin (UVRGB), Lower Ventura River Groundwater Basin (LVRGB), Ojai Valley Groundwater Basin (OVGB), and Upper Ojai Groundwater Basin (UOGB) (fig. 1). The documentation of the model was provided in Exhibit 45 (Cardno, 2021a). The PRMS precipitation-runoff model provided runoff and mountain-front recharge estimates used as input for the Modflow-OWHM (version1) model (MF-OWHM1). The MF-OWHM1 version used was not included with the shared files, but Mr. Hanson was the lead developer of this version and was able to obtain the copy of that same version from that same date.

The MF-OWHM1 model was built with the aid of the USGS model GUI, by Model Muse Version 4.3.0.35. The model codes used for both models and input and output files were only provided for the MF-OWHM model (no files were provided for the PRMS model). The model was developed using MF-OWHM version 1 (Hanson et al., 2014), but could have used the more recent MF-OWHM version 2 (Boyce et al., 2020) as well as the Basin Characterization Model (BCM) (Flint et al., 2020) rainfall-runoff-recharge model instead of PRMS.

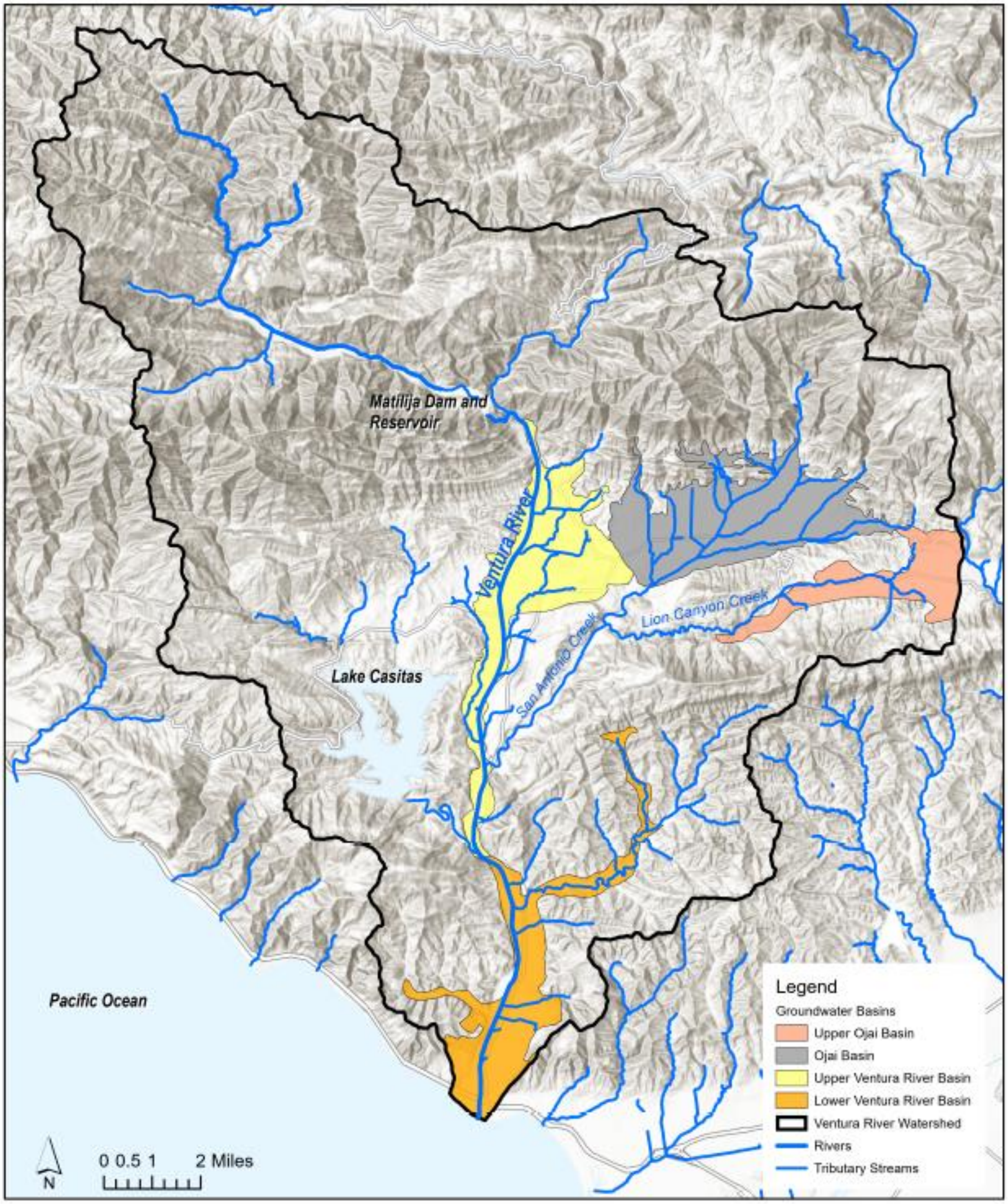


Figure 1. -- Archer Exhibit 1 Watershed Map (Cardno, 2021b).

5.1.1 PRMS Model Description

The PRMS model is described by Cardno (2021a), but the PRMS model was not shared, so no additional analysis was performed with respect to the precipitation-runoff model.

4.1.2 MODFLOW-OWHM Model Description

The MF-OWHM1 model is a one-layer model with a north-south orientation with a uniform width grid of 200 ft by 200 ft with 390 rows and 424 columns. The model simulates 48 monthly stress periods with one monthly time step in each period. The historical calibration period of simulation spans the water years 2003 – 2005 and a validation period of 2011-2013. The Streamflow Routing Network (SFR2) is comprised of 2,618 reaches (cells) grouped into 129 river and tributary segments and one diversion segment (presumably the Robles diversion). The initial conditions for groundwater levels (head) are of an unknown origin and estimation method. The distribution of aquifer and surface-water network attributes remains unknown though the final estimated of selected properties were probably derived from model calibration using 27 groundwater-well observation locations with 560 observations. Streamflow output was generated for 5 locations on the surface-water network. There are 273 Multi-aquifer (MNW2) wells in the model, but this includes seven locations for septic infiltration and an additional withdrawal called "Intake2," with all wells present (though some wells are not pumping in some stress periods) for all the simulation period regardless of drill dates. There are 78 Water-balance subregions (WBS, aka "Farms") with 36 land-use types (aka "crops"), and 53 wells used to simulate agricultural pumpage for irrigation in FMP with 53 irrigation wells supplying all irrigation water. Lake Casitas and Matilija Dam were not included in the model.

The overall hydrologic flow budget of inflows and outflows for the entire model region show that the major inflows to groundwater flow are stream leakage with lesser amounts of inflow from Farm-Net Recharge and storage depletion, and the major outflows are stream leakage with lesser amounts of outflow to storage accretion and pumpage for the historical period (fig. 2A). The hydrologic budget inflows and outflows for the "no pumpage scenario" are very similar to the calibrated model with a 15.7 percent increase in stream leakage as outflows with all but 13 of the MNW2 and the 53 FMP agricultural wells with a constrained pumping capacity (fig. 2B).

