California Water and Environmental Modeling Forum

2019 ANNUAL MEETING PROGRAM

The Role of Communication in Water and Environmental Modeling

(SOURCE: www.slideshare.net)

ORGANIZATIONAL MEMBERS

California Department of Water Resources

California State Water Resources Control Board

Contra Costa Water District

Delta Stewardship Council

East Bay Municipal Utility District

ICF

Jacobs

Metropolitan Water District of Southern California

U.S. Bureau of Reclamation

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OFFICERS

Tariq Kadir, Convener

Shyamal Chowdhury, Vice-Convener

Stacy Tanaka, Treasurer

George Nichols, Secretary

Josué Medellín-Azuara, Past Convener

Paul Hutton, Executive Director

SPECIAL THANKS

To Solano Irrigation District for providing a conference room for Steering Committee meetings.

KEYNOTE ADDRESS

Steve Culberson, Lead Scientist
Interagency Ecological Program

Dr. Steve Culberson fancies himself an estuarine ecologist with an emphasis in tidal marsh biogeomorphology. His interests in hydrodynamics, the spatial orientation of habitat features, and systems ecology led him to study the physical underpinnings of the biological interactions and processes that are ecosystems.

As the Interagency Ecological Program's (IEP) lead scientist, Culberson has the privilege of interacting with and organizing the activities of dozens of agency and university scientists on behalf of IEP's six federal and three State agencies through project work teams, synthesis teams, the science management team, and the IEP coordinators team. These interdisciplinary and collaborative efforts form the core of how the IEP is working to inform Bay-Delta science and provide data and information in compliance with regulations governing the State and federal water projects, and for understanding the ecosystems that depend on the San Francisco Estuary.

Culberson served as a US Peace Corps volunteer and volunteer leader in Central Africa after graduating from Oberlin College in Ohio and attending high school in Northern Pennsylvania. Culberson and his family reside in Davis, Calif. where they've lived for more than 25 years.

http://deltacouncil.ca.gov/interagency-ecological-program-lead-scientist-steve-culberson

SUMMARY OF SESSIONS

Monday, April 22

Time	Session	Moderator	Room
8:00 - 8:30	Registration		Sierra Hallway
8:30 - 10:15	1. The Art & Craft of Water Budget Development: Part 1	Abdul Khan	Sierra 1
	2. Modeling in a Changing Climate	Jamie Anderson	Folsom/Natoma
10:15 - 10:30	Break		
10:30 - 12:15	3. The Art & Craft of Water Budget Development: Part 2	Saquib Najmus	Sierra 1
	4. Restoration Modeling	Mike Deas	Folsom/Natoma
12:15 – 1:00	Lunch - Included in registration fee		Restaurant
1:00 - 2:00	5. CWEMF Awards Ceremony	Josué Medellín-Azuara	Sierra 1
2:00 - 2:05	Break		
2:05 - 3:15	6. Pop-up Talks	Stacy Tanaka & Nigel Quinn	Sierra 1
3:15 - 3:30	Break		
3:30 - 5:15	7. Instream Flow Objectives Development	Jane Ling	Sierra 1
	8. Integrated Groundwater-Surface Water Modeling with OWHM Applications	Scott Boyce	Folsom/Natoma
5:30 - 8:00	9. Business Meeting and Social	Tariq Kadir	Cliff House of Folsom

SUMMARY OF SESSIONS

Tuesday, April 23

Time	Session	Moderator	Room
7:30 - 8:00	Registration		Sierra Hallway
8:00 - 9:45	10. C2VSimFG: Development & Application to SGMA	Tyler Hatch	Sierra 1
	11. California Water Plan Update 2018: Envisioning, Tracking & Investing in California Water Sustainability	Abdul Khan	Folsom/Natoma
9:45 - 10:00	Break		
10:00 - 11:45	12. FloodMAR: Using Flood Water for Managed Aquifer Recharge to Support Sustainable Water Resources	Samson Haile-Selassie	Sierra 1
	13. Evolutionary Optimization & Machine Learning in California Water Resources	Tariq Kadir	Folsom/Natoma
11:45 - 12:30	Lunch - Included in registration fee		Restaurant
12:30 - 1:10	14. Keynote Address – Dr. Steve Culberson	Tariq Kadir	Sierra 1
1:10 - 1:15	Break		
1:15 – 3:00	15. Integrated Water Resources Modeling – State of Science & Applications	Mesut Cayar	Sierra 1
	16. Bay-Delta Modeling	Xiaochun Wang	Folsom/Natoma
3:00 - 3:15	Break		
3:15 - 5:00	17. Central Valley Integrated Hydrologic Model Applications & Tools for Sustainable Groundwater Mgt. Planning	Steffen Mehl	Sierra 1
	18. Grab Bag	Ben Geske	Folsom/Natoma
5:00 - 7:00	19. Poster Session and Social *	Stacy Tanaka	Sierra 2

*Posters will be set up by 10:00 am and available for viewing all day. Presenters will be available from 5:00 to 7:00 pm.

SUMMARY OF SESSIONS

Wednesday, April 24

Time	Session	Moderator	Room
7:30 - 8:00	Registration		Sierra Hallway
8:00 - 9:45	20. Modeling CVP/SWP Operations	Walter Bourez	Sierra 1
	21. ET Applications in Support of Water Resources Management & Planning	Mike Tansey	Folsom/Natoma
9:45 - 10:00	Break		
10:00 - 11:45	22. Forecast Informed Reservoir Operations (FIRO)	Chris Delaney	Sierra 1
	23. Flood Modeling	Samson Haile-Selassie	Folsom/Natoma
11:45 - 1:15	Lunch at area restaurants		
1:15 - 3:00	24. CalSim 3.0: Selected Applications	Hongbing Yin	Sierra 1
	25. Water Quality Modeling	Rusty Holleman	Folsom/Natoma
3:00 - 3:15	Break		
3:15 – 5:00	26. Panel Discussion: Water Supply Reliability Estimation	Jay Lund	Sierra 1
	27. Modeling Hydrologic & Environmental Transport Processes at California Foothill Watersheds at Daily or Finer Increments	Levent Kavvas	Folsom/Natoma

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POSTER SESSION

Watercourse Engineering Inc.

LUNCHES

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REFRESHMENTS

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California Water and Environmental Modeling Forum
Promoting Excellence and Consensus in Water and Environmental Modeling
P.O. Box 5051, Vacaville, CA 95696-5051 (916) 850-3110 cwemf@cwemf.org

Dear CWEMF Membership:

Welcome and thank you for participating in CWEMF's 25th Annual Meeting. I hope you will find it both informative and an opportunity to connect with colleagues, old and new.

This year's Annual Meeting theme is ***The Role of Communication in Water and Environmental Modeling***. Communication is at the core of CWEMF's mission. For twenty-five years CWEMF has endeavored to promote the use of models and facilitate dialogue among the California water and environment stakeholders. Our Annual Meeting has evolved into a three-day event packed with technical presentations on a wide array of modeling topics, a poster session, social events, and workshops. In addition to holding the Annual Meeting, CWEMF has facilitated peer reviews, and has in recent years increased its sponsorship of workshops to inform on, train in the use of, and discuss key models and their role in shaping California water policy.

Our session moderators and other CWEMF members have been essential in crafting a rich and diverse Annual Meeting program. This year's session topics reflect timely themes, including the increasing role ground water plays in California's waterscape and regulatory process, the drive toward more integrated modeling, and emerging sciences in modeling. The invited keynote speaker this year is Dr. Steve Culberson, the Interagency Ecological Program Lead Scientist at the Delta Stewardship Council. CWEMF officers will also present this year's winners for the Hugo B. Fischer Award, the Career Achievement Award, and the Distinguished Life Membership Award. Our annual business meeting and social will be held on the first day (following the last session) and will provide CWEMF Officers and Executive Director the opportunity to update members on CWEMF's activities over the previous year, welcome the new Convener, and introduce the new Vice Convener. We will also have a poster session and social, where you'll have an opportunity to try some tasty options with some stimulating conversation.

I would like to thank all the sponsors for their generous contributions for funding the refreshments, lunches, social events, and poster session. Finally, please participate in the Annual Meeting's follow up survey to help us improve and better prepare for next year.

This Annual Meeting also marks the end of my term as Convener. It has been my great pleasure to work with the Executive Director, the Officers, the Steering Committee members, and the members at large. I thank you all and encourage more members to participate in CWEMF's Steering Committee meetings, subcommittees, activities, workshops, and facilitated peer reviews.

Sincerely,

Tariq Kadir

Tariq Kadir, Ph.D., P.E.
CWEMF Convener

CONTENTS

AGENDA

Monday, April 22

8:00 – 8:30 a.m. – Registration in Sierra Hallway

Refreshments sponsored by Hydroprose International Consulting

8:30 – 10:15 a.m.

Session 1. The Art & Craft of Water Budget Development: Part 1

Moderator: Abdul Khan (DWR)
Location: Sierra 1

1. The Water Budget Handbook: An Overview – Abdul Khan (DWR)

2. Systems and Components: A Process for Developing the Total Water Budget – Todd Hillaire (DWR)

3. A Case Study for Estimating Water Budgets Using the Non-Modeling Approach – Saquib Najmus (Woodard & Curran)

Session 2. Modeling in a Changing Climate

Moderator: Jamie Anderson (DWR)
Location: Folsom/Natoma

1. California's Fourth Climate Change Assessment: Information to Support Modeling Studies – Jamie Anderson (DWR)

2. Predictability and Prediction of Hydroclimate in California – Jay Wang (DWR)

3. Exploring Water Resource Systems Vulnerabilities to Climate Change in California – John Kucharski (USACE)

4. A Flood Management Focused Vulnerability Pilot Study of the Tuolumne Watershed – Romain Maendly (DWR)

5. American River Basin Study: Development of Future Climate and Hydrology Scenarios – Ian Ferguson (USBR)

10:30 a.m. – 12:15 p.m.

Session 3. The Art & Craft of Water Budget Development: Part 2

Moderator: Saquib Najmus (Woodard & Curran)
Location: Sierra 1

1. Extracting Meaningful Water Budgets from Integrated Groundwater & Surface Water Models – Frank Qian (Woodard & Curran)

2. California Water Plan Update 2018 Water Balance Data and Tools – Lew Moeller and Jennifer Kofoid (DWR)

3. AB 1755 The Open and Transparent Water Data Act - Putting Data to Work: Progress to Date – Chris McCready and Matt Correa (DWR)

4. Water Budget Handbook: Data Resources Directory – Paul Shipman and Julie Haas (DWR)

Session 4. Restoration Modeling

Moderator: Mike Deas (Watercourse Engineering)
Location: Folsom/Natoma

1. System-wide Tools for Managing Water and Ecosystems – Marisa Escobar (SEI)

2. Drainage Modeling of Managed Wetlands in Suisun Marsh – Stephen Andrews (RMA)

3. A 2-Dimensional Modeling Approach to Support Long-Term Sustainability of a Floodplain Restoration Project – Sam Diaz (CBEC)

4. Linking Hydrodynamic and Ecologic Data in the McCormack-Williamson Tract – Lily Tomkovic (U.C. Davis)

12:15 – 1:00 p.m. – Lunch

Pick up a box lunch and then join us for the CWEMF Awards Ceremony in Sierra 1.

Lunch sponsored by Larry Walker & Associates

1:00 – 2:00 p.m.

Session 5. CWEMF Awards Ceremony

Moderator: Josué Medellín-Azuara (CWEMF/U.C. Merced)
Location: Sierra 1

Presentation of the Hugo B. Fischer, Career Achievement, and Distinguished Life Membership awards.

2:00 – 3:15 p.m.

Session 6. Pop-up Talks

Moderators: Stacy Tanaka (Watercourse Engineering) and Nigel Quinn (USBR/Berkeley National Laboratory)
Location: Sierra 1

Five-minute overviews summarizing modeling work using a maximum of five PowerPoint slides per speaker.

3:30 – 5:15 p.m.

Session 7. Instream Flow Objectives Development

Moderator: Jane Ling (SWRCB)
Location: Sierra 1

1. Implementation of Lower San Joaquin River Flow Objectives – Yongxuan Gao (SWRCB)

2. SacWAM 1.2: Updates – Scott Ligare (SWRCB)

3. How Hydrology and Water Allocation Modeling is Informing State Water Board Instream Flow Objective Development in the Russian, Shasta, South Fork Eel, and Ventura Rivers – Valerie Zimmer (SWRCB)

4. Implementation of Cannabis Cultivation Policy to Protect Instream Flows – Samuel Cole (SWRCB)

3:30 – 5:15 p.m. (cont'd)

Session 8. Integrated Groundwater-Surface Water Modeling with OWHM Applications

Moderator: Scott Boyce (USGS)
Location: Folsom/Natoma

1. MODFLOW One-Water Hydrologic Flow Model Version 2 Overview: New Features and Packages – Scott Boyce (USGS)

2. Conjunctive-Use within the Rio Grande Transboundary Integrated Hydrologic Model using One-Water – Randall Hanson (One-Water Hydrologic)

3. Simulating Two-Way Feedbacks between Surface-Water and Groundwater Management: Application of the Surface Water Operations Process (SWO) in MODFLOW-OWHM v2 – Ian Ferguson (USBR)

4. Decision Tools for Managing Conjunctively Used Water Resources in the Past, Present, and Future – Wesley Henson (USGS)

5. The Salinas Valley Integrated Hydrologic Model: Supporting Projects and Programs in a Highly Operated Basin – Matt Baillie (Wood Environment & Infrastructure Solutions)

6. Incorporating Projected Land Use Changes into the CVHM – Cab Esposito (CSU Chico)

5:30 – 8:00 p.m.

Session 9. Business Meeting and Social

Moderator: Tariq Kadir (CWEMF/DWR)
Location: Cliff House of Folsom

Social sponsored by Jacobs, MBK, Resource Management Associates, and S.S. Papadopulos & Associates (SSP&A)

PLEASE RETURN YOUR NAME BADGE TO THE REGISTRATION TABLE IF YOU WILL NOT BE COMING BACK TO THE ANNUAL MEETING.

AGENDA

Tuesday, April 23

7:30 – 8:00 a.m. – Registration in Sierra Hallway

Refreshments sponsored by LimnoTech

8:00 – 9:45 a.m.

Session 10. C2VSimFG: Development & Applications to SGMA

Moderator: Tyler Hatch (DWR)
Location: Sierra 1

1. Land Use Update for the 2019 C2VSimFG Update – Andres Guillen (DWR)

2. C2VSimFG Enhancement: State of the IDC Calibration – Dominick Amador (Woodard & Curran)

3. State of Calibration for the Groundwater System for California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) – Mesut Cayar (Woodard & Curran)

4. Application of C2VSim for SGMA Water Budgets for the Kern County Subbasin – Mike Maley (Todd Groundwater)

Session 11. California Water Plan Update 2018: Envisioning, Tracking & Investing in California Water Sustainability

Moderator: Abdul Khan (DWR)
Location: Folsom/Natoma

1. California Water Plan Update 2018: Managing Water Resources for Sustainability – Paul Massera (DWR)

2. Tracking Progress Toward Sustainability: The Sustainability Outlook – Lew Moeller (DWR)

3. Future Scenarios of Water Supply and Demand Conditions in the Central Valley, California through 2100: Impacts of Climate Change and Urban Growth – Mohammad Rayej (DWR)

10:00 – 11:45 a.m.

Session 12. FloodMAR: Using Flood Water for Managed Aquifer Recharge to Support Sustainable Water Resources

Moderator: Samson Haile-Selassie (DWR)
Location: Sierra 1

1. Integrated Decision Support Modeling for Supply Constrained Water Resources – Richard Niswonger (USGS)

2. Model Integration for the Merced River Basin Flood-MAR Reconnaissance Study – David Arrate (DWR)

3. Flood MAR Recharge Schedule and Allocation Modeled though IDC-GRAT – Francisco Flores-Lopez (DWR)

4. Water Available for Flood-MAR and Reservoir Operations Vulnerability Assessment – Alex Vdovichenko (DWR)

5. The Diversity of Flood-MAR and Framing Potential Modeling Challenges, Opportunities and Considerations – Philip Bachand (Bachand & Associates)

6. Questions & Answers Panel – All Presenters

Session 13. Evolutionary Optimization & Machine Learning in California Water Resources

Moderator: Tariq Kadir (DWR)
Location: Folsom/Natoma

1. Balancing Flood Risk and Water Supply in California: Policy Optimization Integrating Uncertain Forecast Information and Groundwater Banking – Jon Herman (U.C. Davis)

2. Natural Streamflow and Geomorphic Classification for the State of California – Samuel Sandoval Solis (U.C. Davis)

3. Policy Search for California Water Supply Adaptation to Snowpack Decline – Jonathan Cohen (U.C. Davis)

4. Comparing Machine Learning Methods for Dynamically Identifying Future Water Supply Vulnerabilities in the Northern California Reservoir System – Bethany Robinson (U.C. Davis)

5. Martinez Salinity Estimation using Deep Learning – Kevin He (DWR)

11:45 a.m. – 12:30 p.m. – Lunch

Pick up a box lunch and then join us for the keynote address in Sierra 1.

Lunch sponsored by Pacific Agroecology LLC

12:30 – 1:15 p.m.

Session 14. Keynote Address: Steve Culberson, IEP Lead Scientist

Moderator: Josué Medellín-Azuara (CWEMF/U.C. Merced)
Location: Sierra 1

1:15 – 3:00 p.m.

Session 15. Integrated Water Resources Modeling – State of Science & Applications

Moderator: Mesut Cayar (Woodard & Curran)
Location: Sierra 1

1. Updates on the IWFM Features – Emin Can Dogrul (DWR)

2. Texture2Par: A Parameterization Utility for IWFM and MODFLOW – Vivek Bedekar (SSP&A)

3. Using the Ensemble Smoother to Calibrate Complex Integrated Hydrologic Models – Ayman Alzraiee (USGS)

4. Eastern San Joaquin Water Resources Model (ESJWRM) & Applications to SGMA – Sara Miller (Woodard & Curran)

Session 16. Bay-Delta Modeling

Moderator: Xiaochun Wang (DWR)
Location: Folsom/Natoma

1. DSM2 GTM Sediment Bed Integration – Ali Abrishamchi (DWR)

2. The Effect of Hydrodynamics on Outmigrating Chinook Salmon Swimming and Route Selection – Edward Gross (RMA/U.C. Davis)

3. Refining DETAW Evapotranspiration using Remote Sensing Data – Lan Liang (DWR)

4. DSM2 GIS Reference – Bradley Tom (DWR)

5. Quantifying the Effect of 20 Years of Land Use Change on San Francisco Bay Area Hydrology – Jing Wu (SFEI)

3:15 – 5:00 p.m.

Session 17. Central Valley Integrated Hydrologic Model Applications & Tools for Sustainable Groundwater Management & Planning

Moderator: Steffen Mehl (CSU Chico)
Location: Sierra 1

1. SGMA Climate Change Desktop Tools for IWFM and MODFLOW – Craig Cooledge (Jacobs)

2. Updates to California's Central Valley Hydrologic Model – Jon Traum (USGS)

3. C2VSimFG Updates and Early Comparisons with CVHM2 – Tyler Hatch (DWR)

4. Application of a Fine Scale Water Balance Model to Support Groundwater Sustainability Assessments – Michelle Stern (USGS)

Session 18. Grab Bag

Moderator: Ben Geske (Delta Stewardship Council)
Location: Folsom/Natoma

1. Optimal Selection and Placement of Green Infrastructure for Urban Stormwater Management – Jing Wu (SFEI)

2. Hydrograph Pattern Identification Using Fuzzy Cluster Analysis – Mathew Tonkin (SSP&A)

3. A Comparison of CalSimII and CalSim3: Parallel Application of Two Planning Models – James Gilbert (USBR)

4. Expansion of CalSim3 into the Tulare Basin – Lauren Thatch (USBR)

5. New Agricultural Water Use Package for MODFLOW and GSFLOW – Richard Niswonger (USGS)

5:00 – 7:00 p.m.

Session 19. Poster Session and Social

Moderator: Stacy Tanaka (Watercourse Engineering)
Location: Sierra 2

Poster session sponsored by Watercourse Engineering
Social sponsored by CBEC Eco Engineering, ICF, Tetra Tech, and Woodard & Curran

1. Spatial Analytics to Support Multi-Benefit Landscape Planning in the Face of Stressed Water Resources – Benjamin Bryant (Stanford U.)

2. Calibration of the 3D RMA San Francisco Model for Longfin Smelt Studies – Scott Burdick (RMA)

3. A View into the Delta Plan Performance Measures – Cory Copeland (Delta Stewardship Council)

4. Printing the Delta in 3D – John DeGeorge (RMA)

5. Exploring the Food Water and Energy Nexus with a Hydro-Economic Agricultural Model Application for Kern County – Josue Medellin-Azuara (U.C. Merced)

6. Combining Analytical and Numerical Techniques for Improved Accuracy and Efficiency in Large-Scale Regional Hydrological Modeling – Hubert Morel-Seytoux (Hydroprose)

7. From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed – Greg Reis (Bay Institute)

8. Evaluating Stream Depletions in Small Watersheds and Headwaters of California – stream Depletion Risk Assessment Framework & Tools (sDRAFT) – Jeffrey Sanchez (SWRCB)

9. The Water Budget Handbook: Overview and Systems – Paul Shipman (DWR)

10. The Water Budget Handbook: Data Resources Directory – Paul Shipman (DWR)

11. ECO-PTM – An Individual-based Juvenile Salmonid Migration Model – Xiaochun Wang (DWR)

12. Delta Modeling User Group – Min Yu (DWR)

13. Evaluating the Risks of Hydrologic Variability on California's Linked Food, Energy, and Water Systems – Harrison Zeff (Univ. N. Carolina at Chapel Hill)

14. A GIS and Python Based Tool for MODFLOW and MT3D Models – Jingnan Zhou, Matt Wicks & Reza Namvar (Woodard & Curran)

PLEASE RETURN YOUR NAME BADGE TO THE REGISTRATION TABLE IF YOU WILL NOT BE COMING BACK TOMORROW.

