Attachment 1, Part I – Application Cover Sheet

Application for a grant under § 78645 of the Safe, Clean, Reliable Water Supply Act of 1996

The California State University, Fresno Foundation
(Exact legal name of local entity applying for the grant)

Of 4910 N. Chestnut Avenue
(Mailing address of local entity)

Fresno, CA 93726-1852

Of the County of Fresno, State of California, does hereby apply to the California Department of Water Resources for a grant in the amount of $299,528.

For the following project under the Drainage Reuse Grant Program of the Safe, Clean, Reliable Water Supply Act of 1996:

Sustainable Subsurface Drainage Management at the SJRIP Facility using the CSUID-II Model to Optimize Salt Leaching in 'Jose' Tall Wheatgrass and Alfalfa Fields
(Specify project title)

By [signature] Date 1/5/15
(Signature of authorized representative)

Thomas McClanahan, Ph.D. Associate Vice President
(Print or type name of authorized representative) *(Title)*

Telephone 559-278-0840 E-mail orsp@csufresno.edu

Brief Proposal Description:

The San Joaquin River Improvement Project (SJRIP) has been operated by Panoche Drainage District (PDD) since 1998. Its primary function has been the reuse of subsurface tile drainage water on dedicated cropland to reduce drainage discharge and selenium loading into the San Joaquin River. A number of salt tolerant crops have been cultivated over the past 20 years – the most successful being 'Jose' tall wheatgrass and alfalfa hay - which now dominate the 6,000 acre dedicated facility. A significant agronomic and water quality database has accrued, which with the help of state-of-the-art simulation models of drainage and groundwater quality, could yield valuable insights to guide long-term management of the SJRIP. The proposed project will be conducted in four phases: (1) a data mining and analysis endeavor where existing drainage hydrology and water quality data will be combined and synthesized with data on soil texture, chemistry, hydraulic properties and crop yield to supply input to a state-of-the-art, irrigation and drainage simulation model (CSUID-II). CSUID-II was developed to look more comprehensively at the relationship between irrigation water quality, soil leaching, soil salinity and crop yield. (2) the new CSUID-II, a transient

Attachment 1, Part II – Applicant's Representatives

Project Name Sustainable Subsurface Drainage Management at the SJRIP Facility using the CSUID-II Model to Optimize Salt Leaching in 'Jose' Tall Wheatgrass and Alfalfa Fields

Primary Project Contact

Name Maral Kismetian Title Grants Analyst

Address 4910 N. Chestnut Avenue, Fresno, CA 93726

Telephone 559-278-0840 FAX 559-278-0992

E-mail orsp@csufresno.edu

Alternate Project Contact

Name Dr. Sharon Benes Title Professor

Address Dept. of Plant Science; CA State University, 2415 E. San Ramon Ave. M/S AS72; Fresno, CA 93740-8033

Telephone 559-278-2861 FAX 559-278-7413

E-mail sbenes@csufresno.edu

Alternate Project Contact (If Applicable)

Name Dr. Florence Cassel-Sharma Title Assistant Professor

Address Dept. of Plant Science; CA State University, 2415 E. San Ramon Ave. M/S AS72; Fresno, CA 93740-8033

Telephone 559-278-7955 FAX 559-278-7413

E-mail fcasselss@csufresno.edu

Type of Organization: University

(city, county, water district, university, etc.)

Attach a copy of the applicant's charter and the names and titles of its officers.

Attachment I, Part III – Summary of Project Costs

Provide a summary of the financing information about the proposed project, including cost share (if applicable).

		% of Total Cost
Total Cost of Project:	$299,528	
Amount Requested (CWC §78645):	$299,528	100
Amount of Cost Share[1]:	$0	0
Amount of Federal Contribution:	$0	0
In-kind Contributions:	$0	0
Amount to Funded by Others Sources: (Describe below in table.)	$0	0

Sources of funds from partner agencies for this project, if applicable:

Amount	Name of Source	Status of Funds[2]
$ n.a.		
$		
$		
$		
$		
Total: $		

Additional explanation, if necessary:

This is a new, highly specialized project. This is the first grant proposal submitted in relation to the proposed work so no cost share to report.

Notes:

1. No cost share is required; however, grantees are required to show cost share (e.g., federal, local, or other funds) if an awarded project costs more than the grant amount.
2. Identify the current status of funds: available, planned/budgeted, awarded or pending.

Research and Sponsored Programs

The Corporation will administer grants and contracts on behalf of the University under the following conditions:

1. Grant and contract activity shall include research, public service, and educationally related project proposals and awards involving federal, state, municipal, or county agencies, public or private corporations, private foundations, and/or individuals. When such grant or contract provides for direct funding, use of University facilities or resources, and/or endorsement by the University, then approval as herein described is required.

2. All applicable laws, regulations, rules, policies, and practices shall be satisfied prior to acceptance of the grant or contract issue.

3. Grant and contract proposals shall be reviewed by the project director's department chair, or organizational unit director, as appropriate.

4. The Associate Vice President for Research and Sponsored Programs shall administer the submission and approval of grants and contracts. It shall be the responsibility of the California State University, Fresno Research and Sponsored Programs Office to: ensure that appropriate project clearance(s) and approval(s) are obtained from California State University, Fresno organizational units which might be affected thereby prior to final approval and submission of a proposal), in collaboration with the project director involved; assume responsibility for negotiating any terms and conditions that differ substantially from those initially proposed; and keep all University units affected fully informed as to these negotiations.

5. All grants or contracts are to be accepted in the name of the Foundation, whereupon the Foundation business office shall contact individuals and/or organizational units affected by the award.

6. The Secretary of the Foundation, the Chief Financial Officer of California State University, Fresno or his or her designee, the Director of Foundation Financial Services, the Executive Director of the Foundation, and the Associate Vice President for Research and Sponsored Programs of California State University, Fresno, any two acting together, are hereby authorized to execute any contracts or subsequent amendments, with any governmental or non-governmental agencies or organizations as may be necessary in order to carry out the purposes referenced in this resolution, and that any prior resolutions in conflict herewith are hereby superseded.

Approved by the California State University, Fresno Foundation Board of Governors on June 4, 2009.

PANOCHE DRAINAGE DISTRICT

52027 WEST ALTHEA, FIREBAUGH, CA 93622 • TELEPHONE (209) 364-6136 • FAX (209) 364-6122

December 16, 2014

Maggie Dutton
California Department of Water Resources
Integrated Regional Water Management
South Central Region Office
3374 E. Shields Avenue
Fresno, CA 93726

Dear Ms. Dutton,

Panoche Drainage District (PDD) enthusiastically support the multi-institutional project led by California State University, Fresno entitled : *"Sustainable Subsurface Drainage Management at the SJRIP Facility using the CSUID-II Model to Optimize Salt Leaching in Jose Tall Wheatgrass and Alfalfa Fields"*, submitted to the California Department of Water Resources, for funding considerations under the Drainage Reuse Grant Program (DRGP) through Proposition 204.

The San Joaquin River Improvement Program (SJRIP) was developed in 1998 as a dedicated subsurface drainage reuse area for selenium load management designed to grow varieties of salt tolerant crops that could both withstand the high boron and concentrations of other potentially limiting trace elements and yield a positive economic return. The SJRIP reuse area has successfully accomplished these goals. Continued sustained use of the SJRIP facility will require ever more science-based salinity management where soil leaching rates for the various crops are carefully matched to the salinity of the influent subsurface drainage water and root zone residual salinity to maintain crop yields.

Over the past 15 years PDD has accumulated a significant inventory of drainage flow, drainage water quality, soils and crop yield data that, when fully analyzed, could provide important insights into past subsurface drainage management practices on the SJRIP reuse area. The modeling approach suggested by our Fresno State and Berkeley National Laboratory partners, when combined with additional crop and soil salinity survey data could provide important future technical guidance for future, sustainable best management practices applicable not only the SJRIP reuse area but also other salinity and selenium-affected agricultural lands with restricted drainage.

We look forward to your support of the proposed study.

Best regards,
Dennis Falaschi
General Manager

Board of Directors: John F. Bennett, *President* • Suzanne Redfern-West, *Vice-President* • Michael Stearns, *Secretary*
Stephen Smith • Michael Linneman • Dennis Falaschi, *General Manager*

Westside
www.westsidercd.org
Resource Conservation District
PO Box 6079 Fresno, California 93703-6079

January 5, 2015

California Department of Water Resources
Integrated Regional Water Management
South Central Region Office
3374 E. Shields Avenue
Fresno, CA 93726

SUBJECT: Support for Proposition 204 Application by California State University, Fresno titled: "Sustainable Subsurface Drainage Management at the SJRIP Facility Using the CSUID-II Model to Optimize Salt Leaching in Jose Tall Wheatgrass and Alfalfa Fields"

Ladies and Gentlmen:

Westside Resource Conservation District is pleased to support the subject application because of the applicability to substantial areas of land in the District with similar and complementary conditions. Specifically, tile drainage areas remain within the scope of the District that include both high salt loads and selenium. While the total amount of subsurface drainage in many areas of the District has been reduced, the amount is reflective of the availability of surface water. When surface water supplies are delivered, drainage volumes are likely to increase and the need to manage such water will likely include reuse schemes such as in the SJRIP. The model work proposed will offer better tools on how to not only manage the salt loads but more precisely and successfully manage crop production on any lands where the reuse activity is proposed. Furthermore, the modeling and management practices gleaned from the proposal offers the opportunity to potentially use other water supplies for successful crop growth. Specifically many Westside areas of naturally salinized groundwater could potentially be used for forage crops or other salt-tolerant plants. The proposal results could add precision and certainty to the speculative nature of using such marginal water supplies, especially in the agricultural land areas of Westside Resource Conservation District.

The District requests the Department give all due consideration for the proposal's potential for assisting with using saline waters for successful ongoing crop production.

Sincerely,

Sargeant J. Green
Secretary-Manager

Sustainable Subsurface Drainage Management at the SJRIP Facility using the CSUID-II Model to Optimize Salt Leaching in Jose Tall Wheatgrass and Alfalfa Fields

Nigel W.T. Quinn, PhD, P.E., D.WRE
Sharon Benes, PhD
Florence Cassel, PhD
Ayman Alzraiee
California State University, Fresno

in cooperation with :

Atomic Falaschi
Panoche Water District

Chris Linneman
Westside Drainage Authority

Chris M. Eacock
US Bureau of Reclamation

APPLICATION PACKAGE

Submitted to

California Department of Water Resources
Integrated Regional Water Management
South Central Region Office
3374 E. Shields Avenue
Fresno, CA 93726
Attn: Maggie Dutton

For

Drainage Reuse Grant Program

January 6, 2015

1. Project title and Summary

Sustainable Subsurface Drainage Management at the SJRIP Facility using the CSUID-II Model to Optimize Salt Leaching in Jose Tall Wheatgrass and Alfalfa Fields

The San Joaquin River Improvement Project (SJRIP) facility in the Grasslands Drainage Basin was developed and has been successfully operated by Panoche Drainage District (PDD) since 1998. The primary function of SJRIP has been the reuse of subsurface tile drainage water on dedicated cropland to reduce and eventually eliminate drainage discharge and selenium loading into the San Joaquin River. By meeting the selenium load targets set forth in the Regional Water Quality Control Board's Waste Discharge requirement, PDD has also significantly reduced salt export to the river by 77% through 2013. A number of salt tolerant crops have been cultivated over the past 20 years within SJRIP – the most successful of which have been Jose Tall Wheat Grass and alfalfa hay - which now dominate the 1,700 acres underlain by tile drainage within the 6,000 acre dedicated facility. A significant agronomic and water quality database has been accumulated by Panoche Drainage District staff over the period of operation which, with the help of state-of-the-art simulation models of drainage and groundwater quality, could yield valuable insights and help guide long-term management practices for the continued operation of SJRIP. Panoche Drainage District has been a pioneer in the application of real-time decision support techniques for drainage and selenium load management in the San Joaquin Basin, beginning with drainage policy directives at the landowner level to limit the co-mingling of surface and subsurface drainage and later with investments in drainage reuse facilities and plumbing at the District level.

The proposed project will be conducted in four phases. The first will be a data mining and analysis endeavor where existing drainage hydrology and water quality data will be combined and synthesized with data on soil texture, chemistry and hydraulic properties and on crop yield and morphology to supply input to a state-of-the-art irrigation and drainage water quality simulation model CSUID-II (Colorado State University Irrigation Drainage simulation model). CSUID-II is the result of a radical restructuring of the 20-year old CSUID model to look more comprehensively at the relationship between irrigation water quality, soil leaching, soil salinity and crop yield. In the second phase of the study, the new CSUID-II conceptual model will be further developed to include the steady-state Hoffman Model as an output subroutine such that it can provide output that can be directly compared to the CSUID-II simulation. The significance of this innovation is that the Hoffman model is being used by CVSALTS in their Basin Planning activities to develop minimum water quality limits for applied irrigation water. Provision of both model outputs will allow the important work that has been conducted by Panoche Drainage District within the SJRIP to be utilized for applied water salinity limit decision-making for crops such as alfalfa and Jose Tall Wheat Grass, as well as other salt tolerant crops grown for a long period of time within the SJRIP. In Phase 3, soil salinity surveys will be conducted using the EM-38 electromagnetic instrument on selected fields of alfalfa and 'Jose' tall wheatgrass irrigated with subsurface drainage water so as to validate the model simulation results. Error analysis will be used to improve model parameter calibration. Application of the calibrated model will occur in Phase 4 and the results of the simulations performed, together with crop yield data, will be used to make recommendations for optimal soil leaching rates for irrigation water applications of varying salinity levels.

Current CVSALTS planning activities associated with establishing the Lower San Joaquin River upstream objectives as part of a new Basin Water Quality Control plan consider real-time salinity management as an umbrella concept for the suite of surface and subsurface drainage management actions that will need to be implemented. Improving the scheduling of drainage discharge to the River will likely involve some

of the same policy and structural options selected by PDD, although with the addition of timed release from ponds in non-selenium affected areas. Use of the CSUID-II decision support tool is envisaged beyond the proposed project, as optimal leaching rates for the reuse of saline drainage water of variable quality is contemplated.

2. Principal Investigator/Cooperator(s) and Project Management

Sharon Benes, PhD. Project Director, Co-Lead Principal Investigator.

***Position**:* Professor, Soils & Crop Nutrition, Graduate Program Coordinator, Dept. of Plant Science.
Address: California State University, Fresno, 2415 E. San Ramon Ave. M/S AS 72, Fresno, CA 93740, Phone: (559) 278-2255, e-mail: sbenes@csufresno.edu

Role in project: Professor Benes will be the Project Director and co-Lead Principal Investigator on the Project. She will be jointly responsible with PI Quinn for meeting the project task schedule and for providing all project deliverables. Dr. Benes will be the day-to-day contact for the project. She will coordinate all research activities among investigators and collaborators; and will oversee the activities of the graduate and undergraduate students who will assist in the project.

Qualifications: Dr. Benes' background is in soil and water management and plant nutrition. She has conducted research in salinity-related areas (salt tolerance evaluation in plants, plant response to saline irrigation, soil management under saline conditions) for the past 20 years, focusing, in particular, on the evaluation of salt tolerant forages and halophytes for irrigation with saline waters characteristic of the western San Joaquin Valley. She is the author of more than 15 journal papers related to this topic. See CV in appendix.

