Study Plan
Interim Measure 11 Study Activities for 2013-2014: Klamath Hydroelectric Project

Introduction

The Klamath Hydroelectric Settlement Agreement (KHSA) includes Interim Measure 11 (Interim Water Quality Improvements), which is intended to address water quality improvement in the Klamath River during the interim period leading up to potential dam removal. Regarding Interim Measure 11, the KHSA states "The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs and dissolved oxygen in J.C. Boyle Reservoir." The measure calls for PacifiCorp to spend up to $250,000 per year for studies or pilot projects in consultation with the Interim Measures Implementation Committee[1] (IMIC). These studies or pilot projects need to address the following four categories of studies specified for Interim Measure 11:

- Development of a Water Quality Accounting Framework
- Constructed Treatment Wetlands Pilot Evaluation
- Assessment of In-Reservoir Water Quality Control Techniques
- Improvement of J.C. Boyle Reservoir Dissolved Oxygen

This document describes the proposed studies or pilot projects that PacifiCorp will conduct during 2013-2014 to address the above four categories. Specifically, proposed 2013-2014 Activities related to Interim Measure 11 include:

1: Continued Development of the Water Quality Accounting Framework

2: Planning and Design for a Demonstration Wetlands Facility Adjacent to the Klamath River

3: Preliminary Design of an Organic Matter Removal System at Link River/Keno Reservoir

4: Continued Evaluation of Selective Withdrawal/Intake Barrier Systems for Water Quality Control at Iron Gate Reservoir

5: Pilot Study of Algal Conditions Management within a Selected Reservoir Cove

6: Research on *Microcystis* Genotypes in the Klamath River System

7: Pilot Study of Nutrient Reduction Methods in Klamath Basin Waterbodies

Each of these studies is described below. Costs are still being developed for the various studies.

[1] The IMIC is comprised of representatives from PacifiCorp and other parties to the KHSA. The purpose of the IMIC is to collaborate with PacifiCorp on ecological and other issues related to the implementation of the Non-Interim Conservation Plan Interim Measures set forth in Appendix D of the KHSA.

1: Continued Development of the Water Quality Accounting Framework

Purpose and Objectives

The purpose of Activity 1 of Interim Measure 11 is to continue development of a Klamath water quality improvement tracking and accounting program (KTAP). The key concept behind the program is to facilitate opportunities for collaboration among Basin stakeholders to reduce nutrient, thermal, and other pollutant loads, and provide other water quality benefits within the basin to reduce and offset water quality impairments. This program will provide a record of individual actions and provide a potential basis for a market that facilitates a higher level of activity and collaboration than could be achieved by individual entities and dischargers alone. Additional work during 2013-2014 will include continued collaboration with the KTAP technical group, refinement and testing of the KTAP protocols, testing of protocols, verification, and certification through the implementation of a new pilot project, and development of seasonally based trading ratios[2].

Task and Work Elements

The tasks and work elements associated with this activity in 2013-2014 will include the following:

- Continue collaboration with the KTAP Working Group[3] and other interested stakeholders regarding KTAP protocols and related technical and policy matters associated with KTAP development and implementation.
- Participate with the KTAP Working Group and other interested stakeholders to: (1) refine the credit calculation methodology and range of unit credit costs (including trading ratios); and (2) refine and improve tracking and accounting tools for KTAP (e.g., NTT, Shade-a-lator)[4].
- Conduct a pilot test of the KTAP protocols on an existing example project (e.g., Huseman Ditch diversion relocation project) to assess the utility of the protocols and estimate the amount of time a typical landowner might need in order to complete the protocol steps.
- Coordinate with the KTAP Working Group and identify a nutrient reduction project in the basin to use as a pilot to develop and evaluate, in coordination with basin stakeholders, a model nutrient reduction project that will serve as an example to evaluate methods and protocols for credit calculation, verification, certification, and registration applicable to the Klamath basin and existing KTAP protocols.
- Complete an analysis of previously-proposed methods for determining trade ratios for KTAP (TetraTech 2011) including an assessment of seasonally-based trade ratios.

The above tasks are intended to define the specific features of the program and allow potential participants and other stakeholders to assess the various elements of the program for implementation in the Klamath Basin.