AGENDA

Wednesday, April 24

7:30 – 8:00 a.m. – Registration in Sierra Hallway

8:00 – 9:45 a.m.

Session 20. Modeling CVP/SWP Operations

Moderator: Walter Bourez (MBK)
Location: Sierra 1

1. Understanding Project Operational Decisions – Ron Milligan and Paul Fujatani (MBK)

2. Methods for Modeling Project Operational Decisions – Shankar Parvathinathan and Walter Bourez (MBK)

3. Interpreting Project Operational Modeling – Wesley Walker and Paul Fujitani (MBK)

Session 21. ET Applications in Support of Water Resources Management & Planning

Moderator: Mike Tansey (USBR)
Location: Folsom/Natoma

1. AgriMet Weather Station Network – Jama Hamel (USBR)

2. Integrating Satellite and Surface Sensor Networks for Irrigation Management Decision Support in California – Bekele Temesgen (DWR)

3. OpenET: Filling the Biggest Gap in Water Data for the Western U.S. – Forrest Melton (NASA)

4. West-wide ET Forecast Network (WwET4Cast) – David Yates (NCAR)

10:00 – 11:45 a.m.

Session 22. Forecast Informed Reservoir Operations (FIRO)

Moderator: Chris Delaney (Sonoma Water)
Location: Sierra 1

1. Forecast Informed Reservoir Operations (FIRO): Background – F. Martin Ralph (U.C. San Diego)

2. Forecast Informed Reservoir Operations (FIRO): Supporting Forecast Improvements through Data Collection – Anna Wilson (U.C. San Diego)

3. Forecast Informed Reservoir Operations (FIRO): Advances in Numerical Weather Prediction Forecasts and Verifications of Atmospheric Rivers over the Russian River Test Watershed – Forrest Cannon (U.C. San Diego)

4. Forecast Informed Reservoir Operation (FIRO): Distributed Hydrologic Watershed Modeling in the Russian River Test Watershed – Steve Turnbull (USACE)

5. Forecast Informed Reservoir Operations (FIRO): Risk Based Decision Support System for Flood Operations of Lake Mendocino – Chris Delaney (Sonoma Water)

Session 23. Flood Modeling

Moderator: Samson Haile-Selassie (DWR)
Location: Folsom/Natoma

1. A Framework for Linking the NWS National Water Model with the HEC-HMS to Improve Flood Modeling – Lucian Cunha, David Curtis & Pavithra Prakash (WEST Consultants)

2. Real-Time Inundation Modeling (RTIM) Tool – Developed for Inundation Forecasting in the Central Valley Floodplains – Chong Vang & Laurence Sanati (DWR)

3. Flood Mapping and Resiliency Analyses: Time for a More Comprehensive Approach – Paul Robinson (Hazen & Sawyer)

4. Flood Impact Assessments: Solutions for Shifting Baselines at Gravel Augmentation Projects – Matthew Weber (CBEC)

11:45 a.m. – 1:15 p.m. - Lunch

Lunch at area restaurants

1:15 – 3:00 p.m.

Session 24. CalSim 3.0: Selected Applications

Moderator: Hongbing Yin (DWR)
Location: Sierra 1

1. A Mokelumne System Overview in CalSim 3 – Kevin Fung (EBMUD)

2. Upper American River Representation in CalSim 3.0 – Matthew Bachman (Stantec)

3. Application of CalSim 3.0 in the American River Basin Study – Raymond Hoang (Stantec)

4. Integration of New Delta Hydrology into CalSim 3.0 – Richard Chen (DWR)

Session 25. Water Quality Modeling

Moderator: Rusty Holleman (SFEI)
Location: Folsom/Natoma

1. Three-Dimensional Modeling of Microplastic Transport in San Francisco Bay – Rusty Holleman (SFEI)

2. Bivalve Control on Nutrients and Phytoplankton in Sacramento-San Joaquin Delta – Zhenlin Zhang (SFEI)

3. Interactions between Submerged Aquatic Vegetation, Primary Productivity and Hydrodynamics in the Cache Slough Complex – Eli Ateljevich (DWR)

4. An Alternative Approach to Salinity Forecasting in the Lower San Joaquin River – James Lu (USBR)

5. Simulation of Mercury Methylation and Demethylation Coupled to Oxidation-Reduction Reactions in Sediments of Delta Tributaries – Stefanie Helmrich (U.C. Merced)

3:15 – 5:00 p.m.

Session 26. Panel Discussion: Water Supply Reliability Estimation

Moderator: Jay Lund (U.C. Davis)
Location: Sierra 1

1. Implementing California's Sustainable Groundwater Management Act: Hydroeconomic Modeling of Sustainability – Duncan MacEwan (ERA Economics) & Chuck Young (SEI)

2. Development of Reservoir Operation Changes in Response to Climate Change Scenarios – Joel Herr (Systech)

3. Water Supply Reliability Estimation: Beginnings of a Review – Jay Lund (U.C. Davis)

Session 27. Modeling Hydrologic & Environmental Transport Processes at California Foothill Watersheds at Daily or Finer Increments

Moderator: Levent Kavvas (U.C. Davis)
Location: Folsom/Natoma

1. Watershed Environmental Hydrology-Hydroclimate Model WEHY-HCM for Modeling Interactive Atmospheric-Hydrologic-Environmental Processes at Watershed Scale – Levent Kavvas (U.C. Davis)

2. Modeling Flood and Sediment Conditions at Fine Scale under Changing Climate Conditions during 21st Century by Coupling Physically Based Models: Application to Cache Creek Watershed and Settling Basin – Toan Trinh & Ali Ercan (U.C. Davis)

3. Analysis of Snow Distribution in Extreme Precipitation Events Over Two Sierra Nevada Watersheds – Andres Diaz (U.C. Davis)

4. Calibration and Validation of Watershed Environmental Hydrology Module for Hydrologic Modeling of Floods in Sierra Nevada Foothills – Yoshihiko Iseri (U.C. Davis)

PLEASE RETURN YOUR NAME BADGE TO THE REGISTRATION TABLE.

ABSTRACTS[1]

Session 1. The Art & Craft of Water Budget Development: Part 1

1. The Water Budget Handbook: An Overview

Presenter(s): Abdul Khan (California Dept. of Water Resources)
Presenter(s) Email Address(es): abdul.khan@water.ca.gov
Collaborators: Saquib Najmus (Woodard & Curran), Todd Hillaire (California Dept. of Water Resources), Frank Qian (Woodard & Curran), Paul Shipman (California Dept. of Water Resources), Julie Haas (California Dept. of Water Resources), and Brian Van Lienden (Woodard & Curran)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The California Department of Water Resources has developed the Handbook for Water Budget Development: With or Without Models (Water Budget Handbook) to provide the water resources community of California with a technical resource to develop water budgets for any geographic area and time period. The Water Budget Handbook identifies key components of the hydrologic cycle, establishes a framework and common vocabulary for the total water budget, and depicts the interrelationships among different components of the total water budget, as represented by the land, surface water, and groundwater systems. To properly account for all water budget components under the wide range of circumstances faced by local water agencies, a systematic process of identifying, classifying, summarizing, interpreting, and communicating water budget information is needed. The Water Budget Handbook responds to this need by creating consistent water budget components with definitions and documenting multiple methods for estimating and accounting the water budget components.

2. Systems and Components – A Process for Developing the Total Water Budget

Presenter(s): Todd Hillaire (California Dept. of Water Resources)
Presenter(s) Email Address(es): todd.hillaire@water.ca.gov
Collaborators: Saquib Najmus and Frank Qian (Woodard & Curran)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Developing a total water budget for any geographic area can be a long, arduous process for any level of expertise. To help improve this process, the Handbook for Water Budget Development: With or Without Models (Water Budget Handbook) developed by the California Department of Water Resources focused on providing practical methods and examples to compute water budget components for both modeling and non-modeling efforts. Given the large number of water budget components and their interrelationships and interactions, the Water Budget Handbook organizes the water budget components by one of three systems comprising the total water budget – land system, surface water system, and groundwater system. This presentation will highlight the organization of the systems and the methods for estimating water budget components.

[1] Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

3. A Case Study for Estimating Water Budgets Using the Non-Modeling Approach
Presenter(s): Saquib Najmus (Woodard & Curran)
Presenter(s) Email Address(es): snajmus@woodardcurran.com
Collaborators: Frank Qian (Woodard & Curran); Abdul Khan, Todd Hillaire and Paul Shipman (California Dept. of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Handbook for Water Budget Development: With or Without Models (Water Budget Handbook) developed by the California Department of Water Resources introduces a comprehensive water budget framework that encompasses all the relevant terms in a water budget. The Non-Modeling Approach described in the Water Budget Handbook helps identify data necessary for developing various water budget components and presents guidance on using a compendium of methods and data sources for estimating different water budget components using this approach. A case study for developing the total water budget is presented that is designed to facilitate a user easily navigate through the necessary steps to develop a complete water budget using the Non-Modeling Approach.

Session 2. Modeling in a Changing Climate

1. California's Fourth Climate Change Assessment: Information to Support Modeling Studies
Presenter(s): Jamie Anderson (California Department of Water Resources)
Presenter(s) Email Address(es): Jamie.Anderson@water.ca.gov
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
California is a global leader in using, investing in, and advancing research to set proactive climate change policy. California's Fourth Climate Change Assessment supports the state's comprehensive strategy to take action based on cutting-edge climate research. In addition to providing the scientific foundation for the Fourth Assessment, information produced by this research is available for other scientists and decision makers to use. This talk will review Fourth Assessment key findings and highlight information from the Assessment that could be used to support modeling studies.

2. Predictability and Prediction of Hydroclimate in California
Presenter(s): Jianzhong Wang (California Department of Water Resources)
Presenter(s) Email Address(es): Wangj@water.ca.gov
Collaborators: Hongbing Yin, Erik Reyes, and Tara Smith (California Department of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
In this study we analyzed features of wavelet spectrum of California precipitation and stream flows to investigate their predictability and found another significant ~14 yr oscillation signal besides the 3-5 yr ENSO oscillation signal in their spectrums. As ENSO occurring at the central Pacific tropical ocean incites 3-5 yr ENSO signal in California hydroclimate, the North Pacific Gyre Oscillation (NPGO) occurring at the North Pacific Ocean was found to be a plausible trigger for ~14 yr oscillation signal. In addition, a correlation analysis showed that winter precipitation in current water year is more associated with prior year ENSO and NPGO than current year in Northern California.

A multiple linear regression model is developed between winter precipitation in each of seven California regions and 6 linear/nonlinear predictors (ENSO, NPGO, TNH, $ENSO^2$, ENSO×NPGO, and NPGO×TNH) using

observation data from the period of 1950 through 2004. TNH is a jet stream related atmospheric index (the Tropical/ Northern Hemisphere) that strongly correlates with California precipitation and stream flow. These regression models were validated for the period of 2005 through 2018 and the validation results showed high prediction skills in terms of R^2 (up to 0.75), NCSE score (up to 0.73) and bias ratio (down to -0.22), especially in the Sacramento River basin.

3. Exploring Water Resource Systems Vulnerabilities to Climate Change in California

Presenter(s): John Kucharski (US Army Corps of Engineers, Hydrologic Engineering Center)
Presenter(s) Email Address(es): John.R.Kucharski@usace.army.mil
Collaborators: Romain Maendly (DWR), Jennifer Olszewski (USACE), Wyatt Arnold (DWR)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Over the past couple of decades, acknowledgment of climate change based risks to water resource systems has led to a large number of impact studies. These studies have traditionally been limited to the evaluation of a relatively narrow set of possible future climate states. As a result, a trend towards vulnerability-based, bottom-up study frameworks has emerged. These frameworks emphasize a broader exploration of possible future climate scenarios. However, these bottom-up evaluations are often limited by their inability to provide plausible future flood and drought scenarios. Thus, both traditional and bottom-up analytical frameworks often leave water resource managers with incomplete information about either the range of possible future climate states or how future climate states will impact the extreme flood and drought events that their systems are designed to mitigate. In this presentation, we demonstrate how stochastic weather generation, in conjunction with a structured set of flood and drought relevant climate change pathways, are being used to evaluate the climate based vulnerabilities of the Tuolumne River Watershed water resources system. The application of this approach to other water resource systems is also discussed.

4. A Flood Management Focused Vulnerability Pilot Study of the Tuolumne Watershed

Presenter(s): Romain Maendly (CA Department of Water Resources)
Presenter(s) Email Address(es): Romain.Maendly@water.ca.gov
Collaborators: John Kucharski (USACE), Jennifer Olszewski (USACE), David Arrate (DWR), Wyatt Arnold (DWR), Alex Vdovichenko (DWR), Wesley Walker (MBK)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The California Department of Water Resources (DWR) in cooperation with the United States Army Corps of Engineer (USACE) are using HEC-WAT and the Decision Scaling approach to explore the Tuolumne watershed water system vulnerabilities to climate change and potential adaptations. Decision Scaling links bottom-up vulnerability assessment with multiple sources of climate information. In this case study, we are exploring 64 climate scenarios with 1,000 years of continuous simulation based on California's exceptional seasonal and inter-annual variability. HEC-WAT connects the full suite of Hydrologic Engineering Center (HEC) tools (e.g. HEC-HMS, -ResSim, -RAS, -FIA) to explore the system response to hydrologic changes from flood to drought under the wide range of simulated natural variability and climate perturbed conditions.

The project aims to develop and recommended approach for quantifying deep uncertainties in flood and drought risks, which can be incorporated into the USACE and DWR decision making processes and to help inform future planning projects. This presentation will provide an update on the framework

presented last year. It will describe the models and modeling approach, and early results on the vulnerability of the Tuolumne Watershed.

5. American River Basin Study: Development of Future Climate and Hydrology Scenarios
Presenter(s): Ian Ferguson, PhD, PE (Bureau of Reclamation)
Presenter(s) Email Address(es): iferguson@usbr.gov
Collaborators: El Dorado County Water Agency, Placer County Water Agency, City of Sacramento, City of Roseville, City of Folsom, Regional Water Authority, Stantec
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The American River Basin Study (ARBS) is currently being carried out by the Bureau of Reclamation, Mid-Pacific Region in collaboration with local cost share partners and Stantec. The primary objective of the ARBS is to develop and evaluate adaptation and mitigation strategies to address current and future imbalances between water supplies and demands within the study area. Consideration of climate change impacts on water supplies and demands is critical to analyzing future water supplies and demands and to evaluating potential adaptation and mitigation strategies.

To this end, the ARBS study team has developed a suite of future climate scenarios and corresponding hydrology scenarios. Climate scenarios were developed based on an ensemble of future climate projections statistically downscaled using the Locally Constructed Analogs (LOCA) downscaling procedure. Hydrology scenarios were subsequently developed by using the Variable Infiltration Capacity (VIC) hydrology model to simulate hydrologic conditions under each climate scenario. Finally, the climate and hydrology scenarios were used to develop scenario inputs to CalSim3 to simulate CVP and SWP operations under each future scenario. This presentation will provide a provide a detailed overview of the ARBS climate and hydrology scenarios and development of corresponding scenario inputs to CalSim3.

Session 3. The Art & Craft of Water Budget Development: Part 2

1. Extracting Meaningful Water Budgets from Integrated Groundwater & Surface Water Models
Presenter(s): Frank Qian (Woodard & Curran)
Presenter(s) Email Address(es): fqian@woodardcurran.com
Collaborators: Saquib Najmus (Woodard & Curran), Paul Shipman (DWR), Todd Hillaire (DWR), and Abdul Khan (DWR)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The California Department of Water Resources (DWR) has developed the Handbook for Water Budget Development: With or Without Models (Water Budget Handbook) as a technical resource to develop water budgets for any geographic area and time period. The Water Budget Handbook introduces a comprehensive water budget framework that encompasses all the relevant terms in a water budget. The modeling approach for developing a water budget described in the document involves taking an existing model available for a water budget zone and extracting model outputs consistent with the components described in the water budget framework. In California, two of the more commonly used integrated groundwater & surface water models are U.S. Geological Survey's MODFLOW One Water Hydrology Model (MODFLOW-OWHM) and DWR's Integrated Water Flow Model (IWFM). Many model applications developed using either of these models provide an accounting of most of the relevant water budget components described in the water budget framework. However, mapping model

outputs to the framework is not a straightforward procedure due to differences in assumptions, terminology, and general inconsistencies in how water budget components are interpreted in these models. The Water Budget Handbook is designed to facilitate a user easily navigate the associated complexities and challenges to develop a complete water budget from model outputs.

2. California Water Plan Update 2018 Water Balance Data and Tools
Presenter(s): Lew Moeller and Jennifer Kofoid (California Dept. of Water Resources)
Presenter(s) Email Address(es): Lewis.Moeller@water.ca.gov; Jennifer.Kofoid@water.ca.gov
Collaborators: Tito Cervantes (California Dept. of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Water balances developed by the California Department of Water Resources (DWR) are an essential component of the California Water Plan and associated supporting analyses and documents. Developed and dedicated water supply and use balances determined and compiled as part of California Water Plan Update 2018 (Update 2018) provide a detailed accounting of urban and agricultural water uses, water required for and dedicated to the environment, and water supplies that met those needs for California. Update 2018 adds data for water years 2011-2015 to the data for water years 1998-2010 developed as part of the previous Updates, using inflow-outflow water balance methodology. This presentation will highlight water years 2011-2015 water balance data and tools that have been developed for Update 2018. The Water Supply and Balance team, co-led by Jennifer Kofoid and Tito Cervantes of DWR, consists of members from each of DWR's Region Offices and Headquarters, State Agency partners, as well as, collaborators that include U.C. San Diego, the Western States Water Council, and U.S. Geological Survey.

3. AB 1755 The Open and Transparent Water Data Act - Putting Data to Work: Progress to Date
Presenter(s): Chris McCready and Matt Correa (California Dept. of Water Resources)
Presenter(s) Email Address(es): Christina.McCready@water.ca.gov; Matthew.Correa@water.ca.gov
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The California Department of Water Resources staff will provide updates on State-led implementation efforts of the Open and Transparent Water Data Act (Assembly Bill 1755, Dodd), including a review of legislative requirements, progress to date, overview of datasets being published, and next steps in implementation.

4. Water Budget Handbook: Data Resources Directory
Presenter(s): Paul Shipman and Julie Haas (California Dept. of Water Resources)
Presenter(s) Email Address(es): Paul.Shipman@water.ca.gov and Julie.Haas@water.ca.gov
Collaborators: Brian Van Lienden (Woodard & Curran)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Handbook for Water Budget Development: With or Without Models (Water Budget Handbook) identifies the necessary components for accurate water budget accounting, describes various methods for determining the components, and furnishes a catalogue of resources for the various data elements that might be needed in estimating the water budget components. The Data Resources Directory of the Water Budget Handbook contains the library of resources identified that could be used in estimating

water budgets and provides additional guidance to users on how to make use of the resources effectively.

Session 4. Restoration Modeling

1. System-wide Tools for Managing Water and Ecosystems

Presenter(s): Marisa Escobar (Stockholm Environment Institute)
Presenter(s) Email Address(es): marisa.escobar@sei.org
Collaborators: Jason Nishijima and Jenny Ta (Santa Clara Valley Water District); Doug Chalmers (Stockholm Environment Institute)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Aquatic Habitat Assessment (AHA) modelling platform, which forms part of SEI's existing WEAP (Water Evaluation and Planning) system, integrates hydro-ecological processes within a water operations model. AHA has been applied to a water utility district in California to simulate the effect of different reservoir operation rules on the habitat availability index (HAI) for Chinook salmon and Steelhead in the watershed. The HAI measures suitable habitat area and is estimated for each migratory fish species life stage, including immigration, spawning, incubation, rearing, and emigration. The HAI is estimated by comparing the modelled velocity, depth, and temperature against tolerances defined by biological suitability curves of each life stage. Temperature is modelled using a 1D heat balance equation in streams and reservoirs. Vertical stratification modelling in reservoirs informs release options from different layers, such as "cold water release" from the bottom of the reservoir. Streambed cross-sectional data were used to relate streamflow to velocity and depth at points of interest. The HAI results were linked to visualization tools, such as Tableau, to allow water managers to effectively evaluate the trade-offs of potential modifications to reservoir operations. AHA has the potential to be applied to other areas where system-wide tools for managing water and ecosystems are needed.