Nigel W.T. Quinn, PhD, P.E., D.WRE- Project Manager, Co-Lead Principal Investigator.

***Position** :* Group Research Leader, Berkeley National Laboratory; Associate Research Scientist, California State University, Fresno.
Address **:** 1 Cyclotron Road, Bld. 70A-3317H, Berkeley, CA 94720. *Phone* : 510-486-7056; e-mail nwquinn@lbl.gov.

Role in project: Dr. Nigel Quinn will lead the modeling and data analysis portion of the project. He will coordinate the modeling activities among investigators and will be the primary contact with cooperators. Dr. Quinn will be jointly responsible with the Project Director for meeting the project task schedule and for providing all project deliverables.

Qualifications: Dr. Quinn's background is in irrigation and drainage engineering and surface and groundwater modeling. He has conducted research in surface and groundwater resource management in the San Joaquin Basin for the past 25 years and has led previous cooperative research with the Panoche Drainage District. He has authored most of the publications written on real-time water quality management over the past decade and is the author of more than 50 journal papers in irrigation and drainage hydrology and water quality. See CV in appendix.

Florence Cassel S., Ph.D., Principal Investigator

Position: Assistant Professor, Irrigation/Water Management, Assistant Director of Research, Center for Irrigation Technology (CIT)
Address: California State University, Fresno, 2415 E. San Ramon Ave. M/S AS 72, Fresno, CA 93740, Phone: (559) 278-7955, e-mail: fcasselss@csufresno.edu

Role in project: Dr. Florence Cassel will lead the field data collection part of the project with particular emphasis on the soil salinity surveysusing the electromagnetic induction (EM) remote sensing technology. She will supervise all EM remote sensing activities to be conducted at the Panoche Drainage District. She will develop the protocol and design the complementary soil sampling to validate salinity parameters obtained by the EM salinity surveys. She will also co-supervise with Dr. Benes, the activities of the students from CSU Fresno who will assist with the surveys and laboratory analyses.

Qualifications: Dr. Cassel's background is in soil and water management, and irrigation science.
She has more than 13 years of experience assessing salinization in salt-affected and drainage-impacted areas of the Westside San Joaquin Valley. Particularly, she has expertise in applying the remote sensing EM technology to evaluate and analyze spatial and temporal changes in soil salinity. Dr. Cassel has led numerous research projects related to soil salinity assessment and monitoring, including extensive EM salinity surveys at Red Rock Ranch. She has authored articles on soil and irrigation management, including two books on the principles and applications of the EM technology for salinity assessment in salt-affected soils of California. See CV in appendix.

Ayman Alzraiee, Ph.D., Investigator

Position: Research Scientist, Irrigation/Water Management, Center for Irrigation Technology and Post-Doctoral Fellow, Dept. of Civil & Environmental Engineering, Colorado State University.
Address: Engineering Building, Fort Collins CO, 80523-1372

Role in project: Dr Ayman Alzraiee will lead the development of the CSUID-II model.
Qualifications: Dr. Alzraiee is a mathematical modeler and software engineer with joint appointments at CSU Fresno and Colorado State University. He has been on the development team for the CSUID model for the past 10 years under the direction of Professor Luis Garcia, who recently moved to the University of Vermont as Dean of the Engineering School. Dean Garcia will continue his involvement as a peer review advisor on CSUID-II model development. See CV in appendix.

Ellen Suryadi, Project Grant Administrator

Position: Grant Administrator
Address: Center for Irrigation Technology, California State University, Fresno. 6014 N. Cedar Ave. M/S OF18; Fresno, CA 93710. Phone: 559-278-2066, email: esuryadi@csufresno.edu

Role in project: Ellen Suryadi will be the person responsible for executing the grant agreement and any amendments and approving invoices.
Qualifications: Ms. Suryadi has been administrating project grants for the Center for Irrigation Technology and California Water Institute for over 10 years, and has extensive experience with accounting, invoicing, and personnel management.

Atomic Falaschi. Project Cooperator

Position: SJRIP Manager, Panoche Water District
Address: 52027 West Althea Avenue, Firebaugh, CA 93622. Phone: (209) 620 3831, e-mail: afalaschi@panochewd.org

Role in project and qualifications: Atomic Falaschi is the Manager of the SJRIP facility in Panoche Drainage District and the person responsible for ongoing data collection at the site and decision-making with respect to irrigation management with subsurface drainage water. Atomic is our primary stakeholder and the person most able to implement the findings and recommendations of our study.

Chris Linneman. Project Cooperator

Position: Stakeholder Liaison Westside Drainage Authority, Consulting Engineer
Address: Summers Engineering, P. O. Box 1122, 887 N. Irwin St., Hanford, CA 93232. Phone:559-582-9237. clinneman@summerseng.com

Role in project and qualifications: Chris Linneman is a Civil Engineer with Summers Engineering Inc. and has represented Panoche Water District and allied agricultural landowner interests within the Grassland Bypass Project for over a decade. Chris has assisted Joe McGahan, Westside Drainage Coordinator for the San Luis and Delta Mendota Water Authority, as stakeholder liaison for real-time flow and salinity data collection monitoring in the project area and agency communication. Chris will play a key role in the project by helping to translate project outcomes and recommendations into actions that his client base within the Grasslands drainage basin can take to improve drainage management and sustain crop productivity.

Chris Eacock. Project Cooperator

Position: Grasslands Bypass Project Manager, Soil Scientist
Address: U.S. Bureau of Reclamation, South-Central California Area Office, 1243 N Street, Fresno, California 93721. Phone: 559 487 5133, e-Mail: meacock@usbr.gov

Role in project and qualifications: Chris Eacock is a Project Manager in the Bureau of Reclamation's South Central California office, based in Fresno with responsibilities for agricultural drainage management and oversight of facilities and activities connected with the Grasslands Bypass Project. The Bureau of Reclamation has been a key contributor to the SJRIP project and the Regional Drainage Facility recently constructed at the same facility at a cost of $24 million. Chris continues to provide funding for outreach activities related to the successful operation both of the Regional Treatment Facility and SJRIP.

Other key personnel

A graduate student from CSU Fresno will participate in all phases of the project, including data collection, salinity surveys, laboratory analyses, and model development and validation. The student will be under direct supervision of Dr. Benes and will work closely with Drs Quinn and Alzraiee on the modeling part of the project and with Dr. Cassel on the EM salinity surveys. Steve Mettler (CIT part-time employee) will help perform the salinity surveys. He will prepare all equipment necessary to conduct the surveys, drive the MCA system (see section 6.3), and conduct the ground-truthing soil sampling.
An undergraduate student from CSU Fresno will assist with the soil sampling and perform all necessary laboratory analyses on the collected soil samples.

2.1 Project Team Experience and relationships amongst institutions

The project team that has been assembled for the proposed project has been selected to confer maximum likelihood for success. The team of Professor Sharon Benes, Dr. Nigel Quinn and Dr. Florence Cassel has a combined 70 years of experience working on irrigation and drainage issues on the west-side of the San Joaquin Valley. Dr. Benes has been involved in agronomic research at the SJRIP field site for many years and has worked closely with Panoche Drainage District personnel developing expertise on the yield response of 'Jose' tall wheatgrass – a relatively new crop for the San Joaquin Valley. Dr. Nigel Quinn has been involved in drainage water quality research for the past 26 years and most recently on real-time salinity management within the San Joaquin River and contributing watersheds. He is the Technical Chair of CVSALTS – an organization tasked with developing a new water quality Basin Plan for the San Joaquin valley. He spent six years as part of the Technical Review Team during the first years of

the Grassland Bypass Project and has published widely on selenium drainage issues. Dr. Florence Cassel is a soil scientist and an expert in soil salinity mapping and soil plant relations. She has led a large number of EM salinity mapping campaigns throughout the San Joaquin Valley which have provided essential insight to farmers interested in improving on-farm salt and drainage management. Florence was also one of the lead scientists for managing and evaluating the experiments in Integrated On-farm Drainage Management at Red Rock Ranch in the Westlands Water District. This pioneering research provided the first comprehensive dataset that allowed the concept of this technology to be developed.

In addition, Dr. Benes is currently conducting a trial at UC Westside Research and Extension Center (UC-WSREC) evaluating the performance of new alfalfa varieties selected for salt tolerance. In collaboration with Dr. Cassel, she will apply the EM technique to relate the alfalfa yields to the soil salinities resulting from specific combinations of irrigation water salinity and frequency. Given that soil conditions and irrigation water composition in the Five Points area are similar to those in the SJRIP, this information will be useful for the validation of the CSUID-II model and it will provide valuable information for decision-making in the SJRIP with regard to blending saline water sources and the yield loss thresholds for alfalfa based on soil and irrigation water salinity. Drs. Benes, Quinn, and Cassel have also worked jointly on previous research projects aimed at assessing and managing salinity in various drainage impacted agricultural lands and wetlands of the San Joaquin Valley; and have a long working relationship.

Dr. Ayman Alzraiee holds joint appointments at CSU Fresno and Colorado State University. He is one of the developers of the CSUID software and was responsible for the software design and implementation of the previous CSUID GUI. Dr Alzraiee will lead the development of the CSUID-II model for this project.

Our project cooperators Atomic Falaschi, Chris Linneman and Chris Eacock have been involved in the development of SJRIP and its operation since its inception in 1998. Their field and experiential knowledge will be key in helping to interpret the datasets that have been compiled over the past 15 years and also in technology transfer of new insights or decision support tools that are developed during the term of the proposed project.

2.2. Project management plan

Drs. Benes and Quinn will be responsible for supervising all activities conducted by the research team. Dr. Benes will coordinate the field activities at Panoche Drainage District and Dr. Quinn will lead the modeling tasks and data analyses. Both Drs Benes and Quinn will facilitate data sharing, communication, and reporting among project investigators and collaborators. They will coordinate regular meetings, either to be held at the Panoche Drainage District research site, CSU Fresno, or Berkeley National Laboratory. They will also schedule video conferences, communications through emails and phone conversations to discuss progress and ensure timely completion of all tasks as described in sections 5 and 7. Data sharing will be conducted through emails or file hosting services such as Dropbox or Google Drive.

2.3. Laboratories and facilities

There is more than sufficient institutional capacity, given the individuals involved in the project team to complete the project successfully. The Mobile Conductivity Assessment (MCA) System developed at CSU Fresno will be utilized for the EM remote sensing surveys, as described in section 6. The soil analyses required for soil salinity mapping will be performed in the Benes, Quinn and Cassel Labs which have overlapping capabilities in the use of electromagnetic survey data for this purpose. Facilities at

CSU Fresno, to be used in the project comprise a Graduate Laboratory for processing of soil samples and equipped with soil drying ovens, soil grinders, soil water extraction equipment, conductivity/salinity meters for salinity measurements. The same equipment is available at the Berkeley National Laboratory. Secondary data sources such as weather station data, essential for soil salinity modeling with the CSUID-II model will be furnished by the Panoche Water District.

3. Scope of Work and Project Description

The San Joaquin River Improvement Project (SJRIP) facility in the Grasslands Drainage Basin was developed and has been successfully operated by Panoche Drainage District (PDD) since 1998. The primary function of SJRIP has been the reuse of subsurface tile drainage water on dedicated cropland to reduce and eventually eliminate drainage discharge and selenium loading into the San Joaquin River. By meeting the selenium load targets set forth in the Regional Water Quality Control Board's Waste Discharge requirement, PDD has also significantly reduced salt export to the river by 77% through 2013. A number of salt tolerant crops have been cultivated over the past 20 years within SJRIP – the most successful having been 'Jose' tall wheatgrass and alfalfa hay - which now dominate the 1,700 acres underlain by tile drainage within the 6,000 acre dedicated facility. A significant agronomic and water quality database has been accumulated by Panoche Drainage District staff over the period of operation which, with the help of state-of-the-art simulation models of drainage and groundwater quality, could yield valuable insights and help guide long-term management practices for the continued operation of SJRIP. Panoche Drainage District has been a pioneer in the application of real-time decision support techniques for drainage and selenium load management in the San Joaquin Basin, beginning with drainage policy directives at the landowner level to limit the co-mingling of surface and subsurface drainage and later with investments in drainage reuse facilities and plumbing at the District level.

3.1. Project goals and objectives

The goal of the proposed project is to develop a state-of-the-art, irrigation and drainage water quality simulation model (CSUID-II) to look more comprehensively at the relationship between irrigation water quality, soil leaching, soil salinity and crop yield and ultimately, to guide irrigation and drainage management in the SJRIP. In the initial phase of model development, we will focus on mining the rich data set that has been collected over the past 15 years and using these data with secondary data to develop this root zone salinity management tool. This modeling tool will be used to assist the design of new subsurface tile drainage facilities for SJRIP and can be applied to other saline drainage reuse projects state-wide.

The proposed project will be conducted in four phases that will constitute the four objectives of the study.

1) A data mining and analysis endeavor will be performed where existing drainage hydrology and water quality data will be combined and synthesized with data on soil texture, chemistry and hydraulic properties and on crop yield and morphology to supply input to a state-of-the-art irrigation and drainage water quality simulation model CSUID-II (Colorado State University Irrigation Drainage simulation model). CSUID-II is the result of a radical restructuring of the 20-year old CSUID model to look more comprehensively at the relationship between irrigation water quality, soil leaching, soil salinity and crop yield.
2) The new CSUID-II conceptual model will be further developed to include the steady-state Hoffman Model as an output subroutine such that it can provide output that can be directly

compared to the CSUID-II simulation. The significance of this innovation is that the Hoffman model is being used by CVSALTS in their Basin Planning activities to develop minimum water quality limits for applied irrigation water. Provision of both model outputs will allow the important work that has been conducted by Panoche Drainage District within the SJRIP to be utilized for applied water salinity limit decision-making for crops such as alfalfa and 'Jose' tall wheatgrass, as well as other salt tolerant crops grown for a long period of time within the SJRIP.

