Development of a Decision Support System for Payette Lake, Idaho

Prepared by:

Tamara M. Wood, Ph.D.
U.S. Geological Survey
Oregon Water Science Center
2130 SW 5th Avenue
Portland, Oregon, 97201
electronic mail: tmwood@usgs.gov

Molly S. Wood, P.E.
U.S. Geological Survey
Idaho Water Science Center
230 Collins Rd.
Boise, Idaho, 83702
electronic mail: mswood@usgs.gov

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SUMMARY

PROBLEM

Big Payette Lake is a 21.6 square kilometer natural lake situated in the upper drainage of the Payette River, which drains into the Snake River in southwest Idaho. The City of McCall is located near the outlet at the lake's southern end. The population increases seasonally because McCall is a popular recreation area in both summer and winter. The area's resident population has increased substantially over the last decade as evidenced by the residential and commercial development around the shoreline and heavy recreational use of the lake.

In response to the documented indications that cultural eutrophication is in the beginning stages in Payette Lake, the Payette Lake Watershed Advisory Group (PLWAG) has recognized the need to develop a tool that can be used to make informed management decisions about the land use around the lake (a Decision Support System, or DSS). Such a tool could be used, for example, to anticipate the predicted changes in the productivity and the oxygen budget in the lake based on scenarios for changes in nutrient loading. A necessary first step, however, is to have a fundamental understanding of the hydrodynamics of the lake, which determine residence and mixing time scales.

OBJECTIVES

The goal of this work is to begin the development of a Decision Support System (DSS) for Payette Lake.

To that end, the following specific objectives have been developed:

1. To collect the data at the lake boundaries necessary to complete accurate lake-wide mass balances for water and heat in the lake.
2. To collect velocity and temperature data within the lake at a range of temporal and spatial scales.
3. To develop a hydrodynamic and heat transport model of the lake.
4. To collect dissolved oxygen data and algal mass surrogate data (chlorophyll *a*).
5. To begin long-term monitoring of tributary and outflow nutrient data.
6. (Optional) To develop a dissolved oxygen model.

RELEVANCE AND BENEFITS

According to *Strategic Directions for the Water Resources Division, 1998-2008*, the USGS Water Resources Division will make an effort to "design study products that will be more useful and relevant to solving problems that are faced by water managers and other decision makers." The results from this study will be directly relevant to the PLWAG and the Idaho Department of Environmental Quality, as they try to determine appropriate guidelines for land use in the Payette Lake watershed. Furthermore, this work is consistent with the national priorities put forward in *Facing Tomorrow's Challenges* (U.S. Geological Survey, 2007); it is particularly aligned with the strategic direction of "understanding ecosystems and predicting ecosystem change."

APPROACH

We propose three different levels of effort, denoted Tier 1-3 below, to begin development of the DSS for Payette Lake. Tier 1 is the least expensive and involves the least effort, and Tier 3 is the most expensive and involves the most effort. The choice of the appropriate level of effort for the first year of development will depend on PLWAG needs and resources available.

Tier 1 Elements include monitoring water quality and velocity in the lake; monitoring water quality and streamflow in lake inflows and outflow; collecting meteorological data; collecting profiles of chlorophyll *a*, dissolved oxygen, light transmittance, and temperature in the lake; developing a hydrodynamic and heat transport model; and producing a Scientific Investigations Report.

Tier 2 Elements include all of the elements listed above for Tier 1 and, in addition, re-evaluating lake bathymetry and developing a basic model of dissolved oxygen in the lake, including gas transfer at the air/water interface, photosynthetic production and metabolic consumption processes.

Tier 3 Elements include all of the elements listed above for Tiers 1 and 2 and, in addition, installing profiling multi-parameter datasondes in the lake, adding telemetry for real-time data viewing, installing additional acoustic Doppler current profilers for monitoring velocity patterns in more locations, and developing a more refined dissolved oxygen model.

FULL PROPOSAL

Development of a Decision Support System for Payette Lake, Idaho

Problem/Background

Big Payette Lake is a 21.6 square kilometer natural lake situated in the upper drainage of the Payette River, which drains into the Snake River in southwest Idaho. The lake receives drainage from 373 square kilometers, the majority of which is forested and managed by the U.S. Forest Service. The lake's surface is at an elevation of about 1,520 meters above sea level. The maximum and mean depths are 95 and 28.6 meters, respectively. The mean annual outflow volume is 10.1 cubic meters per second, which yields a retention time of 1.94 years, given a lake volume of 617 cubic hectometers.