2. Drainage Modeling of Managed Wetlands in Suisun Marsh

Presenter(s): Stephen Andrews (RMA)
Presenter(s) Email Address(es): steve@rmanet.com
Collaborators: Scott Burdick, John Takekawa
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
The Delta Smelt Resiliency Strategy identified proposed management actions to address the short-term needs of Delta Smelt. One of these actions included the coordinated flooding and draining of managed wetlands in Suisun Marsh in order to maximize zooplankton production and export to adjacent sloughs. The objective of this modeling effort is to evaluate the capacity for individual managed wetlands within Suisun Marsh to drain within a reasonable amount of time, given their current drainage infrastructure. Pond extents and culvert specifications for 134 ponds and 340 culverts throughout the marsh were collected and digitized by the California Waterfowl Association (CWA). These, along with a digital elevation model (DEM) and stage data available from a network of monitoring stations, were used to create 14 RAS models for all of the ponds. Draining simulations were performed over a typical spring-neap period using observed stage records from February – March 2018. Pond drainage capacity was assessed by the drainage time from a specified initial water surface elevation ("shoot level") to 1ft below that level. An Excel-based "rapid assessment" tool was also developed in order to help wetland managers estimate potential improvements in drainage time associated with specific infrastructure improvements (e.g., adding a culvert). Users are able to quickly retrieve information on any specific

property, add or modify culverts, and then compare drainage and circulation rates with different parameters without reworking the RAS model geometries.

3. A 2-Dimensional Modeling Approach to Support Long-Term Sustainability of a Floodplain Restoration Project

Presenter(s): Sam Diaz, PE (cbec eco engineering)
Presenter(s) Email Address(es): s.diaz@cbecoeng.com
Collaborators: John Stofleth (cbec), Chris Bowles (cbec), Doug Shields (cbec), Kenric Jameson (West Sacramento Area Flood Control Agency)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Our presentation will focus on a 4-mile reach of the Sacramento River downstream of Sacramento, where a major levee setback has been constructed as part of a multi-objective flood control and habitat restoration effort. This project represents an important step towards combining better flood management with significant ecological restoration. In our presentation, we will review cbec's approach to integrating hydrodynamic/sediment transport modeling with geomorphic interpretation to ensure long-term sustainability of the setback project and to enhance restoration benefits afforded by the project. Our approach utilized the 2-dimensional hydrodynamic and sediment transport model, MIKE21C, as an analytical tool for assessing floodplain inundation dynamics and morphological change under design conditions for a 12-mile reach of the Sacramento River. Our assessment supported recommendations for design and restoration actions that optimized both geomorphic and ecologic function. Our analysis provided insight into the geomorphic evolution of the study reach under the design condition and this insight was used to develop long-term floodplain management strategies. The benefits of using a 2-dimensional hydrodynamic/sediment transport model as a tool to describe geomorphic processes and inform erosion control design of key project features will be emphasized.

We will also discuss how these types of levee setbacks represent a significant opportunity for the future; as means of achieving both increased flood protection and habitat restoration to provide multiple benefits to society. This floodplain management approach is illustrative of one of the most promising solutions to the current levee integrity/flood management crisis in California.

4. Linking Hydrodynamic and Ecologic Data in the McCormack-Williamson Tract

Presenter(s): Lily Tomkovic (U.C. Davis)
Presenter(s) Email Address(es): latomkovic@ucdavis.edu
Collaborators: Edward Gross, Rusty Holleman, Carson Jeffres (UC Davis)
Permission to Post pdf of Presentation on CWEMF Website: No

Abstract:
In the Sacramento-San Joaquin Delta we have a unique opportunity in the McCormack-Williamson Tract to evaluate the relationship between hydrodynamically derived parameters and ecological field data. The accidental breaching of the Tract during the 2017 flood offered us a restoration preview where we sampled water quality and ecological data. During the breach, we found a bumper crop of Daphnia pulex, a large-bodied cladoceran, in the Tract that was then exported to downstream sample sites.

Using our calibrated Deltares' D-Flow FM hydrodynamic model coupled with the engine of the D-Water Quality and D-Ecology programmes of the Delft3D suite, DELWAQ, we were able to generate water age estimates. The modeled age gave us insight to the history of the water we sampled at the time of sampling. Using our model, we investigated relationships between predicted age and zooplankton

structure. Preliminarily, the study showed that zooplankton abundance increased with water age within the study area.

Session 7. Instream Flow Objectives Development

1. Implementation of Lower San Joaquin River Flow Objectives
Presenter(s): Yongxuan Gao (SWRCB)
Presenter(s) Email Address(es): yongxuan.gao@waterboards.ca.gov
Collaborators: William Anderson, Timothy Nelson
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
On December 12, 2018, the State Water Resources Control Board adopted amendments to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) that include measures for the protection of fish and wildlife beneficial uses in the Lower San Joaquin River (LSJR) watershed. The amended Bay-Delta Plan establishes LSJR flow objectives for February through June that are designed to restore water flows through the LSJR and three salmon-bearing tributaries, the Stanislaus, Tuolumne, and Merced Rivers. The amendments indicate that the LSJR flow objectives are to be implemented by 2020.

As a default, the LSJR flow objectives require 40 percent of unimpaired flow to be provided from February through June from each of the three tributaries based on a minimum 7-day running average. The amendments also allow for adaptive implementation methods involving modification to the default averaging period and adjustments to the required percent of unimpaired flow within a range of 30-50 percent if certain criteria are met. The amendments call for a number of activities to assist with implementation including: formation of a technical advisory group of stakeholders, called the Stanislaus, Tuolumne, and Merced (STM) Working group to assist with the implementation, monitoring, and effectiveness assessment of the flow requirements; development of biological goals to inform adaptive implementation and future modifications to the LSJR flow objectives; development of specific compliance methods for the default and adaptive implementation methods; and development of specific monitoring and evaluation measures. This presentation will provide an overview of possible implementation methods for the LSJR flow objectives.

2. SacWAM 1.2: Updates
Presenter(s): Scott Ligare (SWRCB)
Presenter(s) Email Address(es): Scott.Ligare@waterboards.ca.gov
Collaborators: Matt Holland (SWRCB), Chuck Young (SEI), Andy Draper (Stantec), Brian Joyce (SEI), Vadim Demchuk (SWRCB), Alessia Siclari Melchor (SWRCB), Subir Saha (SWRCB)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Sacramento Water Allocation Model (SacWAM) is a hydrology/system operations model developed by the Stockholm Environment Institute (SEI) and State Water Resources Control Board (State Water Board) to assess potential revisions to instream flow and other requirements in the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (2006 Bay-Delta Plan). Since the initial release of version 1.05 in October of 2017, many refinements have been made to the model. These changes to the existing conditions simulation include: refinement of upper watershed hydropower operations, implementation of wheeling of Project water through Jones and Banks Pumping Plants, allocation logic for projects on the Yuba, Bear, and American Rivers, refinement of

demand and diversions from Mill, Deer, Antelope, Cow and Battle Creeks, changes to unimpaired upper watershed inflows, an overhaul of demand priorities, and many other minor changes. Together these changes increase model flexibility and improve responses to alternative scenarios as well as produce baseline results that are closer to recent observed operations.

3. How Hydrology and Water Allocation Modeling is Informing State Water Board Instream Flow Objective Development in the Russian, Shasta, South Fork Eel, and Ventura Rivers

Presenter(s): Valerie Zimmer (SWRCB)
Presenter(s) Email Address(es): valerie.zimmer@waterboards.ca.gov
Collaborators: Kevin DeLano, Rajaa Hassan, Vivian Sieu, Robert Solecki, Adam Weinberg, Daniel Worth
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The State Water Board, through collaboration with a variety of partners and stakeholders, is leading the development of surface water-groundwater hydrologic characterization models (hydrology models) and water allocation models in the Russian, Shasta, South Fork Eel, and Ventura River watersheds. The development of these models will provide the basis for assessments of the benefits and impacts of potential watershed management actions on fish habitat, existing water users, and other beneficial uses. These four watersheds provide important habitat for anadromous fish, spanning from small pools in the upper reaches where juvenile fish may be rearing, to the mainstem where winter flows provide passage to and from the sea. Characterizing very small tributaries in lower flow conditions and understanding the natural temporal variations in the hydrograph are important objectives of the modeling efforts and present technical challenges. Another important objective of the modeling effort is to accurately account for surface water and groundwater diversion in the absence of robust records. Each watershed has unique ecology, geology, hydrology, and water use characteristics to consider during model development. This talk will focus on the unique technical questions for each watershed and how modeling is informing development of instream flow objectives at the State Water Board.

4. Implementation of Cannabis Cultivation Policy to Protect Instream Flows

Presenter(s): Samuel Cole, PE (SWRCB)
Presenter(s) Email Address(es): Samuel.Cole@waterboards.ca.gov
Collaborators: William Anderson (SWRCB)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
On June 27, 2016, the Governor signed Senate Bill 831, which among other things, codified Water Code section 13149 and authorized the State Water Board to adopt interim and long-term principles and guidelines (requirements) for cannabis cultivation as part of a state policy for water quality control. The State Water Board has developed narrative and numeric instream flow requirements for cannabis diversions statewide, and a real-time operational compliance and informational website. Under a rapid timeline, the State Water Board drafted a Cannabis Cultivation Policy that was adopted in October 2017, which includes both water quality and water rights requirements. The Policy includes authorization of diversions subject to interim monthly instream flow requirements calculated by applying the Tessmann Method (see Policy page 51) to a predicted historical monthly flow data set sourced from a flow modeling effort for all streams statewide conducted by the United States Geological Survey, in cooperation with The Nature Conservancy and Trout Unlimited (Carlisle et al. 2016). Comparison of the prior day's average gaged streamflow vs. the Tessmann flow requirements is used as an indicator of current hydrologic conditions. Cannabis cultivators who divert water subject to the Cannabis Policy requirements are required to check the State Water Board's "Online Mapping Tool" website daily to

determine if diversions are currently authorized, within the November-March diversion season. Points of diversion are assigned a compliance gage of best fit based on an automated calculation using distance and several metrics for hydrologic similarity.

Session 8. Integrated Groundwater-Surface Water Modeling with OWHM Applications

1. MODFLOW One-Water Hydrologic Flow Model Version 2 Overview: New Features and Packages

Presenter(s): Scott E. Boyce (PhD US Geological Survey, California Water Science Center)
Presenter(s) Email Address(es): seboyce@usgs.gov
Collaborators: Randy Hanson (US Geological Survey, California Water Science Center), Wes Henson, PhD (US Geological Survey, California Water Science Center), Ian Ferguson, PhD, PE (Bureau of Reclamation), Steffen M. Mehl, PhD (California State University at Chico)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The One-Water Hydrologic Flow Model (One-Water) is a fusion of multiple MODFLOW-2005 variants now able to simulate and help understand the conjunctive use of groundwater and surface water combined with land use. The first version, released in 2014, was selected by The World Bank Water Resource Software Review in 2016 as one of three recommended simulation programs for conjunctive use and management modeling. Version 2, released in 2018, includes modified-existing MODFLOW packages and new packages that aid evaluating Best Management Practices (BMP). The input structure is designed to maintain backward compatibility with existing MODFLOW models and provides alternative input structures that are easier to update and maintain. One-Water is well suited for simulation of urban and agricultural settings by including dynamic estimation of water consumption and groundwater pumpage for irrigation, routing and management options for surface-water deliveries, detailed water-budget output, and embedded functionality for reservoir operations. This dynamic estimation makes One-Water a powerful tool for evaluation of future scenarios and assessing groundwater sustainability, adaptation, and climate change. This presentation will provide an overview of the improvements to One-Water and ideology behind developing a One-Water style simulation model.

2. Conjunctive-Use within the Rio Grande Transboundary Integrated Hydrologic Model using One-Water

Presenter(s): Randall T. Hanson (One-Water Hydrologic)
Presenter(s) Email Address(es): RandyTHanson@gmail.com
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: UNKNOWN
Abstract:
For more than 30 years the agreements developed for the aquifer systems of the lower Rio Grande and related river compacts of the Rio Grande River have evolved into a complex setting of transboundary conjunctive use. The conjunctive use now includes many facets of water rights, water use, and emerging demands between the states of New Mexico and Texas, the United States and Mexico, and various water-supply agencies. The analysis of the complex relations between irrigation and streamflow supply-and-demand components and the effects of surface-water and groundwater use requires an integrated hydrologic model to track all of the use and movement of water. The Integrated Hydrologic Flow Model, One-Water, provides the integrated approach needed to assess the stream-aquifer interactions that are dynamically affected by irrigation demands on streamflow allotments that are supplemented with

groundwater pumpage. The USGS in cooperation with the USBR, developed a new historical model called the Rio Grande Transboundary Integrated Hydrologic Model (RGTIHM). This model demonstrates the ability to simulate the existing streamflow-diversion relations of historical conditions through 2014 that represent the conjunctive use of the surface water released and delivered through the USBR Lower Rio Grande Project that is supplemented with groundwater for irrigation and water supply. This new One-Water modeling framework can now internally analyze complex relations that previous techniques had limited ability to assess.

3. Simulating Two-Way Feedbacks between Surface-Water and Groundwater Management: Application of the Surface Water Operations Process (SWO) in MODFLOW-OWHM v2

Presenter(s): Ian Ferguson, PhD, PE (Bureau of Reclamation)
Presenter(s) Email Address(es): iferguson@usbr.gov
Collaborators: Scott Boyce, PhD (US Geological Survey, California Water Science Center), Randy Hanson (US Geological Survey, California Water Science Center), Wes Henson, PhD (US Geological Survey, California Water Science Center)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:

It is well established that groundwater pumping affects surface-water supplies by reducing groundwater discharge to streams and/or increasing seepage losses from stream channels. Conversely, surface-water management can affect groundwater supplies and use by altering the timing, location, and quantity of groundwater recharge and demand. Understanding these interactions between groundwater and surface-water supplies, management, and use is critical to conjunctive water management. The majority modeling approaches used in water resources planning and management, however, focus on either the physical system (hydrologic processes) or the managed system (water operations), with limited or simplified treatment of the other. These models are typically unable to simulate two-way feedbacks between hydrologic processes and water management.

The Surface Water Operations Process (SWO) was developed by USGS and Reclamation to allow fully-coupled simulation of surface-water operations within MODFLOW-OWHM, including interactions and feedbacks between groundwater and surface-water supplies, demands, and management. SWO includes a new interpretive scripting language, the S-Language, that allows users to define surface-water operating rules directly within MODFLOW, including water allocations and accounting, reservoir releases and diversions, in-stream flow requirements, and other management objectives. Here we present key features of SWO and demonstrate how SWO can be used to evaluate impacts of groundwater management on reservoir operations and vice versa.

4. Decision Tools for Managing Conjunctively Used Water Resources in the Past, Present, and Future

Presenter: Wesley Henson (US Geological Survey, California Water Science Center)
Presenter Email Address: whenson@usgs.gov
Collaborators: Scott Boyce, Randy Hanson, DJ Martin and Marisa Earl
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:

Groundwater and surface water are conjunctively used for water supply in the Salinas Valley located in coastal California. The 7 billion-dollar agricultural industry in the valley provides up to 50% of America's Lettuce and Broccoli. Thus, sustainable development of water resources in the valley contributes to national food security. Groundwater sustainability is key to preserving this vital industry because groundwater withdrawals have resulted in water-level declines and related seawater intrusion since

the 1930s. New methods have been developed for estimating land use and agricultural water demands and reservoir operations. These new methods were integrated into the Salinas Valley Integrated Hydrologic Model (SVIHM) to make an effective tool for decision-making.

The SVIHM is a good example of how an integrated model can be used to evaluate conjunctively used water supply under past, present, and future conditions. This tool has been used to develop historical hydrologic budgets, evaluate current strategies to attain groundwater sustainability, and optimize reservoir operations to secure additional water supply through conservation. In addition, the SVIHM is part of a regional Reclamation Water Smart study—the Salinas Carmel River Basin Study (SCRBS). The SCRBS is evaluating future water demand and supply deficits under climate change. The SCRBS engages multiple groundwater and surface water models, multiple ensemble informed climate scenarios, and three socioeconomic development models to evaluate uncertainty under current operations. In addition, selected portfolios of potential mitigation strategies will be evaluated to reduce drought risks through the year 2100.

5. The Salinas Valley Integrated Hydrologic Model: Supporting Projects and Programs in a Highly Operated Basin

Presenter: Matt Baillie (Wood Environment and Infrastructure Solutions)
Presenter Email Address: matt.baillie@woodplc.com
Collaborators: Les Chau, Seth Jelen, and Masoud Meshkat (Wood Environment and Infrastructure Solutions); Scott Boyce and Wes Henson (US Geological Survey California Water Science Center); Howard Franklin and Amy Woodrow (Monterey County Water Resources Agency)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Salinas Valley Groundwater Basin, located along California's Central Coast, has a well developed agricultural economy and relies on two large reservoirs (Nacimiento and San Antonio) to provide a variety of services (storage, flood control, groundwater recharge, environmental, and recreation). Flow from the Salinas River to groundwater is substantial throughout the Basin. Groundwater conditions (e.g., groundwater heads near the River) have a strong influence on the amount of reservoir release required to satisfy downstream demands. Therefore, evaluation of optimal reservoir management strategies benefits from a tightly coupled representation of operations and potential losses along the stream network. The Salinas Valley Integrated Hydrologic Model (SVIHM) is a MODFLOW-OWHM model developed by the USGS California Water Science Center that has been calibrated with over 40 years of historical hydrologic measurements. The SVIHM has been coupled with a new Surface Water Operations (SWO) module to quantify the maximum benefits of physical and operational modifications to the reservoirs, along with potential benefits of future projects. The SVIHM is a novel tool for simulating current and future conditions and is being used to support several programs in the Basin. These projects include an engineering feasibility study and EIR for a proposed tunnel linking the Nacimiento and San Antonio reservoirs and development of the Basin Groundwater Sustainability Plan. Potential additional water supply from optimized reservoir operations may be available to supply water resources for downstream demand, enhanced flood control, and augmented seawater intrusion mitigation, with the ultimate goal of bringing the Basin into a sustainable state.

6. Incorporating Projected Land Use Changes into the CVHM

Presenter(s): Cab M. Esposito (CSU Chico)
Presenter(s) Email Address(es): cmesposito@csuchico.edu
Collaborators: Steffen Mehl (CSU Chico), Eric Houk (CSU Chico), Dave Brown (CSU Chico), Edward Roualdes (CSU Chico)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
California's Central Valley relies on groundwater to meet both agricultural and municipal demands. The evolution of agricultural and municipal demands can be considered through land use changes which have been shown to have both positive and negative effects on groundwater systems. Sustainable management of California's groundwater resources under SGMA requires an analysis of future stressors, such as land use change and climate change. The Central Valley Hydrologic Model (CVHM) is a U.S. Geological Survey MODFLOW based conjunctive use model that accounts for surface-water and groundwater to assess the water requirements of a region. Land use change projections from the State of California's 4th Climate Change Assessment were incorporated into the CVHM to investigate how future land use changes affects water demand. The CVHM was modified to incorporate 80 years of projected land use change while controlling for annual climatic variability. The projected land use changes include increased urban areas and perennial agriculture with corresponding decline in annual agriculture. The incorporation of projected land use decreased groundwater demand by 25% across the entire Central Valley. The cumulative effect of large shifts in land use is shown in subregional changes in groundwater levels, ranging from a projected 5.1 meters of decline to 4.0 meters of rise.

Session 10. C2VSimFG: Development & Applications to SGMA

1. Land Use Update for the 2019 C2VSimFG Update

Presenter(s): Andres Guillen (California Department of Water Resources)
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Collaborators: Tyler Hatch (California Department of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Land use data is an important input to C2VSimFG for estimating water demands and groundwater pumping. In 2019, DWR updated the C2VSimFG landuse dataset to incorporate additional field scale data, refine the resolution of the 2009 datasets, and include data from local models. Field scale land use data obtained from Westlands Water District and San Joaquin County was added to existing field scale data. The resolution of the 2009 data was refined from a 56-meter grid to a 30-meter grid in response to updated data from USDA Crop Data Layer (CDL). Both the additional field scale data and the 2009 refined data were used in regenerating a land use distribution for each element in C2VSimFG. Local model data were obtained from Butte, Glenn, Colusa, Yuba counties. The conversion of the local-model land use data to the C2VSimFG elements was performed with the aid of python-based scripting tools. This was done as an additional step after processing the field scale data because the local model data was aggregated to each local model element. In addition, each of the local models included data for different ranges of years, slightly different land use categories, and overlapping areas. One key limitation is the land use data represents a single land use distribution for each year. However, the methods used to develop the land use coverage allows a user to make localized edits to selected areas in the model domain. This can allow field-scale corrections to be made as new or better information becomes available.

2. C2VSimFG Enhancement: State of the IDC Calibration

Presenter(s): Dominick Amador (Woodard & Curran)
Presenter(s) Email Address(es): damador@woodardcurran.com
Collaborators: Tyler Hatch, Tariq Kadir, Abdul Khan, Paul Shipman, Mesut Cayar, Ali Taghavi
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
The California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG Beta 2.0) IDC has undergone significant enhancements since the initial C2VSimFG Beta release in May 2018. This presentation will provide a brief overview of the IDC processes within the C2VSimFG, while focusing on model data development, calibration of the surface water processes, and IDC results. Since the initial Beta release, local collaboration has allowed the DWR to refine water budgets and reflect local knowledge and irrigation practices at the regional scale. Discussion of the IDC calibration process will cover a series of example case-studies and explain how various datasets have facilitated model enhancement.