[2] Trade ratios in water quality trading indicate the units of pollution reduction or other water quality benefits that a user of offsets may acquire to offset a unit of its own emissions or effects. Trading ratios are frequently used to account for a number factors in water quality trading programs such as: the location of the sources in the watershed; the distance between the benefits and the effects to be offset; uncertainty or the lack of surety of benefits; and equivalency among multiple pollutant forms (e.g., biologically available phosphorous and bound phosphorous).

[3] The U.S. Environmental Protection Agency, Oregon Department of Environmental Quality, California North Coast Water Quality Control Board, PacifiCorp, and other partners have been involved in the scoping and design phase of the KTAP along with other participants. The KTAP Working Group includes participants from these groups that continue collaboration on program development, protocols, and implementation as well as outreach to other basin entities that have an interest in this program.

[4] This work element will be coordinated as appropriate with similar work being contemplated through an Oregon 319(h) grant submitted by the Klamath Basin Rangeland Trust.

Schedule and Deliverables

Specific schedule and deliverables for this study during 2013-2014 are still under development.

2: Planning and Design for a Demonstration Wetlands Facility Adjacent to the Klamath River

Purpose and Objectives

The purpose of Activity 2 of Interim Measure 11 is to continue important activities for anticipated development of wetland systems for water quality improvement in the upper Klamath River basin. Constructed and diffuse source wetland treatment systems have been identified as potentially viable means of improving water quality conditions in the upper Klamath River (Klamath Basin Nutrient Reduction Workshop[5], Mahugh et al. 2008, Lyon et al. 2009, Deas and Vaughn 2006, Ballantine and Tanner 2010, Blankenberg et al. 2008). As described below, PacifiCorp proposes the concept of a demonstration wetlands facility (DWF) adjacent to the upper Klamath River. The DWF would provide an important opportunity for interested stakeholders and researchers to investigate the site-specific requirements, effectiveness, feasibility, and costs of wetland technologies in the Upper Klamath basin. This information would be valuable for future planning, design, and ultimate implementation of wetland technologies to improve water quality in the Upper Klamath basin.

Under Activity 2, PacifiCorp will coordinate with stakeholders to develop a DWF Research and Implementation Plan that will lay out the planning, design, and implementation of the DWF, including locating potential sites for the DWF. The DWF itself would be constructed, operated, and maintained by stakeholder "partners" that have an interest in pursuing the unique and important wetland research and demonstration opportunities that the DWF would provide to inform basin-wide planning for water quality improvement strategies. The DWF could consist of a newly identified site or could be integrated and developed within an existing wetland site that has already been identified and held in reserve.

Conceptual Description and Location of the Facility

PacifiCorp envisions a DWF that would consist of a constructed wetland demonstration area, flow control structures, and other ancillary facilities (e.g., fencing, access) or a diffuse source wetland system on the fringe of an existing agricultural land parcel. The wetland demonstration area would encompass an area of about 1 to 3 acres, perhaps consisting of a series of wetland types or "cells". The constructed wetland demonstration cells would allow various evaluations, tests, or experiments to be conducted to: (1) assess specific types of wetland components (e.g., soils and vegetation types) and their relative performances; (2) evaluate wetland performance under climatic influences and real-world conditions specific to the Upper Klamath basin; or (3) verify important assumptions used to design and construct full-scale wetland treatment system or diffuse source wetland system elsewhere in the basin.

PacifiCorp will coordinate with potential stakeholder partners to locate potential candidate sites for the DWF focused on available properties adjacent to the Klamath River, and that ideally have existing water rights and water delivery infrastructure. Included within the properties to be considered could be PacifiCorp-owned properties adjacent to the river from the vicinity of Keno dam downstream to Copco reservoir, including potential treatment wetland candidate locations previously evaluated on PacifiCorp properties by Lyon et al. (2009). The previous evaluation by Lyon et al (2009) can be downloaded from PacifiCorp's Project website (http://www.pacificorp.com/es/hydro/hl/kr.html) under the "Water Quality Reports & Data" link.

[5] The Klamath Basin Nutrient Reduction Workshop was held in September 2012 in Sacramento, California as an activity conducted pursuant to Interim Measure 10 of the KHSA. Constructed and diffuse wetland treatment systems were identified at the workshop as key options for nutrient and organic matter reduction in the upper Klamath Basin.