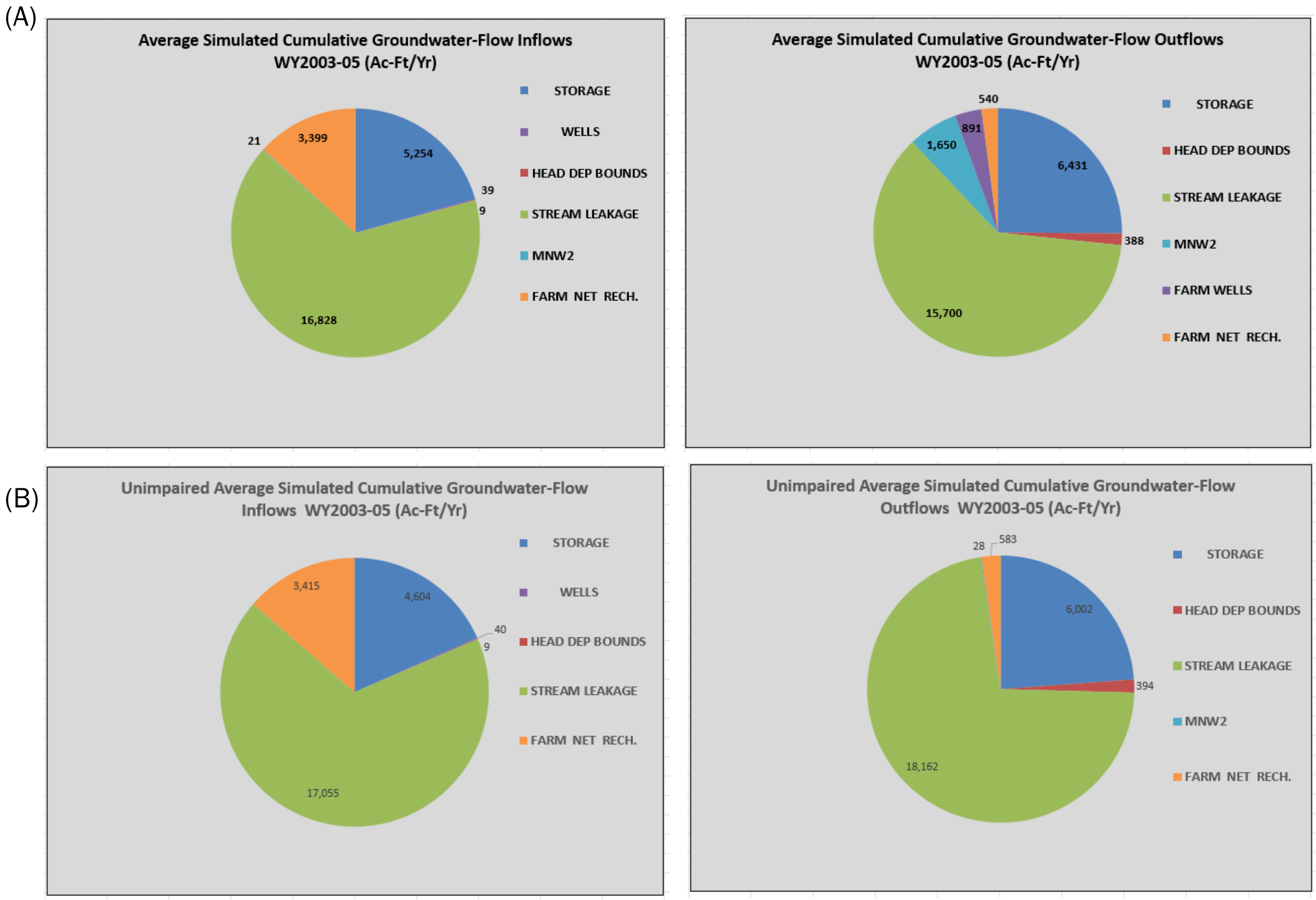


Figure 2. -- Pie charts of the percentages of the cumulative average groundwater inflows and outflows for the MF-OWHM1 model for (A) the historical period, and (B) the historical period with pumpage removed.

4.1.3 Model Calibration and Validation

The MF-OWHM model was calibrated against 560 groundwater-level observations from 27 wells. No validation period was used for the Archer model. Model was also calibrated against several streamflow gages for the Ventura River at Foster Park (USGS 1111850/VCWPD 608), Matilija Creek (VC603A, VC604, VC602B), and San Antonio Creek (VCWPD 605). The model appears to be too leaky with a relatively large uniform streambed conductivity and width-depth relations that facilitate the relatively large proportions of stream inflow and outflow.

The FMP process within MF-OWHM1 was used to simulate the supply-and-demand components of the model and agricultural irrigation as well as use and movement of water across the landscape for both models. Agricultural supply and demand was operated under the “zero scenario” for balancing supply against irrigation demand, where additional water is imported into the model to compensate for the supply deficit relative to demand. This option was used to represent the CMWD surface-water deliveries from Lake Casitas for irrigation. However, this feature also could have been directly specified using the “non-routed delivery” option within FMP to each WBS for each monthly stress period. The use of the “zero scenario” within the Farm Process (FMP3) was used instead of deficit irrigation or nonrouted-deliveries option to replicate potential surface-water deliveries from CMWD (Cardno, 2021a). This external supply of water sustained consumption as evapotranspiration for agricultural irrigation as well as (a) additional to runoff to streamflow and (b) groundwater recharge as deep percolation. The additional external water also replaced the pumpage that was reduced for the farm wells for the “no pumpage scenario” that resulted in sustained consumption, runoff, and deep percolation from irrigation with this external water source (fig. 3). The “external water” represents about an average of 16 cfs of simulated imported water for the historical case and 23 cfs for the “no pumpage scenario” yet the historical reported agricultural delivery from CMWD was about 9 cfs. This external water represents 30 percent of all average monthly inflow onto the landscape for the historical model and this increases to 44 percent for the “no pumpage scenario.” This is about 66 percent more simulated surface-water delivery than the reported deliveries from CMWD for the historical period. This indicates that the model overestimates demand (Total Farm Delivery requirement, TFDR) as well as simulated imported surface-water deliveries (fig. 4). This approach to irrigation supply is not recommended and may be difficult to maintain if the model is used for any other potential applications, such as climate change or sustainability assessments.