3. State of Calibration for the Groundwater System for California Central Valley Groundwater-Surface Water Simulation Model (C2VSim)

Presenter(s): Mesut Cayar (Woodard & Curran)
Presenter(s) Email Address(es): mcayar@woodardcurran.com
Collaborators: Tyler Hatch, Tariq Kadir, Abdul Khan, Paul Shipman, Ali Taghavi, Dominick Amador, Lisbeth DaBramo
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
The beta version of the Fine Grid version of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG Beta) was released in May 2018. C2VSimFG Beta has since been further refined and calibrated for beta version 2.0 release (C2VSimFG Beta 2.0) in mid-April 2019. Calibration of the groundwater system for C2VSimFG Beta 2.0 focused heavily on refinement of the rootzone and land and water use budget components, such as agricultural land use and cropping patterns, crop water demands through adjustment of soil parameters, crop evapotranspiration and irrigation practices; surface water diversions refined and verified through local, state and federal data; and groundwater pumping that reflects locally and regionally known trends. Model parameters associated with small watershed boundaries were calibrated to better represent boundary inflows from the foothills, and groundwater levels near the model boundaries. Calibration for groundwater system was further refined with adjustments to the aquifer hydrogeologic parameters to refine model simulation results relative to the observed general groundwater levels at selected wells, and observed streamflow at specific stream gaging stations. Model water budgets and calibration results, with recommendations on the next steps will be presented in this talk.

4. Application of C2VSim for SGMA Water Budgets for the Kern County Subbasin

Presenter(s): Michael Maley (Todd Groundwater) and Charles Brush (Hydrolytics LLC)
Presenter(s) Email Address(es): mmaley@toddgroundwater.com
Collaborators: Kern River GSA, Kern Groundwater Authority GSA
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
The Kern County Subbasin covers 3,000 square miles at the southern end of the San Joaquin Valley, is the largest subbasin in the state, and has been designated as critically-overdrafted by DWR. Multiple agencies conjunctively manage a complex system of groundwater, imported water, and local surface

water supplies to meet large agricultural and urban demands and to operate large-scale groundwater banking projects. Although several local project groundwater models had been developed, no local basin-wide groundwater model was available for analysis of historical, current, and projected water budgets as required by SGMA. Therefore, the regional C2VSimFG Beta model was selected for SGMA support. Our approach is to update the C2VSimFG Beta model with managed water supply (e.g., surface water deliveries and groundwater banking) and water demand (e.g., land use, ET data and urban use, and banking recovery) data provided by over 20 local water districts. These water supply and demand data were applied to the respective local application areas. Initial simulations identified several model details that required modification to better represent local conditions. The historical model results were compared to measured groundwater levels across the basin to validate the overall effectiveness of these changes. The projected baseline simulation was developed following the SGMA guidelines of using a 50-year sequence of historical hydrology conditions, current land and water use, and projected water supply data. The model-derived water budgets are being finalized and will be presented alongside local water budget data to support individual Groundwater Sustainability Plans.

Session 11. California Water Plan Update 2018: Envisioning, Tracking & Investing in California Water Sustainability

1. California Water Plan Update 2018: Managing Water Resources for Sustainability

Presenter(s): Paul Massera (California Dept. of Water Resources)
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Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The people and ecosystems of California are living a tale of extremes — drought and flood. Numerous critical challenges are threatening our state's water future such as groundwater overdraft, increasing water demands and flood risk, declining ecosystems, aging infrastructure, declining watershed health, including historic levels of tree mortality and resulting catastrophic wildfires. The California Water Plan Update 2018 (Update 2018) recommends actions to overcome these challenges, as well as systemic and institutional challenges that impede progress. Its six goals chart a path to manage water resources for sustainability:

- Improve Integrated Watershed Management.
- Strengthen Resiliency and Operational Flexibility of Existing and Future Infrastructure.
- Restore Critical Ecosystem Functions.
- Empower California's Under-Represented or Vulnerable Communities.
- Improve Inter-Agency Alignment and Address Persistent Regulatory Challenges.
- Support Real-Time Decision-Making, Adaptive Management and Long-Term Planning.

Update 2018 provides an operational description of statewide sustainably, a comprehensive and repeatable method to evaluate the sustainability of the state's water resources to help prioritize water policy and investment, and examines funding scenarios to implement the recommended actions.

For the state to effectively adapt to the many challenges, there are many choices all Californians must make. Update 2018 is a guide for making these choices to improve public health and safety, a healthy economy, ecosystem vitality, and opportunities for enriching human experiences.

2. Tracking Progress Toward Sustainability: The Sustainability Outlook
Presenter(s): Lew Moeller (California Dept. of Water Resources)
Presenter(s) Email Address(es): lewis.moeller@water.ca.gov
Collaborators: Paul Massera (DWR) and Kari Shively (Stantec)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Making water resource decisions, or taking actions, to align desirable outcomes with four basic societal values — public health and safety, healthy economy, ecosystem vitality, and enriching experiences — is critical to managing water for sustainability. It can be as simple as being mindful of not wasting water, and as complex as predicting and planning for the next drought or flood. Daily, every Californian is responsible for doing their part. But how will Californians know whether their actions are moving the state in the right direction?

One basic long-standing challenge to water resource resilience and reliability in California is the lack of a consistent, comprehensive, and practical method to collect, organize, and standardize data needed to enable water managers to evaluate status, trends, and outcomes to assess current and future sustainability. In addition, productive planning and the setting of policy priorities require a mutual understanding of challenges, resource limitations, management deficiencies, and shared intent. Accordingly, there is a need to develop data driven tools to identify, through the lens of the four societal values, desirable water management outcomes (intended outcomes) and indicators to track status and progress toward sustainability.

This presentation will focus on the Sustainability Outlook as an evolving method used for informing strategic planning and prioritization of water management actions (e.g., regulations, policies, projects) and investments within a watershed or region, setting intended outcomes consistent with the four societal values, and determining whether actual outcomes are consistent with intended outcomes.

3. Future Scenarios of Water Supply and Demand Conditions in the Central Valley, California through 2100: Impacts of Climate Change and Urban Growth
Presenter(s): Mohammad Rayej (California Dept. of Water Resources)
Presenter(s) Email Address(es): Mohammad.Rayej@water.ca.gov
Collaborators: Abdul Khan, Salma Kibrya, and Paul Shipman (California Dept. of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
A fully integrated water supply and demand model WEAP (Water Evaluation and Planning) was applied to project future water conditions in the Central Valley, California in support of California Water Plan Update 2018. Future scenarios are driven by changes in climate, population, urban growth and land use through 2100. The results include long term projections of water demands, supply deliveries and unmet demands (supply shortfalls) in agricultural, urban indoor, and urban outdoor sectors as well as long-term storages in major surface reservoirs and groundwater aquifers in the Central Valley. The future scenario analysis also includes vulnerability maps based on statistical frequency analysis to help identify vulnerable regions prone to long-term water shortages.

Session 12. FloodMAR: Using Flood Water for Managed Aquifer Recharge to Support Sustainable Water Resources

1. Integrated Decision Support Modeling for Supply Constrained Water Resources

Presenter(s): Richard Niswonger (USGS)
Presenter(s) Email Address(es): rniswon@usgs.gov
Collaborators: Wesley Kitlasten (USGS, Carson City, NV), Eric D. Morway (USGS, Carson City, NV), Murphy Gardner (USGS, Carson City, NV), Enrique Triana (RTI, Fort Collins, CO), R. Steven Regan (USGS, Lakewood, CO)
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
Flood-MAR has great potential to enhance sustainability of groundwater resources and improve water supply in California. As described in the literature, benefits and challenges of MAR are regionally dependent. Therefore, decision support modeling is an integral component of Flood-MAR planning and implementation. Recently, the GSFLOW and MODSIM models were integrated to simulate reservoir operations and water-rights allocation for Flood-MAR applications. MODSIM is a linked-flow network management model, and GSFLOW is an integrated hydrologic model. MODSIM-GSFLOW is an ideal tool for evaluating Flood-MAR where surface water is appropriated, reservoirs are managed for multiple purposes, and groundwater pumping captures surface water. MODSIM-GSFLOW can be used to evaluate impacts of climate change on water resources, including the impacts of an earlier snow-melt pulse, reduced summer flows, and other factors affecting Flood-MAR. MODSIM-GSFLOW applications will be presented to illustrate how modeling can be used for Flood-MAR planning and consideration of regionally specific factors.

2. Model Integration for the Merced River Basin Flood-MAR Reconnaissance Study

Presenter(s): David Arrate (DWR)
Presenter(s) Email Address(es): David.Arrate@water.ca.gov
Collaborators: Romain Maendly (DWR), Francisco Flores-Lopez (DWR), Alex Vdovichenko (DWR), Shem Stygar (DWR), Clark Churchill (DWR), Wyatt Arnold (DWR), Lee Bergfeld (MBK), Wesley Walker (MBK), Ali Taghavi (Woodard & Curran), Liz DaBramo (Woodard & Curran)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The California Department of Water Resources (DWR), in partnership with the Merced Irrigation District (MID), is conducting a preliminary study to ascertain the potential of Flood-MAR on the Merced River Basin within the San Joaquin Valley. This reconnaissance study is a proof of concept evaluating the feasibility and effectiveness of Flood-MAR and testing theories in overcoming barriers and challenges to project planning and implementation. This study will integrate the inputs and outputs of the following models: SAC-SMA-DS, CalLite, HEC-HMS, HEC-ResSim, HEC-RAS, HEC-FIA, IDC, GRAT, C2VSIM, and potentially unspecified environmental and economic models. The presentation will show how at least nine different modeling tools and extensive data sets are being used and integrated to model flows from headwater in the Merced River watershed to groundwater using the agricultural fields within the MID area for both current conditions and climate change scenarios. This presentation will show how each model was setup, modified, and adapted for use in this Flood-MAR study and how integration issues such as time step and file formats have been resolved. The objectives of this study

are to quantify the flood risk reduction, groundwater recharge, ecosystem enhancement, and other benefits of potential Flood-MAR projects in the Merced River Basin.

3. Flood MAR Recharge Schedule and Allocation Modeled though IDC-GRAT

Presenter(s): Francisco Flores-López (DWR)
Presenter(s) Email Address(es): Francisco.FloresLopez@water.ca.gov
Collaborators: Daniel Mountjoy (Sust. Conserv.), Glen Low (Earth Genome), David Arrate (DWR), Alex Vdovichenko (DWR), Shem Stygar (DWR), Romain Maendly (DWR), Wyatt Arnold (DWR), Jennifer Marr (DWR), James Wieking (DWR), Lee Bergfeld (MBK), Wesley Walker (MBK), Sercan Ceyhan (Woodard & Curran), Liz DaBramo (Woodard & Curran), Ali Taghavi (Woodard & Curran)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Integrating water management activities, from the headwaters to groundwater, can help water managers maximize their water supply portfolio and support multiple benefits. Using flood water resulting from, or in anticipation of, rainfall or snow melt for managed aquifer recharge on agricultural lands, working landscapes, and managed natural lands (i.e., Flood-MAR) is an integrated resource management strategy that can support multiple benefits. DWR is currently evaluating Flood-MAR opportunities at the watershed scale in the Merced River Basin. The Merced River Basin reconnaissance study integrates eight different modeling tools and extensive data sets to quantify flood risk reduction, groundwater recharge potential, and other benefits using the agricultural fields within the Merced Irrigation District (MID). This presentation focuses on diverting available flood water to working agricultural fields within the MID service area to estimate the potential groundwater recharge.

Famers are justifiably concerned about the crop health effects of applying excess water on agricultural lands and field studies of this new recharge strategy are limited. DWR's Integrated Water Flow Model Demand Calculator (IDC) is used to simulate root zone saturation levels in different crop/soil combinations to determine the acceptable recharge duration and dry down interval to maintain acceptable soil oxygen conditions. The output of this analysis informs how Groundwater Recharge Assessment Tool (GRAT) calculates the amount of water that can be applied across an agricultural region during peak water availability events. The results of these tools are critical to identify the highest potential for recharge locations on agricultural landscapes while preserving crop health.

4. Water Available for Flood-MAR and Reservoir Operations Vulnerability Assessment

Presenter(s): Aleksander Vdovichenko (DWR)
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Collaborators: Lee Bergfeld (MBK), Francisco Flores-Lopez (DWR), David Arrate (DWR), Romain Maendly (DWR), Shem Stygar (DWR), Clark Churchill (DWR), Wyatt Arnold (DWR), Wesley Walker (MBK), Ali Taghavi (Woodard & Curran), Liz DaBramo (Woodard & Curran)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Merced Flood-MAR study is a DWR led evaluation of multiple levels of Flood-MAR implementation, with one aspect focusing on reservoir operations. The Merced HEC-ResSim Planning-Level Model was developed to simulate the existing and modified reservoir operations to determine water available for Flood-MAR. The Flood-MAR deliveries are calculated based on four factors which can be considered collectively or individually. These factors include the reservoir spill and snowmelt releases, flow at a downstream location, conveyance capacity, and groundwater recharge capacity and local practices.

Using the reservoir operation rules and the four factors, the model calculates the Merced River flow, canal deliveries, and Flood-MAR deliveries which will be used in other aspects of the study.

In addition, the study assesses the vulnerability of reservoir operations due to changing hydrology by evaluating the effects of climate change on flood management, water supply reliability, and drought resiliency. The flood management aspect of the vulnerability analysis includes an assessment of the change in flow peaks, flow volume and duration of flooding events. The water supply reliability was evaluated by assessing the change in carryover storage and deliveries for irrigation demands. The drought resiliency assessment includes the change in magnitude and duration of the historical and future drought events. The results of the reservoir operations vulnerability analysis will be used to determine the multiple benefits of Flood-MAR implementation.

5. The Diversity of Flood-MAR and Framing Potential Modeling Challenges, Opportunities and Considerations

Presenter(s): Philip Bachand (Bachand & Associates)
Presenter(s) Email Address(es): philip@bachandassociates.com
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract: Flood – Managed Aquifer Recharge (Flood-MAR) has gained great interest in the age of the Sustainable Groundwater Management Act (SGMA) as Groundwater Sustainability Agencies (GSAs) and participating stakeholders in medium, high and critically overdrafted basins begin developing strategies for sustainable groundwater management. Potential Flood-MAR opportunities range across scale and infrastructure, and across geography and regions. Thus, Flood-MAR concept encompasses a diversity of approaches, environments, benefits, and stakeholders. Full benefits from its implementation could extend beyond the local jurisdiction of GSAs but only fully realized through more regional coordination and collaboration associated with water and natural resources management in California. This presentation discusses different Flood-MAR case studies in California representing the diversity of systems, and the associated technical, logistical and social opportunities and challenges. From these case studies, we identify examples of data and information gaps, and the potential considerations in developing and applying models and other analytical tools.

Session 13. Evolutionary Optimization & Machine Learning in California Water Resources

1. Balancing Flood Risk and Water Supply in California: Policy Optimization Integrating Uncertain Forecast Information and Groundwater Banking

Presenter(s): Jon Herman (UC Davis)
Presenter(s) Email Address(es): jdherman@ucdavis.edu
Collaborators: Scott Steinschneider (Cornell University)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Short-term weather forecasts are not codified into the operating policies of federal, multi-purpose reservoirs, despite their potential to improve service provision. This is particularly true for facilities that provide flood protection and water supply, since the potential flood damages are often too severe to accept the risk of inaccurate forecasts. Instead, operators must maintain empty storage capacity to mitigate flood risk, even if the system is currently in drought, as occurred in California from 2012-2016. This study investigates the potential for forecast-informed operating rules to improve water supply

efficiency while maintaining flood protection, combining state-of-the-art weather hindcasts with a novel tree-based policy optimization framework. We hypothesize that forecasts need only accurately predict the occurrence of a storm, rather than its intensity, to be effective in regions like California where wintertime, synoptic-scale storms dominate the flood regime. We also investigate the potential for downstream groundwater injection to improve the utility of forecasts. These hypotheses are tested in a case study of Folsom Reservoir on the American River. Because available weather hindcasts are relatively short (10-20 years), we propose a new statistical framework to develop synthetic forecasts to assess the risk associated with inaccurate forecasts. The efficiency of operating policies is tested across a range of scenarios that include varying forecast skill and additional groundwater pumping capacity. Results suggest that the combined use of groundwater storage and short-term weather forecasts can substantially improve the tradeoff between water supply and flood control objectives in large, multi-purpose reservoirs in California.

2. Natural Streamflow and Geomorphic Classification for the State of California

Presenter(s): Samuel Sandoval Solis (UC Davis)
Presenter(s) Email Address(es): samsandoval@ucdavis.edu
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Alterations to flow regimes from regulation for human use and climate change affect the functioning of rivers. However, the absence of a quantitative, transferable framework for evaluating the relationships between hydrologic inputs, geomorphic functions, and ecological responses remains a major limitation to setting environmental flows standards. This research addresses this gap by developing a hydrologic classification for the State of California and a geomorphic classification for the Sacramento basin and the entire coast of California. The framework organizes river reaches into: (1) *natural streamflow classes* based on (a) a classification model that clustered hydrologic indices calculated directly from unimpaired streamflow data and (b) a regression model using a set of climatic, landscape and local geomorphic controls over the flow regime, (2) a series of seasonal flow characteristics called *functional flow components* constrained by temporal (seasonal) ranges and hydrologic (average flow percentile-based) thresholds (e.g. summer low flows), (3) a *geomorphic classification* that identifies main channel types (e.g. riffle-pool) based on field data collection and cluster analysis of main geomorphic characteristics. Organizing hydrologic and geomorphic data by natural streamflow and geomorphic classifications provides a means of understanding relationships between flow and channel forms that are important for environmental conservation and restoration of aquatic and riparian ecosystems throughout the State of California.

3. Policy Search for California Water Supply Adaptation to Snowpack Decline

Presenter(s): Jonathan Cohen (UC Davis)
Presenter(s) Email Address(es): joncohen@ucdavis.edu
Collaborators: H.B. Zeff (UNC Chapel Hill), Jon Herman (UC Davis)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
While the impacts of climate change on annual runoff volumes remain highly uncertain, the effects of rising temperatures on snowpack are projected with high confidence. The continuing shift from snow to rain in snowmelt-driven basins will cause an intra-annual shift in the hydrologic flow regime, effectively shifting reservoir inflow magnitudes early in the water year. This will reduce inflows during the critical reservoir refill period from April through June. As well, seasonal snowpack-to-streamflow

forecasts assuming stationary hydrology will become increasingly inaccurate, diminishing intra-annual predictability. We test the impacts of these nonstationary effects on operations of the California Central Valley water supply network using the newly developed ORCA (Operation of Reservoirs in California) simulation model. ORCA incorporates operating rules for major reservoirs in the northern Sierra Nevada and management of the Sacramento-San Joaquin Delta. After identifying water supply vulnerabilities in an ensemble of climate projections, opportunities for adaptation are explored via the top of conservation pool curve, release curtailment rules, and snowpack-to-streamflow forecasting methods. We employ a multi-objective evolutionary algorithm to search for optimal combinations of these policies under 70 random scenarios for the time period 2069-2099, during which the effects of snowpack decline become prevalent. The policy search minimizes flood risk while maximizing carryover storage, Delta outflow, and CVP and SWP Delta pumping exports. After cross-validation against the remaining scenarios, results show that shifting the reservoir refill period slightly earlier in time enables policies that trade off a small amount of flood risk while improving upon the other three objectives.

4. Comparing Machine Learning Methods for Dynamically Identifying Future Water Supply Vulnerabilities in the Northern California Reservoir System

Presenter(s): Bethany Robinson (UC Davis)
Presenter(s) Email Address(es): bjrobins@ucdavis.edu
Collaborators: Jon Herman (UC Davis)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Adaptation to climate change will depend on the ability to identify signals in observed hydrologic data that reliably indicate future vulnerabilities. This study compares a variety of machine learning methods for this purpose, testing which of multiple indicator variables can predict changes in reservoir supply reliability (regression) and binary vulnerability outcomes (classification) over lead times between 0 and 20 years. Methods are tested using a multi-reservoir simulation model called Operation of Reservoirs in California (ORCA) to simulate the reliability of the northern California reservoir system for an ensemble of downscaled CMIP5 inflow scenarios. The indicator variables and reliability metrics are calculated dynamically over multiple rolling windows to identify trends in observations. Regression methods are compared using R-squared, while classification methods are compared using precision and recall. Common issues such as overfitting are discussed for all methods. Preliminary results show that very few (under 5) indicators can still reliably predict reliability, suggesting a promising tradeoff between the number of indicator variables and the performance of the machine learning methods. Longer rolling windows of reliability (up to 50 years) can be predicted more accurately than shorter windows (e.g. 1-year lead time). The multivariate combination of indicator values that precede drops in system reliability, balancing the tradeoff between error rate and lead time, represent signals that may be used in this system to indicate future vulnerability based on observations. These signals can be used to improve monitoring of long-term water supply vulnerabilities, allowing planners to better design adaptation pathways under a changing climate.