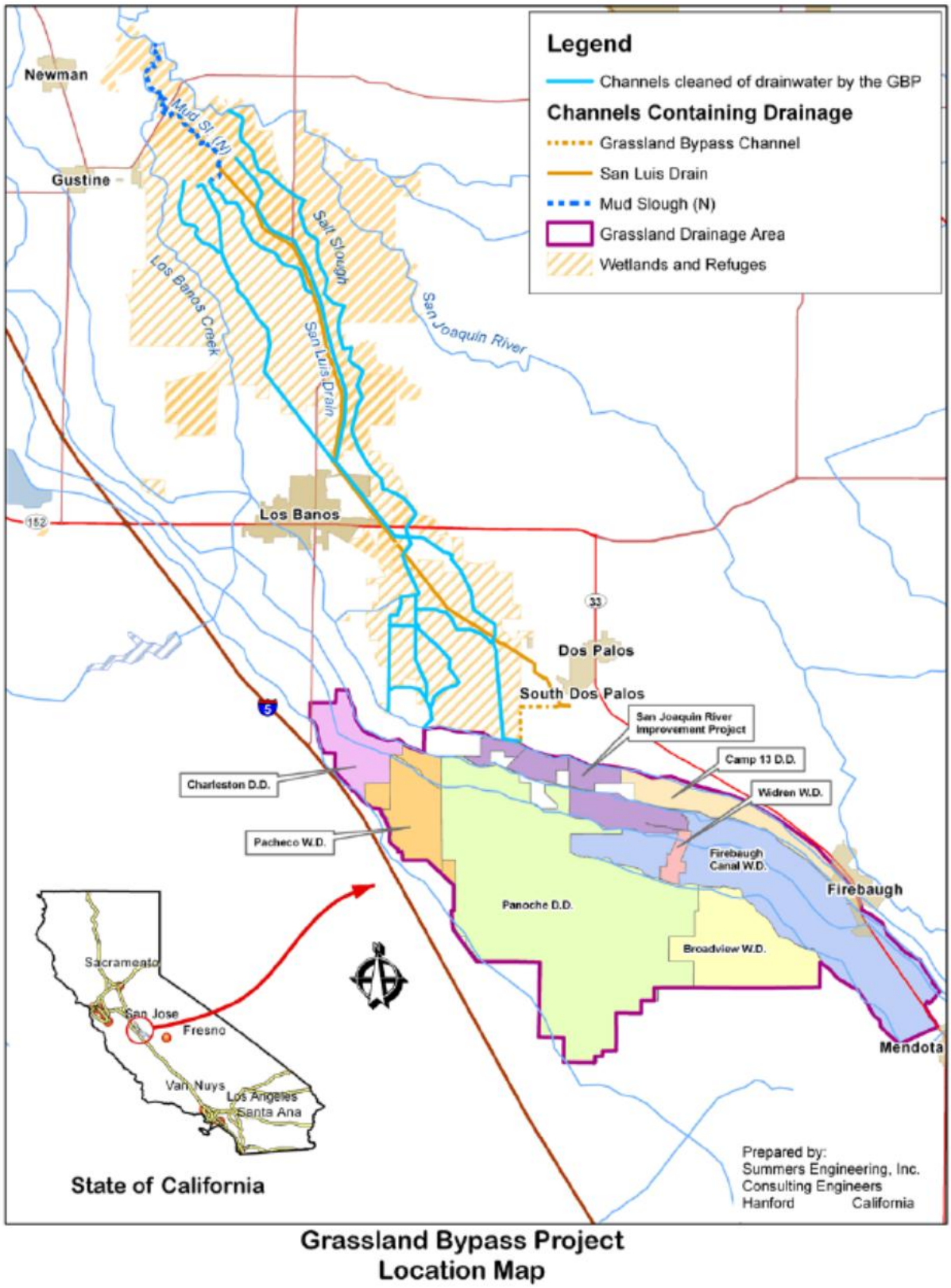
3) Soil salinity surveys will be conducted using the EM remote sensing technique on selected fields of alfalfa and 'Jose' tall wheatgrass irrigated with subsurface drainage water so as to validate the model simulation results. Error analysis will be used to improve model parameter calibration. Information from the EM soil salinity monitoring campaigns conducted for the saline-irrigated, alfalfa variety trial at UC-WSREC will also be incorporated to examine the robustness of the model.
4) Application of the calibrated model: results of the simulations performed, together with crop yield data, will be used to make recommendations for optimal soil leaching rates for irrigation water applications of varying salinity levels.

Current CVSALTS planning activities associated with establishing the Lower San Joaquin River upstream objectives as part of a new Basin Water Quality Control plan consider **real-time salinity management as an umbrella concept** for the suite of surface and subsurface drainage management actions that will need to be implemented. Improving the scheduling of drainage discharge to the River will likely involve some of the same policy and structural options selected by PDD, although with the addition of timed release from ponds in non-selenium affected areas. Use of the CSUID-II decision support tool is envisaged beyond the proposed project, as optimal leaching rates for the reuse of saline drainage water of variable quality is contemplated. This model could also be utilized for management decisions for forage production using other saline water sources such as saline well waters or wastewaters.

3.2. Description of project location

Project location: The SJRIP facility is located between the Delta Mendota Canal and Central California Irrigation District's Main Canal, and between Russell Avenue and Fairfax Avenue in Fresno County (Figure 1). The current SJRIP facility covers approximately 6,000 acres (Figure 2).

GIS coordinates: Latitude: 36.8944, Longitude: -120.5619
Congressional District: 18
California State Senate District Number: 16
California Assembly District Number: 30



Grassland Bypass Project
Location Map

Figure 1. Map of Grasslands drainage subarea showing location of SJRIP facility

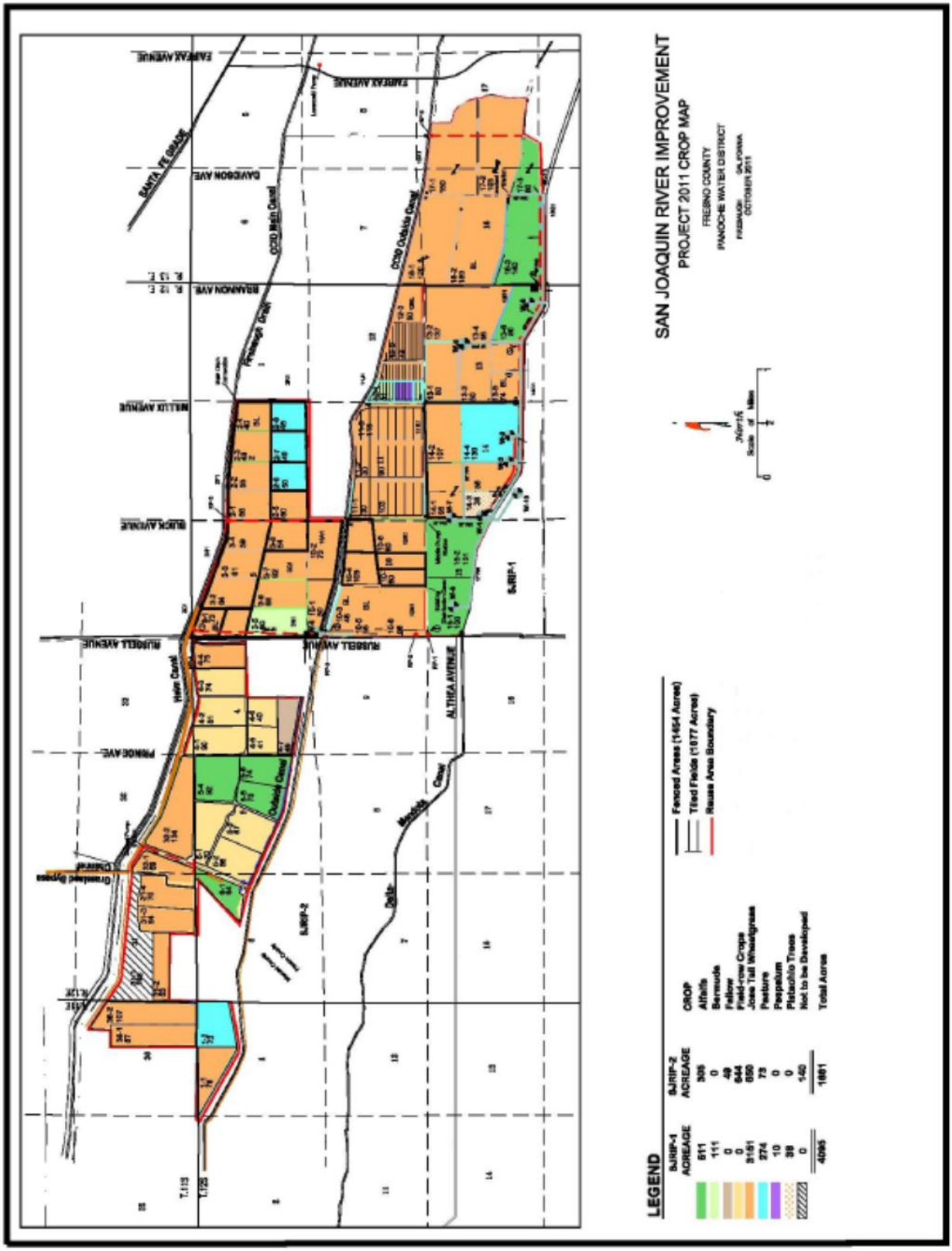


Figure 2. Detailed map of the 6,000 acre SJRIP facility showing crop distribution,

3.3 Description of existing contracts, Memorandums of Understanding, Joint Powers Authorities or other formal agreements with project partners.

In March 1996, the Grassland Basin Drainers (those agricultural entities within the selenium-impacted area of the Grassland sub-Basin that drained to the San Joaquin River) formed a regional drainage entity under the umbrella of the San Luis & Delta-Mendota Water Authority to implement the Grassland Bypass Project. This entity included approximately 97,000 acres of irrigated farmland on the west side of the San Joaquin Valley (also known as the Grassland Drainage Area). The Grassland Bypass Project is an innovative program that was designed to improve water quality in the San Joaquin River through a commitment to selenium load reduction and to prevent potential contamination of fresh water within wetland delivery channels. The Grassland Bypass Project combines subsurface drainage flows on a regional basis from the project participants and, through a "Use Agreement" with the US Bureau of Reclamation has utilized a 28 mile reach of the San Luis Drain to convey flows around sensitive, seasonal areas of the managed wetlands. The Grassland Bypass Project has included monthly and annual limits on the selenium load that could be discharged to the San Joaquin River. A procedure was also included to assess incentive fees if monthly or annual load limits were exceeded. Through a variety of drainage reduction practices, the Grassland Drainers have been able to reduce their discharge to the San Joaquin River by 41%, resulting in a selenium load reduction of 54%, salt load reduction of 29%, and a boron load reduction of 14%. In September 2001, the Use Agreement for the first five years of the Grassland Bypass Project expired and a new Use Agreement was signed. Monthly and annual selenium load limits were significantly reduced as part of the new Use Agreement with the goal of zero drainage discharge by the end of the Agreement term. Table 1 shows the yearly reductions in drainage discharge and salt, selenium and boron loading into the San Joaquin River from 1998 to 2011 and Figure 3 shows the reductions in Se discharge in relation to the discharge targets established in the Grasslands Bypass agreement.

Table 1. Progressive reduction in salt loading to the San Joaquin River 1998-2011.

Water Year	Reused Drain Water	Displaced Selenium	Displaced Boron	Displaced Salt
	(acre feet)	(pounds)	(pounds)	(tons)
1998¥	1,211	329	NA	4,608
1999¥	2,612	321	NA	10,230
2000¥	2,020	423	NA	7,699
2001	2,850	1,025	61,847	14,491
2002	3,711	1,119	77,134	17,715
2003	5,376	1,626	141,299	27,728
2004	7,890	2,417	193,956	41,444
2005	8,143	2,150	210,627	40,492
2006	9,139	2,825	184,289	51,882
2007	11,233	3,441	210,582	61,412
2008	14,955	3,844	238,435	80,900
2009	11,595	2,807	198,362	60,502
2010	13,119	3,298	370,752	75,362
2011	21,623	4,394	454,675	102,417

NA = Not Available

¥ PDD drainage reuse project prior to SJRIP

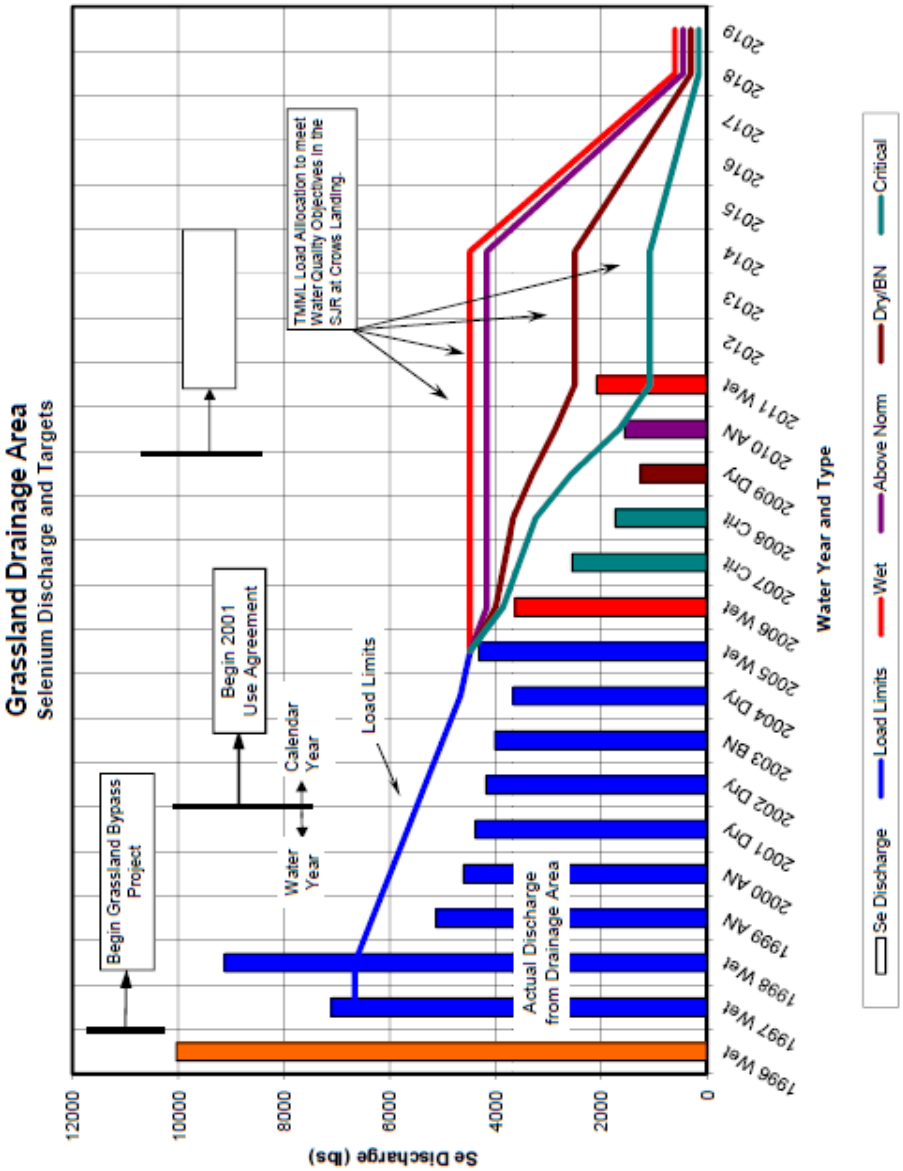


Figure 3. Selenium reduction schedule through 2019. Selenium load reduction activities will have a roughly proportional impact on salt loading to the San Joaquin River.

Panoche Drainage District implemented the first phase of the San Joaquin River Water Quality Improvement Project (SJRIP) as a means of reusing and disposing of subsurface agricultural drainage water generated throughout the Grassland Drainage Area. Phase I included the initial purchase of 4,000 acres of farmland, of which approximately 1,800 acres were planted to a mix of pasture crops and 220 acres of asparagus, a salt tolerant vegetable crop. Resources over the next 10 years were focused on expanding the acreage of the developed reuse area and constructing the necessary infrastructure. The acreage of 'Jose' tall wheatgrass increased rapidly between 2004 and 2008 reaching ~3,750 acres in 2012 (Figure 3). Tall wheatgrass is a highly salt tolerant forage which can be irrigated with more saline

water than the other crops in the SJRIP. Yields have averaged ~6 tons per acre with the hay sold for ~ $120/ton, mostly to local dairies (Linneman et al., 2014).