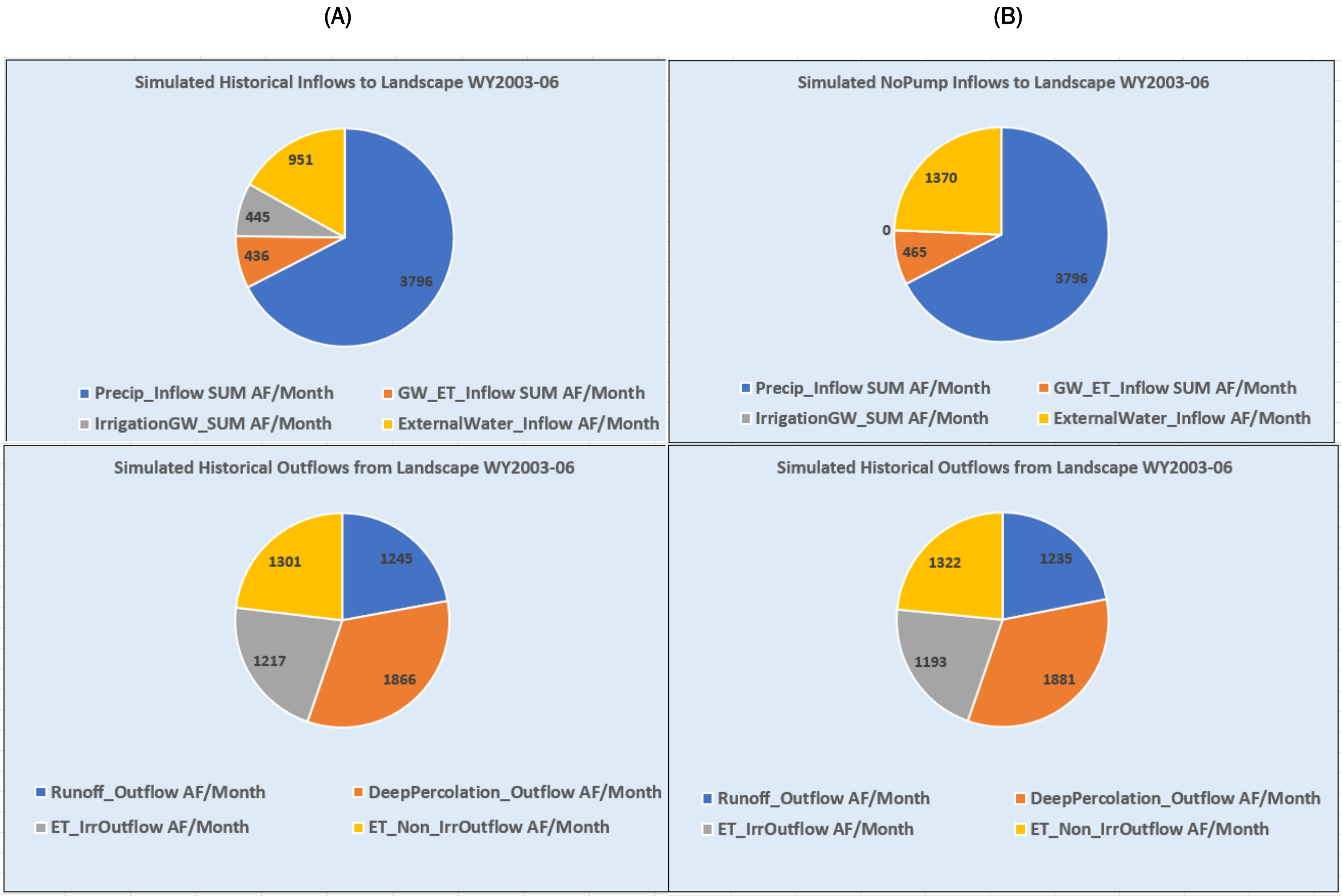


Figure 3. -- Example of portions of inflows and outflows flows from use of the “Zero Option” within the Farm Process in the Archer Model for (A) the calibrated model, and (B) the “no pumpage scenario."

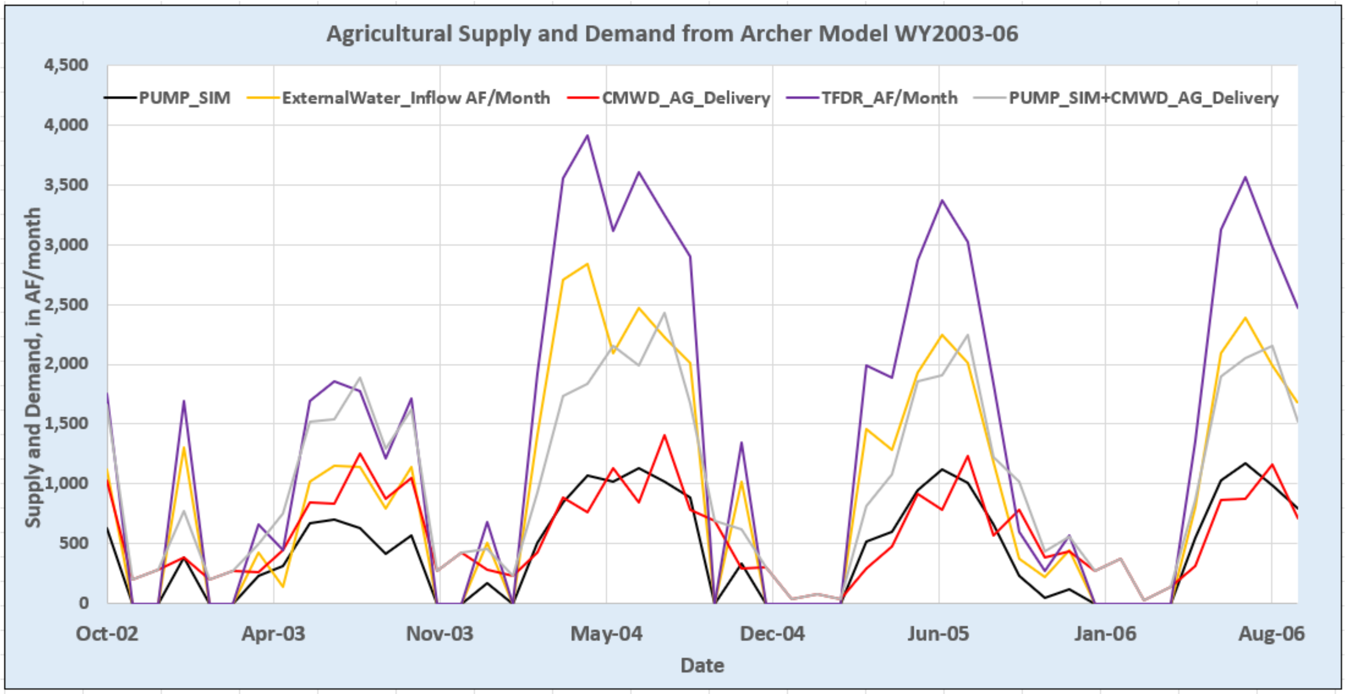


Figure 4. -- Comparison of Archer model irrigation supply as groundwater pumpage and external deliveries with reported surface-water deliveries and demand as total farm delivery requirement (TFDR) for the historical period WY2003-06.

4.1.3.1 Groundwater Calibration and Validation

Overall this model showed a Root Mean Squared Error of 31.2 ft that represents about 2.5 percent of the range of measured groundwater levels and an average error of -7 ft and an R^2 of about 0.99 with a 17.5 ft offset of simulated groundwater-level overestimation from measured values (fig. 5). These estimates are similar to the reported model error analysis (Cardno, 2021a). However, the distribution of error residuals appear to be multimodal over the four subbasins and may represent subregional systematic errors with only 34 percent of the residuals within 10 ft of the measured values and 60 percent within 20 ft. of measured values (fig. 6).

