

GRANT REQUEST FORM (GRF)

CEC-270 (Revised 02/13)

CALIFORNIA ENERGY COMMISSION

New Agreement EPC-14-067 (To be completed by CGL Office)

Division	Agreement Manager:	MS-	Phone
ERDD	Sonya Ziaja		

Recipient's Legal Name	Federal ID Number
The Regents of the University of California, on behalf of the Berkeley campus	94-6002123

Title of Project
Improving Hydrological Snowpack Forecasting for Hydropower Generation Using Intelligent Information Systems

Term and Amount	Start Date	End Date	Amount
	5/13/2015	12/31/2018	\$ 1,100,000

Business Meeting Information
 ARFVTP agreements under \$75K delegated to Executive Director.

Proposed Business Meeting Date	5/13/2015	<input checked="" type="checkbox"/> Consent	<input type="checkbox"/> Discussion
Business Meeting Presenter	Sonya Ziaja	Time Needed:	minutes

Please select one list serve. Select

Agenda Item Subject and Description

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, ON BEHALF OF THE BERKELEY CAMPUS. Proposed resolution approving Agreement EPC-14-067 with The Regents of the University of California, on behalf of the Berkeley campus for \$1,100,000 grant to conduct research to improve snowpack forecasting in the Sierra Nevada that can be used to facilitate reliable hydropower generation. (EPIC funding) Contact: Sonya Ziaja (Staff presentation: 5 minutes)

California Environmental Quality Act (CEQA) Compliance

1. Is Agreement considered a "Project" under CEQA?

 Yes (skip to question 2)

 No (complete the following (PRC 21065 and 14 CCR 15378)):

Explain why Agreement is not considered a "Project":

This Agreement proposes to install sensors where the State already has instruments and meteorology stations, collect data from those sensors, and provide analytical studies. As proposed, the Agreement would not cause any significant direct or indirect environmental impacts.

2. If Agreement is considered a "Project" under CEQA:

 a) Agreement **IS** exempt. (Attach draft NOE)

 Statutory Exemption. List PRC and/or CCR section number: _____

 Categorical Exemption. List CCR section number: _____

 Common Sense Exemption. 14 CCR 15061 (b) (3)

Explain reason why Agreement is exempt under the above section:

 b) Agreement **IS NOT** exempt. (Consult with the legal office to determine next steps.)

Check all that apply

 Initial Study

 Environmental Impact Report

 Negative Declaration

 Statement of Overriding Considerations

 Mitigated Negative Declaration
List all subcontractors (major and minor) and equipment vendors: (attach additional sheets as necessary)

Legal Company Name:	Budget
University of California Merced	\$ 236,263

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List all key partners: (attach additional sheets as necessary)

Legal Company Name:
NONE

Budget Information

Funding Source	Funding Year of Appropriation	Budget List No.	Amount
EPIC	13-14	301.001A	\$1,100,000
			\$
R&D Program Area: EGRO: EA		TOTAL:	\$1,100,000
Explanation for "Other" selection			
Reimbursement Contract #:		Federal Agreement #:	

Recipient's Administrator/ Officer **Recipient's Project Manager**

Name:	Jyl Baldwin	Name:	Steven Glaser
Address:	621A Sutardja Dai Hall	Address:	621A Sutardja Dai Hall
City, State, Zip:	Berkeley, CA 94720-0001	City, State, Zip:	Berkeley, CA 94720-0001
Phone:	510-642-8110 /	Fax:	- -
E-Mail:	jbaldwin@berkeley.edu	E-Mail:	glaser@berkeley.edu

Selection Process Used

Competitive Solicitation Solicitation #: PON-14-309
 First Come First Served Solicitation

The following items should be attached to this GRF

1. Exhibit A, Scope of Work	<input checked="" type="checkbox"/> Attached
2. Exhibit B, Budget Detail	<input checked="" type="checkbox"/> Attached
3. CEC 105, Questionnaire for Identifying Conflicts	<input checked="" type="checkbox"/> Attached
4. Recipient Resolution	<input checked="" type="checkbox"/> N/A <input type="checkbox"/> Attached
5. CEQA Documentation	<input checked="" type="checkbox"/> N/A <input type="checkbox"/> Attached

 Agreement Manager Date Office Manager Date Deputy Director Date

Exhibit A Scope of Work

I. TASK/ACRONYM TERM LISTS

A. Task List

Task #	CPR ¹	Task Name
1		General Project Tasks
2		Real-Time Ground Measurement System
3		Hydrologic Data Information System
4	X	Blended Hydrologic Data
5	X	Hydrologic Snowpack Forecasting Improvements
6		Estimating ROI From Using Real-Time Data System
7		Evaluation of Project Benefits
8		Technology/Knowledge Transfer Activities

B. Acronym/Term List

Acronym/Term	Meaning
CAM	Commission Agreement Manager
CAO	Commission Agreement Officer
CPR	Critical Project Review
DWR	Department of Water Resources
LIDAR	Light Detection And Ranging
MODIS	NASA Moderate-Resolution Imaging Spectroradiometer
PG&E	Pacific Gas and Electric
PRMS	Precipitation-Runoff Modeling System
ROI	Return on Investment
SMUD	Sacramento Municipal Utility District
TAC	Technical Advisory Committee
WSN	Wireless Sensor Network

II. PURPOSE OF AGREEMENT, PROBLEM/SOLUTION STATEMENT, AND GOALS AND OBJECTIVES

A. Purpose of Agreement

The purpose of this Agreement is to fund the installation and operation of a hydrological observatory, consisting of satellite ground cover and wireless sensor networks, measuring snow depth, temperature relative humidity, solar radiation, and soil moisture, on the North Fork of the Feather River to improve real time estimates of catchment runoff for optimizing hydrogeneration.