5. Martinez Salinity Estimation using Deep Learning

Presenter(s): Kevin He (CA DWR)
Presenter(s) Email Address(es): kevin.he@water.ca.gov
Collaborators: Nicky Sandhu, Liheng Zhong, Yu Zhou, Kijin Nam (CA DWR)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Modeling the flow-salinity relationship at Martinez, the downstream boundary of the Sacramento-San Joaquin Delta (Delta), plays an important role in guiding real-time Delta operations as well as long-term Delta planning activities. Previous efforts have applied a conceptual-empirical model (Martinez Salinity Generator (MSG)) and a data-driven model (multi-layer perceptron (MLP) neural network) to derive Martinez salinity based on net Delta outflow (NDO) and the stage at Martinez. This study proposes a new deep learning approach, the Long Short-Term Memory (LSTM) network, to estimate salinity at Martinez. LSTM is a special type of recurrent neural networks (RNNs), designed to model long-term dependencies more accurately than conventional RNNs. Martinez salinity and stage data along with NDO data in two 12-year periods (1991-2002 and 2003-2014) are utilized to train and test LSTM, respectively. Results indicate that LSTM provides Martinez salinity estimates that are comparable or superior to their counterparts obtained from the calibrated MSG and trained MLP. The Nash-Sutcliffe Efficiency values of Martinez salinity estimates derived from three methods (LSTM, calibrated MSG, and MLP) over the testing period are 0.943, 0.928, and 0.926, respectively. The corresponding Root Mean Square Errors are 1996, 2249, and 2269 μS/cm, respectively. Overall, the study indicates that LSTM has the potential to supplement the current practice in estimating Martinez salinity.

Session 15. Integrated Water Resources Modeling – State of Science & Applications

1. Updates on the IWFM Features

Presenter(s): Emin Can Dogrul (California Department of Water Resources)
Presenter(s) Email Address(es): Can.Dogrul@water.ca.gov
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
As the questions that arise for the planning and management of water resources become more complex, new features are being added to IWFM to address these challenging questions. This presentation will outline new and improved features of IWFM as well as plans for future developments. Two new developments, model feature tagging and multi-model simulations, are particularly exciting. Model feature tagging allows easy addition of new model features (i.e. elements, nodes, streams, etc.) to an already developed IWFM model, local grid refinement and extraction of child models from parent models. Multi-model simulations allow linking two or more IWFM models developed independently for neighboring areas. The linked models don't need to have computational grids aligned perfectly in the horizontal and vertical directions. Linkage can be described for both subsurface (groundwater flow) and surface flows (stream flows, bypasses, diversions, etc). Possible uses of the multi-model simulation feature include linking local IWFM models to C2VSim for boundary conditions, linking neighboring local IWFM models to study the effect of water resources management strategies in one model area on the neighboring model areas. Other developments include updated stream-aquifer interaction, subsidence calculations and the public release of IWFM Application Programming Interface (API).

2. Texture2Par: A Parameterization Utility for IWFM and MODFLOW

Presenter(s): Vivek Bedekar (S.S. Papadopulos & Associates, Inc. - SSP&A)
Presenter(s) Email Address(es): vivekb@sspa.com
Collaborators: Leland Scantlebury (SSP&A), Marinko Karanovic (SSP&A), Matt Tonkin (SSP&A)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Texture2Par is a pre-processing utility program designed for use with IWFM and MODFLOW models. Texture2Par facilitates the assignment of aquifer parameter values directly to IWFM and MODFLOW model input files on the basis of sediment texture data acquired from stratigraphic logs. The aquifer properties that can be ascribed using Texture2Par are: horizonal hydraulic conductivity, vertical hydraulic conductivity, specific yield and specific storage. Texture2Par uses estimates of soil coarseness derived from stratigraphic logs for inferring values for aquifer properties. Model-wide, spatially distributed aquifer properties are computed by Texture2Par based on information about the model discretization; values for each aquifer property corresponding to entirely coarse and entirely fine material; and, values for the percentage of coarse material at boring locations. A relatively small number of inputs is required to generate spatially distributed, potentially heterogeneous, parameter values throughout a model domain. This enables Texture2Par to be easily integrated within a parsimonious model calibration (parameter estimation) workflow that utilizes sediment texture data. In some instances, the percent coarseness of sediments translates to different values for bulk aquifer properties in different areas: for instance, in areas of differing cementation, compaction or sorting. To accommodate this, Texture2Par incorporates pilot points enabling the values for aquifer parameters associated with entirely coarse and entirely fine textures (and all fractions lying in between) to vary in space. Pilot points can be grouped with specific model nodes or cells to form distinct geological zones that exhibit different relationships between sediment texture and aquifer properties. Examples are presented here using the Sacramento Valley implementation of the IFWM code, SVSIM.

3. Using the Ensemble Smoother to Calibrate Complex Integrated Hydrologic Models

Presenter(s): Ayman Alzraiee (USGS)
Presenter(s) Email Address(es): aalzraiee@usgs.gov
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: No

Abstract:
Calibration of input parameters in complex models is largely hampered by the expensive computational cost required to compute the parameter-observation sensitivity matrix (Jacobian Matrix). Data assimilation-based (DA) methods, such as the Ensemble Smoother (ES), Ensemble Kalman Filter (EnKF), and Ensemble Kalman Smoother (EnKS), avoid the explicit computation of the Jacobian matrix by generating an ensemble of realizations for model input and response variables that are used by the DA procedure to update both model input parameters and output given a set of observations. These methods have successfully estimated a large number of unknown parameters (~10^6) using a relatively small number (~10^2–10^3) of forward model runs. Additionally, DA methods offer a unified framework in which both parameter estimation and uncertainty quantification are achieved simultaneously. A case study for using the Ensemble Smoother to calibrate a complex integrated hydrologic model demonstrates the ability of the DA method to estimate a large number of input parameters at high spatial resolution.

4. Eastern San Joaquin Water Resources Model (ESJWRM) & Applications to SGMA

Presenter(s): Sara Miller (Woodard & Curran)
Presenter(s) Email Address(es): smiller@woodardcurran.com
Collaborators: Ali Taghavi (Woodard & Curran), San Joaquin County, Local Agency Representatives
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
The Eastern San Joaquin Water Resources Model (ESJWRM) was built on an IWFM-2015 (Integrated Water Flow Model) platform and was developed over the past several years to support development of a Groundwater Sustainability Plan (GSP). The calibrated model with a monthly hydrologic period covering water years 1969 through 2018 is used as the basis for analyzing historical, current and projected water budgets; potential impacts of climate change; stainable groundwater management conditions; potential effects of proposed actions and projects; and potential directions for sustainability indicators. The model was developed with the collaboration of a dedicated stakeholder group of local agency representatives. The model development process and application and analysis to support GSP development will be presented.

Session 16. Bay-Delta Modeling

1. DSM2 GTM Sediment Bed Integration

Presenter(s): Ali Abrishamchi (California Department of Water Resources)
Presenter(s) Email Address(es): Ali.Abrishamchi@water.ca.gov
Collaborators: Kijin Nam (California Department of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
The California Department of Water Resources Delta Modeling Section is developing a new Delta Simulation Model 2 (DSM2) General Transport Model (GTM) as a part of the DSM2 modeling suite. GTM was designed so that other water quality modules could be added to it. A suspended sediment module, which is referred to as the GTM-SED, is being developed and has been preliminarily calibrated for the Delta. In parallel, a group of mercury experts are developing GTM modules for mercury and bed sediments, since sediment in the river bed is closely tied to the fate of mercury. This sediment bed module is integrated into the GTM-SED to improve the interaction between bed sediments and suspended sediments in the water column. The integration involved updates to the GTM suspended sediment implementation, and the revised GTM-SED module was then preliminarily re-calibrated to reflect the effect of the updates by changing the erosion coefficient, particle sizes, and boundary suspended sediment concentration (SSC) compositions. The best performing erosion coefficient is found between 10^{-8} and 10^{-7} kg/m^2/s, and fine particle diameter of 0.004 mm and sand diameter of 0.5 mm or 2 mm was found to perform well. Also, the results showed much lower suspended sediment concentration in the central Delta than at the upstream Sacramento River and San Joaquin River domain boundaries due to quick sediment settling in the upstream area.

2. The Effect of Hydrodynamics on Outmigrating Chinook Salmon Swimming and Route Selection
Presenter(s): Edward Gross (RMA/U.C. Davis)
Presenter(s) Email Address(es): edgross@ucdavis.edu
Collaborators: Rusty Holleman, Michael Thomas
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
Out-migrating Chinook salmon smolt route selection influences the likelihood of salvage or entrainment at water export facilities and natural mortality in the estuary. Smolt swimming behavior may influence route selection at junctions. In order to evaluate the influence of salmon swimming on salmon distribution and route selection, multi-dimensional acoustic telemetry data has been collected at the junction of the San Joaquin River and the head of Old River. The dataset has been analyzed to determine the trajectory and velocity over ground of tagged smolts. An approach to identify likely behavior change points has been developed. In addition, a high-resolution three-dimensional hydrodynamic model of the region has been developed. The model results are used to estimate hydrodynamic velocity along with the observed smolt telemetry tracks. The vector difference of the velocity over ground and hydrodynamic velocity provides an estimate of salmon smolt swimming speed. Several uncertainties limit the accuracy of swimming speed estimates including uncertainty in vertical position of smolts in the acoustic telemetry data and imperfect velocity predictions by the hydrodynamic model. The uncertainty of swimming speed estimates is evaluated as a step toward developing relationships between environmental stimuli and swimming behaviors.

3. Refining DETAW Evapotranspiration using Remote Sensing Data
Presenter(s): Lan Liang (DWR)
Presenter(s) Email Address(es): lan.liang@water.ca.gov
Collaborators: Tariq Kadir and Bob Suits
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The model DETAW (Delta Evapotranspiration of Applied Water) v2.0 developed by the Bay-Delta Office, Department of Water Resources, simulates the actual evapotranspiration (ETa) and root zone water balance in 168 subareas and for 15 land use categories in the Sacramento-San Joaquin Delta. Although ETa Delta-wide was calibrated and validated, ETa at the local scale requires refinement, due to limited data when DETAW was originally developed. In recent years, high spatial resolution Delta ETa estimated by multiple remote sensing models have been developed. Among those, ETa estimated by METRIC (Mapping Evapotranspiration at High Resolution with Internalized Calibration) by the ITRC (Irrigation Training and Research Center at California Polytechnic State University) for 2011, 2014, 2015 and 2016, UCD-PT (Optimized Priestley-Taylor) by University of California, Davis for 2015, DisALEXI (Disaggregated Atmosphere-Land Exchange Inverse Method) by Agricultural Research Service, Department of Agriculture for 2015, and METRIC by Land IQ, Inc., for 2015, were selected and analyzed using ArcGIS. The statistics of monthly ETa for each of the DETAW subareas and land use categories were computed. This analysis aims to extract the deterministic characteristics of the spatial and temporal distribution of ETa in the Delta, which will be used to recalibrate DETAW ETa at the local scale. Since DETAW's integration with the Delta Channel Depletion model v1.0 (DCD1.0) and Delta Simulation Model 2(DSM2), the reliable local scale ETa should improve the estimates of Delta local drainages, diversions, flow circulation and water quality as well.

4. DSM2 GIS Reference

Presenter(s): Bradley Tom (DWR)
Presenter(s) Email Address(es): Bradley.Tom@water.ca.gov
Collaborators: Nicky Sandhu, Kevin He
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:

The DSM2 GIS Reference Project is an update of all information in DSM2 that is derived from georeferenced information. The project's basic principle is that all information that is georeferenced or derived from georeferenced information will be first input into one of the GIS tools used for DSM2, which include ArcGIS, QGIS, and the DSM2 Cross-Section Development Program (CSDP). We are using the CSDP to update cross-sections using bathymetry data collected since the last update, and to calculate more accurate channel lengths. We will also update reservoir data, output locations, and gate positions using GIS. We will then recalibrate the Hydro and Qual models. We will then release a recalibrated DSM2 model, a summary report, and an improved CSDP with updated documentation.

5. Quantifying the Effect of 20 Years of Land Use Change on San Francisco Bay Area Hydrology

Presenter(s): Jing Wu (San Francisco Estuary Institute)
Presenter(s) Email Address(es): jingw@sfei.org
Collaborators: David Senn, Pete Kauhanen (San Francisco Estuary Institute)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:

Water resources management is critical in San Francisco Bay area which is home to over 7 million people and counting. During the past 20 years, impervious surface associated with population increase and urbanization has increased by 10%. The changes in land uses have profound impact on local hydrology and delivery and transport of stormwater pollutant loads, which has important ramification for local and regional water supply, flood control, and stormwater pollution control.

A regional hydrological model, based on USEPA's HSPF (Hydrological Simulation Program-Fortran), was developed to quantify the significant changes in hydrology that have occurred between 1990s and 2016 due to land use change. The model was calibrated at 8 USGS stations where long-term flow data are available. The calibrated model was then used to estimate the changes in flow volume and peak flow for individual watersheds as well as the region as a whole. The model results show that changes in flow volume could range from 5% to 75%, while peak flow could become two to three times higher. And the changes in land use have bigger impact on small storms than large storms. These estimates provide stakeholders and government agencies with critical and quantitative information to better support water resources management in the region. As the region is projected with continuous urban growth and compounded with future climate changes, this regional model could serve as a powerful tool to understand the impact of climate change and land use on local hydrology and stormwater pollutant loads.

Session 17. Central Valley Integrated Hydrologic Model Applications & Tools for Sustainable Groundwater Management & Planning

1. SGMA Climate Change Desktop Tools for IWFM and MODFLOW

Presenter(s): Craig Cooledge (Jacobs)
Presenter(s) Email Address(es): craig.cooledge@jacobs.com
Collaborators: Tyler Hatch (DWR), Wyatt Arnold (DWR)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Groundwater Sustainability Plan regulations require the development of projected water budgets over the 50-year planning and implementation horizon for compliance with the California Sustainable Groundwater Management Act of 2014. The California Department of Water Resources (DWR) has provided climate change datasets (gridded precipitation and evapotranspiration change factors), for four future scenarios, for usage in the development of projected water budgets. Many Groundwater Sustainability Agencies will utilize numerical models in the development of these projected water budgets. To help facilitate the development of projected groundwater budgets, DWR has released two toolsets to assist in the incorporation of changes in climate for IWFM and MODFLOW based models. The two toolsets have been developed with the Python programming language and implemented in the ESRI ArcGIS platform in the form of an ArcToolbox. The toolbox facilitates the mapping of the IWFM or MODFLOW grid to the Variable Infiltration Capacity (VIC) grid to establish a spatial relationship between the user's groundwater flow model and VIC. Historic precipitation and evapotranspiration timeseries are then perturbed using change factors to produce projected climate inputs based on the climate scenarios. Final tool outputs can then be plugged directly into the groundwater model. Presentation attendees will leave the session with a general understanding of the DWR climate change products and associated tools, that will help facilitate the development of project water budgets. Utilizing these resources could significantly reduce the burden of generating projected water budgets using a numerical model.

2. Updates to California's Central Valley Hydrologic Model

Presenter(s): Jon Traum (USGS)
Presenter(s) Email Address(es): jtraum@usgs.gov
Collaborators: Claudia Faunt (USGS)
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
The US Geological Survey (USGS) originally developed the Central Valley Hydrologic Model (CVHM) to quantify groundwater availability. For a variety of reasons, including supporting tools and analyses needed to implement the Sustainable Groundwater Management Act (SGMA), the CVHM is being extensively updated and refined. This new version of the model is referred to as CVHM2. Major updates in CVHM2 include updates to the model framework and stresses and extensive updates to the numerical code. The updates to the framework and stresses include: enhanced details in the properties to define subsidence, an extended model simulation period, increased resolution on the water balance subregions and number of layers, addition of water banking, underflow from small watersheds, and updated land use and surface-water delivery data. The numerical code has been updated from MODFLOW-FMP1 to MODFLOW-OWHM2, which utilizes FMP4. CVHM2 utilizes many new OWHM2 features, which provide a more accurate and complete simulation of hydrologic processes. The OWHM2 code also simplifies the input datasets of many MODFLOW packages, which aid in the construction and modification of model input files. An example is the enhanced simulation of semi-

routed surface water deliveries in OWHM2, which allows for a simplified construction of the stream flow routing (SFR) network. OWHM2 also includes additional options for generating model output, which minimize the required post-processing to develop water budgets and allow the user to more easily evaluate and visualize complex model outputs such as land subsidence. To provide information for SGMA, the USGS and California Department of Water Resources (CA-DWR) are capitalizing on these simplified input and output datasets to compare the USGS's CVHM2 and CA-DWR's C2VSIM models with an initial focus on input datasets. The purpose of this comparison is to understand and explain existing differences between the models and, where possible, improve both models.

3. C2VSimFG Updates and Early Comparisons with CVHM2

Presenter(s): Tyler Hatch (DWR)
Presenter(s) Email Address(es): tyler.hatch@water.ca.gov
Collaborators: Can Dogrul (DWR), Dominick Amador (Woodard Curran), Mesut Cayar (Woodard Curran), Andres Guillen (Woodard Curran), Jon Traum (USGS), Claudia Faunt (USGS)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Department of Water Resources has been updating the fine-grid version of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG). Ongoing efforts to reduce model uncertainty and minimize error have led to some notable revisions to the model since May 2018. In addition, outreach to several local agencies has resulted in additional information to help fill gaps in the input data. Since C2VSimFG simulates the same domain as CVHM2, coordination between DWR and the USGS has been ongoing to compare the models. Phase 1 of this comparison has focused on input datasets, including: precipitation, rim hydrology, diversions, evapotranspiration, and land use. Future phases of comparison will involve noting differences in model structure as well as comparing model results. The goal of the comparison effort is to provide awareness of the similarities and differences and work towards alignment on key datasets and model processes for better consistency among users. Attendees of this presentation will get a better understanding of the changes to C2VSimFG since the May 2018 Beta release, the release schedule for the first full version, and initial findings of select input data comparisons between C2VSimFG and CVHM2.

4. Application of a Fine Scale Water Balance Model to Support Groundwater Sustainability Assessments

Presenter(s): Michelle Stern (USGS)
Presenter(s) Email Address(es): mstern@usgs.gov
Collaborators: Lorraine Flint, Alan Flint
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Long-term historical climate, evapotranspiration, and recharge and runoff estimates are vital to quantifying how the water supply within a hydrologic basin or region has changed and how it will change under future projected climate. The Basin Characterization Model (BCM) is a fine-scale, spatially distributed water balance model that provides monthly estimates of climate, plant water use, and natural (unimpaired) recharge and runoff in a basin under historical and future climate conditions. The BCM uses monthly climate grids that are spatially downscaled to 270-meter resolution to calculate potential evapotranspiration, snow accumulation and melt, soil storage, actual evapotranspiration, recharge, and runoff at a monthly time step. The BCM has been calibrated regionally for California and applied in numerous watersheds and sub-watersheds using a local calibration in many locations. Applications of the BCM include development of groundwater basin-specific boundary conditions of

natural recharge and runoff to support groundwater models such as One Water, MODFLOW, and the Central Valley Hydrologic Model. Other applications include scenario testing to evaluate changes in water supply components as a result of changes in land use (urbanization or agriculture), soil management, climate, and managed aquifer recharge using flooding in agricultural areas. Examples will be shown that can support activities to understand the sustainability of groundwater under varying climatic, land use, and management scenarios.

Session 18. Grab Bag

1. Optimal Selection and Placement of Green Infrastructure for Urban Stormwater Management
Presenter(s): Jing Wu (San Francisco Estuary Institute)
Presenter(s) Email Address(es): jingw@sfei.org
Collaborators: Pete Kauhanen, Jen Hunt, Tony Hale, Lester McKee
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Addressing stormwater runoff and pollution challenges associated with urbanization is complex and often relies on costly engineering, especially in highly-developed urban environments. Increasingly, distributed management of stormwater runoff using Green infrastructure (GI) has emerged as a multi-benefit solution that can address both stormwater quality and quantity concerns. However, planning and implementing GI cost-effectively to achieve management goals remains a challenge and requires an integrated watershed approach.

GreenPlan-IT, a planning tool that couples Non-dominated Sorting Genetic Algorithm (NSGA-II) with SWMM, was used to identify near-optimal combinations of GIs that maximize stormwater volume/pollutant load reduction and minimize total relative cost at a watershed scale. The selection and placement of four GI types (bioretention, permeable pavement, tree box, and flow-through planter) were analyzed based on their cost and effectiveness. The results show that between optimal solutions and non-optimal solutions, the effectiveness in load reduction could vary as much as 30% and the difference in total relative cost could be well over $100 million. Such an analysis provides stormwater managers with a wide range of near-optimal retrofit and buildout scenarios that take into consideration environmental benefits and economic costs of various GI alternatives and could be used to inform policy decisions regarding future stormwater management investments. It also highlights the benefit of using an integrated watershed approach to help identify the most cost-effective solutions for achieving management goals with a limited budget.

2. Hydrograph Pattern Identification Using Fuzzy Cluster Analysis
Presenter(s): Matthew Tonkin (S.S. Papadopulos & Associates, Inc. - SSP&A)
Presenter(s) Email Address(es): matt@sspa.com
Collaborators: Matthew O'Connell (SSP&A), Vivek Bedekar (SSP&A)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Groundwater models are usually calibrated based on model-wide groundwater level measurements. Often, large-scale models cannot represent fine details of individual hydrographs for many reasons including the model spatial discretization (e.g. several monitoring wells may be located within a single model cell), limits on the model representation of fine-scale features and processes, and imperfect knowledge or representation of short-duration perturbations in stresses impacting individual well hydrographs. However, if the primary modeling objective is resource management via water budget

analysis such differences may provide a “noisy” distraction from the overarching objective of identifying, modeling, and calibrating to, dominant cause-effect relationships. One solution to this problem is to select fewer well hydrographs for calibration, that are “most representative” of these dominant relationships. Here, this selection is facilitated by a hydrograph pattern identification procedure developed using fuzzy cluster analysis. The procedure identifies dominant signals in time-series data and groups wells into “clusters” using inter-well correlations, whereby wells that exhibit sufficiently similar patterns of time-varying behavior attain membership of the same cluster. A “characteristic hydrograph” can be constructed for each cluster that exhibits the dominant patterns expressed within that cluster. This can reduce the noise in the calibration dataset and enable calibration to focus on reproducing those patterns by, for example, (a) condensing the original (raw) data to much smaller number of “characteristic hydrographs” for use directly as calibration targets; (b) retaining the raw data, but weighting observations based on their correlation with the “characteristic hydrographs”; or, other procedures that focus the calibration on the salient groundwater responses. Examples are presented here using the Sacramento Valley implementation of the IFWM code, SVSIM.