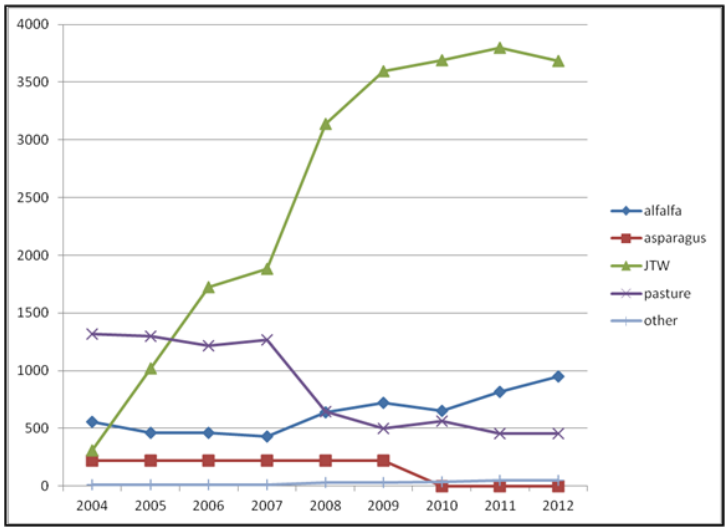


Figure 4. History of crop acreage in the SJRIP reuse area. JTW represents 'Jose' tall wheatgrass and pasture consisted of bermudagrass, tall fescue and a mix of other grasses.

Alfalfa is more sensitive to salinity, but higher yielding and more profitable than tall wheatgrass. Currently, the SJRIP has ~950 acres of alfalfa that are irrigated with a blend of drain water and well water, with yields of ~9 tons/acre, sold at $225/ton. Pistachio was introduced in 2004 as a nut crop which could generate extra revenue for the SJRIP. About 40 acres of pistachio are currently planted. Laboratory and field data (Sanden et al., 2013) indicate that pistachio is at least moderately tolerant to salinity and boron; however, the long term sustainability of using 3 – 4 dS/m drainage water with a boron concentration of 4 to 8 ppm remains a concern. The pistachio acreage could increase in the future as a means to help the overall project become self-sustaining. Asparagus is no longer grown in the SJRIP and grazing has been phased out for the most part.

The volume of agricultural subsurface drainage water discharged to the San Joaquin River has been greatly reduced by reusing the drainage water to irrigate planted fields in the SJRIP. Additionally, by reducing the amount of drain water conveyed to the River, the project also curtails nutrient loading (mainly nitrate) to the San Joaquin River. Currently, 5,140 of the 6,000 acres now comprising the SJRIP have been planted: in order to meet future load targets and maintain long term viability, the entire area needs to be provided with subsurface drainage and planted with salt tolerant crops.

The Grassland Bypass Project has, from its official origin in 1996, been a unique cooperative effort between regulators such as the California Regional Water Quality Control Board and the US-EPA, water agencies such as the US Bureau of Reclamation and California Department of Water Resources, fish and wildlife conservation agencies such as the California Fish and Wildlife Service and US Fish and Wildlife Service and private water district entities such as Grassland Water District and Panoche Drainage District (which undertook a leadership role among participating agricultural water districts). The San Luis and Delta Mendota Water Authority (a joint powers agency) has also played an important leadership role in pursuing grant funding and in project implementation connected to SJRIP and other project-related reuse facilities. At various times representatives from Bay Area municipal entities such as Contra

Costa County and environmental non-profits such as Environmental Defense have participated in the Technical Review Team which oversees monitoring and scientific interpretation of the monitoring data for the Grassland Bypass Project.

The Center for Irrigation Technology at California State University, Fresno has had a long association with reuse projects having been involved with experimentation in Integrated On-Farm Drainage management (IFDM) (PI's Cassel and Benes) at Red Rock Ranch in Westlands Water District and more recently, at the SJRIP Facility. PI Benes investigated the biomass yield and nutritional quality of various forages, including 'Jose' tall wheatgrass, and the evapotranspiration (ET) potential of the tall wheatgrass under irrigation with saline drainage water in the IFDM at Red Rock Ranch (Suyama et al., 2007; Benes et al. 2012). Her current work at UC-WSREC relating alfalfa yield response to soil salinity distribution under saline irrigation will provide useful data for calibration of the CSUID-II model. PI Quinn was an early participant in the TRT of the Grassland Bypass project (until 2005) and continues to contribute to the annual Grassland Bypass project report. As such the Project PI's are already well known cooperators to the Grassland Bypass Project and can provide effective technology transfer to many of the cooperating entities identified above. This can significantly contribute to the success of the project proposal.

3.4. Overview of outcomes and deliverables

The following outcomes and deliverables will be obtained from the proposed project:

Objective 1:

- Compilation, synthesis, and analyses of existing 15-year hydrologic, soil, plant, and water data from the SJRIP project and the UC Westside Research & Extension Center (WSREC) at Five Points, including Drainage hydrology; Water pH, electrical conductivity, salt constituents; Soil texture, hydraulic conductivity, salt constituents, Crop yield, morphology, rooting depth.
- Development and calibration of conceptual root zone salinity models.
- Deliverables: database consisting of 15-year of hydrologic, soil, plant, and water information, root zone salinity models.

Objective 2:

- CSUID-II model and GUI development.
- Model calibration using SJRIP and WSREC compiled data.
- Deliverables: Calibrated CSUID-II model with post-processing visualization tools.

Objective 3:

- Model validation with soil salinity surveys and soil water monitoring data.
- Deliverables: soil salinity maps, CSUID-II comparison results with salinity survey data.

Objective 4:

- Apply model to 1) simulate and analyze soil salinity dynamics to determine optimal leaching fraction, 2) evaluate subsurface drainage application schedules to establish optimal irrigation,
- Deliverables: Recommended leaching fractions, irrigation schedules, and drainage configuration based on varying levels of applied drainage water EC.

These deliverables will be obtained following the scheduled timeline outlined in section 7 to ensure timely completion of each project task. In addition, the project team will prepare annual and final reports, present project results at conferences and growers' meetings; and prepare journal publication(s) on the research findings. Informal workshop and/or demonstration day will be organized by CSUF and Berkeley National Laboratory at the end of the second year of the proposed project to demonstrate the CSUID-II model tool, present modeling results for management of drainage water and optimizing of crop production.

3.5. Description of project components that will be funded by DWR.

Regional reuse within the SJRIP involves the reapplication of saline and seleniferous drainage water to fields of plants that can reduce drainage volumes via evapotranspiration (ET). The SJRIP was initiated in 1998 with partial funding from the US Bureau of Reclamation which continues to provide funding for expansion of the Reuse area and the construction and operation of the adjacent selenium treatment facility. Panoche Drainage District has received additional state and federal grants to fund agronomic research in the Reuse area and research into salt and selenium and salinity treatment systems, in particular, reverse osmosis technology. Experimentation with various cultivars over the past 15 years has identified forage such as 'Jose' tall wheatgrass that have commercial value beyond the use for Se removal and reduction of drainage volumes. The Reuse Area currently has 5,140 acres in production and plans to eventually encompass 6000 acres with the installation of subsurface drainage facilities on up to 1,500 more acres within this area.

To date there have been no modeling studies that target salinity management at the Reuse facility. Funds requested from DWR under this grant program will focus on mining the rich data set that has been collected over the past 15 years and using these data with secondary data to develop a state-of-the-art root zone salinity management tool. This modeling tool will be used to assist the design of new subsurface tile drainage facilities for SJRIP and can be applied to other saline drainage reuse projects state-wide.

4. Project Objectives and Program Priorities

4.1 Background

Soil is said to be saline if salts have accumulated in a concentration that causes a loss in crop yield. In agriculture, this is often caused by salts from irrigation water or salts from shallow groundwater. Yield reductions occur when salts accumulate in the crop root zone. Salt accumulation in the crop root zone produces osmotic stress which in can reduce crop yield and growth, as plants are unable to extract sufficient amounts of water from the soil solution. Salts that contribute to high salinity are water soluble and are therefore easily transported by water. A portion of accumulated salts can be leached by precipitation or irrigation water, which moves salts to deeper soil depths past the crop root zone when no drainage barriers are present within the soil profile. (Hoffman, 2010)

During the irrigation process and depending on the applied water's salt content, salts can be both precipitated within the soil (left by the irrigation water in the soil) or dissolved into the irrigation water as the water passes through the soil profile. As water higher in salt content is used to irrigate crops, salinity gradually increases in the soil profile, most significantly in the crop root zone. Beyond a certain threshold, as salinity in the crop root zone increases relative crop yield decreases

The salt tolerance of crops continually changes over the course of the season. Most crops are tolerant during germination but sensitive during emergence and early seedling development. Once established, crops usually become more tolerant as they progress through the later stages of growth. However, salt stress delays both germination and emergence. Because of evaporation salt concentration is higher in seed beds than at deeper levels in the soil profile, and as a result the juvenile roots of emerging seedlings are exposed to greater salt stress in comparison with the salinity levels at deeper soil depths. Consequently, losses in plant population and yield reductions can occur if proper irrigation management is not practiced. Salt tolerance during emergence does not correlate well with salt tolerance in terms of yield and varies among crop species. Tolerance during emergence is based on survival, while tolerance after emergence is based on growth or yield. The majority of published data indicates that crops are more salt sensitive in the seedling stage than during germination. Seedlings are also more salt sensitive when compared to older more established plants (Hoffman, 2010).

There are several ways to prevent or reduce the effects of soil salinity on crops during emergence and early growth stages. Irrigation can be employed before a crop is planted. This process, known as pre-plant irrigation leaches, leaches salts to lower soil depths below the reach of seedling roots. Farmers may also overplant seeds, with the expectation that a certain number will not germinate or plant seeds in the sloping portion of a bed furrow, which places the seeds in an area of lower salinity. (Hoffman, 2010)

4.2 Steady-state and transient drainage salinity models

Models can be used in order to help predict the relationships between applied water salinity, leaching fraction, and soil salinity. These models help predict outcomes in certain situations when direct field measurements cannot be made. Currently, steady-state and transient models are used to assess water quality. Steady-state models are independent of time and are generally simpler than transient models. Steady-state models require less data than transient models and assume that transient models will converge into a steady state if the weather, irrigation, and the crop in question remain constant. Transient models are time dependent and their analysis is based around many different time-dependent variables. Unlike steady-state models, transient models can account for changes in weather, irrigation, and crop but require more data to do so.

The Colorado State University Irrigation and Drainage Model (CSUID) is a three dimensional groundwater flow model capable of calculating solute transport through the soil profile and considers irrigation timing and drainage architecture for individual crop requirements (Manguerra and Garcia, 1995). The model also solves the Richard's equation and advective-dispersive equation for one-dimensional vertical flow and salt transport in the soil profile above the water table. Additionally, the model solves the depth-averaged Boussinesq equation and two-dimensional advective-dispersive transport equation for areal flow and transport in the fully saturated zone below the water table. CSUID can be used for drainage design and for development of drainage management solutions.

The model can predict multiple crop stresses such as water deficit, water excess, and salinity while allowing for spatial and temporal variability while allowing for spatial and temporal variability of three dimensional soil parameters and two dimensional parameters. Three dimensional soil parameters include hydraulic conductivity, dispersivities, porosity, specific of storativity, and other Van Genuchten parameters. Two dimensional parameters include irrigation depths and preferential flow (Alzraiee and Garcia, 2013, Manguerra and Garcia, 1995).

Development of a new version of the CSUID model to produce CSUID-II will be supported, in part, by the current proposal. CSUID-II model development to date has been undertaken as a collaboration between Colorado State University and Berkeley National Laboratory. Dr Ayman Alzraiee is the primary developer of the new model. The CSUID model requires a technical understanding of soil hydrology and calls for a wide variety of site-specific input parameters and their function within the model. The CSUID model is capable of simulating three-dimensional flow beneath a field or larger subarea. This feature makes CSUID's transient analysis very robust and allows for more precise crop yield predictions to be made.

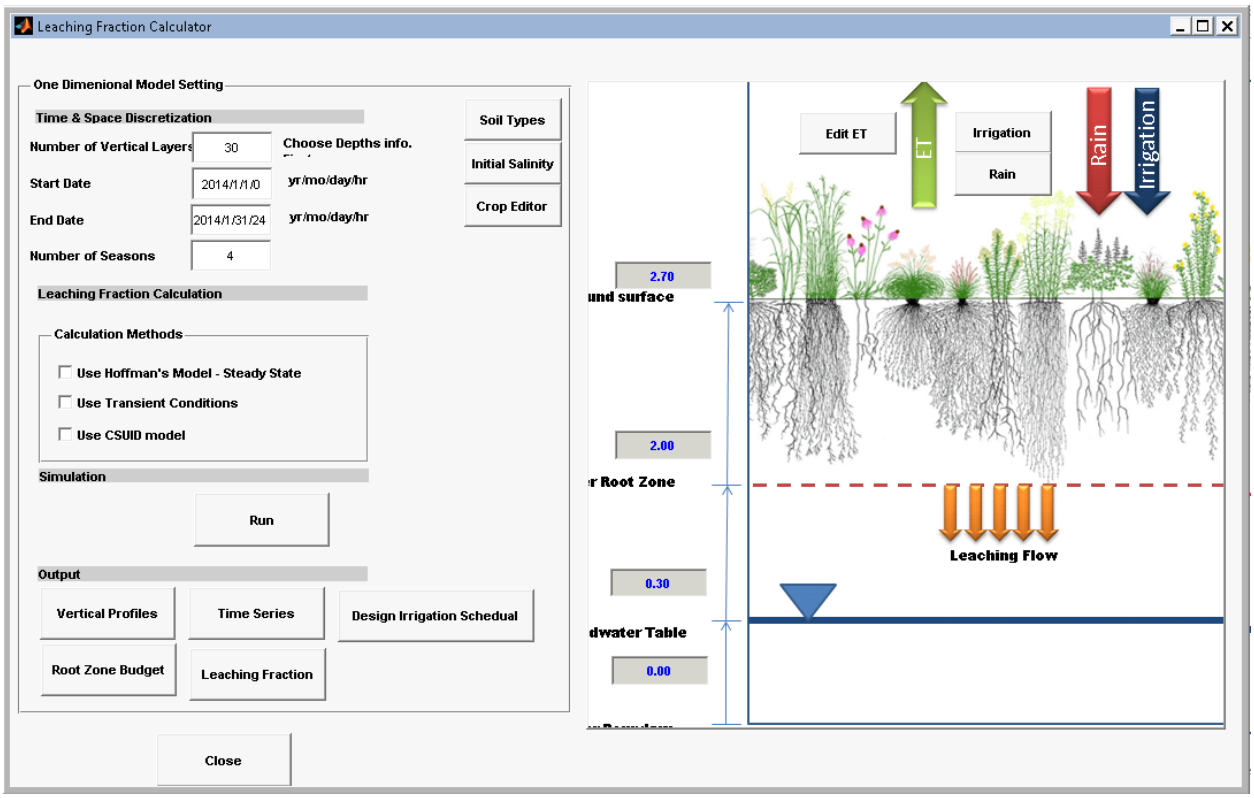


Figure 5. Conceptual model of root zone salinity simulated by a rough prototype of CSUID-II Graphical user Interface.