Task and Work Elements

The tasks and work elements associated with this activity in 2013-2014 will include the following:

- Discuss the DWF concept with the IMIC and other potential stakeholder partners, and convene a Technical Advisory Committee[6] (TAC) to move forward with further DWF planning during 2013-2014 (as described further in the bullets below).
- Coordinate with the IMIC, the TAC, and other interested stakeholder partners to integrate recommendations from the Klamath Basin Nutrient Reduction Workshop (held in September 2012) and the pending final report (to be issued in summer 2013) regarding the uses and locations of constructed and diffuse source wetland treatment systems in the Klamath Basin.
- Coordinate with the IMIC, the TAC, and other interested stakeholder partners to identify partnership opportunities with organizations that could contribute technical expertise, matching funds, or other in-kind assets for the planning and eventual implementation and operation of the DWF[7].
- Coordinate with the IMIC, the TAC, local landowners, and other potential stakeholder partners to locate potential candidate sites for the DWF on suitable available properties (public or private) in the Klamath Basin and assess potential landowner interest in participating in a wetland demonstration.
- Provide the IMIC, the TAC, and other potential stakeholder partners with information on potential PacifiCorp-owned sites to be considered for the DWF and conditions related to the DWF that PacifiCorp would require for planning and implementation.
- Work with the IMIC, the TAC, and other potential stakeholders to develop a DWF Research and Implementation Plan that describes research objectives, preferred features of the DWF, anticipated studies, the expected participants and their associated funding or in-kind commitments, and the process and schedule for further planning and design.
- If a feasible candidate site is located, begin conceptual level design that will be necessary to secure permits and describe the project so that the DWF concept is easily communicated to other stakeholders or project participants and can be assessed as a potential candidate for shared funding from other interested agencies or funding sources in addition to PacifiCorp.

From the above steps, further actions as appropriate for final planning and implementation will be determined.

Schedule and Deliverables

✓ Discuss the DWF concept with the IMIC	July – August 2013
✓ Collaboration, coordination, and information development for DWF planning	August – December 2013
✓ Develop Draft DWF Research and Implementation Plan	January – April 2014
✓ Complete Final DWF Research and Implementation	May 2014

[6] PacifiCorp envisions that the Technical Advisory Committee would consist of interested participants from the IMIC, potential stakeholder partners, or other invited experts. The cost for participation in the Technical Advisory Committee would be borne in-kind by each participant or their affiliated organizations, and is not a part of the proposed budget by PacifiCorp for this Activity under IM 11.

[7] PacifiCorp's obligations for the work elements conducted under this study will be limited to activities that can be completed according to the IM 11 fund amount specifically dedicated to this study. If activities as defined in the final Study Plan might exceed the IM 11 fund amount, the additional fund amount will need to be supplied by other separate funding sources.

Plan

3: Preliminary Design of an Organic Matter Removal System at Link River/Keno Reservoir

Purpose and Objectives

During 2011 and 2012, studies were conducted under Interim Measure 11 to assess the potential efficacy of reducing organic matter (OM) from Klamath River water using a hydrodynamic separation technology that is employed in stormwater treatment. OM in the Klamath River can be present in either dissolved or particulate form. This technology targets the particulate OM, which comprises an appreciable fraction of summer period OM.

The purpose of Activity 3 is to conduct Phase III of the project in 2013-2014, which will consist of: (1) additional in-field assessments of the hydrodynamic separation technology (to refine the experiments performed in 2012); and (2) complete the development of preliminary design and cost estimates of an OM removal system at Link River/Keno Reservoir.

Task and Work Elements

The tasks and work elements associated with this activity in 2013-2014 will include the following:

- Refine prototype hydrodynamic separator design and operation (i.e., modifying inlet flume, installing flow meters, and other refinements).
- Conduct additional in-field assessments (to refine the experiments performed in 2012) to: (1) test a wider range of flows; (2) test different screen sizes; and (3) test different sump/outlet ratios.
- Assess dissolved oxygen (DO) improvements within Keno Reservoir that might be expected from the system based on USGS modeling efforts on the modeled effects of algae removal on Keno reservoir water quality conditions (Sullivan et al. 2012).
- Become familiar with, and coordinate as appropriate with, other research or investigation activities that may be occurring with regard to OM or algae biomass removal, and disposal/use in the area (i.e., Link River, Keno reservoir, Upper Klamath Lake).
- Based on the results of the additional in-field experiments (as describe in bullets above), develop detailed OM removal efficiency curves for use in the subsequent conceptual design of potential scaled-up OM separation facilities.
- Prepare and refine schematics, diagrams, and layouts of the conceptual design of potential scaled-up OM separation facilities. Evaluate the pros and cons of alternative design concepts, and identify potential environmental issues and regulatory permitting requirements.
- Prepare and refine general estimates of the types and quantities of materials, removal system components, and other work needed to support potential scaled-up OM separation facilities.
- Prepare and refine cost estimates for construction and operation of conceptual project configurations.

Schedule and Deliverables

✓ Design modifications on prototype separator	July 2013
✓ Conduct additional in-field separator experiments	August – October, 2013
✓ Evaluation of anticipated system removal efficiencies and related DO improvements in Keno Reservoir	December 2013 – April 2014

✓ Prepare conceptual design information for potential scaled-up OM separation facilities	March – June 2014
✓ Completion of draft Phase III Report	July 2014
✓ Completion of final Phase III Report	October 2014

4: Continued Evaluation of Selective Withdrawal/Intake Barrier Systems for Water Quality Control at Iron Gate Reservoir

Purpose and Objectives

During 2011 and 2012, studies were conducted under Interim Measure 11 to test the installation of an adjustable barrier or cover on the intake tower trash rack at Iron Gate reservoir as a means of improving water quality released from the reservoir and to evaluate the vertical migration of cyanobacteria (blue-green algae) within the vicinity of the Iron Gate intake. The concept behind the intake barrier or cover is to control the depth at which water is withdrawn from the reservoir into the intake, and thereby potentially enhance water quality downstream of Iron Gate dam by excluding or reducing the potential entrainment of biomass from blooms of cyanobacteria (blue-green algae) and potential associated algal toxins (i.e., microcystin).

The purpose of Activity 4 is to continue to evaluate the selective intake cover system on the intake tower at Iron Gate reservoir to improve water quality in Iron Gate powerhouse releases to the Klamath River and develop data that will be applicable to the design and implementation of system refinements or other similar systems that might improve water quality conditions during the interim period prior to planned dam removal. The continued evaluation will provide additional information needed to ultimately design and implement a more permanent and effective intake cover or algae exclusion system.

Task and Work Elements

The tasks and work elements associated with this activity in 2013-2014 will include the following:

- Automated *in situ* data collection to assess algae conditions in the vicinity of the intake and in releases to the Klamath River. The data collection will occur during about a 3-4 week period in August – September 2013 and will focus on water quality conditions in the vicinity of the intake. The data will be used to characterize cyanobacteria bloom and vertical migration conditions in the vicinity of the intake for use in evaluating the performance of the existing intake cover as well as alternative conceptual cover system configurations and operations. The data collection program will consist of the following elements:
    - An automated meteorological station will be deployed near Iron Gate dam to record hourly data on weather conditions, including (but not limited to) air temperature, wind speed and direction, barometric pressure, and precipitation. These data will characterize weather conditions that coincide with cyanobacteria bloom conditions in the reservoir.
    - Three to four *in situ* sondes will be deployed in a vertical array just upstream (approximately 40-80 ft) of the intake tower to record hourly data on water quality conditions, including (but not limited to) chlorophyll-a and phycocyanin. The array will include sondes at three to four depths covering the photic zone. These data will characterize the vertical positions and movements of cyanobacteria in the vicinity of the intake.
    - One *in situ* sonde is, and will continue to be, deployed in the Klamath River downstream of Iron Gate dam to record hourly data on water quality conditions, including (but not limited to) chlorophyll-a and phycocyanin. This sonde is deployed in the river near the Iron Gate Hatchery

bridge. The data from this sonde will be used to assess the downstream conditions of cyanobacteria (and other water quality conditions) in releases to the Klamath River.

