Klamath Basin

Water Quality Monitoring Plan

Prepared for:

Klamath Basin Monitoring Program (KBMP)

Adopted April 27, 2010

Editors: Chantell F. Royer &

Andrew P. Stubblefield

Klamath Watershed Institute

Humboldt State University

Department of Forestry & Wildland Resources

Updated August 30, 2016

Table of Contents

Contents

1.0 Introduction

The Klamath River Basin and its tributaries span two states, California and Oregon (Figure 1). Thirty-six percent of the Klamath Basin lies within Southern Oregon and 64% lies within northern California. The 10 million acre basin is renowned for its lakes, rivers, hunting, fishing and agriculture (NRC, 2008). The Klamath Basin is home to six federally recognized tribes, several National Wildlife Refuges, Parks and Forests. Historically, the Klamath River Basin has had the third largest salmon run on the West Coast next to the Columbia and Sacramento Rivers (NCRWQCB 2008b). Within the Klamath Basin, the mainstem Klamath River originates in the upper basin at the outlet of Upper Klamath Lake and flows approximately 250 miles from Oregon through California to the Pacific Ocean. The main tributaries to the Klamath River are the headwaters rivers of the Williamson and Sprague above Upper Klamath Lake, and the Lost, Shasta, Scott, Salmon and Trinity Rivers.

There are several dams within the Klamath Basin. On the mainstem Klamath River, there are six dams: Link, Keno, JC Boyle, Copco I &II, and Iron Gate. The four lower dams (JC Boyle, Copco I & Copco II and Iron Gate) are subject to removal by 2020 depending on the outcome of settlement agreements among federal, state, county, tribal and non-governmental organizations; the removal would open-up the historic salmonid spawning range within the basin. The Trinity River has two dams, the Trinity and Lewiston. Both are part of the Central Valley Project, which diverts approximately 52% of the flow from the Trinity River to the Project. The Shasta River has one permanent dam that creates Dwinnell Reservoir, which is maintained for agriculture irrigation use.

The Klamath River has received national attention due to water allocations, water quality and endangered species issues. In 2002, a large return of adult salmon, low flows, and high temperatures resulted in a massive fish die-off of an estimated 33,000 fish (CDFG, 2004); limited water allowances to farmers in 2001 and the following lack of protections of water for fish use in 2002 may have contributed to the die-off. Toxic algae blooms (predominantly *Microcystis aeruginosa*) occur annually within several of the reservoirs (Copco I, Iron Gate and Dwinnell) and have documented levels of toxicity, sometimes 10-100’s times what the World Health Organizations considers a moderate health risk (Kann, 2006). In addition, declining water quality throughout the Basin over the past few decades has led to the listing of several waterbodies within the Klamath Basin as impaired under section 303(d) of the federal Clean Water Act.

Figure 1: Map of the Klamath Basin with select cities, tribal lands, subbasins and dams.

While the regulatory agencies from Oregon, California and U.S. Environmental Protection Agency oversee the Total Maximum Daily Load (TMDL) and Action Plan implementation, much of the water quality data relied upon for those efforts is collected by other monitoring entities.

Many diverse and discrete parties conduct monitoring in the Klamath Basin including state and federal agencies, tribal entities, PacifiCorp, and watershed groups. Historically, many members of these various organizations collaborated on an informal level, exchanging information and collaborating in an effort to reduce duplication of effort. After many years of operating within the confines of an informal process, coupled with the complexity and severity of the problems facing the Klamath Basin, and decreasing levels of available resources, there was a clear need for the development of a more coordinated and sustainable monitoring program.

The North Coast Regional Water Quality Control Board (NCRWQCB), with support from the U. S. Environmental Protection Agency and the California State Water Quality Control Board's Non-Point Source Program submitted a contract to facilitate the development of a coordinated monitoring and assessment program within the Klamath Basin. The rationale behind the support of the project were to: 1) create a comprehensive and inclusive monitoring strategy; 2) develop an effective and efficient way of using resources; 3) generate a holistic picture on the health of the basin; and 4) further develop interagency partnerships to improve the health of the basin. The development of the interagency monitoring effort required a neutral party to assist in the analysis and development of a monitoring program that was agreeable to a diverse group of organizations. Klamath Watershed Institute, an affiliate of Humboldt State University, demonstrated the required skills for effective execution of the coordination effort.

The original Klamath Basin Water Quality Monitoring Plan was the product of two years of coordination among members of the Klamath Basin Monitoring Program (KBMP). The updated Klamath Basin Water Quality Monitoring Plan recognizes the evolution of monitoring efforts and that the needs of resource managers change over time. The continuation of coordinated water quality monitoring will support decisions made in the Klamath Basin regarding resource management, including: implementation measures to achieve Total Maximum Daily Loads (TMDLs) such as nutrients, dissolved oxygen, temperature, microcystin, and ecosystem health which will expedite the recovery of impaired beneficial uses for the benefit of all California and Oregon residents and Tribal communities. It also recognizes monitoring to support the Klamath Hydroelectric Settlement Agreement (KHSA), Klamath Basin Restoration Agreement (KBRA), and Upper Klamath Basin Comprehensive Agreement (UKBCA). The cooperative monitoring that is taking place under the KHSA addresses baseline water quality monitoring in the Klamath River within and downstream of the hydroelectric reach. This monitoring supports water quality improvement activities, dam removal studies, permitting studies (as necessary), and forms a long-term record to assess trends and other potential changes in the basin. In addition, the KHSA funds monitoring for blue-green algae (BGA) and associated toxins in order to protect public health. The coordinated monitoring effort under the KHSA supplements monitoring done by KBMP members within the Klamath Basin.

1.1 Statement of Purpose

The purpose of the Klamath Basin Water Quality Monitoring Plan is to serve as a foundation for the continued collaboration within the Klamath Basin, by: 1) recommending water quality investigations to answer questions for resource managers, 2) providing for data management, data sharing and data communications to resource managers and other water quality investigators, and 3) provide for consistent sampling methods and quality assurance protocols to assure the comparability of data among the various agencies, watershed groups and tribal governments conducting work within the Klamath Basin.

The monitoring plan seeks to include all agencies and organizations engaging in water quality monitoring in the Klamath Basin (Figure 1). The Klamath Basin Water Quality Monitoring Plan is not intended to replace individual water quality monitoring efforts or autonomy, but expands on the current coordinated monitoring effort in the Klamath Basin that benefits long-term coordination and collaboration, and enhances the ability to secure stable funding for these continued efforts.

1.2 Organization

The Klamath Basin Water Quality Monitoring Plan is organized by subbasin with subsections addressing water quality issues within each subbasin. Initially the Klamath Basin Water Quality Monitoring Plan consisted of: 1) review of existing efforts conducted by organizations within the basin, and development of monitoring goals and objectives; 2) identification of a monitoring network based upon existing legacy sites that best address the beneficial uses within each subbasin; 3) implementation of comparable Quality Assurance and Quality Control (QA/ QC) measures using multistate (Oregon and California) guidelines; 4) identification of consistent Standard Operating Procedures; and 5) development of a sustainable monitoring framework that addresses both long and short-term water quality data needs.

The established monitoring network shall be evaluated annually (Appendix III). The Steering Committee (SC) shall review water quality data and evaluate the relevance or applicability of sites or parameters on a location by location basis and offer recommendations that best support the monitoring needs and requirements necessary to answer management questions and support beneficial uses. The SC shall make recommendations for incorporating measures that are coupled with increased funding, including the addition of sites and parameters that may be added to the monitoring network. This may also include the implementation of special studies identified by the SC (Chapter 8), as well as identified gaps in monitoring by region (Chapter 5 and Chapter 8.2). Additionally, as the funding for monitoring grows, it is anticipated that funds for supporting the KBMP organizational staff will grow as well. A proposal outlining the step-wise approach toward a fully staffed KBMP organization is outlined in the report, Support for Long-Term Water Quality Monitoring Plan Implementation (KBMP, 2009).

1.3 Legal Basis and Authority

The Klamath Basin Monitoring Program (KBMP) is a voluntary organization that has no independent legal or regulatory authority. It is an organization comprised of individuals, groups, agencies, and governments that have an interest in the water quality conditions within the Klamath River Basin. It is the hope that the collaborative effort to develop the Klamath Basin Monitoring Program will assist in securing funding and further develop the KBMP into a self-sustained monitoring organization, working on the issues that are important for the improvement of water quality in the Basin.

1.4 Committee Members

KBMP members are encouraged to support the various agencies and organizations engaged in the collection of water quality information within the Klamath Basin. Committee organization has shifted from having a Steering Committee and Subbasin leads to a Steering Committee with additional committees covering Strategic Plan/Funding, Monitoring Plan, and Blue-Green Algae. Additional temporary committees can be formed by the Steering Committee to help address a specific and time sensitive need. Committee members serve as oversight and have provided additional comments and recommendations. Committee members represent additional knowledge support for each specific topic and provide additional comments and guidance.

Table 1: KBMP Steering Committee members as of July, 2016.

Name	Organization	Role
Susan Corum	Karuk Tribe	Chair
Mike Deas	Watercourse Engineering Inc.	Co-Chair
Chris Marquis	State Water Resources Control Board	Secretary
Rick Carlson	U. S. Bureau of Reclamation	Member
Clayton Creager	North Coast Regional Water Quality Control Board	Member
Lyra Cressey	Salmon River Restoration Council	Member
Demian Ebert	PacifiCorp	Member
Heather Hendrixson	The Nature Conservancy	Member
Sue Keydel	U. S. Environmental Protection Agency	Member
Greg Laurie	U. S. Forest Service/ Klamath National Forest	Member
Ally Lutes	Shasta Valley Resource Conservation District	Member
Crystal Robinson	Quartz Valley Indian Reservation	Member
Mike Hiatt	Oregon Department of Environmental Quality	Member
Randy Turner	Klamath Basin Monitoring Program	Member

1.5 Member Organizations

Members of the Klamath Basin Monitoring Program have reviewed and provided input in the drafting of the initial Klamath Basin Water Quality Monitoring Plan; a comprehensive list of contributing organizations is provided (Table 2) below.

Table 2: Participating organizations to KBMP as of July, 2016. Voting members are noted*.

Aquaterra Consulting	PacifiCorp*
Aquatic Ecosystem Sciences*	Portland State University
Bureau of Land Management*	Quartz Valley Indian Reservation*
California Department of Fish and Wildlife*	Resighini Rancheria
California Department of Health Services	Riverbend Sciences
California Department of Water Resources	Salmon River Restoration Council*
California State Coastal Conservancy	San Francisco Estuary Institute
CalTrout	Scott River Water Trust
Colorado State University	Scott River Watershed Council
E & S Environmental*	Shasta Valley Resource Conservation District*
Farm Stream Solutions	Siskiyou County Public Health
French Creek Watershed Advisory Group*	Siskiyou Resource Conservation District
GEI Consultants	Southern California Coastal Water Research Project
Greenway Partners	Southern Oregon University
Hoopa Valley Tribal EPA	Sprague Watershed Council
Humboldt County	State Water Resources Control Board*
Humboldt State University	Stillwater Sciences*
Jefferson Fish Society	The Nature Conservancy (Oregon and California)*
Karuk Tribe*	Trinity River Restoration Program
Trout Unlimited -Formerly Klamath Basin Rangeland Trust*	U. S. Bureau of Reclamation*
Klamath Bird Observatory*	U. S. Department of Agriculture- Natural Resources Conservation Service
Klamath Riverkeeper	U. S. Environmental Protection Agency*
Klamath Tribes*	U. S. Fish and Wildlife Service*
Klamath Watershed Partnership	U. S. Forest Service*
Klamath Wetland Education & Research Institute	U. S. Geological Survey
Mid Klamath Watershed Council	University of California Berkeley
National Fish and Wildlife Foundation	University of California Davis
National Oceanic and Atmospheric Administration	University of California Santa Cruz
National Park Service	University of Wyoming
Normandeau Associates	Watercourse Engineering*
North Coast Regional Water Quality Control Board*	Watershed Initiatives
Oregon Department of Environmental Quality*	Watershed Research and Training Center*

Oregon Institute of Technology	Yurok Tribe Environmental Program*
Oregon State University*	Watershed Sciences Inc.
Oregon Water Resources Department*	Waterways Consulting
Oregon Watershed Enhancement Board	Willamette Partnership

2.0 Description of Current Monitoring Efforts and Maps

2.1 Background

Water quality monitoring in the Klamath Basin dates back to the early 1900's, with the publication of *Quality of the Surface Waters in Oregon* (Van Winkle, 1914), a concerted effort toward understanding the water quality issues did not begin until the late 1900's. As the region has developed, there have been land use and hydrologic regime alterations, as well as increased sedimentation, which along with natural variation in climate has led to a decline in water quality and fish populations (NRC, 2008). Although the Klamath Basin is renowned for salmon and steelhead fishing, and supports substantial sport, commercial and tribal fisheries, many fish populations have declined over the decades throughout the Basin. For example, Coho (*Oncorhynchus kisutch*) populations in the lower basin are listed as threatened and endemic shortnose and Lost River (*Chasmistes brevirostris* and *Deltistes luxatus*) sucker populations in the upper basin are listed as endangered (NCRWQCB, 2008a).

In response to the decline of the salmon populations, as well as declining water quality throughout the Basin the Pacific Coast Federation of Fishermen Association (PCFFA) and other organizations brought suit against the EPA alleging that the EPA had a nondiscretionary duty to establish TMDLs if the State did not. The case *Pacific Coast Federation of Fishermen's Association et. al. v. EPA [Marcus]* established a consent decree in March 1997 for TMDL development of 17 California watersheds, including the Klamath Basin. The EPA Regions (9 and 10) worked collaboratively with the Regional Water Board, and Oregon Department of Environmental Quality (ODEQ) on the development of coordinated TMDLs for the Klamath River mainstem.

As a result, the states' water quality agencies, the North Coast Regional Water Quality Control Board (NCRWQCB) and the Oregon Department of Environmental Quality (ODEQ), under the guidance of the U. S. Environmental Protection Agency began developing allowable Total Maximum Daily Loads (TMDLs) for waterbodies in the Klamath Basin. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDLs also provide an analytical basis for planning and implementing pollution controls. The TMDL Implementation process can take the form of regulatory actions (e.g.

pollution control permits), non-regulatory actions (e.g. self-determined pollution control), or amendments to the states' Water Quality Control Plan. California and Oregon through their respective Water Quality Control Plans, in concert with Tribal Water Quality Control Plans, set the water quality standards to which waterbodies are compared. The Water Quality Control Plan for the North Coast Region (the Basin Plan) (NCRWQCB 2007), in the case of California, identifies the existing and potential beneficial uses of water within the North Coast Region and the water quality objectives necessary to protect those uses. The aim of TMDL development and implementation are ultimately to restore the capability of waterbodies to support beneficial uses within the Klamath Basin.

The Klamath River mainstem TMDL for California was adopted by EPA Region 9 on December 28, 2010. The Klamath River mainstem TMDL for reaches within Oregon is still under reconsideration and has not been adopted by EPA Region 10. However due to California TMDL allocations related to pollutants that originate in Oregon and a Memorandum of Agreement for cooperation on basin-wide TMDL implementation, which was signed by EPA Regions 9 and 10, ODEQ, and the CA NCRWQCB, implementation of the CA NCRWQCB TMDL Action Plan has proceeded since the CA adoption date.

Beneficial, or designated, uses as defined by the Clean Water Act are uses that society, through state and federal governments, determines should be attained in the waterbody, such as, warm water aquatic ecosystems, public water supply, and recreational fishing (see Appendix V for CA beneficial uses). The most sensitive beneficial uses from the standpoint of water quality management are municipal, domestic drinking water supply, contact recreation, (ODEQ, 2002) and uses associated with maintenance of rare, resident and anadromous fisheries and cultural uses and practices (NCRWQCB, 2008a).

TMDL development has been an ongoing process in the Basin since 1998, with the drafting of the South Fork Trinity TMDL. TMDL development for waterbodies within the Basin are based on water quality monitoring conducted by monitoring organizations and to a lesser extent, regulatory agencies (NCRWQCB and ODEQ). The TMDL process begins with a 303(d) listing under the Clean Water Act. TMDLs are then developed using available and appropriate monitoring data. However, water quality monitoring conducted by a multitude of organizations may vary in quality among entities, presents several data use issues such as, varying monitoring goals and objectives, data that may not be readily accessible, as well as varying standard operating procedures for collecting water samples and quality assurance and control measures for analysis and data evaluation.

The purpose of formalizing the KBMP and drafting the Klamath Basin Water Quality Monitoring Plan is to develop a collaborative plan for sampling and analyzing to provide comparable water quality data throughout the Klamath River Basin under a unified set of goals and objectives (Chapter 3). Under the established goals and objectives, members seek to establish and maintain a long-term monitoring network of sites aimed at improving the understanding of the water quality and the ecology of the Basin as well as informing TMDL development and achievement of action plan goals.

The Klamath Basin Water Quality Monitoring Plan is also part of the monitoring program identified in the Klamath River TMDL (NCRWQCB, 2009). In addition to the Klamath Basin Water Quality Monitoring Plan, the AIP 2009 Monitoring Plan is also identified. In 2008, the United States, the states of California and Oregon, and PacifiCorp executed an Agreement in Principle (AIP) describing the framework for an approach to study the water quality conditions of the Klamath River pursuant to the possible removal of several of PacifiCorp’s dams on the Klamath River. In 2010 the AIP was superseded by the Klamath Hydroelectric Settlement Agreement (KHSA) which included Interim Measure 15, which funds long-term baseline water quality monitoring in support of dam removal, nutrient removal, blue-green algae monitoring to protect public health, and a variety of special studies. The KHSA monitoring supports a range of objectives and has advanced coordination of monitoring by the signatories to the agreement and helped support additional coordination among stakeholders in the basin. The two plans, the Klamath Basin Water Quality Monitoring Plan and KHSA Monitoring Plan (Interim Measure 15), are similar in content, but vary in geographic scope. The KHSA Monitoring Plan, updated annually, includes monitoring of the Klamath River mainstem (including reservoirs) from Link River dam downstream through the estuary and is specific to the Klamath River. The KHSA Plan addresses public health monitoring of cyanobacteria and associated toxins, and comprehensive baseline water quality monitoring in the Klamath River. The Klamath Basin Water Quality Monitoring Plan address water quality basin wide. Within the region where two plans overlap, such as the Klamath River, both plans utilize the same monitoring locations and parameters in an effort to provide continuity and comparability between the two monitoring plans.

2.2 Organizations Collecting Water Quality Data

The collection of water quality data in the Klamath Basin is currently a multi-organizational effort. While some members of various organizations collaborate on an informal level, exchanging information and collaborating in an attempt to reduce duplication and effort, many work on independent projects addressing water quality issues. The Klamath Basin Monitoring Program made every effort to identify organizations conducting water quality monitoring in the

Klamath Basin, from the comprehensive list of KBMP members (Table 2), a subset of organizations were identified for inclusion in the Klamath Basin Water Quality Monitoring Network. The groups in Table 3 performed water quality monitoring in the Klamath Basin in 2014. The locations for the 2014 monitoring is found in Figure 2.

Table 3: Organizations collecting water quality data in the Klamath Basin as of August 2014.

California Department of Water Resources
Hoopa Tribe
Karuk Tribe
Klamath Tribes
McBain Associates
Michigan-California Timber Company
Oregon Water Resources Department
Oregon Department of Environmental Quality
PacifiCorp
Quartz Valley Indian Reservation
Resighini Rancheria
Salmon River Restoration Council
Siskiyou Resource Conservation District
Scott River Water Trust
Shasta Valley Resource Conservation District
Siskiyou County RCD
The Nature Conservancy
U. S. Bureau of Reclamation
U. S. Bureau of Land Management
U. S. Fish and Wildlife Service
U. S. Forest Service
U. S. Geological Survey
Yurok Tribe

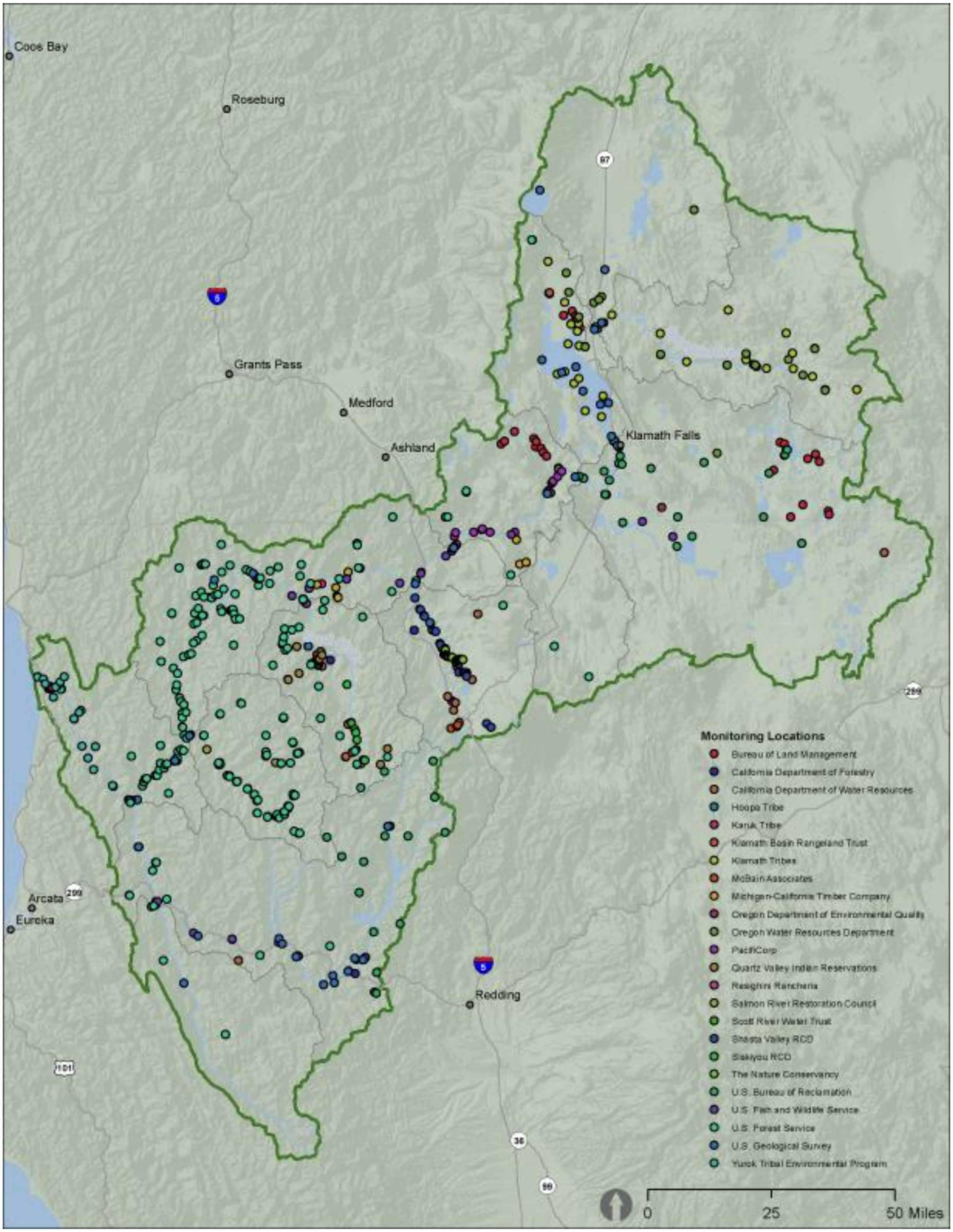


Figure 2: 2014 monitoring efforts by KBMP organizations.

2.3 Current Water Quality Monitoring Efforts

The rationale and regulatory authority behind individual organizations conducting water quality monitoring are varied. Many types of organizations conduct water quality monitoring within the Klamath Basin (List 1). Generally water quality monitoring occurs on the basis of regulatory authority, permitting, research, assessment, compliance and restoration. For example, Tribal entities such as the Karuk Tribe conduct water quality monitoring to:

> *"protect, promote, and preserve the cultural resources, natural resources, and ecological processes upon which the Karuk People depend. This mission requires the protection and improvement of the quality and quantity of water flowing through Karuk Ancestral Territory and Tribal trust lands."*

Regulation and compliance monitoring are rooted in the federal Clean Water Act (CWA). The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Except for waters located in Indian country, the quality of surface and ground water in the North Coast Region of California is governed by the Water Quality Control Plan of the North Coast Region (Basin Plan) as developed and implemented by the Regional Water Board. The Basin Plan identifies the existing and potential beneficial uses of water within the North Coast Region and the water quality objective necessary to protect those uses. Together water quality objectives, beneficial uses, and the anti-degradation policy are known as water quality standards. Under section 303(d) of the CWA, states are required to develop a list of water bodies (stream/river segments, lakes) where legally required pollution control mechanisms are not sufficient or stringent enough to meet water quality standards applicable to such waters. Placement of a water body on the 303(d) list triggers the development of a Total Maximum Daily Load (TMDL) for water body pollution/stressor combination. The subsequent development of an implementation plans to achieve TMDL goals may result in an amendment to the state Basin Plan. As part of a collaborative effort by the NCRWQCB and ODEQ Klamath River TMDLs and implementation strategies are currently under development for the Klamath River.

Currently the draft Klamath River TMDL Implementation plan includes several primary elements for successful restoration of water quality conditions in the Basin:

- Reduction of point and nonpoint source nutrient loads in Oregon and California;
- Protection of thermal refugia
- Addressing the water quality impacts from the throughout the Basin.

Implementation of Klamath Basin TMDLs has included many types of actions undertaken by the NCRWQCB and regulate activities on a broad scale. A few examples of these actions include: the Temperature Policy which regulates activities that could negatively impact water temperature; Implementation of the USFS Waiver; Implementation of the Shasta River Waiver; Scott River Waiver; and Implementation of the 5C County Road Management Waiver.

The NCRWQCB has been working on the development of large-scale water quality improvement projects based on a collaborative design and development workshop including treatment wetlands around Upper Klamath Lake. In addition the NCRWQCB has issued grants to Shasta Valley RCD and the Klamath Watershed Partnership to develop watershed stewardship adaptive management frameworks that involve development of pilot applications of the Klamath Tracking and Accounting Program and development of collaborative monitoring programs based on the KBMP model.

Nearly all of the federally-recognized tribes located in the North Coast's Klamath Basin have received "treatment as a state" from EPA for purposes of conducting water quality monitoring under section 106 of the CWA. As such, these tribes are authorized to conduct water quality monitoring under Section 106 of the CWA for all waters located within the boundaries of their respective reservations, and are subject to the quality assurance and quality control requirements in 40 C.F.R.31.24.

In addition to regulatory and permitting requirements, water quality monitoring also occurs for research and restoration purposes. The Klamath Blue Green Algae Workgroup has supported researchers at the University of California Santa Cruz in researching nutrient limitations on the growth of blue-green algae (*Microcystis aeruginosa*) and the production of microcystin toxins in Iron Gate and Copco 1 Reservoirs.

The variability in monitoring in the Basin is reflected by the variability in the rational and purposes behind the monitoring. Despite this variability, several multi-agency projects occur within the Basin. One example is sampling conducted annually under the KHSA. In 2009, representatives of the federal government, Oregon, California and PacifiCorp executed an Agreement in Principle (AIP), in part describing the framework for an approach to study the water quality conditions of the Klamath River pursuant to the possible removal of several of PacifiCorp's dams on the Klamath River by 2020 (NCRWQCB, 2009). The AIP, since replaced by the KHSA and Interim Measure 15, stipulates that PacifiCorp will fund water quality monitoring including on-going blue-green algae (*Microcystis aeruginosa*) toxin monitoring, for public health and baseline monitoring; funding of $500,000 will be provided per year for monitoring to be performed by an entity agreed upon by the parties and in coordination with appropriate water quality agencies. The scope of the IM 15 monitoring is limited to the Klamath River from Link Dam to the Estuary, with the exception of the monitoring of the mouths of the Shasta, Scott, Salmon, and Trinity Rivers (Figure 3). Collaborating on the project are the Bureau of Reclamation, PacifiCorp, Regional Board, EPA, Karuk Tribe, and Yurok Tribe. Monitoring plans and results are published annually on the KBMP website.

Another group collaborating on water quality related work is the Tribal Water Quality Work Group composed of the Karuk, Quartz Valley Indian Reservation, Yurok, Resighini Rancheria and Hoopa Tribal Governments. The work group formed after the fish die-off in 2002. The group is committed to preventing future disasters through sound scientific research, data analysis, and planning (TWQWG, 2009).

While these groups illustrate that collaboration is effective on a local scale, networking with all the organizations throughout the Basin is a challenge. Efforts are being made to enhance communication among monitoring organizations through the hosting of a series of interactive maps of water quality conditions in the basin, and by assisting KBMP member organizations upload of data in the California Environmental Data Exchange Network (CEDEN), a centralized water quality data clearinghouse. The interactive maps include real time water quality data (sondes), blue-green algae posting information, and fish health readiness. Current efforts to upload water quality data to CEDEN will allow future expansion of interactive maps to include historic water quality data that can be queried by users based on selected location, analyte, time period, or other parameters. It is the hope that these communication tools with the guidance of the Klamath Basin Water Quality Monitoring Plan will foster enhanced understanding and collaboration among regulatory agencies, monitoring organizations and the public regarding water quality issues facing the Klamath Basin.

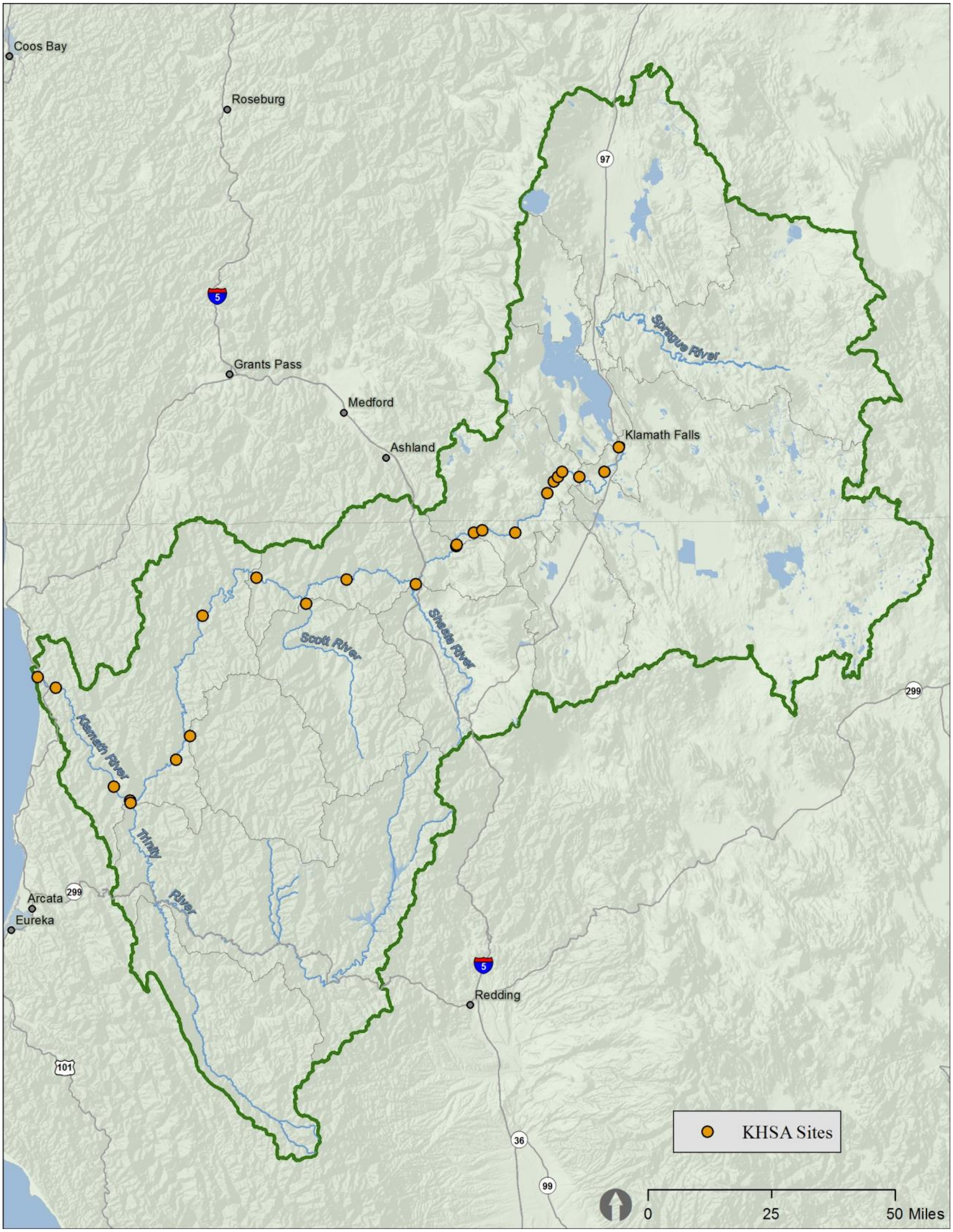


Figure 3: Klamath Hydroelectric Settlement Agreement Monitoring Locations in 2014.

2.4 Current Water Quality Monitoring by Parameter

As part of the effort to capture organizations actively engaged in water quality monitoring, KBMP has conducted comprehensive surveys annually since 2010. Monitoring organizations were asked to identify monitoring locations, parameters, frequency and season of monitoring. Every effort was made to include all organizations collecting water quality information within the Basin. The maps presented below (Figures 4-11) are a visual compilation of 303(d) listed parameters and the frequency of collection for the 2014 monitoring season.

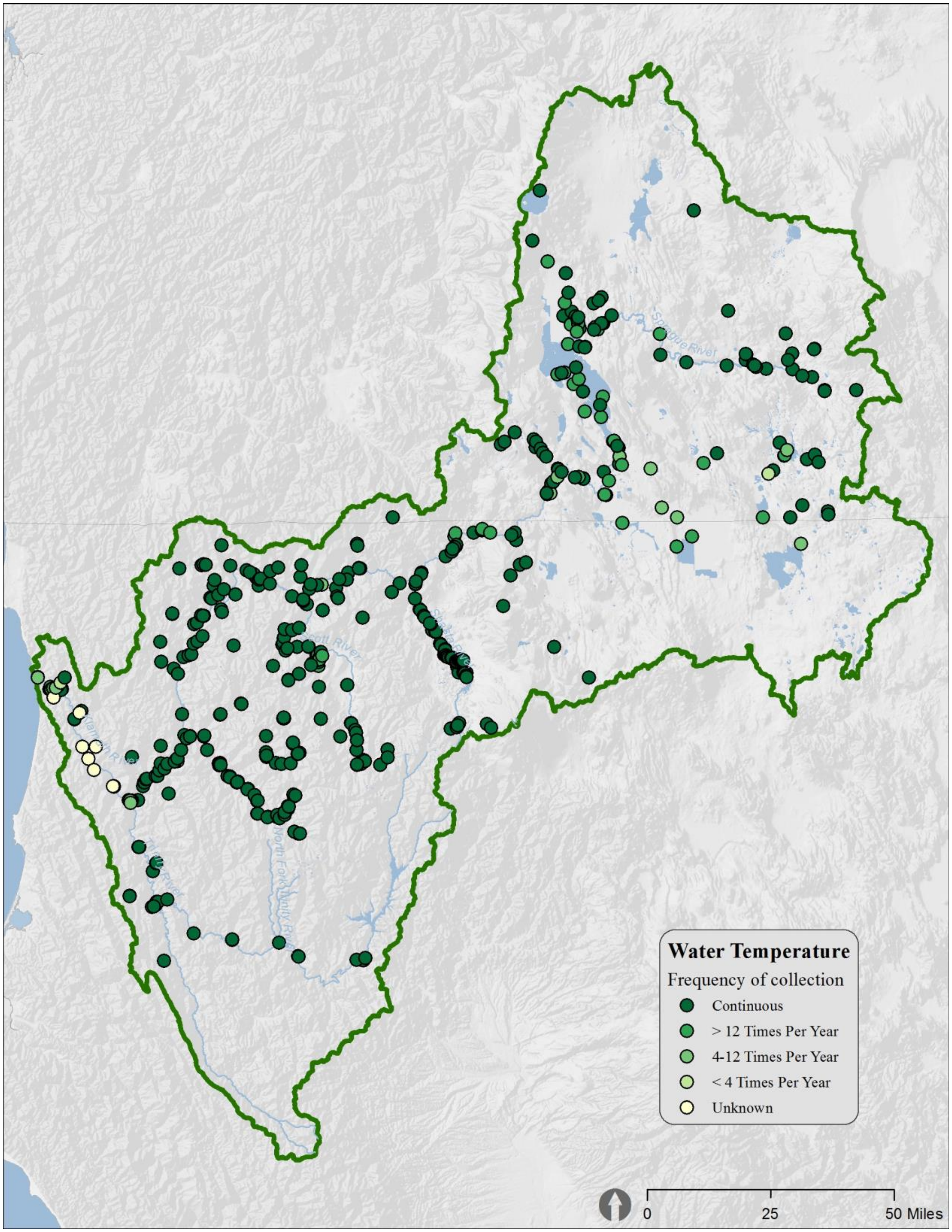


Figure 4: **Water temperature monitoring throughout the Klamath Basin.**

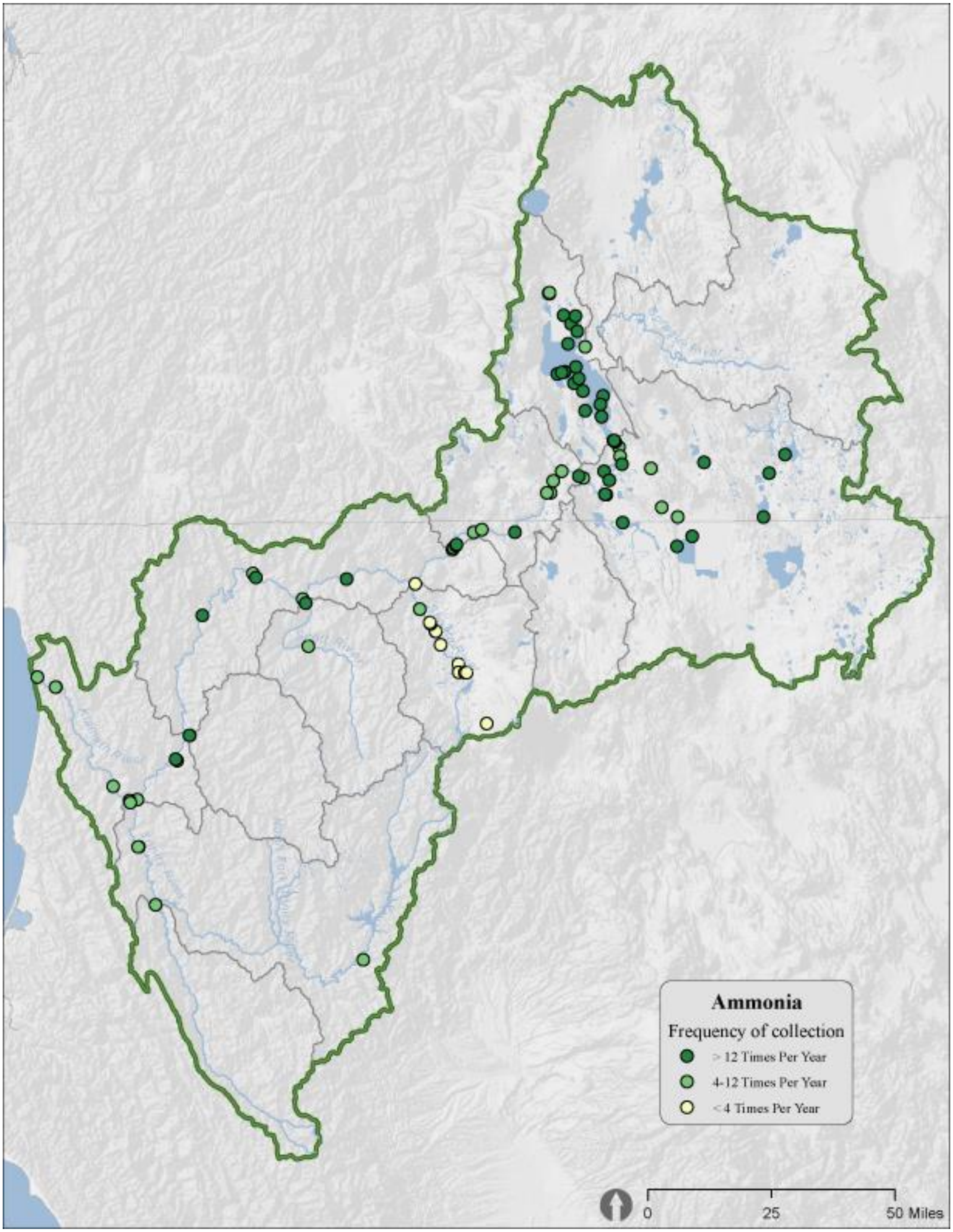


Figure 5: Ammonia monitoring throughout the Klamath Basin.

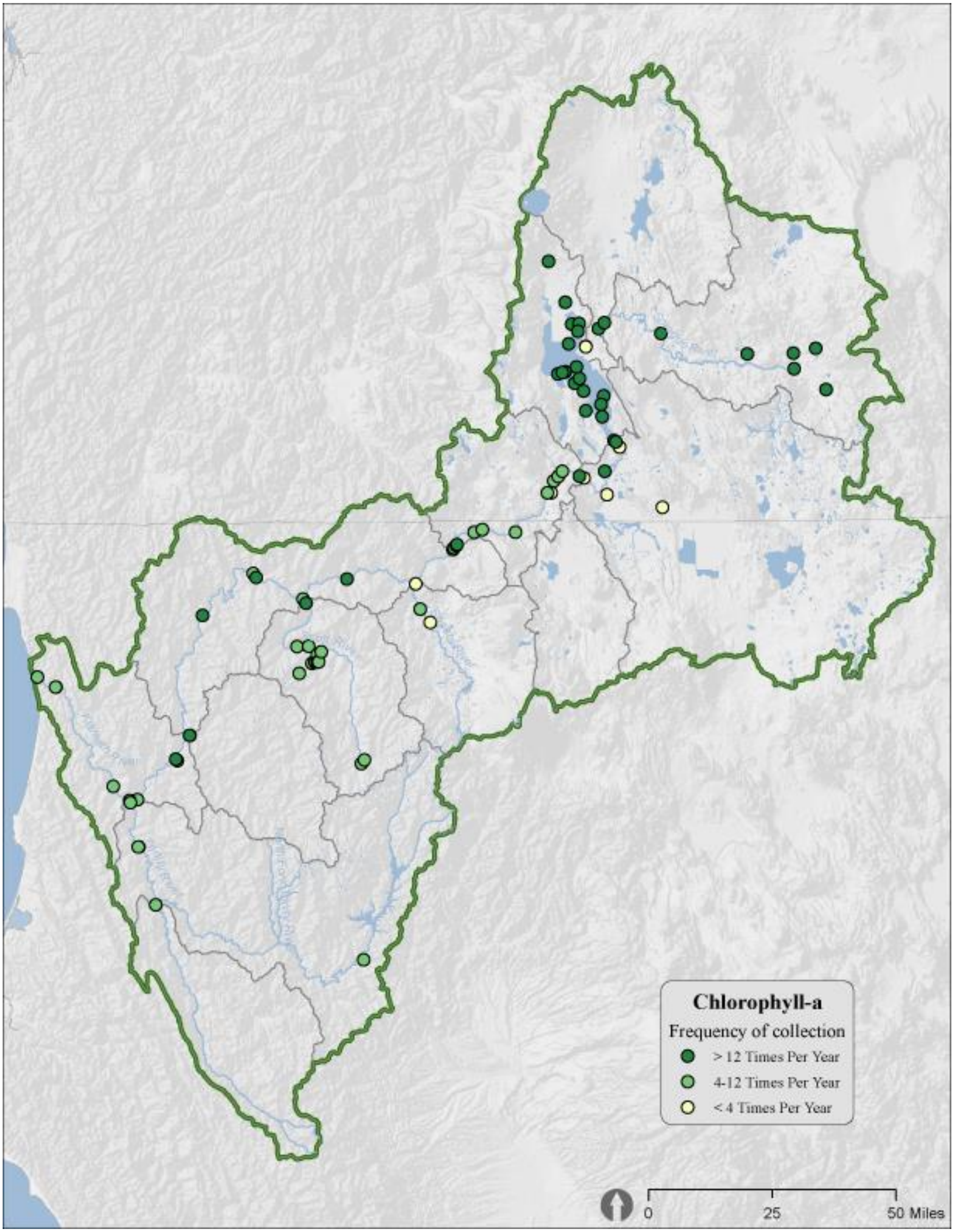


Figure 6: Chlorophyll-a monitoring throughout the Klamath Basin.

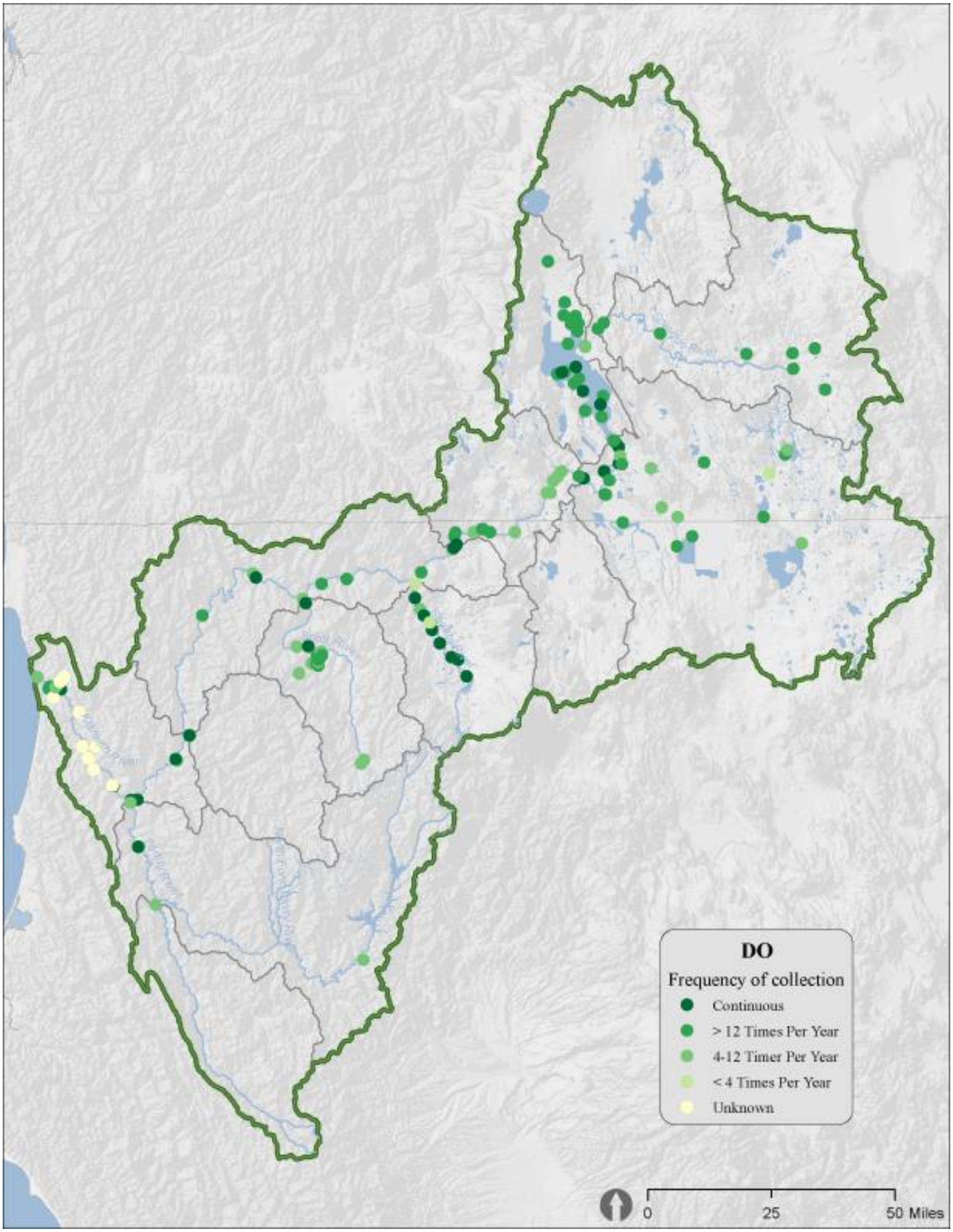


Figure 7: Dissolved oxygen monitoring throughout the Klamath Basin.

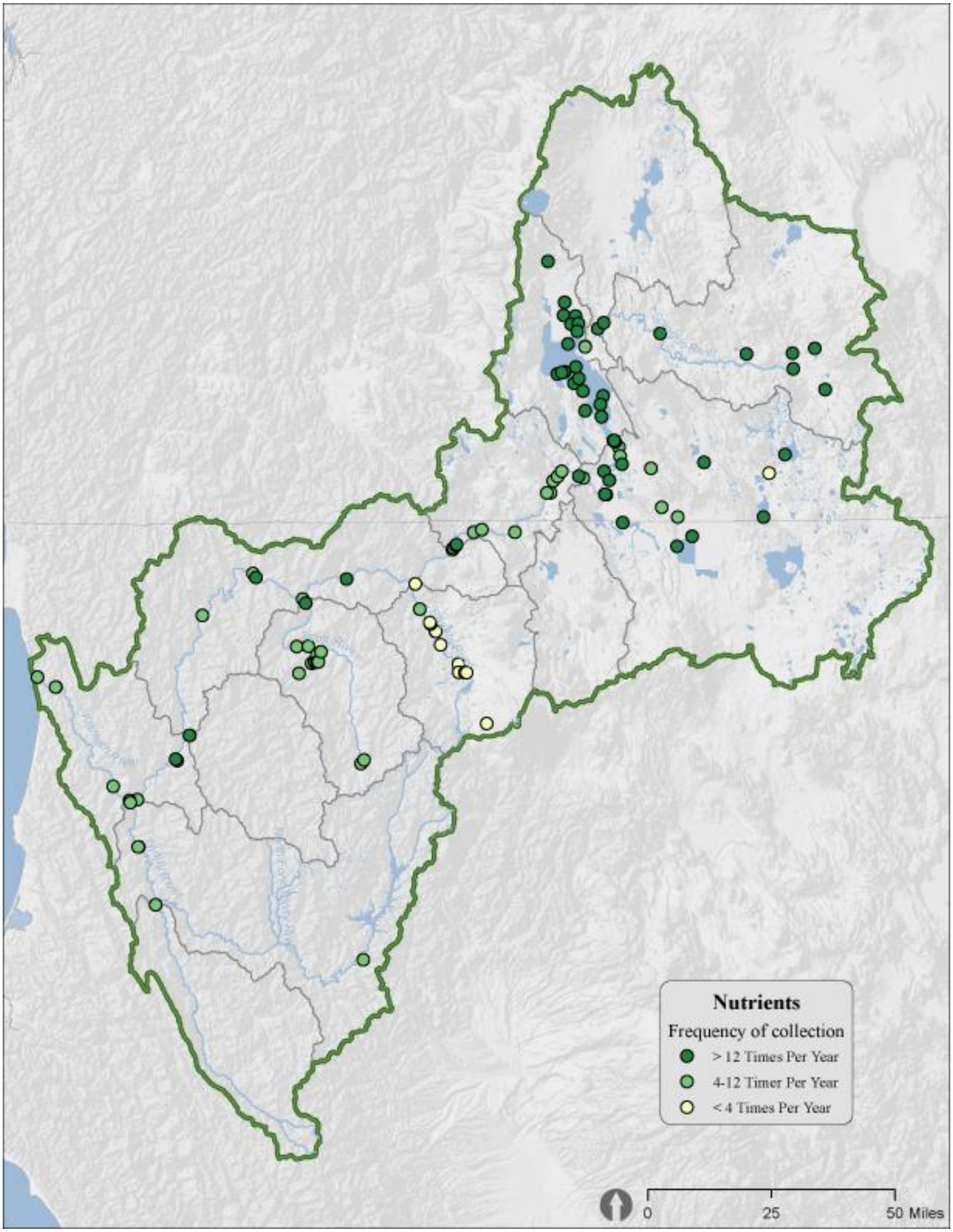


Figure 8: Nutrient monitoring throughout the Klamath Basin.