The City of McCall is located near the outlet at the lake's southern end. The population increases seasonally because McCall is a popular recreation area in both summer and winter. The area's resident population has increased substantially over the last decade as evidenced by the residential and commercial development around the shoreline and heavy recreational use of the lake. Some evidence of eutrophication of the lake was documented in studies as early as 1964, and 1967-1969 (Idaho Department of Health, 1970). On the basis of those studies, the Idaho Department of Health recommended the construction of a sewage treatment system that was completed in the mid-1980s. A subsequent limnological assessment documented significant nutrient and chlorophyll *a* concentrations around the shoreline in the west and southeast basins, and

was the first study to measure dissolved oxygen in the deepest parts of the lake in the west basin, where a substantial dissolved oxygen deficit was found (Falter and Mitchell, 1981; Falter, 1984).

The recent increases in development pressure, coupled with evidence of water-quality degradation and eutrophication, prompted local residents to request a comprehensive water-quality study of the lake. The Idaho State Legislature responded by passing the Big Payette Lake Water Quality Act in 1993. The Act mandated the formation of a water-quality council which was tasked with developing a water-quality study of the lake and its watershed. As a result, relatively consistent water quality data have been collected for the past 13 years. Starting in 1994, the council requested the U.S. Geological Survey (USGS) to assist with portions of the water-quality study. As the Idaho Department of Environmental Quality (IDEQ) is the agency responsible for the management of Idaho lakes, they agreed to cooperatively fund the USGS portion of the water-quality study. Over the course of water years 1997 through 2007 (with the exception of 2004), the IDEQ and the USGS cooperatively funded water-quality monitoring of the lake. In 2004, the IDEQ conducted sampling on the lake. Since 2005, the USGS, in cooperation with the IDEQ, has collected monthly samples for nutrients and chlorophyll-a in the lake, as well as profiles of temperature, pH, dissolved oxygen, and specific conductance. The outflow of the lake has been gaged continuously since WY1909 (site ID 13239000). Consistent monitoring (on a monthly to bimonthly basis) of the nutrient concentrations in the outflow by the USGS began in 1994, and continues to the present, with the exception of 2004 and 2005. The inflow to the lake (site ID 13238322) was gaged between WY1995 and WY2003. Nutrient concentrations were monitored on a monthly to bimonthly basis during this time.

Probably the most ambitious effort to understand the lake ecology to date was undertaken by the USGS in 1995 through 1996 and was described in Woods (1997). This work concluded that the percentage of nutrients contributed to the lake by sources other than the main tributary (nonpoint sources around the shoreline and smaller tributaries) increased between 1995/1996 and 1975 (U.S. Environmental Protection Agency, 1977). This work also documented hypolimnetic oxygen depletion that was greater than would have been predicted based

on nutrient and chlorophyll *a* concentrations in the lake, and on the basis of which the lake was classified as oligotrophic. In the following year (1997) high resolution profiles of chlorophyll *a* by *in-vivo* fluorescence were collected on 4 dates (Woods, 1998). Those profiles shed new light on the inconsistency between the oligotrophic classification of the lake and the hypolimnetic oxygen deficits, because the new instrumentation was able to identify peaks in chlorophyll *a* below the photic zone that were missed with the grab sampling scheme used in 1995 and 1996. Thus the amount of biomass in the lake was underestimated in those years.

As part of the 1996 study, periphyton production was measured on artificial substrate at 19 littoral stations around the shoreline of the lake. An attempt was made to correlate this periphyton production to various indices of nearshore development, but no strong relation was found. The same type of information was collected again in 2006. A cursory examination of the data found the results to be consistent with those of 1996, although no rigorous statistical interpretation of those data was attempted by the USGS, nor has it been published by others. Attempts, therefore, to develop empirical relations that would guide management decisions about land use around the lake have not been successful.

Monitoring of the lake water quality continues in order to establish long-term trends. Monitoring alone, however, is an inefficient way to arrive at a better fundamental understanding of this hydrodynamically complex lake ecosystem. This is because mixing and transport are likely to be highly variable both in space and time, and may operate in ways that are not apparent until the response of the lake to wind forcing and solar radiation input at the surface is understood.