- Alternative conceptual cover system configurations and operations will be developed that would potentially improve the effectiveness of a cover system to reduce algal biomass entrainment into the intake tower. In addition, design concepts may include the potential use of geotextile curtains to preferentially guide flow in the vicinity of the intake to reduce the entrainment of algae into the Iron Gate intake.
- Conduct additional measurements of flow velocities and develop local bathymetry in the vicinity of the intake using GPS, an Acoustic Doppler Current Profiler (ADCP), and a hydrographic echo sounder (depth sounder). This information will be used to support planning for the potential use of geotextile curtains and for potential later development of hydraulic/hydrodynamic modeling tools that may be used to assess potential geotextile curtain design and placement.
- Based on the results of the previous studies and work activities described above, develop a design and implementation plan for potential cover and barrier curtain systems. Prepare and refine general estimates of the types and quantities of materials, system components, and other work needed to support implementation of a system for implementation prior to planned dam removal.

Schedule and Deliverables

✓ Monitoring of algae conditions in the vicinity of the intake	August – September 2013
✓ Additional field data collection (e.g., ADCP)	August – October 2013
✓ Define and assess alternative conceptual configurations	September 2013 – April 2014
✓ Completion of draft report	July 2014
✓ Completion of final report	September 2014

5: Pilot Study of Algal Conditions Management within a Selected Reservoir Cove

Purpose and Objectives

The purpose of Activity 5 is to conduct pilot tests in a reservoir cove where potential algae control strategies for localized areas of the reservoirs can be assessed. These tests will provide information to assess whether these potential algae control strategies in areas of the reservoirs may be an effective and economic algae control strategy to reduce public health concerns during the interim period prior to potential dam removal. Pilot testing would include the following algae control strategies:

- Environmentally-safe algaecide application. Applications of environmentally-safe hydrogen peroxide-based (H_2O_2) algaecide to reduce algal concentrations.
- Mechanical mixing of the water column. Mechanical mixing to disrupt the ability of algae to preferentially migrate through the water column and form surface blooms.
- Accelerated flow exchange. Pumping to accelerate flow exchange in the cove to levels sufficient to reduce algal growth rates.
- Water cannon sprinklers. Induced water sprinkling sufficient to disrupt the water surface (quiescence) and reduce surface algae bloom formation.

A portion of Long Gulch cove in Iron Gate reservoir is the site that is anticipated for use as the management strategy assessment area for these pilot tests during 2013-2014. Conditions in the test management area will be controlled through a lake divider curtain to segregate the test area from the open reservoir and thereby assess the persistence of the localized water quality treatment improvements and improve the ability for these strategies to be assessed through a small-scale deployment and/or evaluation. Information regarding lake divider curtains and examples of successful applications can be found on the internet at this link: http://www.curryindustries.com/limnocorrals.html.

Task and Work Elements

The tasks and work elements associated with this activity in 2013-2014 will include the following:

- A detailed testing design and monitoring plan will be developed. The plan will provide details on the set-up and sequencing of pilot tests of the algae control strategies in the cove, including data collection and monitoring consistent with permit requirements.
- A lake divider curtain will be designed, fabricated, and installed at the cove selected for the management pilot tests.
- The various materials and equipment required for the various pilot tests will be developed, delivered, and readied for installation in the cove.
- Pilot tests will be conducted during the period of August-October 2013 and May-October 2014 according to the sequence and timing as determined in the detailed testing design and monitoring plan.
- Based on the results of the work activities and tests described above, a detailed technical report will be prepared, including recommendations for development and implementation of a system for algae management within reservoir coves and/or high public use areas of the reservoirs.

Schedule and Deliverables

✓ Detailed testing design and monitoring plan	July – August 2013
✓ Divider curtain design and fabrication	July – August 2013
✓ Pilot testing: 2013	August – October 2013
✓ Control strategies materials development, delivery, and installation	January – April 2014
✓ Pilot testing: 2014	May – October 2014
✓ Completion of draft project report	November 2014
✓ Completion of final project report	December 2014

6: Research on *Microcystis* Genotypes in the Klamath River System

Purpose and Objectives

Under Activity 6, researchers at Oregon State University (Theo Dreher, PhD and Timothy Otten, PhD) will examine the genotypes of *Microcystis* populations throughout the Klamath River in order to establish the relationships between populations across some 250 river miles between Upper Klamath Lake (UKL) and the river mouth. In particular, the study is intended to determine whether populations in the river downstream of Iron Gate reservoir are determined principally by physical transport from that reservoir or whether there is evidence for endemic, independent populations downriver. In addition, the study will add to our knowledge of

the relationship between the *Microcystis* genotypes flowing out of Upper Klamath Lake and those present in the Copco/Iron Gate reservoir system.