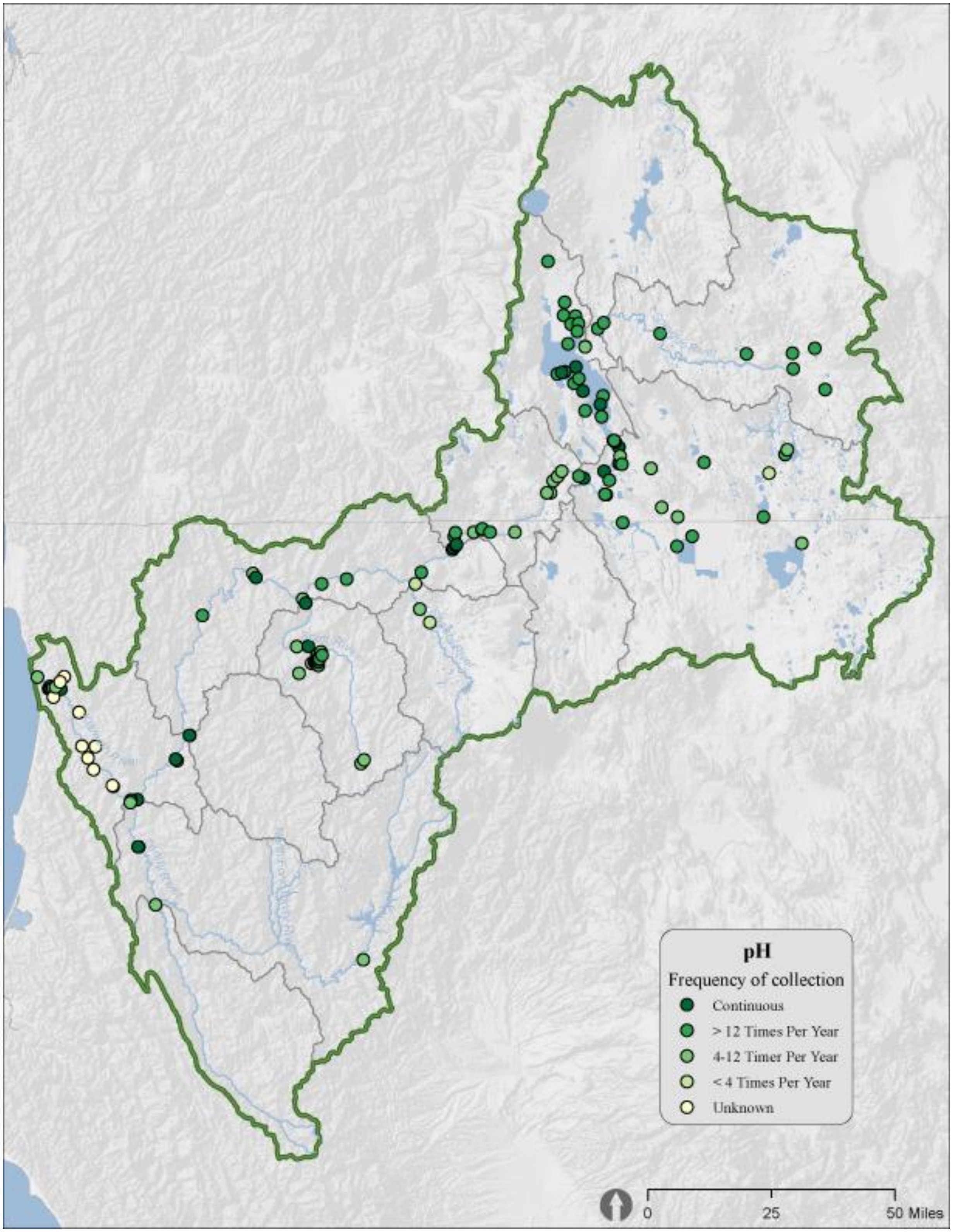


Figure 9: pH monitoring throughout the Klamath Basin.

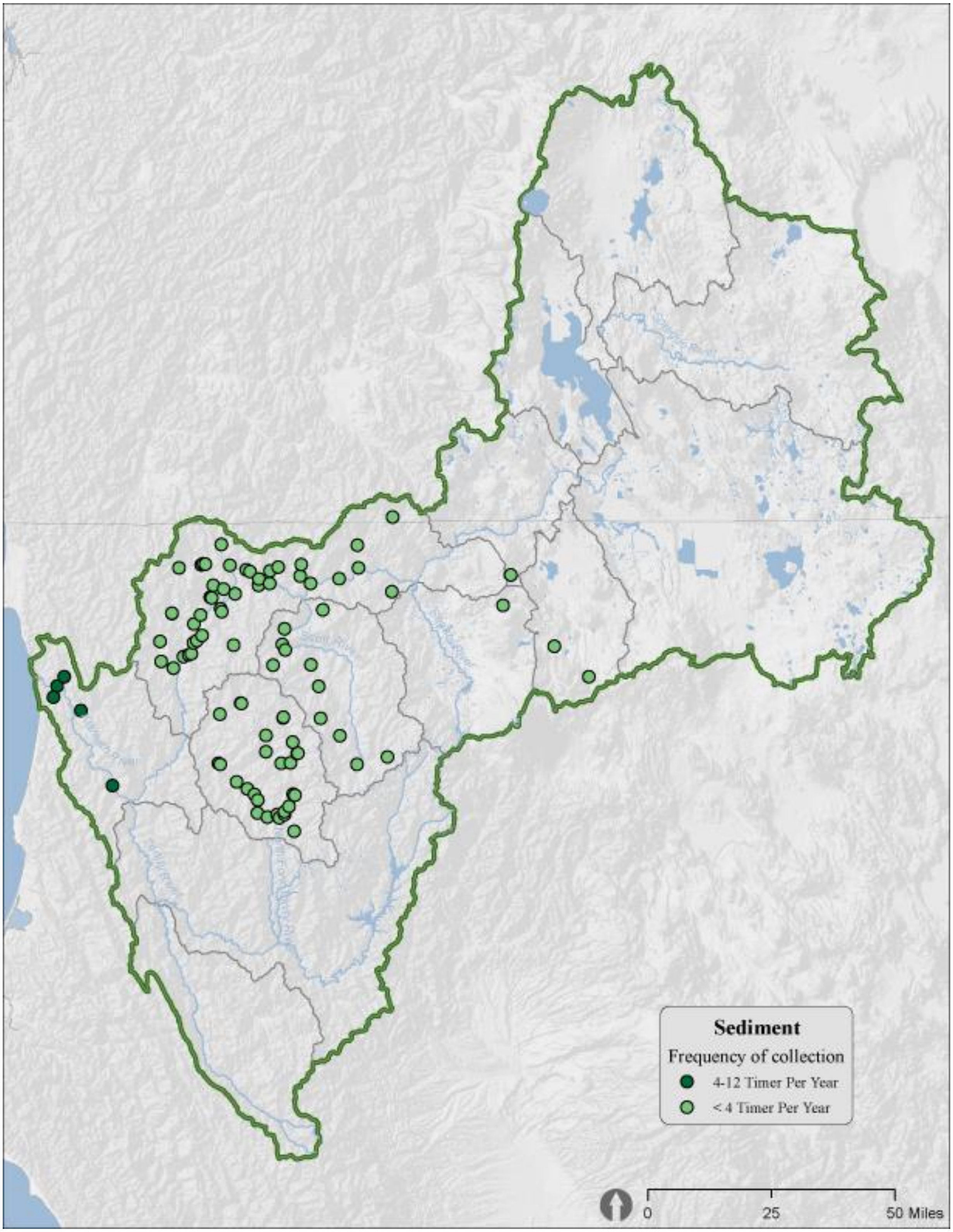


Figure 10: Sediment monitoring throughout the Klamath Basin.

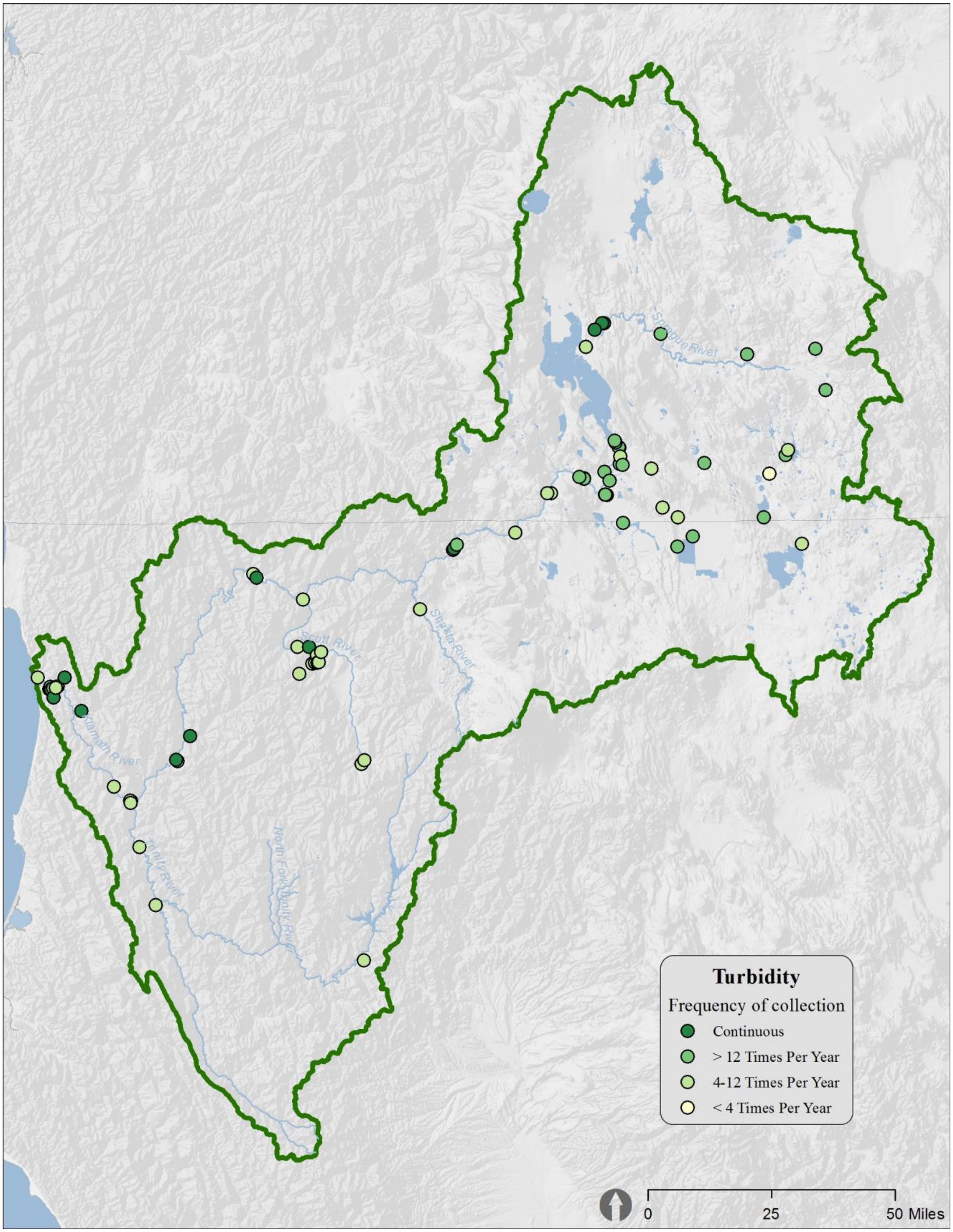


Figure 11: Turbidity monitoring throughout the Klamath Basin.

3.0 Goals and Objectives

The Klamath Basin Water Quality Monitoring Plan has been developed to reflect the vision and mission of the KBMP and the regulatory agencies' goals and objectives, such as achieving objectives within the Total Maximum Daily Load allocations, administered by California's Regional Water Quality Control Board and the Oregon Department of Environmental Quality. Through a collaborative process the KBMP drafted both a vision and mission for the organization as well as goals and objectives for the Monitoring Plan.

3.1 KBMP Vision and Mission

The vision and missions statements as developed by KBMP are presented below.

Vision

The mission of the KBMP is to implement, coordinate and collaborate on water quality monitoring and research throughout the Klamath Basin. The KBMP provides guidance and technical support for monitoring activities, and promotes the sharing of high quality data to inform resource management within the basin.

Mission

The Klamath Basin Monitoring Program facilitates the coordination and implementation of water quality monitoring in support of the stewardship, protection, and restoration of all beneficial uses within the Klamath River watershed, with the ultimate goal of restoring water quality.

3.2 RWQCB and ODEQ Regulatory Program Goals and Objectives

Oregon and California water quality regulatory agencies (RWQCB and ODEQ) have developed goals and objectives regarding water quality monitoring efforts. Both the RWQCB and ODEQ aim to identify water quality issues that limit or impair beneficial uses of a water body, and emphasize water quality protection and enhancement. The RWQCB employs state-wide monitoring program (SWAMP) with, consistent and objective monitoring, sampling and analytical methods; consistent data quality assurance protocols; and centralized data management to facilitate their objectives, and ODEQ has a similar program (WQX). In addition, the NCRWQCB has adopted the goal of using watershed stewardship adaptive management frameworks within Klamath Sub-basins through the integrated use of collaborative subbasin monitoring frameworks, project development, and project tracking as illustrated in Figure 12.

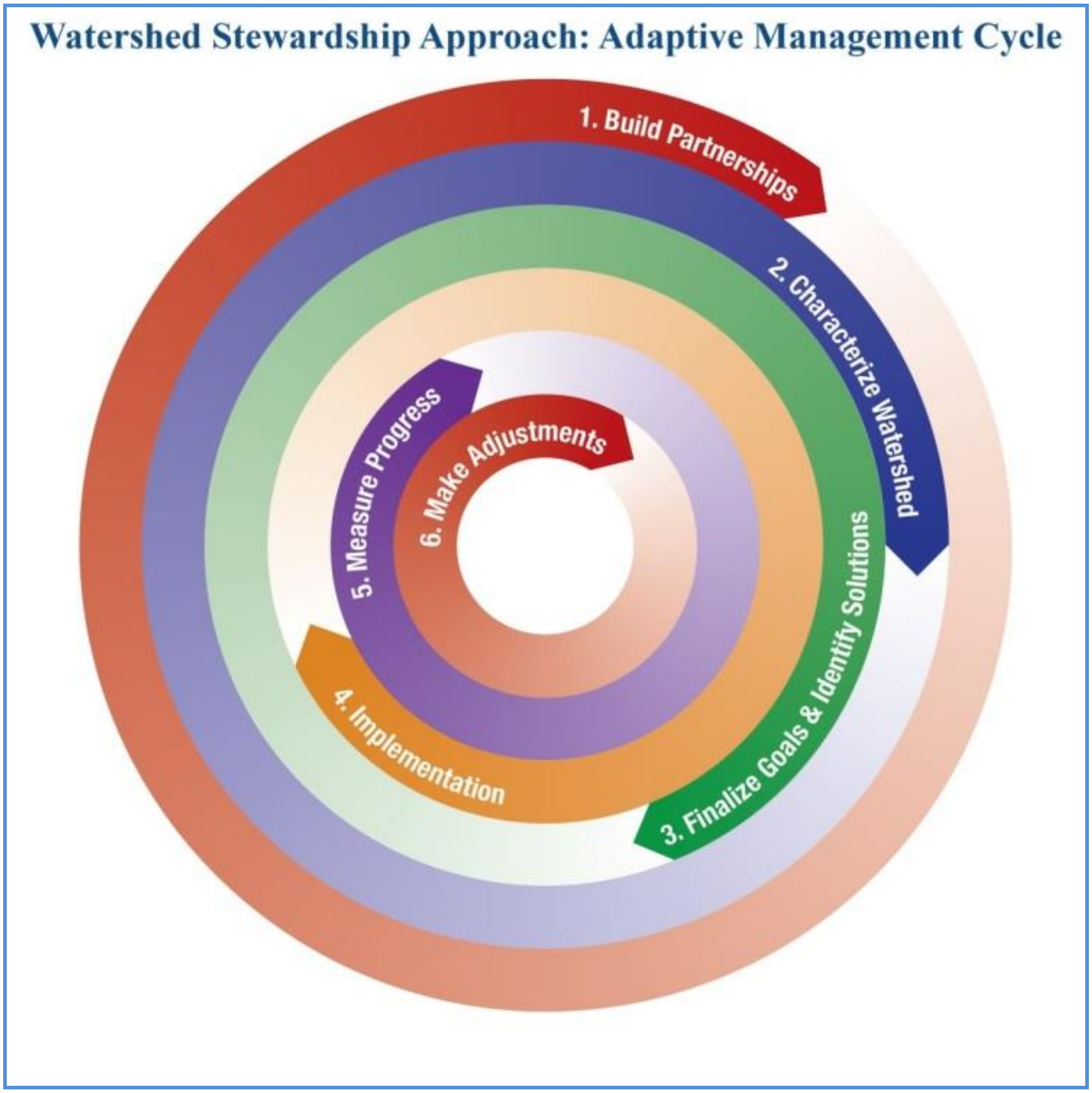


Figure 12: Watershed Stewardship Approach: Adaptive Management Cycle

See Appendix II for a complete list of RWQCB and ODEQ Regulatory Program Goals and Objectives.

3.3 Klamath Basin Water Quality Monitoring Plan Goals and Objectives

Many of the goals outlined by the RWQCB and ODEQ are echoed by the KBMP Vision and Mission statements and Monitoring Plan Goals and Objectives. The KBMP Water Quality Subcommittee drafted goals and objectives for the Monitoring Plan that seek to develop and maintain long-term monitoring network of sites that capture status and trends of selected indicators throughout the basin over time and space. The specific goals of the Monitoring Plan are listed below:

- Develop and maintain a coordinated long-term monitoring network of sites that capture status and trends of selected indicators throughout the Klamath Basin over time and space
- Coordinate monitoring activities to inform TMDL development and implementation and achievement of action plan goals
- Frame monitoring objectives in terms of supporting beneficial uses and improving the understanding of the ecology of the Klamath Basin
- Strive for consistent quality assurance and control regarding all monitoring activities
- Provide accessible data in a timely manner to better inform regulatory agencies, organizations, tribal community and the public
- Identify and document the effects of climate change and supply data to support climate change models to enhance the understanding of future impacts on water quality within the Klamath Basin.

Regarding the consistency of goals and objective posed by RWQCB and ODEQ, the one goal and objective that is not directly identified by either the RWQCB or the ODEQ is to document the effects of climate change on water quality within the basin. Climate change, in the state of California is expected to dramatically alter water resources. The California Climate Change Center predicts increased temperature, reduced snowpack, truncated rainy season and increased fire frequency and severity (CCCC, 2006). There is currently a data gap concerning the implications of climate change for Klamath Basin.

4.0 Coordinated Regional Monitoring Plan

4.1 Overview

The two key components to the Klamath River Basin Water Quality Monitoring Sites are existing legacy sites and identified special studies. The backbone of the network is built on legacy sites identified by organizations conducting monitoring in the basin as well as TMDL Action Plan trend and compliance monitoring sites identified to date NCRWQCB and ODEQ. For each monitoring location the rational / purpose as well as beneficial uses are identified. Currently the monitoring network consists of baseline monitoring parameters agreed upon by the Steering Committee (Table 1). The list of parameters does not represent the extent of measured parameters, but rather a set of agreed upon essential parameters basin-wide. Justification of the analytes can be reviewed in section 4.7 of this document. Also built into the Klamath Basin Water Quality Monitoring Plan are mechanisms for updating and evaluating the success of the Plan (Appendix III) as well as adopting special studies (Chapter 8, Appendix IV). Special studies are defined projects that will help improve monitoring measurements or the interpretation of monitoring data, in particular by elucidating cause-effect relationships.

Monitoring sites were selected based upon their ability to track water quality affecting the most sensitive of beneficial uses as well as large-scale trends in water quality. The monitoring sites were selected using 303(d) listing as well as regional expertise over the scope of the Basin. Since 303(d) listings are based on water quality impairment to beneficial uses, adequate sampling at the subbasin scale may be evaluated for meeting the goals and objectives of the RWQCB, ODEQ and KBMP. Regional expertise, key personnel actively collecting water quality data, participated by crafting and addressing water quality concerns through the “Big 5 Questions”.

The “Big 5 Questions” were drafted by the Water Quality Monitoring Subcommittee in an effort to characterize water quality issues within each subbasin. For each subbasin in the Klamath Basin a representative from the Water Quality Monitoring Subcommittee answered the following questions:

- What are the baseline trends?
- ∗ Does water quality support beneficial uses?
- ∗ How is the water quality affected by climate change?
- ∗ What are the effects of regulatory actions on water quality?
- ∗ What are the effects of land and water management actions on water quality?

The goal of the “Big 5 Questions” was in part to address water quality concerns not identified by 303(d) listings as well as establish baseline for future evaluation under the antidegradation section of the Clean Water Act. As part of the Clean Water Act, antidegradation policies are designed to maintain high quality waters. Responses to the “Big 5 Questions” have been incorporated into the subbasin sections of this document, for the full responses refer to Appendix I.

The KBMP Water Quality Subcommittee also recognized the importance of consistent quality assurance and control and standard operating procedures regarding all monitoring activities. These areas of concern are address in chapters 6 and 7.

4.2 Defining Subbasin Boundaries

Traditionally hydrologic regions are distinguished using a U. S. Geologic Survey system divided and sub-divided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are arranged within each other, from the smallest (cataloging units) to the largest (regions). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system (Seaber et. al. 1987). In California, however, there is the CalWater system which delineates the hydrologic units further into watershed and subwatershed. In the CalWater system, the USGS equivalent to an accounting unit is called a basin, and a cataloging unit is called a subbasin.

Members of Water Quality Subcommittee felt the CalWater system best represented the subbasin delineation in the lower basin. The CalWater system is different than the USGS subbasin delineation. Under the USGS delineation, the Middle Klamath subbasin is not represented. Under the CalWater system, the Middle Klamath subbasin at the upper border is delineated by the Iron Gate Dam, an administrative boundary, and at the lower border the mouth of the Salmon River. Iron Gate Dam on the Klamath River is generally accepted as the boundary between the upper and lower basin, an important distinction for management purposes (NRC, 2008). For consistency, the CalWater definitions of basin and subbasin are employed nearly throughout the Klamath Basin Water Quality Monitoring Plan except for a recent separation of the Lake Ewauna/Keno Reservoir reach to be consistent with the Klamath Tracking and Accounting Program reporting zones, as seen in Figure 13.

.

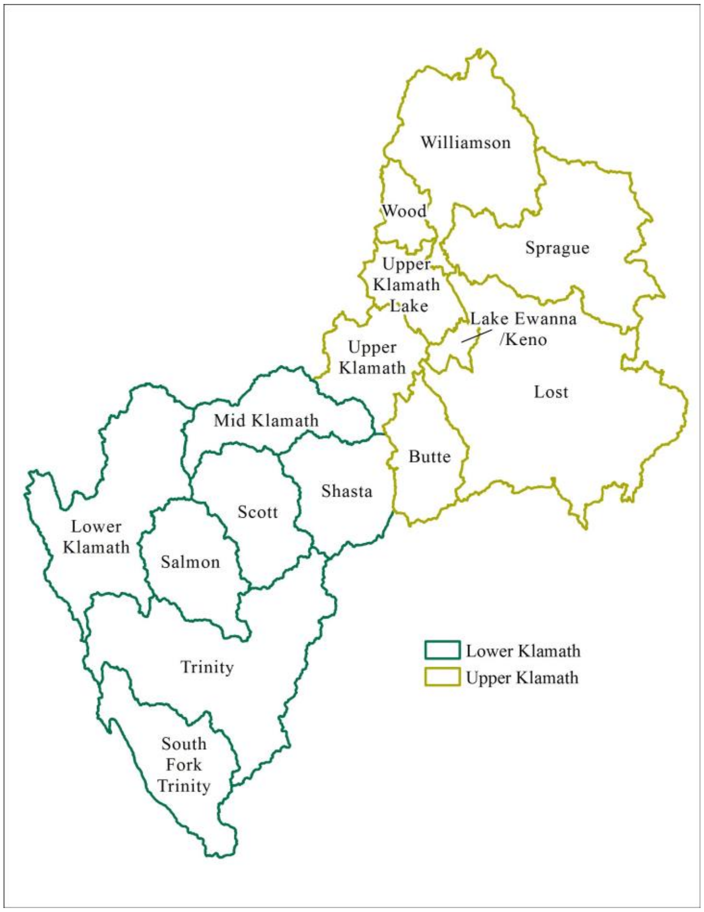


Figure 13: Klamath River Subbasin Boundaries based on Klamath Tracking and Accounting Program Reporting Zones

4.3 Conceptualizing the Scope

The combination of elevated temperatures, nutrients, pH, depressed dissolved oxygen have been attributed to increased incidence of fish disease and reduction of habitat, high concentrations of toxic blue green algae and disrupted traditional cultural uses of the river by resident Tribes (NCRWQCB 2010).

Fish disease may be a primary contributor to salmon decline in the Klamath Basin. *Ceratonova (syn Ceratomyxa) shasta*, a myxozoan parasite, poses a lethal threat to salmonid stocks in the Basin. C. shasta affects salmonid primarily in the digestive tract, but may also be present in the liver, gall bladder, spleen, gonads, kidney, heart, gills, and muscle tissue. Mortality as a result of infection varies depending on host resistance, temperature and infection dose, and juvenile Chinook and Coho salmon exposed to the parasite infected with *C. shasta* may have mortality as high as 98% (Hallett et al. 2012; Ray et al. 2012; Stocking et. al., 2006). *C. shasta* has a complex life cycle involving a polychaete worm (*Manayunkia speciosa*) host, as well as salmon. Low velocity flows and nutrient rich habitat sometimes associated with algae (*Cladophora*), as well as eddies and sand / silt deposits (Jordan 2012) provide ideal habitat for *M. Speciosa* (Stocking and Bartholomew, 2004; Stocking, 2006).

The overlap between returning infected salmonids and polychaete worms (*M. speciosa*), downstream from Iron Gate Dam results in elevated prevalence of infection in polychaetes, with a "hot zone" of high parasite densities occurring between the confluence with the Shasta River and Indian Creek (Stocking and Bartholomew, 2007, Bartholomew and Hallett, unpublished data). Non-dynamic hydrologic regimes (e.g. 2010) in these river sections may allow the establishment of high densities of *M. speciosa*, as it supports low velocity habitat (Stillwater, 2009).

The presence of and severity of nuisance algae in the Klamath basin are strongly influenced by nutrient elevated concentrations. *Microcystis aeruginosa*, toxic blue green algae, in the Klamath River poses a health risk for recreational, and cultural uses and the associated toxin microcystin, may pose a consumptive health risk (Kann and Corum, 2006; Kann and Corum, 2007; Kann, 2007). Some research has noted that some sections Klamath River are more often limited by nitrogen than phosphorus (Hoopa TEPA, 2008; PacifiCorp 2006). To better understand nutrient as well as organic enrichment and temperature dynamics, the North Coast Regional Water Quality Control Board, for the development of the *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California,* developed peer reviewed [conceptual models] that illustrate the linkage between primary stressors (e.g., excess phosphorous), environmental processes, and critical endpoints including Beneficial Uses (see pages 32 and 33 in above link).

The water quality conceptual models are useful for visualizing the relative contribution to impairments throughout the Basin (Figures 14, 15, 16) as estimated by the TMDL model. Water Quality Conceptual Models, describe the technical approach used in the problem statement assessment identified in the *Klamath River TMDLs Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California*. As stated in the draft TMDL, the conceptual models, "[a]im to ensure a comprehensive assessment and decision framework. The Regional Water Board has adopted the technical approach from the California Nutrient Numeric Endpoints (CA NNE) framework and TMDL models. The CA NNE is used to assess and describe the water quality impacts associated with nutrient and organic enrichment and temperature alteration. The approach involves the development of conceptual models that illustrate how key factors and processes link the primary stressors (nutrients and organic enrichment, and altered temperature regime) with impacts on beneficial uses” (NCRWQCB, 2010).

Similar to the (CA NNE) framework, the TMDL model, illustrates the broadest impact of modeled water quality impairments to the Klamath Basin conceptual source loadings of Carbonaceous Biological Oxygen Demand (CBOD), phosphorus, and nitrogen (Figures 14, 15, and 16 respectively) through the Basin (NCRWQCB, 2010). The conceptual source loading models indicate that the bulk of nitrogen, phosphorus and CBOD reside in the mainstem, with little contribution from the main contributing subbasins (Shasta, Scott, Salmon, and Trinity Rivers). High levels of nitrogen and phosphorus in waterbodies has the potential to impact basin-wide water quality by increasing primary production. Increases in primary production cause fluctuations in dissolved oxygen, increases in pH in such a weakly buffered system, and the potential to increase ammonia. CBOD is associated with bacteria in the water breaking down the organic material through chemical processes that consume oxygen from the water column. The amount of oxygen potentially consumed by this process is referred to as the CBOD (EPA, 2008).

The goal of this Plan is to develop a monitoring network that captures the magnitude and origin of water quality impairments and best represents status and trends in water quality, aiding in the enhancement of existing water quality models, compliance and trend monitoring, and restoration of beneficial uses.

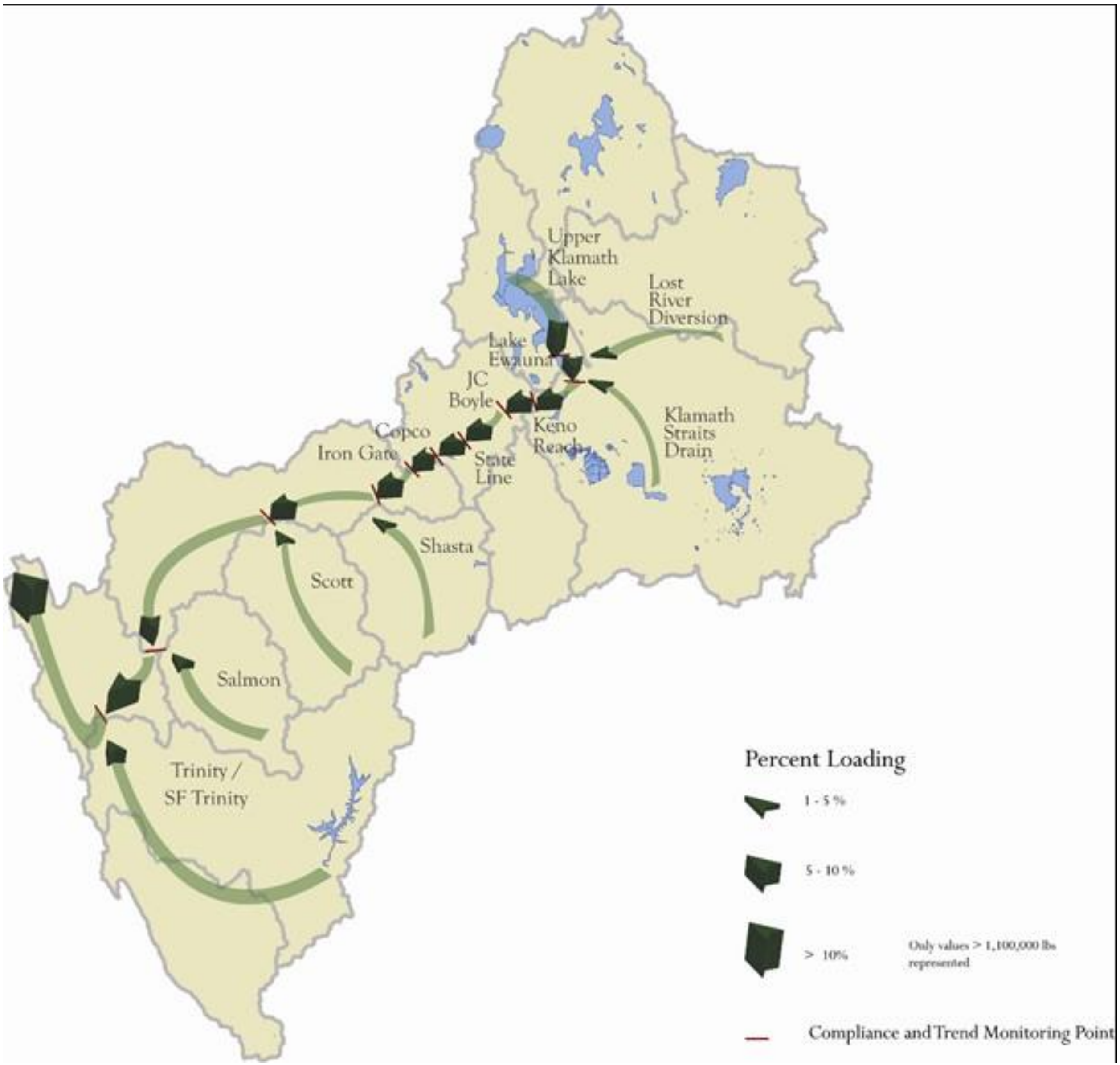


Figure 14: Flow diagram of Carbonaceous Biological Oxygen Demand (CBOD) based on source loading TMDL model; arrows represent percent of total existing conditions (NCRWQCB 2008).

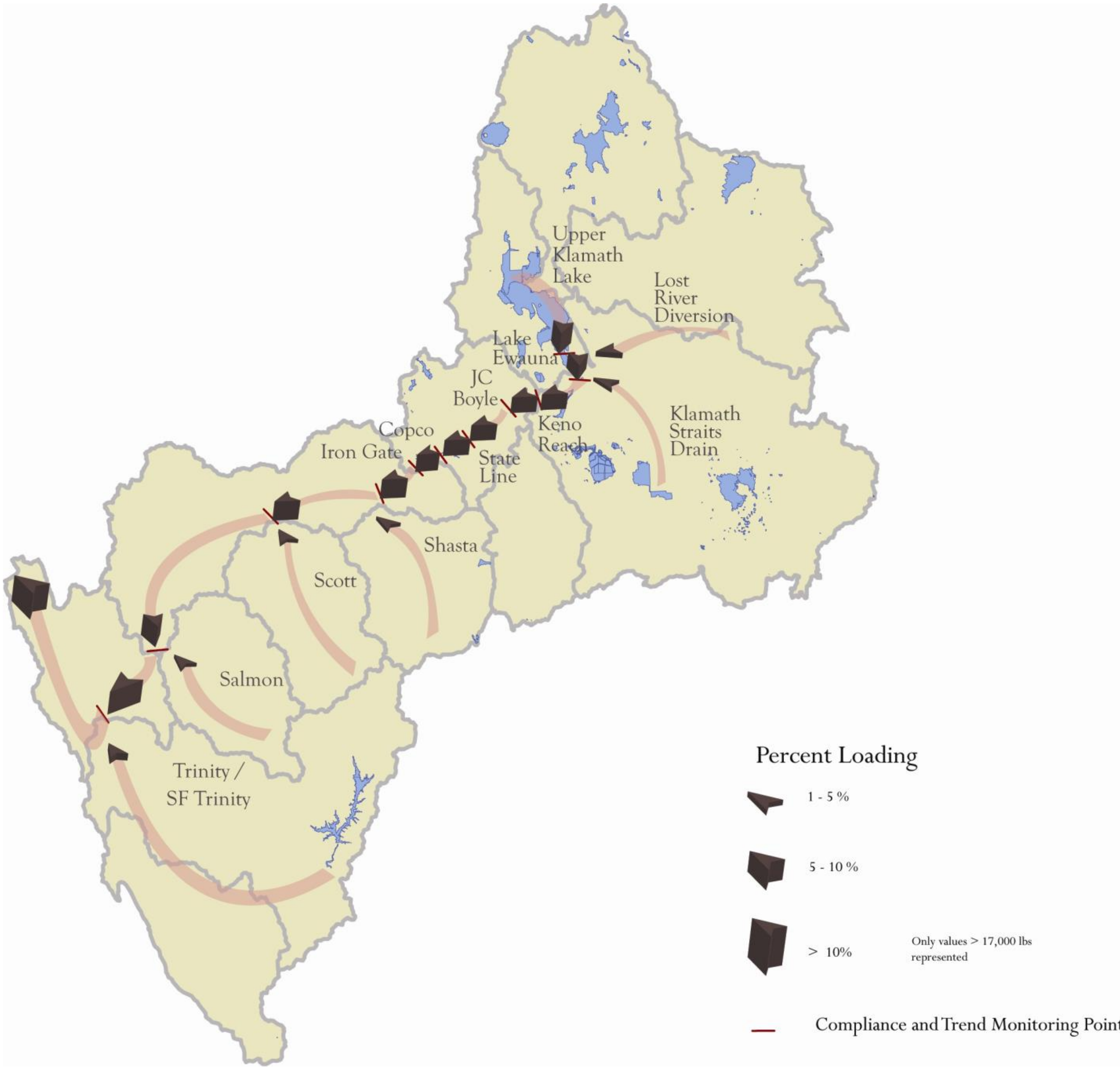


Figure 15: Flow diagram of Phosphorus based on source loading TMDL model; arrows represent percent of total existing conditions (NCRWQCB 2008).

Figure 16: Flow diagram of Nitrogen based on sources loading TMDL model; arrows represent percent of total existing conditions (NCRWQCB 2008).

Table 4: TMDLs in the Klamath River Basin. Data sources EPA 2008, NCRWQCB 2008.

Subbasins	TMDL(s)	Agency
Sprague and Williamson River	Dissolved oxygen, chlorophyll-a, and pH, temperature	ODEQ
Upper Klamath and Agency Lakes	Dissolved oxygen, chlorophyll-a, pH	ODEQ
Lower Lost River (OR)	DO, pH, ammonia toxicity, chlorophyll-a	ODEQ
Lower Lost River (CA)	CBOD, dissolved inorganic nitrogen	EPA
Klamath River (CA)	Nutrients, temperature, dissolved oxygen, sediment*, microcystin	NCRWQCB
Klamath River (OR)	Dissolved oxygen, pH, ammonia, chlorophyll-a	ODEQ
Shasta Subbasin	Temperature, dissolved oxygen	NCRWQCB
Scott Subbasin	Temperature, sediment	NCRWQCB
Salmon Subbasin	Temperature	NCRWQCB
Trinity and South Fork Trinity Rivers	Sediment	EPA

* Klamath River sediment impairments are being addressed through the temperature TMDL implementation plan which includes controls for sediment discharges.

4.4 Water Quality Sampling Parameters

See Appendix VI

Figure 17: Proposed water quality monitoring network of sites.

4.6 Proposed Long-term Site Locations and Rational and Purpose

See Appendix VII

4.7 Justification of Analytes

- **Temperature -** controls rate reactions in aquatic system and can be a stressor to aquatic life.

- **Dissolved Oxygen -** is important to aquatic ecosystem function. Low concentrations can be a stressor to certain aquatic life.

- **pH -** conditions are important for aquatic life, with typical acceptable pH concentrations in a range of 6 to 9. At elevated pH, unionized ammonia can be toxic to aquatic life, a condition exacerbated by elevated temperatures.

- **Conductance -** represents ions that are in solution. This parameter is often used as a conservative constituent and to identify inputs or effects of land use practices.

- **Inorganic/Organic N (ammonia, nitrate, nitrite, organic N) -** Inorganic nutrients (ammonia, nitrite, nitrate) are readily available for primary production. Nitrate is a component of fertilizers, sewage, and manure. Total nitrogen (organic plus inorganic forms) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms. Ammonia can be toxic to fish and other aquatic life at relatively low levels (unionized ammonia) when elevated pH and temperature conditions are present. The conversion of ammonia to nitrite and nitrate consumes oxygen.

- **Inorganic/Organic P (orthophosphate, organic P) -** Inorganic nutrients (orthophosphate) are readily available for primary production. Total phosphorus (organic plus orthophosphate) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms.

- **Particulate and Dissolved C (particulate and dissolved organic carbon) -** This is a measure of the organic matter within the system, and is necessary for the partitioning of organic matter fractions into particulate, dissolved, labile, and refractory. Organic matter consumes oxygen during decay and releases nutrients. Elevated levels of total organic carbon can cause an increase in biological oxygen demand, decreasing D.O. in the water column resulting in unfavorable conditions for aquatic life. Analysis of organic carbon is used to determine organic matter loads. Special studies will be used to identify stoichiometry of organic matter (C, N, and P fraction) and to partition particulate and dissolved matter into refractory and labile forms.

- **TSS/VSS (total and volatile suspended solids) -** TSS and VSS together define the organic (VSS) and inorganic (TSS-VSS) fraction of suspended material. Total Suspended Solids in the water column can impact aquatic life by clogging fish gills, decreasing foraging success, and ultimately can result in decreasing growth rates of fish inhabiting water with high levels of suspended solids. This provides insight on bulk organic matter loads, and coupled with inorganic suspended solids can be used to estimate light extinction.

- **Alkalinity -** Understanding alkalinity, helps to identify the buffering capacity of waters and the ability of an aquatic system to resist changes in pH (e.g., in response to primary production). Elevated pH levels my cause stressful conditions for aquatic life.

- **Water Column Chl-A/Pheo -** This measure of Chlorophyll-a and Phaeophytin-a (a breakdown product of chlorophyll-a) are indirect measurements of primary production, and can be used to estimate productivity. This parameter is well a recognized index of nutrient pollution (U.S. EPA, 2000).

- **Phytoplankton species -** Sampling is needed to identify species presence and absence. Determination of population variations can provide insight into trophic status, nutrient availability, BGA species, potential toxins and health advisories. Consideration should be given to further reducing the sampling frequency in mid-winter.

- **Microcystin -** The California 2006 Section 303(d) list identified microcystin as an impairment in the segment from and including the Copco Reservoirs down to Iron Gate Dam, including the segment of Klamath River between those reservoirs. California's 2008 *Public Review Draft Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters* (Regional Water Board 2008) recommends that the mainstem Klamath River from downstream of Iron Gate Dam to the confluence of the Trinity River be listed as impaired for microcystin (Klamath River from Iron Gate Dam to Scott River - Middle Klamath River HA, and from Scott River to the Trinity River - Middle & Lower Klamath River HA).

- **CBOD -** Carbonaceous Biological Oxygen Demand (CBOD) is associated with bacteria in the water breaking down the organic material through chemical processes that consume oxygen from the water column. The amount of oxygen potentially consumed by this process is referred to as the CBOD (EPA, 2008). CBOD loading are calculated as part of the Klamath TMDL.

5.0 Water Quality Background by Subbasin

Given the size of the Klamath Basin, water quality issues facing each subbasin were evaluated individually by member(s) of the Water Quality Subcommittee. Members addressed the "Big 5 Questions" (Appendix 1) in an effort to characterize water quality issues facing individual subbasins. Responses were incorporated into the background section as well as the limiting factors section. The limiting factors section refers to impairment affecting the subbasin identified by the regulatory agencies as well as subcommittee members. Recommendations for monitoring are indicated by the NCRWQCB, ODEQ as well as the Water Quality Subcommittee.

The KBMP Water Quality Subcommittee recommended a consistent and a comparable set of water quality parameters to be measured throughout the Basin. The Water Quality Subcommittee identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. The Water Quality Subcommittee also recommended CBOD for Oregon and continuous sediment monitoring for California. Sampling frequency includes bi-monthly sampling May through October and monthly sampling the remainder of the year, including punctuated flow event sampling.

5.0.3 Williamson, Sprague, and Upper Klamath Lake

Background:

Located in Oregon, the Williamson and Sprague Rivers supply about one-half of the inflow to Upper Klamath Lake. The drainage area for Upper Klamath Lake is about 3,800 square miles (ODEQ, 2002). The major tributaries to the lake are the Williamson and Wood Rivers. The Williamson River is the largest, with substantial amount of its flow derived from the Sprague River. The Williamson River subbasin and the Sprague River subbasin have a drainage area of approximately 3,000 square miles and constitutes 79% of the total drainage area that contribute to Upper Klamath Lake (ODEQ 2002). The Sprague River has a drainage area of 1,580 square miles 53 percent of the Williamson River subbasin (ODEQ, 2002).

Upper Klamath and Agency Lakes are large (235.4 and 35.6 km^2, respectively), shallow (mean depth approximately 2 meters), hypereutrophic lake systems. Low dissolved oxygen and pH water quality violations have led to the 1998 303(d) listing of both Upper Klamath and Agency Lakes (ODEQ, 2002). Water quality standards have been established to protect the beneficial uses of Upper Klamath and Agency Lakes. The most sensitive beneficial uses are protected aquatic resources, including the endangered species (shortnose sucker, Lost River sucker), and interior redband trout (ODEQ, 2002). Other potentially affected beneficial uses include public Domestic Water Supply, Salmonid Fish Spawning (Trout), Private Domestic Water Supply, Salmonid Fish Rearing (Trout), Industrial Water Supply, Resident Fish and Aquatic Life, Irrigation, Wildlife and Hunting, Livestock Watering, Fishing, Boating, Water Contact Recreation, Hydro Power, Aesthetic Quality (Oregon Administrative Rules 350-41-0952) .

Land ownership in the Upper Klamath Lake drainage is predominantly private and United States Forest Service, accounting for 42.3% and 53.4% of the land area, respectively. Crater Lake National Park makes up 3% of the land area. Nearly 1% of the area is National Wildlife Refuge. Land use in the Upper Klamath Lake drainage is predominantly forested (69.4%) and shrubland/grassland (13.7%). Agriculture (farming) and grazing occur on 5.5% of the drainage. Wetlands and water make up 6% and 3.7% of the surface area, respectively.

There have been major alterations of land use in the watershed resulting in degradation of riparian regions and increased phosphorus loading in Upper Klamath Lake. Approximately, 110,000 acres have been converted from riparian habitat to flood irrigated land uses, including 35,000 acres of wetlands to pasture and agriculture on the lake periphery (ODEQ, 2002). Conversion to agricultural and livestock grazing and other related factors may account for nearly 90% of the external phosphorus loading to Upper Klamath Lake (Gearheart et al., 1995).

However, the increased levels of phosphorus in Upper Klamath and Agency Lakes during summer months are attributed to increases from internal loading via lake sediments during the summer period (Barbiero and Kann, 1994; Laenen and LeTourneau, 1996). On an annual average, internal phosphorus loading was approximately 61% of the total loading to the lake, while external loading comprised 39% of the total phosphorus sources, with each having a standard deviation of 9% (ODEQ, 2002).

Low dissolved oxygen and high pH levels have been linked to high algal productivity in both lakes (Kann and Walker, 2001). Chlorophyll-*a* concentrations exceeding 200 µg/l are frequently observed in the summer months (Kann and Smith, 1999). Algal blooms are accompanied or followed by excursions from Oregon's water quality standards for pH, dissolved oxygen and free ammonia (ODEQ, 2002). Based upon monitored levels of dissolved oxygen, pH and chlorophyll-a, both Agency Lake and Upper Klamath Lake have been designated as water quality limited for resident fish and aquatic life (ODEQ 303(d) List 1998).

Limiting Factors

Table 5: 303(d) list of stream segments that do not meet water quality standards within the Upper Klamath Lake Drainage.

Impairments	Region
Temperature	Perennial Streams of the Upper Klamath Lake Drainage
Dissolved Oxygen	Perennial Streams of the Upper Klamath Lake Drainage, Agency Lake, Upper Klamath Lake
pH	Perennial Streams of the Upper Klamath Lake Drainage, Agency Lake, Upper Klamath Lake, Sprague River
Chlorophyll-a	Upper Klamath and Agency Lakes

The KBMP Water Quality Subcommittee identified additional potential limiting factors to address: nutrient loading, phytoplankton interactions.

Recommendations

List of Recommendations from ODEQ WQCP (Conditions Assessment and Problem Description):

• Temperature: Williamson River, Sprague River Drainage, Agency Lake, Upper Klamath Lake, and tributaries based on exceedance of the numeric temperature criteria of the Oregon water quality standard.

• pH: Sprague River, mouth to North/South Fork, Agency, Upper Klamath lakes based on exceedance of numeric pH criteria of the Oregon water quality standard.
• DO: Agency, Upper Klamath Lakes, Sprague River, mouth to North/South Fork based on the toxicity absolute minimum criteria of 4.0 mg/l an Oregon water quality standard; also based on listing specifications for 'cold' or 'cool' water.
• Chlorophyll-a: Klamath and Agency Lakes. Listed as a surrogate measure for nuisance phytoplankton growth.
• Habitat*:* Three mile Creek, mouth to headwaters based on low pool frequency and minimal large woody debris occurrence, relative to ODFW benchmarks.

List of Recommendations from the (NCRWQCB)

Link River:
Collect a full suite of data, including temperature, DO, total PO4 (PO4-T), NH4/NH3, NO2/NO3, CBOD5, CBOD20, Inorganic Suspended Solid (ISS), chlorophyll-a, algal-biomass: chlorophyll-a ratio, algal C:N:P ratio, dissolved organic matter (C,N, and P), particulate organic matter (C, N, and P), alkalinity, pH, and flow.

Time span and frequency: Data should be collected on a weekly basis from June 1st to July 31st, as this period covers the most critical water quality conditions at this location. For DO and temperature, continuous data (i.e., on an hourly-basis) is recommended. Monitoring pre-dawn and afternoon concentrations of several key nutrients, such as PO4-T, NH4/NH3, NO2/NO3, and Chlorophyll-a would be ideal, in order to characterize the magnitude of diurnal fluctuation.

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

Specific recommendations for the Williamson, Sprague, and Upper Klamath Lake subbasin are monitoring of nutrient loading and phytoplankton interaction, in addition to monitoring 303 (d) listed impairments.

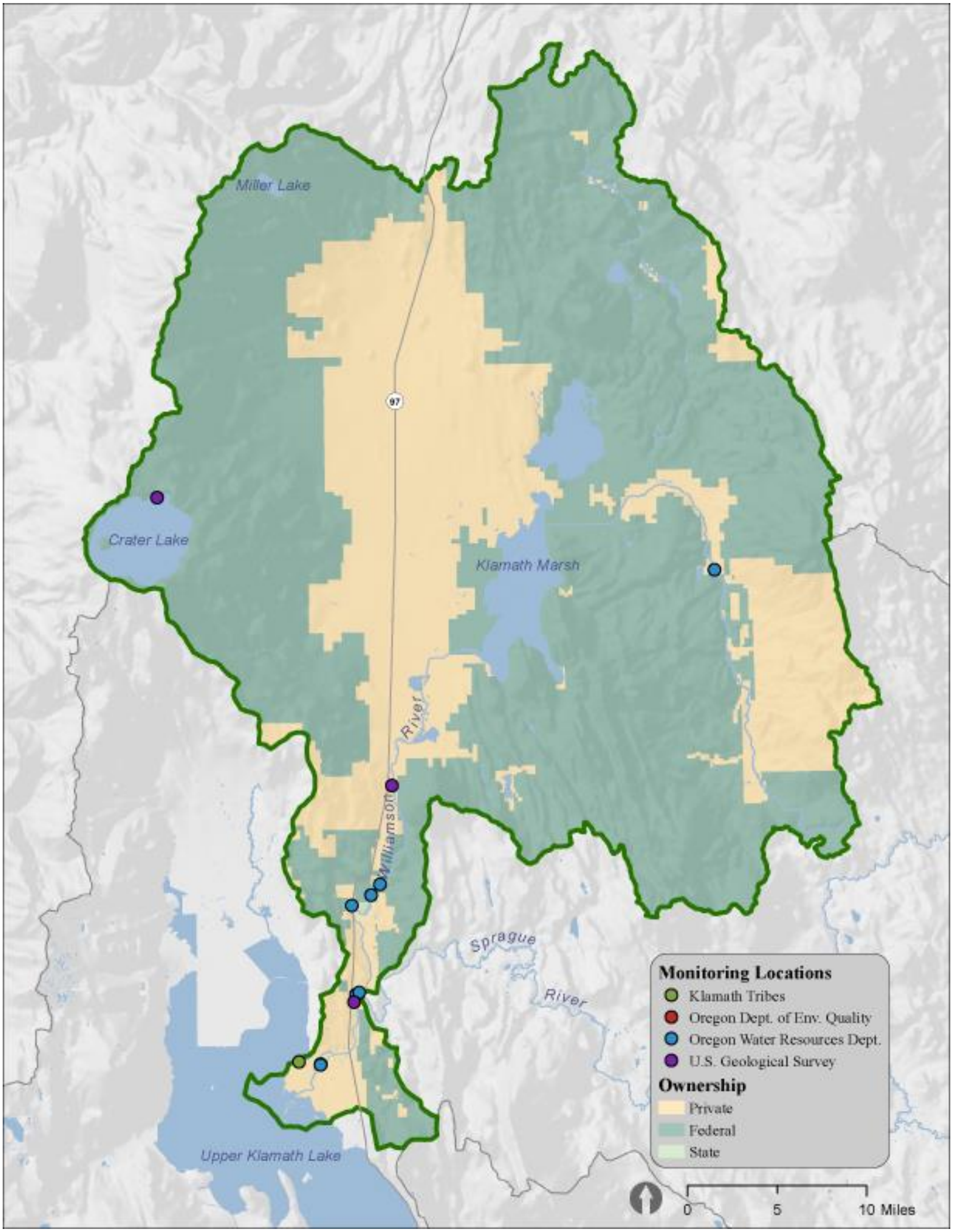


Figure 18: Williamson River subbasin with identified ownership and water quality monitoring by organizations.