3. A Comparison of CalSimII and CalSim3: Parallel Application of Two Planning Models

Presenter(s): James Gilbert (Bureau of Reclamation)
Presenter(s) Email Address(es): jmgilbert@usbr.gov
Collaborators: Nancy Parker (Bureau of Reclamation)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Development and review of the combined Sacramento-San Joaquin CalSim3 model is occurring in parallel with continued application of CalSimII to operations and planning analysis of the CVP and SWP. As part of ongoing testing of the preliminary version of the combined CalSim3 model, we have adapted recent CalSimII analysis studies to the CalSim3 framework. We will present a summary of each study, describe implementation differences (and consistencies) between CalSimII and CalSim3, and highlight comparisons of key results.

4. Expansion of CalSim3 into the Tulare Basin

Presenter(s): Lauren Thatch (Bureau of Reclamation, Colorado School of Mines)
Presenter(s) Email Address(es): lthatch@usbr.gov
Collaborators: James Gilbert (Bureau of Reclamation), Nancy Parker (Bureau of Reclamation), Andy Draper (Stantec)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Historically, the representation of water conveyance and use in the Tulare Basin of California’s Central Valley has been greatly simplified in CalSim modeling applications. Given the increased focus on groundwater sustainability in the region brought about by SGMA, the expansion of CalSim3 to include the dynamics of the Tulare Basin represents considerable potential as an analytical tool. Reclamation has initiated expansion of the CalSim3 model to include the major water supply and use components within the Kings, Kaweah, Tule, and Kern River drainages. We will present an overview of ongoing CalSim3 development efforts for this region, including: Water Budget Area and Demand Unit delineations, system connectivity, and synthesis of hydrologic inputs.

5. New Agricultural Water Use Package for MODFLOW and GSFLOW
Presenter(s): Richard Niswonger (USGS)
Presenter(s) Email Address(es): rniswon@usgs.gov
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
The agricultural Water Use (AG) Package was developed for simulating demand-driven and supply-constrained agricultural water use in GSFLOW models. The AG Package makes use of existing hydrologic simulation capabilities provided by GSFLOW. Distribution of water for irrigation is automatically simulated using daily potential evapotranspiration and the antecedent soil-water conditions. Net irrigation water requirement (NIWR) is diverted into canals and routed to fields using the MODFLOW SFR Package, or NIWR can be supplied/supplemented by groundwater wells. NIWR can be simulated following 3 different options, including: user-specified, optimal irrigation for well-water conditions, and using a trigger threshold and specified irrigation duration and rate. Combined with MODFLOW or GSFLOW, the AG Package can simulate dynamic agricultural water use in developed basins while providing flexibility to represent a range of grower behaviors and irrigation infrastructure.

Session 19. Poster Session

1. Spatial Analytics to Support Multi-Benefit Landscape Planning in the Face of Stressed Water Resources
Presenter(s): Benjamin Bryant (Water in the West and the Natural Capital Project, Stanford University)
Presenter(s) Email Address(es): bpbryant@stanford.edu
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
Water availability is a major driver of land use decisions, and plays a particularly stark role in California's Central Valley. Availability and reliability of water most obviously play a role in determining where and what crops to cultivate. However, the constraints imposed by the Sustainable Groundwater Management Act, along with climate-driven variability, have increased interest in alternative land uses that can help adapt to scarcity and variability, either by providing alternative revenue streams, or by augmenting accessible water resources. Examples include flood-managed aquifer recharge with dedicated and on-farm elements, as well as coordinated temporary and permanent fallowing to improve habitat for native and migratory plants and animals.

While they often negatively affect direct revenues from cultivation, each of these actions can have multiple public and private benefits. A variety of academics and NGOs are now working on spatially explicit optimization tools to target alternative land use actions and characterize their benefits so that they can be considered as part of coordinated responses to changing water resources. This poster provides an overview of recent efforts being undertaken on this front, characterizing them in terms of the combinations of landscape management actions and benefits that the speak to. It will also include a specific case study focused on fallowing and desert habitat in the San Joaquin Valley. It concludes by providing a vision and assessment of the scientific gaps needed to help achieve holistic multi-benefit planning, including improved connection to established water management models.

2. Calibration of the 3D RMA San Francisco Model for Longfin Smelt Studies
Presenter(s): Scott Burdick (RMA)
Presenter(s) Email Address(es): scott@rmanet.com
Collaborators: Steve Andrews, Ed Gross
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
The RMA UnTRIM model was applied to simulate three-dimensional hydrodynamics in the San Francisco Estuary. The model domain extends from the Pacific Ocean through the San Francisco Estuary including the California Delta. The model calibration focused on a late fall to summer time period for water year 2013 and 2016. Hydrodynamic model skill was assessed based on comparison to continuous monitoring observations of water level, flow and salinity and USGS salinity transects. Performance metrics include correlation coefficient (R), the difference between predicted mean and observed mean (bias), root mean square error (RMSE) and a model skill metric. The longitudinal near bottom salinity isohaline position, known as X2, based on USGS Polaris Cruise salinity transects and hydrodynamic model predictions were compared. The RMA UnTRIM grid resolves Suisun Marsh, Napa-Sonoma Marsh and Petaluma River and associated marshes. Flow and Stage were predicted accurately in the majority of the model domain. Delta salinity was under predicted in both water years, likely due to the uncertainty in agricultural diversion flows and the volume and salinity content of agricultural return flows.

3. A View into the Delta Plan Performance Measures
Presenter(s): Cory Copeland (Delta Stewardship Council)
Presenter(s) Email Address(es): Cory.Copeland@deltacouncil.ca.gov
Collaborators: Scott Navarro (Delta Stewardship Council), Chris Kwan (Delta Stewardship Council), Martina Koller (Delta Stewardship Council)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Delta Stewardship Council is unveiling the Delta Plan Performance Measures dashboard; a website to view and access performance measures information and data relevant to Delta Plan strategies and recommendations. Delta Plan performance measures track the progress in meeting the coequal goals of a reliable water supply for California and a healthy Delta ecosystem. Additional performance measures track implementation status in the Delta as an Evolving Place, Water Quality, and Protect People and Property areas of the Delta Plan. The performance measures serve multiple purposes: meet requirements of the Delta Reform Act, are a tool for communicating with Delta managers and interested public, and support adaptive management of the Delta. This poster will showcase the dashboard structure and key features that are relevant to the CWEMF community.

4. Printing the Delta in 3D
Presenter(s): John F. DeGeorge (Resource Management Associates, Inc.)
Presenter(s) Email Address(es): jfdegeorge@rmanet.com
Collaborators: Curtis C. Schmutte (Curt Schmutte Consulting)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Sacramento-San Joaquin Delta is a fascinating and complex physical environment encompassing an area of over 1,000 square miles with over 700 miles of interconnected waterways. Grasping the full detail of the Delta is challenging even for the many professionals who spend much of their careers working in the system. Field visits, photographs, maps, videos, and model visualizations all play important roles communicating the nature of the Delta. For those of us who are looking for a new way

of grasping the Delta geometry, we can turn to 3D printing! Using relatively inexpensive 3D printing technology, it is possible to create accurate 3D physical models using topographic and bathymetric data. DEM and LIDAR data are processed to generate 3D model object files which can then be input to standard 3D printing software. This poster presents an overview the data transformation process, scaling decisions, and material selection for the final 3D print.

5. Exploring the Food Water and Energy Nexus with a Hydro-Economic Agricultural Model Application for Kern County

Presenter(s): Josue Medellin-Azuara (School of Engineering, University of California, Merced), Alvar Escriva-Bou (Public Policy Institute of California, Water Policy Center), Spencer Cole (School of Engineering, University of California, Merced), Jorge Valero (School of Engineering, University of California, Merced), and Ulises Yepiz (School of Engineering, University of California, Merced)
Presenter(s) Email Address(es): jmedellin-azuara@ucmerced.edu
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Agriculture in California's San Joaquin Valley, one of the most productive regions in the world will be challenged by more frequent and extreme climate events, which include severe multi-year droughts. With a chronic groundwater overdraft since the first half of last century, the 2014 Sustainable Groundwater Management Act (SGMA) offers some long-term relieve as a balance in recharge and extraction in California's groundwater basins has to be achieved by 2040. An average yearly overdraft of roughly 1.8 million acre-foot would require cutbacks in roughly the same amount to achieve long term groundwater basing balance. This will result in permanent retirement of at least 700 thousand acres in the San Joaquin Valley This research presents the potential economic costs for agriculture and related sectors in the San Joaquin Valley in its gliding path towards groundwater sustainability. A hydro-economic approach connecting models of agricultural production and water use, groundwater, and land use data in Kern County has been employed to explore links between food production, water and energy. The role of markets and enhanced water supplies is also explored.

6. Combining Analytical and Numerical Techniques for Improved Accuracy and Efficiency in Large-Scale Regional Hydrological Modeling.

Presenter(s): Hubert J. Morel-Seytoux (Hydroprose)
Presenter(s) Email Address(es): hydroprose@sonic.net
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Examples are provided for the stream-aquifer flow exchange when the connection between the river and the aquifer is saturated or unsaturated, when the river flows within its banks or overflows into the adjacent flooding zone. Cooperation is needed with MODFLOW code running experts to provide more comprehensive comparisons of the standard MODFLOW (or IWFM, or MIKE-SHE or others, etc.) approach with the composite analytical approach.

7. From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed

Presenter(s): Greg Reis (The Bay Institute)
Presenter(s) Email Address(es): reis@bay.org
Collaborators: Gary Bobker (The Bay Institute), Peter Vorster (The Bay Institute), Bill Bennett (The Bay Institute), Jon Rosenfield (San Francisco Baykeeper)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
In 1998, The Bay Institute produced the seminal report, *From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed* (STS). This report described the San Francisco Bay watershed's uplands, lowlands, Delta, pelagic waters, and the nearshore Ocean as an integrated whole. STS provided detailed analyses of: 1) natural ecosystem structure, function, and organization; 2) transformations of the watershed; and 3) ecological responses to human-induced changes in the watershed and concluded with recommendations for building a practical framework for ecosystem restoration and management. Twenty years later, The Bay Institute reissued STS, with an afterward describing major changes that occurred in the Bay's watershed since the report was first published. Many trends have continued, such as increasing water diversions and decreasing freshwater flows to the estuary. Exports from the Delta have accelerated, while diversions upstream of the Delta have stabilized, peaking around 1998. One of the most dramatic changes is the frequency of reversed Old and Middle River flows (OMR) more negative than -10,000 cfs. The update reflects new understanding of future threats to the Bay and its watershed; projections of a warmer climate and sea level rise now play a dominant role in many decisions. Many watershed impacts continue to worsen. Yet there is hope--many habitat restoration projects have been implemented since 1998, many more are planned, and our scientific understanding of species' and ecosystem needs has improved dramatically over the past two decades.

8. Evaluating Stream Depletions in Small Watersheds and Headwaters of California – stream Depletion Risk Assessment Framework & Tools (sDRAFT)

Presenter(s): Jeffrey Sanchez (SWRCB)
Presenter(s) Email Address(es): Jeffrey.Sanchez@waterboards.gov
Collaborators: Behrooz Etebari (SWRCB)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Extraction of groundwater is widely recognized as having the potential to deplete surface waters from nearby streams. The stream Depletion Risk Assessment Framework & Tools (sDRAFT) has been proposed as a consistent way to qualitatively and quantitatively assess impacts to surface waters from groundwater well pumping in valley and headwater areas. Groundwater located in alluvial valley bottom settings is most likely to be connected to surface waters, and wells in these settings would present the greatest risk of near-term streamflow depletion due to pumping. sDRAFT identifies existing tools to locate the valley bottom portions of the landscape which are most likely to have sedimentary deposits with rapid connectivity between surface and groundwaters, as well as tools to estimate the impact of groundwater pumping on streamflow. A significant body of scientific literature exists which established archetypal numerical and analytical methods for quantifying impacts to surface waters, and a novel framework for their application has been proposed. sDRAFT can be applied to a watershed without any knowledge of existing or proposed well locations, or can be applied to specific wells with known locations. sDRAFT relies entirely on publicly available tools and datasets including Digital Elevation Models (DEMs), hydrography data from the National Hydrography Dataset (NHD), and Well Completion Reports (WCRs). Results from the sDRAFT can be used to develop management practices to protect streamflow from depletion by groundwater pumping.

9. The Water Budget Handbook: Overview and Systems
Presenter(s): Paul Shipman (DWR)
Presenter(s) Email Address(es): Paul.Shipman@water.ca.gov
Collaborators: Abdul Khan (DWR) and Todd Hillaire (DWR)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The poster provides an overview of the Water Budget Development Practitioner's Handbook (Water Budget Handbook) by the California Department of Water Resources. The Water Budget Handbook identifies key components of the hydrologic cycle, establishes a framework and common vocabulary for the total water budget, and depicts the interrelationships among different components of the total water budget, as represented by the land, surface water, and groundwater systems. This poster provides a visualization of these systems interacting in a 3D-schematic as well as giving an overview of the handbook itself and how it can be used to develop water budgets for any geographic area and time period, using data and models, or a combination thereof. Please consider stopping by to learn more about the Water Budget Handbook!

10. The Water Budget Handbook: Data Resources Directory
Presenter(s): Paul Shipman (DWR)
Presenter(s) Email Address(es): Paul.Shipman@water.ca.gov
Collaborators: Julie Haas (DWR)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The poster provides an overview of Section 9 of the Water Budget Development Practitioner's Handbook (Water Budget Handbook) known as the Data Resources Directory. The Data Resources Directory furnishes a catalogue of resources for the various data elements that might be needed in estimating the water budget components. It also provides additional guidance to users on how to make use of the resources effectively. This poster would walk the user through the process of using the Data Resources Directory to support their work in creating a water budget.

11. ECO-PTM – An Individual-based Juvenile Salmonid Migration Model
Presenter(s): Xiaochun Wang (DWR)
Presenter(s) Email Address(es): Xiaochun.Wang@water.ca.gov
Collaborators: Russell Perry (USGS), Adam Pope (USGS), Dalton Hance (USGS)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Various water resource management actions have been planned to protect and restore salmon populations for a healthy Delta ecosystem. Currently, evaluating the effectiveness of these actions mainly relies on field studies and/or expert opinion. Field studies can be costly and may not provide a complete assessment over a range of applications due to limited study areas, durations, and river conditions. Expert opinion, although valuable, may under or over emphasize the importance of certain project components. To supplement field studies, and provide water resource professionals a quantitative assessment tool, the California Department of Water Resources (DWR) in collaboration with the United States Geological Survey (USGS) has been developing an ecological modeling tool, Ecological Particle Tracking Model (ECO-PTM). ECO-PTM is an individual-based juvenile salmonid migration model that is based on a random-walk particle-tracking method, but with fish-like behaviors attached to the particles. The behavioral parameters are estimated from acoustic telemetry tag data of juvenile late-fall Chinook salmon from various field studies, using a stochastic optimization tool,

Particle Swarm Optimization. ECO-PTM can simulate juvenile salmonid migration timing, routing, and survival. This poster describes ECO-PTM and its behavioral modules, as well as its performance and a preliminary application to assist water resource management planning, assessment, and decision making related to juvenile salmonid survival outcomes.

12. Delta Modeling User Group
Presenter(s): Min Yu (DWR)
Presenter(s) Email Address(es): Min.Yu@water.ca.gov
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
This poster provides an overview of the Delta Modeling User Group, including objectives, goals, website and contact information.

13. Evaluating the Risks of Hydrologic Variability on California's Linked Food, Energy, and Water Systems
Presenter(s): Harrison Zeff (University of North Carolina at Chapel Hill)
Presenter(s) Email Address(es): zeff@live.unc.edu
Collaborators: Greg Characklis (University of North Carolina at Chapel Hill)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Changes in water availability represent both supply risks and financial risks to many sectors and groups in California, with links between the food, energy, and water systems leading to feedbacks and vulnerabilities that are difficult to evaluate when considering each system individually. Here, we use a probabilistic, simulation-based model to assess how the impacts of hydrologic variability cascade through this inter-related system and translate into supply and financial risks to a range of water users, including large growers, irrigation districts, groundwater banks, electric power utilities, electricity consumers and urban water utilities. The rules-based simulation approach presents some advantages over existing water management models by representing decisions of individual players using forecasts at highly resolved temporal scales to coordinate surface and groundwater supplies. In particular, irrigation districts and groundwater banks in the San Joaquin Valley are vulnerable to variability in exports from the San Francisco Bay-Delta via the State Water Project (SWP) and Central Valley Project (CVP). Probabilistic results describe both the supply and financial risks of variable SWP/CVP deliveries to these groups, and may be useful in developing improved drought management plans and long term investment strategies.

14. A GIS and Python Based Tool for MODFLOW and MT3D Models
Presenter(s): Jingnan Zhou (Woodard & Curran), Matt Wicks (Woodard & Curran), Reza Namvar (Woodard & Curran)
Presenter(s) Email Address(es): jzhou@woodardcurran.com; mwicks@woodardcurran.com; rnamvar@woodardcurran.com
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Recharge Estimator (RE) Tool, a GIS based tool, was developed to quantify the recharge component of water budgets and conceptual models, or developing input files of the MODFLOW models. RE Tool is capable of estimating recharge from distributed recharge sources such as rain and point recharge sources such as recharge ponds. RE Tool includes urban and agricultural applied water components.

The amount of recharge water that percolates deep into the aquifer is calculated based on the percentage of pervious land surface and soil drainage properties at the recharge locations. RE Tool results could be organized into shapefiles and time series of recharge quantities or into text files for import into MODFLOW models.

Loading Rate Estimator (LRE) Tool, a Python based tool, was developed for adding TDS and NO3 concentrations to the MODFLOW recharge components for water quality transport models. LRE Tool uses Python code to read the flow recharge volume generated by RE Tool and a set of input files with water quality concentrations for each recharge component, and then calculate loading rate based on the mass balance method. LRE Tool results could be organized into text files for import into MT3D models. RE and LRE Tools are very useful for development of hydrologic models (MODFLOW) and water quality transport models (MT3D).

Session 20. Modeling CVP/SWP Operations

Abstracts were not submitted for this session.

Session 21. ET Applications in Support of Water Resources Management & Planning

1. AgriMet Weather Station Network

Presenter(s): Jama Hamel (USBR)
Presenter(s) Email Address(es): jhamel@usbr.gov
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The AgriMet program is a cooperative network of over 300 agricultural based weather station located in 10 states in the Western United States that provide crop consumptive water use data to a variety of users. The program began in 1983 with three automatic agricultural weather stations in the Pacific Northwest in cooperation with Reclamation and the Bonneville Power Administration. The program piggybacked on the existing regional Hydromet program, a satellite telemetry network used by Reclamation that provides information necessary for water management and operations in the region. AgriMet is unique from other ET networks as it is the only network that covers multiple state and regional boundaries and has the reputation as the leader for ET data collection and quality control. These stations collect weather data, including temperature, humidity, solar radiation, wind and precipitation, to estimate ET and crop water requirements. AgriMet uses crop coefficients to generate crop-specific ET based on a reference ET for alfalfa. Crop coefficients are linked to plant growth stages, and accurately reflect the consumptive use of over 40 different crops grown in the region. Reclamation updates AgriMet crop water use charts each morning to reflect ET based on the previous day's weather conditions.

2. Integrating Satellite and Surface Sensor Networks for Irrigation Management Decision Support in California

Presenter(s): Bekele Temesgen (CA DWR), Forrest Melton (NASA ARC-CREST)
Presenter(s) Email Address(es): bekele.temesgen@water.ca.gov, forrest.s.melton@nasa.gov
Collaborators: Lee Johnson, Alberto Guzman, Tianxin Wang, Isabel Zaragosa, Michael Cahn, Ricardo Trezza

Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Satellite mapping of evapotranspiration (ET) from irrigated agricultural lands can provide agricultural producers and water managers with information that can be used to optimize agricultural water use, especially in regions with limited water supplies. The Satellite Irrigation Management Support (SIMS) framework integrates satellite data with information from agricultural weather networks to map crop canopy development, basal crop coefficients (Kcb), and basal crop evapotranspiration (ETcb) at the scale of individual fields. Information is distributed to agricultural producers and water managers via a web-based irrigation management decision support system and web data services. SIMS also provides an application programming interface (API) that facilitates integration with other irrigation decision support tools and estimation of total crop evapotranspiration (ETc).