This genetic analysis of *Microcystis* populations in the Klamath River system will provide valuable information for the potential management of *Microcystis*. If population characteristics are conserved across the sites, then monitoring of upriver sites will be highly predictive of downriver populations after allotting for the appropriate travel period. As such, one of the key outcomes for this study will be to determine how closely the *Microcystis* population in the river below Iron Gate dam mirrors the in-reservoir population. If they are genetically identical, then it can be surmised that during periods of high microcystin concentration in the reservoir, downriver sites should expect to see a similar pulse of toxigenic cyanobacteria. From a public health perspective, this information can serve as an early warning of toxigenic *Microcystis*. Conversely, if the reservoir and downriver populations are largely distinct, then this analysis will allow us to identify stretches of the river likely harboring and/or propagating toxigenic *Microcystis* strains. These locations could then be targeted for applied management techniques aimed at diminishing the presence of *Microcystis* in these locales.

Task and Work Elements

The tasks and work elements associated with this activity in 2013-2014 will include the following:

- The Dreher Laboratory at Oregon State University will conduct genetics analyses on a comprehensive set of samples collected in 2012[8]. The analyses will identify *Microcystis* genotype groups (including by time and location) and will determine the proportion of toxigenic *Microcystis*. As components of the analyses, the Dreher Laboratory will:
    - Conduct 454 sequencing analysis of cpcBA and ITS loci to identify OTU genotype groups and SNPs;
    - Conduct qPCR determination of mcyE/cpcA ratios to determine the proportion of toxigenic *Microcystis*.
- The Dreher Laboratory at Oregon State University will prepare a report of the study results.

Schedule and Deliverables

✓ Conduct genetic analyses on samples	July – September 2013
✓ Analyze data and prepare study report	October – December 2013
✓ Issue study report	January 2014

7: Pilot Study of Nutrient Reduction Methods in Klamath Basin Waterbodies

Purpose and Objectives

The purpose of Activity 7 is to conduct a proof-of-concept level investigation of potential approaches to reducing nutrient concentrations, notably phosphorus (P), as a means for overall water quality improvement in Upper Klamath Lake (UKL), Keno Reservoir, and the Klamath River and reservoirs (J.C. Boyle, Copco, and Iron Gate) downstream. This pilot study will assess the effects of treating isolated volumes of water from the area to reduce nutrient concentrations (and associated algae growth and biomass effects) through flocculation,

[8] During the 2012 bloom season (April -December), a comprehensive set of samples was collected with the help of several groups working in the Klamath Basin and archived in the Theo Dreher laboratory at Oregon State University. During 2012, the Dreher laboratory determined and validated the utility of several specific genetic markers and signatures that can be used to discern Microcystis population genotypes throughout the Klamath River, including an ability to distinguish toxigenic and non-toxigenic subpopulations. The 2012 work now makes it possible to conduct the work in 2013 under this Activity 6.

binding, or sequestration experiments in discrete containers or possibly limnocorrals (geotextile membranes that can be deployed to isolate discrete portions of a waterbody or water column).

Study results would inform the applicability of these nutrient reductions approaches in the Upper Klamath Basin, which include potential approaches for addressing Upper Klamath Basin nutrient impairment as discussed at the Klamath Basin Nutrient Reduction Workshop (held in September 2012) conducted pursuant to Interim Measure 10. Results from the pilot study could lead to development of prescriptions that would reduce nutrient concentrations in UKL, Keno Reservoir, and the Klamath River and reservoirs, which would reduce releases of algal biomass to downstream river and reservoir reaches.