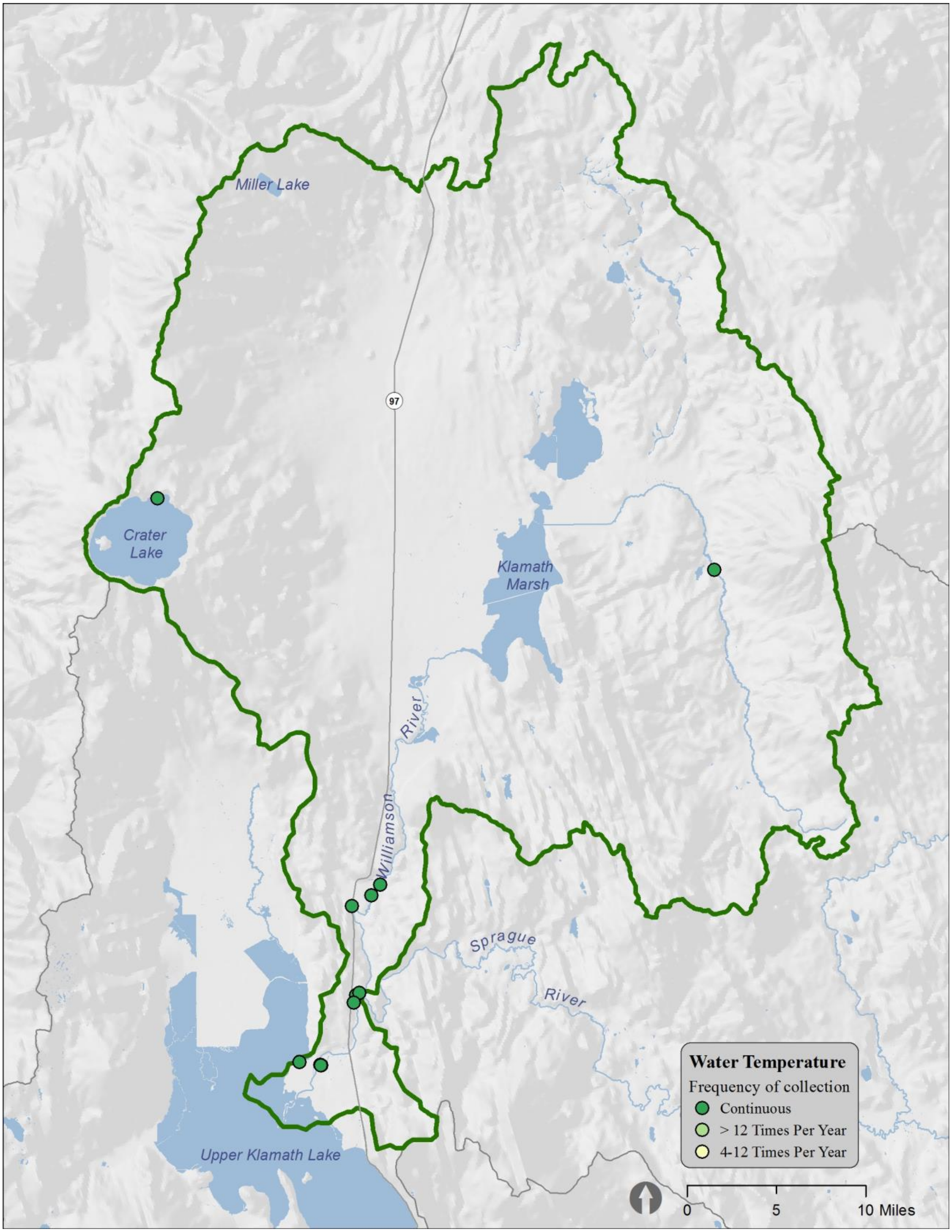


Figure 19: Water temperature monitoring in the Williamson River subbasin in 2014.

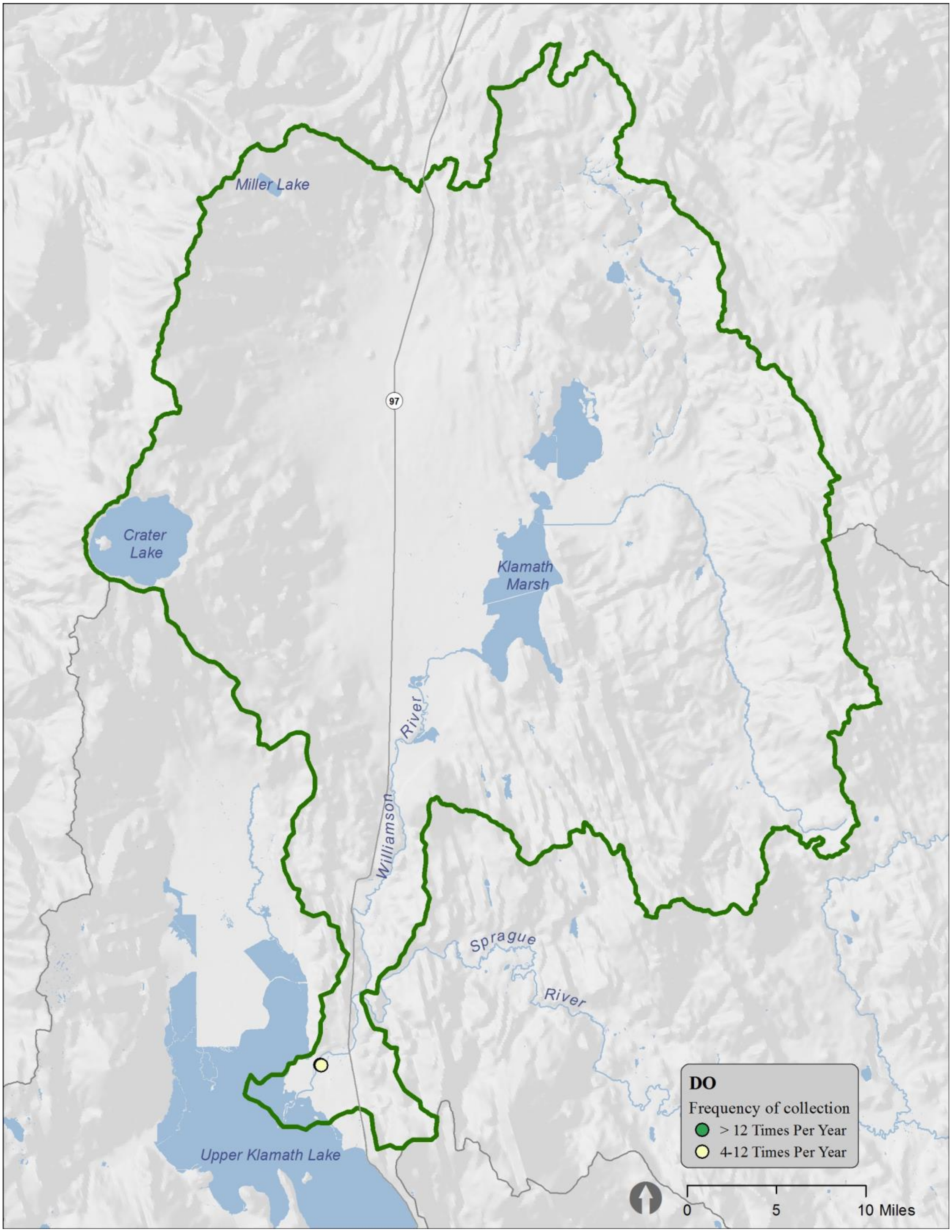


Figure 20: Dissolved oxygen monitoring in the Williamson River subbasin in 2014.

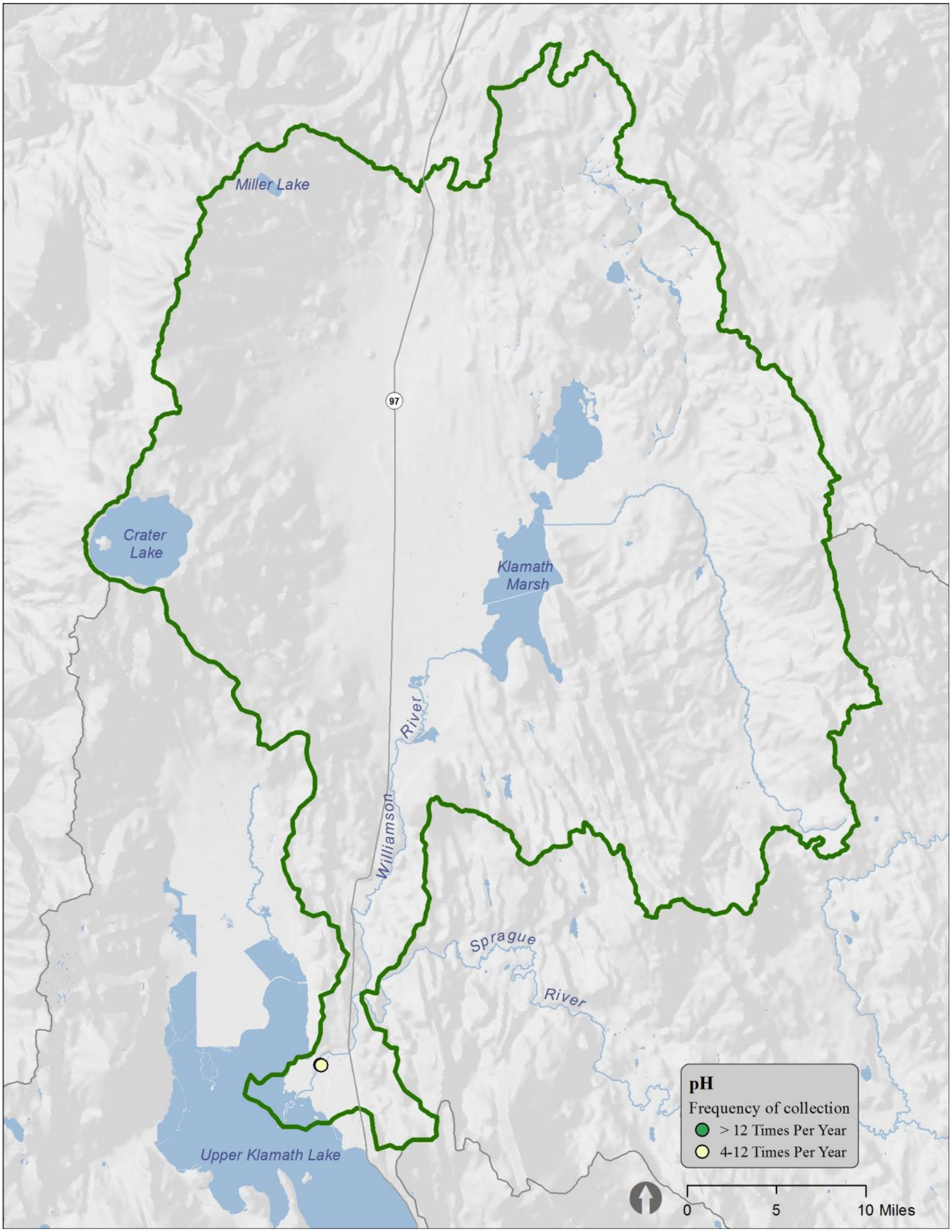


Figure 21: pH monitoring in the Williamson River subbasin in 2014.

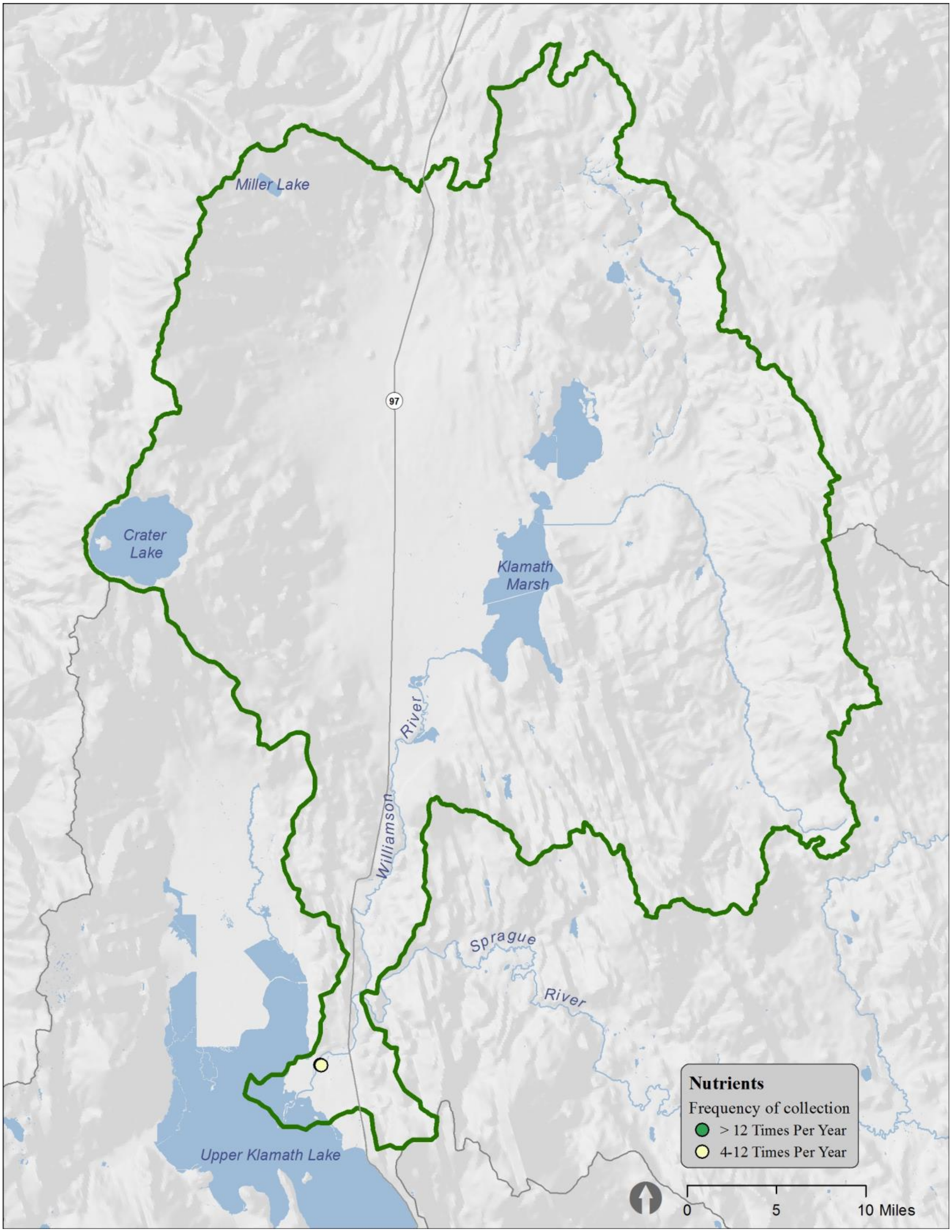


Figure 22: Nutrient monitoring in the Williamson River subbasin in 2014.

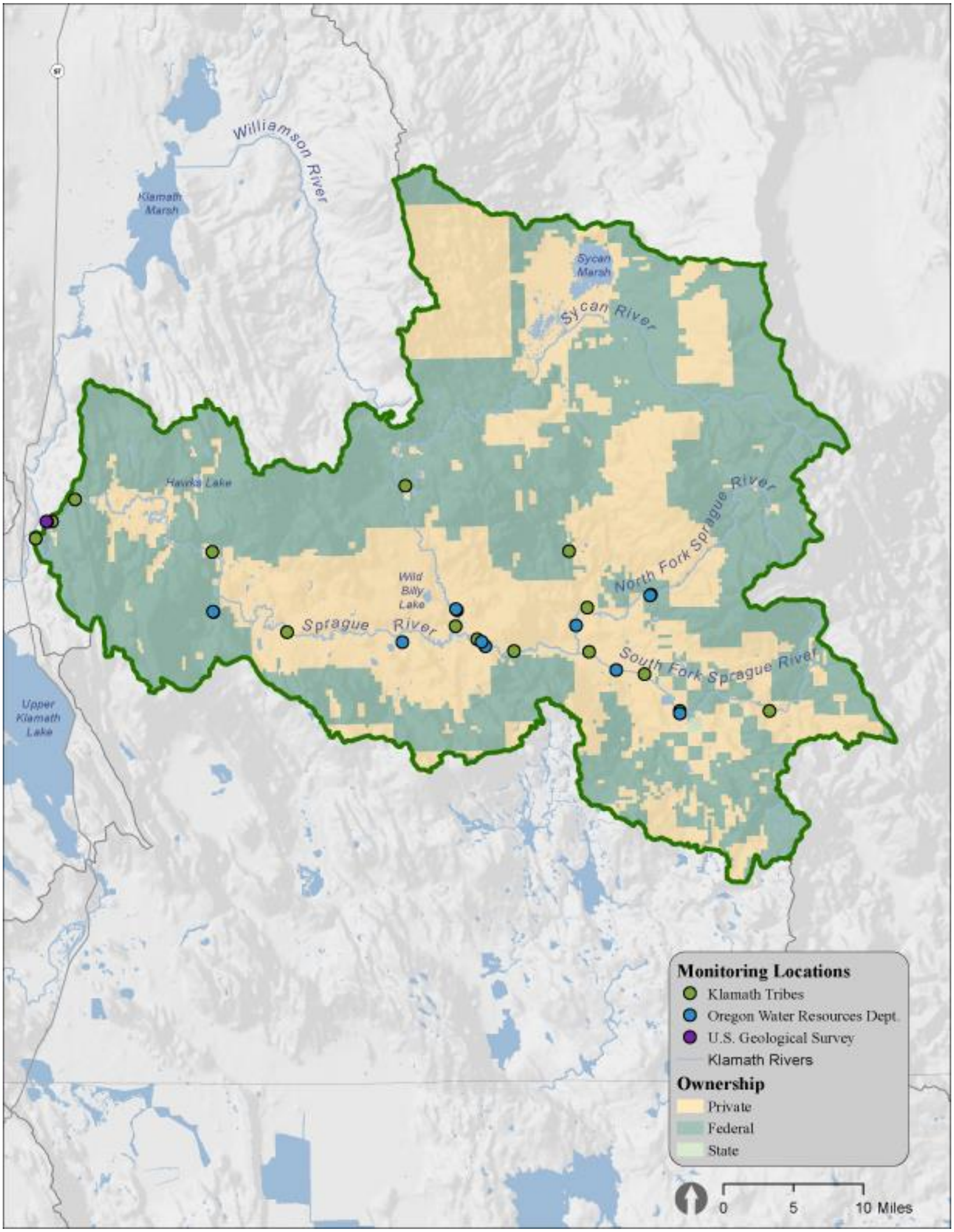


Figure 23: Sprague River subbasin with identified ownership and water quality monitoring organizations.

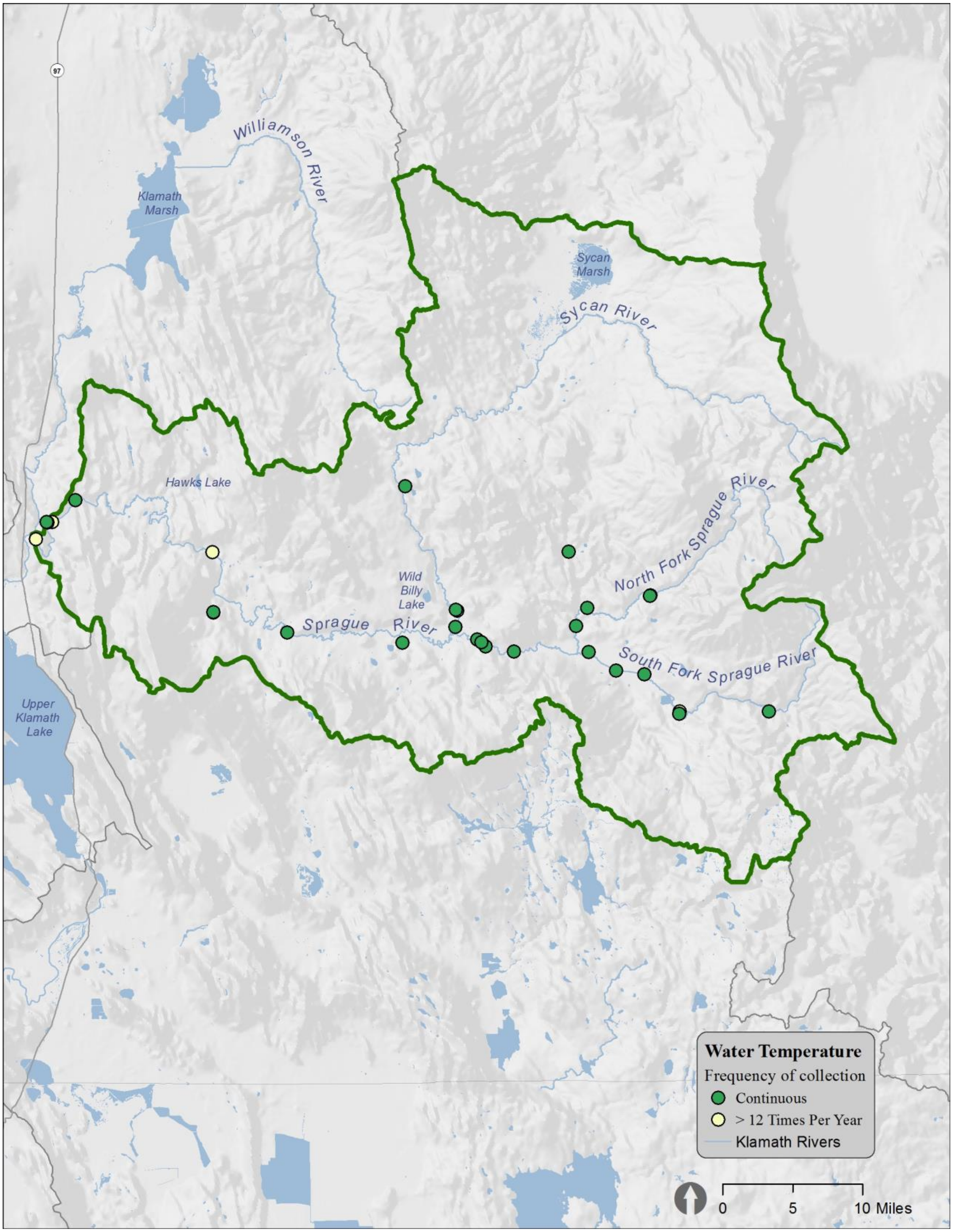


Figure 24: Water temperature monitoring in the Sprague subbasin in 2014.

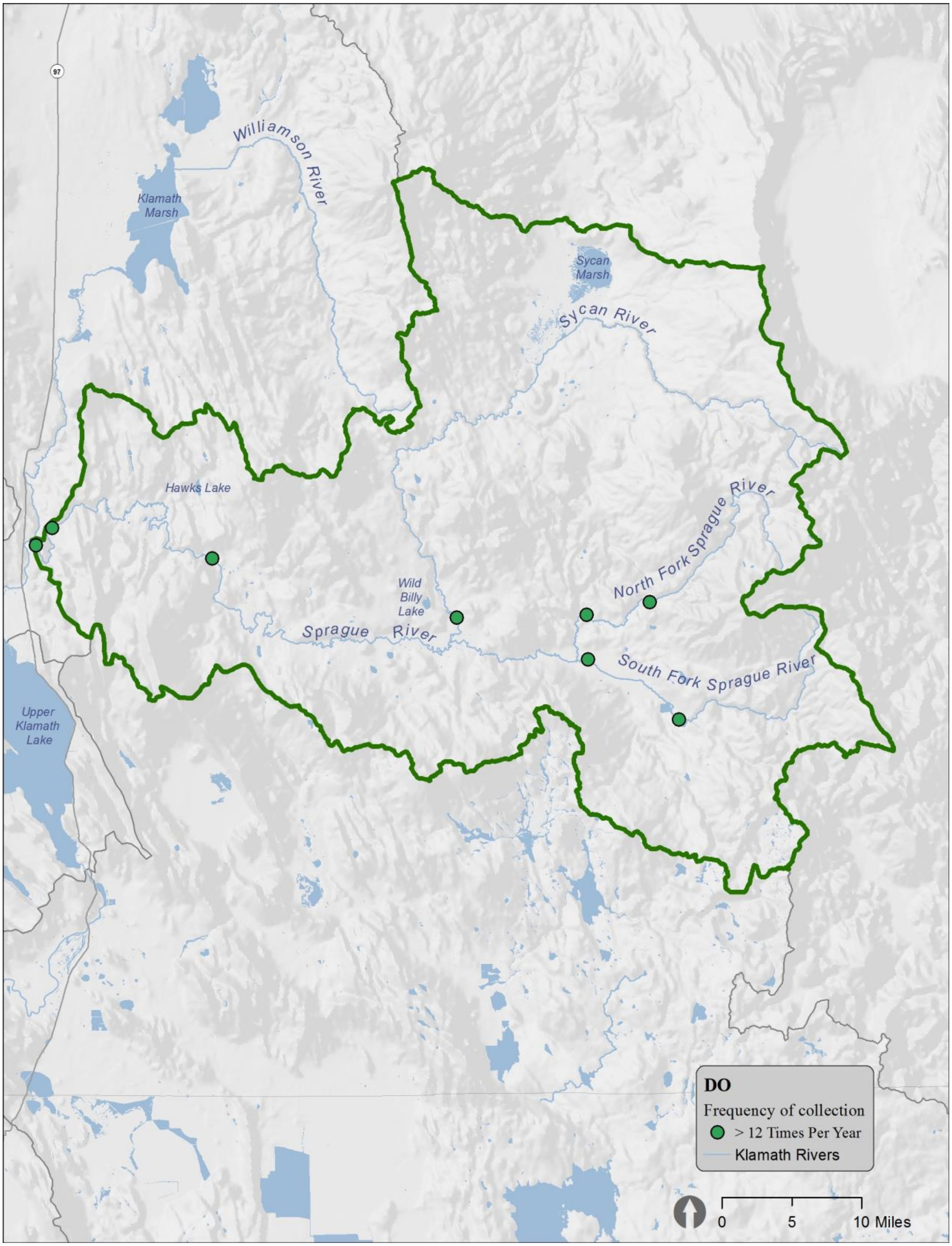


Figure 25: Dissolved oxygen monitoring in the Sprague subbasin in 2014.

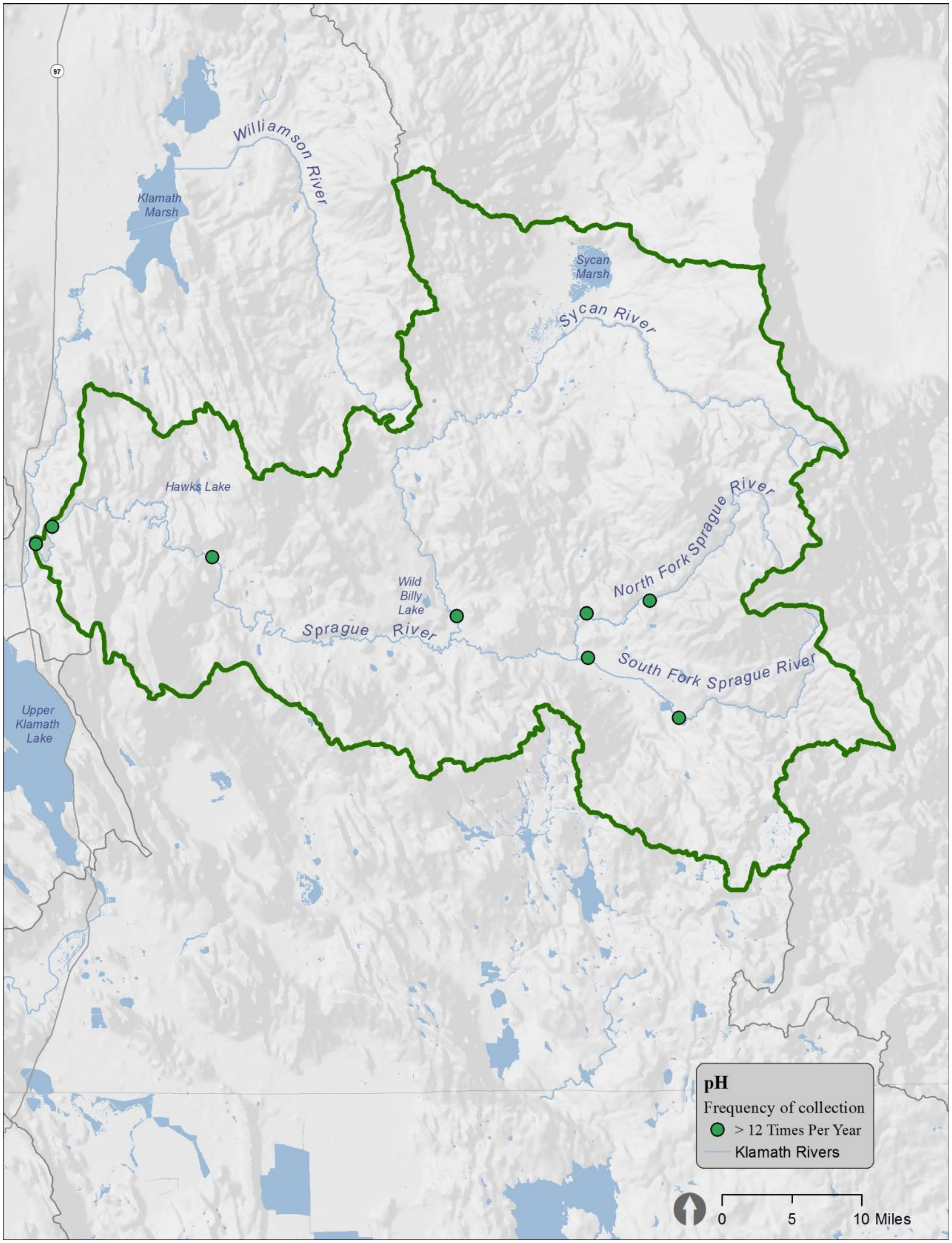


Figure 26: pH monitoring in the Sprague subbasin in 2014.

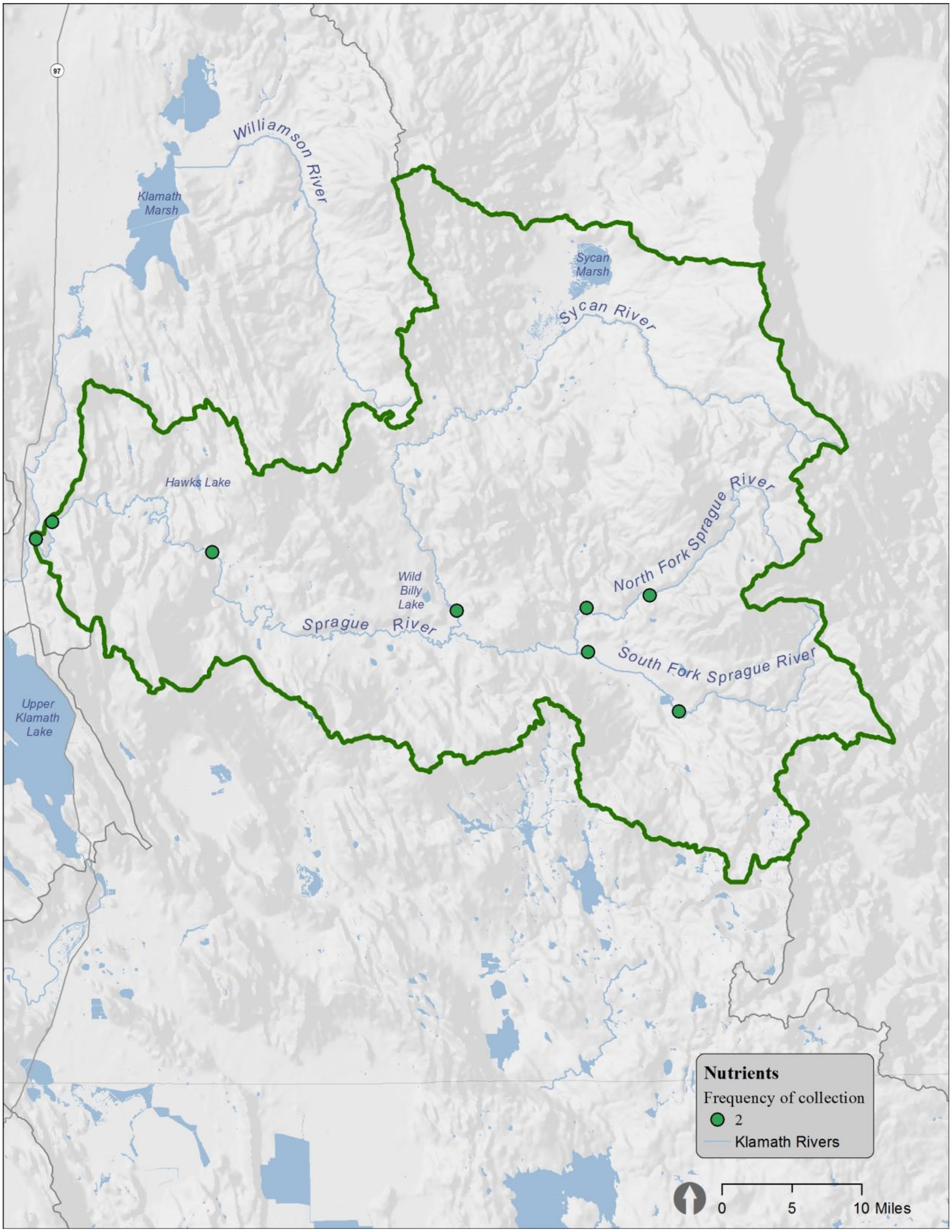


Figure 27: Nutrient monitoring in the Sprague subbasin in 2014.

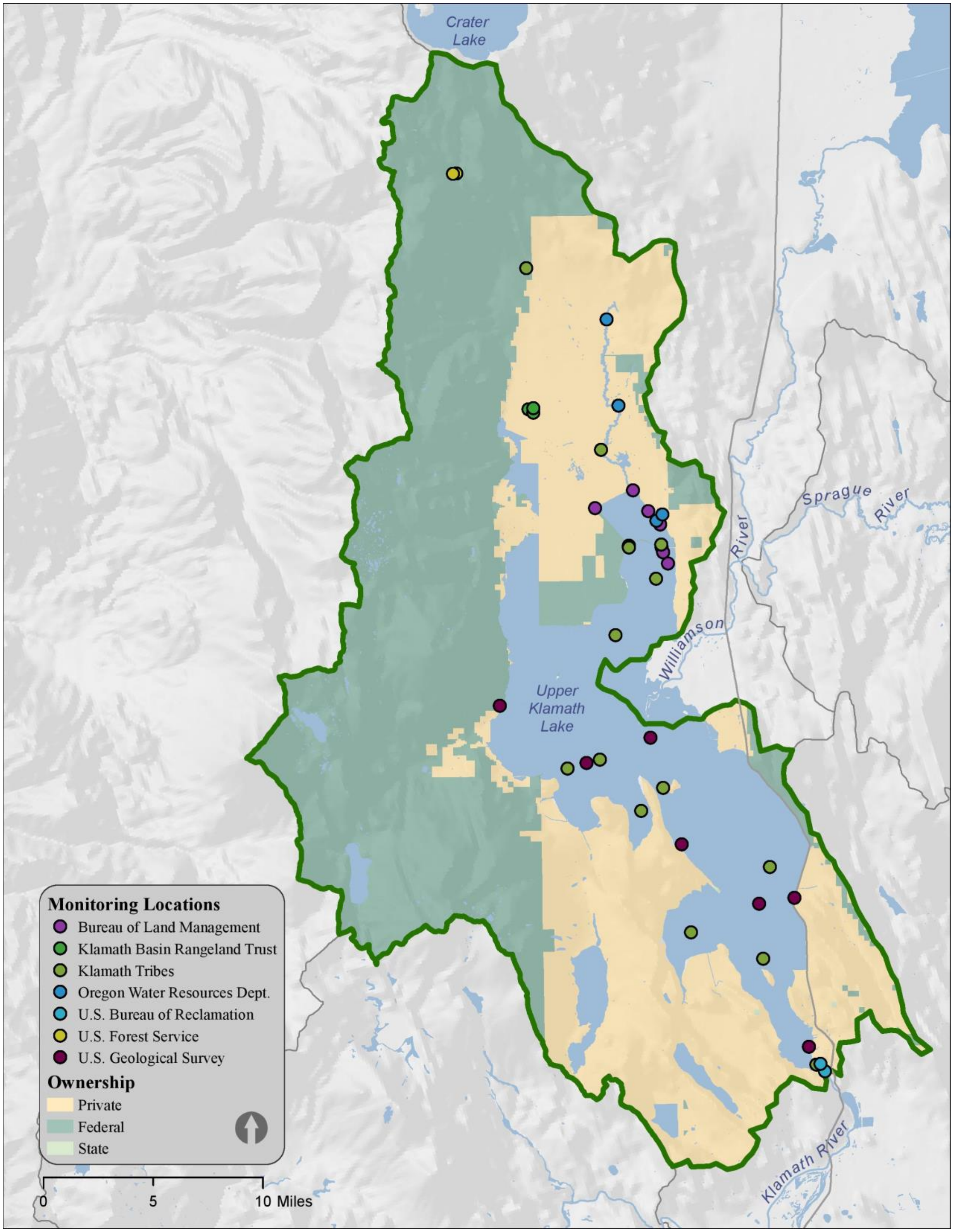


Figure 28: Upper Klamath Lake subbasin with identified ownership and water quality monitoring organization.

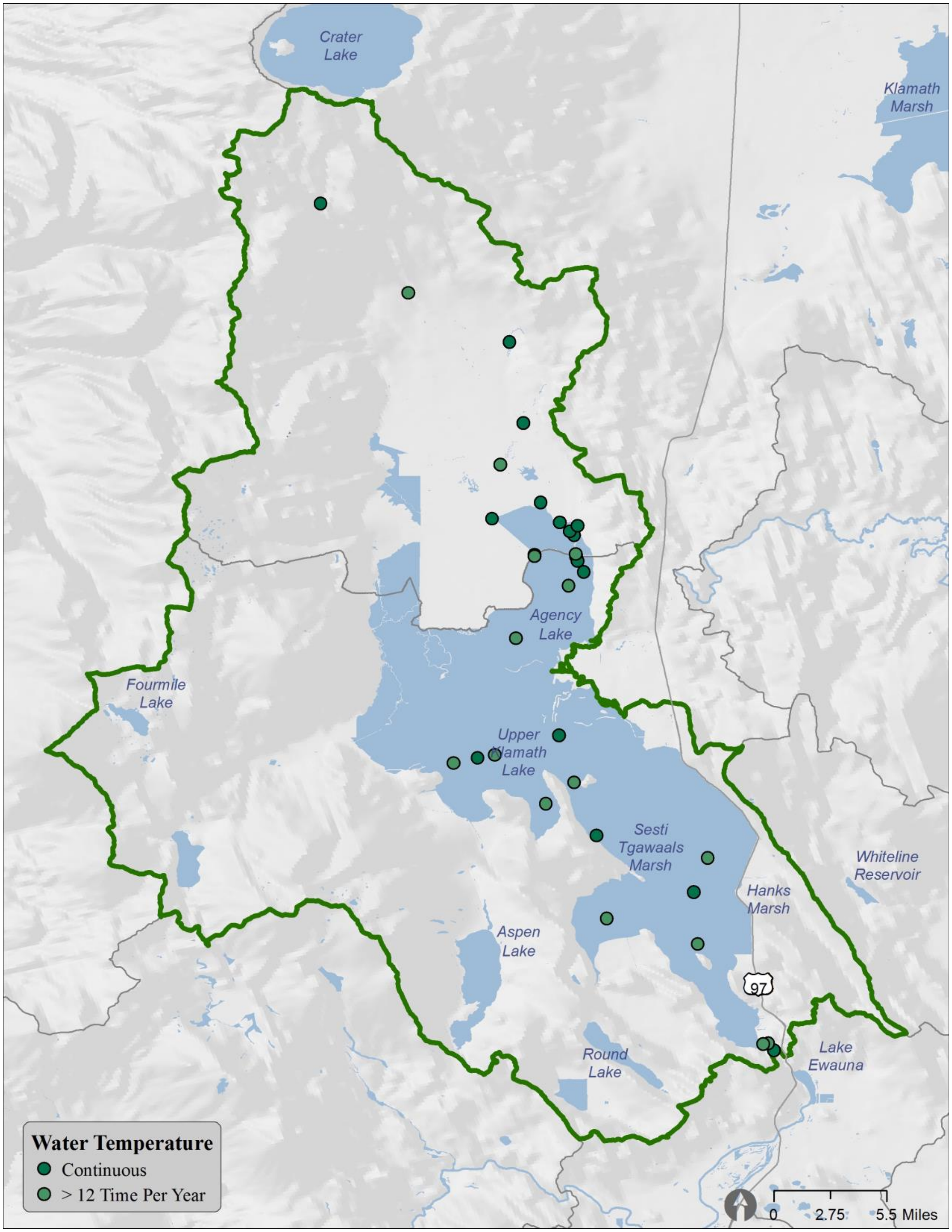


Figure 29: Water temperature monitoring in the Upper Klamath Lake subbasin in 2014.

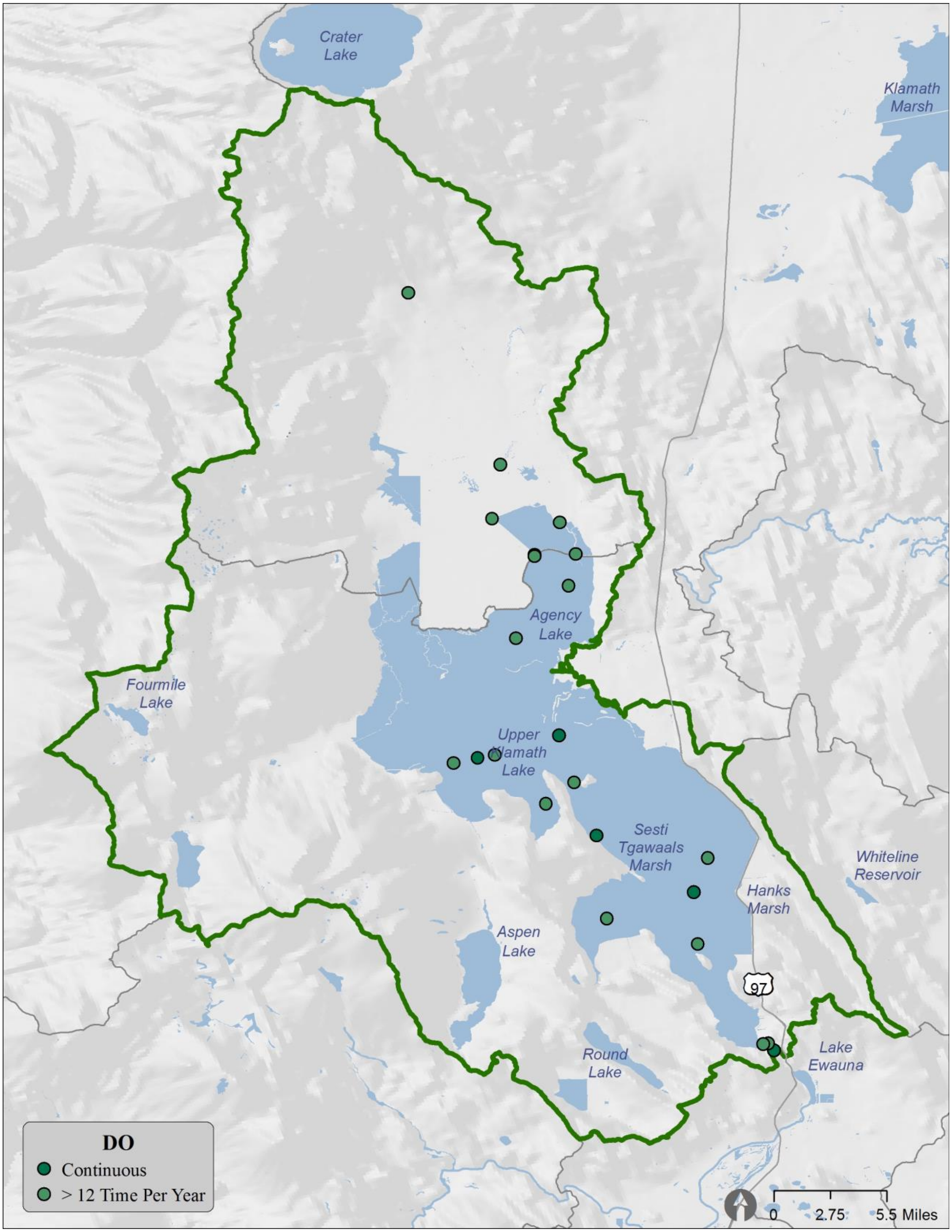


Figure 30: Dissolved oxygen monitoring in the Upper Klamath Lake subbasin in 2014.

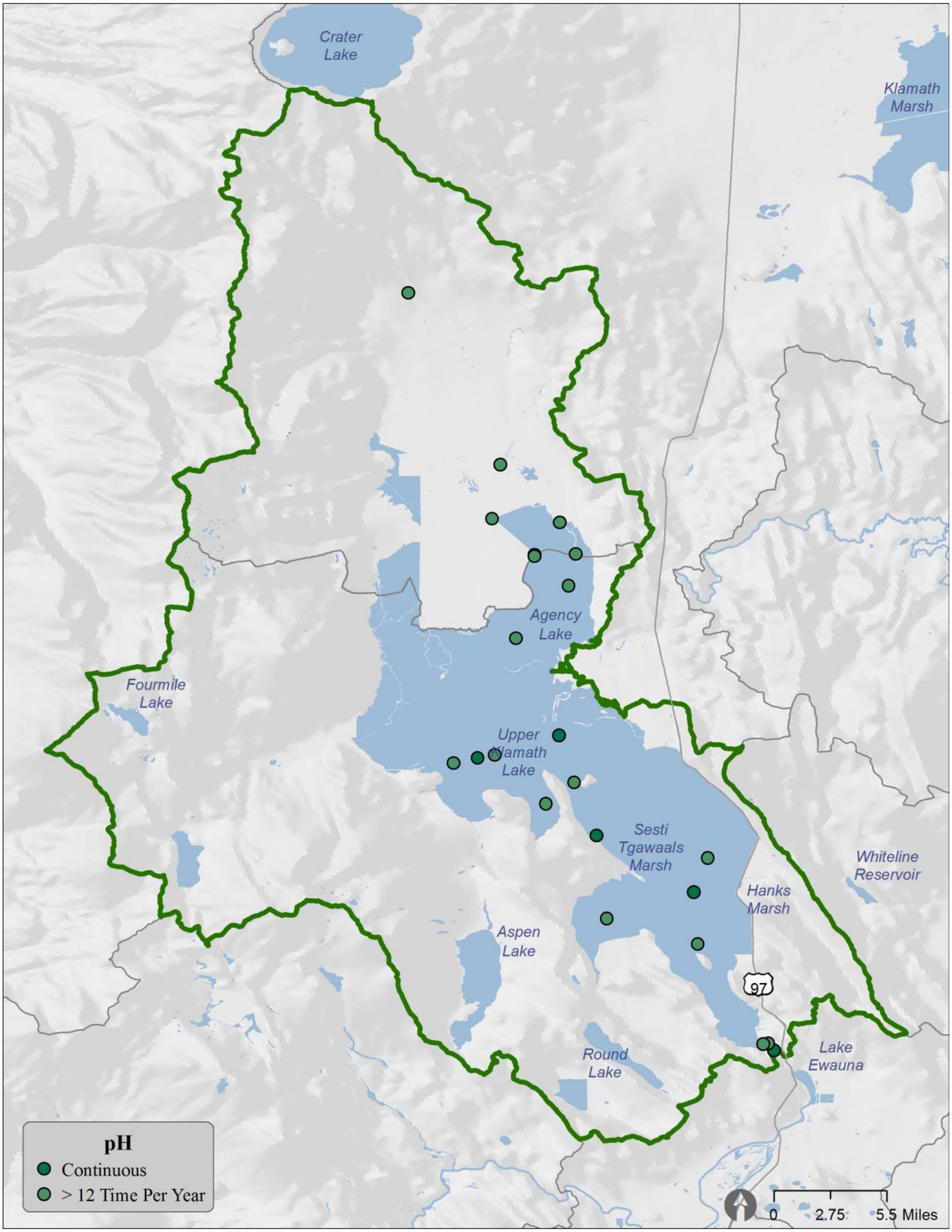


Figure 31: pH monitoring in the Upper Klamath Lake subbasin in 2014.

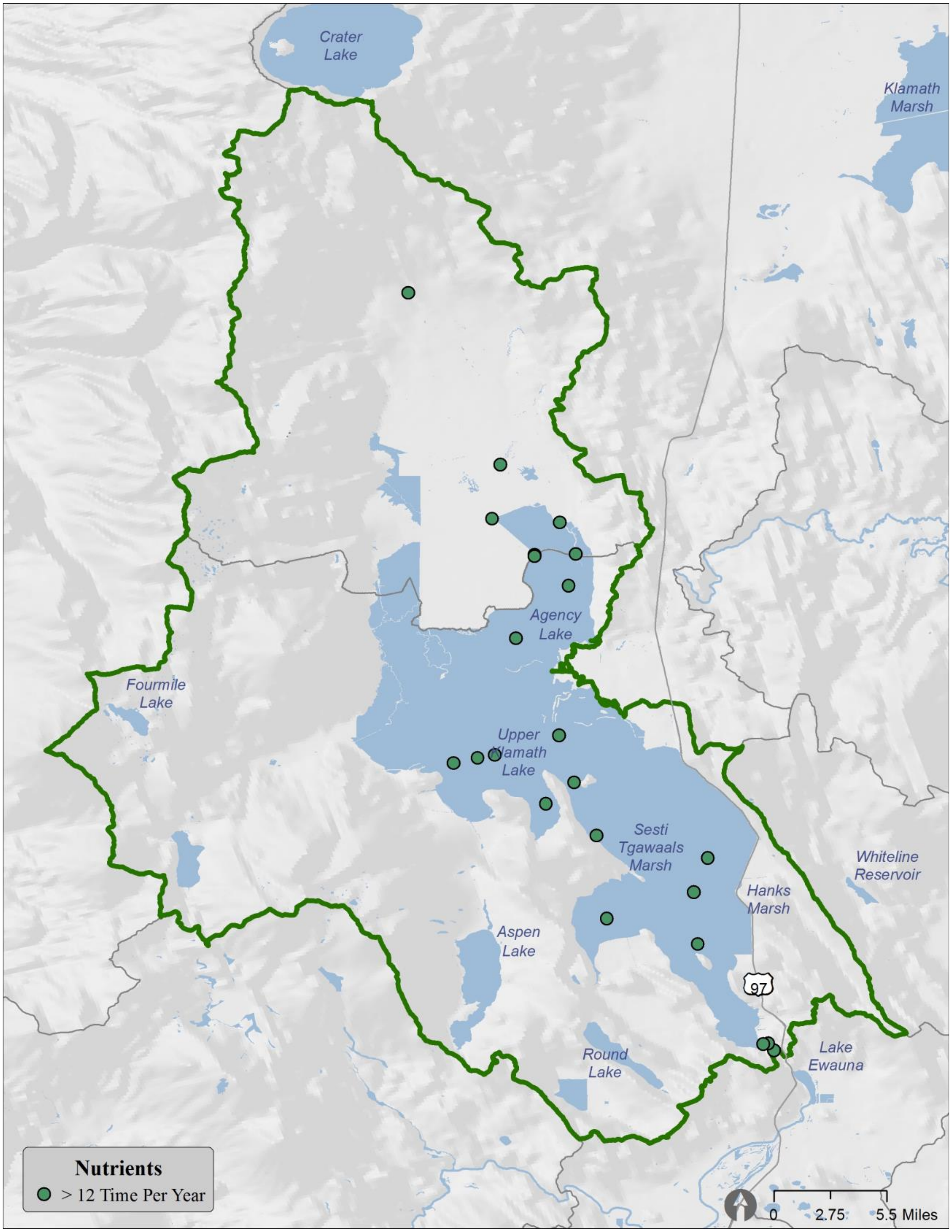


Figure 32: Nutrient monitoring in the Upper Klamath Lake subbasin in 2014.