In response to the documented indications that cultural eutrophication is in the beginning stages in Payette Lake, the Payette Lake Watershed Advisory Group has recognized the need to develop a tool that can be used to make informed management decisions about the land use around the lake (a Decision Support System, or DSS). Such a tool could be used, for example, to anticipate the predicted changes in the productivity and the oxygen budget in the lake based on scenarios for changes in nutrient loading. A necessary first step, however, is to have

a fundamental understanding of the hydrodynamics of the lake, which determine residence and mixing time scales.

The need for a DSS for Payette Lake comes at a good time, because much progress has been made over the past few decades in understanding the fundamental energy pathways in deep stratified lakes. Through these pathways the wind and solar radiation at the surface of the lake ultimately determines the advective and diffusive transport of quantities of interest, and in that way influences chemical and biological processes in the lake. The most important pathway of mechanical energy in deep stratified lakes can be simplified to the following (Wuest and Lorke, 2003): Wind blowing over the surface of the lake sets the surface boundary layer in motion, and causes a setup of the lake surface and downwelling of the top of the metalimnion in the downwind direction. This transfers energy to basin-scale internal waves that exist primarily in the stratified but relatively non-turbulent interior of the lake. In a lake the size of Payette Lake these basin-scale internal waves are likely to be standing seiches, although in lakes big enough to be affected by the earth's rotation they take the form of Kelvin and Poincare waves. The internal seiching of the lake transfers energy from these basin-scale oscillations to a turbulent bottom boundary layer where mixing occurs. Thus the lake can be divided into three layers: the turbulent surface boundary layer, the quiescent interior, and the turbulent bottom boundary layer (Wuest and Lorke, 2003). If fine enough measurements of velocity and temperature are available, the characterization of the lake can be further refined to include, for example, five layers instead of three (Eckert, et al. 2002). A transfer of energy from basin scales to turbulent motions (mixing) also can occur at sloping boundaries that intersect the metalimnion when internal waves break in a manner analogous to surface waves breaking on a sloping beach (Boegman, et al. 2005), or when velocity shear creates unstable density profiles (Lorke, et al. 2005). The pathway of energy from solar radiation interacts with the mechanical energy pathway, in that solar radiation increases the temperature at the surface of the water column on both a seasonal (creating the seasonal thermocline, suppressing turbulence, and generating the density stratification needed for internal waves) and a daily basis (interacting with the wind to determine the depth of the diurnal mixed layer [Imberger, 1985]). In

temperate climates, rapid mixing of the water column occurs with the onset of winter when cooling at the surface of the water column generates sufficient potential energy in the form of unstable density gradients to cause vertical convection.

The facts that lakes can be divided into regions with very different turbulence characteristics, that the majority of turbulent mixing occurs in well-defined regions near the boundaries, and that basin-scale internal waves in the metalimnion are the primary means of cascading energy from wind to turbulent eddies, have implications for the transport and mixing of geochemical constituents of interest: dissolved oxygen and nutrients, for example (Eckert, et al. 2002). Transport on very short (hours to days) time scales is accomplished by the horizontal currents and vertical movement of isotherms characterizing the dominant modes of internal waves particular to each lake basin. Turbulent mixing in the bottom boundary layer tends to occur on much longer (weeks to months) time scales. The time scale of many chemical reactions of interest tends to fall in between these two extremes. Biological processes also are influenced by the different regimes in a lake. Turbulence in the surface mixed layer can maintain populations of sinking cells in the light near the water surface (Spigel and Imberger, 1987); turbulence in the thermocline is suppressed by strong stratification, and algal populations there rely instead on the large vertical excursions of the thermocline due to internal waves to bring them nearer the surface (Denman and Gargett, 1983). On seasonal time scales, spring phytoplankton blooms can begin only after summer stratification in the surface layer begins and winter turbulence is decreased (Peeters, et al. 2007). The turbulence “climate” in the lake can influence the type of algal populations that develop, and can vary from season to season and with meteorological conditions (Berman and Shteinman, 1998).