Task and Work Elements

The tasks and work elements associated with this activity in 2013-2014 will include the following:

- Discuss with the IMIC and other potential stakeholder partners the specific approaches to reducing nutrients in area waters that should be considered in the pilot study during 2013-2014 (as described further in the bullets below).
- Coordinate with the IMIC and other interested stakeholder partners to integrate pertinent recommendations from the Klamath Basin Nutrient Reduction Workshop (held in September 2012) and the pending final report (to be issued in summer 2013) regarding specific techniques for reducing nutrient concentrations in the Klamath Basin using coagulant flocculation, binding, or sequestration.
- Contact researchers at the U.S. Geological Survey regarding the pilot study of low-intensity chemical dosing (LICD) currently being conducted at Twitchell Island in the Sacramento-San Joaquin Delta (Delta) area. LICD is defined as the carefully-metered addition of low concentrations of chemicals coagulants to enhance and accelerate the rate of P removal from the water column through precipitation and settling of chemically-formed and naturally-occurring particulate P. An LICD approach may be another technique of interest for reducing nutrient concentrations (as well as dissolved organic matter) in the Klamath Basin.
- Coordinate with the IMIC and other interested stakeholder partners to identify partnership opportunities with organizations that could contribute technical expertise, matching funds, or other in-kind assets for this pilot study[9].
- Develop a Study Plan in 2013 that describes study objectives, proposed pilot studies, the expected participants and their associated funding or in-kind commitments, and the process and schedule for completing study tasks.
- Implement the pilot study experiments and investigations in 2014 based on the Study Plan. For example:
    - Conduct multi-day bench-scale experiments using area water samples, and/or multi-day limnocorral experiments in area waters with carefully controlled and dosed applications of flocculation, binding, or sequestering products (e.g., alum, Phoslock®, iron sulfate, polyaluminum chloride).
    - Test water samples for changes in total and dissolved nutrient concentrations, dissolved oxygen, pH, algal density, algal species, chlorophyll-a, and microcystin levels.
    - If applicable, test sediment samples for changes in sediment oxygen demand, total nutrient concentrations, and benthic community response.

[9] PacifiCorp's obligations for the work elements conducted under this study will be limited to activities that can be completed according to the IM 11 fund amount specifically dedicated to this study. If activities as defined in the final Study Plan might exceed the IM 11 fund amount, the additional fund amount will need to be supplied by other separate funding sources.

From the above steps, further actions as appropriate for other testing and implementation will be determined.

Schedule and Deliverables

✓ Coordination, and information development for pilot study planning	July – August 2013
✓ Develop Draft Study Plan	September – November 2013
✓ Complete Final Study Plan	December 2013
✓ Implement pilot study experiments and investigations, and complete study reports	During 2014 (per Study Plan)

References

Ballantine, D.J. and C.C. Tanner. 2010. Substrate and filter materials to enhance phosphorus removal in constructed wetlands treating diffuse farm runoff: a review. New Zealand Journal of Agricultural Research 53 (1):71-95.

Blankenberg, A., K. Haarstad, and A. Sovik. 2008. Nitrogen retention in constructed wetland filters treating diffuse agriculture pollution. Desalination 226 (1): 114–120.

Deas, M.L. and J. Vaughn. 2006. Characterization of Organic Matter Fate and Transport in the Klamath River below Link Dam to Assess Treatment/Reduction Potential. Prepared by Watercourse Engineering, Inc. for U.S. Bureau of Reclamation Klamath Area Office. September 30.

Lyon, S., A. Horne, J. Jordahl, H. Emond, and K. Carlson. 2009. Preliminary Feasibility Assessment of Constructed Treatment Wetlands in the Vicinity of the Klamath Hydroelectric Project. Draft Report. Prepared by CH2M HILL and Alex Horne Associates. Prepared for PacifiCorp Energy. January 2009.

Mahugh, S, M.L. Deas, R.A. Gearheart, J. Vaughn, R. Piaskowski, and A. Rabe. 2008. Keno Reservoir Feasibility Study, Phase II – Identification and Assessment of Potential Treatment Wetland Sites in the Upper Klamath River. Prepared for U.S. Bureau of Reclamation, Klamath Basin Area Office. Proposal No. 07SF200051. June 18. 49 pp.

Sullivan, A.B. S.A. Rounds, M.L. Deas. and I.E. Sogutlugil. 2012. Dissolved Oxygen Analysis, TMDL Model Comparison, and Particulate Matter Shunting: Preliminary Results from Three Model Scenarios for the Klamath River Upstream of Keno Dam, Oregon. United States Geological Survey. Open-File Report 2012–XXXX. DRAFT.

Tetra Tech. 2011. Technical Background and Initial Recommendations for Development of Klamath Trading Ratios. Memorandum prepared by J. Butcher and provided to G. Louie and C. Creager. December 30. 17 pp.