The new model will update CSUID's crop salinity production functions with improved algorithms and update the crop database with salt tolerant crops such as 'Jose' tall wheatgrass. A major feature of CSUID has always been its ability to account for unique subsurface drainage system configurations – subsurface drains can be installed at various depths below the soil surface. Each drain can be set so have a specific slope, conductance, length, and diameter. Setting up the model to simulate complex configurations has been challenging – this limitation will be addressed in the new Graphical User Interface (GUI) under development in CSUID-II.

After a simulation is run in CSUID, various output parameters, such as average root zone salinity, water table elevation, and total head can be displayed layer by layer. The color of each layer represents a value; colors are chosen to represent higher or lower values. In CSUID-II – the three-dimensional model domain will be capable of rotation and closer viewing with the new GUI design. CSUID-II will also allow for the selection of an expanded array of time-specific model output parameters– these parameter values can then be intercepted at specific times during the modeling simulation.

4.3. Description of project goals and objectives

Objective 1. Data assimilation and synthesis (Benes, Quinn, graduate student: budget $ 85,000)

- Compile, synthesize and analyze field data from the SJRIP project site and the UC Westside Research & Extension Center (WSREC) at Five Points.
- Obtain data from secondary proximate sources for climate and water quality parameters used in model calibration and validation.
- Develop and validate conceptual root zone salinity models using available data.

Objective 2. CSUID-II model and GUI development (Quinn, Alzraiee: budget $ 70,000)

- Complete development of GUI-based model input forms.
- Connect the GUI to the CSUID-II executable.
- Develop CSUID-II post-processing tools to provide enhanced output visualization.
- Calibrate the model using compiled data from SJRIP and WSREC.
- Develop capability to automate comparisons between model predictions of soil salinity and field salinity surveys.

Objective 3. Model validation with soil salinity survey and soil water monitoring data (Cassel, Quinn, grad student: budget $ 70,000)

- Design soil salinity assessment campaigns.
- Schedule salinity surveys according to irrigation schedules to achieve optimal moisture conditions.
- Perform soil salinity survey on each field using the EM remote sensing technique.
- Use ESAP software to determine number and location of soil salinity samples to obtain from field.
- Perform saturated extract salinity measurements on soil samples to obtain best fit model to calibrate instrument and develop soil salinity maps for each experimental plot.
- Compare CSUID-II results with field salinity surveys.

Objective 4. Model-based decision support and project technology transfer (Quinn, Alzraiee, Benes, Cassel: budget $ 60,000)

- Use calibrated model to simulate soil salinity dynamics over growing season.
- Analyze soil salinity dynamics to determine optimal leaching fraction.
- Evaluate subsurface drainage application schedules to determine optimal irrigation schedules given fluctuations in applied drainage water EC.
- Use CSUID-II to design optimal drainage configurations for maximum yield and drainage use efficiency.
- Prepare journal paper(s) on research findings.
- Prepare annual and final project reports.
- Conduct informal workshops and presentations at conferences and directly to growers regarding project findings and implications.

4.3. Program priorities

The proposed project meets several of the stated Proposition 204 Program priorities for on-farm demonstration projects for control of salinity, reduction of selenium, reuse of drainage water and use of salt tolerant crops. The following specific priority areas are covered in this proposal:

(a) *Resolve existing uncertainties and demonstrate the technical and economic feasibility and environmental acceptability of* ***drainage reuse****, toxic constituent reduction and salt concentration methods under development within the drainage problem area.*
(b) *Identify, investigate, develop and implement promising new technologies that will facilitate drainage source reduction through* ***productive use of drainage water*** *and/or its constituents.*

The proposed research is specifically focused on filling important knowledge gaps that are critical to the development of practices and programs to address salinity drainage issues. The project does this initially by data mining a 15-year data resource compiled by the Panoche Drainage District and other contributors to the SJRIP drainage reuse area that has been in existence since 1998. There has been no comprehensive effort to analyze and synthesize this data since the initiation of the project. This task is the largest of the tasks associated with the project and is key to the model development, model validation and technology transfer and design implementation tasks that follow. The project will provide a state-of-the-art analytical tool that can be useful for drainage system design at existing and future IDFM or subsurface drainage reuse projects.

5. Task Breakdown and budget explanation

5.1.1 Task 1: Data assimilation and synthesis *(Benes, Quinn, graduate student: budget $85,000)*

- Compile, synthesize and analyze field data at the SJRIP project site and from the UC-WSREC in Five Points ($45,000)

One of the major problems affecting simulation modeling of the dynamics of soil salinity in the crop root zone and the seasonal impact on crop yield is the lack of detailed field data to permit rigorous model calibration. Although the SJRIP project site has not been instrumented to the same extent as experimental plots in agricultural experiment stations – the fact that these data have been collected over many years supports simulation modeling and model calibration through a trial and error process. The rich data set collected over the past 15 years at the SJRIP site has not been analyzed to date and has the potential to yield important insights into best management practices for alfalfa and 'Jose' tall wheatgrass production with saline irrigation water. This will inform current San Joaquin River Basin planning activities, in particular CVSALTS which has struggled to develop maximum allowable salinity concentrations for even a limited number of sensitive crops grown in the basin because of the dearth of field data. Field data from stakeholder-run agricultural operations can be more valuable than data from agricultural experiment stations where crops are grown under carefully controlled conditions without regard for cost-effectiveness. In the case of 'Jose' tall wheatgrass, this cultivar is being grown without pesticides with yields approaching 6 tons/acre – this crop will likely be a valuable component in systems that employ a variant of Integrated On-Farm Drainage Management (IFDM) as is practiced in SJRIP. DWR support of this phase of the project will also provide guidance for and improve the design of other future cooperative stakeholder-operated ventures.

The major effort associated with this task will be that of data compilation from field records and notebooks associated with the SJRIP Project from 1998 to present.

- Obtain data from secondary proximate sources for climate and water quality parameters used in model calibration and validation ($15,000)

Associated with the above task will be the acquisition and synthesis of secondary data such as weather records from the Panoche WD CIMIS station and the provision of soils data from the NRSCS SURGO database. These secondary data are necessary as input data to CSUID-II. Data synthesis and analysis of the primary data will involve time series and statistical analysis to identify trends and to see if this can be associated with differences in key parameters such as leaching rate, EC of influent tile drainage water, reuse rates and drainage characteristics of fields.

- Develop and validate conceptual root zone salinity models using available data ($25,000)

The initial model screening analysis will provide a basis for the development of conceptual root zone salinity models and validation of the CSUID-II model simulation results.

5.1.2 Budget justification

The major activity under Task 1, involving PI's Benes and Quinn and the graduate student, in cooperation with Atomic Falaschi, SJRIP Project Manager, will be the review, synthesis and analysis of the data collected over the past 15 years by Panoche Drainage District and cooperating agencies and researchers. This is estimated to take 1 week of time for PI Benes and two weeks of time for PI Quinn and about 60% of the grad student's time in year 1. Additional tasks of secondary data collection and integration are necessary to acquire climate and essential soils data for the model over and above those data collected routinely by the District. Data completion and testing of a conceptual mass balance model will be conducted by PI Quinn to ensure data completeness prior to transitioning into the CSUID model development phase. PI salary and graduate student budget information is provided in a detailed budget attachment in Part 6 of the proposal

5.2 Task 2: Development of new CSUID-II model and user interface. (Quinn, Alzraiee: budget $ 70,000)

- Complete development of GUI-based model input forms ($10,000).
- Connect the GUI to the CSUID-II executable ($15,000).
- Develop CSUID-II post-processing tools to provide enhanced output visualization ($15,000)
- Calibrate the model using compiled data from SJRIP ($20,000)
- Develop capability to automate comparisons between model predictions of soil salinity and field salinity surveys ($10,000)

A new CSUID-II GUI is being developed jointly by Colorado State University and Berkeley National Laboratory to facilitate preprocessing of model input data and visualizing and analyzing of mode outputs (Figure 6). The new GUI will utilize MATLAB as its "engine" which provides access to a toolbox of widely used visualizing software. This addresses an important failing of customized graphics-based software in the past which has often languished after the original software programmer was no longer available for software support. It is rare that software is sufficiently documented to make an easy transition from one software engineer to another. However, by using the numeric engine and standard libraries of MATLAB the GUI source code becomes much more readily accessible to interested users who can more

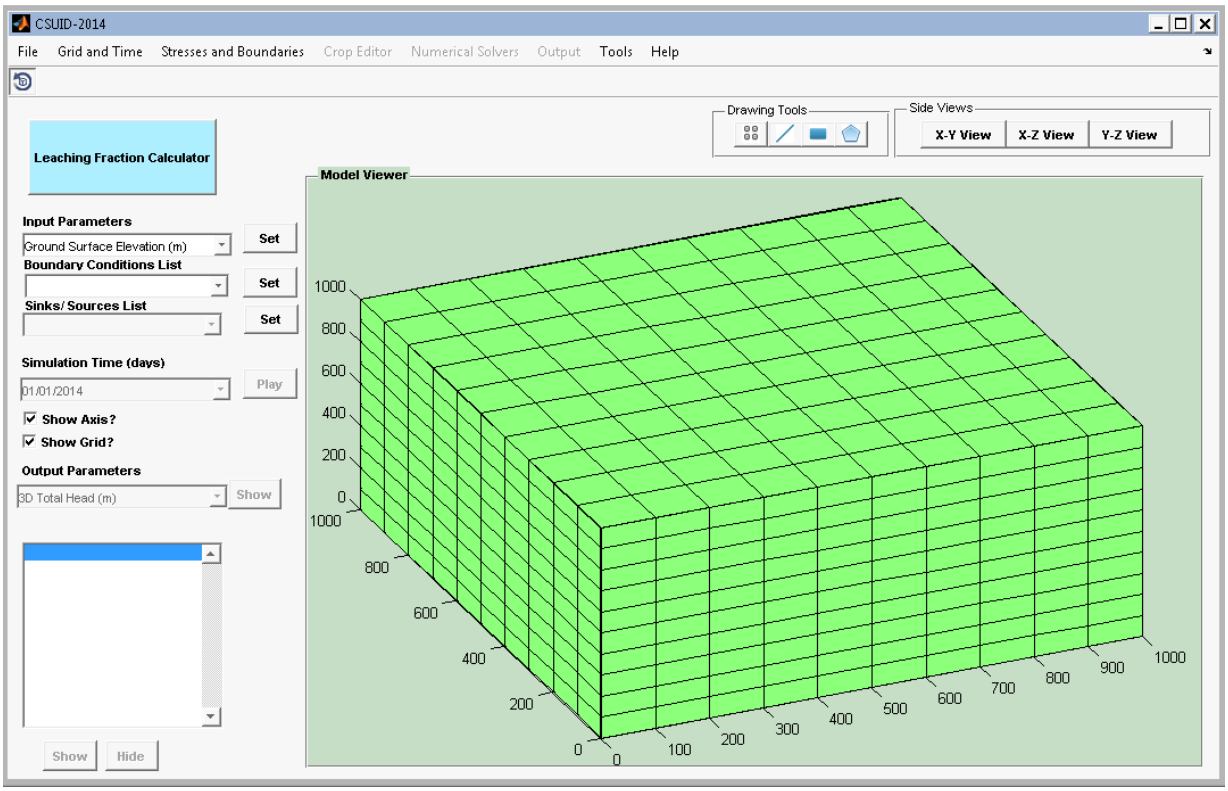


Figure 6: The main of CSUID new Graphical User Interface.

readily customize it and enhance it for future work. This strategy is much more likely to lead to the long term acceptance and use of the new model and could lead to the formation of a user community. There are three main steps or subtasks associated with this phase of the project: (a) develop GUI input forms and model building tools, (b) connect the GUI to the CSUID-II executable, and (c) develop CSUID-II post-processing tools to provide enhanced output visualization. Subtask (a) has been largely completed by Colorado State University and Berkeley National Laboratory under separate support. Subtasks (b) and (c) will be completed during 2015 with partial support from the proposed project.

5.2.1 Budget justification

The series of tasks associated with the development of the new model interface with MATLAB and the design and implementation of the new CSUID-II Graphical User Interface (GUI) will be carried out by Investigator Alzraiee with guidance from PI Quinn. These tasks are estimated to take 100% of Investigator Alzraiee's time in year 1 of the project and 2 weeks of PI Quinn. Salary details for PI Quinn and Investigator Alzraiee are provide in Section 6 of the proposal. PI Quinn is paid through a subcontract with Berkeley National Laboratory. Investigator Alzraiee is employed by both Colorado State University and CSU Fresno and is paid through CSU Fresno as a Visiting Scientist.

5.3 Task 3: Model validation with soil salinity survey and soil water monitoring data (Cassel, Quinn, graduate and undergraduate students: budget $ 70,000)

- Design soil salinity assessment campaigns ($5,000)
- Choose survey schedule according to irrigation schedule to achieve optimal moisture conditions.
- Perform the soil salinity survey in each field using EM-38 instrument.
- Use ESAP software to determine number and location of soil salinity samples to obtain from field ($20,000).
- Perform saturated extract soil salinity measurements on soil samples to obtain a best fit model to calibrate the instrument ($15,000) and develop a soil salinity map for each experimental plot ($15,000).
- Compare CSUID-II results with field salinity surveys ($15,000).

Soil salinity surveys will be conducted using the EM-38 electromagnetic instrument on selected fields of alfalfa and 'Jose' tall wheatgrass irrigated with subsurface drainage water. The EM method has been accepted as a cost-effective tool to monitor and diagnose soil salinity over large areas, because it allows for rapid and above-ground, non-invasive measurements of salinity with high accuracy. The primary purpose for the soil salinity surveys in the proposed project is the validation of CSUID-II model simulation results. Error analysis will be used to improve model parameter calibration. Soil salinity surveys will be scheduled so as to ensure uniform and adequate soil moisture in the fields. Such conditions are critical to the validity of the EM surveys.

Since the EM measurements are influenced by several soil properties, calibration of the data will be conducted through soil sampling to obtain saturated soil paste salinity values (EC_e). Optimal sampling plans will be generated using the statistical package ESAP, specially developed to analyze EM data (Lesch and Rhoades, 1999). Twelve sites characterizing the spatial distribution of salinity across the fields will be selected for the survey calibration. At these sites, soil samples will be collected using a hydraulic soil sampler in 0.3 m increments to a depth of 1.2 meter. Samples will be analyzed for soil water content, EC_e, and saturation percentage (SP) following standard analytical methods (Gavlak, 2003; Rhoades, 1996). Soil salinity will then be estimated for each sampled depth using ESAP. Contour maps showing the salinity distribution within the fields will be generated with ArcGIS using the kriging or inverse-distance weighing interpolation.

5.3.1 Budget justification

Budget for this task covers the deployment of the Mobile Conductivity Assessment (MCA) System used for the salinity surveys (see section 6.3) under the supervision of PI Cassel and for analyses of the soil samples collected during ground-truthing in the Cassel Laboratory at CSU Fresno. This also covers the development of soil salinity regression models for each field site that relate EM-38 readings (bulk soil EC) at all sampled depths to EC_e, the soil salinity measure typically used to predict crop yield response, as well as the development of all soil salinity maps. Undergraduate and graduate students, as well as a temporary CIT employee will assist PI Cassel in this task. Salary support for PI Cassel, students, and CIT employee is shown in the detailed budget in Section 6 of this proposal.