Understanding the thermal profile and internal wave regime of the lake, therefore, is crucial to understanding how mixing and horizontal transport occurs on time scales of days to weeks. The development of this understanding as it applies specifically to Payette Lake is proposed by means of both high resolution temperature data collection and a modeling effort. These approaches complement each other—observations of

temperature provide direct evidence of the internal wave regime at the locations where data are collected, and allow the calibration and validation of a numerical model. The numerical model provides a means to interpolate between observations and determine conditions in areas of the lake other than the limited number of sites where instrumentation is deployed. Once properly calibrated and validated, the numerical model also provides a means to test alternative scenarios (for example, the role of meteorological forcing, the rate of depletion of dissolved oxygen, the expected effect of increased nutrient inputs on phytoplankton biomass). Several studies demonstrate the viability of the approach of identifying the internal wave regime in lakes by means of temperature profiles (Antenucci, et al. 2000 [Lake Kinneret]), modeling (Pan, et al. 2000 [Lake Kinneret]), or both (Appt, et al 2004 [Lake Constance]; Hodges, et al. 2000 [Lake Kinneret]; Rueda, et al. 2003 [Lake Tahoe]; Umlauf and Lemmin, 2005 [Lake Geneva]).

Objectives

The goal of this work is to begin the development of a Decision Support System (DSS) for Payette Lake. The first step in this development is to obtain a good understanding of the hydrodynamics of the lake on a large range of spatial (from lake-wide waves to turbulent eddies) and temporal (advection by mean currents to turbulent mixing) scales. As algal biomass, nutrients and dissolved oxygen are the water quality constituents that are of potential concern for managers, particularly into the future, a second step is to relate the hydrodynamics to the mass balance and transport of these quantities. To that end, the following specific objectives have been developed:

1. To collect the data at the lake boundaries necessary to complete accurate lake-wide mass balances for water and heat in the lake.
2. To collect velocity and temperature data within the lake itself at the range of temporal and spatial scales required to define role of large-scale advection to small-scale mixing processes in determining the movement of water and water quality constituents around and through the lake.

3. To develop a hydrodynamic and heat transport model that can accurately reproduce the advective and mixing characteristics of the lake as observed at specific sites in the previous objective, and provide information in unmonitored areas of the lake.

4. To collect dissolved oxygen data and algal mass surrogate data (chlorophyll *a*) within the lake that will demonstrate the effect of transport processes at various temporal and spatial scales on these constituents.

5. To begin long-term monitoring of tributary and outflow nutrient data that will be required for establishing trends over time. With the ongoing monitoring of nutrients in the lake, this also provides the basis for calculating nutrient mass balances.

6. (Optional) To develop a dissolved oxygen model that includes oxygen transfer across the air/water interface and oxygen demand at the sediment/water interface, as well as oxygen consumption and photosynthetic production within the water column.

Study Relevance and Benefits

According to *Strategic Directions for the Water Resources Division, 1998-2008*, the WRD will make an effort to "design study products that will be more useful and relevant to solving problems that are faced by water managers and other decision makers." The results from this study will be directly relevant to the Payette Lake Watershed Advisory Group and the Idaho Department of Environmental Quality, as they try to determine appropriate guidelines for land use in the Payette Lake watershed. It is unusual for managers and stakeholders to invest in such a tool prior to the onset of more severe water quality problems, so the PLWAG is to be commended for being pro-active. Furthermore, this work is consistent with the national priorities put forward in *Facing Tomorrow's Challenges* (U.S. Geological Survey, 2007); it is particularly aligned with the strategic direction of "understanding ecosystems and predicting ecosystem change." This work is the first step in a comprehensive and interdisciplinary understanding of Payette Lake. The DSS will ultimately predict ecosystem

change due to human activities, but it will be based on a sound understanding of the functioning of the lake. And lastly, The USGS Strategic Plan states that it is a long-term program goal to "maintain, provide and improve long-term environmental and natural resources information, systematic analyses and investigations, and predictive tools for scenario building and decision making about natural systems."

Approach

We propose three different levels of effort, denoted Tier 1-3 below, to begin development of the DSS for Payette Lake. Tier 1 is the least expensive and involves the least effort, and Tier 3 is the most expensive and involves the most effort. The choice of the appropriate level of effort for the first year of development will depend on the resources available and how quickly the PLWAG wishes to move through the development.

