

## I. Title Page

**Project Title:** Nutrient and Sediment Loading Predictions for Prescribed Fire Using Optimized WEPP Model

**Theme/Subtheme:** Water Quality/Water Quality Modeling

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**Total Funding Requested:** \$270,193

**Total In-kind Contributions:** \$0

## **II. Proposal Narrative**

### **Justification**

This project is being submitted under the Water Quality Modeling Subtheme in the RFP, but also serves to support several important research needs identified in the RFP, the Draft Science Plan, and the Tahoe TMDL Pollutant Reduction Opportunity Report as it will: predict water quality impacts from prescribed fire; investigate seasonal and temporal soil hydrophobicity and runoff quality; provide relevant information for erosion model improvement, development, and validation for the Lake Tahoe Basin; and generate refined erosion estimates for single storm episodes as compared to seasonally weighted or seasonally adjusted annual erosion loads. This project, while specific to prescribed fire, will optimize the WEPP model with local data, with results that are expected to be applicable beyond the scope of this project, such as improving WEPP's application to other non-urban fire and non-fire related sources and its application to evaluate best management practices at the necessary smaller-scales for siting, design, cost-benefits, and long-term effectiveness.

### **Background and Problem Statement**

The Lake Tahoe TMDL will address pollutant loading from nutrients and sediment to meet its clarity target of 30 meters, and while non-urban upland fire and non-fire related sources have been identified as contributors, little is known about specific loading from prescribed fire. Further, little is known about the spatial and temporal variability of soil hydrophobicity in the Lake Tahoe Basin, or its associated effects on runoff quality, quantity, and erosion. Investigations to fill these knowledge gaps have been identified as priorities in both the Draft Science Plan and the Tahoe Pollutant Reduction Opportunity Report, and will serve to provide relevant information for erosion model improvement specific to the Lake Tahoe Basin.

Erosion model improvements have also been identified as a priority research need so that simulations can be performed both at the smaller-scale and for single storm events, which is appropriate to realistically evaluate non-urban fire and non-fire sources and best management practices. While WEPP is currently the most sophisticated erosion prediction technology, it has only recently been applied to the Lake Tahoe Basin and remains in need of optimization through calibration and validation efforts using locally-measured data.

### **Summary of Project Team Experience**

Dr. Mark Grismer of UC Davis and Michael Hogan of Integrated Environmental Restoration Services (IERS) are members of the IERS team who will be working on this project. Mark and Michael have conducted applied erosion-related research in the Tahoe Basin for several years, and have contributed significantly to the development of the Lake Tahoe TMDL. Together they provide the critical understanding of erosion-related needs within the Tahoe Basin, and the expertise to conduct research that is relevant and scientifically defensible. In addition, IERS has developed the necessary working relationships with the managing agencies and relevant stakeholders in the Tahoe Basin, which ensures that there will be meaningful and productive engagement for the duration of the project.

Dr. Wally Miller of University Nevada Reno has conducted applied research in the Tahoe Basin and eastern Sierras for the past 20 years. His research has focused on soils, hydrology, water quality, and nutrient and sediment transport processes

Drea Traeumer and Dr. Erin Brooks are experienced WEPP modelers, each being one of the handful of experts in the world capable of utilizing the model to its full capabilities. Drea was the first to apply WEPP in the Tahoe Basin in 2006, and Erin is currently applying the model as part

of a current research project. Erin's participation in this project will allow coordination between the two projects, prevent any duplication of efforts, and ensure that relevant information is shared so that WEPP may be applied to the Tahoe Basin to the best of its abilities.

### **Goals, Objectives, and Hypothesis Testing**

The objective of this project is to provide temporal and spatial predictions of nutrient and sediment loadings at the hillslope scale for prescribed fire using an optimized WEPP model. Optimization will be performed through calibration and validation efforts using locally-measured data for: WEPP's most sensitive erodibility parameters (hydraulic conductivity, interrill erodibility, bulk density); runoff quantity and quality; and sediment yield and composition. Validation will be evaluated through quantitative measures of goodness of fit, which will be calculated and presented.

While the objective of this project is specific to prescribed fire, the results will serve to support additional needs within the Tahoe Basin by: improving WEPP's application to other non-urban fire and non-fire sources; evaluating best management practices for siting, design, cost-benefits, and long-term effectiveness; providing loading results at the sub-watershed scale for integration into the larger-scale watershed model being used for the TMDL; and supporting future IWQMS and EIP efforts that require the use of the best available science.