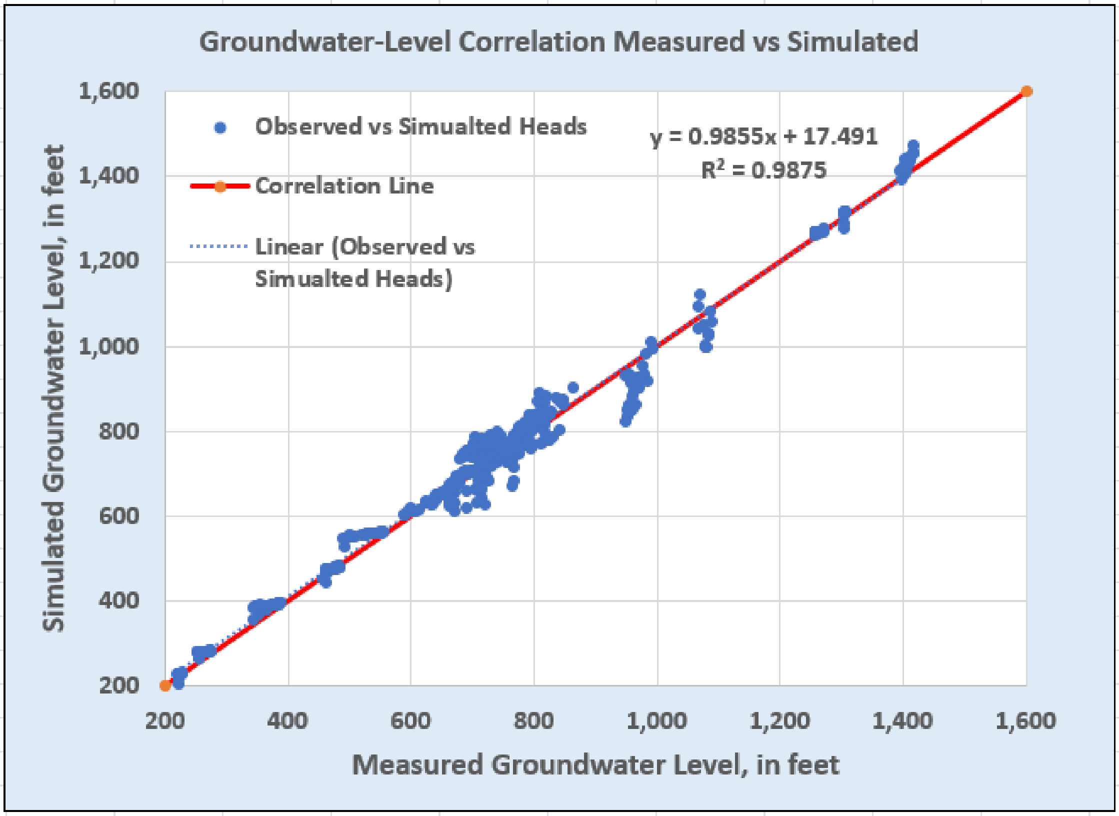


Figure 5. -- Auto Correlation diagram of measured versus simulated groundwater levels for the Archer model (Cardno, 2021a).

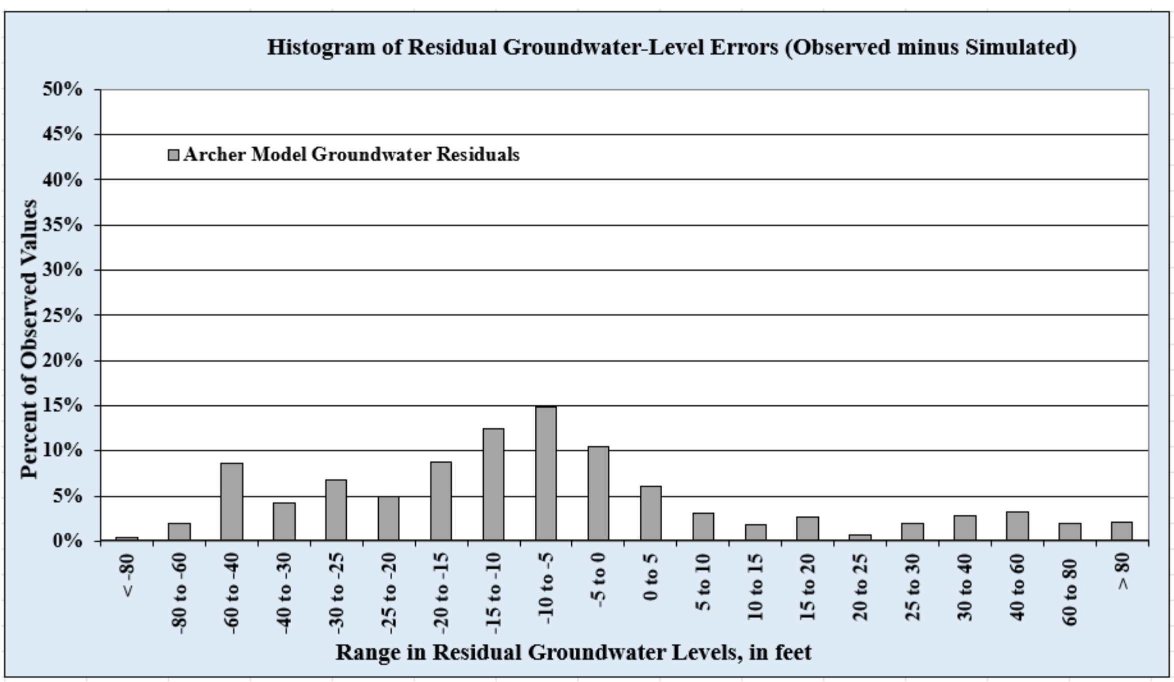
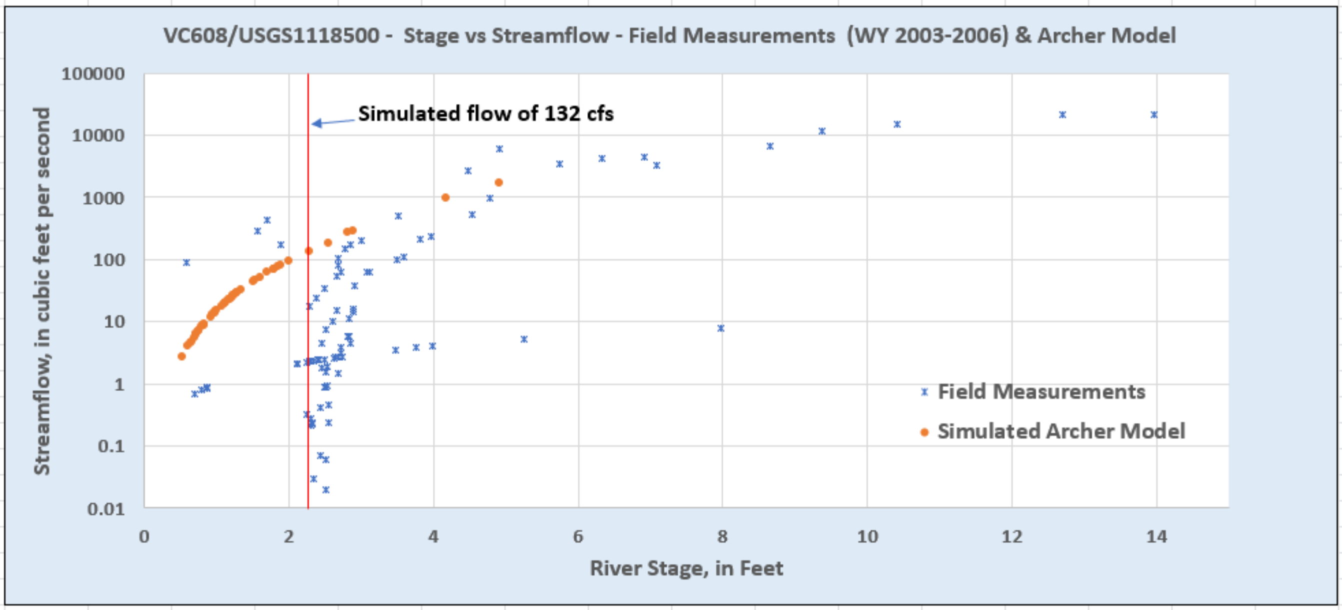


Figure 6. -- Distribution of groundwater-level error residuals (observed minus simulated) for the Archer model (Cardno, 2021a).