¹ Please see subtask 1.3 in Part II of the Scope of Work (General Project Tasks) for a description of Critical Project Review (CPR) Meetings.

Exhibit A

Scope of Work

B. Problem/ Solution Statement

Problem

Hydropower operations have become increasingly complicated and unpredictable due in part to climate change. The connection between seasonal snowpack (precipitation) and forecasts of streamflow is at present largely through empirical relations based on historical data. Climate change introduces additional non-stationarity, resulting in empirical relations becoming less reliable. Greater accuracy is needed to manage ever-increasing demands on available water runoff. Better accuracy, wider coverage, and more-timely data processing and reporting are needed for optimal water management, especially as both constraints and opportunities increase as climate change affects the hydrologic cycle.

For example, an efficient and effective energy supply depends on managing the intersections between supply (water, sunlight, gas, and wind), demand and the generation and transmission systems required to deliver that energy. Renewable energy sources, including solar and wind, are playing an increasingly important role in the power generation portfolio in California, in the US, and internationally. One challenge associated with wind and solar is intermittency, and control of these energy sources. In California, hydropower can fill gaps left by renewable power generation sources.

Solution

We will install four wireless sensor networks and blend the real-time information with satellite and Light Detection And Ranging (LiDAR) remote sensing data. The wireless sensor network is made up of small sensors stations mounted on poles linked by low-power radio. This allows for many sensors to measure over a large area without using connecting wires, which mitigates environmental impact. A representative illustration of a sensor station can be seen in Figure 1. Advanced hydrologic modeling and data management capabilities will provide Pacific Gas and Electric (PG&E) with the information needed to more effectively manage limited hydropower resources using smarter monitoring networks for physical quantities of interest. Precipitation-Runoff Modeling System (PRMS), which PG&E uses, and companion models that provide a richer treatment of subsurface fluxes, that have the potential to greatly improve hydrologic forecasting for the Sierra Nevada and other areas in California, when run with accurate, spatially dense input data. The economic value of the system will be directly proven by comparing prediction methodology Precipitation-Runoff Modeling System (ROI) through Sacramento Municipal Utility District (SMUD)'s finance models.

This will allow further evaluation and improvement of both the PRMS model and decisions based on the PRMS hydrologic forecasts and their uncertainty. The value-added products and the improvements of the products to the PG&E PRMS model will be quantified throughout the year by comparing estimates of snowpack, snowmelt, soil moisture and runoff with actual measurements. The dollar value of the improvements will be quantified by modeling the realized reduction in uncertainty relative to revenue gained or lost based on improved operations.

The snow depth, temp/rH and solar radiation sensors are mounted on a roughly 15 foot tall pole to keep them out of the Sierra snow. The aluminum pole is bolted to a piece of U-channel, i.e., a stop-sign post that was driven five feet into the ground. The upright assembly is then bolted to the channel. The sensors themselves are mounted on a preassembled crossarm so that the station can be quickly assembled. The electronics package sits in an approximately 12 inch square NEMA enclosure located about 5 feet above ground. Three to four volumetric soil

Exhibit A Scope of Work

moisture transducers are installed along the side of a small diameter hole, approximately 3 feet deep. The wires pass through a small diameter conduit into the control box.

Our deployments have minimal environmental impact because: 1) we can pre-determine locations for every network element; 2) we can remotely log into and reprogram the network and fix problems remotely; 3) all components are modular and quick to assemble (all the dirty work is done before fieldwork--fiberglass hole drilling etc); 4) batteries are spec'd to need minimal maintenance ; 5) we reduce visibility with camouflage. We expect that it will take our crew less than a week to install a full network.



Figure 1: finished sensor station installed near the top of Echo Peak, southeastern American River basin.
(Photo Credit, Steven Glazer 2014)

Exhibit A Scope of Work

C. Goals and Objectives of the Agreement

Agreement Goals

The goals of this Agreement are to:

- Lower hydro generation costs;
- Create an intelligent water-information system to optimize real-time knowledge of hydrology across the Sierras;
- Mitigate the effects of climate change on California hydropower generation;
- Make better, more-detailed water-basin storage and runoff predictions;
- Use hydro as a “battery” to fill in for non-continuous renewable-energy sources;
- Demonstrate the actual cost savings from using an intelligent water-information system.

Ratepayer Benefits:² This Agreement will result in the ratepayer benefits of greater electricity reliability and lower costs by furthering the ability of hydropower to respond to fluctuations in demand and supply as intermittent renewable energy resources come online. It will advance water management information technology by providing real-time information not currently available and integrating this information into energy supply operations tools. This will improve hydrological forecasting skill, which will not only improve day-ahead scheduling accuracy that will decrease costs to ratepayers and increase real-time flexibility to support grid reliability, but decrease environmental and safety impacts of unexpected spills.

The Agreement allows direct mitigation of climate change effects on hydroelectric water availability by providing real-time information to the utility’s planning models. Currently they use regression models with about 50 years of data, which is of less and less use with climate change. This knowledge of how much water is available, where it is, and what it is doing will provide much more reliable and hence cheaper hydropower electricity.

Technological Advancement and Breakthroughs:³ This Agreement will lead to technological advancement and breakthroughs to overcome barriers to the achievement of the State of California’s statutory energy goals by estimating the availability of snow water for more efficient hydroelectric generation. The project utilizes a new technology of wireless sensor stations linked by low-power radio that has been spun into a startup. This allows for very compact, camouflaged equipment to measure many important parameters. The program will integrate ground and satellite based sensing to give localized real time measurements. This allows for the use of physical-based rather than regression-based models, and a much better water runoff prediction.