5.4 Task 4: Model-based decision support and project technology transfer (Quinn, Alzraiee, Benes, Cassel: budget $ 60,000)

- Use calibrated model to simulate soil salinity dynamics over growing season.
- Analyze soil salinity dynamics to determine optimal leaching fraction.
- Evaluate subsurface drainage application schedules to determine optimal irrigation schedules given fluctuations in applied drainage water EC.
- Use CSUID-II to design optimal drainage configurations for maximum yield and drainage use efficiency ($35,000).
- Prepare journal paper(s) on research findings ($5,000).
- Prepare annual and final project reports ($10,000).
- Conduct informal workshops ($5,000) and presentations at conferences and directly to growers regarding project findings and implications ($5,000).

Application of the calibrated model will occur in Phase 4 and the results of the simulations performed, together with crop yield data, will be used to make recommendations for optimal soil leaching rates for irrigation water applications of varying salinity levels.

5.4.1 Budget justification

Budget for this task covers use of the soil salinity data gathered under Task 3 to calibrate and validate the CSUID-II model developed under Task 2. It also covers use of the final version of the model to determine optimal soil leaching fraction and use of CSUID-II to design an optimal system of tile drains in the undrained portion of the SJRIP site. This budget task also includes review by PI's Benes and Cassel. Budget for preparation of annual and final reports and for drafting of a journal paper is estimated to be 1 week/year for PI's Quinn, Benes and Cassel and for Investigator Alzraiee.

5.5 Documentation of proposed costs and billing rates

Billing rates for all Project PI's, Investigator Alzraiee and the graduate student hired for the project are provided in Section 6 in a spreadsheet developed by the CSU Fresno Office of Research and Sponsored Programs. Salary rate for co-PI Quinn is shown as a subcontract to Berkeley National Laboratory using the University of California salary structure at current pay rate. A domestic GSRA rate is used in estimation of graduate student pay – set at 20 hours/week during fall and spring semesters and full-time during the summer months. All travel costs are estimated using the official state mileage rate.

5.6 Schedule for implementing each task, including the start and end date for each task.

The schedule for task completion is provided in Section 7 of this proposal. This includes start and end dates for each of the four major tasks and subtasks. No interruptions are foreseeable at this point in time.

5.7 Development of performance measures for appropriate tasks.

The proposed project is sequential by design – hence the deliverable results obtained from Task 1 will feed into Tasks 2, 3 and 4. Likewise the field soil salinity data collected in Task 3 will be inputted into the new CSUID-II model developed in Task 2, to perform the analysis and design support activities included in Task 4. Deliverables include the database and input data module for CSUID-II that will include all the pertinent data required to perform model simulations. Final deliverables include a project report and one or more journal papers that result from the proposed two-year research project.

5.8 Expected results and outcomes of project based on proposed tasks.

As previously described – the expected final outcome of the sequence of project tasks will be a state-of-the-art root zone salinity simulation model that will be calibrated and validated for use in the SJRIP Project area. Specific outcomes expected of this decision support tool are as follows:

(a) Use for optimization of soil salinity leaching rates to maximize yields of 'Jose' tall wheatgrass and alfalfa, the two dominant crops in the SJRIP, and to enhance the sustainability of their yields over the long term. Model calibration will produce the first salinity production function for 'Jose' tall wheatgrass under saline irrigation which will be useful for other agronomic studies using saline drainage as an irrigation water source.

(b) Capability to improve drainage design (depth and spacing) for up to 1,500 acres of land within SJRIP that will eventually require the installation of subsurface drains.

Performance measures are included after each Task description in Section 6 – which provides details of materials and standard methodologies used (where applicable) in the proposed project.

5.9 Summary of deliverables and reporting tasks

These are covered in detail in section 6.4.

6. Materials, Methods, and Scientific Merit

6.1 Data assimilation and synthesis

A combination of statistical data analysis tools will be deployed to organize and synthesize the existing data and combine these data with secondary watershed data to create input data files for the CSUID-II model. Over 15 years of field data has been collected on soils, cropping and crop yield, subsurface drainage water application and drainage water quality. Groundwater levels and limited groundwater quality data are also available. No electromagnetic soil salinity surveys have been conducted at the SJRIP site – however, there are limited soil texture and salinity data which can provide some information on previous soil salinity conditions in the crop rooting zone.

6.1.1 Performance measures and outcomes

The compiled dataset will be made available as an access database. However the more useful task outcome will be the model database developed as part of this task. When utilized by a model the assimilated data are able to forecast future conditions such as trends in soil salinity and crop yields based on assumptions of future management of the SJRIP facility and in the surface drainage and subsurface drainage water quality diverted into the facility.

6.2. Development of new CSUID-II model and user interface

Recent trends in simulation model development have favored the concept of object - programming and the use of standardized frameworks such as the Object Modeling System (OMS) and Open MI (Modeling Interface) for designing, building, validating and deploying agro-environmental models. In the case of the OMS – the framework contains four software platforms that facilitate: (1) model development, (2) model deployment (cloud services), (3) data provisioning and (4) a knowledge base (component repository). The Open MI framework, on the other hand, operates at two levels. At the users' level, the Open MI provides a standard interface which allows component models to exchange data with each

other and with other modelling tools as they run. The Open MI Standard connects models from different suppliers, domains, concepts and spatial and temporal resolutions. Linked models may run asynchronously with respect to timesteps, with data represented on different geometries (grids) which can be exchanged seamlessly.

Rather than use these state-of-the art object frameworks, which still involve considerable coding to stitch together the component objects to achieve full functionality, a new approach is being taken to treat the CSUID-II simulation engine as a component object within a more readily customizable framework – MATLAB. The primary advantages of this approach are as follows :

(a) Mathworks Inc., the author of MATLAB, continually updates the software program taking advantage of new GUI technology, advanced numeric matrix solving routines and visualization techniques. This reduces the scope of model maintenance to just the numeric simulation model.

(b) MATLAB has become a standard data analysis and visualization tool at Universities throughout the US. There are large numbers of scientists and engineers with the programming skills to be able to continue development of the CSUID-II model beyond the term of the proposed project.

(c) MATLAB has advanced image processing and remote sensing capability within its allied packages – making it possible to directly import soil salinity survey data and utilize the post processed salinity maps to improve CSUID model calibration. This capability can be extended to evapotranspiration estimation using field based techniques such as METRIC, SEBAL and ReSET – which provide better resolution than highly averaged techniques such as the Penman-Monteith equation. Use of these highly disaggregated methods can improve the resolution and utility of the CSUID-II model for salinity management.

6.2.1 Performance measures and outcomes

The final CSUID-II deliverable can be readily shared using a no-cost, run-time MATLAB license that can be obtained an no cost. This will enhance the technology transfer outcome of the proposed project. Since there are no competing drainage salinity simulation models in the scientific literature that have been field tested – the project team envisages that a successful outcome to this project could have significant benefits to future design and operation of drainage reuse facilities and agricultural entities practicing IFDM technology.

6.3 Model validation with soil salinity survey and soil water monitoring data

Model validation will be conducted using data derived from soil salinity surveys conducted in selected 'Jose' tall wheatgrass and alfalfa fields at Panoche Drainage District using the electromagnetic (EM) induction technique. An EM sensor consists of a transmitter coil and a receiver coil that operates on the following principle: the transmitter coil induces an electromagnetic field in the ground, which in turn creates a secondary magnetic field that is measured by the receiver coil (McNeill, 1980). The ratio of both EM fields is proportional to the depth-weighted apparent electrical conductivity (EC_a) in the volume of soil below both coils (McNeill, 1980). The sensor's response is influenced by soil salinity, moisture, texture, and temperature.

A Mobile Conductivity Assessment (MCA) System developed at California State University Fresno will be deployed for the soil salinity surveys. The MCA system comprises four basic components mounted on a vehicle: 1) a dual-dipole EM-38 sensor, 2) a global positioning system (GPS) receiver, 3) a computer, and

4) a hydraulic soil sampler. The EM instrument operates at a frequency of 14.6 kHz and has a fixed inter-coil spacing of 1 m. For this study, the EM-38 sensor will be placed in a plastic carrier-sled attached to the rear of the vehicle. The EM 38 sensor will be operated in both horizontal and vertical positions at the soil surface to obtain effective measurements depth of 0.9 m and 1.8m, respectively. The GPS receiver will provide geo-referencing of the EM data. Since the EM measurements are relative, calibration of the data through soil sampling is necessary to obtain absolute salinity values. Optimal sampling plans will be generated using the statistical package ESAP, specially developed to analyze the EM data (Lesch and Rhoades, 1999). Twelve sites characterizing the spatial distribution of salinity across the fields will be selected for calibration. At these sites, soil samples will be collected in 0.3 m increments using a soil sampler to a depth of 1.2 m. Samples will be analyzed for soil water content, EC, and saturation percentage (SP) following standard analytical methods (Gavlak, 2003; Rhoades, 1996). Soil salinity will then be estimated using ESAP and contour maps showing the salinity distribution within the soil profiles will be generated with ArcGIS using the kriging or inverse-distance weighing interpolation.

6.3.1 Performance measures and outcomes

The immediate outcome of the soil salinity survey tasks are detailed maps of 0.3 m increment and bulk soil salinity in the crop root zone.

6.4 Model based decision support and project technology transfer

The final calibrated and validated CSUID-II model will be completed in Task 4 and will be the result of the sequence of tasks beginning with the conceptual model development in Task 1, CSUID-II code development in Task 2 and soil salinity and agronomic data collection in Task 3. As noted earlier the final project deliverable will be a state-of-the-art, root zone salinity simulation model for use in the SJRIP Project area with the following features:

(a) Use for optimization of soil salinity leaching rates to maximize yields of 'Jose' tall wheatgrass and alfalfa, the dominant crops in the SJRIP. Model calibration will produce the first salinity production function for 'Jose' tall wheatgrass under saline irrigation which will be useful for other agronomic studies using saline drainage as an irrigation water source.

(b) Capability to improve drainage design (depth and spacing) for up to 1,500 acres of land within the SJRIP that will eventually require the installation of subsurface drains.

6.4.1 Performance measures and outcomes

The new CSUID-II model will be built upon a MATLAB platform which will make the model more extensible, easier to share and more likely to remain supported beyond the life of the proposed project. The model user interface will also take advantage of current GUI technical innovations that are made available and continually upgraded in MATLAB. This will help to ensure the model's longevity and increase the likelihood it will be applied to similar saline drainage reuse projects or future implementation of the IFDM (Integrated On-Farm Drainage Management) concept.

7. Schedule

Table 2. Timeline of proposed project tasks

Task Description	Year 1												Year 2											
	2015 - 2016												2016-2017											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Compile, synthesize, analyze SJRIP and WSREC field data	■	■	■	■	■	■	■	■																
Obtain climate and water quality data from secondary proximate sources			■	■	■	■	■	■																
Develop and validate conceptual root zone salinity models									■	■	■													
Complete development of GUI-based model input forms												■	■											
Connect GUI toCSUID-II executable												■	■											
Develop CSUID-II post-processing visualization tools												■	■											
Calibrate model														■	■									
Develop capability for comparisons between model and field data														■	■									
Design soil salinity assessment campaigns						■	■																	
Schedule and perform salinity surveys, ground-truthing soil sampling							■	■	■	■														
Analyze soil samples							■	■	■	■	■													
Analyze soil survey data and develop salinity maps								■	■	■	■	■	■											
Compare survey data with model results																■	■	■						
Use calibrated model to determine optimal leaching fraction, irrigation schedules, and design optimal drainage configurations																			■	■	■	■		
Preparation of annual and final reports											■	■											■	■
Preparation of journal article(s)																					■	■	■	■
Presentation of project results at conferences and growers' meetings																				■	■	■	■	■
Conduct workshops																							■	■

8. Budget

For a narrative, **please refer to section 5** where this is a task breakdown and budget explanation for each task. As this is a new cooperative research effort among PI's Benes, Quinn and Cassel-Sharma, there is no cost share.

Table 3. Cost estimates for each task*

Task	Grant amount requested ($)	Total costs ($)
Compile, synthesize, analyze SJRIP and WSREC field data	45,000	45,000
Obtain climate and water quality data from secondary proximate sources	15,000	15,000
Develop and validate conceptual root zone salinity models	25,000	25,000
Complete development of GUI-based model input forms	10,000	10,000
Connect GUI toCSUID-II executable	15,000	15,000
Develop CSUID-II post-processing visualization tools	15,000	15,000
Calibrate model	20,000	20,000
Develop capability for comparisons between model and field data	10,000	10,000
Design soil salinity assessment campaigns	5,000	5,000
Schedule and perform salinity surveys, ground-truthing soil sampling	20,000	20,000
Analyze soil samples	15,000	15,000
Analyze soil survey data and develop salinity maps	15,000	15,000
Compare survey data with model results	15,000	15,000
Use calibrated model to determine optimal leaching fraction, irrigation schedules, and design optimal drainage configurations	35,000	35,000
Preparation of annual and final reports	10,000	10,000
Preparation of journal article(s)	5,000	5,000
Presentation of project results at conferences and growers' meetings	5,000	5,000
Conduct workshops	5,000	5,000

* The total cost estimate for all tasks has been rounded off to $285,000 for simplicity, and do not include the indirect costs (see Table 4 below).

Table 4. Cost estimates for salaries, benefits, travel, and other direct support expenditures

	Year 1	Year 2	Total
A. Personnel Wages			
1) PI Benes	6,222	6,222	12,444
2) Co-PI Cassel	7,917	7,917	15,834
3) Co-PI Alzraiee	16,000	16,000	32,000
4) Project coordinator Suryadi	1,179	1,179	2,358
5) Graduate and undergraduate students	33,200	33,200	66,400
Subtotal Personal Wages	***64,518***	***64,518***	***129,037***
B. Fringe Benefits			
1) PI Benes	2,489	2,489	4,978
2) Co-PI Cassel	792	792	1,584
3) Co-PI Alzraiee	1,080	1,080	2,160
4) Project coordinator Suryadi	813	813	1,626
5) Graduate and undergraduate students	2,241	2,241	4,482
Subtotal Fringe Benefits	***7,415***	***7,415***	***14,830***
SUBTOTAL Personal Wages and Benefits	***71,933***	***71,933***	***143,867***
C. Travel			
Local travel	5,000	5,000	10,000
Subtotal travel	***5,000***	***5,000***	***10,000***
D. Other direct support			
Materials and supplies	3,000	3,000	6,000
Subaward (PI Quinn)	62,699	62,699	125,398
Subtotal Other direct support	***65,699***	***65,699***	***131,398***
Total of direct costs	**142,632**	**142,632**	**285,265**
Indirect costs (5%)	7,132	7,132	14,263
TOTAL PROPOSED COSTS	**149,764**	**149,764**	**299,528**

9. Deliverables

Project deliverables will include the submittal of monthly invoices, an annual progress report and a final project report. A post-completion report will also be submitted as a project deliverable according to DWR requirements. Other additional deliverables may be applicable to the project, including technical studies, technical memorandums, and other documents useful for reporting the progress of the project. Scientific publication(s) will be developed for submission in peer-reviewed journal(s) in the area of water and soil management. Workshops and/or demonstration days will be conducted by CSUF and Berkeley National Laboratory at the end of the second year to demonstrate the CSUID-II model tool, present modeling results for management of drainage water and optimization of crop production.

The proposed timelines for these deliverables is described in Table 2 of section 7.