3. OpenET: Filling the Biggest Gap in Water Data for the Western U.S.

Presenter(s): Forrest Melton (NASA ARC-CREST), Justin Huntington (Desert Research Institute)
Presenter(s) Email Address(es): forrest.s.melton@nasa.gov; justin.huntington@dri.edu
Collaborators: Robyn Grimm, Jamie Herring, Tyler Erickson, Maurice Hall, Martha Anderson, Wim Bastiaanssen, Britta Daudert, Conor Doherty, Joshua Fisher, Mackenzie Friedrichs, Alberto Guzman, Christopher Hain, Gregory Halverson, Jordan Harding, Tim Hessels, Lee Johnson, Charles Morton, Mutlu Ozdogan, Mitch Schull, Gabriel Senay, Jonna Von Opstal, Yang Yun

Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
Developing innovative and effective water management strategies is difficult without accurate, consistent information about evapotranspiration (ET) from agricultural lands, the largest beneficial use of water by people in the western US. Recent advances in remote sensing of ET have led to the development of multiple approaches for ET mapping that are advancing towards operational use by US state and federal agencies. The OpenET project aims to integrate many of these advances and to support further improvements in water management by increasing access to remotely sensed ET data. The OpenET project is developing a shared platform for data processing and distribution to provide automated and widely accessible ET data at user-defined scales and timeframes.

4. West-wide ET Forecast Network (WwET4Cast)

Presenter(s): David Yates (NCAR), Mike Tansey (USBR), and Andy Wood (NCAR)
Presenter(s) Email Address(es): yates@ucar.edu, mtansey@usbr.gov, andywood@ucar.edu
Collaborators: Jama Hamel (USBR)

Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
In the western United States, multiple networks of agricultural meteorological stations, such as CIMIS in California and the Agrimet network across much of the western US, provides real-time meteorological data, including the estimation of reference evapotranspiration (ETo). Some of these stations have long period of records and have been in use for many years as tools for irrigation scheduling and other water management activities. Forecasting ETo at these stations offers user groups

a new opportunity to account for meteorological risks in their water management decisions. Reclamation and NCAR are developing a web-based platform to provide short-term (1 to 14-days) ETo forecasts based on an ensemble of climate model forecasts (the NOAA Global Ensemble Forecast System or GEFS) across the region. The forecasts are provided on approximately 1/2 degree grids and are then filtered and bias corrected, to provide probabilistic forecasts at the station level. In addition to the short range forecasts, the system will also generate seasonal forecasts (1 to 6 months) using long-range outputs from NOAA and other sources, to generate station level outlooks on a daily basis. After development and testing are complete, the goal of the project is make the forecasts available to network user groups for their use.

Session 22. Forecast Informed Reservoir Operations (FIRO)

1. Forecast Informed Reservoir Operations (FIRO): Background

Presenter(s): F. Martin Ralph, Center for Western Weather and Water Extremes (CW3E)
Presenter(s) Email Address(es): mralph@ucsd.edu
Collaborators: Jay Jasperse (Sonoma Water), Cary A. Talbot (U.S. Corps of Engineers Research and Development Center)
Permission to Post pdf of Presentation on CWEMF Website: UNKNOWN
Abstract:
This presentation will provide background on the creation of the FIRO steering committee (FIRO SC) and describe the framework under which assessment of potential viability of this alternative management strategy in this reservoir was conducted. The framework, described in detail in the FIRO work plan, consists of the following steps: develop evaluation criteria and methodology; identify science needs and carry out research studies to address them; evaluate results; evaluate FIRO viability; and develop implementation strategies. Accomplishments of the FIRO SC to date will be highlighted.

2. Forecast Informed Reservoir Operations (FIRO): Supporting Forecast Improvements through Data Collection

Presenter(s): Anna M. Wilson, Center for Western Weather and Water Extremes (CW3E)
Presenter(s) Email Address(es): anna-m-wilson@ucsd.edu
Collaborators: Stephen Turnbull (USACE ERDC), Carly J. Ellis (CW3E), Douglas Alden (CW3E), F. Martin Ralph (CW3E)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
This presentation will describe in detail some of the ongoing data collection and monitoring efforts to improve precipitation forecast skill to support FIRO viability. These efforts include the collection of unique, high density datasets of atmospheric rivers, which are highly impactful storms that bring the majority of the precipitation to this watershed, both offshore and when they make landfall and begin interacting with the terrain. Another key component of this effort is collecting data when the precipitation hits the ground and begins moving through the landscape. Data are continuously collected from 6 meteorological and soil moisture stations, 10 rain gages, and 6 additional tributary stream gaging stations installed during 2017 to augment existing USGS stream gaging stations and NOAA rain gages and soil moisture stations. Data are also collected to investigate the isotopic signature of the precipitation, groundwater, and streamwater before, during, and after storms.

3. Forecast Informed Reservoir Operations (FIRO): Advances in Numerical Weather Prediction Forecasts and Verifications of Atmospheric Rivers over the Russian River Test Watershed

Presenter(s): Forest Cannon, Center for Western Weather and Water Extremes (CW3E)
Presenter(s) Email Address(es): fcannon@ucsd.edu
Collaborators: Luca Delle Monache (CW3E), Rachel Weihs (CW3E), Andrew Martin (CW3E), John Helly (CW3E), F. Martin Ralph (CW3E)

Permission to Post pdf of Presentation on CWEMF Website: UNKNOWN

Abstract:
Atmospheric Rivers (ARs) contribute approximately 50% of the water in the Russian River and are responsible for all the floods in the region since 1997. Nonetheless, forecast of ARs have landfall errors of 300-500 km 3-4 days ahead of time and intensity errors (integrated water vapor transport; IVT) of 100-200 kg/m/s). In order to support FIRO, the Center for Western Weather and Water Extremes (CW3E) at Scripps Institution of Oceanography has developed a regional version of the Weather Research and Forecasting (WRF) model, West-WRF, focusing on forecasts of ARs and the associated precipitation. West-WRF is run in near real time once a day from December through March with nested grids of 9, 3 and 1 km. West-WRF forecasts the location of landfall 5-6 days ahead of time better than several other commonly used models. West-WRF also is a valuable research tool to better understand variables that contribute to precipitation variability, which in turn can lead to focus areas for model improvements. Further, West-WRF can be used to force hydrologic models to better understand how precipitation variability impacts stream flow. In addition to the model development, CW3E develops model verification tools to assess the skill of forecast variables that are important for FIRO.

4. Forecast Informed Reservoir Operation (FIRO): Distributed Hydrologic Watershed Modeling in the Russian River Test Watershed

Presenter(s): Steve Turnbull, U.S. Corps of Engineers Research and Development Center (ERDC)
Presenter(s) Email Address(es): Stephen.J.Turnbull@erdc.dren.mil
Collaborators: Cary Talbot (ERDC), Chuck Downer (ERDC)

Permission to Post pdf of Presentation on CWEMF Website: UNKNOWN

Abstract:
In the Russian River Valley of California a multi-agency research effort, FIRO, is assessing the application of forecast weather and streamflow predictions to potentially enhance the operation of reservoirs. The initial focus of FIRO has been on Lake Mendocino, an important USACE flood control, water supply, and power generation project in the Upper Russian River watershed. As part of this effort the Engineer Research and Development Center is assessing the ability of utilizing the physics based, distributed watershed model, Gridded Surface Subsurface Hydrologic Analysis (GSSHA) to simulate stream flows, reservoir stages, and discharges while being driven by weather forecast products. A key question in this application is the calibration of parameters to allow for accurate calculations of forecasted stream flows for the upper Russian River watershed that includes Lake Mendocino as a test reservoir. To help resolve this question, GSSHA models of varying grid resolutions of 30, 50, 100, and 270m were derived from common inputs of: DEM, soils, land use, stream network, reservoir characteristics, and specified inflows and discharges. All the models were calibrated in both event and continuous simulation mode to the existing gage network for the period 2004 to 2005, and using the additional available data collected from October 2017 to May 2018 by CW3E. Select models are also being calibrated using West-WRF generated rainfall and meteorological forcings. We are researching if the improved precipitation and meteorological forecasts provided by CW3E at Scripps/UCSD together with the GSSHA model can ultimately provide sufficient accuracy to reliably allow lakes to store more water for urban and ecological flows, while maintaining or even enhancing the flood risk requirements.

5. Forecast Informed Reservoir Operations (FIRO): Risk Based Decision Support System for Flood Operations of Lake Mendocino

Presenter(s): Chris Delaney (Sonoma Water)
Presenter(s) Email Address(es): chris.delaney@scwa.ca.gov
Collaborators: Michael Konieczki (HDR, Inc.), John Mendoza (Sonoma Water), Robert Hartman (Hartman Consulting Services), Jay Jasperse (Sonoma Water)
Permission to Post pdf of Presentation on CWEMF Website: UNKNOWN
Abstract:

A FIRO decision support system (DSS) has been developed for managing flood control operations of Lake Mendocino. The DSS was developed by California Department of Water Resources following the framework of the Yuba-Feather Forecast-Coordinated Operations (F-CO) DSS, and incorporates the Ensemble Forecast Operations (EFO) model, a probabilistic forecasting system that utilizes 15-day ensemble streamflow predictions (ESPs) issued by NOAA's California-Nevada River Forecast Center (CNRFC). The EFO model individually simulates each member of an ESP to forecast the risk of reaching critical operational pool elevation and release thresholds. A preliminary viability assessment (PVA) demonstrated that implementation of the EFO approach of flood management for Lake Mendocino could significantly improve water supply reliability without increasing downstream flood risk over the historical period of 1986 to 2010. The Lake Mendocino EFO model was also evaluated for water year 2017 using historical forecasts issued by the CNRFC, and results of the 2017 analysis reinforced the findings of the PVA. The Lake Mendocino DSS is currently being used by operators in their decision-making process. Further refinements to the DSS are planned and will be completed through future research of the EFO approach for further improvements in water supply reliability and flood management.

Session 23. Flood Modeling

1. A Framework for Linking the NWS National Water Model with the HEC-HMS to Improve Flood Modeling

Presenter(s): Luciana Cunha, David C Curtis and Pavithra Prakash (WEST Consultants)
Presenter(s) Email Address(es): pprakash@westconsultants.com
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:

HEC HMS (HMS), developed by the US Army Corps of Engineers (USACE), is one of the most widely used hydrologic modeling programs in the world. HMS is in the class of models known as event-based or models that do not explicitly address hydrologic processes that take place between storms such as evapotranspiration and percolation of water through the soil column. Hydrologic losses from incident rainfall are modeled simplistically using an initial loss and a continuing loss parameter.

Increasingly, HMS is being applied to forecast operations both by the USACE and outside agencies. In forecast environments, inter-storm processes become important because antecedent moisture conditions are critical to the prediction of the rising limb of a flood hydrograph and for initial estimates of reservoir inflows, especially after lengthy dry spells. Time spent waiting for the initial catchment response needed to adjust the HMS loss parameters is time lost for flood mitigation or planning reservoir operations.

An innovative approach that bridges the gap between HMS event-based modeling and continuous soil moisture accounting approaches is discussed in this presentation. Historical hydrologic losses were developed for reservoirs in the Ft. Worth District of the USACE. Relationships between HMS initial and continuous loss parameters and soil column moisture conditions in upstream catchments modeled by the National Aeronautics and Space Administration (NASA) were drawn. A spreadsheet tool was developed that incorporates the NASA soil moisture data, continuously updated and publicly available online, to provide improved estimates of initial and continuous loss parameters for HMS in a real-time river forecast environment.

The approach used to track soil moisture is very similar to the approach used by the NWS National Water Model. The newly available 25year retrospective analysis of the National Water Model contains the necessary historical information to leverage the approach used with the NASA model. The National Water Model data offers significantly higher temporal and spatial resolution which can further improve hydrologic loss estimation for HEC-HMS. Utilizing this approach, two diverse models from the NWS and USACE can be operationally linked in near-real time to improve reservoir operations.

2. Real-Time Inundation Modeling (RTIM) Tool – Developed for Inundation Forecasting in the Central Valley Floodplains

Presenter(s): Chong Vang, PE, CFM (DWR), Laurence Sanati, PE (DWR)
Presenter(s) Email Address(es): chong.vang@water.ca.gov, laurence.sanati@water.ca.gov
Collaborators: Chris Ferrari, PE (GEI Consultants)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Within the California Department of Water Resources (DWR), the Hydrology and Flood Operation Office (HAFOO) is charged with analyzing and predicting river flows and estimating its impact due to extreme precipitation events. Numerous hydraulic, hydrology, scientific and engineering models, and resources has been collected and developed by HAFOO to forecast potential flooding and its resulting physical and financial impacts. Using hydrodynamic models developed as part of the Central Valley Floodplain Evaluation and Delineation (CVFED) project, a Real-Time Inundation Modeling (RTIM) tool has been developed to use forecasted hydrology from the California-Nevada River Forecasting Center (CNRFC) along with the CVFED models developed from the US Army Corps of Engineers (USACE) Hydrologic Engineer Centers River Analysis System (HEC-RAS) program to determine the stage forecasts and potential inundation areas due to compromised levees during high water conditions in real-time.

RTIM can assist decision makers by providing detailed hydraulic intel within the floodplain including, the maximum extent of inundation, flood water arrival times, and flood water depths and velocities. RTIM is a system-wide model of the Sacramento River beginning upstream at Hamilton City and extending into the Delta. It includes major tributaries, such as the Feather River system and American River, as well as local streams. Additional capabilities include automated processing of hydrologic inputs and postprocessing of simulation results for real-time visualization. The results can then be rapidly disseminated to various partner agencies and critical decision makers through the tool's connectivity to the Flood Emergency Response Information Exchange (FERIX) platform.

3. Flood Mapping and Resiliency Analyses: Time for A More Comprehensive Approach

Presenter(s): Paul Robinson (Hazen & Sawyer)
Presenter(s) Email Address(es): pmrobinson@hazenandsawyer.com
Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
The past few years have been challenging for many communities in the US. Traditionally, many have relied on the FEMA 100-year or 1% annual exceedance probability floodplain map as the standard to estimate their personal, organizational or community flood risks, but many have been left surprised by the scale of the challenges they faced from recent events. So, what's missing? What else should we be looking at to make our communities to be more resilient?

Based on recent experiences, it is clear that current flood maps may not consider all the hydrologic and hydraulic risks for complex flood and stormwater management systems, including the threat of erosion and sedimentation, fire and aging infrastructure. For many reasons, we typically underestimate the impacts of asset conditions, stormwater infrastructure, geomorphic processes, ecosystem factors, or even how engineered flood management systems may be operated in our assessments of flood risks. Climate change and variability, coupled with land use changes, create previously unthought of imperatives. Permitting entities and credit rating agencies are starting to incorporate climate and resilience factors into assessments. The implications and risks of sustaining economically thriving communities is therefore becoming more complex. A "100-year floodplain map" should only be one part of the resiliency planning puzzle. This presentation will highlight some thoughts and lessons learned in some of the factors that we need to consider in risk assessment, mapping and communication.

4. Flood Impact Assessments: Solutions for Shifting Baselines at Gravel Augmentation Projects

Presenter(s): Matthew Weber (cbec, inc. eco engineering)
Presenter(s) Email Address(es): m.weber@cbecoeng.com
Collaborators: Ben Taber, Chris Bowles, and Chris Hammersmark (cbec); Tom Gohring (Sacramento Water Forum); Dan Tibbitts (SAFCA)
Permission to Post pdf of Presentation on CWEMF Website: Yes

Abstract:
A typical flood impact analysis uses a hydraulic model to analyze existing and post-project conditions to assess how a project may change flood water surface elevations. This approach, however, is problematic for gravel augmentation projects, which seek to replace spawning gravels that have washed away over time below a dam. The hydraulic model may show that the added gravel causes a small rise in water surface elevation, but the river below the dam has historically eroded causing a shifting baseline (i.e., nonstationarity). Therefore, it is necessary for flood impact assessments for gravel augmentation projects to consider sediment erosion rates to understand whether the added gravel causes a flood impact. This project seeks to understand average erosion rates within the Lower American River by conducting a topographic change detection analysis for two time periods: 1997 to 2006/2008 and 2006/2008 to 2017. In addition, a two-dimensional hydraulic model (using HEC-RAS 2D) was created for historic conditions (2006/2008), current conditions (2017), and future conditions (2017 plus gravel augmentation design surfaces) to create a more comprehensive understanding of how flood water surface elevations are changing between past, present, and future conditions.

Session 24. CalSim 3.0: Selected Applications

1. A Mokelumne System Overview in CalSim 3

Presenter(s): Kevin Fung (EBMUD)
Presenter(s) Email Address(es): kevin.fung@ebmud.com
Collaborators: United States Department of the Interior, Bureau of Reclamation; Stantec
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Mokelumne System is the main source of drinking water for the East Bay Municipal Utility District (EBMUD), which serves 1.4 million customers in Alameda and Contra Costa Counties. In CalSim II, the system was represented as an optional module with limited representation and logic. CalSim 3 expands the spatial resolution to incorporate the upper Mokelumne and more detailed representation of the existing middle and lower Mokelumne River. EBMUD staff has been reviewing the new updates against internal EBMUDSIM planning model and collaborating with United States Bureau of Reclamation (USBR) Consultant's at Stantec. This presentation will cover an overview of EBMUD operations and planning of the Mokelumne system facilities as well as provide status updates on CalSim 3 model review progress.

2. Upper American River Representation in CalSim 3.0

Presenter(s): Matthew Bachman (Stantec)
Presenter(s) Email Address(es): matthew.bachman@stantec.com
Collaborators: United States Department of the Interior, Bureau of Reclamation; El Dorado County Water Agency; Placer County Water Agency; City of Sacramento; City of Roseville; City of Folsom; Regional Water Authority
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
CalSim 3 is being used as the main analytical tool to conduct the integrated surface water/groundwater analyses as well as the regional and system-wide operations for the ARBS. Starting with a relatively coarse operations model that had been previously designed to simulate hydropower relicensing effects, the Project team added to and refined Upper American River operating criteria for regional projects & applicable interests, added granularity to regional infrastructure representations, and updated agency-specific water portfolios in the development of this consensus-driven and informed model. These model updates were developed in consultation with the non-Federal Project Partners and other local water agencies and reflect both existing and future levels of development. This presentation will cover the development and implementation of these model updates, as well as the integration of the American River Module with the broader CVP/SWP system model as a whole.

3. Application of CalSim 3.0 in the American River Basin Study

Presenter(s): Raymond Hoang (Stantec)
Presenter(s) Email Address(es): Raymond.Hoang@stantec.com
Collaborators: United States Department of the Interior, Bureau of Reclamation; El Dorado County Water Agency; Placer County Water Agency; City of Sacramento; City of Roseville; City of Folsom; Regional Water Authority
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The United States Department of the Interior, Bureau of Reclamation, Mid-Pacific Region in collaboration with local cost share partners and Stantec is conducting the American River Basin Study

(ARBS), where CalSim 3.0 is used as the primary analytical tool. The ARBS objectives are to address regional demand-supply imbalance, infrastructure deficiencies under the threat of climate change and integrate regional water supply reliability with operational flexibility for Reclamation's Folsom Dam and Reservoir to help meet all authorized purposes of the CVP.

CalSim 3.0 model capabilities were expanded to meet the needs of the ARBS. Refinements include development of climate change hydrology, updated urban and agricultural demands for future planning horizons and the addition of the upper American River module. This presentation will cover an overview of the study objectives, details of the CalSim 3.0 application and its technical additions.

4. Integration of New Delta Hydrology into CalSim 3.0
Presenter(s): Richard (ZhiQiang) Chen (California Department of Water Resources)
Presenter(s) Email Address(es): ZhiQiang.Chen@water.ca.gov
Collaborators: Hongbing Yin, Mei Lui, Lan Liang (California Department of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
We have integrated the new surface and subsurface hydrology of Sacramento-San Joaquin Delta Channel Depletion Model (DCD) into CalSim 3. DCD simulates the daily diversions, drainages and seepages of (Delta Simulation Model 2) DSM2 nodes from 1922 through current. These channel depletion components of DSM2 nodes have been aggregated and counted as monthly Delta accretions and depletions in CalSim3. DCD also simulates deep percolations of 168 islands in the Delta, which are used as the surface recharges to groundwater in the groundwater model of CalSim3. Through the underneath aquifer in the Delta, CalSim3 model takes groundwater from the adjacent watersheds to supplement Delta island consumptive use. This implementation improves the simulation of surface and subsurface water in the Delta and its surrounding areas in CalSim3.

The presentation will describe the new Delta hydrology, the associated implementation in CalSim 3, and its impact on Delta surface water and groundwater.

Session 25. Water Quality Modeling

1. Three-Dimensional Modeling of Microplastic Transport in San Francisco Bay
Presenter(s): Rusty Holleman (UC Davis)
Presenter(s) Email Address(es): cdholleman@ucdavis.edu
Collaborators: Carolynn Box (5 Gyres), Meg Sedlak (SFEI), Rebecca Sutton (SFEI)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Microplastic pollution is a growing concern around the world, but the pathways between terrestrial sources and plastics in the global ocean are poorly understood. In estuaries, a combination of energetic mixing, strong density-driven circulation, and a wide range of particle characteristics motivate the use of fully three-dimensional hydrodynamic models to quantify transport of microplastics. Such models are an essential part of understanding the spatial distribution of plastic pollution, in particular for particles which are not sufficiently buoyant to make it to mid-ocean patches. In this study we have developed a three-dimensional hydrodynamic model of San Francisco Bay and the coastal ocean, and conducted transport studies reflecting a range of particle characteristics. Model results demonstrate strong interactions between particle settling/rising velocity and three-dimensional circulation, with many dense particles never leaving the Bay and some buoyant particles efficiently transported beyond

the San Francisco Bight. We discuss how these findings inform microplastic mass balances and the design of future observational campaigns.