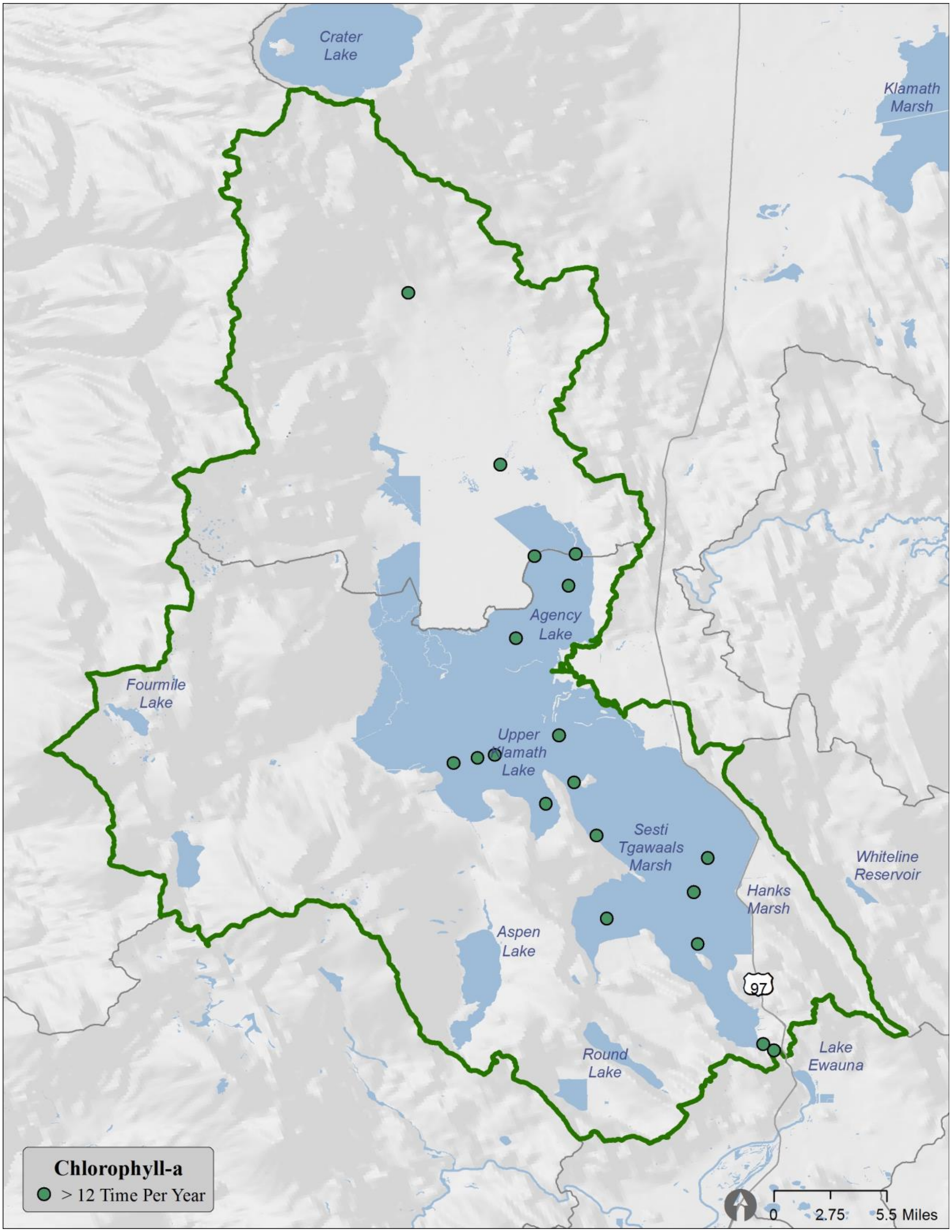


Figure 33: Chlorophyll monitoring in the Upper Klamath Lake subbasin in 2014.

5.0.4 Lost River

Background

The Lost River subbasin spans two states, California and Oregon and is divided into TMDL regions: Upper Lost and Lower Lost. Both the EPA and the ODEQ have evaluated the Lost River. The Oregon TMDL is currently in progress. EPA Region 9 has developed TMDLs to address impairments in the California portion of the Lost River (nitrogen and BOD), and ODEQ is developing TMDLs to address impairments for the Oregon portion of the Lost River (low dissolved oxygen, pH, ammonia and temperature) (EPA, 2008).

The Lost River watershed encompasses an area of approximately 2,996 square miles. Approximately 56 percent of the watershed (roughly 1,667 square miles) lies in California and 44 percent (roughly 1,328 square miles) is in Oregon (EPA, 2008). Land use primarily includes agricultural and private, the U.S. Bureau of Reclamation's Klamath Project, the Tule Lake and Lower Klamath National Wildlife Refuges. The area is surrounded by Bureau of Land Management, National Forest Service and Lava Beds National Monument lands.

This is a very complex system with many components. The Upper Lost River system from Clear Lake to Malone Dam (just across the Oregon boarder) is mostly canyon and forest. Downstream of the Malone Dam is the beginning of the USBR Klamath Project. Water flows through the Klamath Project to the Tule Lake National Wildlife Refuge; approximately 40% of water is then pumped to the Lower Klamath National Wildlife Refuge. From the Lower Klamath National Wildlife Refuge, water is pumped through the Klamath Straits Drain and flows into the Klamath River. There are three protected refuges in this system: Clear Lake, Tule Lake, and Lower Klamath Refuge. Each refuge is managed differently and so each contributes differently. Water is also imported to the Lost River from Upper Klamath Lake and the Klamath River by way of the A-Canal, the Lost River Diversion Channel, as well as smaller canals such as the Ady Canal. At times water is also returned, to the Klamath River from the Lost River through the Lost River Diversion Channel. Which way the water flows depends on which system needs the water each day. In the winter the Lost River Diversion Channel usually flows from the Lost River to the Klamath River and in the summer it usually flows from the Klamath River to the Lost River (Asbill Appendix 1).

Water quality in the Lost River system is impaired by low dissolved oxygen concentrations and elevated pH caused by excessive BOD and nutrient loading that causes excessive algal growth. According to the model developed to support the CA Lower Lost River TMDL (EPA 2008), the most significant nutrient-related (dissolved inorganic nitrogen (DIN)) and BOD (specifically, carbonaceous BOD, or CBOD) impairment in the system was low dissolved oxygen levels. The analysis also found that DIN and CBOD reductions sufficient to attain the dissolved oxygen standard would also be sufficient to attain the pH standards. The TMDLs, when implemented, are expected to result in achieving the applicable water quality standards for nutrients, dissolved oxygen, and pH for the Lower Lost River in California (EPA, 2008).

While species found in the Lost River were those common to eutrophic lakes, slow-moving waters and tolerant of high turbidity; low dissolved oxygen and elevated pH threaten the federally endangered shortnose suckers (*Chasmistes brevirostris*) and Lost River suckers (*Deltistes luxatus*).

Limiting Factors

Table 6: 303(d) list of stream segments that do not meet water quality standards with the Lost River subbasin.

State	Impairments	Region
OR	DO	Lost River
OR	pH	Lost River
OR	Ammonia toxicity	Lost River
OR	Chlorophyll-a	Lost River
CA	Dissolved Oxygen	Lost River, Tule Lake, and Mt Dome
CA	pH	Lost River, Tule Lake, and Mt Dome
CA	Nutrients	Lost River, Tule Lake, and Mt Dome
CA	pH	Tule Lake and Lower Klamath Lake National Wildlife Refuge

The KBMP Water Quality Subcommittee identified additional potential limiting factors to address: bacteria, algae, nutrients and water chemistry.

Recommendation:

List of Recommendations from the (NCRWQCB)

Link:
Collect a full suite of data, including temperature, DO, total PO4 (PO4-T), NH4/NH3, NO2/NO3, CBOD5, CBOD20, Inorganic Suspended Solid (ISS), chlorophyll-a, algal-biomass: chlorophyll-a ratio, algal C:N:P ratio, dissolved organic matter (C,N, and P), particulate organic matter (C, N, and P), alkalinity, pH, and flow.

Time span and frequency: Data should be collected on a weekly basis from June 1st to July 31st, as this period covers the most critical water quality conditions at this location. For DO and temperature, continuous data (i.e., on an hourly-basis) is recommended. Monitoring pre-dawn and afternoon concentrations of several key nutrients, such as PO4-T, NH4/NH3, NO2/NO3, and Chlorophyll-a would be ideal, in order to characterize the magnitude of diurnal fluctuation.

Lost River Diversion Channel (LRDC):
Data are needed to characterize the contribution of loading to the Klamath River only during the period when water flows from the Lost River to the Klamath River. The same suite of temperature and water quality data recommended for Link River is necessary. Flow data are necessary and assumed to be available.

Klamath Strait Drain (KSD):
The same suite of constituents noted above for Link River are also needed for KSD, in order to better characterize this boundary. Diurnal DO and temperature, and pre-dawn and afternoon nutrient monitoring are not as important.

The monitoring frequency should be weekly, and the starting time can be 4 days later than that for Link River (i.e., it can start from June 5th and extend to August 4th). This shift in dates takes into account the time of travel from Link River to the KSD entrance location.

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

Specific recommendations for the Lost River subbasin are monitoring of bacteria, algae and water chemistry, in addition to monitoring 303 (d) listed impairments. Sampling is recommended in the Oregon and California portions of the Lost River.

Additionally, monitoring below Link Dam for blue-green algae, aka cyanobacteria, (including cell count and enumeration of Microcystins auregenosa and Anabaena at a minimum) and cyanotoxins (including microcystins and anatoxins) is recommended from approximately June 1st until levels fall below and remain below regional, state and World Health Organization recommended levels, as applicable.

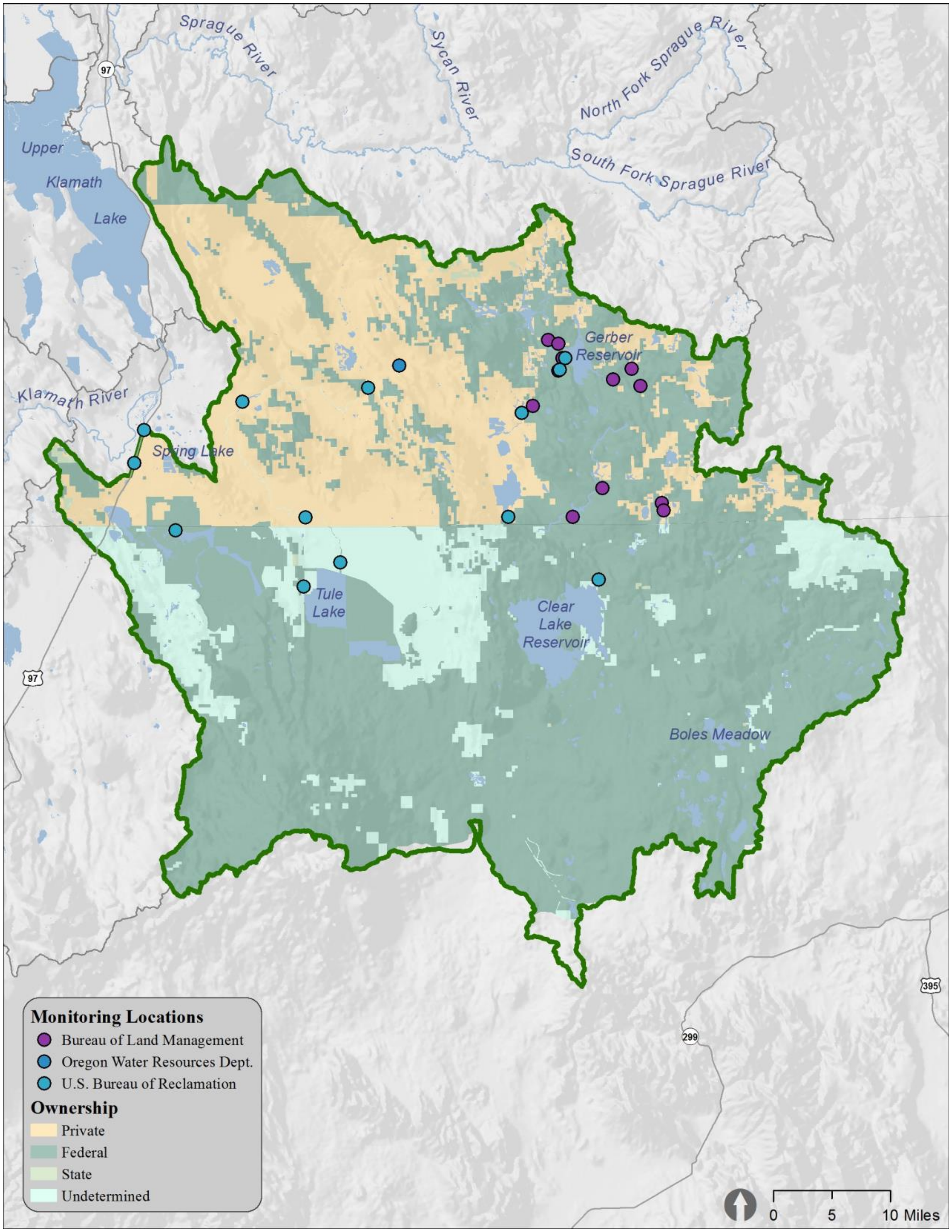


Figure 34: Lost River subbasin with identified ownership and water quality monitoring organizations.

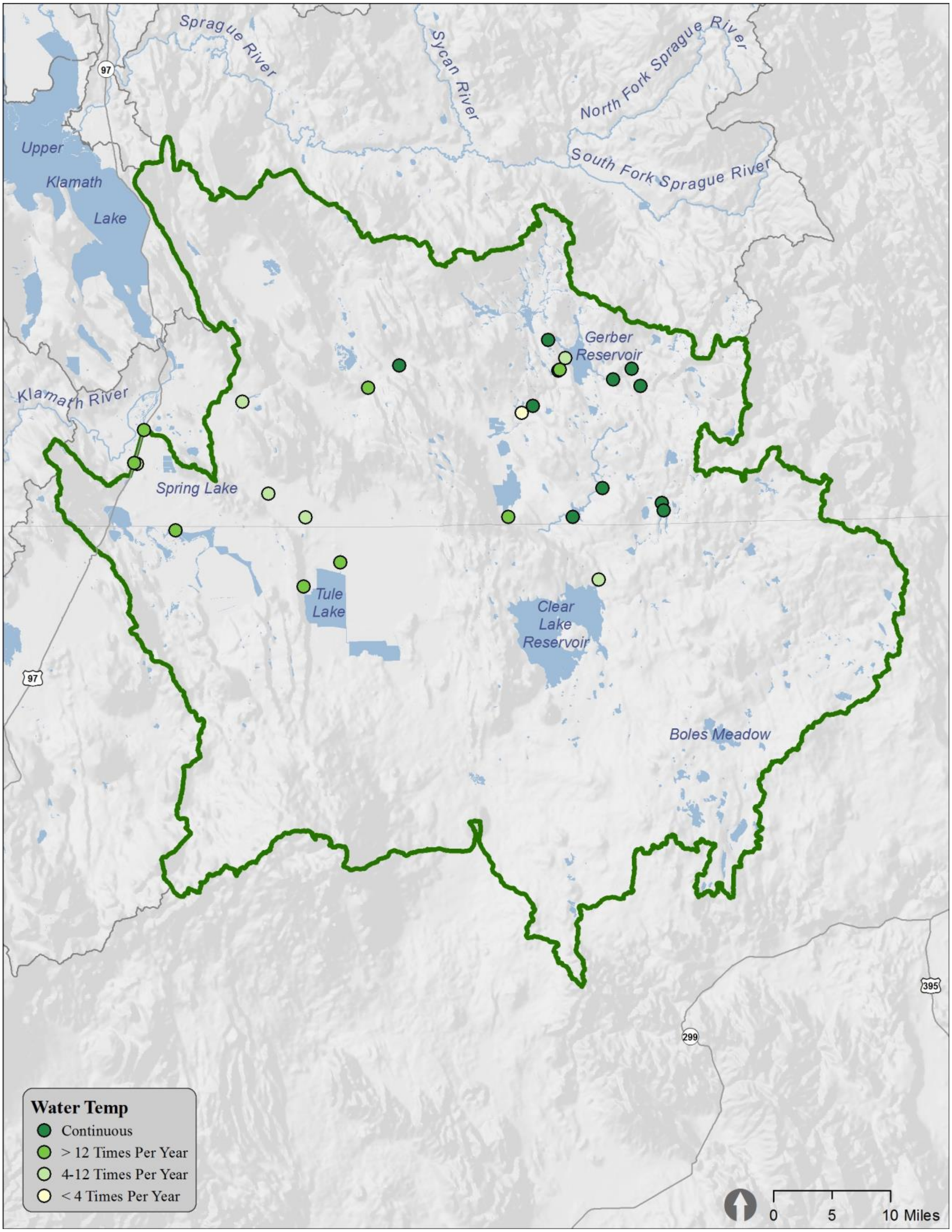


Figure 35: Water temperature monitoring in the Lost River subbasin in 2014.

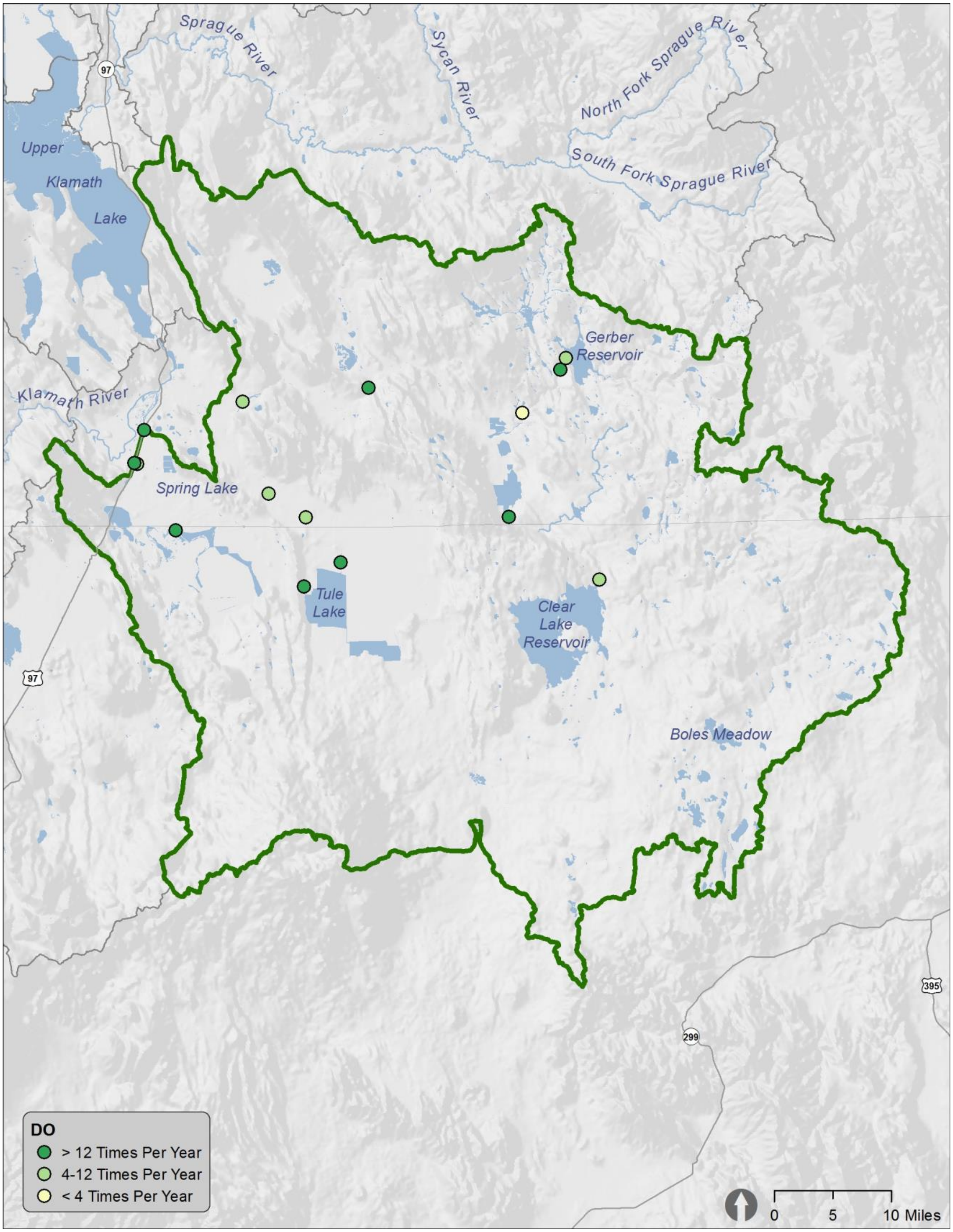


Figure 36: Dissolved oxygen monitoring in the Lost River subbasin in 2014.

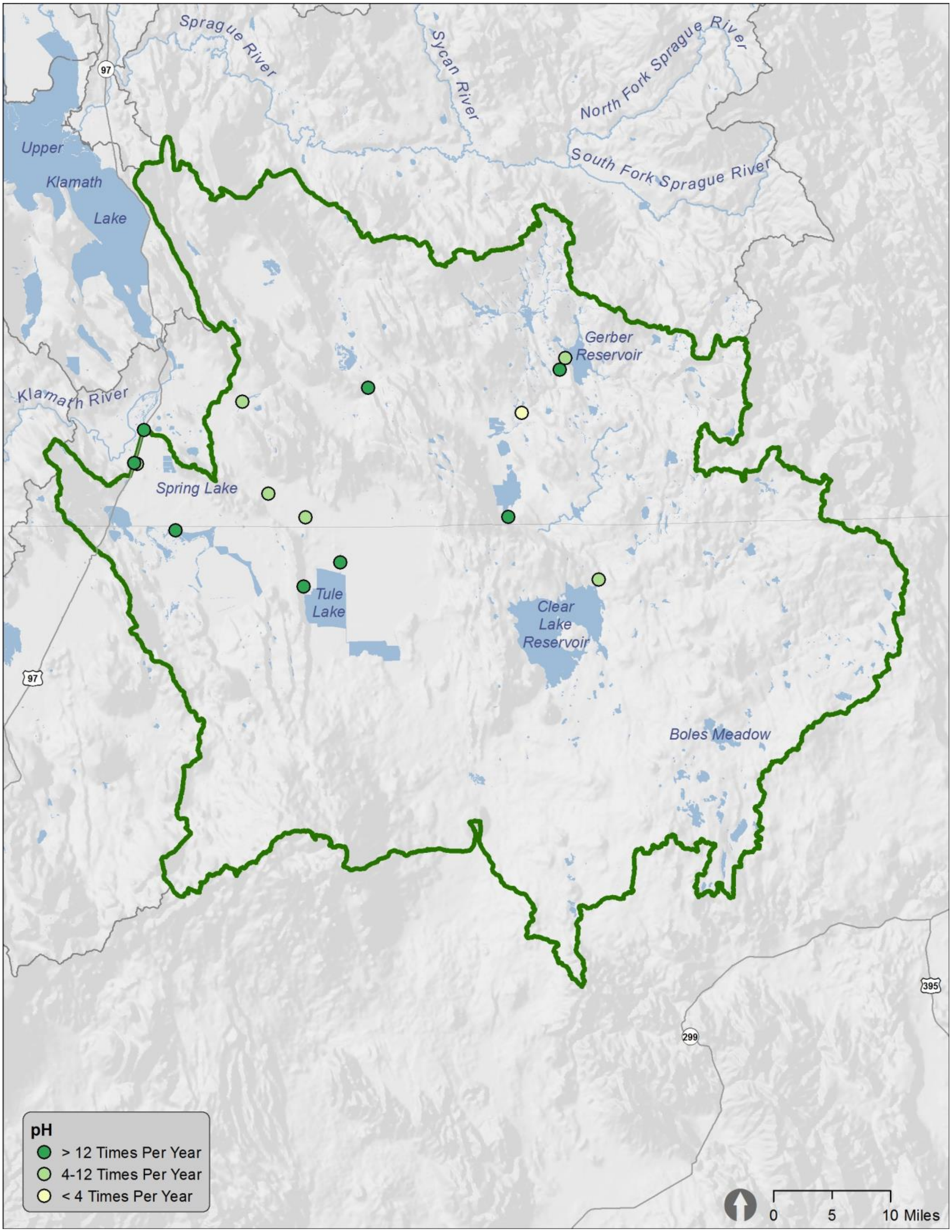


Figure 37: pH monitoring in the Lost River subbasin in 2014.

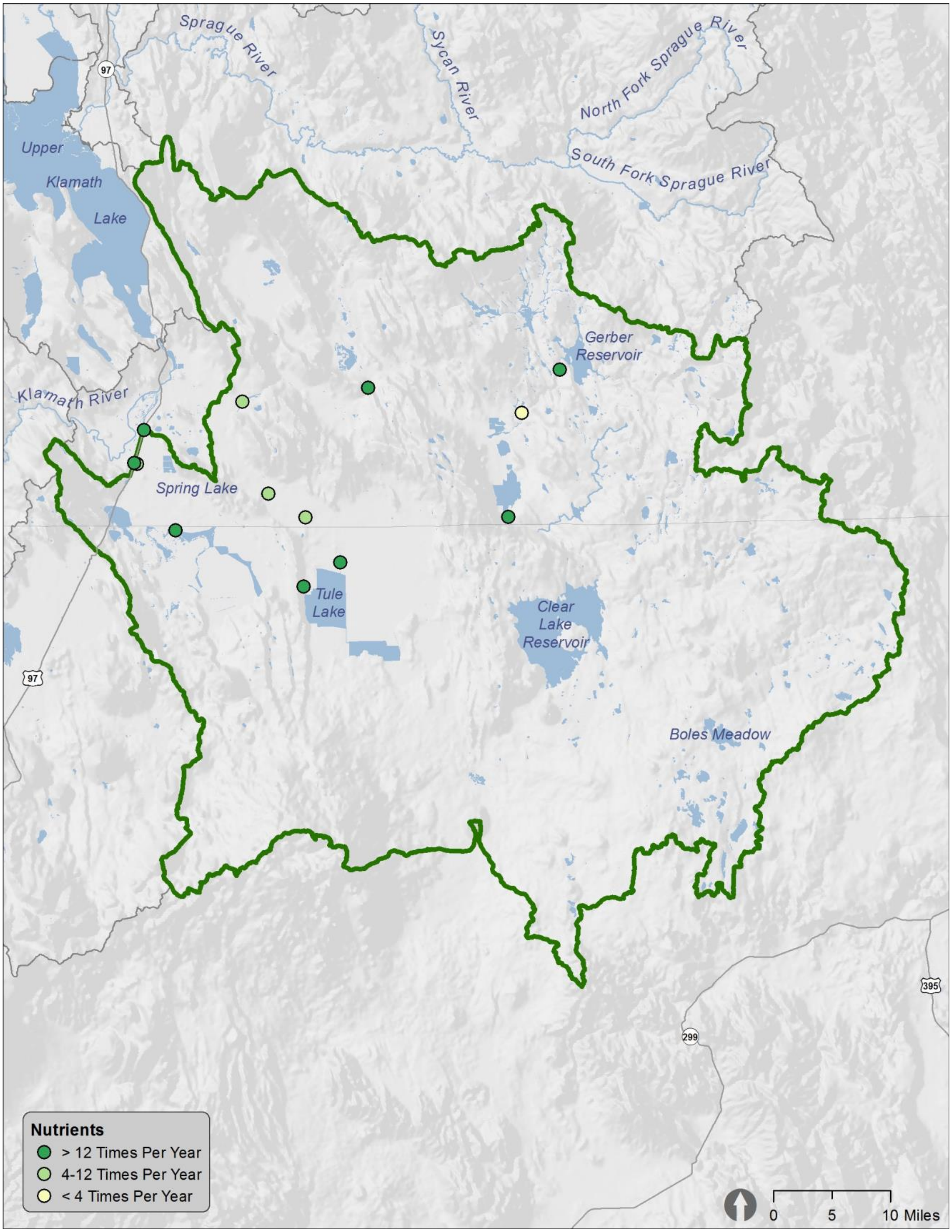


Figure 38: Nutrient monitoring in the Lost River subbasin in 2014.

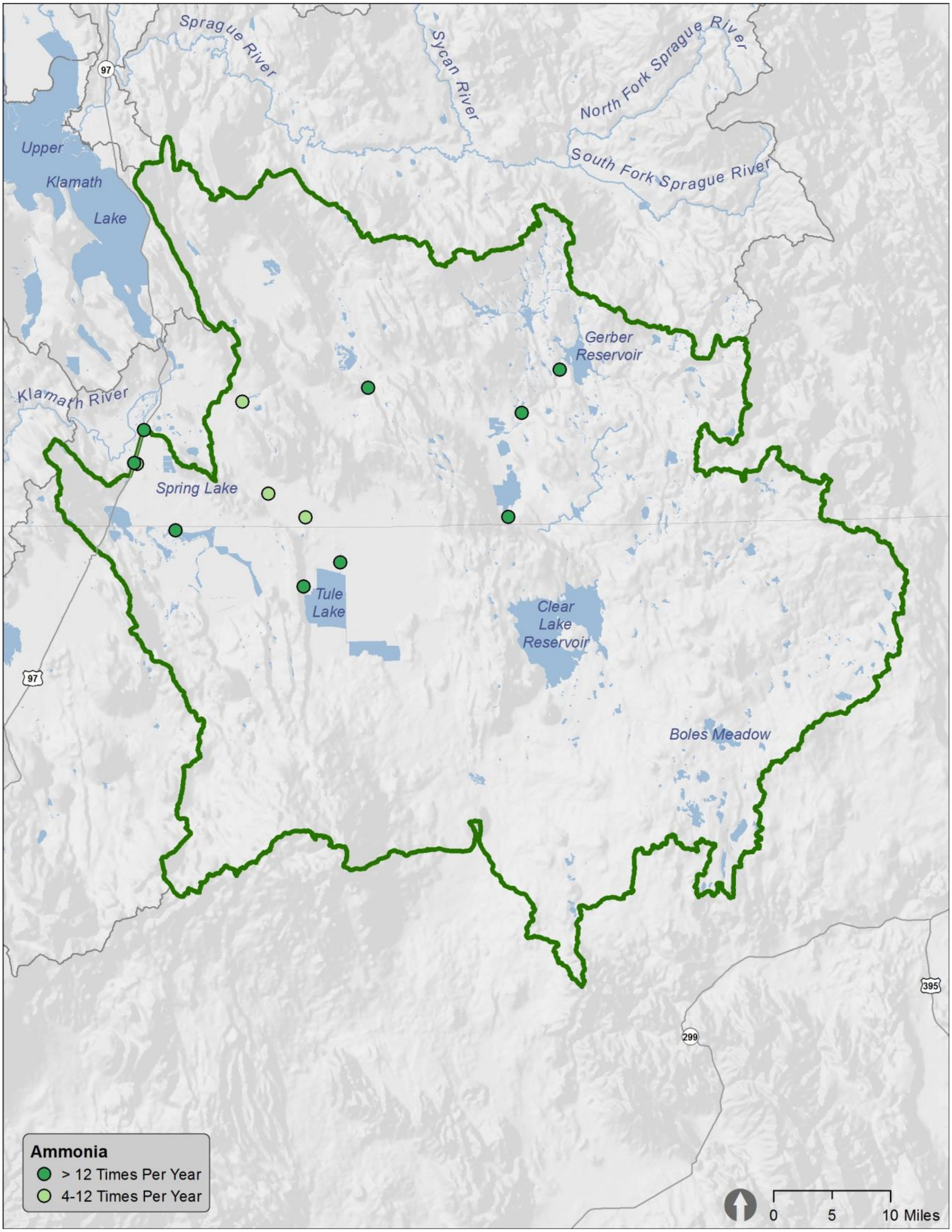


Figure 39: Ammonia monitoring in the Lost River subbasin in 2014.

5.0.5 Lake Ewauna/Keno Reservoir and Upper Klamath

Background

The CalWater Subbasin designation defines the Upper Klamath subbasin from Link River Dam to Iron Gate Dam, straddling California and Oregon. Both the Oregon and California portions of the Upper Klamath River TMDLs are in progress. The text of this section refers to this as a single subbasin but the maps have been updated to follow the Klamath Tracking and Accounting Program's split into separate subbasins for Lake Ewauna/Keno Reservoir and Upper Klamath.

The Upper Klamath subbasin contains the majority of impoundments in the Klamath Basin. The lower most impoundment (Iron Gate Dam) is a barrier to salmonid migration, restricting salmonids from accessing their historic range. The effects of the land and water management actions on the Upper Klamath subbasin are considerable. In the upper basin, hypereutrophic Upper Klamath Lake (UKL), impacted by land and water uses upstream, provides the majority of load of nutrients and organic matter to downstream river reaches. Small, municipal and industrial uses in the Klamath Falls area are also minor contributors. The Bureau of Reclamation Klamath Project diverts water from the nutrient rich Upper Klamath Lake for irrigation. The primary source of water for irrigators is from UKL. There is debate over the overall impacts of the initial load of nutrients contained in diverted UKL are reduced prior to entering the Klamath River via Klamath Straits Drain. The input of nutrients to the Klamath River from agricultural return flows via the Klamath Straits Drain have been modeled for the Klamath River TMDL, but have yet to be quantified by regular monitoring. In this reach of the Klamath River, Klamath Hydroelectric Project impoundments (reservoirs) have changed the aquatic environment from riverine to more quiescent lake conditions, changing the water quality response of the river to upstream inflows borne out of UKL and other inputs to the system (Deas, Appendix 1).

There is little baseline data for this region, maybe 6 to 8 years. There is a wide range of variability and longer data sets are required. There have been many impacts over the last 100 or so years and parsing out individual effects are challenging (Deas, Appendix 1).

Within the Project Reach, J.C. Boyle dam to Iron Gate dam, pH and dissolved oxygen vary on a seasonal basis. The pH of surface water is controlled primarily by atmospheric CO2 and carbonate buffering photosynthesis and respiration (Stillwater Sciences, 2009). Blooms of algae followed by die-offs can cause variations in average pH and diel fluctuations in pH on longer time scales (Horne and Goldman, 1994; Wetzel, 2001). Most reservoirs in this subbasin exhibit summertime hypolimnetic anoxia; anoxia results from thermal stratification and microbial decomposition of algae. Dissolved oxygen levels vary as the thermocline shifts, the lower epilimnion of Iron Gate Reservoir ranges from 5-7mg/L and Copco 1 Reservoir ranges from 0.5-6 mg/L (FERC, 2007). During the summer and fall dissolved oxygen falls below the Basin Plan minimum criteria of 8 mg/l. Following mid-afternoon peak photosynthetic activity, the Klamath River mainstem downstream of Iron Gate Dam regularly exceeds the Basin Plan maximum dissolved oxygen level of 8.5 (June through October) (Karuk Tribe, 2002 and 2003; YTEP, 2005). Both Copco and Iron Gate reservoirs create a thermal phase shift (thermal lag) whereby the release from Copco and Iron Gate dams during the spring are slightly cooler and during the fall are slightly warmer than inflowing conditions. This is due to the large thermal mass of the reservoirs compared to river reaches.

Water entering this subbasin is generally high in nutrients since the incoming flow is from Upper Klamath Lake. Nutrients from upstream origins have the potential to impact water quality by increasing algal growth and decay, which can lead to increased levels of turbidity, large fluctuations of dissolved oxygen and pH levels, and resulting toxic substances such and ammonia and hydrogen sulfide (Stillwater Science, 2009). Based on mass-balance nutrient budgets, Iron Gate and Copco reservoirs combined retain approximately 12 percent and 18 percent of the total phosphorous and total nitrogen inflow, respectively (Kann and Asarian, 2007).

In recent years, there has been public health concern from contact / ingestion of microcystin in reservoir waters, surface scums and fish tissue. Since 2004, Klamath River monitoring has documented elevated levels of cyanobacteria including *Microcystis aeruginosa* (MSAE) and the toxin microcystin. Microcystins are a class of toxic chemicals produced by some strains of cyanobacteria including MSAE, and are released into waters when cyanobacterial cells die or cell membranes degrade. MSAE counts and microcystin concentrations found in Klamath River waters within Copco and Iron Gate Reservoirs have exceeded action levels defined by the California State Water Resources Control Board Blue Green Algae Work Group and the Klamath Blue Green Algae Work Group. Late summer conditions are typically characterized by dense cyanobacterial blooms that form thick scums in parts of the reservoirs. The blooms at times can span much of the open water areas within the reservoirs. Since 2005, Copco and Iron Gate reservoirs were posted with public health advisories as a result of summer blooms of MSAE; and in 2005 and 2008, reaches of the Klamath River downstream of Iron Gate dam were also posted.

The presence of microcystin has also be detected in fish tissue (yellow perch) in Copco and Iron Gate reservoirs and in mussels collected below Iron Gate Dam. A study conducted in 2007 indicated that 85% of fish and mussel tissue samples collected July through September 2007 in Iron Gate and Copco 1 Reservoir, exhibited microcystin bioaccumulation (Kann, 2007). Results indicate that all of the World Health Organization (WHO) total daily intake (TDI) guidelines values were exceeded, including several observations of values exceeding acute TDI thresholds (Ibelings and Chorus, 2007; Kann, 2008). However, in 2008, yellow perch and crappie samples from Iron Gate reservoirs, and rainbow trout from the Klamath River and above Copco Reservoir and below Iron Gate dam were collected for fish tissue analysis. All of the 203 fish tissue samples collected in May, July, and September 2008 were below detection for total free microcystins (Carlson, 2009). The difference between the 2007 and 2008 samples may be the result of change in MSAE and microcystin between the two years since BGA dynamics are so variable on both spatial and temporal scales. Mussel tissue have consistently been found to contain significantly elevated microcystin concentrations when sampled during summer blooms.

As a result, California has listed the portions of the Klamath River within its jurisdiction for impairments due to elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen. In March 2008, the USEPA added the reach of the Klamath River that incorporates Copco 1 and 2 and Iron Gate Reservoirs to the 303(d) list for the blue-green algae toxin, microcystin (NCRWQCB, 2008a).

Potentially affected beneficial uses include cultural, agriculture, municipal, industrial, environmental, recreation (boating, hunting, and fishing). Agriculture, municipal, and industrial uses are largely limited to the Link Dam to Keno Dam reach. Downstream of this reach, fishing and recreation may not be fully supported by water quality.

Limiting Factors

Table 7: 303(d) impaired waters of the Upper Klamath subbasin.

State	Impairments	Region
OR	Dissolved Oxygen	Upper Klamath
OR	pH	Upper Klamath
OR	Ammonia toxicity	Upper Klamath
OR	Chlorophyll-a	Upper Klamath
CA	Mercury	Copco 1 Reservoir
CA	Microcystin	Copco 1 and 2 Reservoirs
CA	Mercury	Iron Gate Reservoir
CA	Microcystin	Iron Gate Reservoir
CA	Mercury	Klamath Straights Drain
CA	Organic Enrichment/Dissolved Oxygen	Klamath River from the Oregon Border to Copco 1 Reservoir
CA	Nutrients	Klamath River
CA	Temperature	Klamath River

Recommendations

List of Recommendations from the (NCRWQCB)

If microcystis blooms downstream of J.C. Boyle are a concern, then algae species composition data would also be useful.

Lake Ewauna/Keno Reservoir:

Monitoring is recommended at Miller Island and Hwy 66 for temperature (continuous), DO (continuous), NH4, N02/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH.

These data would need to be monitored on a weekly basis. For Miller Island, the monitoring time span should be June 5th to August 4th (the same as for KSD). For the Hwy 66 station, a monitoring time span from June 7th to August 6th would be appropriate.

It would also be valuable to measure hydrogen sulfide levels at least one or two times over the course of the monitoring event, during the anoxic period.

Keno Reach:
A monitoring station should be set up at the end of the Keno Reach, before entry to J.C. Boyle Reservoir. Similar constituents and frequency as for KSD would be useful. The starting time, however, can be shifted to June 7th to August 6th (which is the same as for the Hwy 66 location.

These data would be useful in characterizing water quality processes occurring within the Keno Reach. They would also ensure more accurate representation of boundary conditions for the downstream J.C. Boyle model.

J.C. Boyle Reservoir:
Continuation of monitoring at the current location upstream of the dam is recommended. The same suite of parameters as for the Lake Ewauna/Keno Reservoir should be collected. The monitoring should be performed weekly from June 7th to August 6th

Copco Reservoir:
Two monitoring stations are recommended: one at the upstream end and one near the dam. The same suite of constituents collected for Lake Ewauna/Keno Reservoir should be collected here, at a weekly frequency. For the upstream station, samples should be collected from June 7th to August 6th. For the downstream station, data should be collected from June 17th to August 16th.

Jenny Creek:
A monitoring station at the mouth of Jenny Creek is recommended. Similar constituents and frequency as for KSD would be useful. The monitoring period should be from June 17th to August 16th.

Iron Gate Reservoir:
Two monitoring stations are recommended: one that characterizes the outflow from Copco Reservoir before it enters Iron Gate Reservoir, and one immediately upstream of Iron Gate Dam. Constituents should be the same as for Lake Ewauna/Keno Reservoir and should be

collected at a weekly frequency. The upstream station should be monitored from June 17th to August 16th and the downstream station from July 1st to August 31st.

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Additionally, regular monitoring for cyanotoxins (microsystin as well as anatoxin, and cylindrospermopsin) is recommended from May until late fall (e.g. October to November) to assess potential public health threats due to the presence of these toxins. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

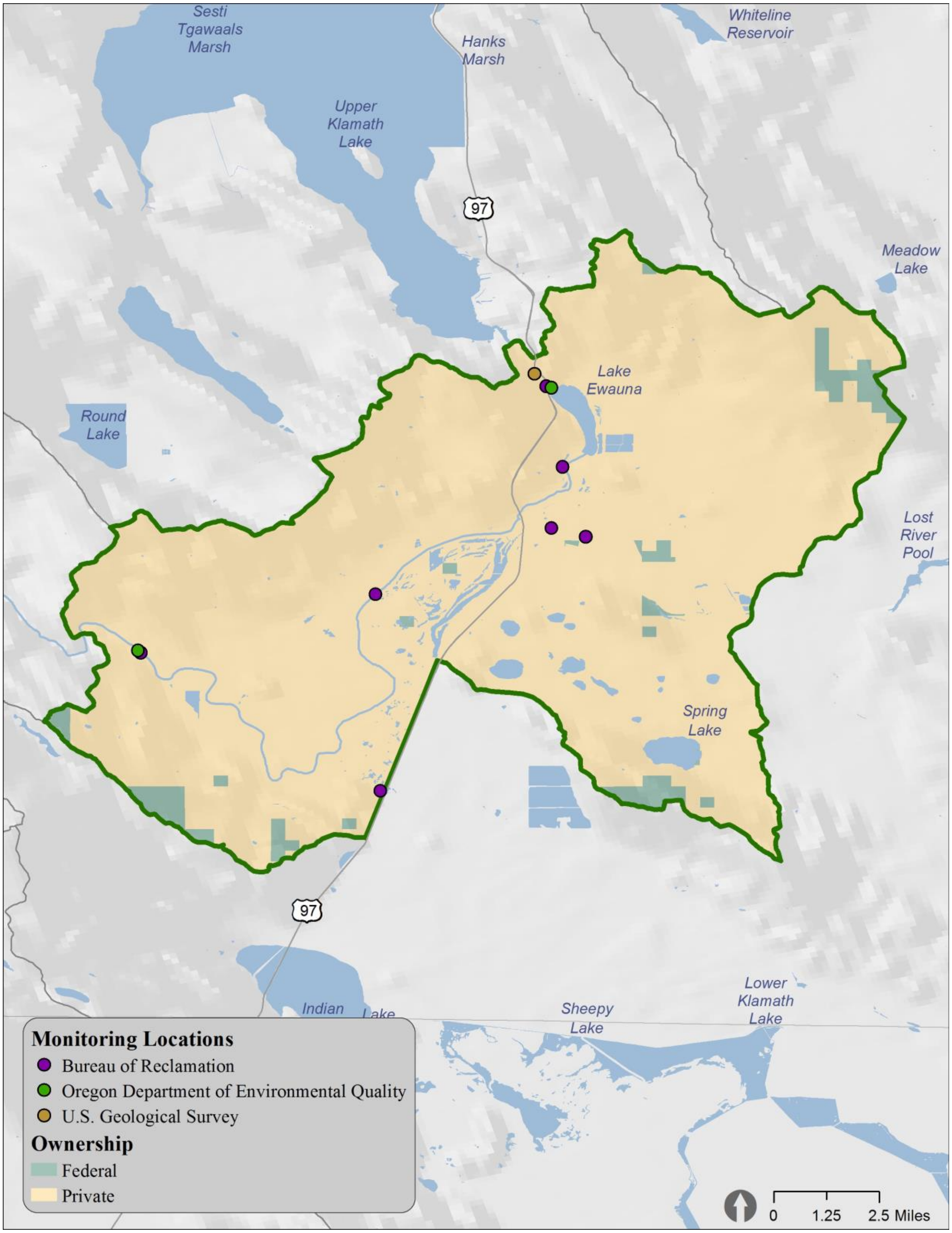


Figure 40: Lake Ewauna/Keno Reservoir subbasin with identified ownership and water quality monitoring organizations.

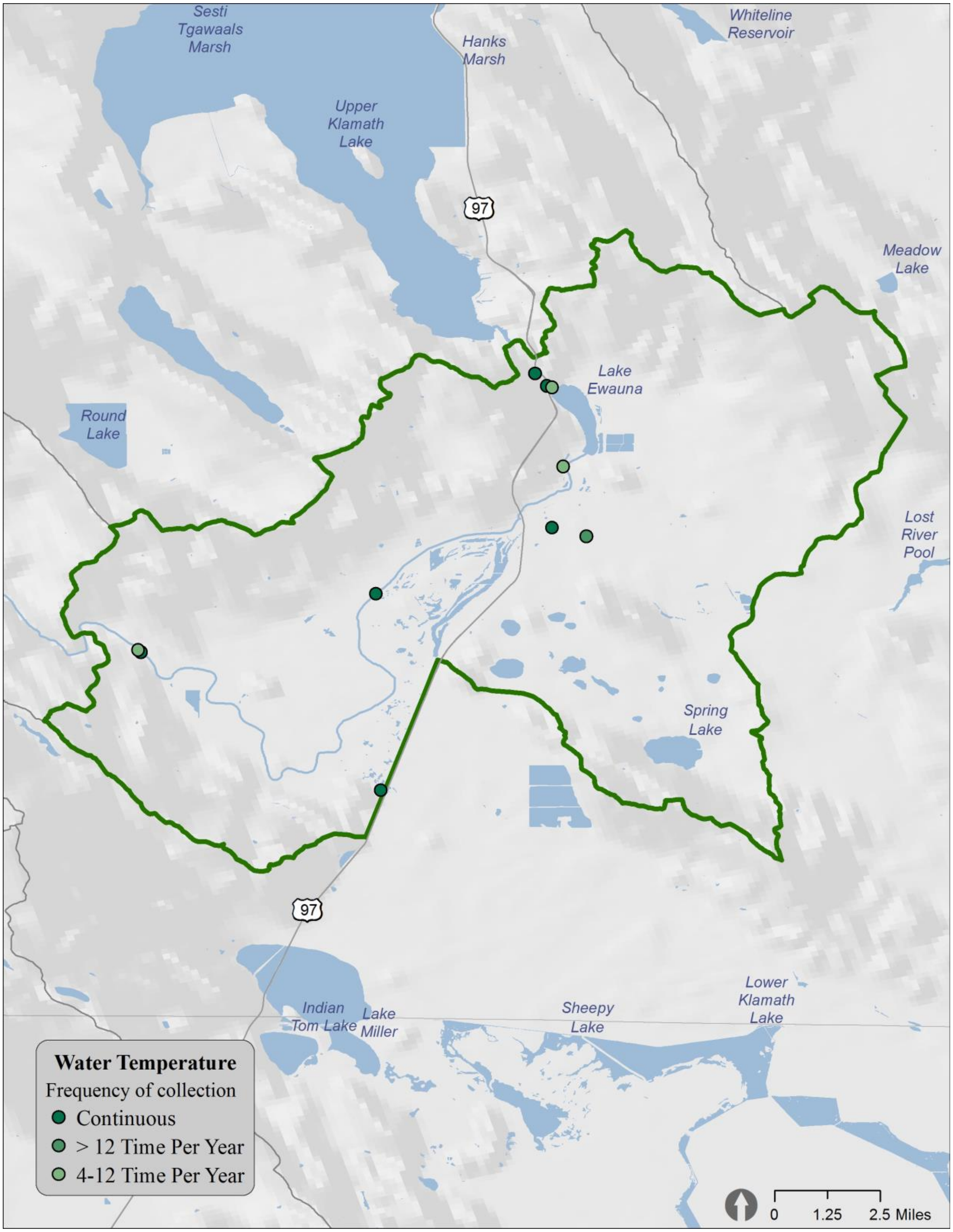


Figure 41: Water temperature monitoring in the Lake Ewauna/Keno Reservoir subbasin in 2014.