4.1.3.2 Streamflow Calibration and Validation

The calibration of streamflow for the Archer model is briefly summarized in the model documentation (Cardno, 2021a). Based on a preliminary analysis of the streamflow input attributes it appears that the model may be too leaky with a uniform vertical streambed conductivity for the entire surface-water network. The model report does acknowledge that the model may have some limitations of use with a reported normalized flow residual for the calibration of 2.8 cfs, which combined with their streamflow analysis that low flow regimes may still be relatively uncertain. For comparison, about 40 percent of the monthly reported gaged streamflows are less than or equal to 2.8 cfs at the Foster Park Gage (USGS 11118500/VC608). The analysis against periodic USGS field measurements of stage and width at the Foster Park gage for the period WY2003-06 also indicate that the model structure may not represent some of the river attributes that affect simulation of leakage through the underestimation of river stage (fig. 7A) and width (fig. 7B) for flows less than about 132 cfs.

(A)



(B)

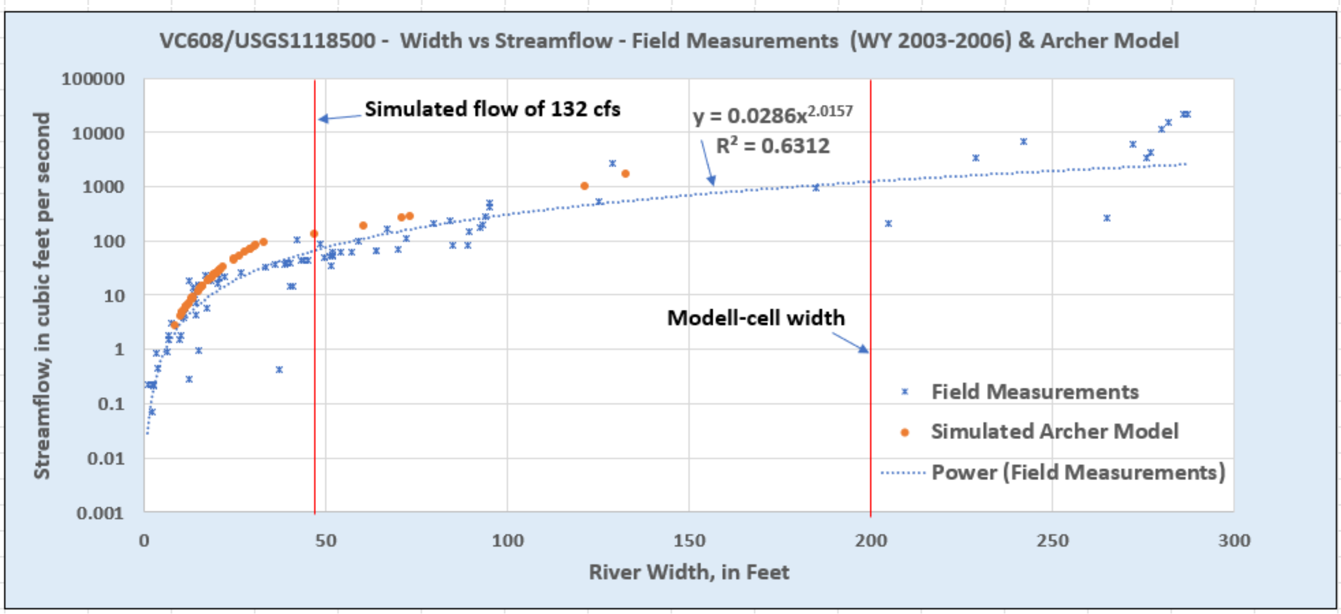


Figure 7. -- Graphs of Streamflow versus (A) Field measurements of gage height and simulated river depth, and (B) field measurements and simulated river widths for the period of simulation, WY2003-06.

4.1.4 Model Limitations

As stated in Archer's Model Documentation report (Cardno, 2021a):

> "We constructed the GFM to simulate regional groundwater flow and groundwater-surface water interaction within the four groundwater basins of the Watershed. We did not intend for this model to provide site-specific data or to provide absolute values of heads or flows. The model has limitations related to data availability and model design that should be recognized during the interpretation of model results.
>
> The model range of uncertainty in streamflow is a consideration when interpreting model results or predictive scenarios that involve simulated streamflow values. The average normalized flow residual for the calibration period is 2.8 cfs, representing the general range of uncertainty in simulated flow values. The monthly stress periods also limit the model to output average monthly flow values, which may not accurately capture short term flashy peak flow events or rapid baseflow recession that is characteristic of this system. Another limitation of the GFM is the lack of temporally and spatially-extensive model input data. Groundwater flow and storage are largely controlled by the shape of the alluvial aquifers, and although the alluvial thickness in the GFM was based on the geologic data available, the process of interpolation introduces uncertainty. The number of head and streamflow observations were also limited by available gage data. Another data gap are the well extraction records for domestic and agricultural wells. Pumping data were only available for the Ojai Basin, so the groundwater extraction component of the water budget in the other basins has a greater level of uncertainty. The extraction data is also limited by the lack of information on water delivery amounts by CMWD to each of the four basins. These deliveries could be a major component of a basin's water budget, especially during dry months and/or in areas with a high density of agriculture."

Additional limitations that are not identified in this disclaimer include:

(1) Insufficient time period of simulation: Longer time periods are needed to allow climate variability and any delayed effects of groundwater flow to be manifested and confirm that the model can provide a robust representation of the past and a tool that can aid with alternate futures as well as potentially climate change and sustainability analysis.
(2) Insufficient layering: Multiple model layers are necessary to assess the effects of selected attributes such as perched layers, wellbore flow, and variable sedimentary facies with related different distributions of aquifer properties
(3) Missing features: This could include the effects of faults and the base of the Matilija Dam as additional flow barriers.
(4) Better representation of landscape and supply and demand features as the exclusion of the two reservoirs and not using nonrouted deliveries for Casitas surface-water deliveries will limit the utility of the model.
(5) The ability to simulate lower rates of streamflows will require the use of more advanced features in MF-OWHM2 such as ICALC=4 instead of ICALC=2 for the flow-stage-width relations used to route surface-water flows.
(6) The ability to more accurately represent land use as fractions of a model cell as is available in MF-OWHM2 (Boyce et al, 2020) could also allow for a more accurate representation of the use and movement of water across the landscape.
(7) The use of other rainfall-runoff models such as BCM (Flint el al, 2020) would facilitate additional applications of the model.