### **Approach, Methodology, and Location**

This will be a two-year project conducted in two phases in the Lake Tahoe Basin to locally optimize WEPP for post-prescribed fire (pile burning) conditions during both the dry season and the snowmelt season, and to predict sediment and nutrient loadings from prescribed fire under these conditions at the hillslope scale. Data collection efforts as proposed are intensive; however, this is expected to be a necessary component as they do not currently exist locally for prescribed fire sites. The lead investigator for this project is aware of WEPP research projects funded in Round 7, and will continue to coordinate with the investigators of those projects to ensure that there is no duplication of efforts. To date, none have been identified.

In response to agency recommendations to increase the synergy of SNPLMA research efforts and to include wildfire investigations in our scope, we will collaborate with colleagues on another funded proposal, Project 8-2B12, and also conduct rainfall/runoff simulations and sampling on local wildfire sites, should the opportunity present itself, to collect important post-wildfire data to support future efforts to predict sediment and nutrient impacts from wildfire (that are beyond the scope of this project).

Collaboration with research project 8-2B12, "Developing fuels treatments for balancing fuel reduction, soil exposure, and potential for erosion in the Tahoe Basin" will occur by providing project 8-2B12 with supplemental sampling of runoff for nutrients (phosphorus and nitrogen) at project 8-2B12 prescribed fire sites. This modification will allow both projects to generate uniform data, with the intent to increase the understanding of nutrient ("clear pollution") impacts from multiple treatments on prescribed fire sites.

Should wildfire occur in the Tahoe basin during the term of this project, we will shift our sampling efforts from two prescribed sites to two wildfire sites. This will be possible through our collaboration efforts with research project 8-2B12, as we will use data from two of their prescribed sites to fill our data gap.

Spatial and temporal data will be collected from prescribed fire sites on both volcanics and decomposed granitics, which is necessary for calibrating WEPP so that seasonal (dry and snowmelt) and spatial soil hydrophobicity that exists in the Lake Tahoe Basin can be simulated and the impacts of this hydrophobicity on runoff, erosion, and water quality can be better understood.

Rainfall and runoff simulators will be used at four prescribed fire sites (2 volcanic and 2 granitic) to measure hydraulic conductivity, interrill erodibility, bulk density, infiltration and runoff rates, sediment yield, sediment composition (particle-size distributions and OM content) and runoff total and inorganic phosphorus and nitrogen concentrations. Two rainfall and two runoff simulations will be conducted at each site during both the dry season and the snowmelt season. Rainfall simulations will be conducted on 1m x 1m plots, and runoff simulations will be conducted on 2m x 5m plots. Design storm(s) and application rates for the simulations will be determined through discussions with management agencies and stakeholders. Rainfall and runoff simulations are being combined for this project to generate the data needed to both calibrate WEPP parameters (through rainfall simulations) and to evaluate WEPP erosion and sediment yield predictions at the hillslope-scale (runoff simulations). In situ sampling will also be conducted for nutrients during the snowmelt season, with sample collectors installed in preferential infiltration areas (to be determined during dry-season rainfall and runoff simulations).

WEPP predictions will be evaluated using goodness of fit, and simulations using the optimized WEPP will then be performed for specific design storms (to be determined through stakeholder and management involvement) to predict sediment and nutrient loadings at the hillslope-scale.

### **Phase I: Calibrate WEPP for Application to Prescribed Fire**

- For all rainfall/runoff simulator sampling events, data will be collected for: hydraulic conductivity; interrill erodibility (sediment yield); bulk density; infiltration and runoff rates; runoff total and inorganic phosphorus and nitrogen concentrations, and sediment composition (particle-size distributions and OM content)
- Phase I meeting with management agencies and stakeholders to explain project and gain feedback for: site selection; prescribed fire management practices to be sampled; design storm(s) to be simulated using rainfall simulators; and design storm(s) to be simulated using optimized WEPP
- Identify 2 post-prescribed fire monitoring sites (1 volcanic and 1 granitic) and three treatments per site (undisturbed, slash piles, and woody-material piles)
- Conduct 2 rainfall and 2 runoff simulation sampling events per site during dry season
- Conduct 2 rainfall 2 runoff simulation sampling events per site during snowmelt season
- Conduct in situ sampling for nutrients during snowmelt season
- Measure burn pile characteristics, including pre-burn soil moisture and fuel moisture, burn temperature and duration, and soil temperature.
- In addition to laboratory analyses for particle size distribution, TSS, and total and inorganic phosphorus and nitrogen, laboratory analyses for phosphorus on sediment will be measured. These data will allow for comprehensive load estimations (e.g. adsorbed phosphorus load estimations will be possible as a result of the supplemental analyses, and will be in addition to estimations for sediment loads, dissolved nitrogen loads in runoff, and dissolved phosphorus loads in runoff).
- Measure erosion at the hillslope-scale using silt fences, so that hillslope-scale predictions by WEPP can be compared to measured data. Silt fences have been used by the USFS as an economical method to measure hillslope erosion. Precipitation data loggers will be used at each site so that spatial storm parameters (rainfall intensity and amount) can be measured for use in WEPP.
- Calibrate (optimize) WEPP using above measured data
- Predict sediment loadings for dry season and snowmelt season at the hillslope-scale using optimized WEPP