For the first time the rate of return of new methodologies of increasing snow water estimate certainty will be calculated. This will inform the utilities whether the technology is cost effective and by how much they can reduce the rates.

² California Public Resources Code, Section 25711.5(a) requires projects funded by the Electric Program Investment Charge (EPIC) to result in ratepayer benefits. The California Public Utilities Commission, which established the EPIC in 2011, defines ratepayer benefits as greater reliability, lower costs, and increased safety (See CPUC “Phase 2” Decision 12-05-037 at page 19, May 24, 2012, http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF).

³ California Public Resources Code, Section 25711.5(a) also requires EPIC-funded projects to lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state’s statutory and energy goals.

Exhibit A

Scope of Work

Agreement Objectives

The objectives of this Agreement are to:

- Install real-time wireless sensor networks to measure snow depth, temperature relative humidity, solar radiation, and soil moisture at four sites in the North Fork of the Feather River
- Integrate ground-based, LiDAR, and satellite measurements to accurately estimate snowpack and soil-water storage, precipitation, and evapotranspiration across the basin.
- Integrate the spatially distributed hydrologic information into PG&E's PRMS hydrologic model to forecast runoff and reduce uncertainty in forecasts.
- Measure the dollar value of improved hydrologic data on hydrogenation costs by running comparative data through utility financial models.

III. TASK 1 GENERAL PROJECT TASKS

PRODUCTS

Subtask 1.1 Products

The goal of this subtask is to establish the requirements for submitting project products (e.g., reports, summaries, plans, and presentation materials). Unless otherwise specified by the Commission Agreement Manager (CAM), the Recipient must deliver products as required below by the dates listed in the **Project Schedule (Part IV)**. Products that require a draft version are indicated by marking “**(draft and final)**” after the product name in the “Products” section of the task/subtask. If “(draft and final)” does not appear after the product name, only a final version of the product is required. With respect to due dates within this Scope of Work, “**days**” means working days.

The Recipient shall:

For products that require a draft version

- Submit all draft products to the CAM for review and comment in accordance with the Project Schedule (Part IV). The CAM will provide written comments to the Recipient on the draft product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- Submit the final product to the CAM once agreement has been reached on the draft. The CAM will provide written approval of the final product within 15 days of receipt, unless otherwise specified in the task/subtask for which the product is required.
- If the CAM determines that the final product does not sufficiently incorporate his/her comments, submit the revised product to the CAM within 10 days of notice by the CAM, unless the CAM specifies a longer time period.

For products that require a final version only

- Submit the product to the CAM for approval.
- If the CAM determines that the product requires revision, submit the revised product to the CAM within 10 days of notice by the CAM, unless the CAM specifies a longer time period.

For all products

- Submit all data and documents required as products in accordance with the following Instructions for Submitting Electronic Files and Developing Software:

Exhibit A Scope of Work

- **Electronic File Format**

Submit all data and documents required as products under this Agreement in an electronic file format that is fully editable and compatible with the Energy Commission's software and Microsoft (MS)-operating computing platforms, or with any other format approved by the CAM. Deliver an electronic copy of the full text of any Agreement data and documents in a format specified by the CAM, such as memory stick or CD-ROM.

The following describes the accepted formats for electronic data and documents provided to the Energy Commission as products under this Agreement, and establishes the software versions that will be required to review and approve all software products:

- Data sets will be in MS Access or MS Excel file format (version 2007 or later), or any other format approved by the CAM.
- Text documents will be in MS Word file format, version 2007 or later.
- Documents intended for public distribution will be in PDF file format. The Recipient must also provide the native Microsoft file format.
- Project management documents will be in Microsoft Project file format, version 2007 or later.

- **Software Application Development**

Use the following standard Application Architecture components in compatible versions for any software application development required by this Agreement (e.g., databases, models, modeling tools), unless the CAM approves other software applications such as open source programs:

- Microsoft ASP.NET framework (version 3.5 and up). Recommend 4.0.
- Microsoft Internet Information Services (IIS), (version 6 and up) Recommend 7.5.
- Visual Studio.NET (version 2008 and up). Recommend 2010.
- C# Programming Language with Presentation (UI), Business Object and Data Layers.
- SQL (Structured Query Language).
- Microsoft SQL Server 2008, Stored Procedures. Recommend 2008 R2.
- Microsoft SQL Reporting Services. Recommend 2008 R2.
- XML (external interfaces).

Any exceptions to the Electronic File Format requirements above must be approved in writing by the CAM. The CAM will consult with the Energy Commission's Information Technology Services Branch to determine whether the exceptions are allowable.

MEETINGS

Subtask 1.2 Kick-off Meeting

The goal of this subtask is to establish the lines of communication and procedures for implementing this Agreement.

Exhibit A Scope of Work

The Recipient shall:

- Attend a “Kick-off” meeting with the CAM, the Commission Agreement Officer (CAO), and any other Energy Commission staff relevant to the Agreement. The Recipient will bring its Project Manager and any other individuals designated by the CAM to this meeting. The administrative and technical aspects of the Agreement will be discussed at the meeting. Prior to the meeting, the CAM will provide an agenda to all potential meeting participants. The meeting may take place in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The administrative portion of the meeting will include discussion of the following:

- Terms and conditions of the Agreement;
- Administrative products (subtask 1.1);
- CPR meetings (subtask 1.3);
- Match fund documentation (subtask 1.7);
- Permit documentation (subtask 1.8);
- Subcontracts (subtask 1.9); and
- Any other relevant topics.