10. Literature cited

1. Alzraiee, A. H., L. A. Garcia, and T.K. Gates, 2013. *Modeling Subsurface Heterogeneity of Irrigated and Drained Fields. I: Model Development and Testing*. *Journal of Irrigation and Drainage Engineering* 139.10: 797-808.
2. Benes S.E., Adhikari D.D, Grattan S.R., Snyder R.L., 2012. *Evapotranspiration Potential of Forages Irrigated with Saline-Sodic Drainage Water*. Agric.Water Manage 105:1-7.
3. Central Valley Water Quality Control Board, 2011. The Water Quality Control Plan for the California Regional Water Quality Control Board - Central Valley Region. Rep. Fourth ed.
4. Gavlak, R., D. Horneck, R.O. Miller, and J. Kotuby-Amacher. 2003. Soil, plant and water reference methods for the western region. WREP-125, 2nd edition, Oregon State Univeristy, Corvallis, OR.
5. Hoffman, G. J, 2010. *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta*.
6. Lesch, S.M., and J.D. Rhoades. 1999. ESAP-95 Software Package Version 2.01R. USDA-ARS, George E. Brown Jr. Salinity Laboratory, Riverside, CA.
7. Letey, J., Hoffman, G.J., Hopmans, J.W., Grattan, S.R., Suarez, D., Corwin, D.L., Oster, J.D., Wu, L., Amrhein, C., 2011. *Evaluation of soil salinity leaching requirement guidelines*. Agric. Water Manage 98:502-506.
8. Linneman, C., Falaschi, A., Oster, J.D., Kaffka, S., Benes, S., 2014. *Drainage reuse by Grassland Area farmers: the road to zero discharge*. Proceedings of the "Groundwater Issues and Water Management—Strategies Addressing the Challenges of Sustainability" meeting. U.S. Committee on Irrigation and Drainage (US-CID), Sacramento, CA, Mar. 4-7, 2014.
9. Maas, E.V., and S.R. Grattan, 1999. *Crop yields as affected by salinity*. In: Agricultural Drainage, eds. R.W. Skaggs and J. van Schilfgaarde, Monograph 38 Am. Soc. Agron., Madison, WI, pp. 55-108.
10. Manguerra, H.B., and L.A. Garcia, 1995. *Irrigation-Drainage Design and Management Model: Validation and Application*. Journal of Irrigation and Drainage Engineering 121.1: 83-94.
11. Rhoades, J.D. 1996. Salinity: Electrical conductivity and total dissolved salts. In D.L. Sparks (Ed.) Methods of Soil Analysis, Part 3 Chemical Methods. American Society of Agronomy, Madison, WI.
12. Sanden, B.L., Ferguson, L., Corwin, D.L. 2013. *Development and long-term salt tolerance of pistachios from planting to maturity using saline groundwater*. Proc. VI Inter. Sym. on almonds and pistachios. Murcia Spain, May 27-31.
13. Suyama H., Benes S.E., Robinson P.H., Getachew G., Grattan S.R., Grieve C.M., 2007. *Biomass yield and nutritional quality of forage species under long-term irrigation with saline-sodic drainage water: field evaluation.* Anim. Feed Sci. Technol. 135:329-345.

APPENDIX – Curriculum Vitae

Dr. Sharon E. Benes

Department of Plant Science
California State University, Fresno
2415 E. San Ramon Ave., M/S AS72
Fresno, CA 93740-8033

Tel (559) 278-2255; FAX 278-7413
e-mail: sbenes@csufresno.edu
web: http://www.fresnostate.edu/jcast/plantsci/

EDUCATION

Ph.D. Plant Physiology: University of California, Davis. 1995
M.S. Plant Pathology: North Carolina State University. 1984
B.S. Botany, cum laude, minor in Plant Science: University of New Hampshire. 1982

PROFESSIONAL EXPERIENCE

- 2010 - Present *Full Professor,* Department of Plant Science, CSU Fresno
- 2004 - 2010 *Associate Professor*, " " "
- 1998 - 2004 *Assistant Professor,* " " "
- 2002 - Present *Graduate Coordinator*, Department of Plant Science, CSU Fresno
- 1998 - Present *Thesis Chair,* 15 Graduate Students (M.S. Degree), CSU Fresno
- 2000 - 2014 *Chair*, Research & Scholarly Activity Committee, Jordan College of Agricultural Sciences & Technology, CSU Fresno

AWARDS

- 2009 *Outstanding Advisor Award, CSU Fresno*
- 2001 *Outstanding Research and Scholarly Activity Award* – Jordan College of Agricultural Sciences and Technology, CSU Fresno.
- 2001, 2000 *Provost's Outstanding Faculty Recognition: Research*. CSU Fresno

AREAS OF EXPERTISE

- Plant response to saline conditions
- Crop salt tolerance evaluation, especially forages
- Use of saline waters for irrigation
- Soil management under saline conditions
- Utilization of halophytes for saline cropping systems
- Selenium accumulation in forages and grazing animals

TEACHING EXPERIENCE

- Undergraduate: Soil Science and Soils Laboratory; Crop Nutrition; Food, Society, and Environment (general education course)
- Graduate course: Soil-Plant-Water Relations; Plant Nutrition; Graduate Seminar (Use of Genetically Engineered Crops in Agriculture)

PROFESSIONAL SERVICES

- 2000-03, 08-010, *Governing Board*, California Chapter, American Society of Agronomy
- 2014-017 *Executive Board*, " " "
- 2007- 012 *Advisory Board, & Testing Committee*, CA Certified Crop Advisors (CCA)
- 2013 *Proposal Review Panel*, USDA- AFRI Foundational Program Panel- Contaminants of Emerging Concern in Soil and Water, June 12-14th

OUTREACH & INTERNATIONAL EXPERIENCE

- 2014: 5 month sabbatical, Univ. of Western Australia, Perth; School of Plant Biology. Host: Dr. Tim Colmer
- 2006: 5 month sabbatical, National Univ. of Argentina (Cordoba), Faculty of Agronomy. Host: Dr. Maria Aiazzi.
- 2008: Technical Review Panel for Ocean Desert Enterprises (ODE; Netherlands). Reviewed demonstration cropping system & soil management for the salt-afffected San Luis Rio Colorado Delta area, Mexico. Site visit: Nov. 2008
- 2007: Technical Review Panel: WaterWatch Consulting (Netherlands) & Shell Oil Co. Reviewed design of constructed wetlands for remediation of oil-produced water in Oman, U.A.E. Review session, July 9-10, The Hague, Netherlands
- 2003: Reviewer: Santa Clara Water District, Landscape Redwood Decline Investigation: Reviewed report from one-year investigation by an environmental consulting firm.

SELECTED PUBLICATIONS

- Diaz F., **Benes S.E.,** Grattan S.R. (2013). Field performance of halophytic species under irrigation with saline drainage water in the San Joaquin Valley of California. Agric.Water Manage. 118:59-69.
- **Benes S.E.,** Adhikari D.D, Grattan S.R., Snyder R.L. (2012). Evapotranspiration Potential of Forages Irrigated with Saline-Sodic Drainage Water. Agric.Water Manage 105:1-7.
- Juchem S.O., **Benes S.E.,** Robinson P.H., Grattan S.R., Vasquez P., Chilibroste P., Brito M. (2012). Grazing as an alternative for utilization of saline-sodic soils in the San Joaquin Valley: selenium accretion and performance of beef heifers. Science Total Environ 419(1): 44-53.
- Goorahoo D., Cassel-Sharma F., Adhikari D.D., **Benes S.E.** (2011). Soil-Water-Plant Relations. Chapter 3 (pp. 23-73). *In* Irrigation 6th Ed. , L. E. Stetson and B. Mecham (Eds.). Handbook compiled by the Irrigation Association (IA), Alexandria, VA.
- Grattan S.R., Oster J.D., **Benes S.E.,** Kaffka S.R. (2011). Chapter 22: *Use of Saline Waters for Irrigation.* Agricultural Salinity Assessment and Management, American Society of Civil Engineers (ASCE), New York, NY. pp. 687-719.
- Grattan S.R., Benes S.E., Peters D.W., Diaz F. (2008). *Feasibility of Irrigating Pickleweed (Salicornia bigelovii. Torr) with Hyper-saline Drainage Water.* J Environ. Qual. 37: S-149-156S. http://jeq.scijournals.org/content/vol37/5_Supplement/
- Masters D.G., **Benes S.E.**, Norman H. (2007). *Biosaline Agriculture for Forage and Livestock Production*. Ag. Ecosyst. Environ. 119:234-248. doi:10.1016/j.agee.2006.08.003. http://www.sciencedirect.com/science?
- Suyama H., **Benes S.E.,** Robinson P.H., Getachew G., Grattan S.R., Grieve C.M. (2007). *Biomass yield and nutritional quality of forage species under long-term irrigation with saline-sodic drainage water: field evaluation.* Anim. Feed Sci. Technol. 135:329-345. http://www.sciencedirect.com/science
- Suyama H., **Benes S.E.,** Robinson P.H., Grattan S.R., Grieve C.M., Getachew, G. (2007). *Forage Productivity, and Quality under Irrigation with Saline-sodic Drainage Water: Greenhouse evaluation*. Agric. Water Manage. 88:159-172. doi:10.1016/jagwat.2006.10.011. http://www.sciencedirect.com/science
- Ayars J.E., **Benes S.**, Basinal L., Jacobsen T. (2005). *Chapter 4. Drainage Water* and **Benes S.**, Grattan S., Finch C., Basinal L. (2005). *Chapter 5. Crop Selection for IFDM Systems*. In: **A Technical Advisor's Manual**. Managing Agricultural Irrigation Drainage Water. A guide for developing Integrated On-Farm Drainage Management systems. www.sjd.water.ca.gov/publications/drainage/ifdmtmanl/intro.pdf
- **Benes S.**, Jacobsen T., Basinal L. (2004). *Chapter 5. Drainage Water Characteristics* and Benes S., Grattan S., Finch C., Basinal L. (2004). *Chapter 6. Plant Selection for IFDM*. In: A Landowner's Manual: Managing Agricultural Irrigation Drainage Water. A guide for developing Integrated On-Farm Drainage Management systems. http://www.fresnostate.edu/jcast/cit/

Nigel W.T. Quinn, PhD, P.E., D.WRE

Staff Geological Scientist, Research Leader
HydroEcological Engineering Advanced Decision Support (510) 486-7056
Earth Sciences Division, Bld 64-209 (510) 486-7152 (FAX)
Lawrence Berkeley National Laboratory nwquinn@lbl.gov
Berkeley, CA 94720.

ACADEMIC DEGREES

BSc (Hons) Agricultural Engineering (summa cum laude), Cranfield University, England	1977
MS Agricultural and Civil Engineering, Iowa State University, Ames, IA.	1981
PhD Water Resources Systems Engineering, Cornell University, Ithaca, NY.	1987

ACADEMIC

Staff Scientist : Lawrence Berkeley National Laboratory	Oct 90 –
Group Leader: HydroEcological Engineering Advanced Decision Support	Sept 02–
Visiting Scientist, Energy Biosciences Institute, University of California, Berkeley	Jan 08 –
Associate Scientist, Dept. of Civil Engineering, University of California, Merced	Jun 05 –
Adjunct Research Professor, Dept. of Plant Science, CSU, Fresno	May 05 –
Research Associate IV : Cornell University Program on Science, Technology and Society	Jan 87 – Sep 90
General Electric Fellow : Cornell University Program on Science, Technology and Society.	Jan 85 – Jan 87
Research and Teaching Assistant : Cornell University Department of Agricultural Engineering.	Jan 81 – Jan 85
Lecturer : Iowa State University Faculty Department of Agricultural Engineering.	Dec 77 – Jan 81

INDUSTRY / GOVT.

Water Resources Engineer/Consultant : US Bureau of Reclamation,	Sep 90 – present
Consultant Hydrologist, MFG Inc. (TetraTech Inc.)	Sep 00 – Oct 04
Senior Water Resources Engineer: Interagency San Joaquin Valley Drainage Program	Jan 87 – Sep 90
Research Engineer, US Dept. of Agriculture, ARS	Jan 78 – Dec 79
Irrigation Engineer : Tate and Lyle Corporation Spalding, England.	Jun 77 – Dec 77

RESEARCH INTERESTS

Application of systems analysis techniques to solving complex water resources problems. Analysis of environmental, social and economic impacts of global climate change in the San Joaquin Valley. Development of decision support systems and simulation models to improve understanding and facilitate negotiation of solutions to future water resource and water quality problems. Primary research focus during past decade has been on developing decision making tools for assessing the impacts of drainage water quality projects on the west side of the San Joaquin Valley with an emphasis on salinity and selenium drainage. Field research has included investigations of natural selenium in-transit losses in a wetland channel used for drainage discharges and surface water deliveries, cooperative work with private and public wetlands in the Grasslands Basin to develop

monitoring and management responses to a salinity TMDL and participation in microbial mesocosm studies to identify bacterial species capable of selenium bioremediation. Results of these natural system bioremediation experiments are being used to help optimize the performance of an algal-bacterial selenium bioremediation plant for treating agricultural drain water in the Panoche Water District in the western San Joaquin Valley. Recent research projects in algal biofuels – specifically technical and economic evaluation of current technologies, feedstock production resource assessment and bench-scale carbon assimilation studies.

PROFESSIONAL SERVICE

Chair Technical and Economic Committee, CVSALTS – Central Valley Salinity Coalition, (2008 – present)
Convener, 2002, 2003, 2004, California Water and Environmental Modeling Forum.
Co-Chair and Founder, Water and Environment Technology Team (WETT), LBNL.
Berkeley Laboratory Delegate, White House Conference on Industrial Ecology
Department of Energy, Water-Energy Nexus Committee
San Joaquin River Management Program (Water Quality Subcommittee)
American Society of Civil Engineers
American Geophysical Union
US Committee on Irrigation and Drainage
International Environmental Modeling and Software Society (Fellow; Board of Directors)
Chair, Technical Committee and Member Executive Committee, Central Valley Salinity Coalition

LICENCES

Registered Professional Engineer

RECENT JOURNAL ARTICLES : 2010-2014

1. Quinn N.W.T. and Olga Epshtein. 2014. Seasonally-Managed Wetland Footprint Delineation and Evapotranspiration Estimation using Landsat ETM and Satellite Imagery. Journal of Environmental Modeling and Software. 04/2014; 54(April):9-23.
2. Quinn N.W.T. 2011. Contrasts in the use of information technology for real-time salinity management in the San Joaquin Basin, California, USA and Hunter River Basin, New South Wales, Australia. Agricultural Water Management. Vol. 98 (6), p.930-940, Apr 2011.
3. Quinn N.W.T., R. Ortega and L. Holm. 2011. Environmental sensor networks and continuous data quality assurance to manage salinity within a highly regulated river basin. Decision Support Systems in Agriculture, Food and the Environment: Trends, Applications and Advances.
4. Quinn N.W.T., R. Ortega, P.J.A, Rahilly and C.W. Royer. 2010. Use of environmental sensors and sensor networks to develop water and salinity budgets for seasonal wetland real-time water quality management. Environmental Modelling and Software. Vol 25, 1045-1058.
5. Quinn N.W.T, 2009. Information technology and innovative drainage management practices for selenium load reduction from irrigated agriculture to provide stakeholder assurances and meet contaminant mass loading policy objectives. Agricultural Water Management, 96 (3), p.484-492, Mar 2009.