- Predict nutrient loadings at the hillslope-scale using runoff nutrient concentration and flow data
- Prepare and submit Phase I Technical Report for agency review
- Revise Phase I Technical Report based on review comments
- Present Phase I Technical Report to management agencies and stakeholders

**Phase II: Validate WEPP and Predict Nutrient and Sediment Loadings from Prescribed Fire at the Hillslope Scale**

- Phase II meeting with management agencies and stakeholders to gain feedback for: site selection; prescribed fire management practices to be sampled; design storm(s) to be simulated using rainfall/runoff simulators; and design storm(s) to be simulated using optimized WEPP
- Identify 2 alternate post-prescribed fire monitoring sites (1 volcanic and 1 granitic)
- Repeat data collection as described in Phase I at the alternate sites
- Conduct nutrient sampling at 4 prescribed sites in collaboration with research project 8-2B12
- Validate WEPP for runoff, sediment yield, and sediment composition by applying calibrated model at hillslope-scale and performing goodness of fit evaluation
- Predict sediment loadings at the hillslope-scale using optimized WEPP
- Predict nutrient loadings at the hillslope-scale using runoff nutrient concentration and flow data
- Prepare and submit Final Technical Report for agency review
- Revise Final Technical Report based on review comments
- Present Final Technical Report to management agencies and stakeholders

**Strategy for Engaging Managers**

IERS has established working relationships with managing agencies and stakeholders in the Lake Tahoe Basin, and will lead the efforts of coordination and engagement to ensure relevant sample design and simulations are executed for this project. The engagement strategy includes several meetings that will allow meaningful input from managing agencies and stakeholders when developing the study design, and will also include annual presentations to share results.

**Deliverables and Products**

Quarterly project accomplishment reports and invoices will be submitted on the specified dates. A Phase I Technical Report will be prepared and submitted upon completion of Phase I, and a Power Point presentation of the Phase I Technical Report will be given to management agencies and stakeholders. A Final Technical Report will be prepared and submitted upon completion of Phase II, and a Power Point presentation of the Final Technical Report will be given to management agencies and stakeholders.

### Schedule of Milestones and Deliverables

Milestones/Deliverables	Starting Date	Ending Date
Establish agreement between PSW and Em Consulting, LLC	6/1/2008	8/31/2008
Establish subagreements and contracts between Em Consulting, LLC, IERS, and UNR	7/1/2008	8/31/2008
Conduct rainfall/runoff simulations and sampling from prescribed fires (and potentially wildfires) during dry season to calibrate WEPP model for application to prescribed fire	9/1/2008	10/31/2008
Conduct rainfall/runoff simulations/sampling and in situ sampling from prescribed fires (and potentially wildfires) during snowmelt season to calibrate WEPP model for application to prescribed fire	4/1/2009	6/30/2009
Install silt fencing to measure hillslope erosion during rainfall and snowmelt events	9/1/2008	8/31/2009
Calibrate WEPP model and predict nutrient and sediment loadings from prescribed fires during dry season and snowmelt season at the hillslope-scale	11/1/2008	6/30/2009
Prepare and submit Phase I Summary Report	7/1/2009	8/15/2009
Present results of Phase I Summary Report to Basin stakeholders and management agencies	8/15/2009	9/30/2009
Conduct rainfall/runoff simulations and sampling from prescribed fires (and potentially wildfires) during dry season to calibrate WEPP model for application to prescribed fire.	9/1/2009	10/31/2009
Conduct rainfall/runoff simulations/sampling and in situ sampling from prescribed fires (and potentially wildfires) during snowmelt season to calibrate WEPP model for application to prescribed fire	4/1/2010	6/30/2010
Install silt fencing to measure hillslope erosion during rainfall and snowmelt events	9/1/2009	8/31/2010
Calibrate/validate WEPP model and predict nutrient and sediment loadings from prescribed fires during dry season and snowmelt season at the hillslope-scale	11/1/2009	7/15/2010
Prepare and submit Final Technical Report	7/15/2010	8/31/2010
Present Final Technical Report to Basin stakeholders	9/1/2010	9/30/2010