The technical portion of the meeting will include discussion of the following:

- The CAM's expectations for accomplishing tasks described in the Scope of Work;
 - An updated Project Schedule;
 - Technical products (subtask 1.1);
 - Progress reports and invoices (subtask 1.5);
 - Final Report (subtask 1.6);
 - Technical Advisory Committee meetings (subtasks 1.10 and 1.11); and
 - Any other relevant topics.
- Provide an *Updated Project Schedule*, *List of Match Funds*, and *List of Permits*, as needed to reflect any changes in the documents.

The CAM shall:

- Designate the date and location of the meeting.
- Send the Recipient a *Kick-off Meeting Agenda*.

Recipient Products:

- Updated Project Schedule *(if applicable)*
- Updated List of Match Funds *(if applicable)*
- Updated List of Permits *(if applicable)*

CAM Product:

- Kick-off Meeting Agenda

Exhibit A Scope of Work

Subtask 1.3 Critical Project Review (CPR) Meetings

The goal of this subtask is to determine if the project should continue to receive Energy Commission funding, and if so whether any modifications must be made to the tasks, products, schedule, or budget. CPR meetings provide the opportunity for frank discussions between the Energy Commission and the Recipient. As determined by the CAM, discussions may include project status, challenges, successes, advisory group findings and recommendations, final report preparation, and progress on technical transfer and production readiness activities (if applicable). Participants will include the CAM and the Recipient, and may include the CAO and any other individuals selected by the CAM to provide support to the Energy Commission.

CPR meetings generally take place at key, predetermined points in the Agreement, as determined by the CAM and as shown in the Task List on page 1 of this Exhibit. However, the CAM may schedule additional CPR meetings as necessary. The budget will be reallocated to cover the additional costs borne by the Recipient, but the overall Agreement amount will not increase. CPR meetings generally take place at the Energy Commission, but they may take place at another location, or may be conducted via electronic conferencing (e.g., WebEx) as determined by the CAM.

The Recipient shall:

- Prepare a *CPR Report* for each CPR meeting that: (1) discusses the progress of the Agreement toward achieving its goals and objectives; and (2) includes recommendations and conclusions regarding continued work on the project.
- Submit the CPR Report along with any other *Task Products* that correspond to the technical task for which the CPR meeting is required (i.e., if a CPR meeting is required for Task 2, submit the Task 2 products along with the CPR Report).
- Attend the CPR meeting.
- Present the CPR Report and any other required information at each CPR meeting.

The CAM shall:

- Determine the location, date, and time of each CPR meeting with the Recipient's input.
- Send the Recipient a *CPR Agenda* and a *List of Expected CPR Participants* in advance of the CPR meeting. If applicable, the agenda will include a discussion of match funding and permits.
- Conduct and make a record of each CPR meeting. Provide the Recipient with a *Schedule for Providing a Progress Determination* on continuation of the project.
- Determine whether to continue the project, and if so whether modifications are needed to the tasks, schedule, products, or budget for the remainder of the Agreement. If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Deputy Director of the Energy Research and Development Division.
- Provide the Recipient with a *Progress Determination* on continuation of the project, in accordance with the schedule. The Progress Determination may include a requirement that the Recipient revise one or more products.

Recipient Products:

- CPR Report(s)
- Task Products (draft and/or final as specified in the task)

CAM Products:

- CPR Agenda
- List of Expected CPR Participants

Exhibit A Scope of Work

- Schedule for Providing a Progress Determination
- Progress Determination

Subtask 1.4 Final Meeting

The goal of this subtask is to complete the closeout of this Agreement.

The Recipient shall:

- Meet with Energy Commission staff to present project findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement. This meeting will be attended by the Recipient and CAM, at a minimum. The meeting may occur in person or by electronic conferencing (e.g., WebEx), with approval of the CAM.

The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be divided into two separate meetings at the CAM's discretion.

- The technical portion of the meeting will involve the presentation of findings, conclusions, and recommended next steps (if any) for the Agreement. The CAM will determine the appropriate meeting participants.
- The administrative portion of the meeting will involve a discussion with the CAM and the CAO of the following Agreement closeout items:
 - Disposition of any state-owned equipment.
 - Need to file a Uniform Commercial Code Financing Statement (Form UCC-1) regarding the Energy Commission's interest in patented technology.
 - The Energy Commission's request for specific "generated" data (not already provided in Agreement products).
 - Need to document the Recipient's disclosure of "subject inventions" developed under the Agreement.
 - "Surviving" Agreement provisions such as repayment provisions and confidential products.
 - Final invoicing and release of retention.
- Prepare a *Final Meeting Agreement Summary* that documents any agreement made between the Recipient and Commission staff during the meeting.
- Prepare a *Schedule for Completing Agreement Closeout Activities*.
- Provide *All Draft and Final Written Products* on a CD-ROM or USB memory stick, organized by the tasks in the Agreement.

Products:

- Final Meeting Agreement Summary (*if applicable*)
- Schedule for Completing Agreement Closeout Activities
- All Draft and Final Written Products

REPORTS AND INVOICES

Subtask 1.5 Progress Reports and Invoices

The goals of this subtask are to: (1) periodically verify that satisfactory and continued progress is made towards achieving the project objectives of this Agreement; and (2) ensure that invoices contain all required information and are submitted in the appropriate format.