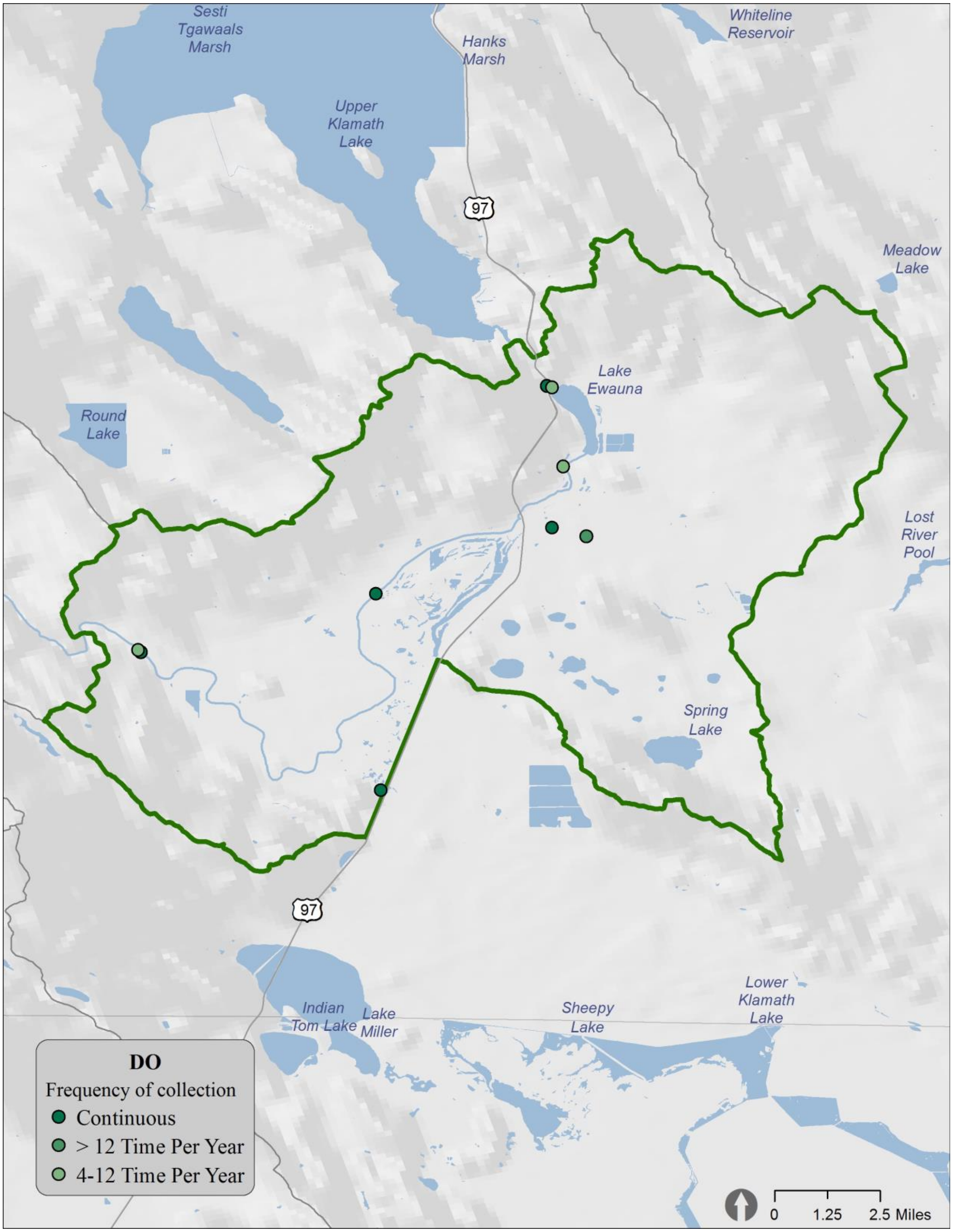


Figure 42: Dissolved oxygen monitoring in the Lake Ewauna/Keno Reservoir subbasin in 2014.

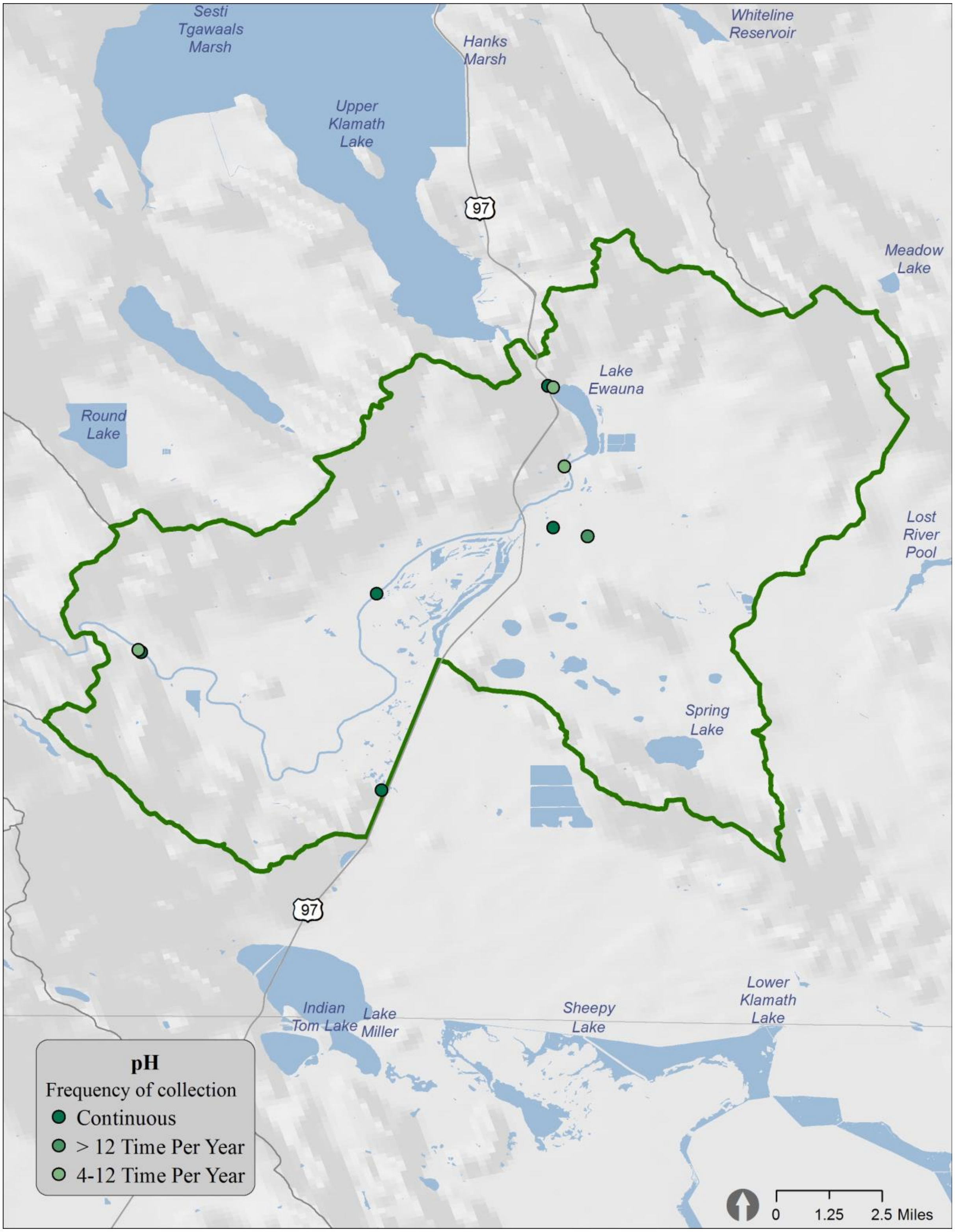


Figure 43: pH monitoring in the Lake Ewauna/Keno Reservoir subbasin in 2014.

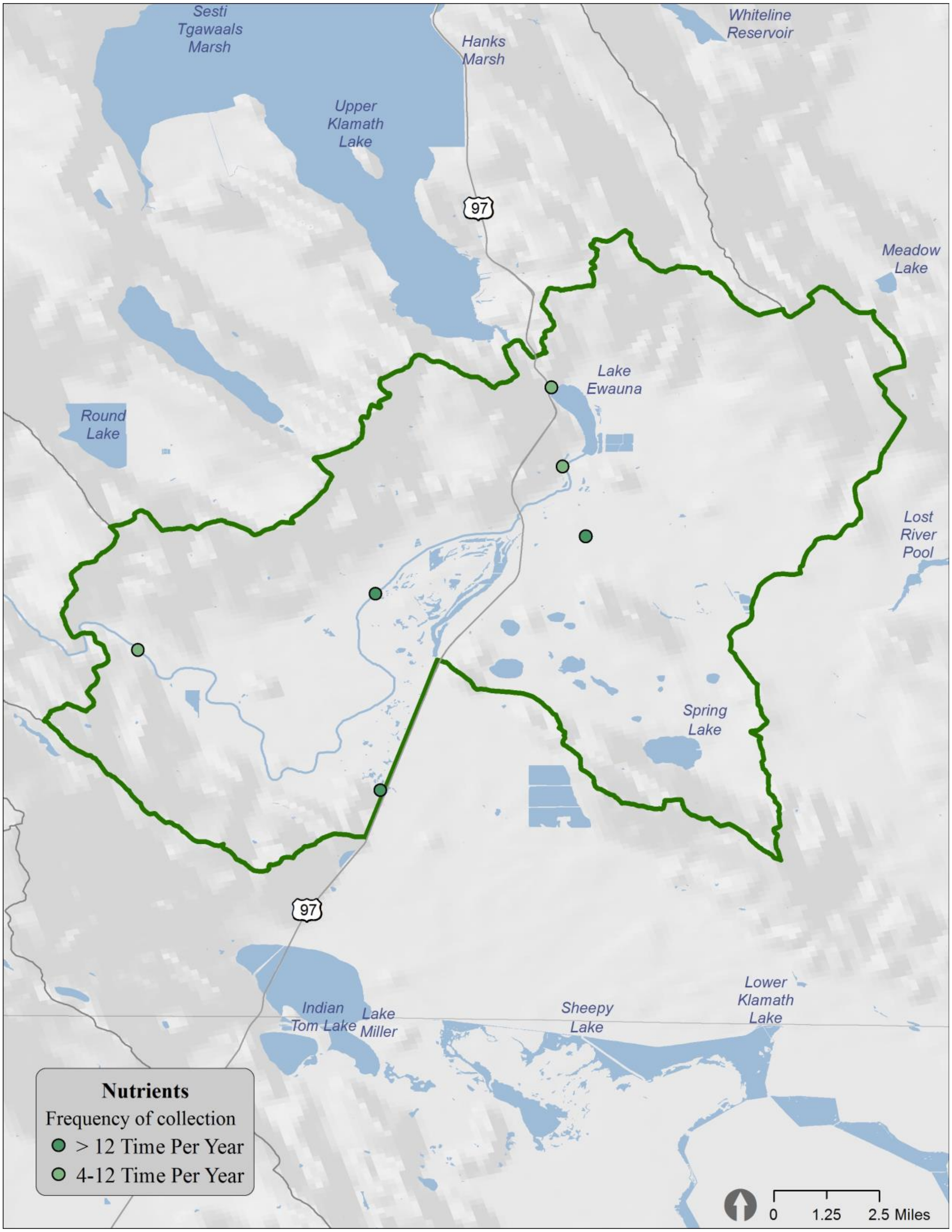


Figure 44: Nutrient monitoring in the Lake Ewauna/Keno Reservoir subbasin in 2014.

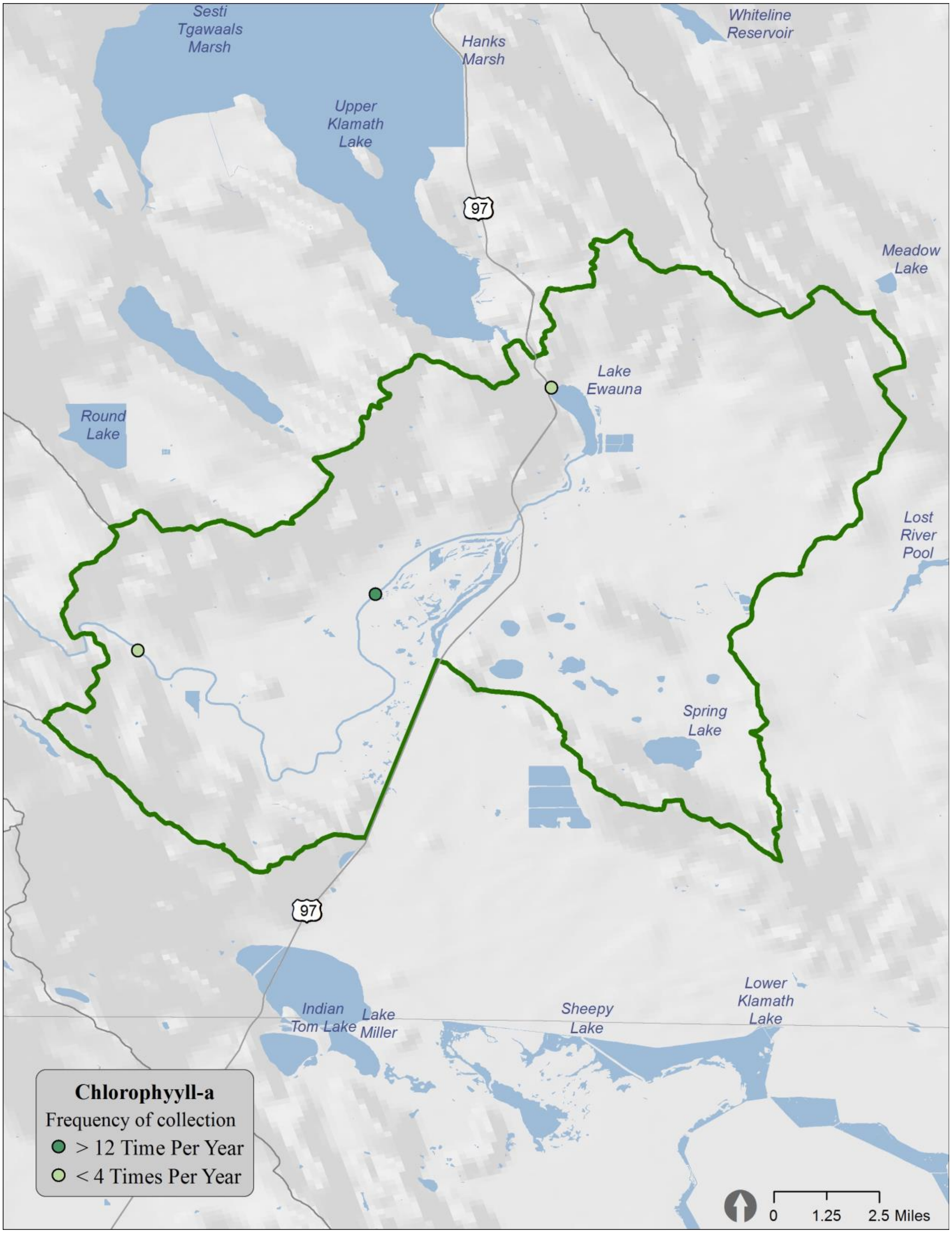


Figure 45: Chlorophyll-a monitoring in the Lake Ewauna/Keno Reservoir subbasin in 2014.

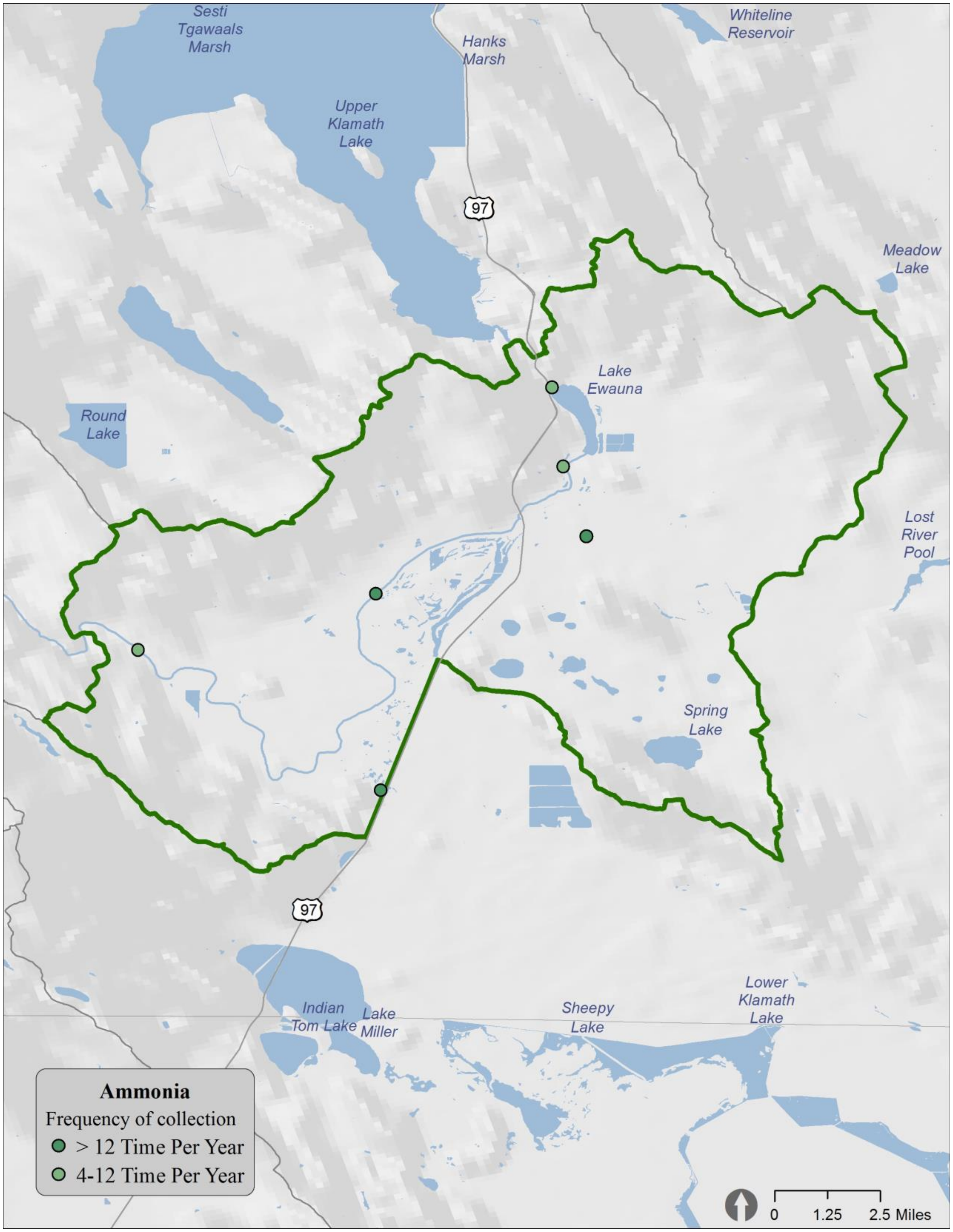


Figure 46: Ammonia monitoring in the Lake Ewauna/Keno Reservoir subbasin in 2014.

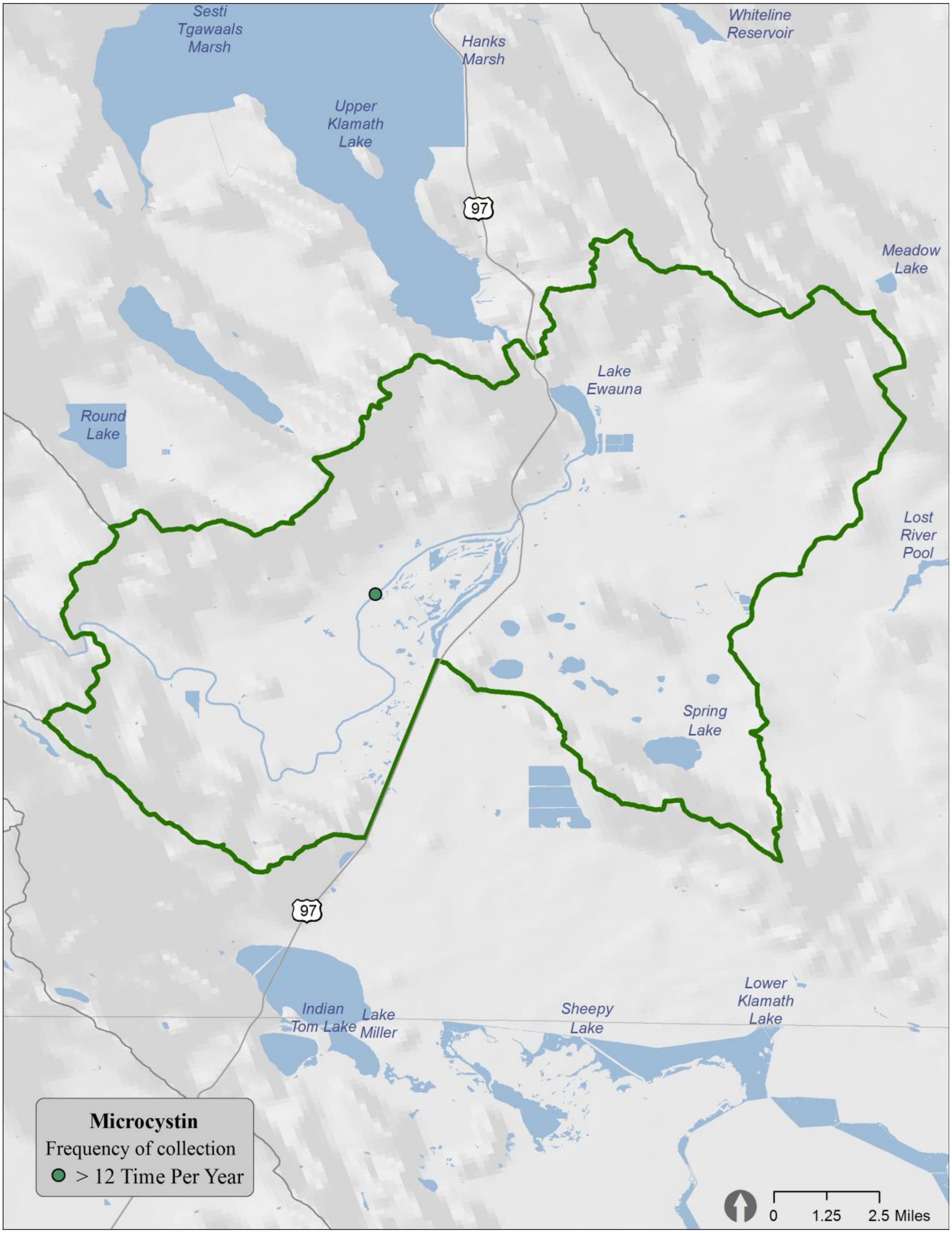


Figure 47: Microcystin monitoring in the Lake Ewauna/Keno Reservoir subbasin in 2014.

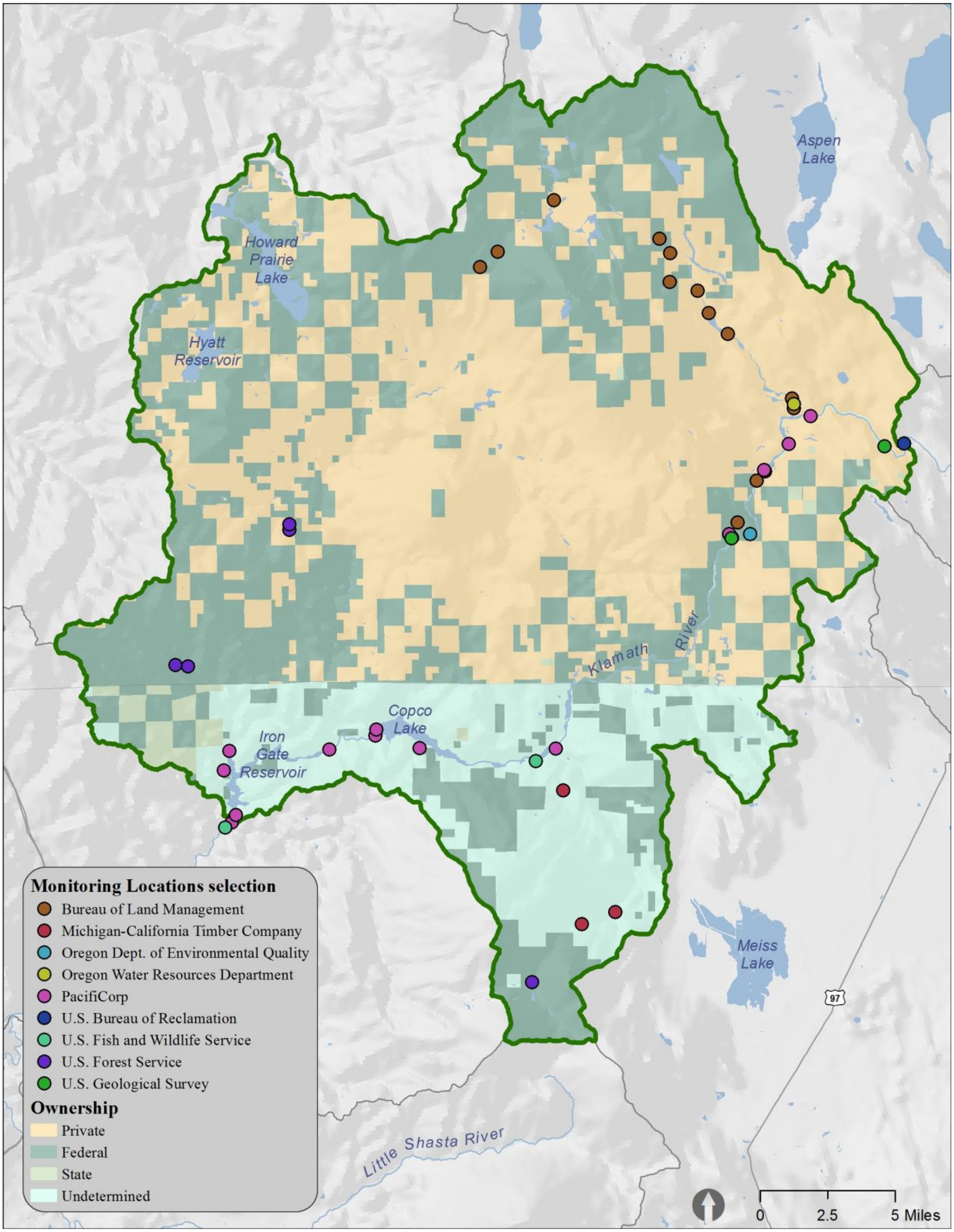


Figure 48: Upper Klamath River subbasin with identified ownership and water quality monitoring organizations.

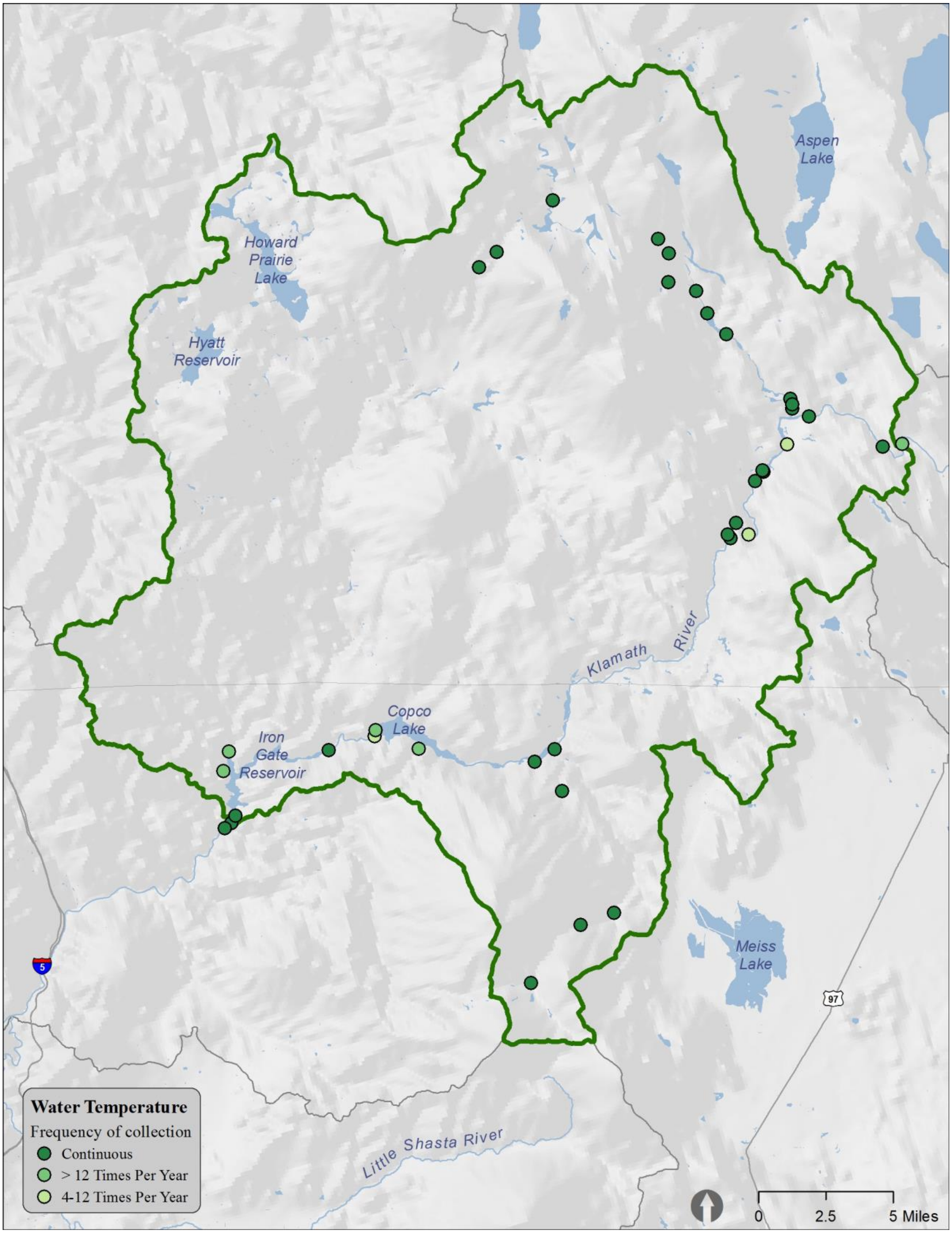


Figure 49: Water temperature monitoring in the Upper Klamath River subbasin in 2014.

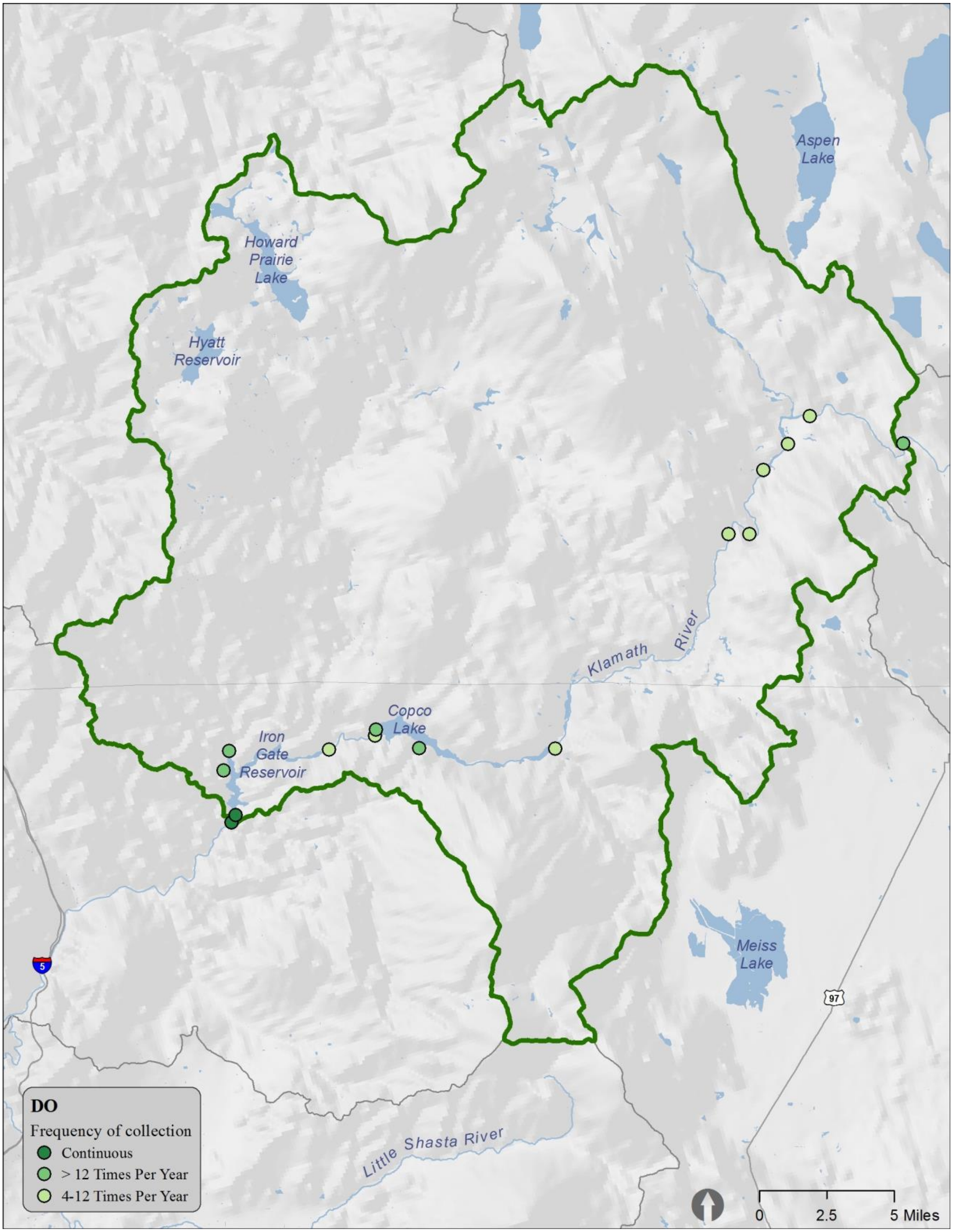


Figure 50: Dissolved oxygen monitoring in the Upper Klamath River subbasin in 2014.

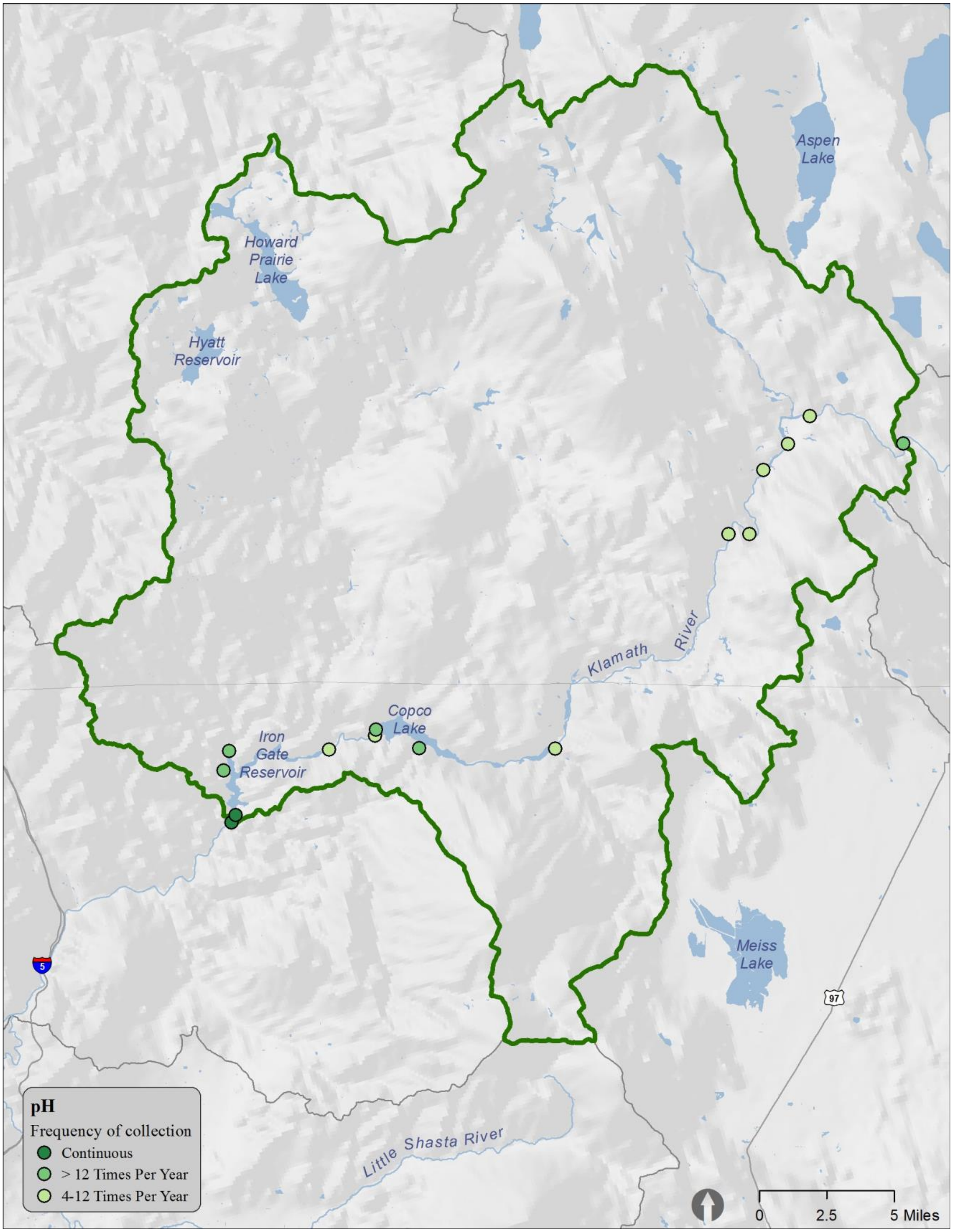


Figure 51: pH monitoring in the Upper Klamath River subbasin in 2014.

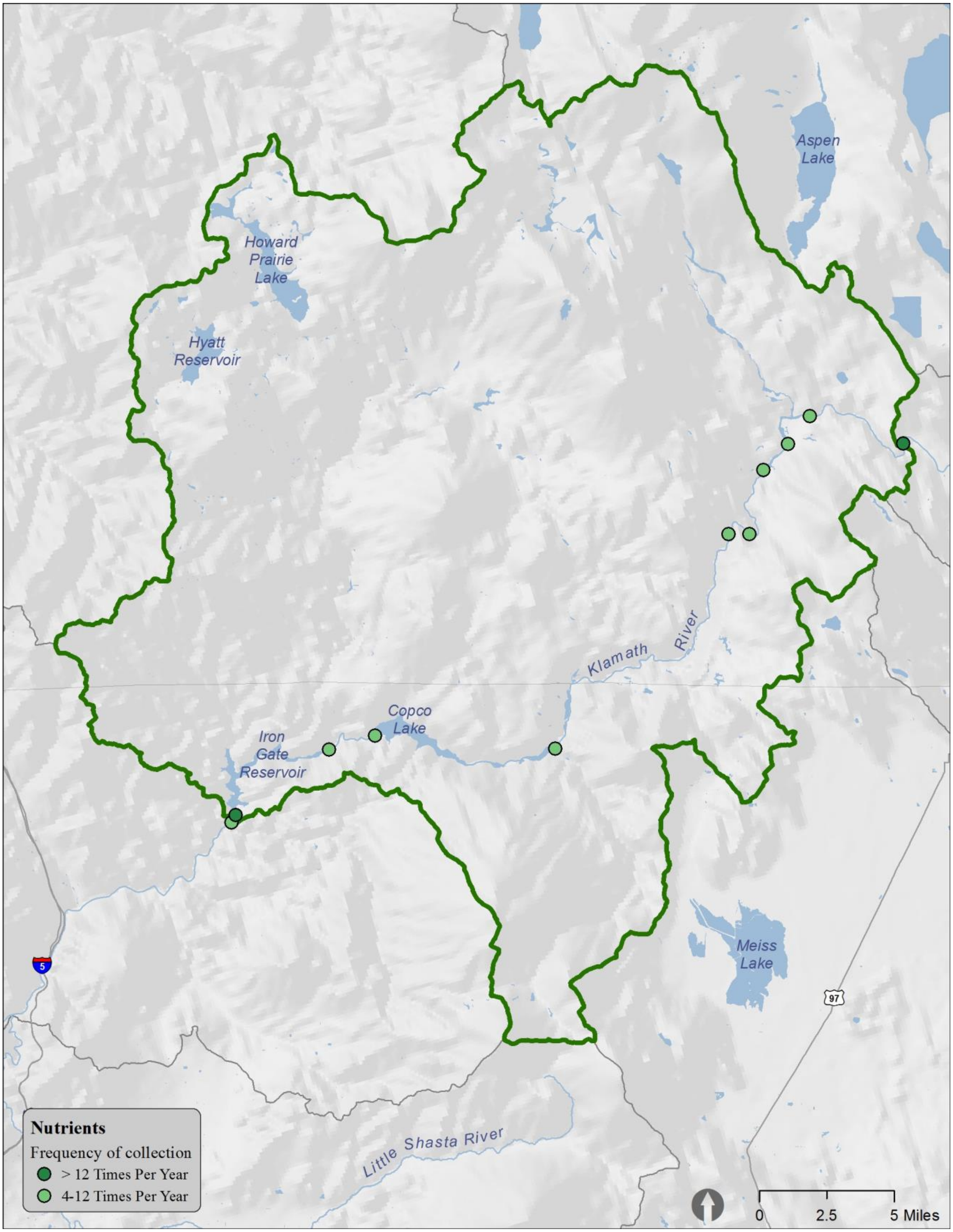


Figure 52: Nutrient monitoring in the Upper Klamath River subbasin in 2014.

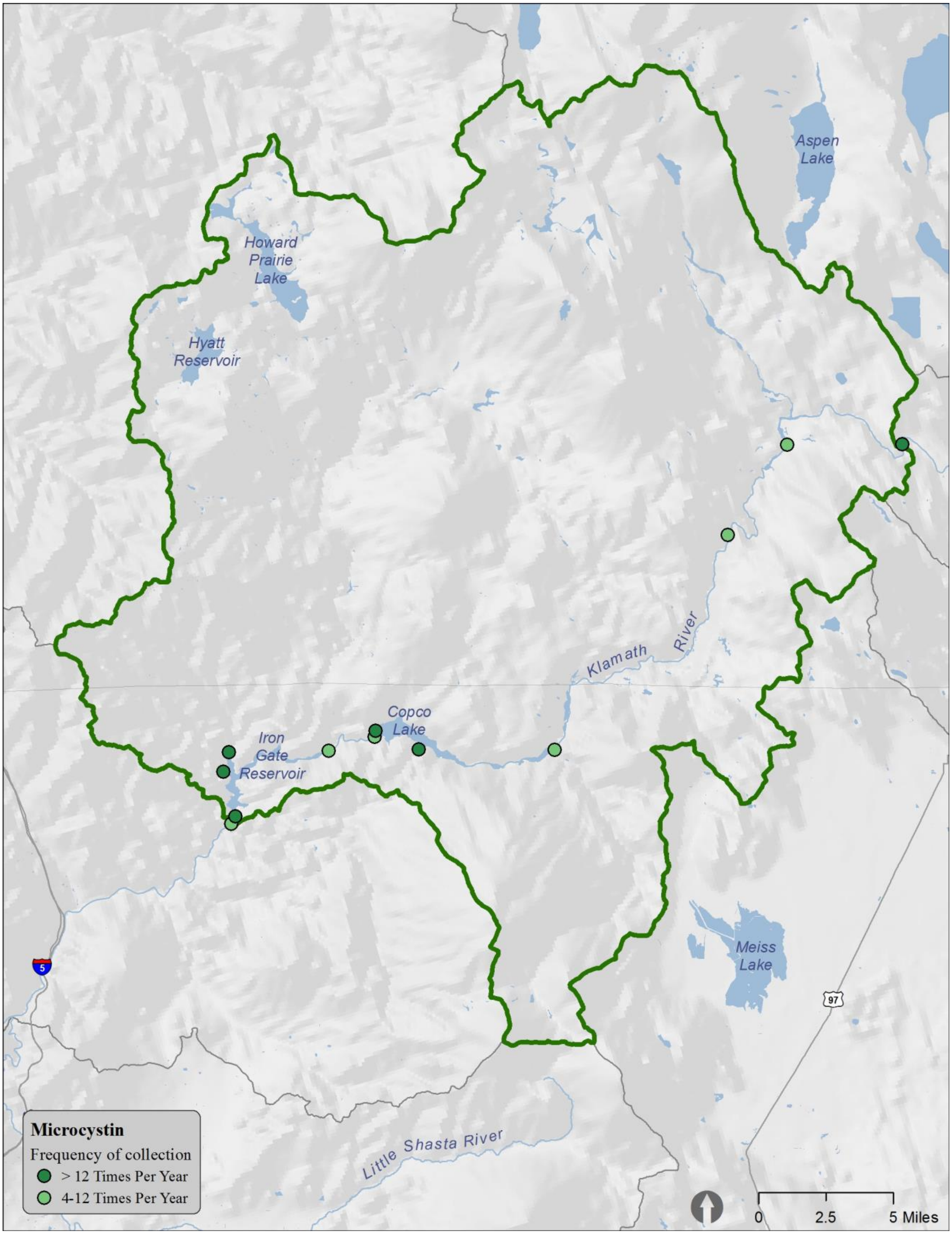


Figure 53: Microcystin monitoring in the Upper Klamath River subbasin in 2014.

5.0.6 Butte

Background
Butte subbasin is primarily a closed subbasin; it is not currently included in this review.

5.0.7 Shasta

Background

The Shasta subbasin has a long history of water resource development. Agricultural land uses and water management practices have had a significant impact on water quality, including raising temperature and nutrient levels. Supporting projects that reduce ponding and warm water returns in the Shasta will continue to be a major focus for the RCD (Karen Mallroy Appendix 1). Low dissolved oxygen concentrations and elevated water temperatures in the Shasta River, its tributaries, and Lake Shastina have resulted in degraded water quality conditions that do not meet applicable water quality objectives and that impair designated beneficial uses. The Shasta River watershed was listed as impaired for organic enrichment/dissolved oxygen in 1992, and as impaired for temperature in 1994, pursuant to Section 303(d) of the Clean Water Act. These listings were confirmed in the TMDL analysis (NCRWQCB, 2006). Dissolved oxygen concentrations are regularly too low to comply with the Basin Plan dissolved oxygen objectives. Water temperature conditions regularly exceed temperature thresholds protective of salmonids.

The designated beneficial uses associated with the cold freshwater salmonids fishery are the designated beneficial uses most sensitive to the dissolved oxygen and water temperature impairments. Other designated beneficial uses that are not fully supported include: cold freshwater habitat; rare, threatened, and endangered species; migration of aquatic organisms; and spawning, reproduction, and/or early development of fish, commercial and sport fishing; and contact and non-contact water recreation, cultural uses and subsistence fishing. Important species in the Shasta River watershed include coho, Chinook salmon and trout.

Currently, there is not enough data to establish baseline trends in the Shasta subbasin. The Shasta River temperature source analysis identifies the sources that affect the temperature of the Shasta River watershed. Five primary factors have been identified as affecting stream temperatures in the Shasta River watershed. Human activities have affected, or have a potential to affect, each of these factors. The factors include:

- Reduced stream shade resulting from agricultural practices, grazing and livestock activities;
- Tailwater return flows;
- Flow modification and diversion;
- spring inflow; and
- Lake Shastina and minor channel impoundments.

In addition, microclimate alterations resulting from near-stream vegetation removal may increase temperatures, where microclimates exist. Changes in channel geometry from natural conditions can also negatively affect water temperatures. These factors have not been quantified for the Shasta River temperature TMDL (NCRWQCB, 2006).

Within the Shasta subbasin, the North Coast Regional Water Quality Control Board with the assistance of organizations collecting water quality information in the Shasta subbasin are in the process of developing a Water Quality Compliance and Trend Monitoring Plan. The purpose of the plan is, "to determine, on a watershed scale, if water quality standards are being met, and to track progress toward meeting water quality standards." Locations and parameters identified from this process shall be included in a later version of this document, the Klamath Basin Water Quality Monitoring Plan.

Limiting Factors

Table 8: 303(d) impaired waters of the Shasta subbasin.

Impairments	**Region**
Temperature	Entire water body
Organic Enrichment/Dissolved Oxygen	Entire water body
Aluminum	Mainstem Shasta River
Mercury	Shasta River and Lake Shastina

The KBMP Water Quality Subcommittee identified additional potential limiting factors to address: bacteria, sediment

Recommendations:

List of Recommendations from the (NCRWQCB)

At the mouth of the Shasta River regular monitoring of the following parameters are recommended: temperature (continuous), DO (continuous), NH4, N02/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH.

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

Specific recommendations for the Shasta subbasin are monitoring of bacteria and sediment, in addition to monitoring 303 (d) listed impairments.

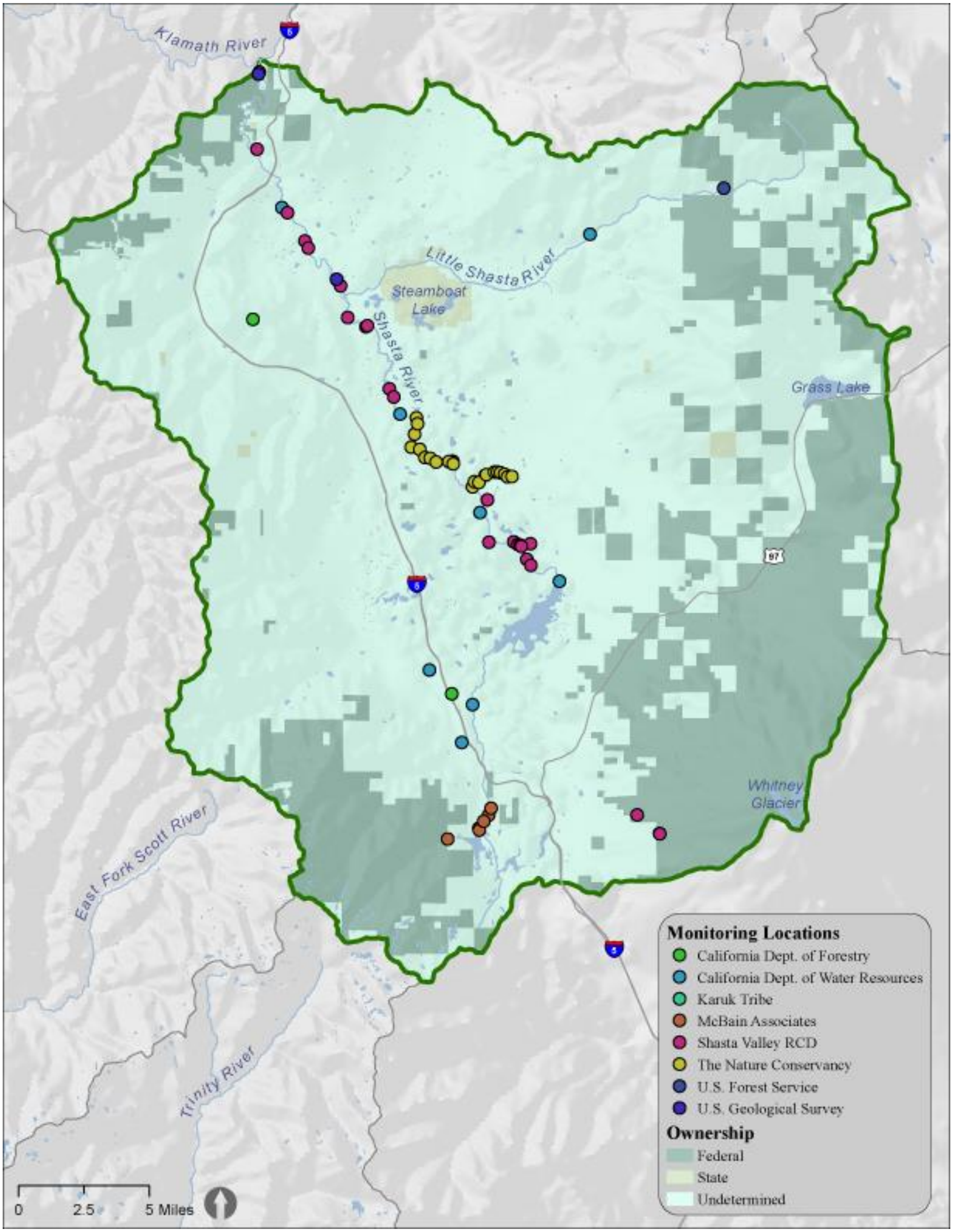


Figure 54: Shasta River subbasin with identified ownership and water quality monitoring organizations.