4.1.5 Model Pumping Scenarios

The application of pumping scenarios is also an issue. Global assessments may also require subregional assessments of pumpage. Just turning the MNW2 wells off still allows them to participate in wellbore flow in a multi-layered model, but with this 1-layer model this results in no wellbore flow. Also it is not clear how the supply and demand framework is preserved if water is no longer available for public supply for thousands of residents. As was shown in our analysis of the FMP approach with using the “zero scenario” that supplied external water for irrigation, the model compensated and required additional surface-water deliveries which were not part of a feedback loop within the surface-water system and a broader context of conjunctive use of all the water everywhere, all the time. Using the Surface-water Operations Process of MF-OWHM2 could facilitate reservoir operations and related deliveries and give a better preservation of supply and demand within conjunctive use under any type of changes in supply components such as potential changes of pumpage or surface-water deliveries. Thus, pumping scenarios by themselves may be an incomplete assessment of conjunctive use and assessment of sustainability without assessment of the potential effects from potential changes in surface-water deliveries and climate variability.

SECTION 5: Review of Archer Expert Opinions

There are numerous misrepresentations and/or omissions within some of the examples provided by Archer (Cardno, 2021b) that may render their opinions invalid as stated. While the groundwater flow may contribute to surface water as rejected recharge and rejected groundwater and surface water may contribute to groundwater recharge in selected reaches, this probably varies with climate variability, human development throughout different parts of the surface-water network. Yet the portrayal of groundwater and surface-water connected throughout the Ventura Watershed may be overstated. While the surface water and groundwater represent one resource that are conjunctively used, their connection may vary in space and time.

The following issues were identified with specific statements in the Archer opinion document and related exhibits presented by Archer (Cardno, 2021b) as follows:

(a) Section 1,2.1: The concept of "draining" misrepresents the source and movement of surface water. While some of the surface water is a contribution from the discharge of groundwater into the surface-water system, not all surface water is derived from exfiltration of groundwater. Surface water can also exit the basin simply as runoff from precipitation, inefficient irrigation, or urban runoff that never entered the groundwater-flow system.

(b) Section 1.3.2: The use of the Santa Clara-Calleguas Basin study (Hanson et al., 2003) to represent bedrock as non-water bearing is misleading and inaccurate as that model included both rejected recharge and runoff from surrounding bedrock which flowed as surface water from surrounding canyons that infiltrates along the mountain front borders into the alluvial aquifer systems and is commonly referred to as Mountain-Front recharge. Also groundwater underflow occurred from the surrounding bedrock into the alluvium. These groundwater underflows are commonly referred to as Mountain-Block recharge and are referred to as "bedrock recharge" by Hanson et al. (2003).

(c) Section 1.3.3: This section summarizing interconnectivity does not include a discussion of groundwater underflow as another potential component of groundwater discharge from one subbasin to another, or alternatively, as coastal subsurface discharge. This section also does not address wellbore flow as another important element of interconnectivity.

(d) Section 1.3.6: The depiction of potential groundwater-surface-water interactions (Exhibits 29-32) shows the relationship of nearby groundwater levels relative to land-surface and streambed elevations but does not include the measured or simulated streamflow stage elevation through time. So these examples demonstrate the potential for groundwater discharge to the streambed but without the inclusion of the streamflow stage, it remains uncertain if there could be a groundwater contribution. Exhibit 29 (Well 09B01) only shows groundwater levels above the streambed for brief periods of time in about 11 instances. Similarly Exhibit 30 (Well 16C04) only shows three occurrences of the groundwater levels at the streambed elevation for the period 1949-2020. In contrast Exhibit 31 (Well 20A01) shows more periods of groundwater levels sustained above the streambed elevation. Exhibit 32 (Well 29F02) shows three relatively brief episodes where groundwater levels are above the streambed elevation and potentially contributing groundwater discharge to the river channel.

    All of these examples also exhibit seasonal groundwater level fluctuations of 10-40 ft which are more typical of semi-confined or confined aquifer conditions. So the groundwater levels do provide examples of potential connection with surface-water channels, but may represent examples with some degree of confinement and do not show the stream stage time series with them.

(e) Section 1.3.7: Discussion of GDEs does not differentiate between indigenous instream aquatic and riparian vegetation and invasive species such as Arundo, which may not be considered a beneficial use and may interfere with ecological communities that depend on groundwater discharge within

GDEs. The projects that have attempted clearing of Arundo were also not considered or mentioned. While the areas mentioned may have GDEs, the type of vegetation and related habitat is not described and remains uncertain based on this description.

(f) Section 1.3.8: The estimates of contributions to Lake Casitas from the Robles Diversion and the surrounding tributaries of Coyote Creek are misrepresented. Based on our recent analysis of the reservoir and Robles Diversion, the Robles Diversion on the Ventura River only contributes on average about a third of the water entering Lake Casitas, with the remainder from surrounding watershed runoff. Most of the diversions from Robles Diversion occur during periods of higher streamflow and were further reduced pursuant to the Biological Opinion since 2006.

(g) Section 1.3.9: The Archer Model developed for this opinion has several issues that make it unusable in its current form to reliably draw analysis or interpretations related to groundwater-surface-water interactions. This model is potentially unreliable and limited in its uses for assessing surface-water groundwater interactions that could aide water-resource management or assessment of conjunctive use and sustainability because of the following issues:

    (1) The omission of the reservoirs and simulation of those deliveries along with not developing a multi-layer model,

    (2) The limited time period of simulation and not including additional hydrologic flow barriers,

    (3) The misrepresentation of the surface-water deliveries for irrigation and public water supply, and

    (4) The representation of the stream channel attributes.

(h) While the “no pumpage scenario” showed some effects from pumpage on streamflow at selected points (Exhibit 47), most of the differences in flow occur during low-flow conditions and do not account for the potential uncertainty of the model. The lack of layering would also tend to diminish the delay of these potential effects.

(i) Section 1.4.5: The model analysis used to determine effects of pumpage on streamflow remains uncertain with respect to local pumpage effects versus well pumpage from upstream regions that may be indirectly affecting the simulated streamflow in the Lower Ventura River Basin. Since pumpage was not turned on and off by subregion, this conclusion remains somewhat uncertain.

(j) Section 1.5.2: Archer claims that the sedimentary layering and semi-confined units do not separate the Ojai Basin into multiple disconnected basins, but the effects of these attributes are difficult to assess with their 1-layer model.

(k) Section 1.5.9: The depiction of flow through fine-grained layers is not consistent with most aquifer and geomechanics analysis of land subsidence. For example, the reference to Konikow and Neuzil (2007) (Archer Exhibit 63) describes the storage depletion from fine-grained layers and not flow through them. So this is typically not the case to have flow through fine-grained layers but instead flow from them as a mechanical compression that results in interior storage depletion from within the fine-grained layer and vertical flow from that layer into adjacent aquifers. The additional example of the wellbore flow in the Oxnard Plain is somewhat misrepresented as the original study indicated that wellbore flow can occur in both directions and based on geochemical analysis, the effects of wellbore leakage were not areally extensive (Hanson et al, 2003). The issues of the abandoned wells in the Oxnard Plain were first identified by upward flow to the land surface. The effects of wellbore flow between aquifer layers cannot be evaluated with the one-layer model from Archer.