Tier 1 The elements of this least expensive level of effort are designed to provide a firm foundation on which to base future efforts. The tasks included in Tier 1 are as follows:

1. (Objective 1) The gaging station at USGS site 13238322, which was discontinued in WY2004, will be re-established in order to monitor inflows to the lake. Measurements of inflow are critical to the mass balance in the lake and to the modeling effort. This station will be an index velocity site, and a temperature sensor also will be installed to continuously monitor the temperature of the lake inflows.

   The location of the gage site is upstream of a small ungaged tributary to Payette Lake, but is convenient for access and is upstream of backwater from the lake. The cost-effective option that we propose is to re-establish the gage at the previous location, and estimate the discharge of the small ungaged tributary using StreamStats (http://water.usgs.gov/osw/streamstats/). Discharge statistics of the ungaged tributary will be compared to the discharge statistics at the gage site, and the

percentage of ungaged flow will estimated and added to the gage flow to estimate total inflow to the lake.

2. (Objective 5) Inflow nutrient concentrations will be monitored at 3 tributaries to the Lake (at the gaging station on the North Fork Payette River, Fall Creek and Dead Horse Creek) with biweekly equal-width-increment composited samples during the months April through November. The samples will be analyzed at the USGS National Water Quality Laboratory in Denver, Colorado. The samples will be analyzed for the same suite of water quality constituents currently included in the USGS water quality sampling program for Payette Lake. These include: total nitrogen, total phosphorus, dissolved nitrite + nitrate, ammonia, and orthophosphate.

   Field processing and equipment cleaning protocols are designed to procure samples in which concentrations at a parts per billion level of concentration can be detected (U.S. Geological Survey, variously dated; Horowitz et al., 1994). Data quality assurance is provided by the collection of samples designed for that purpose. These include equipment blanks (the first sample collected during each sampling day), split samples and method replicates (one sample of each type collected every other sampling trip), standard reference samples (one sample per season), and spiked samples (one sample per season). The budget for analytical services includes 20% of the number of environmental samples as the number of samples collected for quality assurance purposes.

3. (Objective 5) Outflow concentrations will be monitored at the existing gaging station (USGS site ID 13239000). Sample collection will be the same as described for the inflow.

4. (Objective 4) High resolution profiles of in-vivo chlorophyll *a* and light transmittance will be collected on the same schedule as routine lake monitoring. These profiles will be collected with a Sealogger (Seabird Electronics, Inc., model SBe-25). Because the instrument scans at a rate of 8 scans per second, at the recommended descent rate of 0.25 m per second the profiles have a

resolution on the order of 3 cm. The full suite of variables measured includes: depth (pressure), temperature, conductivity, dissolved-oxygen concentration and saturation, pH, oxidation-reduction potential, light transmissivity, photosynthetically active radiation, and chlorophyll *a* fluorescence.

Data quality assurance is provided primarily by proper calibration and maintenance of the equipment, according to manufacturer's specifications, and the collection of information in the field and subsequent processing of the data according to USGS protocols (Wagner et al. 2000). Additional quality assurance of the chlorophyll *a* fluorescence will be provided by the grab samples collected at each site as part of the ongoing monitoring of water quality in the lake.

5. (Objective 1) Two rafts will be installed on the lake in order to measure wind speed and direction, air temperature, and relative humidity directly over the surface of the lake. These meteorological datasets are used to determine the flux of mechanical and heat energy at the air/water interface. The rafts will most likely be installed at the southern end of both arms of the lake.

6. (Objective 1) One station to measure incoming short- and long-wave solar radiation will be installed at an appropriate location near the shoreline of the lake. The collection of on-site solar radiation data is a critical to determining the heat budget of the lake.

7. (Objective 2) Profiles of temperature will be measured on a continuous basis at two established water quality sites in the lake. The temperature will be measured at a vertical and temporal resolution adequate to identify internal wave motions, particularly at the thermocline, and to accurately describe the thickness of the surface and bottom boundary layers.

   The cost-effective method that is proposed uses internally logging thermistors mounted on a weighted cable, which will be suspended from surface buoys co-located with the weather stations described in part 5) above. The thermistors will be mounted at 2-m intervals through most of the water column, and at 1 to 0.5-m intervals through the surface boundary layer and thermocline. Data

from the thermistors will be downloaded at least once during the season, as well as after the final retrieval in the fall. A three-point temperature check of all of the thermistors will be done before they are deployed, and again after final retrieval in order to provide quality assurance of the data.