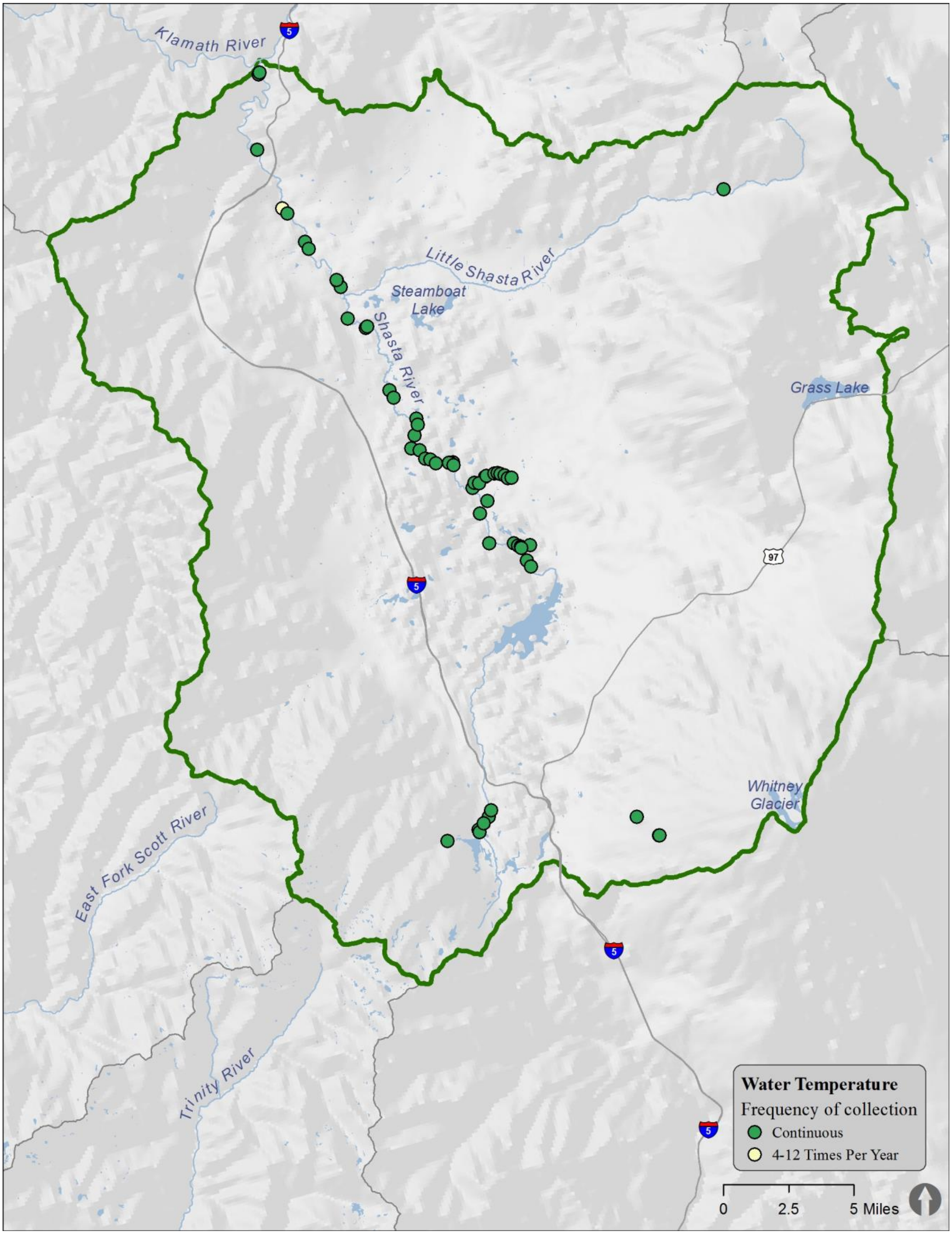


Figure 55: Water temperature monitoring in the Shasta River subbasin in 2014.

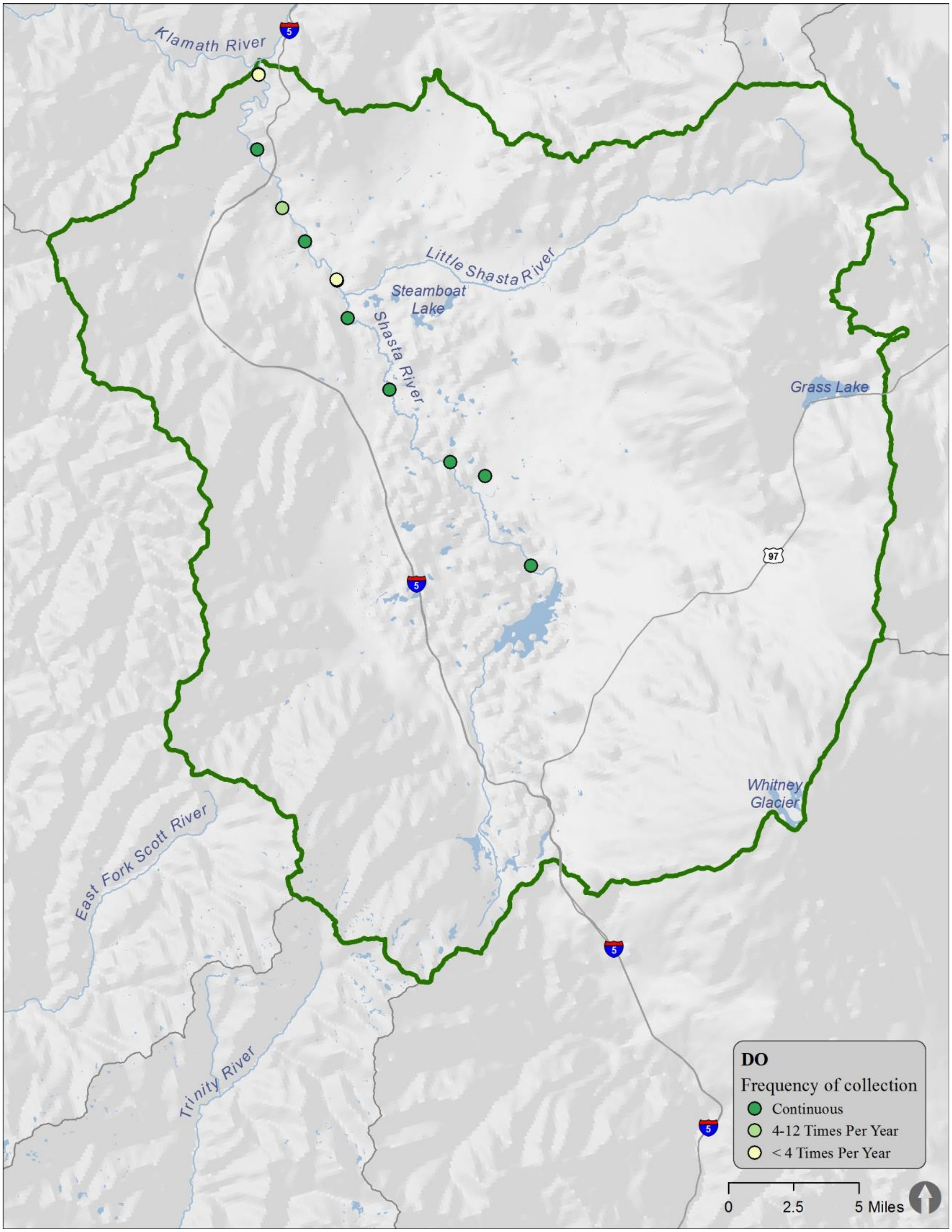


Figure 56: Dissolved oxygen monitoring in the Shasta River subbasin in 2014.

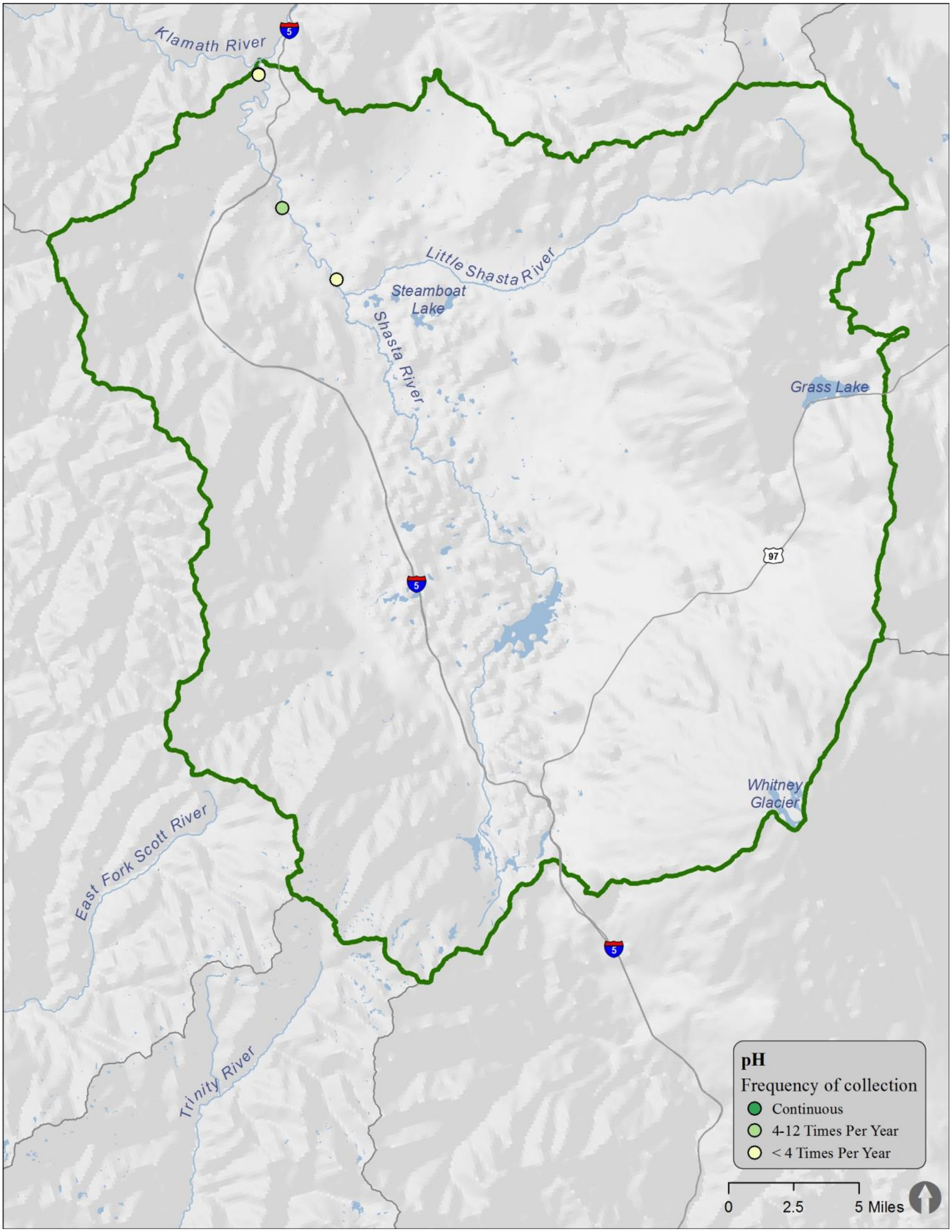


Figure 57: pH monitoring in the Shasta River subbasin in 2014.

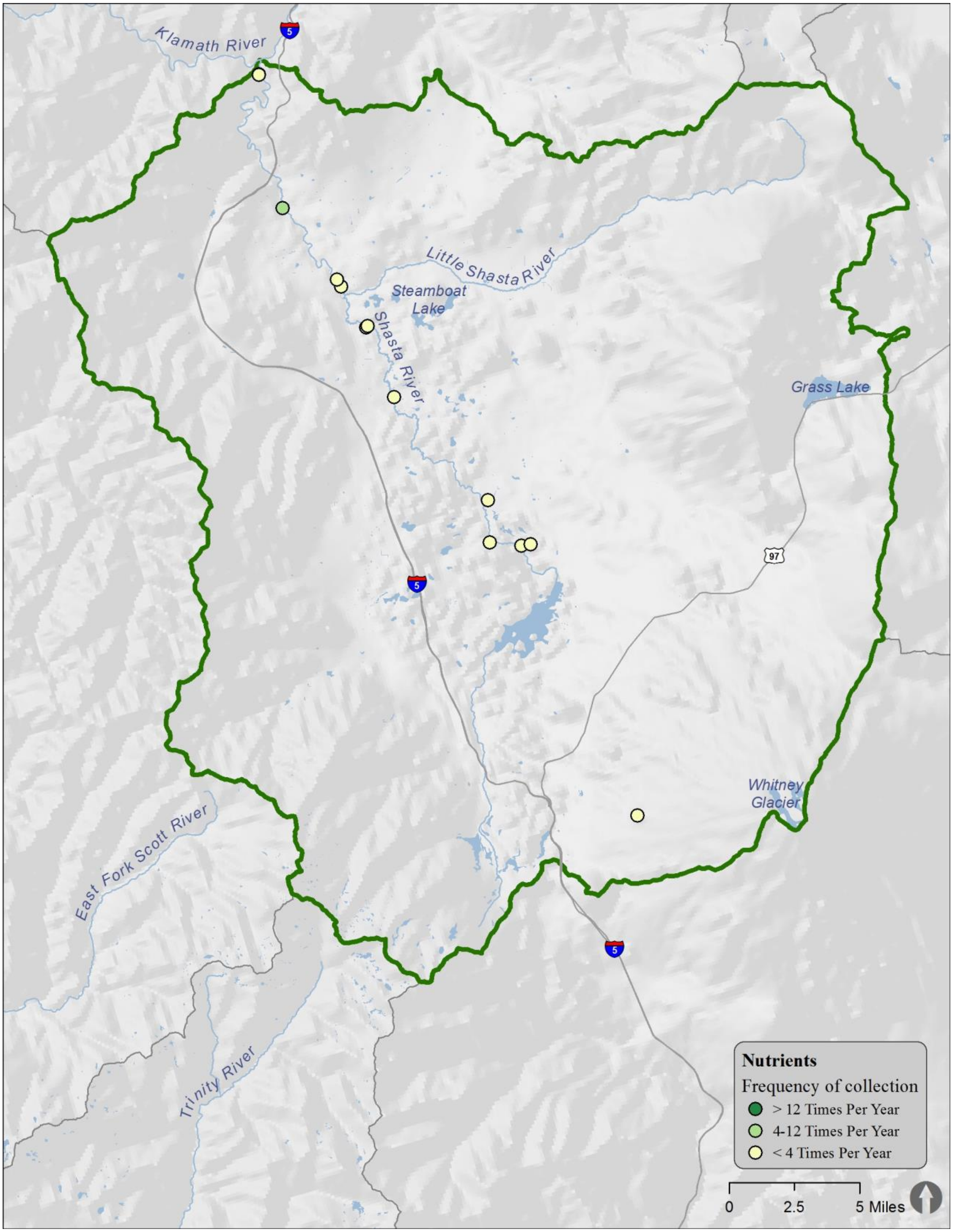


Figure 58: Nutrient monitoring in the Shasta River subbasin in 2014.

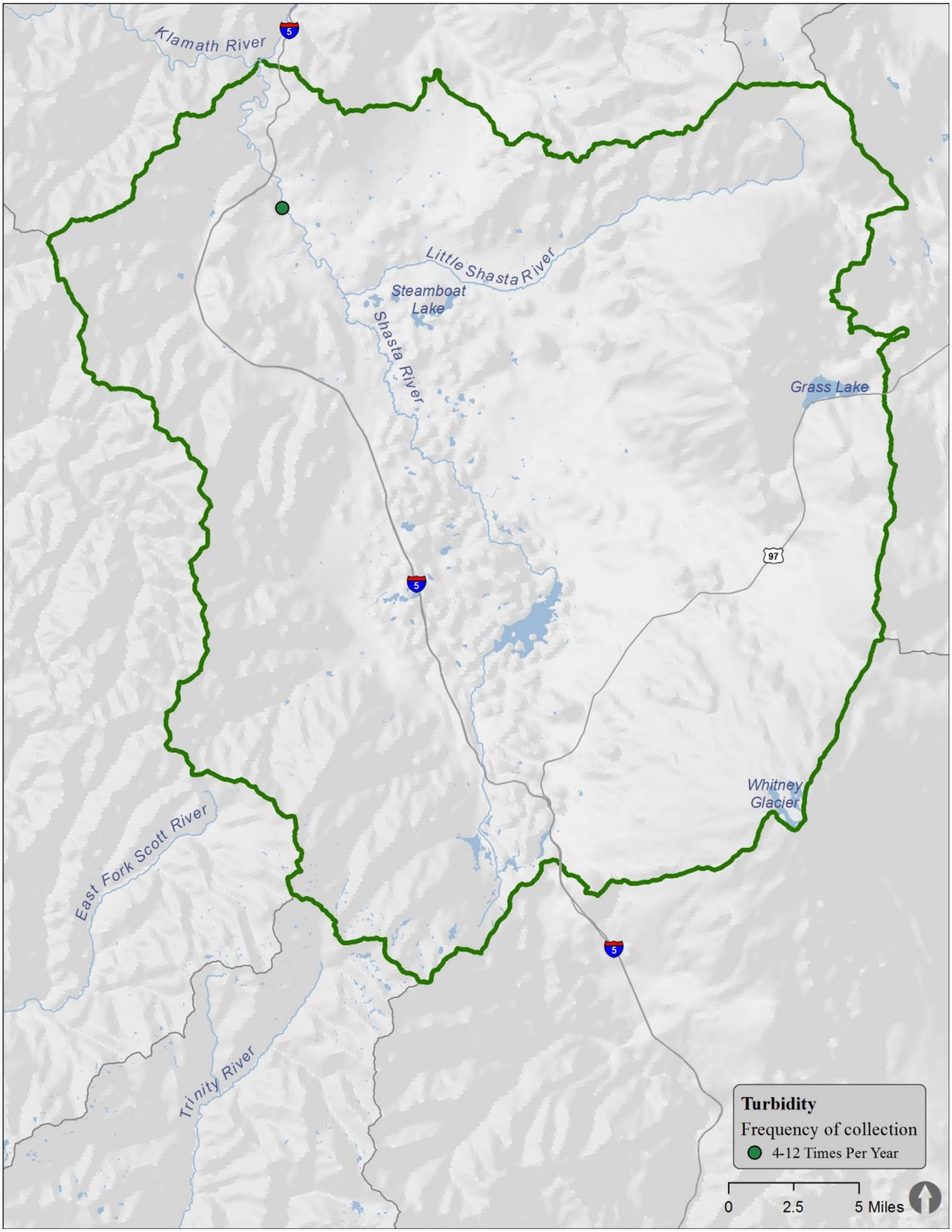


Figure 59: Turbidity monitoring in the Shasta River subbasin in 2014.

5.0.8 Scott

Background

Elevated surface water temperatures and increased sediment loads have impaired many designated uses of the Scott River, including cold water fishery beneficial uses of migration, spawning, reproduction and early development (NCRWQCB, 2005a). Salmonid populations in the Scott River watershed have declined significantly from historic levels and coho salmon are listed as threatened under the state and federal Endangered Species Acts.

Excessive sediment loads and elevated water temperatures have resulted in the non-attainment of water quality objectives for sediment, suspended material, settleable material, and water temperature (NCRWQCB, 2005a). Excessive sediment fills pools, reducing available habitat. Fine sediment, which constitutes most of the additional sediment load, fills and buries the gravels that salmonids require to spawn. In addition, the influx of fine sediments reduces the number of macroinvertebrates available for food during salmonid rearing. Excess sediment produces wider, shallower channels which are subject to solar heating and contribute to the non-attainment of temperature objectives (NCRWQCB, 2005a). However, recent requirements from the Scott TMDL implementation plan has led to priority changes for local restoration and monitoring groups. This regulatory action has promise of improving water quality and fish populations.

Land use practices in the Scott subbasin include: timber harvesting, irrigation of agricultural land, and live stock grazing. These land use activities have the potential to affect water quality through: increased solar radiation, increased sediment loads, water extraction and the loss of large woody debris, all resulting in microclimate / habitat alterations.

Microclimate alterations also have the potential to impact stream temperatures. Diversions of surface water lead to relatively small temperature impacts in the mainstem Scott River, but have the potential to affect temperatures in smaller tributaries, where the amount of water diverted is large relative to the total flow. The source analysis conducted by the NCRWQCB (NCRWQCB, 2005a) found that the primary human-caused factor affecting stream temperatures is increased solar radiation resulting from reductions of shade provided by vegetation. Groundwater inflows are also an important driver of stream temperatures in the Scott Valley.

Agriculture and livestock grazing also have the ability to introduce nutrient and bacteria pollution. According to the Quartz Valley Tribe, E.coli monitoring in 2007 indicated an exceedance of the USEPA Ambient Surface Waters level standard and in 2008 of exceedance to the North Coast Basin Plan (Crystal Bowman Appendix 1). This is a public health threat and is therefore not meeting the beneficial uses of recreation. Exceedances were documented in both tributaries and the mainstem Scott. Sonde monitoring efforts by the Quartz Valley Tribe in 2007 and 2008 indicate dissolved oxygen and pH Basin Plan requirements for salmonids are not being met in various locations on the mainstem Scott. This is directly related to consistently high levels of nitrogen (> 0.12 mg/l) detected on the mainstem Scott River and Shackleford Creek (Crystal Bowman Appendix 1). Nutrients do not directly affect salmonids, but can impact them indirectly by stimulating the growth of algae and aquatic macrophytes to nuisance levels that can adversely impact dissolved oxygen and pH.

Climate related impacts are anticipated to stress limited water resources. The agricultural community will require more groundwater wells to meet their existing needs as surface flows decrease. Increased withdrawals from the aquifer would lower the water table thereby decreasing the river depth, velocity and connectivity. As water resources dwindle, a cascade of impacts such as, increased algal growth, alterations to macroinvertebrate assemblages, lowering of the water table and associated plant stress may follow. While it is uncertain the exact impacts of climate change, systems that are impaired may have a difficult time adapting.

Within the Scott subbasin, the North Coast Regional Water Quality Control Board with the assistance of organizations collecting water quality information have developed a Water Quality Compliance and Trend Monitoring Plan. The purpose of the plan is, "to determine, on a watershed scale, if water quality standards are being met, and to track progress toward meeting water quality standards." Under the plan, several parameters have been identified, including: pebble counts, McNeil samples, turbidity, V-star (fraction of a pools volume filled with fines), channel cross-section, benthic macroinvertebrate abundance, riffle surface fine sediment, temperature, effective shade, riparian vegetation extent, and stream flow. While the majority of these parameters are outside of the identified parameters for the Klamath Water Quality Monitoring Plan, several sites identified in the Scott River Watershed Water Quality Compliance and Trend Monitoring Plan shall be included in the monitoring network for turbidity monitoring, including: USGS gage near Fort Jones, Moffett Creek, and a site on Shackleford Creek.

Limiting Factors

Table 9: 303(d) impaired waters of the Scott subbasin.

Impairments	Region
Sediment	Scott
Temperature	Scott
Aluminum	Mainstem Scott from Young's Dam to Boulder Creek
Biostimulatory Conditions/Dissolved Oxygen	Mainstem Scott from Young's Dam to Boulder Creek
pH	Mainstem Scott from Young's Dam to Boulder Creek
pH	Shackleford Creek above Campbell Lake

The KBMP Water Quality Subcommittee identified additional potential limiting factors to address: bacteria, algae, water chemistry

Recommendations

List of Recommendations from the (NCRWQCB)

At the mouth of the Scott River the following parameters are recommended: temperature (continuous), DO (continuous), NH4, N02/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH. Monitoring should be conducted weekly from July 1st to August 31st

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

Specific recommendations for the Scott subbasin are monitoring of bacteria, algae and water chemistry, in addition to monitoring 303 (d) listed impairments.

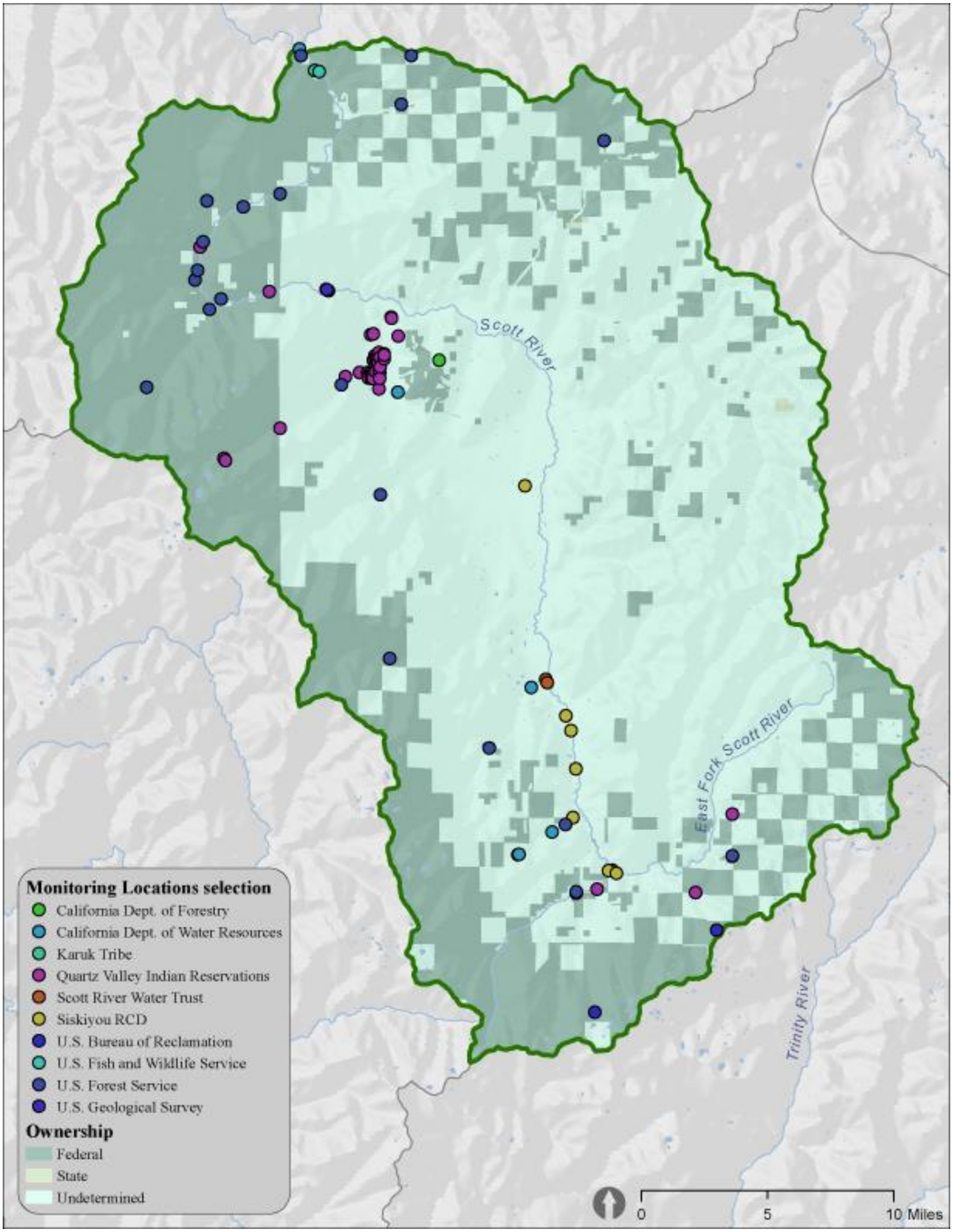


Figure 60: Scott River subbasin with identified ownership and water quality monitoring organizations.

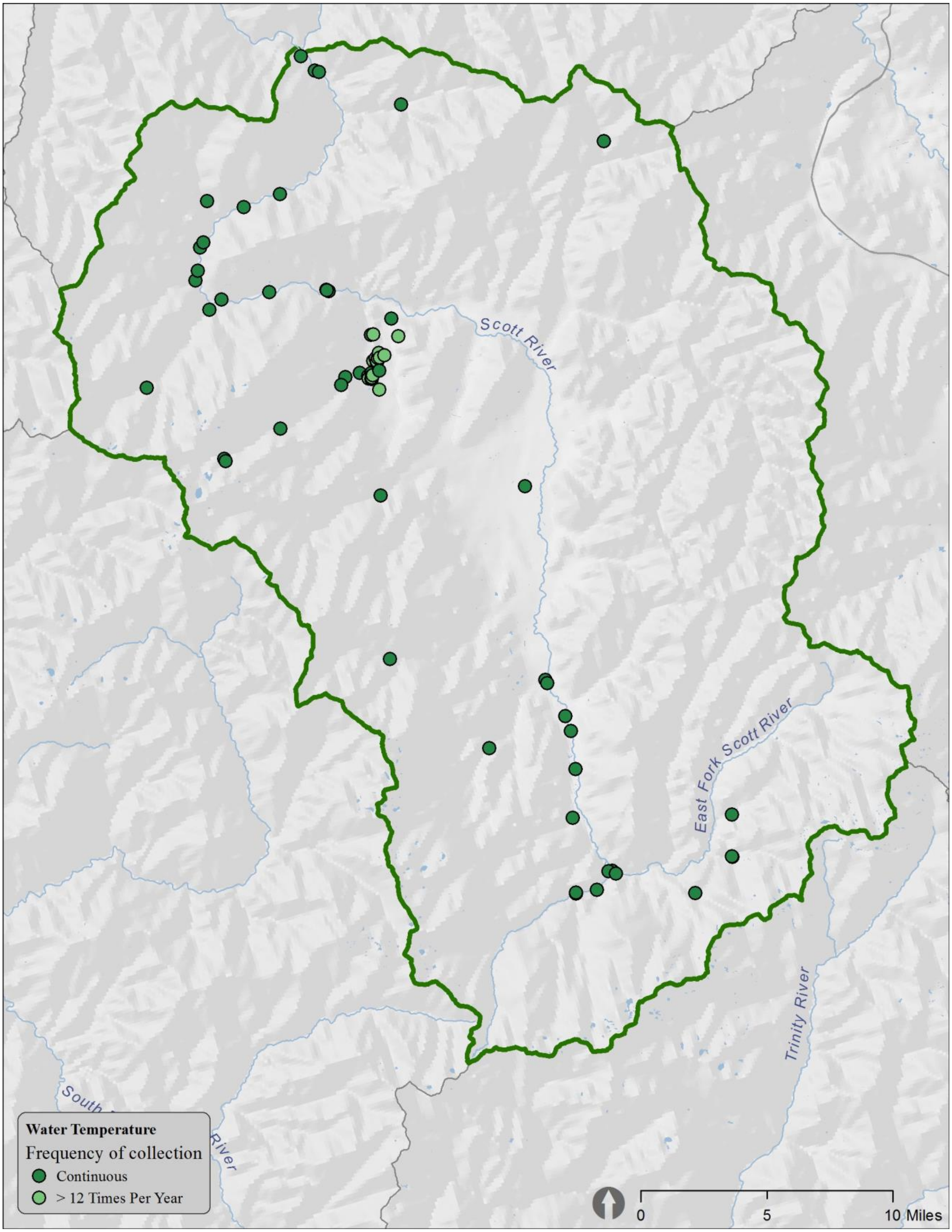


Figure 61: Water temperature monitoring in the Scott River subbasin in 2014.

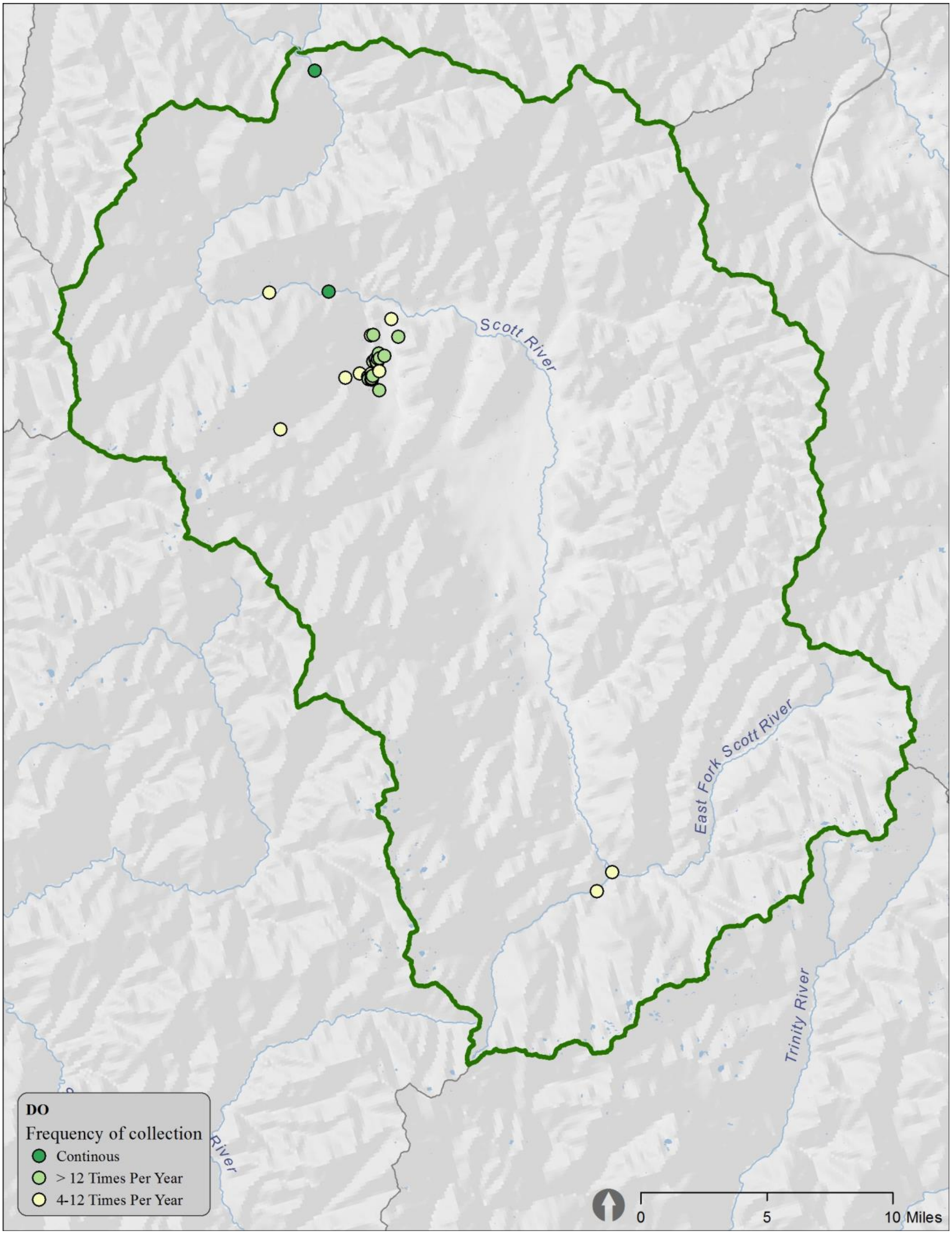


Figure 62: Dissolved oxygen monitoring in the Scott River subbasin in 2014.

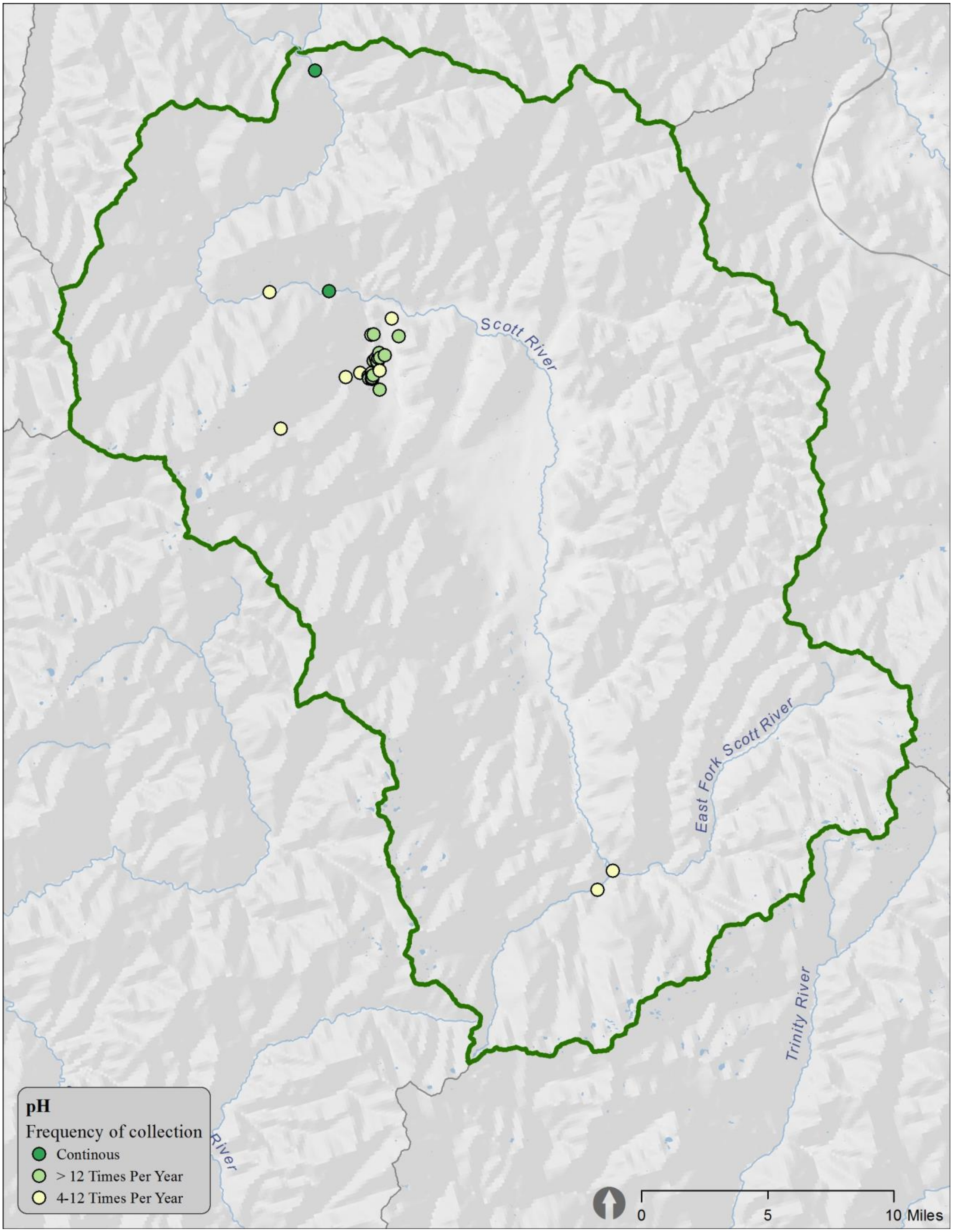


Figure 63: pH monitoring in the Scott River subbasin in 2014.

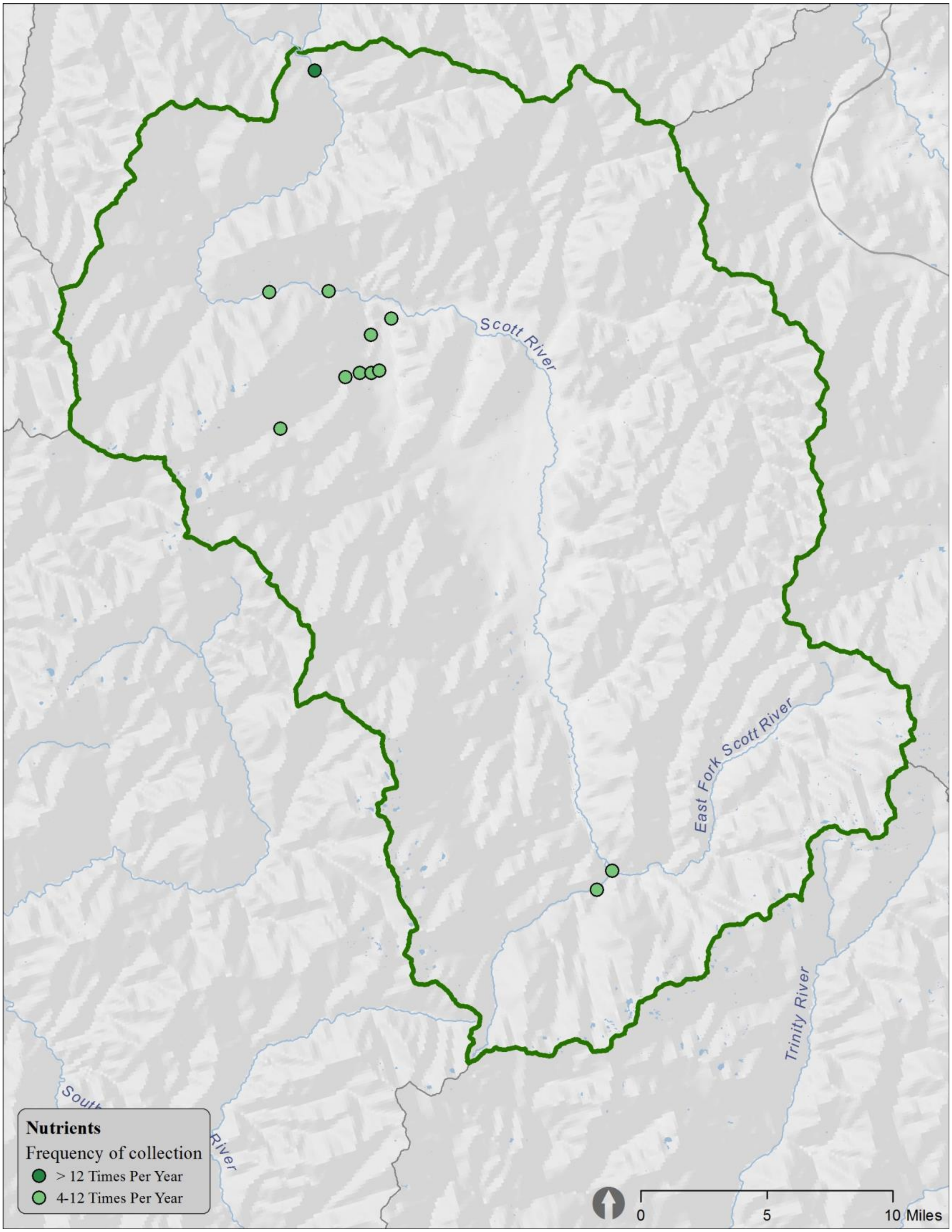


Figure 64: Nutrient monitoring in the Scott River subbasin in 2014.

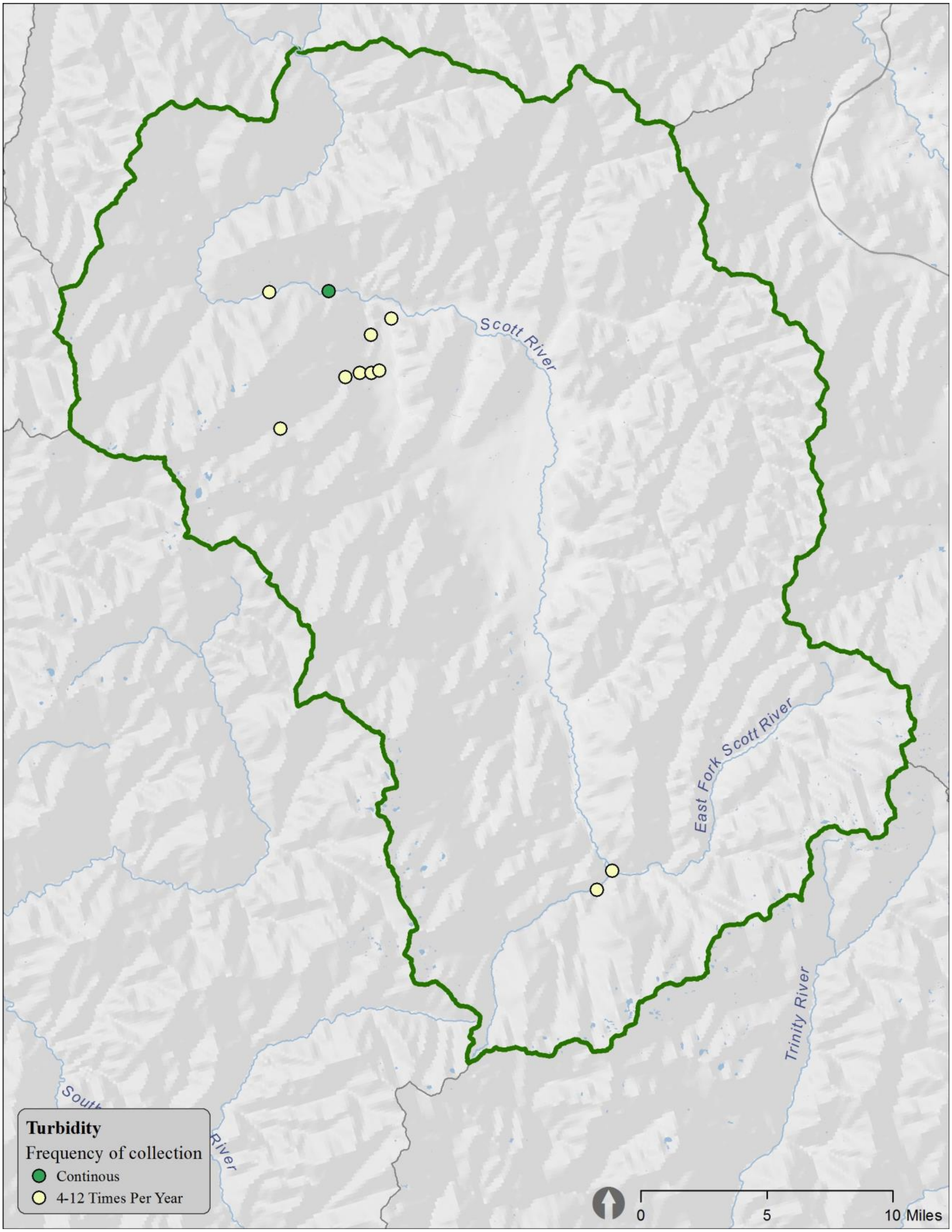


Figure 65: Turbidity monitoring in the Scott River subbasin in 2014.

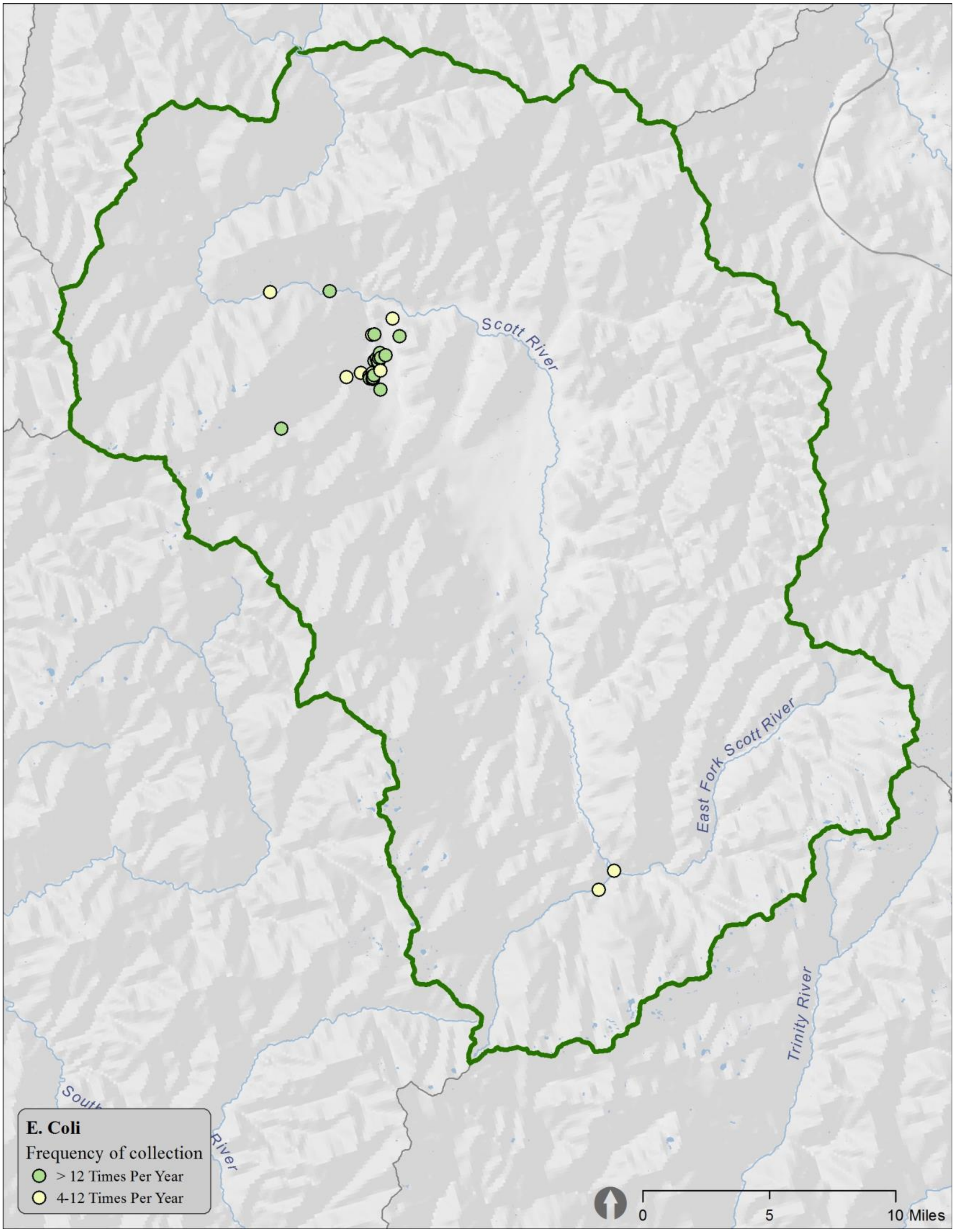


Figure 66: E. coli monitoring in the Scott River subbasin in 2014.

5.0.9 Salmon

Approximately 98.7% of the Salmon River watershed falls under United States Forest Service (USFS) administration (Elder et. al., 2002). The resident population of the Salmon River basin is small; the population is concentrated in and around the communities of Cecilville, Forks of the Salmon, Sawyers Bar, and Somes Bar. Historically the Karuk ancestral territory included about 60% of the Salmon River watershed.

The Salmon River is the most pristine tributary in the Lower Klamath watershed. By volume, it is the second largest tributary of the much larger Klamath River system. It has natural, unregulated flow with no significant diversions and is an essential contributor of cold, clean water to the excessively warm Klamath River. Even so, the Salmon River periodically suffers from excessively high summer temperatures which jeopardize its anadromous fisheries.
The Salmon River Total Maximum Daily Load (TMDL) for temperature has been developed in accordance with Section 303(d) of the Clean Water Act, which identified it as not meeting water quality standards. In 1994, the State of California determined that the water quality standards for the Salmon River are exceeded as a result of impairments associated with temperature and nutrients. In 2004 an analysis and recommendation to delist the Salmon River for nutrient impairment was submitted to the State Water Resources Control Board (SWRCB). The Salmon River TMDL included an Implementation Plan requiring that the USFS (the primary landowner on the Salmon River) take the actions necessary to bring the Salmon River into compliance with clean water standards.

The Salmon River TMDL (NCRWQBC, 2005b) states that stream temperature changes are affected by changes in riparian cover, increased solar heating, and changes in streamside microclimates. Stream temperatures are also affected by other factors, including sediment delivery -- through processes such as channel aggradation and pool infilling. Historic changes in the composition and amount of riparian vegetation have reduced shading and altered stream temperatures from natural levels. TMDL modeling indicates that increased riparian vegetation could reduce stream temperatures in the Salmon River.

Water quality in the Salmon River began to deteriorate from its natural conditions as a result of gold mining activity beginning in the 1850s. The river and streams were dammed, diverted and drained for mining activities, and massive amounts of sediment were discharged into the river. Historically, hydraulic mining activity caused a tremendous amount of change/disturbance to the Salmon River watershed. The structure of the stream channel was greatly modified by mining activity. Although the effects are difficult to quantify, it is likely that wider, shallower channels, reduced pool depth, large cobble/boulder sedimentation, etc., are major contributors to reduced shade, increased insolation, and increased water temperatures (NCRWQCB, 2005b).

More recent management on the Salmon River include road building, commercial timber management, and fire management. These activities have influenced riparian vegetation and sediment delivery patterns in the Salmon River subbasin which have negatively impacted water quality.

The primary beneficial uses of the Salmon River pertain to the anadromous salmonid fishery. The water quality conditions present in the Salmon River are not fully supportive of anadromous salmonid species. The Salmon River retains a small run of spring Chinook salmon. Prior to the early 1900’s the spring run was the dominant run within the Klamath-Trinity river system (Snyder, 1931). Historically, the Shasta, Scott, Salmon, and Trinity rivers all supported large runs. Currently, wild spring Chinook runs face the possibility of extinction in the Klamath River watershed. Today, only the Salmon River and the Trinity River host a viable spring Chinook run. Unlike the Trinity River, the Salmon River run has a completely wild gene stock, making this the last remaining wild spring Chinook run in the Klamath River watershed.

