Development of a Sensor-Based Water Quality Program

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Project Title: ***Integration of High-Frequency, Sensor-Derived Data into Ongoing Water Quality Programs to Improve the Accuracy and Defensibility of New and Ongoing Regulatory Programs***

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Project Costs

	Budget Summary. **This table summarizes the proposed budget. Details regarding the equipment purchases are described in the Project Elements section of this proposal, itemized bids are provided as proposal attachments.**
Labor	$13,760
Materials	$2,000
Equipment*	$126,215
Administration	
Miscellaneous**	$4000
TOTAL	**$262,215**
	* Appendix A provides details and bids for sensors; **Fees to cover database implementation with equal costs share provided by iUtah; *** Fees for laboratory processing costs to validate sensor data.

Additional Funding Sources

The project is broadly applicable, as are the programs and associated funding sources that will directly help with the development of the sensor program. However, all of these programs are ongoing, with very specific goals and objectives. As a result, the financial support takes includes several "in kind" contributions to this projects specific goals and objectives. A brief summary of several important ***partnerships that leverage other funding sources*** follows:

> **US EPA and Utah State University**: Funding from a Wetland Program Development Grant (submitted, see Appendix B)

iUtah: Assistance with Data Management and QA/QC Software and Analytic Tools. Extensive high-frequency QA/QC tools, data storage and high frequency data tools are already available. iUtah will assist with setting up and troubleshooting database setup.

Executive Summary

Deployable sensors that are capable of rapid and accurate water quality measures are increasingly available. Data collected with these high frequency sensors (hereafter sondes) are more accurate than information obtained from the grab samples typically employed by water quality programs. The regulatory benefits of high frequency data are manifold, particularly for episodic pollutant inputs (i.e., spills, irrigation returns), or temporally variant responses to water quality problems (i.e., dissolved oxygen (DO), gross primary production, spring runoff). Despite these advantages, integration of sonde-derived information into water quality programs conducted by Utah's Division of Water Quality (UDWQ) and our collaborative sister agencies continues to be limited. The most significant barrier to widespread application is the capital expense associated with the purchase of sondes, in sufficient quantity, to warrant the resources necessary for program development and implementation. This proposal addresses these resource limitations through the purchase of several types of sondes and associated deployment Standard Operating Procedures (SOPs). Among other things, program development will require pilot field investigations. Many of these investigations will be context dependent especially for the petroleum sensors, which will need to be developed in conjunction with spill investigations. If funded, we will immediately advance integration of these technologies with two important efforts. First, we will use the DO and temperature sondes to expand of the integration of metabolism indicators to support nutrient-related impairments. Second, we will integrate the sondes into experiments that are already planned where will quantify important nutrient biogeochemical processes on Great Salt Lake wetlands that are in close proximity to Willard Bay. While anticipated environmental benefits are manifold, the project emphasizes the infrastructure requirements of Utah's nutrient reduction program. The initial equipment expenses are considerable; however, these costs will quickly be recovered in human resource and laboratory processing cost savings.

Project Need

Like many states, DWQ continues to rely on grab samples for the vast majority of our water quality investigations. While these data are uses, they have several important limitations. For instance, it is nearly impossible to account for episodic events. One obvious example is storms, which often contribute considerable pollutant loads, especially in urban environments. A less obvious example of important episodic inputs is surface runoff from agricultural producers, which typically occur during periods of irrigation. Sometimes, the data collection needs require high frequency data. For instance, after spills we are often interested in quantifying the efficacy of cleanup efforts. Another area where high-frequency data are useful is the use of DO and temperature sensors to quantify ecosystem metabolism—a fundamental ecosystem process. In fact, DWQ has already developed thresholds for Gross Primary Production (GPP) and Ecosystem Respiration (ER) as key indicators of cultural eutrophication, yet application remains limited by a paucity of equipment to obtain the requisite underlying data.

The lack of high frequency data is not simply a matter of convenience, it has the potential to results in costly errors to the regulated community and the environment. DWQ must make regulatory decisions based on the best available data and information. The lack of high frequency data may lead to either over- or under regulation of some pollutant sources. Results from some of the nitrate and phosphate sondes included in this proposal have been used to demonstrate that in some watersheds storm events can account for 80-90% of pollutant loads. If these loads were not quantified, then the potential exists for overemphasizing point sources because these sources are more consistent and therefore more easily quantified with traditional grab samples. In other cases, there may be costs associated with missing important contaminants. For instance, during the oil spill on Red Butte Creek DWQ discovered high concentrations of petroleum products in the Jordan River upstream spill's influence. Ultimately, this discovery led to the discovery and resolution of a situation with an individual was illegally dumping petroleum based products into a storm drain.