8. (Objective 3) Lake bathymetry, which currently exists only as a hardcopy map, will be digitized and a numerical model grid will be developed using specialized software that is currently licensed to the USGS Oregon District. During one or more trips to the site, spot checks will be made with a vessel mounted acoustic Doppler current profiler (ADCP) in order to evaluate the accuracy of the digitized map.

9. (Objective 3) A hydrodynamic and heat transport model of Payette Lake will be developed. This work spans two fiscal years. The model used will be the 3-dimensional model UnTRIM, which uses an efficient numerical method to solve the governing equations on an "unstructured" numerical mesh (Casulli and Zanolli, 2002, 2005). The model is computationally fast and numerically stable. The unstructured mesh allows the size of the polygons that make up the numerical mesh to vary in order to match the scale of changes in bathymetry, while closely matching the contours of the shoreline. In Payette Lake, for example, this would mean that larger polygons would be used in the western basin, and the smallest polygons would be used in the narrows upstream of the western basin. UnTRIM was used recently to model hydrodynamics and heat transport in Upper Klamath Lake, Oregon (Wood, et al., 2007). Approximately half of the data collected during 2008 will be used for calibration, and approximately half for validation, of the model.

10. (Objective 2) An upward-looking ADCP will be deployed on the bottom of the lake, most likely in the Narrows section of the lake near Cougar Island. This instrument collects profiles of horizontal and vertical velocities in the water column above. The resolution depends on how much averaging of the data is done to increase accuracy, but will probably be on the order of about 1 m. The location was selected because a) expected velocities in this area are high enough to be detected with

precision using an ADCP and b) velocity patterns around Cougar Island and into each arm of the lake can be monitored. This ADCP will be rented from another USGS Water Science Center, or from the USGS Hydrologic Instrumentation Facility.

11. (All objectives) A public project website will be developed. This website will describe the study, provide links to publications, and provide updated summary text as approved results are obtained. This proposal for work does not include data telemetry, and therefore, data will not be displayed in real or nearly real time. If at some point in the future data telemetry is installed, data could be displayed in nearly real time.

12. (All objectives) A USGS Scientific Investigations Report (SIR) will be written in FY09 and FY10 presenting the results of the 2008 field season.

Tier 2 Tier two includes all of the elements listed above for Tier 1, and in addition the following:

13. (Objective 3) The USGS will completely re-evaluate the lake bathymetry using a vessel-mounted echo-sounder. The USGS will provide this instrument from existing inventory.

14. (Objective 6) Develop a basic model of dissolved oxygen in the lake, including gas transfer at the air/water interface, photosynthetic production and metabolic consumption processes, based on the bi-weekly dissolved oxygen depth profiles collected with the Sealogger. Gas transfer rates can be estimated using literature formulations (Gelda and Effler, 2002), and photosynthetic production can be estimated from the periphyton production rates provided in Woods (1997).

Tier 3 Tier three includes all of the elements listed above for Tiers 1 and 2, and in addition the following:

15. (Objective 6) Augment the chain of temperature thermistors (item 7 under Tier 1) with profiling multi-parameter datasondes that will measure not only temperature, but also dissolved oxygen, pH, chlorophyll-a, and specific conductance on a temporally continuous basis, by collecting depth

profiles approximately 6 times per day. The profiles will be timed in awareness of the frequency and magnitude of seiches expected at the monitoring sites. The vertical resolution of the profiling will be determined based on timing and battery considerations, but should be between 2 and 10 m over the water column.

16. (All objectives) Data telemetry will be added to the water quality collection sites in order to provide nearly real-time data. This is helpful to project investigators because it provides the means to continually monitor the data being collected for quality assurance purposes. The data can be displayed on the project website in a way that is user-friendly for interested members of the public.

17. (Objective 3) Additional ADCPs will be installed on the lake bottom, for better calibration of the velocity. The exact locations of the additional ADCPs have not yet been determined, but will most likely be in the southern end of the Narrows near Sylvan Beach, the eastern arm of the lake near Shellworth Island, and/or the eastern side of Cougar Island where the lake splits into two arms. These ADCPs will be rented from another USGS Water Science Center, or from the USGS Hydrologic Instrumentation Facility.