Dr. Florence Cassel S.
Department of Plant Science
Center for Irrigation Technology
California State University, Fresno
2415 E. San Ramon Ave. M/S AS 72
Fresno, CA 93740
Tel: (559) 278-7955; Fax: (559) 278-7413
E-mail: fcasselss@csufresno.edu

EDUCATION

Ph.D.	1998	*Soil-Water Physics - Agronomy*, University of Wyoming, Laramie, WY. Dissertation "Assessment of drip irrigation for managing nitrate contamination and sugar beet production in Wyoming"
M.S. + B.S.	1994	"Diplôme d'Ingénieur en Agriculture", *Agricultural Engineering*, Ecole Supérieure d'Agriculture d'Angers (E.S.A.), France.

PROFESSIONAL EXPERIENCE

- 2013-Present *Assistant Director of Research*, Center for Irrigation Technology, CSU Fresno
- 2012- Present *Assistant Professor*, Department of Plant Science, CSU Fresno.
- 2001-2012: *Soil and Water Scientist*, Center for Irrigation Technology, CSU Fresno.
- 2008-Present: *Adjunct Faculty*, Department of Plant Science, CSU Fresno.
- 1998-2001: Elected *Executive Council Member-at-Large* to the Pacific Division of American Association for Advancement of Sciences, San Francisco, CA.

AWARD

2011 - *Coleman Fellowship* for "Entrepreneurship in Water Management and Irrigation Technology".
2011 - Recipient of Federal Labs Consortium, Western State Region.
2009 – *Outstanding Research and Scholarly Activity Award* – Jordan College of Agricultural Sciences and Technology, CSU Fresno.

AREAS OF EXPERTISE

- Remote sensing techniques (electromagnetic induction, satellite & aerial imagery) for water/soil resources management and pollution control at field/regional and watershed scales.
- Salinity monitoring and management.
- Development of crop evapotranspiration estimates and crop coefficient curves from weighing lysimeters.
- Crop production in irrigated systems, with emphasis on drip irrigation; irrigation scheduling.
- Irrigation system design and operation.

TEACHING EXPERIENCE

- Undergraduate and graduate courses taught in: Soil and Water Management; Irrigation Systems; Food, Society, and Environment; Agricultural Laboratory Techniques.
- Guest lectures for: Soils in the Environment (Lab); Research Methodology; Remote Sensing and GIS application; Applied Spatial Technology.

OUTREACH EXPERIENCE

- 2001-2010: Developed workshops and organized field trips for international delegations (Australia, China, Egypt, Iraq, Israel, Japan), universities, federal, state and local agencies, growers, farm advisors. Topics: salinity management, use of electromagnetic induction technique; gypsum Use in Agriculture; irrigation systems and water management in Central Valley.
- 2010: Participated in workshop for a US Marine Corps detachment. California State University Consortium for International Development (CID), Fresno, CA. Topics: salinity and water management, use of electromagnetic induction technique.
- 2005: Soil Salinity Assessment and Mapping Workshop: Theory and Practice, San Luis National Wildlife Refuge Office, Los Banos, CA.

PROFESSIONAL SERVICES

- 2014: *Member*, Soil and Water Conservation, Soil Science Society of America.
- 2011 - 2014: *Board Member, Scholarship Committee Chair, and Water Management Session Chair*, California Chapter of American Society of Agronomy.
- 2011 - 2014: *Member*, Planning committee, Multi-State Salinity Coalition.
- 2006 - 2014: *Member*, Research and Scholarly Activities Committee (RSAC), Jordan College of Agricultural Sciences and Technology, CSU Fresno.

SELECTED PUBLICATIONS and PRESENTATIONS

- Cassel S., F, D. Goorahoo, F. Melton, L. Johnson, C. Lund, C. Krauter, and L. Pierce. 2014. Development of an integrated decision support system to optimize irrigation scheduling and water use efficiency. Annual report, California State University, Fresno. 5 pp.
- Cassel S., F, D. Zoldoske, and X. Yang. 2013. Integrating remote sensing techniques to determine extent of salinization in the San Joaquin Valley of California. Final report, California State University, Fresno. 16 pp.
- Cassel S., F. 2013. Salinity assessment at the New Jerusalem Drainage District. Report submitted as part of the Integrated Drainage and Irrigation Management Plan Task Order. 10 pp.
- Goorahoo, D., F. Cassel S., and S. Benes. 2011. Chapter 3 "Soil water and plant relations". *In* Irrigation 6th edition (eds L. E. Stetson and B. Mecham), Irrigation Association. p 23-73.
- Cassel S., F., D. Goorahoo, and P. Yadavali. 2010. Irrigation strategies for managing salt-affected soils in the San Joaquin Valley, CA. Proceedings, Multi-State Salinity Coalition, Las Vegas, NV.
- Goorahoo, D., F. Cassel S., and S.K.R. Yellareddygari. 2010. Remote sensing as an environmental and agricultural decision making tool for salinity management. Proceedings, Multi-State Salinity Coalition, Las Vegas, NV.
- Goorahoo, D., F. Cassel S, and S. Benes. 2009. Soil salinity characterization in the Westside San Joaquin Valley, CA. Multi-State Salinity Coalition, Indian Wells, CA.
- Cassel S., F., D. Goorahoo, D. Zoldoske, and D. Adhikari. 2009. *Mapping soil salinity using ground-based electromagnetic induction technique*". *In* G. Metternicht and A. Zinck (eds.), Remote Sensing of Soil Salinization: Impact on Land Management, Chap. 11, CRC Press, Boca Raton, FL, p. 199-233
- Cassel S., F. 2007. "Soil Salinity Mapping Using ArcGIS". *In F.J. Pierce (ed.), GIS Applications for Agriculture*, CRC Press, Boca Raton, FL, Chapter 8, p. 141-162.
- Cassel S., F. and D. Zoldoske. 2006. Assessing canal seepage and soil salinity using the electromagnetic remote sensing technology. *In G. Lorenzini and C.A Brebbia (eds) Sustainable Irrigation management, Technologies and Policies.* WIT Press. p. 55-63.

Ayman H. Alzraiee, Ph.D.
1700 W. Plum Street 52B, Fort Collins, CO, USA, 80521
Phone: (970)-286-4380, ayman.alzraiee@gmail.com

EDUCATION

- **Ph.D. Civil and Environmental Engineering** 2007-2012
  Colorado State University, Fort Collins, CO, USA
  Dissertation: "Stochastic Analysis of Flow and Salt Transport in Irrigation and Drainage Subsurface Systems"

- **M.Sc. Civil and Environmental Engineering** 2003-2005
  Colorado State University, Fort Collins, CO, USA
  Thesis: "Using SEAWAT Code to Simulate Seawater Intrusion and Management Alternatives in the Gaza Coastal Aquifer"

- **B.Sc. Civil Engineering** 1996- 2001
  Gaza Strip, Palestine

RESEARCH INTERESTS

- Subsurface hydrology, modeling of groundwater flow, and reactive transport modeling.
- Numerical modeling of multiphase flow and transport in porous media.
- Inversion of high-dimensional hydrogeological systems, hydraulic tomography, and fast Markov chain Monte Carlo Algorithms.
- Stochastic hydrogeology and geostatistical modeling of heterogeneous subsurface.
- Linear (Derivatives of Kalman Filter) and nonlinear (Particle Filters) data assimilation techniques.
- Aquifer subsidence and geo-mechanical properties of subsurface systems (e.g. subsurface gas storage (SGS), response of deep aquifers to CO_2 sequestration).
- Conjunctive surface and groundwater hydrology.
- Crop Yield Modeling and crop interaction with subsurface hydrogeology.
- Groundwater remediation, optimization of remediation systems, reliability of remediation plans.

ACADEMIC AND PROFESSIONAL WORK EXPERIENCE

- (August 2014 - present) **Research Scientist**, California Water Institute, California State University, Fresno.
  - Develop new guidelines for estimating salinity leaching requirements of salinity-impaired soils of the San Joaquin Valley, California by modeling flow and reactive transport in three-dimensional vadose zone.

- **(**2012-2014**) Postdoctoral Fellowship,** Padova University, Italy and Colorado State University.
  - Study aquifer subsidence due to gas frequent injection and extraction in geological formation for storage purposes.

- Assimilate changes in ground surface elevation obtained by Synthetic Aperture Radar (SAR) to estimate the geo-mechanical properties of an aquifer.
- Regional Stream-Aquifer Interaction in the South Platte Basin, Colorado
- Evaluation and documentation of the South Platte Decision Support System (SPDSS) Alluvial Groundwater Model.

REFEREED JOURNAL PAPERS

1- **Alzraiee,** A. H., D. Baú, and A. Elhaddad (2014), Estimation of heterogeneous aquifer parameters using centralized and decentralized fusion of hydraulic tomography data from multiple pumping tests, Hydrology and Earth System Sciences, 11(4), 4163–4208, doi:10.5194/hessd-11-4163-2014.

2- Baù, D., M. Ferronato, G. Gambolati, P. Teatini, and **A. Alzraiee** (2014), Ensemble smoothing of land subsidence measurements for reservoir geomechanical characterization, Int. J. Numer. Anal. Methods Geomech., n/a–n/a, doi:10.1002/nag.2309.

3- **Alzraiee,** A. H., D. A. Bau, and L. A. Garcia (2013), "Multiobjective design of aquifer monitoring networks for optimal spatial prediction and geostatistical parameter estimation", Water Resources Research, 49, 3670–3684, doi:10.1002/wrcr.20300.

4- **Alzraiee**, A., Garcia, L., and Gates, T. (2013). "Modeling Subsurface Heterogeneity of Irrigated and Drained Fields: I. Model Development and Testing." J. Irrig. Drain Eng., 10.1061/(ASCE)IR.1943-4774.0000607 (Mar. 8, 2013).

5- **Alzraiee**, A., Gates, T., and Garcia, L. (2013). "Modeling Subsurface Heterogeneity of Irrigated and Drained Fields: II. Multivariate Stochastic Analysis of Root-Zone Hydrosalinity and Crop Yield." J. Irrig. Drain Eng., 10.1061/(ASCE)IR.1943-4774.0000587 (Apr. 13, 2013).

6- **Alzraiee**, A. and Garcia, L. (2013). "Global Sensitivity Analysis of Variably Saturated Flow and Transport Parameters and its Implication for Crop Yield and Root Zone Hydrosalinity." J. Irrig. Drain Eng., 10.1061/(ASCE)IR.1943-4774.0000638 (May. 29, 2013).

7- **Alzraiee**, A. and Garcia, L. (2012). "Using Cluster Analysis of Hydraulic Conductivity Realizations to Reduce Computational Time for Monte Carlo Simulations." J. Irrig. Drain Eng., 138(5), 424–436.

Eligibility Checklist		
Applicable?		
Yes	**No**	**Eligibility Criteria**
		Local Agency Certification
☑	☐	1) Local Agency: The applicant must provide a written statement (and additional information if noted) containing the appropriate information outlined below: ➪ Is the applicant a local agency as defined in CA Water Code §78640(b)? ➪ What is the statutory or other legal authority under which the applicant was formed and is authorized to operate? ➪ Does the applicant have legal authority to enter into a grant agreement with the State of California? ➪ Describe any legal agreements among partner agencies and/or organizations that ensure performance of the proposal and tracking of funds.
☑	☐	2) Basin Plan: Is each project consistent with a Regional Water Quality Control Plan (Basin Plan)?
		Urban Water Suppliers
☐	☑	3) Urban Water Suppliers: List the urban water suppliers that will receive funding from the proposed grant. Please provide the agency name, a contact phone number and an e-mail address. Those listed must submit self-certification of compliance with CWC §525 *et seq.* and AB 1420 (links to appropriate forms in Appendix A).
☐	☑	4) Urban Water Suppliers: Have all of the urban water suppliers listed in #3 above submitted complete Urban Water Management Plans (UWMPs) to DWR? Have those plans been verified as complete by DWR? If not, explain and provide the anticipated date for having a complete UWMP.
		Groundwater Projects/Users
☐	☑	5) Groundwater Projects: Does the proposal include any groundwater projects or other projects that directly affect groundwater levels or quality? If so, provide the name(s) of the project(s) and list the agency(ies) that will implement the project(s).
☐	☑	6) Groundwater Projects: For the agency(ies) listed in #5 above, how has the agency complied with CWC §10753 regarding Groundwater Management Plans (GWMPs)?
☐	☑	7) Groundwater Users: List the groundwater users that will receive funding from the proposed grant. Please provide the agency/organization name, a contact phone number, and an e-mail address. If there are none, please indicate so and skip to #9.
☐	☑	8) Groundwater Users: Have all of the groundwater users, listed in #7 above met the requirements of DWR's CASGEM Program? http://www.water.ca.gov/groundwater/casgem/ If not, explain and provide the anticipated date for meeting the requirements.
		Agricultural Water Suppliers
☐	☑	9) Agricultural Water Suppliers: List the agricultural water suppliers that will receive funding from the proposed grant. Please provide the agency/organization name, a contact phone number and e-mail address. If there are none, please indicate so and go to #11.
☐	☑	10) Agricultural Water Suppliers: Have all of the agricultural water suppliers, listed in #9 above, submitted complete Agricultural Water Management Plans (AWMPs) to DWR? Have those plans been verified as complete by DWR? If the plans have not been submitted, please indicate the anticipated submittal date.
		Surface Water Diverters
☐	☑	11) Surface Water Diverters: List the surface water diverters that will receive funding from the proposed grant. Please provide the agency/organization name, a contact phone number, and an e-mail address. If there are none, please indicate so.
☐	☑	12) Surface Water Diverters: Have all of the surface water diverters, listed in #11 above, submitted surface water diversion reports to the State Water Resources Control Board in compliance with requirements outlined in Part 5.1 (commencing with §5100) of Division 2 of the CWC? If not, explain and provide the anticipated date for meeting the requirements.

FRESNO STATE
Jordan College of Agricultural Sciences and Technology

January 5, 2015

Jose I. Faria, P.E.
Special Investigations and Regional Planning Branch, Chief
Department of Water Resources
Division of Integrated Regional Water Management
South Central Region Office
3374 E. Shields Ave, Fresno, CA 93726

This letter is to certify that as an applicant to the Proposition 204 Drainage Reuse Grant Program, proposal entitled *"Sustainable Subsurface Drainage Management at the SJRIP Facility using the CSUID-II Model to Optimize Salt Leaching in 'Jose' Tall Wheatgrass and Alfalfa Fields"*, I identify myself (as a representative of California State University, Fresno) as a "local agency" as defined by the CA Water Code §78640(b).

This is based on the language provided in Attachment 1 of the Proposal Solicitation Package which states that , *"local agency" or "agency" means any city, county, district, joint powers authority, or other political subdivision of the state involved with water management.* ***As a political subdivision of the state, public universities,*** *including the University of California,* ***are considered to be a local agencies for this grant program.***

Furthermore as a public university with a teaching and research mission, California State University, Fresno is authorized to receive funding from the California Department of Water Resources.

Respectfully,

Sharon E. Benes, Ph.D.
Professor of Soils and Crop Nutrition
Department of Plant Science
California State University, Fresno
2415 E. San Ramon Ave. M/S AS72
Fresno, CA 93740-8033