Exhibit A Scope of Work

The Recipient shall:

- Submit a monthly *Progress Report* to the CAM. Each progress report must:
 - Summarize all Agreement activities conducted by the Recipient for the preceding month, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. See the Progress Report Format Attachment for the recommended specifications.
 - Provide a synopsis of the project progress, including accomplishments, problems, milestones, products, schedule, fiscal status, and any evidence of progress such as photographs.
- Submit a monthly or quarterly *Invoice* that follows the instructions in the “Payment of Funds” section of the terms and conditions. In addition, each invoice must document and verify:
 - Energy Commission funds received by California-based entities;
 - Energy Commission funds spent in California (*if applicable*); and
 - Match fund expenditures.

Products:

- Progress Reports
- Invoices

Subtask 1.6 Final Report

The goal of this subtask is to prepare a comprehensive Final Report that describes the original purpose, approach, results, and conclusions of the work performed under this Agreement. The CAM will review and approve the Final Report, which will be due at least **two months** before the Agreement end date. When creating the Final Report Outline and the Final Report, the Recipient must use a Style Manual provided by the CAM.

Subtask 1.6.1 Final Report Outline

The Recipient shall:

- Prepare a *Final Report Outline* in accordance with the *Style Manual* provided by the CAM.
- Submit a draft of the outline to the CAM for review and comment.
- Once agreement has been reached on the draft, submit the final outline to the CAM. The CAM will provide written approval of the final outline within 10 days of receipt.

Recipient Products:

- Final Report Outline (draft and final)

CAM Product:

- Style Manual
- Comments on Draft Final Report Outline
- Approval of Final Report Outline

Subtask 1.6.2 Final Report

The Recipient shall:

- Prepare a *Final Report* for this Agreement in accordance with the approved Final Report Outline and the Style Manual provided by the CAM.
- Submit a draft of the report to the CAM for review and comment. Once agreement on the

Exhibit A Scope of Work

draft report has been reached, the CAM will forward the electronic version for Energy Commission internal approval. Once the CAM receives approval, he/she will provide written approval to the Recipient.

- Submit one bound copy of the Final Report to the CAM.

Products:

- Final Report (draft and final)

MATCH FUNDS, PERMITS, AND SUBCONTRACTS

Subtask 1.7 Match Funds

The goal of this subtask is to ensure that the Recipient obtains any match funds planned for this Agreement and applies them to the Agreement during the Agreement term.

While the costs to obtain and document match funds are not reimbursable under this Agreement, the Recipient may spend match funds for this task. The Recipient may only spend match funds during the Agreement term, either concurrently or prior to the use of Energy Commission funds. Match funds must be identified in writing, and the Recipient must obtain any associated commitments before incurring any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Match Funds Status Letter* that documents the match funds committed to this Agreement. If no match funds were part of the proposal that led to the Energy Commission awarding this Agreement and none have been identified at the time this Agreement starts, then state this in the letter.

If match funds were a part of the proposal that led to the Energy Commission awarding this Agreement, then provide in the letter:

- A list of the match funds that identifies:
 - The amount of cash match funds, their source(s) (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied.
 - The amount of each in-kind contribution, a description of the contribution type (e.g., property, services), the documented market or book value, the source (including a contact name, address, and telephone number), and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient must identify its owner and provide a contact name, address, telephone number, and the address where the property is located.
- A copy of a letter of commitment from an authorized representative of each source of match funding that the funds or contributions have been secured.
- At the Kick-off meeting, discuss match funds and the impact on the project if they are significantly reduced or not obtained as committed. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide a *Supplemental Match Funds Notification Letter* to the CAM of receipt of additional match funds.

Exhibit A Scope of Work

- Provide a *Match Funds Reduction Notification Letter* to the CAM if existing match funds are reduced during the course of the Agreement. Reduction of match funds may trigger a CPR meeting.

Products:

- Match Funds Status Letter
- Supplemental Match Funds Notification Letter (*if applicable*)
- Match Funds Reduction Notification Letter (*if applicable*)

Subtask 1.8 Permits

The goal of this subtask is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track. Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement, with the exception of costs incurred by University of California recipients. Permits must be identified and obtained before the Recipient may incur any costs related to the use of the permit(s) for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a *Permit Status Letter* that documents the permits required to conduct this Agreement. If no permits are required at the start of this Agreement, then state this in the letter. If permits will be required during the course of the Agreement, provide in the letter:
 - A list of the permits that identifies: (1) the type of permit; and (2) the name, address, and telephone number of the permitting jurisdictions or lead agencies.
 - The schedule the Recipient will follow in applying for and obtaining the permits.

The list of permits and the schedule for obtaining them will be discussed at the Kick-off meeting (subtask 1.2), and a timetable for submitting the updated list, schedule, and copies of the permits will be developed. The impact on the project if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in progress reports and will be a topic at CPR meetings.

- If during the course of the Agreement additional permits become necessary, then provide the CAM with an *Updated List of Permits* (including the appropriate information on each permit) and an *Updated Schedule for Acquiring Permits*.
- Send the CAM a *Copy of Each Approved Permit*.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 days. Either of these events may trigger a CPR meeting.

Products:

- Permit Status Letter
- Updated List of Permits (*if applicable*)
- Updated Schedule for Acquiring Permits (*if applicable*)
- Copy of each Approved Permit (*if applicable*)

Subtask 1.9 Subcontracts

The goals of this subtask are to: (1) procure subcontracts required to carry out the tasks under this Agreement; and (2) ensure that the subcontracts are consistent with the terms and conditions of this Agreement.

Exhibit A Scope of Work

The Recipient shall:

- Manage and coordinate subcontractor activities in accordance with the requirements of this Agreement.
- Incorporate this Agreement by reference into each subcontract.
- Include any required Energy Commission flow-down provisions in each subcontract, in addition to a statement that the terms of this Agreement will prevail if they conflict with the subcontract terms.
- If required by the CAM, submit a draft of each *Subcontract* required to conduct the work under this Agreement.
- Submit a final copy of the executed subcontract.
- Notify and receive written approval from the CAM prior to adding any new subcontractors (see the discussion of subcontractor additions in the terms and conditions).