The Klamath River Basin Fisheries Task Force, a federal advisory committee, identified high water temperatures and excessive sediment production as the key limiting factors for the anadromous fisheries resource in the Salmon River subbasin (Elder et. al., 2002). The Klamath River Basin Fisheries Task Force was established by the Klamath River Basin Fishery Resources Act of 1987 (P.L. 99-552) (Klamath Act) to provide recommendations to the Secretary of the Interior on the formulation, establishment, and implementation of a 20-year program to restore the anadromous fisheries of the Klamath River Basin Conservation Area.

The Forest Service has identified recent catastrophic fires as a major contributor of sediment to the Salmon River. Catastrophic fires have also eliminated significant areas of riparian cover in the subbasin (De la Fuente, 1993). The reduction of streamside shade by fire can have direct effects on stream temperature. Fire may also lead to increased soil erosion, and increased sediment delivery that in turn can result in stream aggradation, pool filling, and in extreme cases landsliding, debris torrents, or other forms of mass movement. Increased sediment loads can affect stream temperatures by increasing active wetted channel widths, thus increasing solar radiation inputs, and by reducing the depths of pools. It is estimated that 29% of the Salmon River subbasin has burned since the early 70s. 80,000 acre The Hog Fire (1977) burned extensively in the lower North and South Fork watershed and in Nordheimer and Crapo Creeks. In 1987, wildfires burned 90,900 acres in four separate areas, covering much of the Salmon River subbasin. In 1994, the Specimen fire burned approximately 7,500 acres in the Specimen and Little North Fork Drainages of the North Fork (SRRC, 2000). More recently, the 2006 fires burned 50,000 acres in the Salmon River, and the 2008 fires burned 80,000 acres.

Roads are also a serious contributor to impaired water quality. Increased sediment run-off from roads, in riparian areas, and from upslope areas, has filled in pools (De la Fuente 1993). System and non-system Forest Service roads are responsible for the majority of the sediment input to the Salmon River (Elder et. al., 2002).

The 2003 National Research Council report on Klamath Fisheries states that, "Degradation of the Salmon River is primarily physical, and is associated with inadequate forest management leading to catastrophic fires and logging practices, especially road construction and maintenance, that lead to high levels of erosion. In addition, there are some flow barriers on the Salmon River."

The KBMP Water Quality Subcommittee identified additional potential limiting factors to address: algae, bacteria and sediment input into the system due to fire, legacy mining tales and remnant sediment slugs.

Limiting Factors

Table 10: 303(d) impaired waters of the Scott subbasin

Impairments	Region
Temperature	Salmon

Recommendations

List of Recommendations from the (NCRWQCB)

At the mouth of the Salmon River the following parameters are recommended for monitoring: temperature (continuous), DO (continuous), NH4, N02/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH. Monitoring should be conducted weekly from July 1st to August 31st Additional samples should be collected for the Salmon to evaluate day-to-day variability. These samples should be collected one or two days after the weekly monitoring data are collected at these locations.

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

Specific recommendations for the Salmon subbasin are monitoring of algae, bacteria, sediment and invertebrates, in addition to monitoring 303 (d) listed impairments. Water samples should be collected in the North Fork and South Fork Salmon, as well as at the mouth of the Mainstem, in order to determine the source of any impairments.

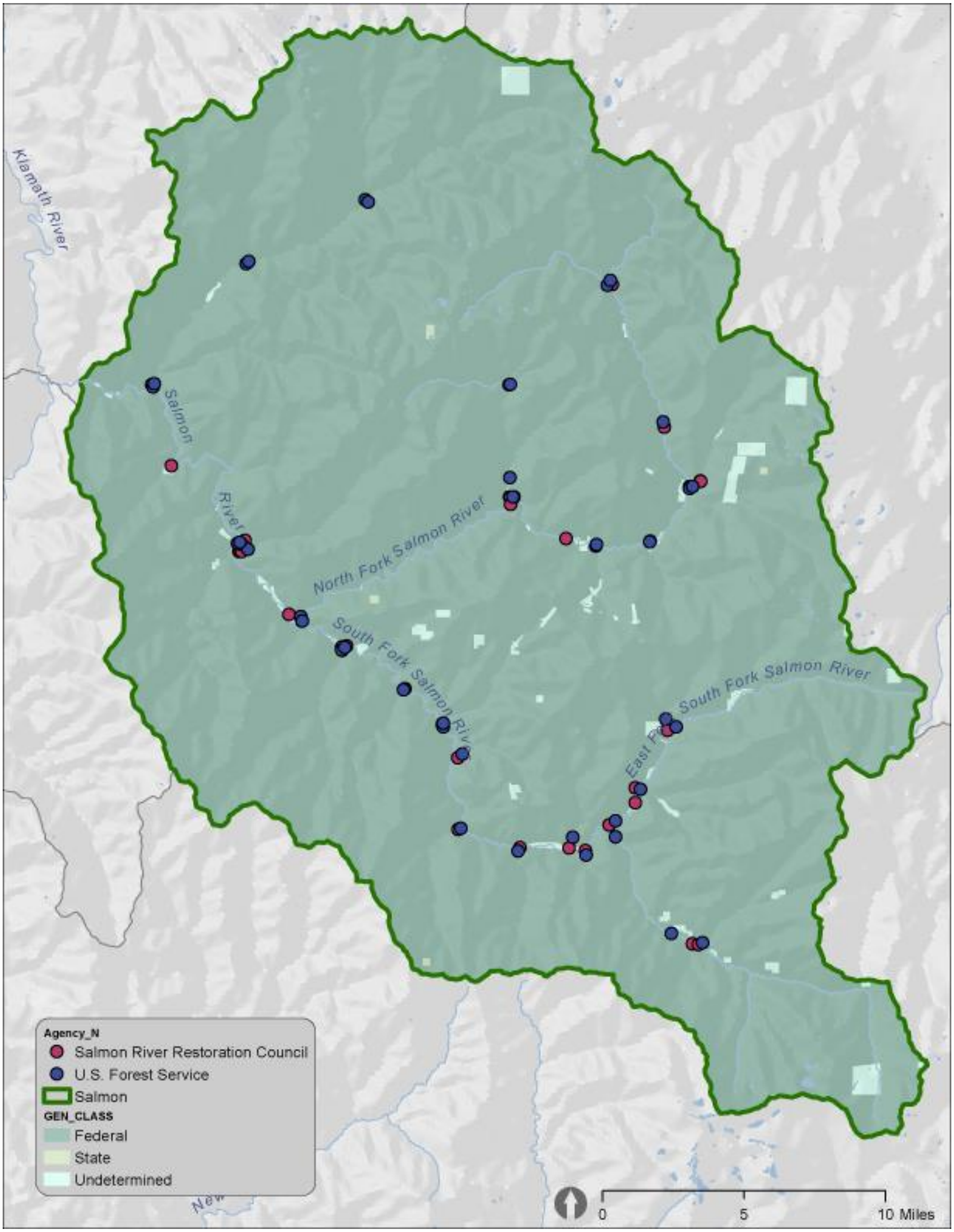


Figure 67: Salmon River subbasin with identified ownership and water quality monitoring organizations.

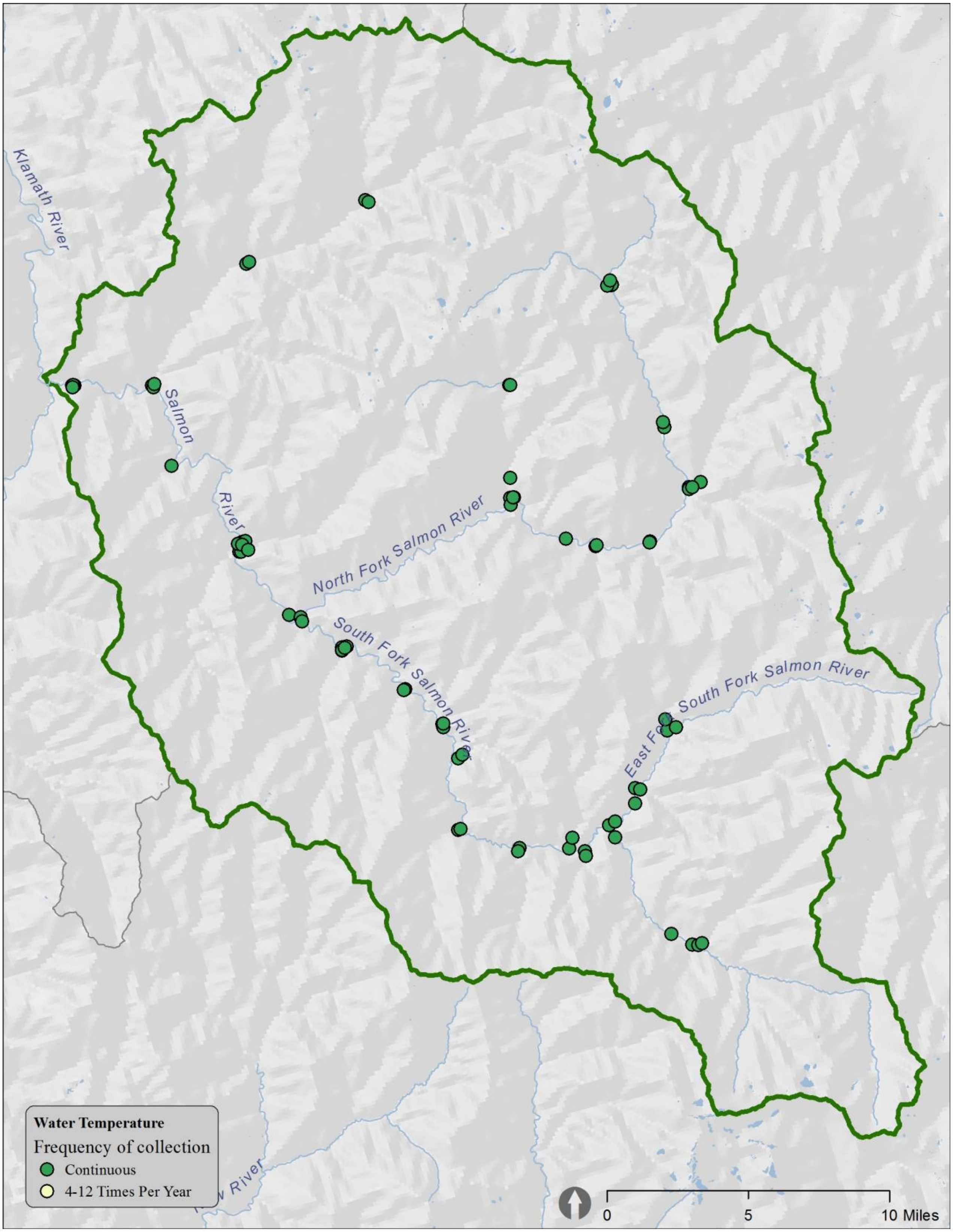


Figure 68: Water temperature monitoring in the Salmon River subbasin in 2014.

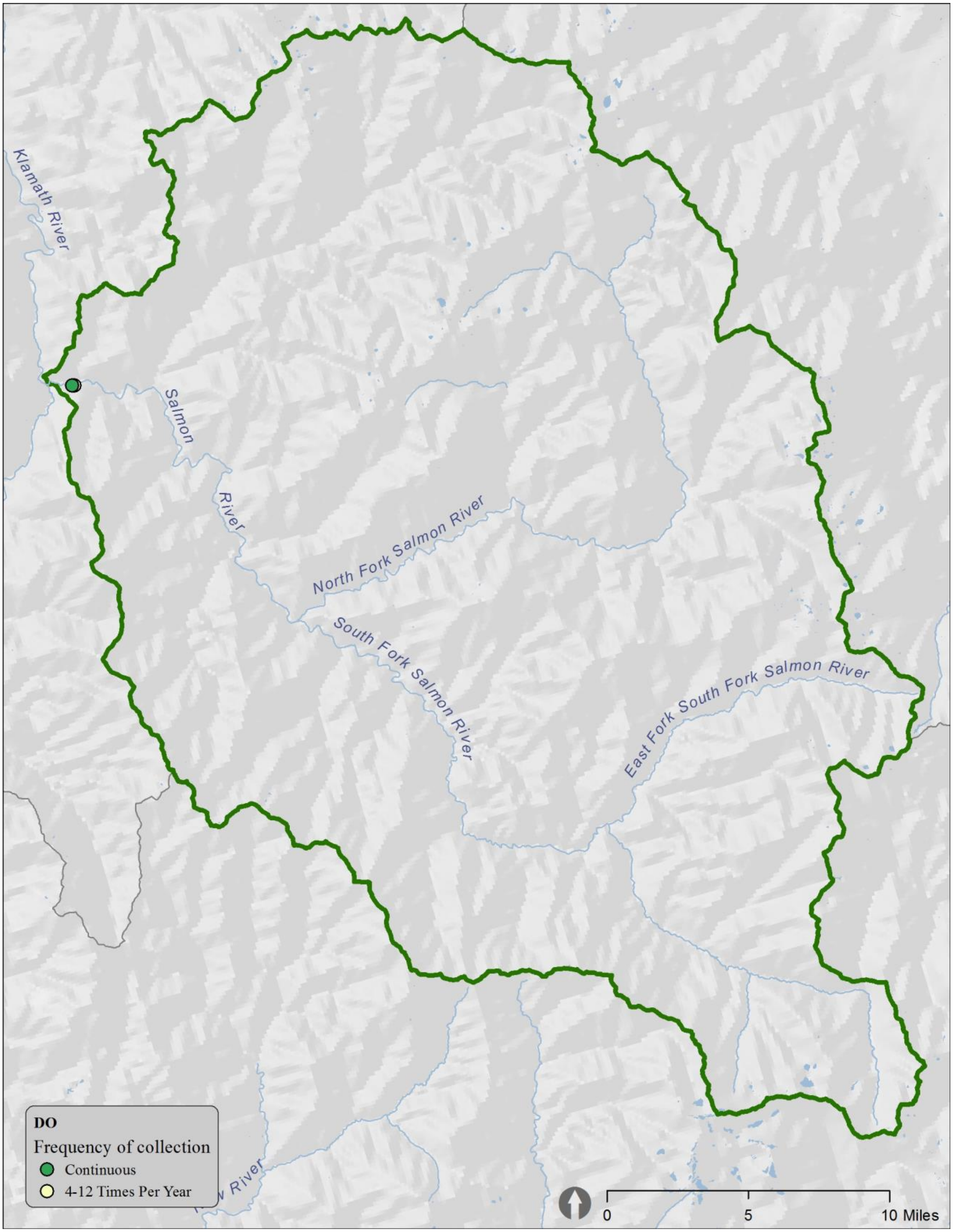


Figure 69: Dissolved oxygen monitoring in the Salmon River subbasin in 2014.

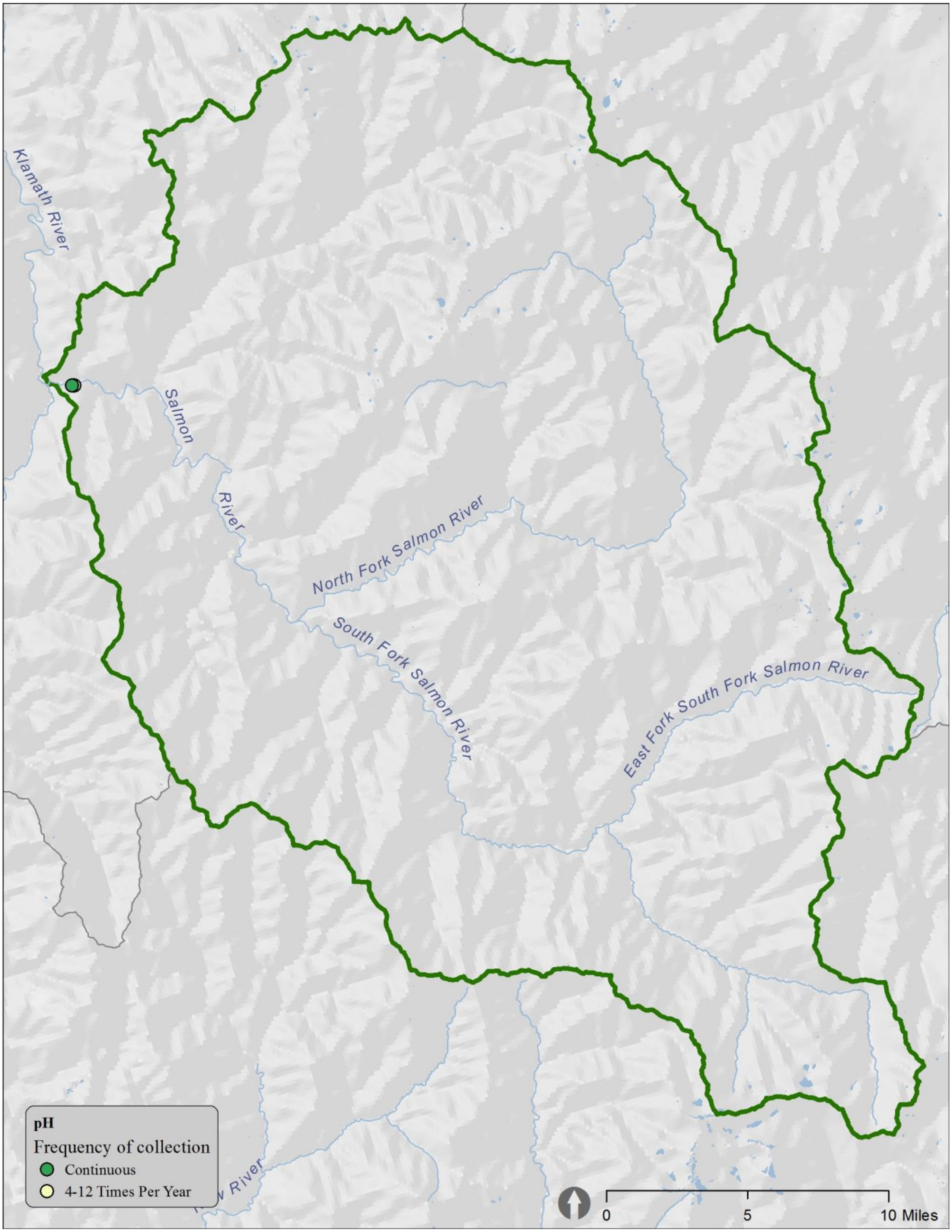


Figure 70: pH monitoring in the Salmon River subbasin in 2014.

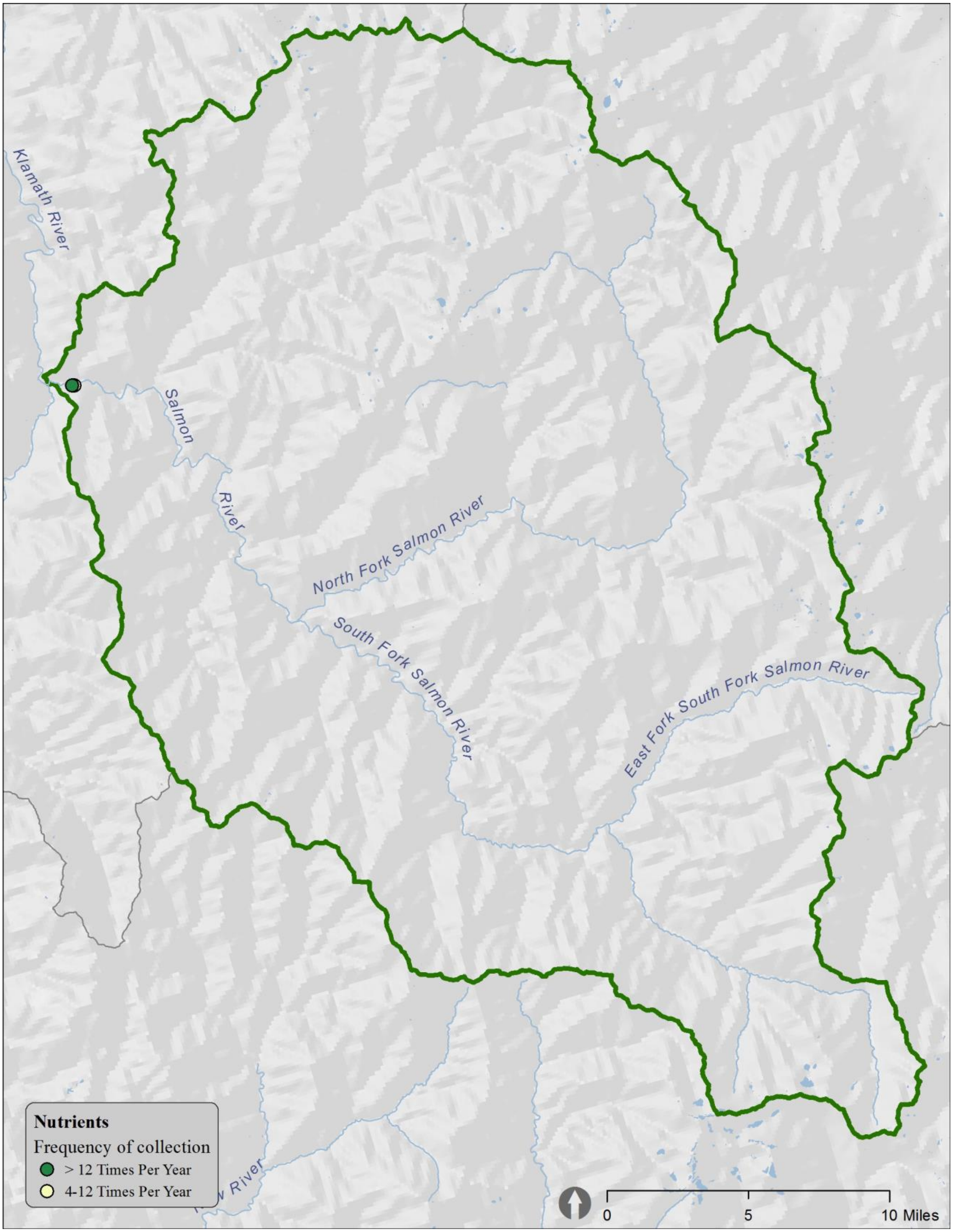


Figure 71: Nutrient monitoring in the Salmon River subbasin in 2014.

5.0.10 Middle Klamath

Background

The Middle Klamath is defined at the upstream boundary by Iron Gate Dam and the downstream boundary by the Salmon River confluence with the Klamath mainstem. Beginning at state line (Upper Klamath), California has listed the portions of the Klamath River within its jurisdiction for impairments due to microcystin, sediment, elevated water temperatures, elevated nutrients, and organic enrichment/low dissolved oxygen.

Through this section of the Klamath River mainstem, the current baseline trends indicate increased water temperatures, elevated nutrient levels, low dissolved oxygen, elevated pH, increased incidence of fish disease, an abundance of plant growth, high Chlorophyll-a levels, and high concentrations of toxigenic blue-green algae (Susan Corum Appendix 1).

Within the Middle Klamath subbasin, several factors affect water quality. The upstream reservoirs, Copco and Iron Gate are highly stratified during the algal growing season May-October (Susan Corum Appendix 1), altering water quality dynamics. Temperatures are cooler in spring and warmer in the fall due to the thermal lag created by the reservoirs. Nutrient dynamics are altered due to highly stratified reservoirs. Grazing reduces riparian vegetation yielding higher river temperatures, by increasing solar inputs due to reduced streamside shade. Copco and Iron Gate Reservoirs provide habitat for algae blooms including the potentially toxic strains such as *Microcystis aeruginosa* (Susan Corum Appendix 1).

There are several sources of sediment input into the Klamath River. Sediment impacts water quality, affecting the ecology of the river system. Both natural and anthropogenic actions may increase sediment inputs. Natural sediment inputs, such as fire removes vegetation leaving the soil surface exposed to increase erosion. Clear cutting can amplify the rate of erosion. Anthropogenic actions such as historic and current mining, forestry practices (i.e. fire suppression), and unmaintained roads may result in increased erosion. Historic mining operations in the Basin have altered stream channels and eroded hill slopes; and current mining re-suspends sediment and mercury in the water column. Forestry practices that may increase erosion rates include clear cutting, salvage logging, fire suppression, and large back burns. Unmaintained roads and culverts may also cause debris torrents, depositing sediment into local rivers and streams.

Current water quality conditions contribute to the non-attainment of beneficial uses; impacted beneficial uses from water quality issues include cold freshwater habitat, rare, threatened or endangered species, migration of aquatic organisms, spawning, reproduction, commercial and sport fishing, cultural use and subsistence fishing, contact and noncontact recreation, wildlife habitat.

Limiting Factors

Table 11: 303(d) impaired waters of the Middle Klamath subbasin.

Impairments	**Region**
Nutrients	Middle Klamath
Temperature	Middle Klamath
Organic Enrichment/ Dissolved Oxygen	Middle Klamath
Microcystin	Middle Klamath
Sediment	Middle Klamath

The KBMP Water Quality Subcommittee identified additional potential limiting factors to address: algae, periphyton, sediment, water chemistry and nutrients.

Recommendations

List of Recommendations from the (NCRWQCB)

Immediately Downstream of Iron Gate Dam:
One monitoring station should be located downstream of Iron Gate Dam - at the end of the turbulent region. This station would also be crucial to understand the nutrient dynamics of the reservoirs. Monitoring should include the same parameters collected for Link River. This will help to characterize inputs to the longest uninterrupted reach of the Klamath River. Samples should be collected on a weekly basis, with pre-dawn and post-dawn monitoring, if possible. Diurnal (continuous) DO and temperature should be included. And, the time period should extend from July 1st to August 31st.

Below channelized section of Iron Gate Dam:
The section of the Klamath River between Scott and Shasta tributaries has recently been demonstrated to have the highest rate of parasite infection of fish within the Klamath system.

To assess nutrient dynamics and characterize daily variability it would be useful to collect diurnal hourly sampling events on three to four days from early spring to mid-fall. The Iron Gate station should be located at either location used by the Humboldt State University / Oregon State University Fish Health research teams. In addition to water chemistry the Nutrient Numeric Endpoint (NNE) parameter for benthic algal biomass should be sampled four times (late spring, early summer, late summer, and late fall). Monitoring should be conducted in close collaboration with the Fish Health Research Group to evaluate: planktonic food source enrichment from reservoir discharges; timing and concentration of parasite spore release; and parasite infection rates among fish and polychaetes.

The following monitoring stations should be located downstream of the Shasta River, downstream of the Scott River, at Seiad Valley, and upstream of the Salmon River should be monitored for: temperature (continuous), DO (continuous), NH4, N02/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH. Monitoring should be conducted weekly from July 1st to August 31st

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

Specific recommendations for the Middle Klamath subbasin are monitoring of algae, periphyton, invertebrates, nutrients, water chemistry and microcystin, in addition to monitoring 303 (d) listed impairments. Additionally, monitoring of blue-green algae, aka cyanobacteria, (including cell count and enumeration of Microcystins auregenosa and Anabaena at a minimum) and cyanotoxins (including microcystins and anatoxins) is recommended from approximately June 1st until levels fall below and remain below regional, state and World Health Organization recommended levels, as applicable.

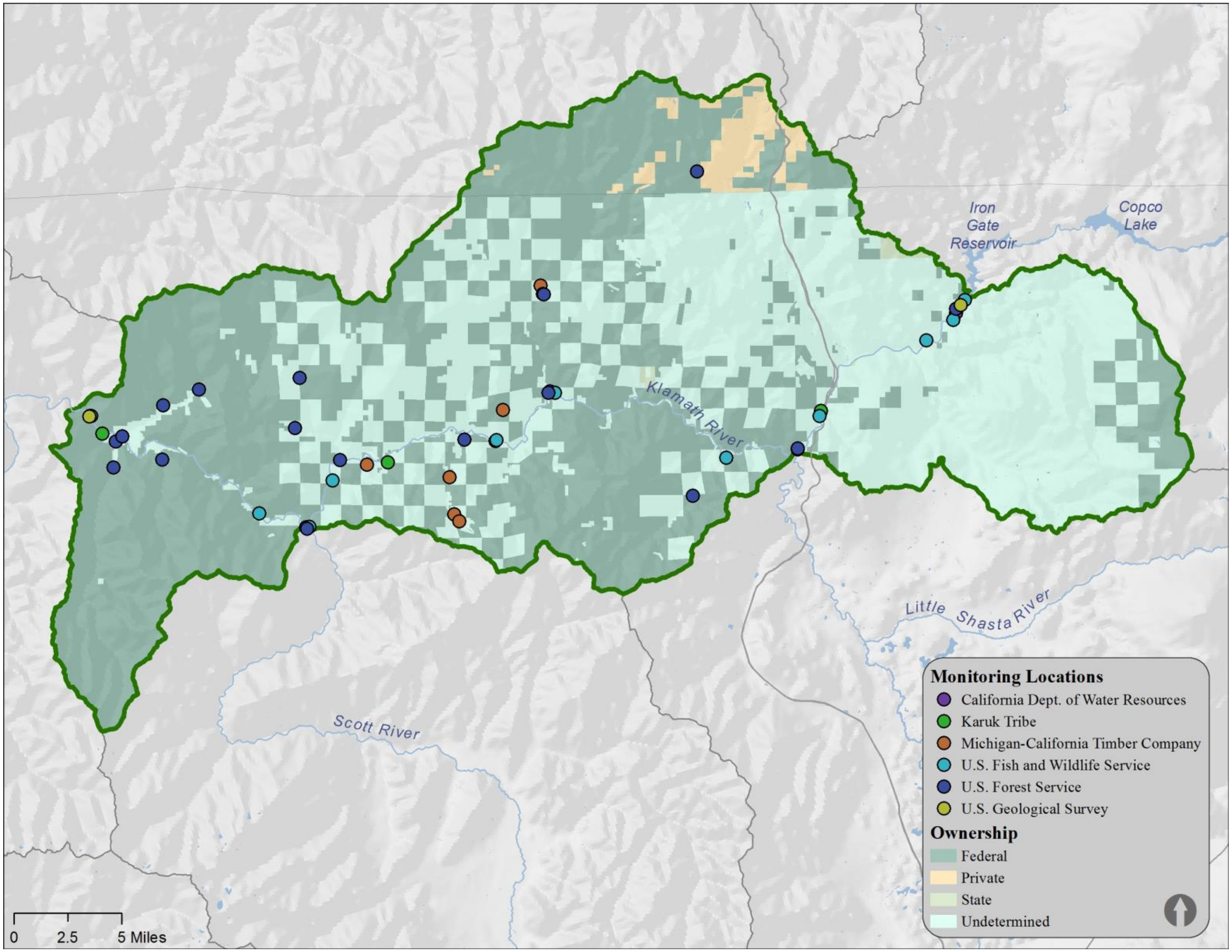


Figure 72: Middle Klamath River subbasin with identified ownership and water quality monitoring organizations.

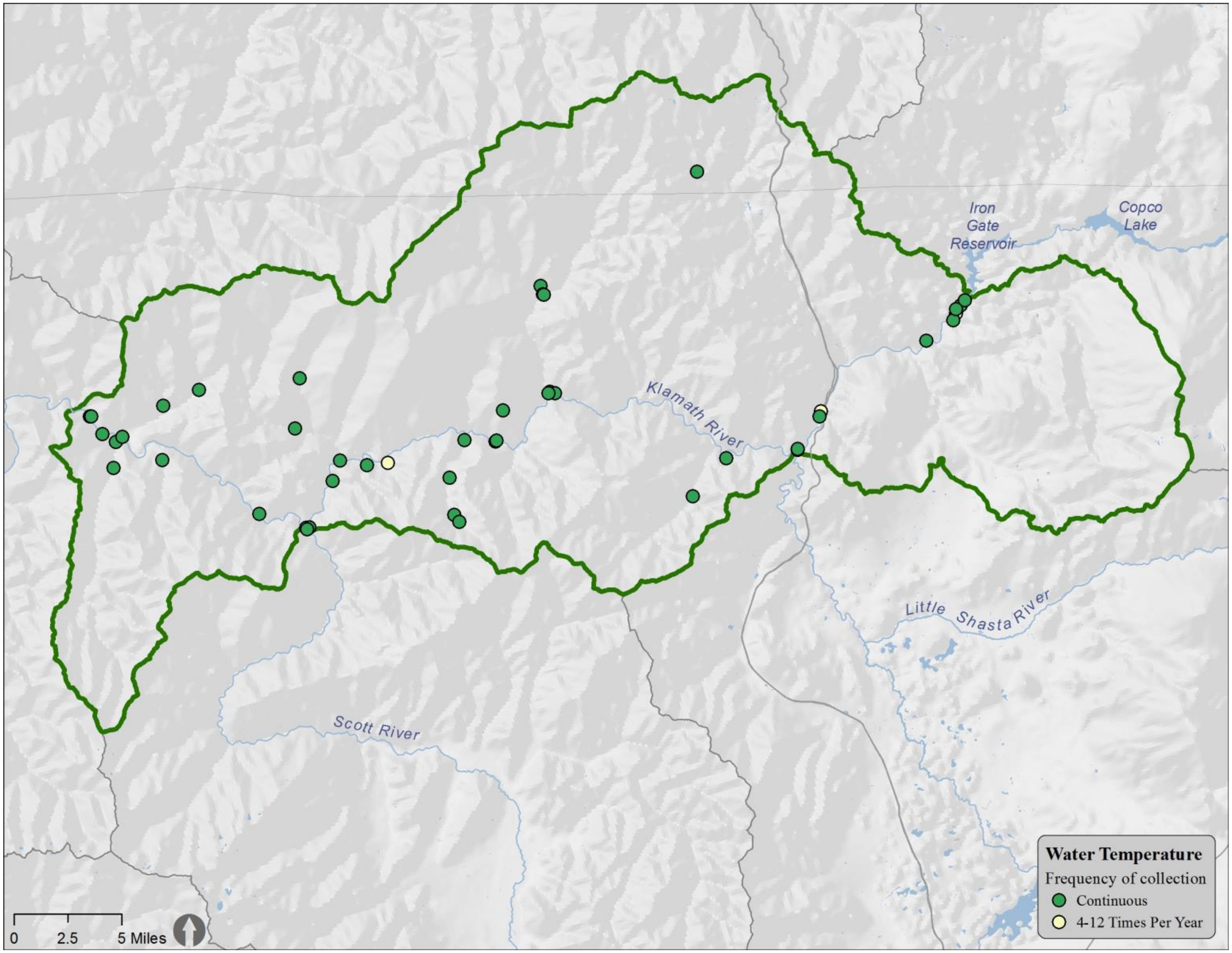


Figure 73: Water temperature monitoring in the Middle Klamath River subbasin in 2014.

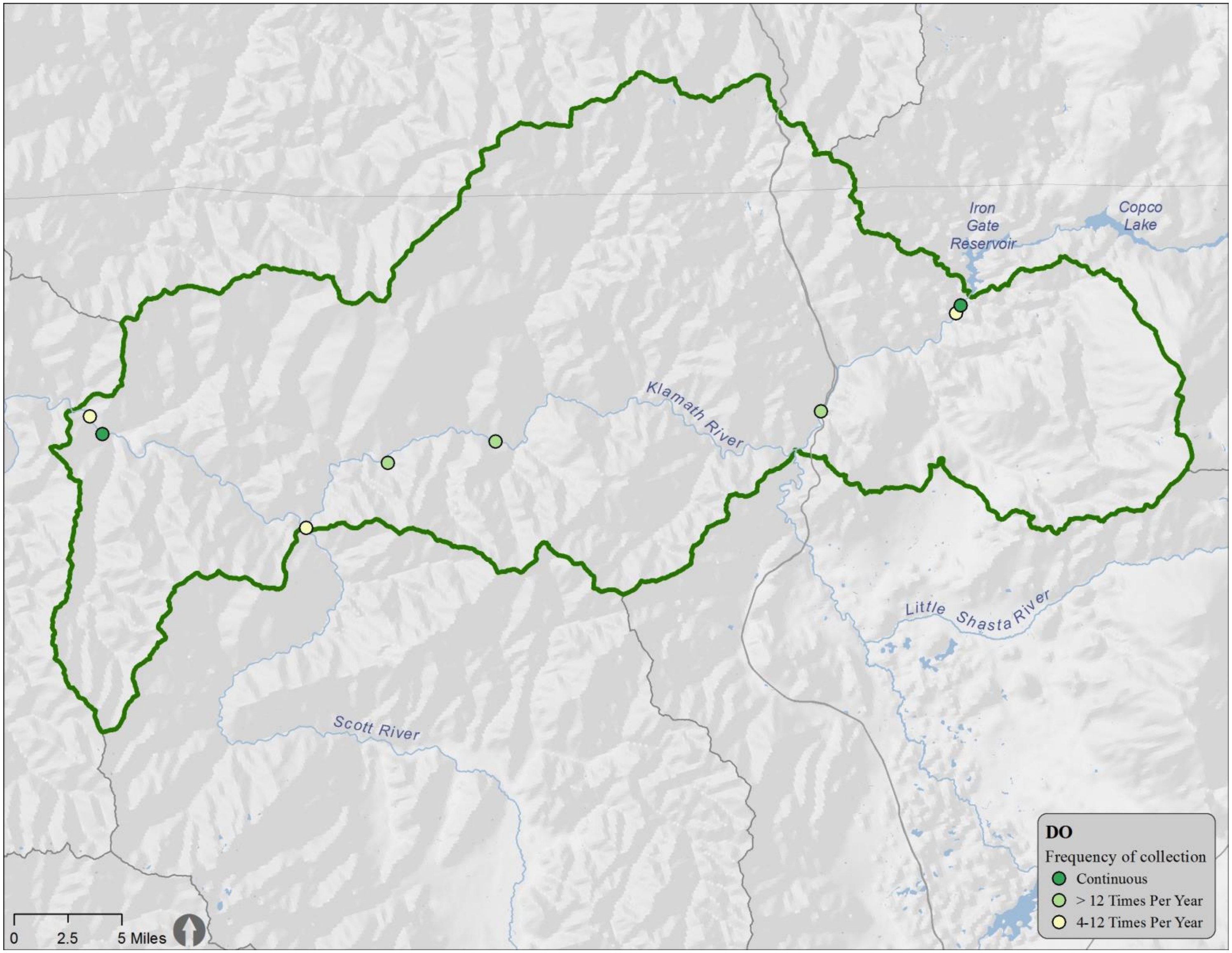


Figure 74: Dissolved oxygen monitoring in the Middle Klamath River subbasin in 2014.

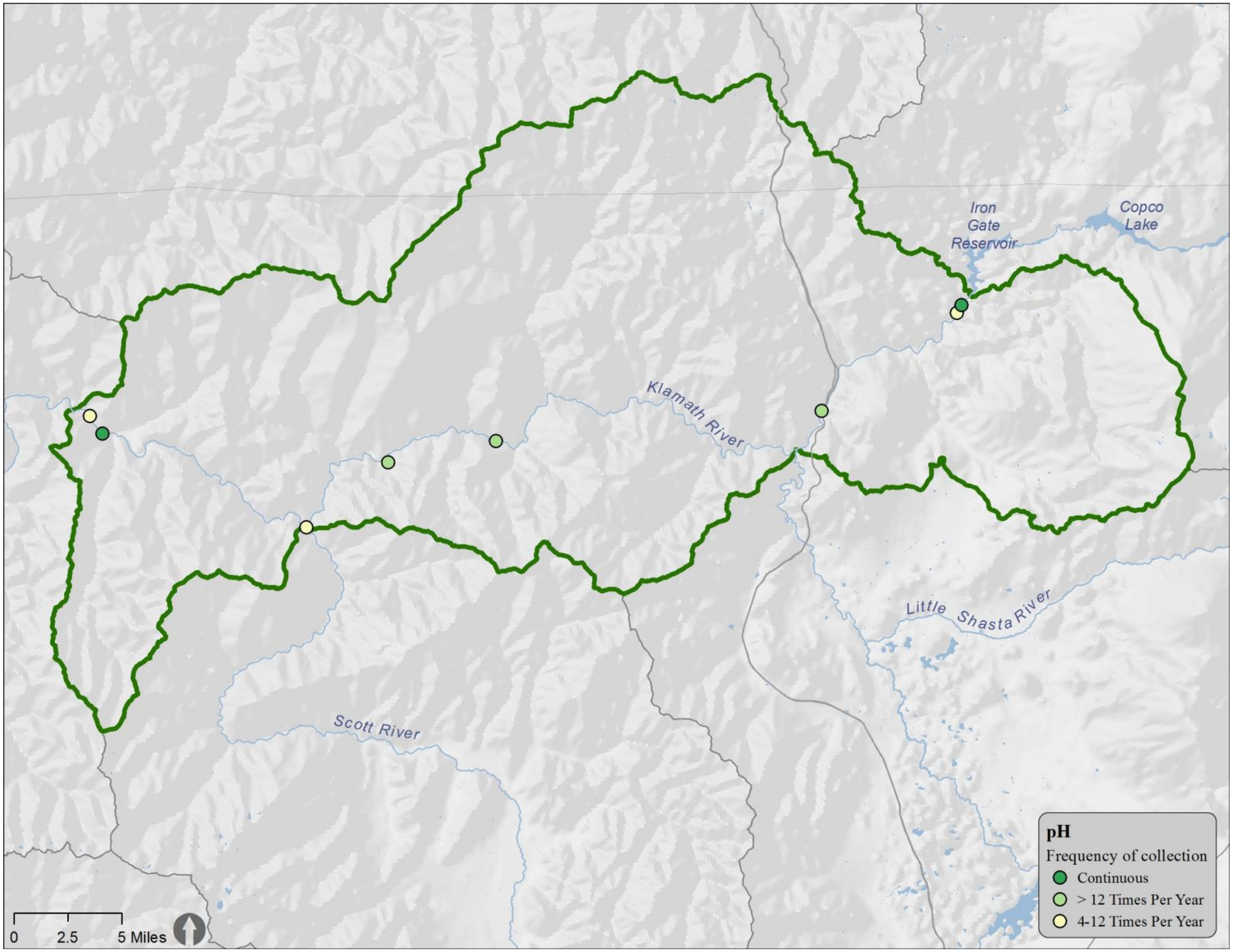


Figure 75: pH monitoring in the Middle Klamath River subbasin in 2014.

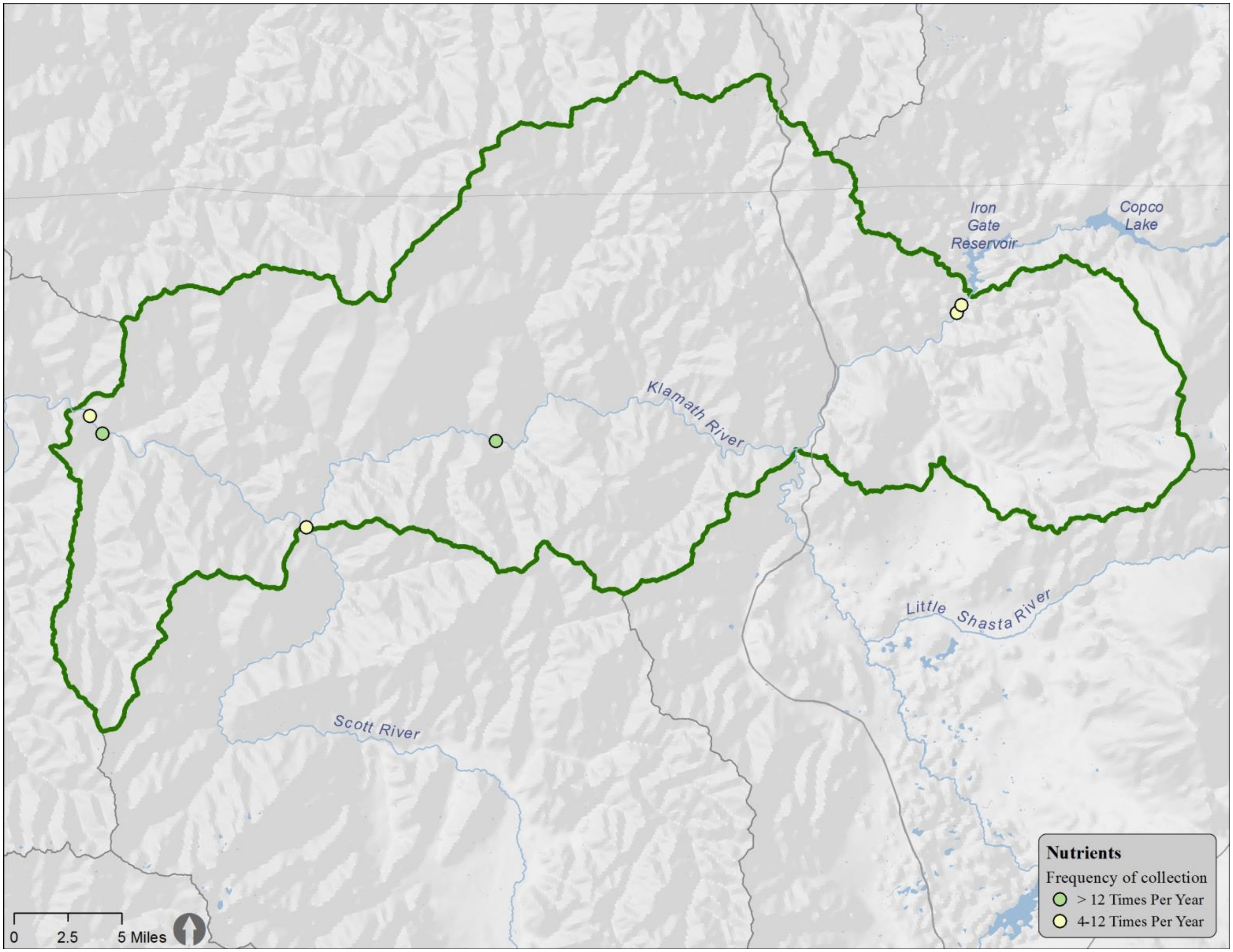


Figure 76: Nutrient monitoring in the Middle Klamath River subbasin in 2014.

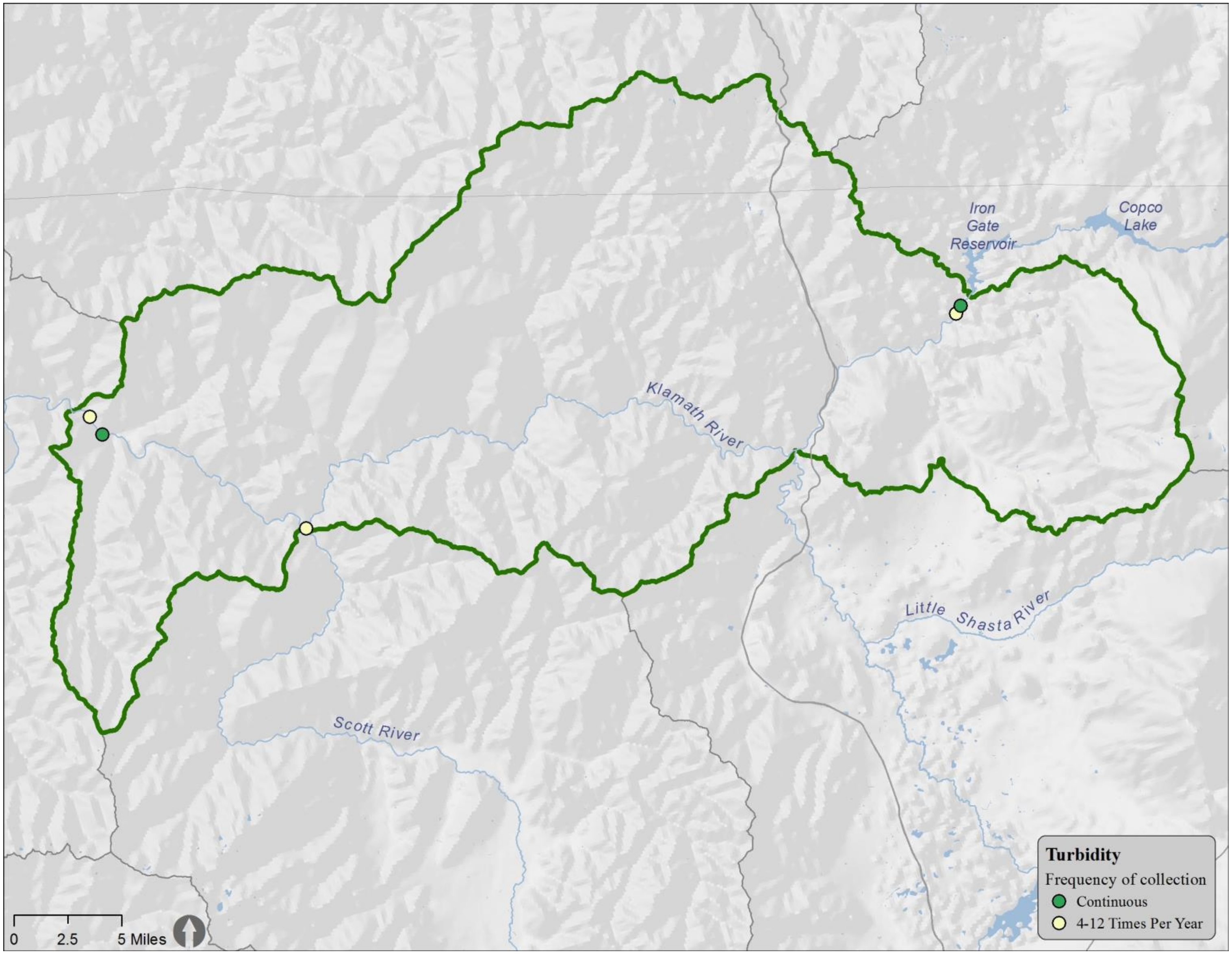


Figure 77: Turbidity monitoring in the Middle Klamath River subbasin in 2014.

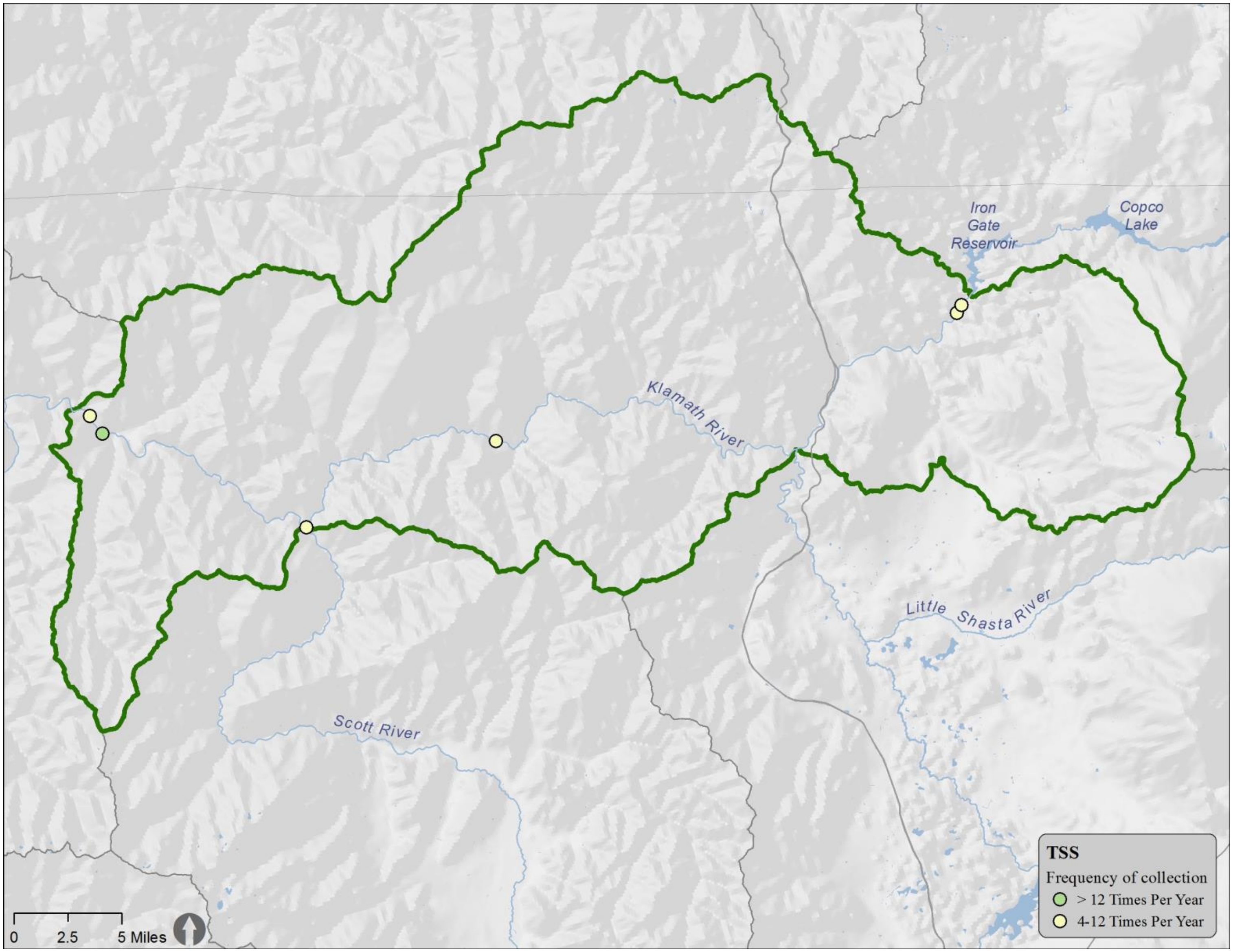


Figure 78: TSS monitoring in the Middle Klamath River subbasin in 2014.