18. (Objective 6) A more refined dissolved oxygen model will be developed that makes use of continuous dissolved oxygen depth profiles.

Reports and Products

The information products of the proposed work will be a Scientific Investigations Report to be published in FY10 and a numerical model. The report will discuss the performance of the numerical model and its calibration and validation with the 2008 data. The temperature and meteorological data collected during the 2008 field

season will be summarized and included as an appendix to the report. The report will be published on the internet, no paper copies will be produced. All the water-quality and streamflow data will available in the USGS database, National Water Information System (NWIS). All other data will be available in the USGS files in Boise.

Work Plan

Budget and personnel details for all tiers available on request

Tier 1

Workplan Schedule	FY2008	FY2009	FY2010
Task 1: Re-establishment of gaging station	April 2008		
Task 2/3/4: Monitor inflow and outflow nutrients; collect high resolution profiles of chlorophyll-a and dissolved oxygen on bi-weekly basis	begin April 2008	end November 2008	
Task 5: Install meteorological stations on the lake	April 2008		
Task 6: Install solar station on shoreline	April 2008		
Task 7: Collect continuous, high resolution profiles of temperature	begin April 2008	end November 2008	
Task 5/6/7: Process and quality assure continuous met and temperature data		December 2008-January 2009	
Task 8: Digitize lake bathymetry		October 2008	
Task 9: Develop hydrodynamic model		October 2008-June 2009	
Task 10: Deploy upward looking ADCP on lake bottom	May 2008		
Task 11: Develop project website	June-July 2008		October – December 2009
Task 10: Retrieve ADCP; process ADCP records		November 2008	
Task 12: Draft of SIR		September 2009	
Task 12: Colleague review of SIR			October 2009
Task 12: Publication of SIR			December 2009

Tier 2

Workplan Schedule	FY2008	FY2009	FY2010
Task 1: Re-establishment of gaging station	April 2008		
Task 2/3/4: Monitor inflow and outflow nutrients; collect high resolution profiles of chlorophyll-a and	begin April 2008	end November 2008	

dissolved oxygen on bi-weekly basis			
Task 5: Install meteorological stations on the lake	April 2008		
Task 6: Install solar station on shoreline	April 2008		
Task 7: Collect continuous, high resolution profiles of temperature	begin April 2008	end November 2008	
Task 5/6/7: Process and quality assure continuous met and temperature data		December 2008-January 2009	
Task 8: Digitize lake bathymetry		October 2008	
Task 9: Develop hydrodynamic model		October 2008-June 2009	
Task 10: Deploy upward looking ADCP on lake bottom	May 2008		
Task 11: Develop project website	June-July 2008		October – December 2009
Task 10: Retrieve ADCP; process ADCP records		November 2008	
Task 12: Draft of SIR		September 2009	
Task 12: Colleague review of SIR			October 2009
Task 12: Publication of SIR			December 2009
Task 13: Re-evaluation of bathymetry	July 2008		
Task 14: Development of DO model		November 2008-February 2009	

Tier 3

Workplan Schedule	FY2008	FY2009	FY2010
Task 1: Re-establishment of gaging station	April 2008		
Task 2/3/4: Monitor inflow and outflow nutrients; collect high resolution profiles of chlorophyll-a and dissolved oxygen on bi-weekly basis	begin April 2008	end November 2008	
Task 5: Install meteorological stations on the lake	April 2008		
Task 6: Install solar station on shoreline	April 2008		
Task 7: Collect continuous, high resolution profiles of temperature	begin April 2008	end November 2008	
Task 5/6/7/15: Process and quality assure continuous met and water-quality data		December 2008-February 2009	

Task 8: Digitize lake bathymetry		October 2008	
Task 9: Develop hydrodynamic model		October 2008-June 2009	
Task 10: Deploy upward looking ADCP on lake bottom	May 2008		
Task 11: Develop project website	June-July 2008		October – December 2009
Task 10/17: Retrieve ADCPs; process ADCP records		November-December 2008	
Task 12: Draft of SIR		September 2009	
Task 12: Colleague review of SIR			October 2009
Task 12: Publication of SIR			December 2009
Task 13: Re-evaluation of bathymetry	July 2008		
Task 14: Development of DO model		November 2008-March 2009	
Task 15: Collect continuous, high resolution profiles of temperature, dissolved oxygen, pH, chlorophyll-a, and specific conductance using automated equipment	begin April 2008	end November 2008	
Task 16: Real-time data telemetry at continuous water-quality stations	begin April 2008	end November 2008	
Task 17: Deploy additional upward looking ADCPs on lake bottom	May 2008		
Task 18: Refine DO model using data collected in Task 15		November 2008-March 2009	