(l) Section 1.6.4: The source of water to Lake Casitas from Robles diversion is potentially misrepresented as “which is filled in large part by water diverted from the Ventura River through the Robles Diversion.” Based on recent analysis of Lake Casitas and Robles Diversion, only about a third of the water that enters Lake Casitas originates from the Robles Diversion over the historical period of operation.

(m) Section 1.6.6: The simulated differences in streamflow are again below the uncertainty stated by Archer's model report of about 2.8 cfs and may require additional refinements of the model to reduce the uncertainty of these estimated differences in streamflow.

SECTION 6: SUMMARY AND CONCLUSIONS

The following summary includes opinions and additional considerations, based on this initial review of the Archer model and opinion. This summary also includes selected rebuttals to points made by Archer in the Opinion document (Cardno, 2021b).

Overall we do not think the Archer model is capable of reliably assessing the effects of groundwater pumpage on surface-water flow and lacks the details needed to assess the potential distribution and allocation of water use and movement in a conjunctive-use framework. In other words, based upon the information available, the model does not appear sufficiently predictive of the relationships between groundwater extraction in the Ojai/Upper Ojai Basins. And surface water flows in the Ventura River to allow Dr. Archer to have rendered the opinions she rendered in her expert report regarding the relationships between upstream groundwater pumping and downstream surface water flows.

The opinions of Dr. Archer are broad and are not supported considering the uncertainties of the model developed. Also a few of the examples that were used to support these opinions were not correctly presented.

SECTION 7: REFERENCES Exhibits and Supporting Data

Boyce, S.E., Hanson, R.T., Ferguson, I., Schmid, W., Henson, W., Reimann, T., Mehl, S.M., and Earll, M.M., 2020, One-Water Hydrologic Flow Model: A MODFLOW based conjunctive-use simulation software: U.S. Geological Survey Techniques and Methods 6–A60, 435 p., https://doi.org/10.3133/tm6a60. (http://pubs.usgs.gov/tm/tm60/)

Cardno (Claire Archer), 2021a, Ventura River Watershed Groundwater – Surface Water Model Report, August, 2021, 62p.

Cardno (Claire Archer), 2021b, Ventura River Watershed/Groundwater Basin Interconnectivity and Boundary Report, August, 2021, 36p.

Flint, L.E., Flint, A.L., and Stern, M.A., 2021, The basin characterization model—A regional water balance software package: U.S. Geological Survey Techniques and Methods 6–H1, 85 p., https://doi.org/ 10.3133/ tm6H1.

Hanson, R.T., P. Martin, K.M. Koczot. 2003. Simulation of ground-water/surface-water flow in the Santa Clara - Calleguas basin, California: U.S. Geological Survey Water-Resources Investigation Report 02-4136, 214 p. (http://water.usgs.gov/pubs/wri/wri024136/text.html).

Hanson, R.T., Boyce, S.E., Schmid, Wolfgang, Hughes, J.D., Mehl, S.M., Leake, S.A., Maddock, Thomas, III, and Niswonger, R.G., 2014, MODFLOW-One-Water Hydrologic Flow Model (OWHM): U.S. Geological Survey Techniques and Methods 6-A51, 122 p. (http://pubs.usgs.gov/tm/tm6a51/)

Konikow, L. F., and Neuzil, C. E. 2007. A method to estimate groundwater depletion from confining layers, Water Resour. Res., 43, W07417.

The above references relied on to prepare this rebuttal report and the CVs of the others from our expert team are provided in the Drop Box Link at:

https://www.dropbox.com/s/7yxph2nw49fi4ks/Hanson_Exhibits.zip?dl=0

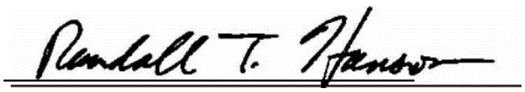
The additional supporting Data for the Archer Exhibits and Model were provided by Dr. Archer for the City of San Buenaventura link:

https://app.box.com/s/t7qj49uxdxop2tl3bx7p01g9nqv5qx6a

Section 8: AFFIRMATION OF EXPERTS

I, Mr. Randall T. Hanson, affirm that the opinions expressed herein are mine, based on the information cited in the attached documents in the references section above and in the attached exhibits, analysis using the available data provided by the City of San Buenaventura, and hydrogeologic brainstorming discussion among experts on the Casitas team.

Signed:



Randall T. Hanson, MS

SECTION 9: Qualifications and CV's of Expert

Mr. Randall T Hanson

Mr. Hanson has more than 46 years of experience in hydrology, hydrogeology, and water-resource investigations, and methods development with emphasis on characterization of groundwater and surface water systems, integrated hydrologic numerical modeling of hydrologic systems, water supply and availability analysis, surface-water and groundwater interaction, water rights, geostatistics, climate analysis, and model linkages to climate models as well as Modflow and related tool and code developments that include over 100 publications.

As a lead USGS research hydrologist for over 38 years, Mr. Hanson developed hydrologic and modeling methods, and water-supply analysis of regional watersheds nationally and internationally. He authored or co-authored nine Techniques and Methods Reports and numerous other methods publications in journals and in other USGS publications. In 2018, he started One-Water Hydrologic to help scientists and engineers use the new version of the Modflow numerical hydrologic model platform called One-Water. Mr. Hanson helped lead and develop One-Water and is also co-author of the newest version of Modflow called One-Water Version 2 (MF-OWHM2) published in April 2020 by the USGS, One-Water Hydrologic Flow Model: A MODFLOW Based Conjunctive-Use Simulation Software Techniques and Methods 6-A60. This innovative integrated hydrologic model code provides simulation and analysis of conjunctive use of water to help assess food and water-security in California's SGMA and worldwide. He also has experience analyzing climate change/variability for sustainability and adaptation using One-Water with linkages to global climate models and with the USGS HydroClimate Toolkit, which he also helped lead development.

Mr. Hanson has conducted numerous studies of coastal aquifers such as the adjacent Santa Clara-Calleguas Basin as well as Pajaro Valley and Salinas Valley in the Monterey Bay region, the Santa Clara Valley, Napa Valley, the Los Angeles Basin and San Diego/Tijuana River watersheds. He is also a leader in the analysis of transboundary aquifers such as the US/Mexico border region, and a coauthor of the UNESCO/OAS ISARM-Americas Guidance Book IV on management and evaluation of transboundary aquifers for the Americas. He has also taught classes and lectured on modeling methods and climate change across the USA and worldwide. While Mr Hanson has not previously provided testimony or deposition in any water-related litigation, a variety of his projects were related to some level of litigation ranging from a Supreme Court case to local water conflicts across the USA.

Mr. Hanson's CV provides details on numerous projects that he has been involved with over the past 46 years, including his research sectors and related list of publications. See attached Exhibit A for Mr. Hanson's full CV.