Project Purpose

Historically, solutions to the inaccuracies associated with infrequent data did not exist. However, technologies are now sufficiently advanced to obtain more accurate information. Moving beyond the status quo requires more than simply purchasing equipment. The programmatic integration of high frequency data must also be considered. The purpose of this proposal is to: **build water quality infrastructure**, and **develop an associated water quality program** that provides UDWQ and our partners with more accurate information that **facilitates more informed water quality decisions**. More accurate measures of water quality and ecological responses that helps **protect important beneficial uses as efficiently and effectively as possible**. Additionally, the hydrocarbon sensors are calibrated to quantify crude and refined petroleum products, which will improve DWQ's ability to respond to future oil spills.

Obtain Equipment, Build Infrastructure

Several types of sondes would considerably benefit many different water quality programs (Appendix B). Given that UDWQ and our partners are tasked with statewide protection of water quality, we could use as many sondes as possible. However, some of this equipment is expensive. The equipment purchases proposed attempts to balance programmatic needs with monetary constraint. In most cases, we've requested four instruments, which would allow for upstream-downstream comparisons and the capability to quantify attenuation or, in the case of nutrient sondes, uptake.

Petroleum-Based Hydrocarbons

Recent technologies have allowed for the use of flourometers to quantify petroleum-based PAHs in the range of crude oil and in the range of refined products. While these cannot replace the need for laboratory analyses, they would improve DWQ with spill responses in several ways. First, the high-frequency of measurements would provide a much clearer picture of spill response and clean-up efforts than daily or weekly grab samples, with considerable savings in human resources. A continual data record would convey response efficacy far better that daily or weekly samples. Once clean-up was complete, sondes upstream and downstream of the spill would help provide concerned stakeholders with long-term assurance that DWQ is monitoring for anything we may have missed. Another advantage of using sondes for spill response is that we could provide the public with some information while waiting on laboratory analyses.

Nitrate and Phosphate Sondes

Recent technological advances make it possible to obtain precise, high frequency nitrate and phosphate data. Nitrate sondes use optics to generate real time nitrate concentrations with reliable detection from 0.007-56 mg/l with 10% accuracy. Phosphate sondes use portable wet chemistry and can capture two measurements per hour, with a detection limit of 0.007 mg/l. Among other things, these sondes would allow accurate characterization of improve load estimates by capturing episodic nutrient inputs (i.e., storms, spring runoff), assist with relatively inexpensive measures of biogeochemical processes (i.e., biological uptake, nitrification), and could help identify specific nutrient sources with upstream and downstream comparative data.

Multi-parameter Sondes

Currently, UDWQ has a limited number of multi-parameter sondes, most of which collect the standard field measurements of DO, temperature, specific conductance and pH. These sondes are used to support routine monitoring and assessment programs, and to provide critical data to calibrate water quality models that are used to create TMDL and permit limits. Indeed, these sondes are routinely over allocated. We propose to purchase several multi-parameter sondes that will be routinely relegated to support nutrient reduction program efforts, or reallocated as needed for emergency response. In addition to the routine field measures, these sondes will have “plug and play” technology so that we can also obtain a more limited number of probes that we can use for important, but less routine, investigations (see Appendix A for details).

Dissolved Oxygen and Temperature Sondes

Two of the most important field parameters for aquatic life beneficial uses are dissolve oxygen (DO) and temperature, yet in both cases diel variation is vary to the extent that grab sample data are practically nonsensical. Conversely, high frequency DO and temperature data quantifies the extent to which aquatic life biota have been exposed to deleterious conditions. These data can also used to generate ecosystem metabolism models that provide ecosystem-level measures of Gross Primary Production (GPP) and Ecosystem Metabolism (ER), which are both important measures of eutrophication responses. Previously, the optical DO measurements required for long-term deployments were only available for multi-parameters sondes; however, less expensive sondes recently been developed that their measurements to these two key water quality parameters.