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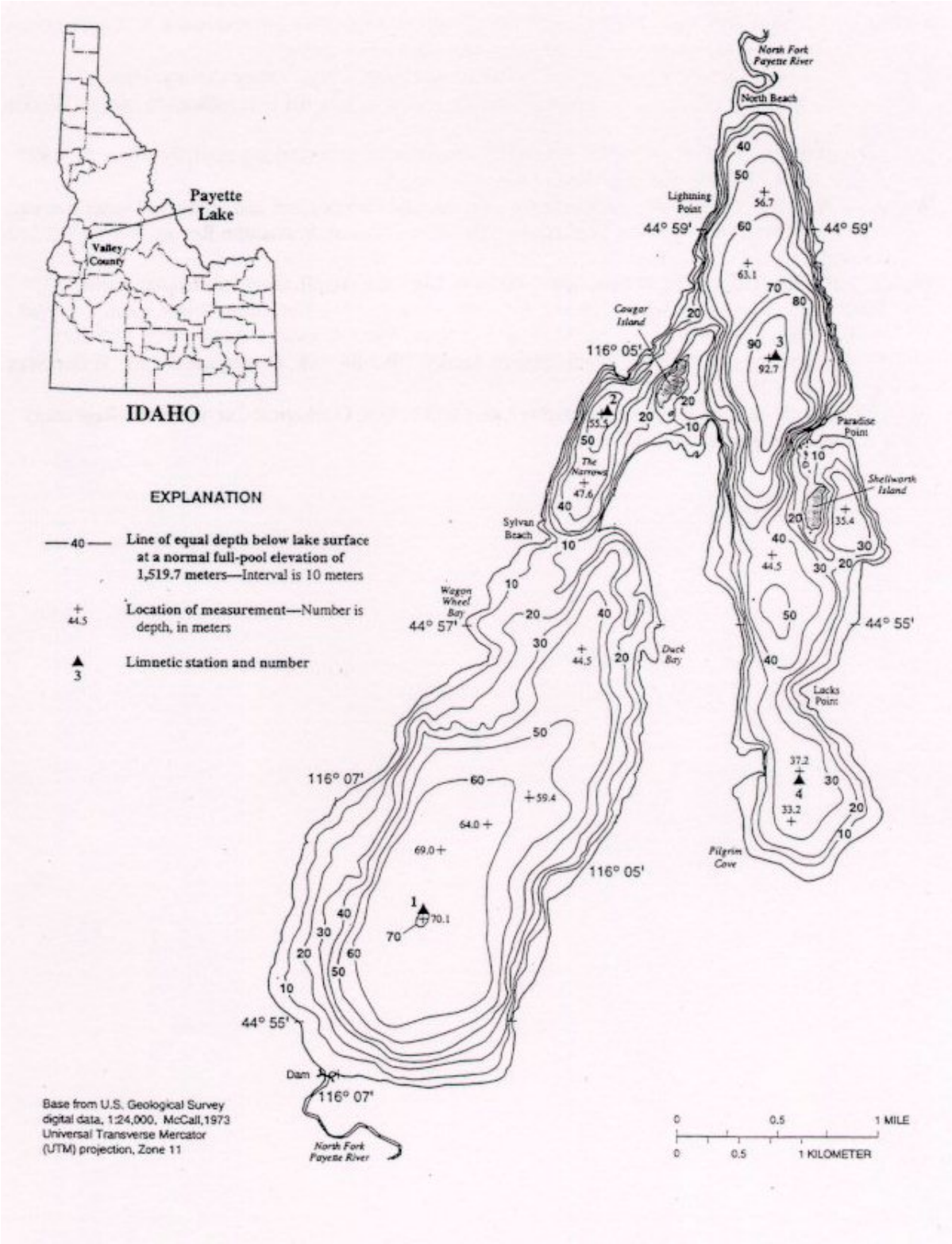
Base Map of Payette Lake, Idaho