Products:

- Subcontracts (*draft if required by the CAM*)

TECHNICAL ADVISORY COMMITTEE

Subtask 1.10 Technical Advisory Committee (TAC)

The goal of this subtask is to create an advisory committee for this Agreement. The TAC should be composed of diverse professionals. The composition will vary depending on interest, availability, and need. TAC members will serve at the CAM's discretion. The purpose of the TAC is to:

- Provide guidance in project direction. The guidance may include scope and methodologies, timing, and coordination with other projects. The guidance may be based on:
 - Technical area expertise;
 - Knowledge of market applications; or
 - Linkages between the agreement work and other past, present, or future projects (both public and private sectors) that TAC members are aware of in a particular area.
- Review products and provide recommendations for needed product adjustments, refinements, or enhancements.
- Evaluate the tangible benefits of the project to the state of California, and provide recommendations as needed to enhance the benefits.
- Provide recommendations regarding information dissemination, market pathways, or commercialization strategies relevant to the project products.

The TAC may be composed of qualified professionals spanning the following types of disciplines:

- Researchers knowledgeable about the project subject matter;
- Members of trades that will apply the results of the project (e.g., designers, engineers, architects, contractors, and trade representatives);
- Public interest market transformation implementers;
- Product developers relevant to the project;
- U.S. Department of Energy research managers, or experts from other federal or state agencies relevant to the project;
- Public interest environmental groups;
- Utility representatives;

Exhibit A Scope of Work

- Air district staff; and
- Members of relevant technical society committees.

The Recipient shall:

- Prepare a *List of Potential TAC Members* that includes the names, companies, physical and electronic addresses, and phone numbers of potential members. The list will be discussed at the Kick-off meeting, and a schedule for recruiting members and holding the first TAC meeting will be developed.
- Recruit TAC members. Ensure that each individual understands member obligations and the TAC meeting schedule developed in subtask 1.11.
- Prepare a *List of TAC Members* once all TAC members have committed to serving on the TAC.
- Submit *Documentation of TAC Member Commitment* (such as Letters of Acceptance) from each TAC member.

Products:

- List of Potential TAC Members
- List of TAC Members
- Documentation of TAC Member Commitment

Subtask 1.11 TAC Meetings

The goal of this subtask is for the TAC to provide strategic guidance for the project by participating in regular meetings, which may be held via teleconference.

The Recipient shall:

- Discuss the TAC meeting schedule with the CAM at the Kick-off meeting. Determine the number and location of meetings (in-person and via teleconference) in consultation with the CAM.
- Prepare a *TAC Meeting Schedule* that will be presented to the TAC members during recruiting. Revise the schedule after the first TAC meeting to incorporate meeting comments.
- Prepare a *TAC Meeting Agenda* and *TAC Meeting Back-up Materials* for each TAC meeting.
- Organize and lead TAC meetings in accordance with the TAC Meeting Schedule. Changes to the schedule must be pre-approved in writing by the CAM.
- Prepare *TAC Meeting Summaries* that include any recommended resolutions of major TAC issues.

Products:

- TAC Meeting Schedule (draft and final)
- TAC Meeting Agendas (draft and final)
- TAC Meeting Back-up Materials
- TAC Meeting Summaries

IV. TECHNICAL TASKS

*Products that require a draft version are indicated by marking “(draft and final)” after the product name in the “Products” section of the task/subtask. If “(draft and final)” does not appear after the product name, only a final version of the product is required. **Subtask 1.1 (Products)** describes the procedure for submitting products to the CAM.*

Exhibit A Scope of Work

TASK 2 REAL-TIME GROUND MEASUREMENT SYSTEM

The goals of this task are to prepare and install four to six wireless sensor networks at key locations chosen by PG&E to accurately measure catchment hydrological parameters in real time. Each sensor network is made up of 15 sensor stations and 20 data repeater stations. Each is mounted on a pole.

The Recipient shall:

- Determine sensor network sites
 - Choose the four to six locations for installation of sensor networks based on PG&E requirements and calculation of best physiographic representation using machine learning models. The four primary sites are Department of Water Resources (DWR) snow-pillow sites: Grizzly Ridge (GRZ), Kettle Rock (KTL), Humbug (HMB), Buck's Lake (BKL). In case one or more of these sites are not available, alternates are Four Trees (FOR), Harkness (HRK/HRF), and Rattlesnake (RTL). These are locations where the state already has existing, and large, equipment such as meteorology stations and snow pillows. The hardware for our sensor networks has a very small footprint compared to what is currently in place.
 - Obtain permits from US Forest Service for Ground Wireless Sensor Network (WSN) sites
 - Integrate sensor networks with DWR. DWR is a partner providing matching funds to purchase the field network equipment. They are not a sub-contractor and will not oversee any part of the project.
- Determine optimal sensor node locations at each network
 - Determine the number of sensor to be placed at each network site based on cost and efficiency
 - Produce map of optimal sensor station locations within the network footprint using the Recipient's machine learning algorithms within scope of Plumas Forest permits
 - Perform radio strength field tests to check for final placements of wireless nodes
- Determine what field sensors will be placed at sensor nodes
 - Identify hydrological variables that are needed for models
 - Identify the best sensors for each hydrological variable based on performance and cost
 - Determine what sensors will be placed at each sensing node location
- Finalize field node mechanical design and preliminary assembly of sensor networks hardware components
 - Analyze current American River mechanical design of sensing and radio relay stations for strengths and weaknesses
 - Specify parts and materials needed for the required wireless networks
 - Assemble mechanical sub-assemblies
 - Calibrate sensors
- Customize software for wireless network hardware
 - Adapt or write software drivers for each sensor for the Metronome NeoMote
 - Adapt or write network integration software
 - Adapt or write software to transmit data over cell or Inmarsat satellite modem
 - Test network sensor software package