Program Development

This project will be phased over several years, although the majority of the work will be phased over several years. In the first couple of years, we’ll work toward SOP development and a thorough literature review that identifies potential applications for the equipment. Subsequently, we’ll finalize SOPs and develop a process that facilitates project prioritization among DWQ staff and our collaborating partners. Coincident with this phase of the study, we’ll be working with iUtah and the Monitoring Section at DWQ on applying the CUaHSI database tools for the long-term and analysis of high-frequency data. The following table provides an example of we envision the project unfolding.

Project Timeline

This table depicts the timeline envisioned for this study. We anticipate completing the vast majority of the work over the first couple of years, with data from many of these instraments already intertwined into DWQ programs.

We also anticipate encountering unforeseen circumstances, especially in the development of database tools for the storage and processing of high-frequency data. While iUtah has working, fully-vetted products, incorporating these tools into DWQ routines and procedures will likely have challenges.

	2014		2015				2016			
	Q3	Q4	Q1	Q2	Q3	Q4				
Project Milestones										
Purchase Equipment	C									
Pilot Projects	………	……………	…………	C						
SOP Dev.			…………	C						
Database Dev.			…………	…………	…………	……………	C			
Final Report						…………..	………	………	………	C

Environmental Benefits

Project Outcomes

Building DWQ's capacity to integrate high-frequency data collection efforts into ongoing monitoring and assessment efforts will improve the accuracy and efficiency throughout several programs, including:

- Responding to emergencies (i.e., spills, pipeline breaks)
- Quantifying nutrient sources
- Better estimates of nutrient loads, improved nutrient budgets
- Ecosystem metabolism assessments
- Wetland assessment procedures

The most important outcome of this work will be positioning DWQ to take advantage of these emerging technologies, which are expected to expand rapidly over the next couple of decades.

Project Outputs

- SOPs for the deployment and interpretation of high-frequency sondes, including QA/QC procedures
- A database that allows data storage and retrieval of high frequency data
- A final report that summarizes our work and outlines recommendations for future work

Project Location

This project will benefit water quality statewide. The proposed pilot projects will occur within the wetlands at the terminus of Bear and Jordan Rivers.

Connection to other Water Quality Programs

The project has applicability to numerous water quality programs. Data obtained from deployments can be used to help with the WLAs used for permits, the data can be used directly in assessments, identification of sources, etc.

Project Experience

Jeff Ostermiller and Toby Hooker are senior scientists at DWQ. Together, they have over three decades experience implementing projects at both State and Regional Scales.

Partnerships

iUtah Utah State University, Old Main Hill Logan, UT 435-881-1202

Proposal Attachments

Appendix A: Equipment Bids and Summary

Appendix B: Wetland Program Development Grant: Pilot Project

Appendix A. Summary table of proposed equipment purchases, parameters collected, cost and rationale. Bids for equipment with proprietary technologies is included. The Turner Designs and multi-parameter sondes may require bids, so we've included preliminary costs estimates from several manufacturers for pre-proposal purposes.			
Equipment	**Parameters**	**Costs**	**Application and Rationale**
Turner Designs			
Hydrocarbon Flourometer: Crude Weight Petroleum	Oil Range PAHs	$2000 * 2 = $4000	Useful for spill responses or evaluation of problem areas for stormwater inputs.
Hydrocarbon Flourometer: Refined Weight Petroleum	Fuel Range PAHs	$5500 * 2 = $11,000	Useful for spill responses or evaluation of problem areas for stormwater inputs.
YSI or Hydrolab			
Multi-Parameter Sondes	pH, temperature, specific conductance, optical DO	$10,000 * 3 = $30,000	These sondes are standard water quality equipment with numerous applications, assigned to support high frequency collection efforts. Important uses include: determine the toxicity of important pollutants like metals and ammonia; measure of ecosystem metabolism (see also MiniDots below); calibration of Waste Load Analysis models used to determine permit limits.
	Turbidity	$4000 * 2 = $8,000	Modification of GPP, pollutant associated with inappropriate BMPs, surrogate for rhodamine for mixing tests
MiniDot			
MiniDot temperature and DO sondes	Temperature, optical DO	$995 * 10 = $10,080 (includes cable)	These sondes provide the two most important metabolism measurements at about one-tenth the cost of multi-parameter sondes. They will be used to bolster nutrient-related assessments.
Nutrient Sensors			
Cycle Pro Phosphate Sensors		$18,578 * 4 = $74,315 Yearly Maintenance: $3850 * 8 = $30,800	
SUNA Nitrate Sensors		$24,255 * 4 = $97,020	