As of the date of this report, Mr. Hanson's professional fees are as follows:

- Office and Field Work, Base Rate: $241/hour
- Exhibit, Deposition, and Testimony Preparation: $361.50/hour
- Deposition and Trial Testimony: $482/hour

Exhibit A- CV of Mr. Randall T. Hanson

Curriculum Vitae

Randall T. Hanson
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San Diego, CA 92107 USA

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C: 619-379-3288
RandyTHanson@gmail.com
Skype: rthanson

ONE WATER

EDUCATION:

UNIVERSITY OF ARIZONA	Hydrology	(Modeling)	Master of Science (1988)
UNIVERSITY OF ILLINOIS	Geology	(Hydrology)	Graduate Studies (1978)
NEW MEXICO INSTITUTE	Mathematics	(Geometry)	B.S. Math (1976)
OF MINING AND TECHNOLOGY	Geology	(Stratigraphy)	B.S. Geology (1976)

GENERAL AREAS OF EXPERTISE: (1) Regional hydrologic investigations/modeling, (2) Climate change/variability, (4) Land subsidence, (5) Develop hydrologic simulation methods, and (6) Conjunctive-Use/Sustainability/Adaptation Analysis.

EMPLOYMENT HISTORY:

1975-1979 Hydrogeologist, W.K. Summers & Assoc., Socorro, New Mexico
1980-1983 Hydrologist, U.S. Geological Survey, Albuquerque, New Mexico
1983-1990 Hydrologist and Research Hydrologist, U.S. Geological Survey, Tucson, Arizona
1991-2017 Research Hydrologist, U.S. Geological Survey, San Diego, California
2018 – present President, One-Water Hydrologic, LLC, San Diego, California

EDUCATION ACTIVITIES: (1) Co-developer and coordinator of USGS Advanced modeling course, "Integrated Hydrologic Modeling with MODFLOW and the Farm Process," 2006-present; (2) Co-instructor of groundwater/subsidence modeling short courses in the China, Mexico, and USA; (3) Technical mentor to graduate students and new hydrologists undertaking groundwater modeling projects in USA and Mexico. (4) Lead instructor for the "One Water" Integrated Hydrologic Flow Model Class USGS/CWEMF 2015-2017.

PROFESSIONAL EXPERIENCE: I am currently leading a new consulting firm for analysis of Conjunctive Use. I was a research hydrologist in the San Diego projects office of the U.S. Geological Survey's (USGS) California Water Science Center and have studied regional flow systems for over 38 years nationally and internationally. Current research incorporates development of new hydrologic methods combined with testing regional hydrologic flow modeling and incorporating new and innovative data from hydroclimatology, geohydrologic framework analysis, wellbore hydraulics and geochemistry, research drilling, and borehole geophysics. Regional water resources studies completed in California include the Santa Clara-Calleguas Basin, Salinas, Pajaro, Santa Clara, Cuyama, and Central Valley. I am also involved with development of new integrated hydrologic models of the Lower Rio Grande and optimization model of the Yuma region, Arizona. Additional research includes leading development of methods to link Global Climate Models to regional hydrologic models and related decision-support tools, assisting Drs. Scott Boyce, Wes Hensen, and Wolfgang Schmid with continued development of the Farm Process and One-Water version of MODFLOW for the simulation of agricultural supply-and-demand as well as artificial recharge and water reuse. I am also leading the development of other new components of MODFLOW, and new methods of climate change/variability analysis throughout the United States and internationally. I was also the USGS representative for UNESCO/OAS--ISARM Strategic Group for Transboundary Aquifers in the Americas, as well as providing guidance in India, Morocco Taiwan, and Mexico.

TOPICS RELATED TO CURRENT WORK: My work represents analyses of water supply and demand within regional flow systems combining new data, new forms of data-collection, and data-integration methods. I lead a team that develops new methods in integrated regional flow modeling, hydroclimatology, hydrostratigraphy, ground-water/surface-water interactions, land subsidence, and wellbore flow. I combine methods development, regional flow analysis/synthesis, and hydroclimatology of regional hydrologic systems with the common goal to build and use more realistic representations of the use and movement of water. These new methods help to better understand the hydrologic cycle and to develop more process-based hydrologic simulation tools that help water-resource managers with operations, planning, and policy issues.

PROJECTS RELATED TO CURRENT WORK
(A) METHODS DEVELOPMENT: One-Water (MODFLOW-OWHM) with new linkage of Subsidence package to surface-water and landscape processes**;** Hydrologic Model Comparisons: MF-FMP/IWFM codes; MODFLOW-LGR/MODPATH linkage and Observations; Local Grid Refinement with FMP3 with NWT and SFR for child models**;** Consumptive-Use Estimates and Tools from Remotely Sensed and Model Data
(B) REGIONAL FLOW ANALYSIS/SYNTHESIS: Simulation and Management Analysis of the Water Resources in the Pajaro Valley, Santa Clara Valley, Central Valley, Salinas Valley, Paso Robles Basin, and Cuyama Valley, California; Lower Rio Grande (US/MX); San Joaquin River Restoration Project, Central Valley, California; Optimization of groundwater deliveries from Colorado River to Mexico
(C) HYDROCLIMATOLOGY: Nevada-California Applications Program, Scripps Institute of Oceanography; Central Valley in response to global climate change; National Assessment of Ground-Water Response in Selected Principal Aquifers to Climate Variability; New Climate Analysis Toolkit; Co-PI USBR-USGS Water Smart Salinas-Carmel River Valleys Climate Change Adaptation Assessment.
INVENTIONS-PATENTS – USGS Developed Well Flowmeter and Downhole Sampler
U.S. Patent No. 6,131,451 – (October, 17, 2000); **U.S. patent No. 6,164,127 –** (December, 26, 2000)
WEB SITES: http://www.one-waterhydrologic.com/ ; http://ca.water.usgs.gov/user_projects/cuyama/ ; http://meteora.ucsd.edu/cap/ ; http://staging-ca.water.usgs.gov/projects/cvhm/climate.html

SELECTED PUBLICATIONS

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PROOF OF SERVICE

Santa Barbara Channelkeeper v. State Water Resources Control Board, et al.
and related cross-action
Los Angeles County Superior Court
Case No. 19STCP01176

STATE OF CALIFORNIA, COUNTY OF ORANGE

I am employed by the law office of Rutan & Tucker, LLP in the County of Orange, State of California. I am over the age of 18 and not a party to the within action. My business address is 18575 Jamboree Road, 9th Floor, Irvine, California 92612. My electronic notification address is mmartinez@rutan.com.

On January 7, 2022, I served on the interested parties in said action the within:

CASITAS MUNICIPAL WATER DISTRICT'S C.C.P § 843 REBUTTAL EXPERT WITNESS DESIGNATIONS AND DISCLOSURE; DECLARATION OF JEREMY N. JUNGREIS IN SUPPORT THEREOF

as stated below:

☒ (Via E-Service to **File & ServeXpress**) I affected electronic service by submitting an electronic version of the document(s) to **File & ServeXpress, LLC**, through the user interface at https://secure.fileandservexpress.com, which caused the document(s) to be sent by electronic transmission to the person(s) at the electronic service address(es) listed.

Executed on January 7, 2022, at Irvine, California.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Marisol Martinez	/s/ *Marisol Martinez*
(Type or print name)	(Signature)