2. Bivalve Control on Nutrients and Phytoplankton in Sacramento-San Joaquin Delta
Presenter(s): Zhenlin Zhang (San Francisco Estuary Institute)
Presenter(s) Email Address(es): zhenlinz@sfei.org
Collaborators: David Senn (San Francisco Estuary Institute)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
To address the complex and multi-purpose management needs for the Sacramento-San Joaquin Delta and Suisun Bay, we present a three-dimensional, mechanistic biogeochemical cycling model that includes nitrogen transformation, phytoplankton dynamics, grazing by zooplankton and clams, and detrital organic processes. Such a mechanistic model provides a holistic approach to quantify the intricate interactions and dependency among the key model variables and can be used as a powerful tool to evaluate the system response to management actions and environmental conditions. The modeled chlorophyll-a, nitrate and ammonia match reasonably well with the observed spatial and temporal variability in these variables. Bivalves (both Potamocorbula and Corbicula) played a central role in controlling phytoplankton biomass particularly during the warmer months of the year. However, due to the slow response of bivalves in growth to food availability, they may not prevent large scale bloom from happening when other conditions (such as light availability) support it. Model scenario runs with either removing bivalves or increasing phytoplankton growth rate show extreme nutrient limitation during the summer months, which indicates that management actions in source control (such as Sac Regional upgrade) are likely to be effective in reducing phytoplankton biomass under these realistic scenarios. The observed level of phytoplankton biomass alone as a food source cannot support the observed growth in the bivalves. It is strongly suggested that other food source, such as detritus (organic matters) may be particularly important in supplementing the food web in the ecosystem.

3. Interactions between Submerged Aquatic Vegetation, Primary Productivity and Hydrodynamics in the Cache Slough Complex
Presenter(s): Eli Ateljevich (Dept. of Water Resources)
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Collaborators: Nicole Cai (VIMS), Joseph Zhang (VIMS)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Submerged aquatic vegetation (SAV) plays a significant role in both the physical and ecological functions of an estuary. It can baffle currents, attenuate waves, recycle nitrogen and phosphorus from the sediment bed, act as a primary producer, and provide habitat for species including fish that threaten Delta natives. This multi-interdisciplinary modeling study arises from SAV questions from the Delta Smelt Resiliency Strategy, and incorporates biogeochemistry, hydrodynamics, and complements ongoing field work by DWR and USGS. An SAV model is coupled to the SCHISM-ICM model for hydrodynamics and water quality. We attempt to simulate the competition between SAV and phytoplankton for light and nutrient supplies in the Cache Slough Complex and in French Island and Little Hastings Tract in particular. The model allows us to simulate changes in water quality and SAV over spatial and seasonal scales. Generally, SAV increases the accumulation of phytoplankton by locally reducing flushing and thus increasing the residence time, but in the meantime, reduces its local growth rate due to light shading and nutrient competition. The interactions are complex, perhaps too much so for quantitative prediction, but the model agrees with field data collected thus far and its conclusions

and uncertainties enhance monitoring by the highlighting knowledge gaps that are most critical to productivity.

4. An Alternative Approach to Salinity Forecasting in the Lower San Joaquin River
Presenter(s): James Lu (USBR)
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Collaborators:
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Abstract:
Reclamation is obligated by Public Law 108-361 to provide salinity forecasts to facilitate timely salt discharges to optimize their assimilation in the Lower San Joaquin River (LSJR). Previous modeling efforts for this purpose were dedicated to the development of the Watershed Analysis Risk Management Framework (WARMF) model, which provides 14-day forecasts for streamflow and electrical conductivity (EC) for several locations within the San Joaquin River Basin. This effort was undertaken to assess application of data-driven forecasting models. Unlike physically based models, data-driven models do not require large amount of input data and can be easily automated. Numerous artificial neural network (ANN) frameworks and regression models were evaluated. Among the data-driven forecasting models evaluated, an inverse gradient regression model stood out in terms of forecast accuracy.

5. Simulation of Mercury Methylation and Demethylation Coupled to Oxidation-Reduction Reactions in Sediments of Delta Tributaries
Presenter(s): Stefanie Helmrich (UC Merced)
Presenter(s) Email Address(es): shelmrich@ucmerced.edu
Collaborators: Dimitri Vlassopoulos (Anchor QEA LLC), Charles N. Alpers (U.S. Geological Survey), Peggy A. O'Day (UC Merced)
Permission to Post pdf of Presentation on CWEMF Website: No
Abstract:
Fish and birds in the San-Francisco Bay-Delta and its tributaries are contaminated with methylmercury (MeHg), which poses a significant threat to human and ecological health. Management of waterbodies could help to reduce MeHg concentrations. Resource managers need a working understanding of biogeochemical processes affecting net MeHg production to make informed decisions. Computer models can be a useful tool in this regard and provide the possibility to investigate responses of a system to various perturbations, such as different management strategies or the possible effects of climate change. A biogeochemical reaction model using the PHREEQC program was modified to improve the description of net MeHg production in sediments. The model connects mercury (Hg) with other environmental constituents such as iron, sulfur, and organic matter, which strongly influence the Hg cycle. Intrinsic rate constants for Hg- methylation and -demethylation pathways, and organic matter degradation via oxidation-reduction reactions, were determined based on a comprehensive literature review of laboratory experiments. We found that it is important to choose internally coherent data sets because experimental conditions, rate calculations, and assumptions in published studies may differ. Reaction model simulations investigated how net MeHg production changed depending on different habitats and seasons. Results were evaluated by comparing simulation output with field data sets. The simulated habitats were Cache Creek Nature Preserve, Cache Creek Settling Basin, and permanent wetlands in the Yolo Bypass. The significance of this work lies in assessing interrelated processes with the computational model, which makes it possible to identify environmental conditions that should be avoided to result in lower net MeHg production.

Session 26. Panel Discussion: Water Supply Reliability Estimation

1. Implementing California's Sustainable Groundwater Management Act: Hydroeconomic Modeling of Sustainability

Presenter(s): Duncan MacEwan (ERA Economics) & Chuck Young (SEI)
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Collaborators: Steve Hatchett (ERA Economics), Richard Howitt (ERA Economics), Vishal Mehta (Stockholm Environment Institute), Laura Forni (Stockholm Environment Institute), Susie Bresney (Stockholm Environment Institute)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Stockholm Environment Institute and ERA Economics are working with stakeholders in Yolo County to support development of the Groundwater Sustainability Plan. Part of the analysis includes evaluating future management scenarios. The project team has developed an integrated hydroeconomic model by linking water resources and economic models based on the Water Evaluation and Planning System (WEAP) and the Statewide Agricultural Production Model (SWAP) frameworks. Yolo-specific versions of the two models have been developed, called YWARM and YCAP respectively. The integrated model will run in a sequential fashion with key data inputs passed between the monthly water resources and economic models on an annual basis. Key water management decisions in Yolo County are made in early April as that is at the end of the wet season, the beginning of the irrigation season, and when the legally binding Solano Decree is used to determine seasonal water availability from Clear Lake. This coincides with grower planting decisions (for annual crops), which are based on water supply conditions, costs, and domestic and export market conditions (prices) for crops. To model this hydroeconomic system, the YWARM model passes average groundwater depth and expected surface water supplies in April to each sub-region of the county represented in the YCAP model. YCAP, in turn, simulates grower planting decisions for each sub-region and passes that back to the YWARM model. The integrated hydroeconomic model is able to simulate crop water use, irrigation, groundwater pumping, and drawdown that is consistent with the cropping mix resulting from grower response to these changing conditions and the broader crop market. During this talk we will present details on the hydroeconomic model linkage and preliminary results of simulated sustainability conditions.

2. Development of Reservoir Operation Changes in Response to Climate Change Scenarios

Presenter(s): Joel Herr (Systech)
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Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Adapting California's water infrastructure and agriculture to climate change is a major challenge facing the state in this century. The changes to temperature, the amount of precipitation, and the mix between rain and snow will change the amount and timing of inflows to reservoirs and require changes to how the reservoirs will be operated. Long-term planning needs to consider how much water will be available for irrigation and domestic use. As part of a study of climate change adaptation in the San Joaquin Valley, a process was developed to determine reservoir operation under changed climate conditions. The WARMF watershed model was applied to the Sierra watersheds of the Stanislaus, Tuolumne, and Merced Rivers. Downscaled climate model output was processed into meteorology inputs for WARMF under historical and various carbon dioxide emission scenarios. The model was run on a daily time step for a 93 year simulation period to determine the projected inflow to New Melones

Reservoir, New Don Pedro Reservoir, and Lake McClure for various climate scenarios. Each reservoir is currently operated under complex rules for downstream flood control, fish flows, and deliveries to water users. The requirements for flood control under each climate change scenario were calculated from the modeled reservoir inflows. Reservoir outflows were calculated to meet the needs of flood control, fish flows, and deliveries to the extent possible. Projected reservoir outflows from the range of climate scenarios provides guidance on likely water availability in the San Joaquin Valley for the coming decades.

3. Water Supply Reliability Estimation – Beginnings of a Review
Presenter(s): Jay Lund (UC Davis)
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Collaborators:
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The Delta Independent Science Board is beginning a review on the estimation of water supply reliability. Such estimates are employed commonly in the management and planning or water facilities and in discussions of environmental water management. So far, the Board has hosted a panel discussion, a one-day workshop, and is digesting results from a broader questionnaire. This presentation will review some approaches and issues in water supply reliability estimation, and provide an opportunity for the audience to suggest points for Board members to consider in this review.

Session 27. Modeling Hydrologic & Environmental Transport Processes at California Foothill Watersheds at Daily or Finer Increments

1. Watershed Environmental Hydrology-Hydroclimate Model WEHY-HCM for Modeling Interactive Atmospheric-Hydrologic-Environmental Processes at Watershed Scale
Presenter(s): M. L. Kavvas (Hydrologic Research Laboratory, Dept. of Civil and Environmental Engineering, University of California, Davis)
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Collaborators: S. Kure (Toyama University, Japan), N. Ohara (University of Wyoming), and S. Jang (K-Water, Korea)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Among the key problems in water resources and environmental engineering and in atmospheric and hydrologic sciences are the modeling of the interaction between the atmosphere and land surface hydrology while also quantifying the surface/subsurface hydrologic flow and environmental transport processes both in vertical and lateral directions, and modeling the heterogeneity in surface and subsurface hydrologic processes. Meanwhile, in standard water resources/environmental engineering practice, the planning and management of the water resources and environmental problems is performed over the geographical region of a watershed. To address these issues, a model of coupled atmospheric-hydrologic-environmental processes at the watershed scale, the Watershed Environmental Hydrology Hydro-Climate Model (WEHY-HCM), has been developed. A numerical atmospheric model (previously MM5 and currently WRF (Weather Research and Forecasting) is coupled to the watershed environmental hydrology model WEHY through the atmospheric boundary layer to form the WEHY-HCM. The WEHY-HCM is especially useful for producing nonexistent atmospheric data as input to the modeling of surface and subsurface hydrologic and environmental processes at sparsely gauged or ungauged watersheds. The continuously changing state of the atmospheric boundary layer

is essential information for the computation of evapotranspiration and other land surface fluxes which in turn affect the land surface and subsurface temperatures. Because such land surface fluxes are the result of the interaction of land surface hydrologic processes with atmospheric processes, their realistic estimation necessitates the coupled modeling of these processes, as is done in the WEHY-HCM. In this presentation, first the modeling of an integrated system of atmospheric processes aloft coupled with atmospheric boundary layer processes, land surface processes, and surface and subsurface hydrologic and environmental processes is described at the scale of a watershed within the framework of WEHY-HCM. Then the application of WEHY-HCM to sparsely-gauged Butte Basin and Indian Creek, California watersheds for the simulation of the time evolution of spatially-distributed precipitation, streamflow and water temperature at hourly, daily and monthly time intervals at selected gauge locations for flow and temperature, and at 3 km grid resolution for precipitation is presented.

2. Modeling Flood and Sediment Conditions at Fine Scale under Changing Climate Conditions during 21st Century by Coupling Physically Based Models: Application to Cache Creek Watershed and Settling Basin

Presenter(s): Toan Trinh, Ali Ercan (U.C. Davis)
Presenter(s) Email Address(es): tqtrinh@ucdavis.edu, aercan@ucdavis.edu
Collaborators: M.L. Kavvas (UC Davis), K. Ishida (Kumamoto University, Japan), I. Fisher (UC Davis), S. Jang (K-Water, Korea), K. Carr (UC Davis), T. Tu (UC Davis)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Effect of climate change on hydrologic flow regimes, particularly extreme events, necessitates modeling of future flows in order to best inform decision makers. The presented modeling approach simulated future flows in the Cache Creek watershed in California, over the 21st century using a hydro-climate model (WEHY-HCM) forced by future climate projections at hourly intervals along the main Cache Creek branch and its tributaries. The results suggest an increasing trend in flood peak discharge magnitudes at the outlet of the studied watershed throughout the 21st century. Similarly, estimates of the 100 and 200-year flood discharge magnitudes increase throughout the study period toward future in the 21st century. The differences among the historical flood frequency, and the flood frequencies during the first half and second half of the 21st century are indicative of the ongoing non-stationarity in the 21st century hydro-climate regime of the study region.

Cache Creek Settling Basin serves to preserve the flood capacity of the Yolo Bypass by trapping the heavy sediment load carried by Cache Creek. The second part of the presentation will report on the flood inundation and relative sediment capture performance at the Settling Basin by a two-dimensional unsteady flow and sediment transport model. The results will be presented for two modeling scenarios, the current condition and an alternative modification scenario, under 10, 50, 100 and 200-year flood events.

3. Analysis of Snow Distribution in Extreme Precipitation Events Over Two Sierra Nevada Watersheds

Presenter(s): Andres Diaz (UC Davis)
Presenter(s) Email Address(es): anjdiaz@ucdavis.edu
Collaborators: Yoshiko Iseri (UC Davis), Toan Trinh (UC Davis), Kei Ishida (Kumamoto University, Japan), M.L. Kavvas (UC Davis), Noriaki Ohara (Univ. of Wyoming), Michael L. Anderson (CA DWR)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
The effects of historical extreme precipitation events on snow distribution were studied over the Stanislaus and Tuolumne river watersheds by means of a physically based snow distribution model. The historical extreme precipitation events were obtained from the Climate Forecast System Reanalysis (CFSR) dataset, which covered a 30-year period between 1980 and 2010. The reanalysis dataset was dynamically downscaled at 3 km resolution using the Weather and Research Forecasting (WRF) regional climate model, and by making use of the downscaled atmospheric variables, the physically based snow model was calibrated validated against field observations on both watersheds. On most cases, the reconstruction of the of the snow conditions in the extreme precipitation events showed significant increases of the snowpack over the mountainous areas in the watersheds, but it highly depended on the atmospheric variables of temperature and solar radiation. For future work, an analysis of the effects of snow distribution and the subsequent soil initial conditions is suggested for the estimates of maximum flood events.

4. Calibration and Validation of Watershed Environmental Hydrology Module for Hydrologic Modeling of Floods in Sierra Nevada Foothills

Presenter(s): Yoshihiko Iseri (University of California, Davis)
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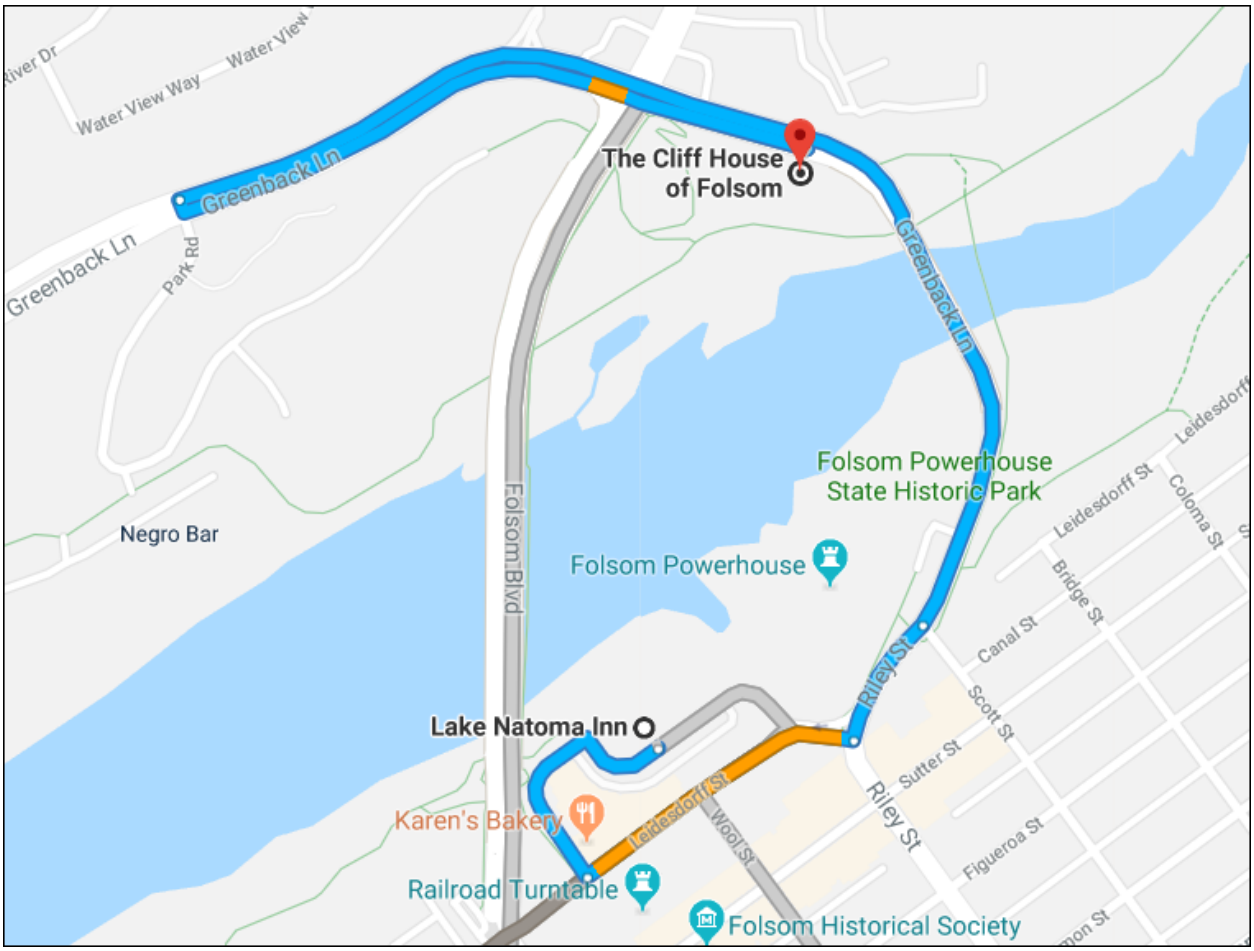
Collaborators: Toan Trinh, Andres J. Diaz, M. Levent Kavvas (University of California, Davis); Kei Ishida (Kumamoto University), Michael L. Anderson (California Department of Water Resources)
Permission to Post pdf of Presentation on CWEMF Website: Yes
Abstract:
Hydrologic modeling is an essential process to quantify the relation between extreme precipitation and floods. One of the most important steps in hydrological modeling is the calibration and validation of the hydrologic model. This study focuses on three watersheds (Mokelumne, Stanislaus, and Tuolumne) along the Sierra Nevada foothills, and calibrate/validate the process-based watershed environmental hydrology (WEHY) module. The atmospheric data which were dynamically downscaled from the Climate Forecast System Reanalysis (CFSR) were used as inputs to WEHY, and the calibration/validation of WEHY was performed in daily scale for water years from 1997-2006. The result indicated calibrated WEHY with downscaled CFSR was capable of reproducing the floods in 1997, and also the model showed reasonable performance in simulating discharges during the validation period.

DIRECTIONS TO BUSINESS MEETING
(CLIFF HOUSE OF FOLSOM)



DIRECTIONS:

- Depart Lake Natoma Inn
- Head southwest on Gold Lake Dr toward Leidesdorff St for 0.2 mi
- Turn left onto Leidesdorff St, travel 0.2 mi
- Turn left onto Riley St, travel 450 ft
- Continue onto Greenback Ln, travel 0.8 mi
- Make a U-turn at Park Rd, travel 0.4 mi
- Destination will be on the right:
  The Cliff House of Folsom, 9900 Greenback Ln, Folsom, CA 95630

LIST OF LOCAL RESTAURANTS

1. Sutter Street Grill – 811 Sutter St
2. Marly and Moo – 608 Sutter St
3. Heckle Alehouse & Eatery – 705 Gold Lake Dr #390
4. Q'Bole! Mexican Cocina & Cantina – 718 Sutter St
5. Chicago Fire - 614 Sutter St
6. Hacienda Del Rio Mexican Restaurant – 702 Sutter St
7. Hop Sing Palace – 805 Sutter St
8. Pizzeria Classico – 702 Sutter St
9. Samuel Horne's Tavern – 719 Sutter St
10. Folsom Hotel – 703 Sutter St
11. Sutter Street Taqueria – 727 Sutter St
12. Pure Life Juice Co. 604 Sutter St #190
13. Cliff House – 9900 Greenback Lane

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