Exhibit A Scope of Work

- Install and field test the wireless sensor networks
- Prepare *Ground Measurement System Design and Testing Report*
- Prepare manuscript for peer-reviewed publication on WSN design and performance

Products:

- Permits for four WSN Sites by the National Forest Service
- Ground Measurement System Design and Testing Report
- Manuscript for peer-reviewed publication on WSN design and performance

TASK 3. HYDROLOGIC DATA INFORMATION SYSTEM

The goals of this task are to design and implement the information technology and models needed to analyze NASA Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite data and provide public access to the final data product.

The Recipient shall:

- Prepare the *Conceptual Design for Project Data and Information System Report*
 - Develop conceptual design and data flow template for project data
 - Update conceptual design and data flow template for post-project operational phase
- Integrate data system for new sensor networks with that for DWR (CDEC), PG&E, and Sacramento Municipal Utility District (SNSJHO)
- Set up system to download existing field data from DWR, PG&E and NOAA and blend with new sensor-network data for this project
- Set up pipeline for NASA MODIS satellite-data products
- Integrate with existing UC (CSNWIS) system to store and serve MODIS products
- Provide portals for public access of MODIS and sensor network data
- Set up system to blend ground-based and remotely sensed Data Into QA/QC-controlled product for this project
- Prepare the *Conceptual Design for Post-project Operational Data and Information System Report*
- Prepare *Hydrologic Data Information System Report* describing the system and providing URLs to the WSN and MODIS product archives
- Prepare manuscript for peer-reviewed publication on data systems

Products:

- Conceptual Design for Project Data and Information System Report
- Conceptual Design for Post-project Operational Data and Information System Report
- Hydrologic Data Information System Report
- Manuscript for peer-reviewed publication on installed Data Systems

TASK 4. BLENDED HYDROLOGIC DATA

The goal of this task is to create snow products from detailed ground data merged with satellite remote imaging that will allow utilities to optimize hydroelectric operations and save significant costs due to the found efficiencies.

The Recipient shall:

- Generate snowpack-storage maps, including snow depth and snow water equivalent, over time over study area

Exhibit A Scope of Work

- Produce soil-water storage maps over time over study area served by sensors as a value added product for the estimation of snow water available to PG&E
- Produce spatially distributed time series maps of energy balance for the study region so that better estimates of the change in snow pack can be better estimated
- Produce spatially distributed maps of estimates of evapotranspiration so that the effects of current density of forest can be determined as well as the advantages of proposed forest thinning by the Forest Service
- Plan for and fly LIDAR for evaluation of snow-depth product
- Produce the *Blended Hydrologic Data Products Report* describing and displaying these maps and the LiDAR-based evaluation
- Prepare manuscript for peer-reviewed publication on Value-Added Products
- Complete Critical Project Review Meeting #2

Products:

- Blended Hydrologic Data Products Report
- Manuscript for peer-reviewed publication on Value-Added Products
- Critical Review Presentation and Report #1

TASK 5. HYDROLOGIC SNOWPACK FORECASTING IMPROVEMENTS

The goals of this task are to integrate the field and satellite blended product into the PRMS hydrologic model used by PG&E, and to update the model to use the detailed real-time data. The work will be completed working with a hydrologic modeler at PG&E.

The Recipient shall:

- Work with PG&E to evaluate existing PRMS parameterization and outputs
- Assess current PRMS model inputs relative to spatial hydrologic maps developed under this project
- Assess current PRMS model outputs relative to spatial hydrologic maps developed under this project
- Identify key improvements in model inputs and parameterization needed to improve forecast skill
- Assess need to update version of PRMS used in PG&Es hydrologic forecasting
- Prepare annual *Improvements in Hydrologic Snowpack Forecasting Report* describing these assessments and key improvements
- Prepare manuscript for peer-reviewed publication on Value-Added Products
- Prepare and conduct Critical Project Review Presentation and Report #2
- Prepare manuscript for peer-reviewed publication on Means to Achieve Forecast Skill Improvement
- Prepare and conduct Critical Project Review Presentation and Report #3
- Complete Critical Project Review Meeting #3

Products:

- Improvements in Hydrologic Snowpack Forecasting Report (annual)
- Manuscript for peer-reviewed publication on Means to Achieve Forecast Skill Improvement
- Critical Review Presentation and Report Critical #3

Exhibit A Scope of Work

TASK 6. ESTIMATING ROI FROM USING THE REAL-TIME DATA SYSTEM

The goal of this task is to determine the financial benefit of using the intelligent water information system. The new methodology will be compared directly with the current PG&E or SMUD standard. The result will be a ROI estimate in dollars.

The Recipient shall:

- Sample water year traditionally and by new method (this project)
- Run water year models through PG&E financial models
- Determine the ROI of Increasing hydrologic data and forecast skill
- Assess potential for further skill improvement with further investments
- Prepare the *ROI from Using the Real-Time Data System Report*
- Prepare manuscript for peer-reviewed publication on ROI

Products:

- ROI from Using the Real-Time Data System Report
- Manuscript for peer-reviewed publication on ROI

TASK 7. EVALUATION OF PROJECT BENEFITS

The goal of this task is to report the benefits resulting from this project.

The Recipient shall:

- Complete three Project Benefits Questionnaires that correspond to three main intervals in the Agreement: (1) *Kick-off Meeting Benefits Questionnaire*; (2) *Mid-term Benefits Questionnaire*; and (3) *Final Meeting Benefits Questionnaire*.
- Provide all key assumptions used to estimate projected benefits, including targeted market sector (e.g., population and geographic location), projected market penetration, baseline and projected energy use and cost, operating conditions, and emission reduction calculations. Examples of information that may be requested in the questionnaires include:
 - For Product Development Projects and Project Demonstrations:
 - Published documents, including date, title, and periodical name.
 - Estimated or actual energy and cost savings, and estimated statewide energy savings once market potential has been realized. Identify all assumptions used in the estimates.
 - Greenhouse gas and criteria emissions reductions.
 - Other non-energy benefits such as reliability, public safety, lower operational cost, environmental improvement, indoor environmental quality, and societal benefits.
 - Data on potential job creation, market potential, economic development, and increased state revenue as a result of the project.
 - A discussion of project product downloads from websites, and publications in technical journals.
 - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
 - Additional Information for Product Development Projects:
 - Outcome of product development efforts, such copyrights and license agreements.

Exhibit A Scope of Work

- Units sold or projected to be sold in California and outside of California.
- Total annual sales or projected annual sales (in dollars) of products developed under the Agreement.
- Investment dollars/follow-on private funding as a result of Energy Commission funding.
- Patent numbers and applications, along with dates and brief descriptions, however no patentable products are expected.
- Additional Information for Product Demonstrations:
 - Outcome of demonstrations and status of technology.
 - Number of similar installations.
 - Jobs created/retained as a result of the Agreement.
- For Information/Tools and Other Research Studies:
 - Outcome of project.
 - Published documents, including date, title, and periodical name.
 - A discussion of policy development. State if the project has been cited in government policy publications or technical journals, or has been used to inform regulatory bodies.
 - The number of website downloads.
 - An estimate of how the project information has affected energy use and cost, or has resulted in other non-energy benefits.
 - An estimate of energy and non-energy benefits.
 - Data on potential job creation, market potential, economic development, and increased state revenue as a result of project.
 - A discussion of project product downloads from websites, and publications in technical journals.
 - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
- Respond to CAM questions regarding responses to the questionnaires.

The Energy Commission may send the Recipient similar questionnaires after the Agreement term ends. Responses to these questionnaires will be voluntary.

Products:

- Kick-off Meeting Benefits Questionnaire
- Mid-term Benefits Questionnaire
- Final Meeting Benefits Questionnaire

TASK 8. TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this task is to develop a plan to make the knowledge gained, experimental results, and lessons learned available to the public and key decision makers.

The Recipient shall:

- Prepare an *Initial Fact Sheet* at start of the project that describes the project. Use the format provided by the CAM.
- Prepare a *Final Project Fact Sheet* at the project's conclusion that discusses results.

Exhibit A Scope of Work

Use the format provided by the CAM.

- Prepare a *Technology/Knowledge Transfer Plan* that includes:
 - An explanation of how the knowledge gained from the project will be made available to the public, including the targeted market sector and potential outreach to end users, utilities, regulatory agencies, and others.
 - A description of the intended use(s) for and users of the project results.
 - Published documents, including date, title, and periodical name.
 - Copies of documents, fact sheets, journal articles, press releases, and other documents prepared for public dissemination. These documents must include the Legal Notice required in the terms and conditions. Indicate where and when the documents were disseminated.
 - A discussion of policy development. State if project has been or will be cited in government policy publications, or used to inform regulatory bodies.
 - The number of website downloads or public requests for project results.
 - Additional areas as determined by the CAM.
- Conduct technology transfer activities in accordance with the *Technology/Knowledge Transfer Plan*. These activities will be reported in the Progress Reports.
- When directed by the CAM, develop *Presentation Materials* for an Energy Commission-sponsored conference/workshop on the results of the project.
- Prepare a *Technology/Knowledge Transfer Report* on technology transfer activities conducted during the project.

Products:

- Initial Fact Sheet (draft and final)
- Final Project Fact Sheet (draft and final)
- Presentation Materials (draft and final)
- Technology/Knowledge Transfer Plan (draft and final)
- Technology/Knowledge Transfer Report (draft and final)

V. PROJECT SCHEDULE

Please see the attached Excel spreadsheet.

STATE OF CALIFORNIA

STATE ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION - RE: UNIVERSITY OF CALIFORNIA, BERKELEY

RESOLVED, that the State Energy Resources Conservation and Development Commission (Energy Commission) adopts the staff CEQA findings contained in the Agreement Request Form; and

RESOLVED, that the Energy Commission approves Agreement EPC-14-067 from PON-14-309 with the **Regents of the University of California, on behalf of the Berkeley Campus** for a **\$1,100,000** grant to conduct research to improve snowpack forecasting in the Sierra Nevada that can be used to facilitate reliable hydropower generation; and

FURTHER BE IT RESOLVED, that the Executive Director or his/her designee shall execute the same on behalf of the Energy Commission.

CERTIFICATION

The undersigned Secretariat to the Commission does hereby certify that the foregoing is a full, true, and correct copy of a Resolution duly and regularly adopted at a meeting of the California Energy Commission held on May 13, 2015.

AYE: [List of Commissioners]

NAY: [List of Commissioners]

ABSENT: [List of Commissioners]

ABSTAIN: [List of Commissioners]

Harriet Kallemeyn,
Secretariat