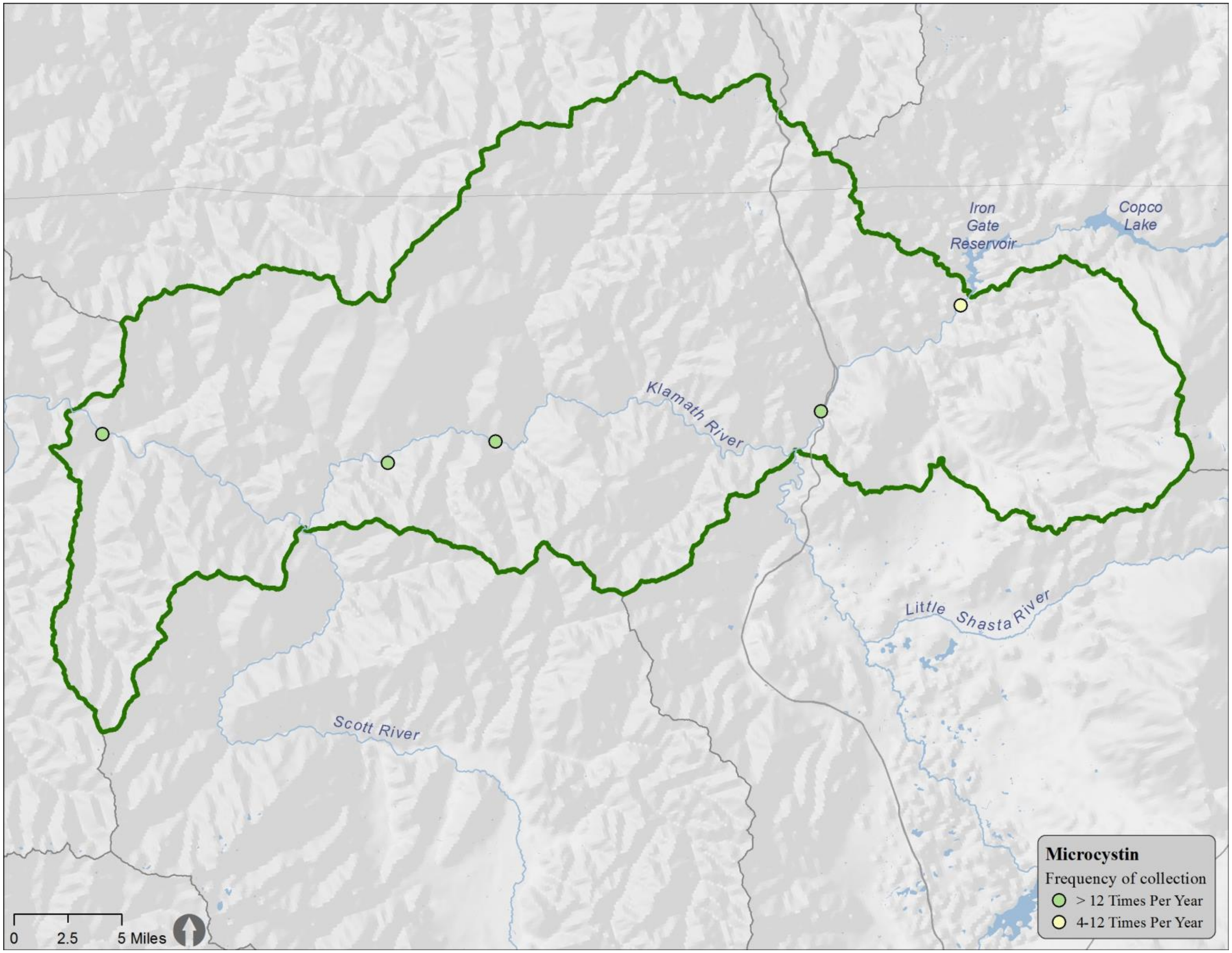


Figure 79: Microcystin monitoring in the Middle Klamath River subbasin in 2014.

5.0.11 Lower Klamath

The Lower Klamath is defined at the upstream boundary by the Salmon River confluence and the downstream boundary by the Pacific Ocean. The current TMDLs for the Klamath River in California, address temperature, nutrient, and organic enrichment/low dissolved oxygen impairments. The portion of the Klamath River downstream of the Trinity River, within the Yurok Reservation, is also listed for sedimentation/siltation.

In the Klamath River in California elevated water temperatures, elevated nutrient levels, low dissolved oxygen concentrations, elevated pH, potential ammonia toxicity, increased incidence of fish disease, an abundance of aquatic plant growth - high Chlorophyll-*a* levels (both planktonic and periphytic algae), decrease the quality and quantity of suitable habitat for fish and aquatic life, and have disrupted traditional cultural uses of the river by resident Tribes (YTEP, 2008). These conditions contribute to the non-attainment of beneficial uses, including the most sensitive beneficial uses: those associated with the cold water fishery (specifically the salmonid fishery) in California, and those related to cultural uses and practices (YTEP, 2008).

Nutrient pollution in the Lower Klamath River causes elevated pH and dissolved ammonia and depressed dissolved oxygen. The source of nutrient pollution is unclear. Some studies related to Klamath Hydroelectric Project (KHP) relicensing have brought to light linkages between nutrient pollution in the Lower Klamath River and fish health (YTEP, 2006); conversely other studies have demonstrated that the reservoirs act to retain nutrients coming from the headwaters of the Klamath River (Kann and Asarian, 2007; NCRWQCB 2008). Algae beds and deposits of benthic organic matter in the Klamath River just below Iron Gate Dam provide ideal habitat for a polychaete worm that plays host to one of the Klamath River's most prominent fish diseases, the protozoan *Ceratomyxa Shasta* (Stocking and Bartholomew, 2004). The combination of direct stress to fish from water pollution in combination with increased abundance of pathogens has lead to more than 40% of downstream migrant juvenile Chinook salmon dying before they reach the ocean in some years (Foott et. al., 2003, Nichols and Foott, 2005).

Nutrient pollution in the Lower Klamath River can be traced to several sources: agricultural activities, the nitrogen fixing blue-green algae species *Aphanizomenon flos-aquae* that flourishes in Upper Klamath Lake and Klamath Hydroelectric Project reservoirs, and from the Lost River basin via direct winter pumping (Kier Associates, 2007).

The recent discovery of toxic algae species, such as *Microcystis aeruginosa* (MSAE), in KHP reservoirs (Kann and Corum, 2006; Kann and Corum, 2007; Kann, 2007) and the Klamath River
(YTEP, 2005), now pose risks to human health in late summer and fall from recreational or cultural-use contact. Data collected under the Yurok SAP (2008) is intended to help better understand the complex nature of Klamath River nutrient pollution and the prevalence of algal toxins on the Yurok Indian Reservation.

Within this reach, the Hoopa Tribal waters overlap with the Klamath River mainstem at Satins Rest Bar. Hoopa have developed Water Quality Standards for the Klamath River, which are applicable under the CWA, for nutrients parameters, dissolved oxygen, temperature microcystins cell density and microcystins levels.

Limiting Factors

Table 12: 303(d) impaired waters of the Lower Klamath subbasin.

Impairments	**Region**
Dissolved Oxygen	Lower Klamath
Temperature	Lower Klamath
Nutrients	Lower Klamath
Microcystin	Lower Klamath
Sediment	Lower Klamath (Yurok Reservation)

The KBMP Water Quality Subcommittee identified additional potential limiting factor to address: bacteria

Recommendations

List of Recommendations from the (NCRWQCB)

Monitoring is recommended downstream of the Salmon River, upstream of the Trinity River, downstream of the Trinity River, and at Turwar for the following parameters: temperature (continuous), DO (continuous), NH4, No2/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH. Monitoring should be conducted weekly from July 1st to August 31st

Two to three monitoring locations in the estuary should be selected (longitudinally). Monitored constituents should include: temperature (continuous), DO (continuous), NH4, N02/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH, with the addition of salinity.

A periphyton survey, as noted above, should also be conducted for Iron Gate to Turwar. Currently modeling does accurately reproduce the significant diurnal fluctuation of DO in the estuary. This may, in part, be a result of periphyton growth.

Additionally, a monitoring station should be located in the Pacific Ocean, at a distance far enough from the estuary to avoid impacts from flushing. Tidal elevation, temperature, salinity, and the suite of constituents collected for temperature (continuous), DO (continuous), NH4, N02/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH should be monitored. Both surface and bottom data are needed. Continuous tidal, temperature, and DO are recommended. The other parameters can be collected weekly. The sampling period should be from July 1st to August 31st.

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including large flow event sampling.

Specific recommendations for the Lower Klamath subbasin are bacteria (estuary), sediment, microcystin and atmospheric monitoring in the estuary, in addition to monitoring 303 (d) listed impairments. Additionally, monitoring of blue-green algae, aka cyanobacteria, (including cell count and enumeration of Microcystins auregenosa and Anabaena at a minimum) and cyanotoxins (including microcystins and anatoxins) is recommended from approximately June 1st until levels fall below and remain below regional, state and World Health Organization recommended levels, as applicable.

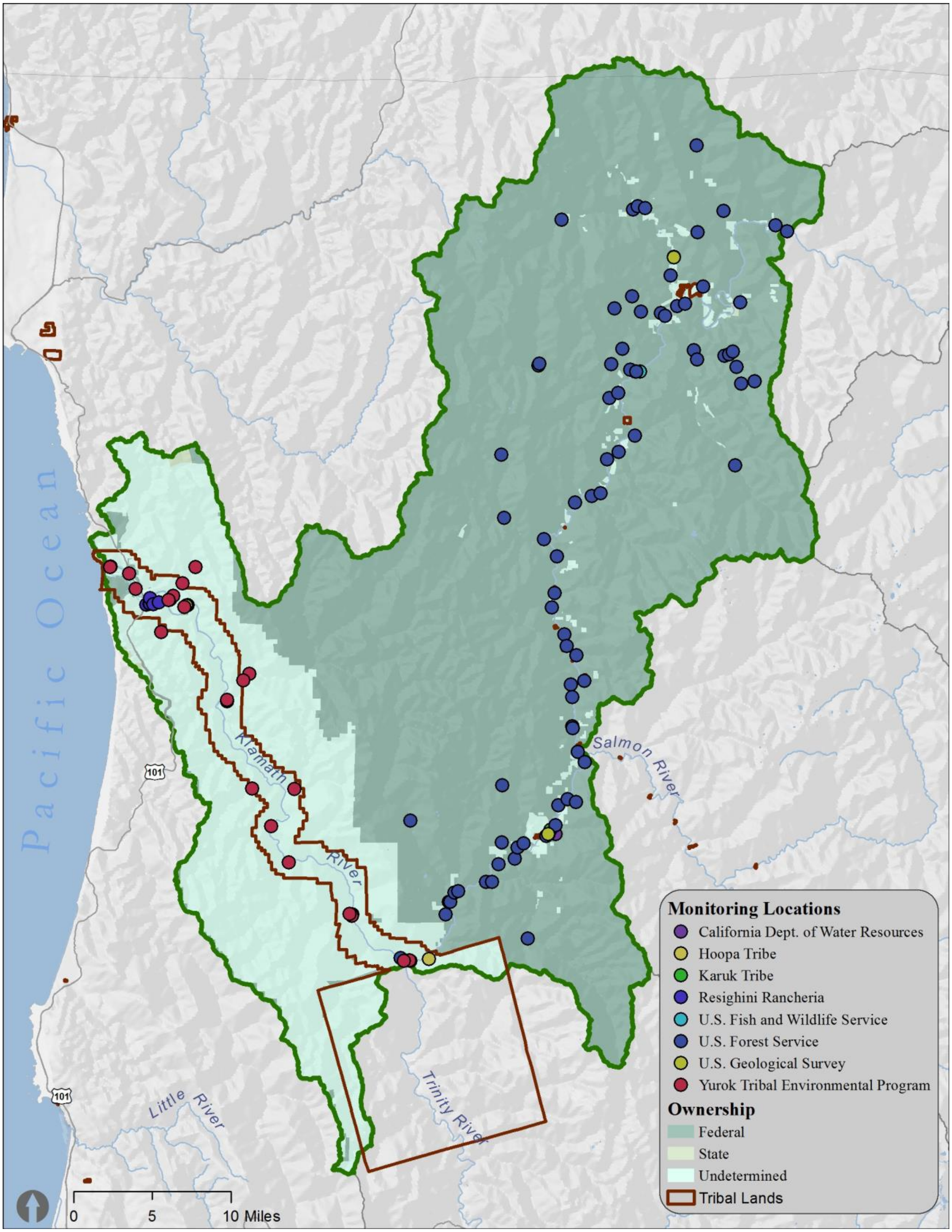


Figure 80: Lower Klamath River subbasin with identified ownership and water quality monitoring organizations.

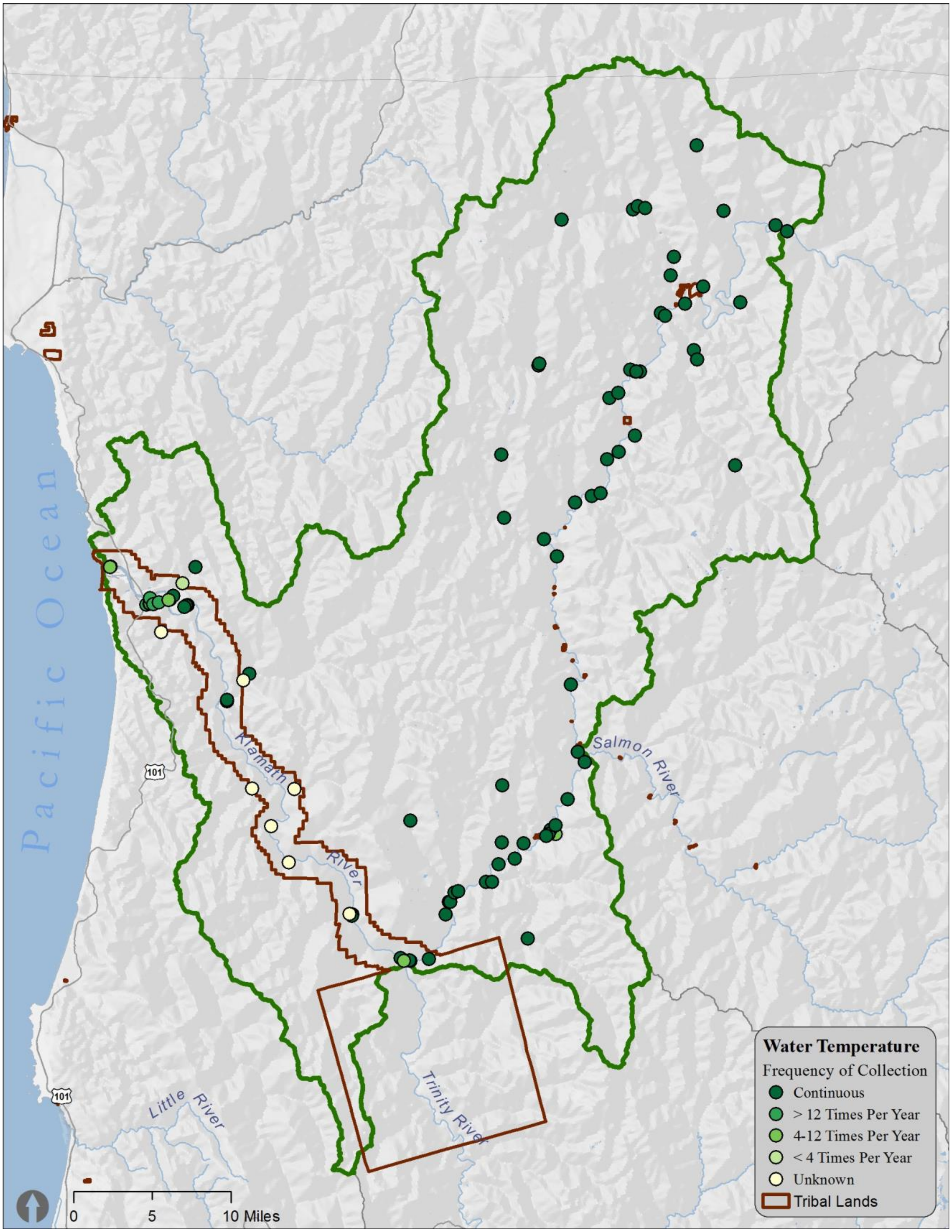


Figure 81: Water temperature monitoring in the Lower Klamath River subbasin in 2014.

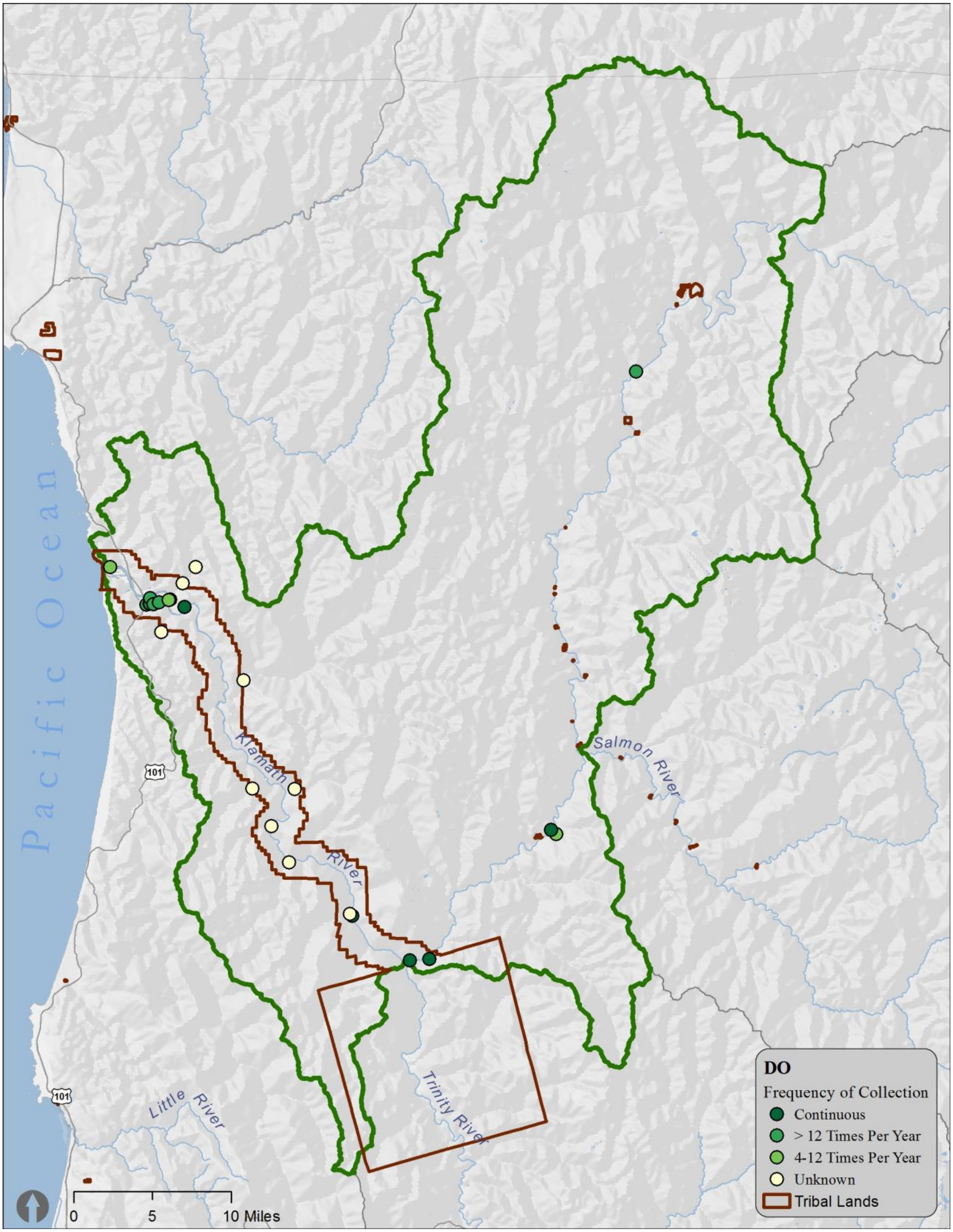


Figure 82: Dissolved oxygen monitoring in the Lower Klamath River subbasin in 2014.

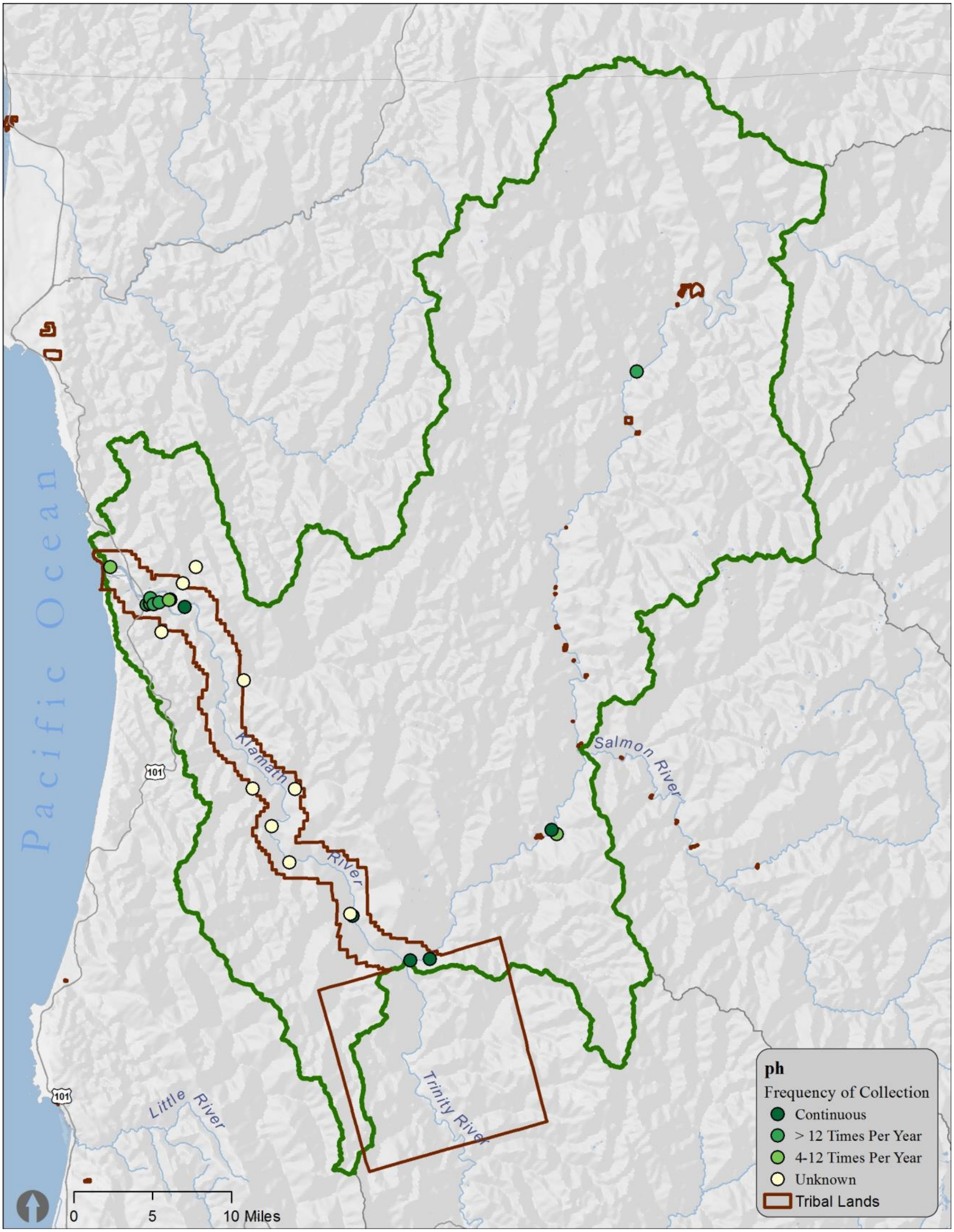


Figure 83: pH monitoring in the Lower Klamath River subbasin in 2014.

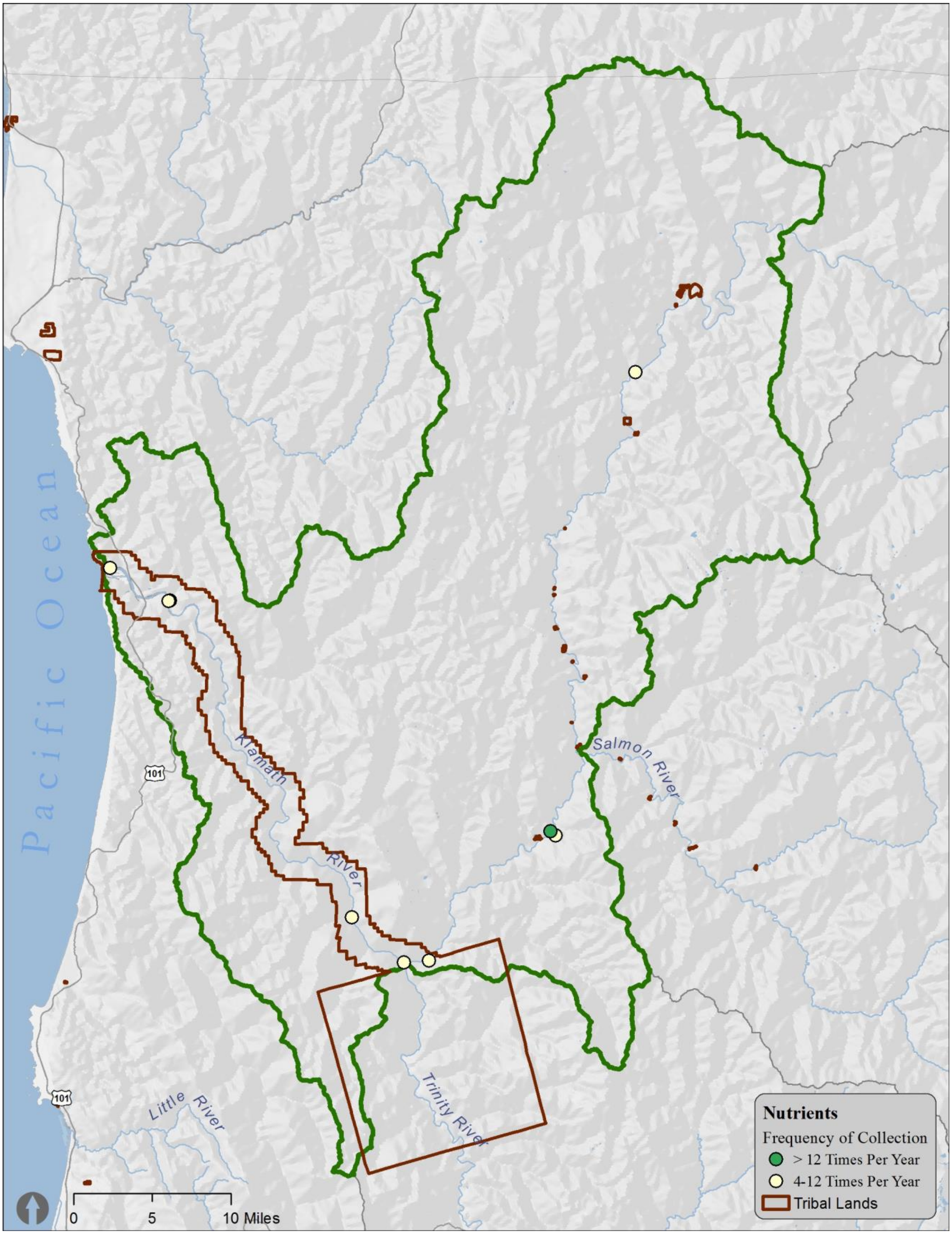


Figure 84: Nutrient monitoring in the Lower Klamath River subbasin in 2014.

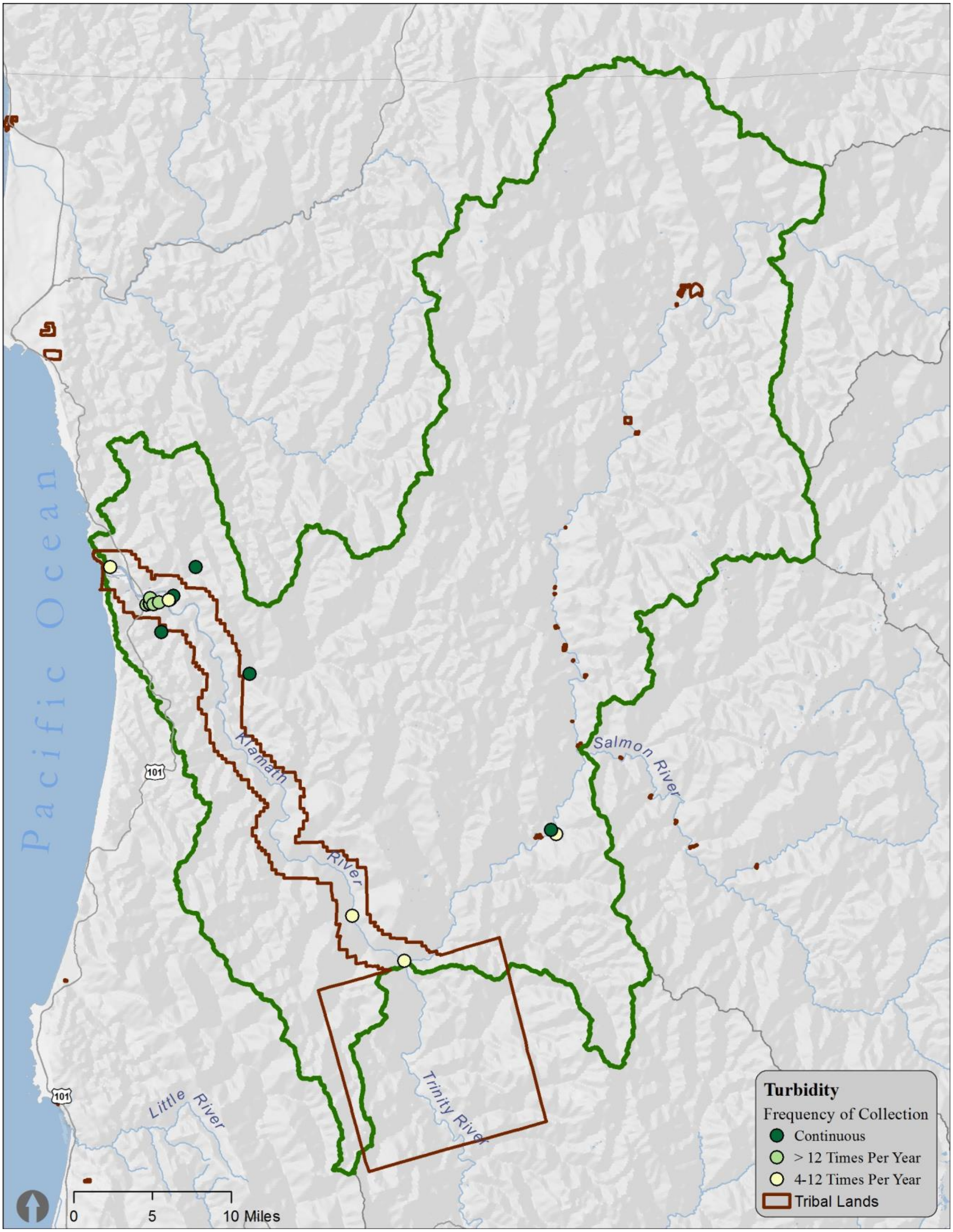


Figure 85: Turbidity monitoring in the Lower Klamath River subbasin in 2014.

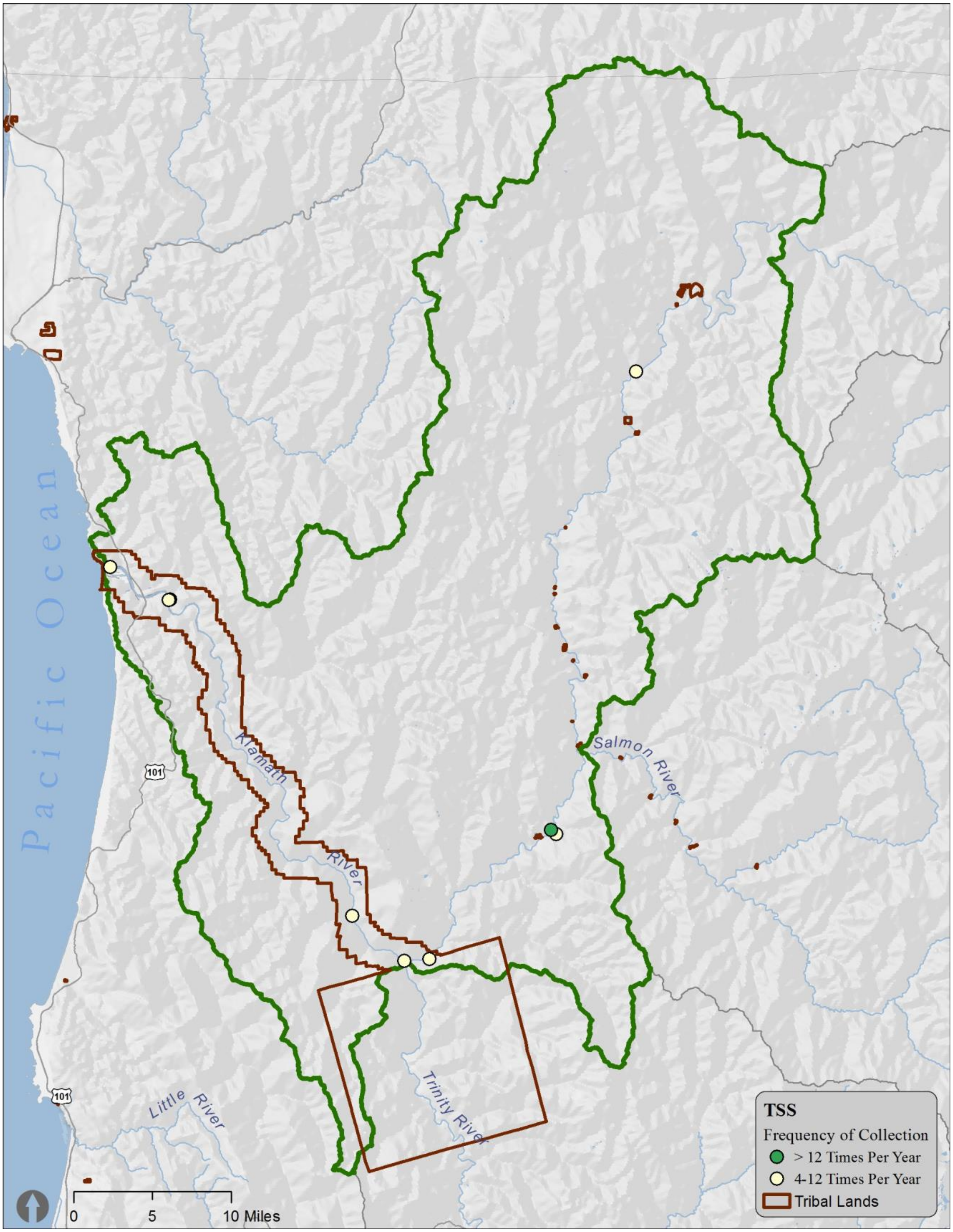


Figure 86: TSS monitoring in the Lower Klamath River subbasin in 2014.

5.0.12 Trinity / South Fork Trinity

The Trinity River is largely oligotrophic, particularly compared to the Klamath River. The Trinity River is the largest tributary to the Klamath River, draining an area of approximately 3,000 square miles (EPA, 2001). The terrain is varied with elevations from 30 to 9,000 feet. The majority of the basin is public land including the Trinity Alps Wilderness areas, the Shasta-Trinity National Forest, Six Rivers National Forest, Bureau of Land Management, and Bureau of Reclamation. Industrial timber companies and other private landowners make up the remaining portions of the basin. The Hoopa Valley Tribe occupies a portion of the lower basin, bisecting the mainstem Klamath at Saints Rest Bar.

Impoundment and diversion play a major role in the Trinity basin. Historic forest practices and associated sediment yield are also deemed problematic throughout much of the watershed predominantly in the mainstem Trinity River, but also in many tributaries (Deas Appendix 1). The Trinity and Lewiston dams built in the early 1960's, significantly impacts the flow and functional use of the Trinity River. While the diversions from the Trinity River have been reduced, diversions to the Sacramento Basin continue to impact the natural variability of the Trinity River as well as the Lower Klamath River. Land use activities in the Trinity include mining, timber harvesting, road construction, recreation and a limited degree of residential development in certain locations. Habitat degradation, exacerbated by human activites, has contributed to a dramatic decline in the populations of coho, chinook, and steelhead from historical levels. While disturbance is a natural part of stream ecosystems, and salmonid populations naturally fluctuate in response to disturbances, human activities have resulted in increased severity and frequency of disturbances.

The beneficial uses associated with cold water fish habitat are currently impaired in the Trinity River Basin. The primary adverse impacts associated with excessive sediment in the Trinity River pertain to anadromous salmonid fish habitat. The Trinity River has historically been recognized as a major producer of chinook and coho salmon and steelhead trout (EPA, 2001). The populations of several anadromous salmonid species present in the Trinity River and its tributaries are in severe decline. The population of coho salmon (*Oncorhynchus kisutch*) is listed as threatened under the federal Endangered Species Act.

Research is an important part of restoring the Trinity and S. F. Trinity. Within this large basin, the focus is primarily on the mainstem downstream of the North Fork. Trinity River Restoration Program (TRRP) is very active in research, monitoring, and resource management. TRRP is active in temperature monitoring and management. Recent efforts have included flows to encourage coarse sediment transport and bank restoration activities. The Hoopa Valley Tribe also has an active program on reservation lands collecting flow and temperature data in several tributaries. Additional research that includes the tributary streams, particularly in the middle of the Trinity basin, including the South Fork Trinity River would be beneficial (Deas Appendix 1).

The monitoring network recommendations include several locations in the Trinity / SF Trinity. Due to data availability (as of 2009) few sites were included; more sites will be included as data becomes available. KWI is working with the TRRP to obtain additional information regarding monitoring the Trinity / SF Trinity. A recent addition is the Mill Creek site in the Hoopa reservation, included in the monitoring plan for its cultural and fisheries related significance.

Limiting Factors

Table 13: 303(d) impaired waters of the Trinity and S. F. Trinity subbasins.

Impairment	Region
Sediment	Trinity River / S. F. Trinity River

The KBMP Water Quality Subcommittee identified additional potential limiting factor to address: *temperature*, bacteria, and algae.

Recommendations

List of Recommendations from the (NCRWQCB)

At the mouth of the Trinity River the following parameters are recommended: temperature (continuous), DO (continuous), NH4, No2/NO3, PO4-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD5, CBOD20, alkalinity, and pH. Monitoring should be conducted weekly from July 1st to August 31st Additional samples should be collected for the Trinity to evaluate day-to-day variability. These samples should be collected one or two days after the weekly monitoring data are collected at these locations.

List of Recommendations from the (KBMP)

The KBMP Water Quality Subcommittee has identified continuous temperature, dissolved oxygen, pH, and EC as important baseline parameters for the Klamath River Basin. Grab samples of chlorophyll-a, total organic carbon, total nitrogen and total phosphorus are also identified. CBOD is recommended for Oregon and continuous sediment monitoring is recommended for California. Sampling frequency includes bi-monthly sampling May-October and monthly sampling the remainder of the year, including event sampling.

Specific recommendations for the Trinity and S. F. Trinity subbasin are bacteria, algae and invertebrates in addition to monitoring 303 (d) listed impairments.

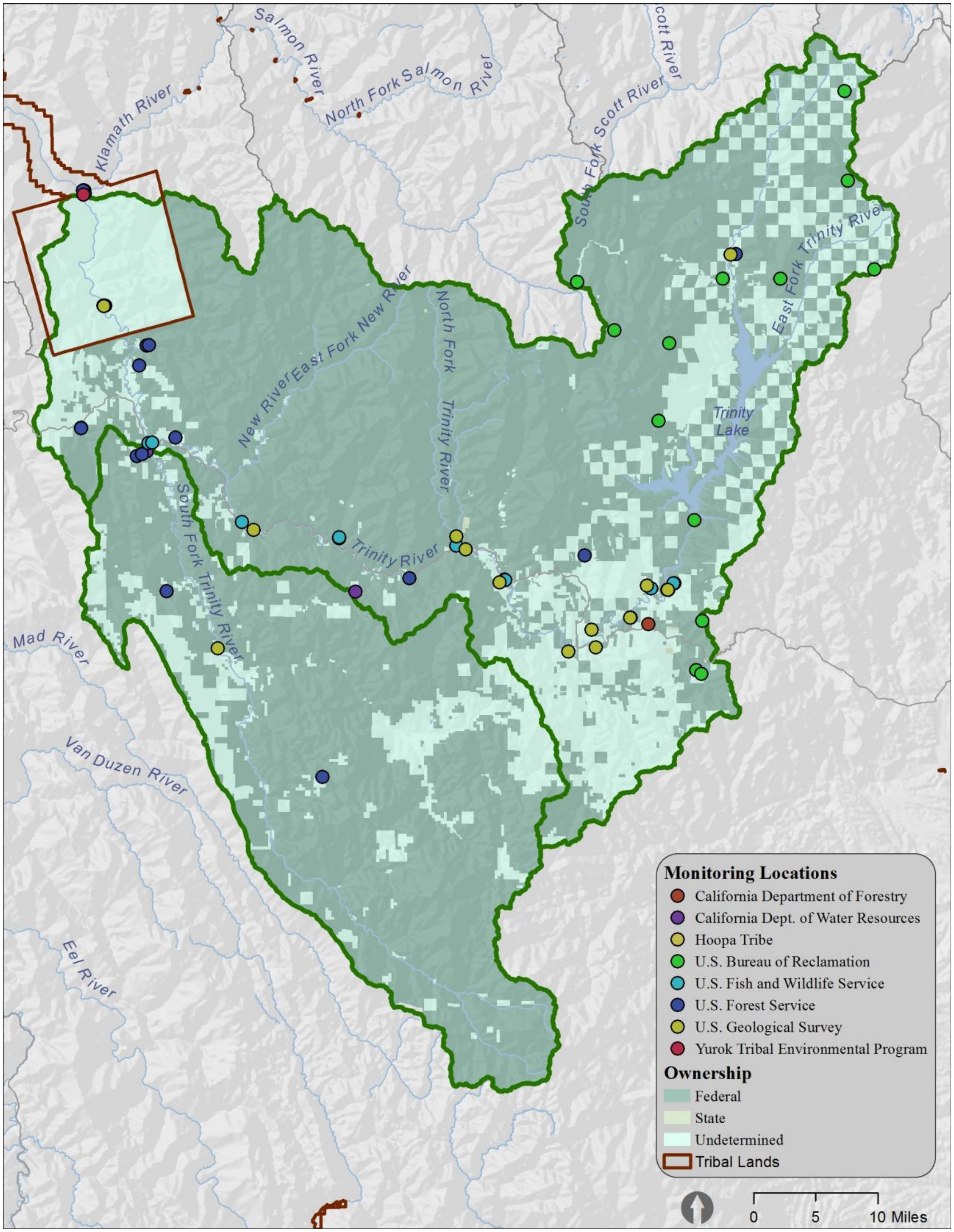


Figure 87: Trinity and South Fork Trinity River subbasins with identified ownership and water quality monitoring organizations.

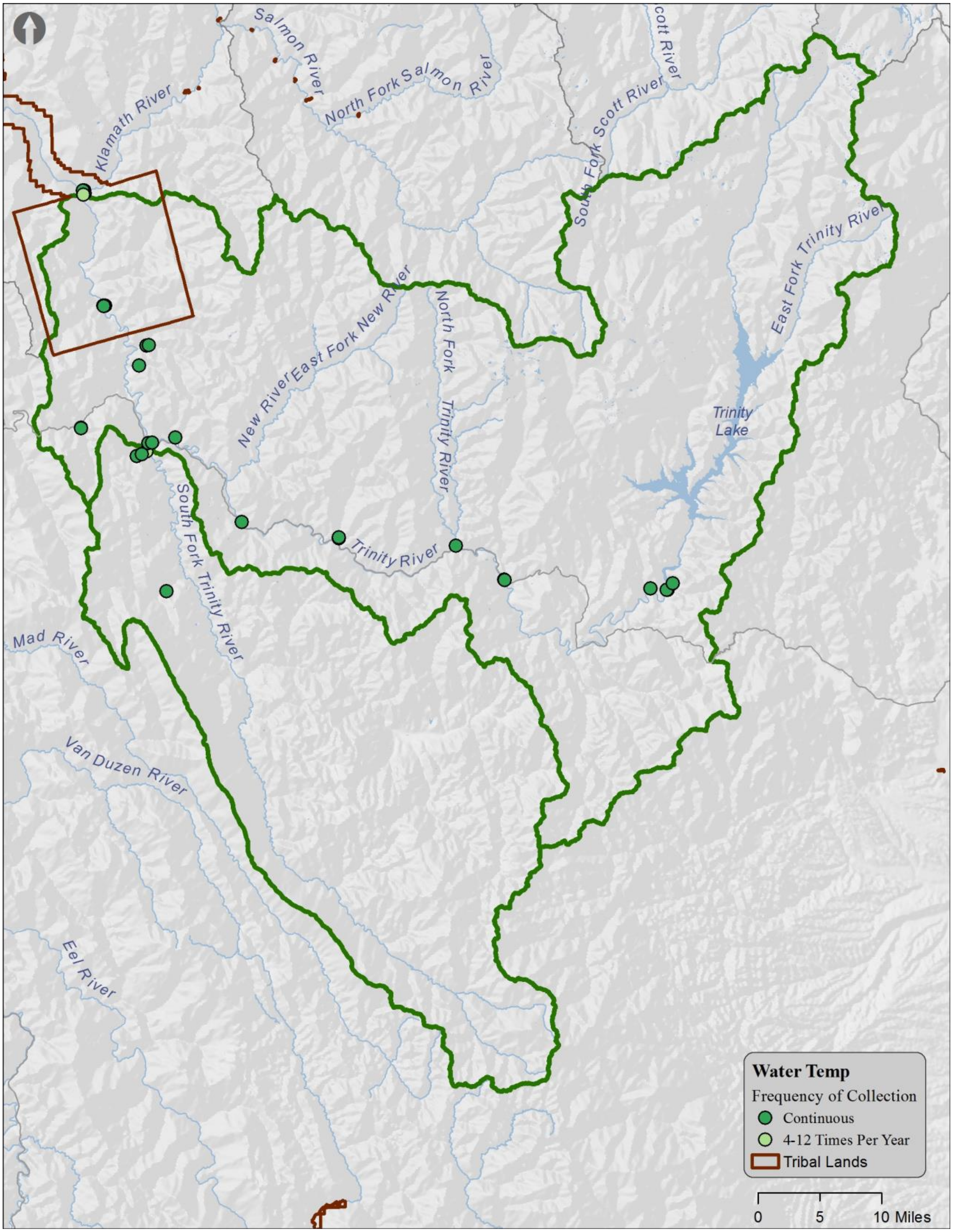


Figure 88: Water temperature monitoring in the Trinity and South Fork Trinity River subbasins in 2014.

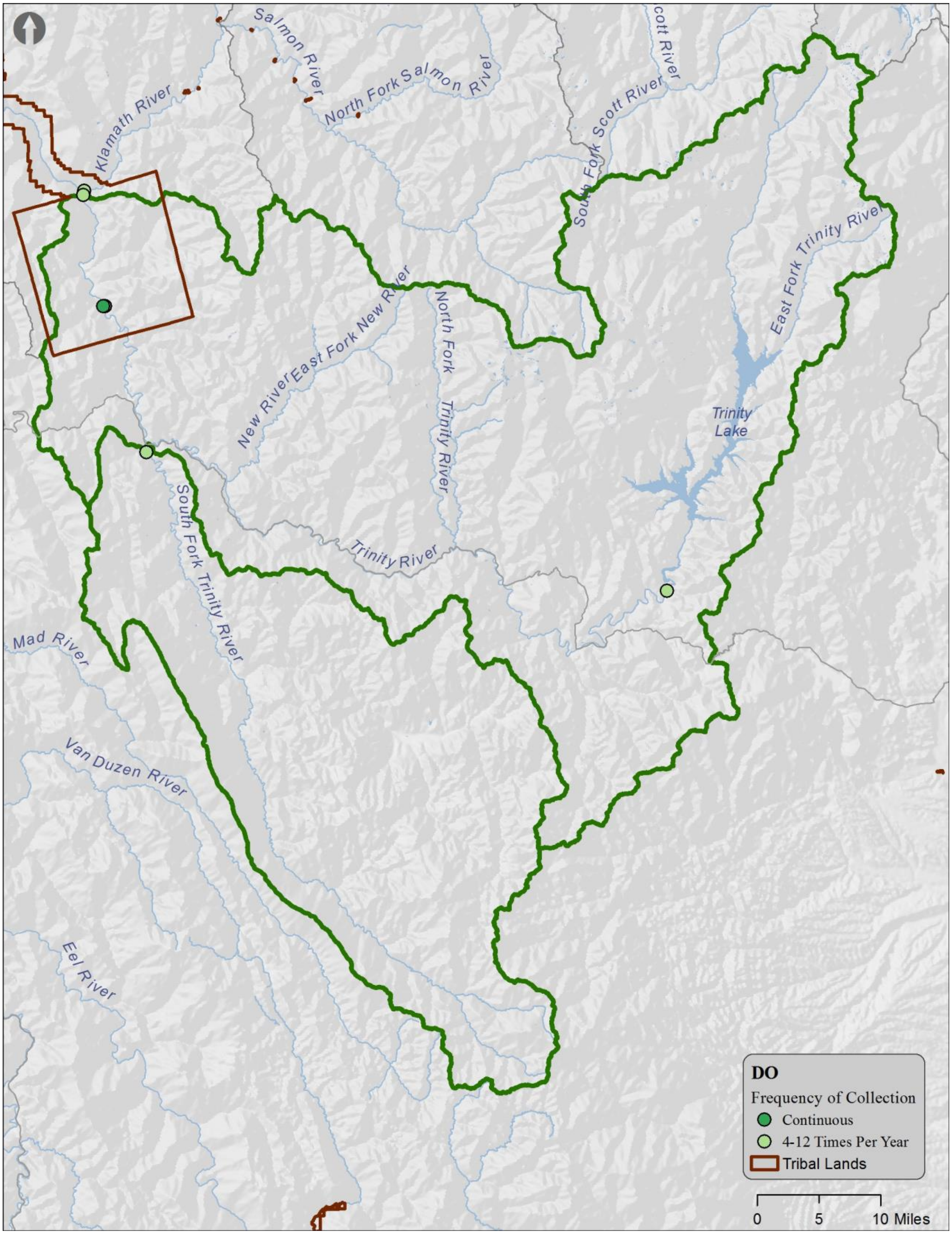


Figure 89: Dissolved oxygen monitoring in the Trinity and South Fork Trinity River subbasins in 2014.

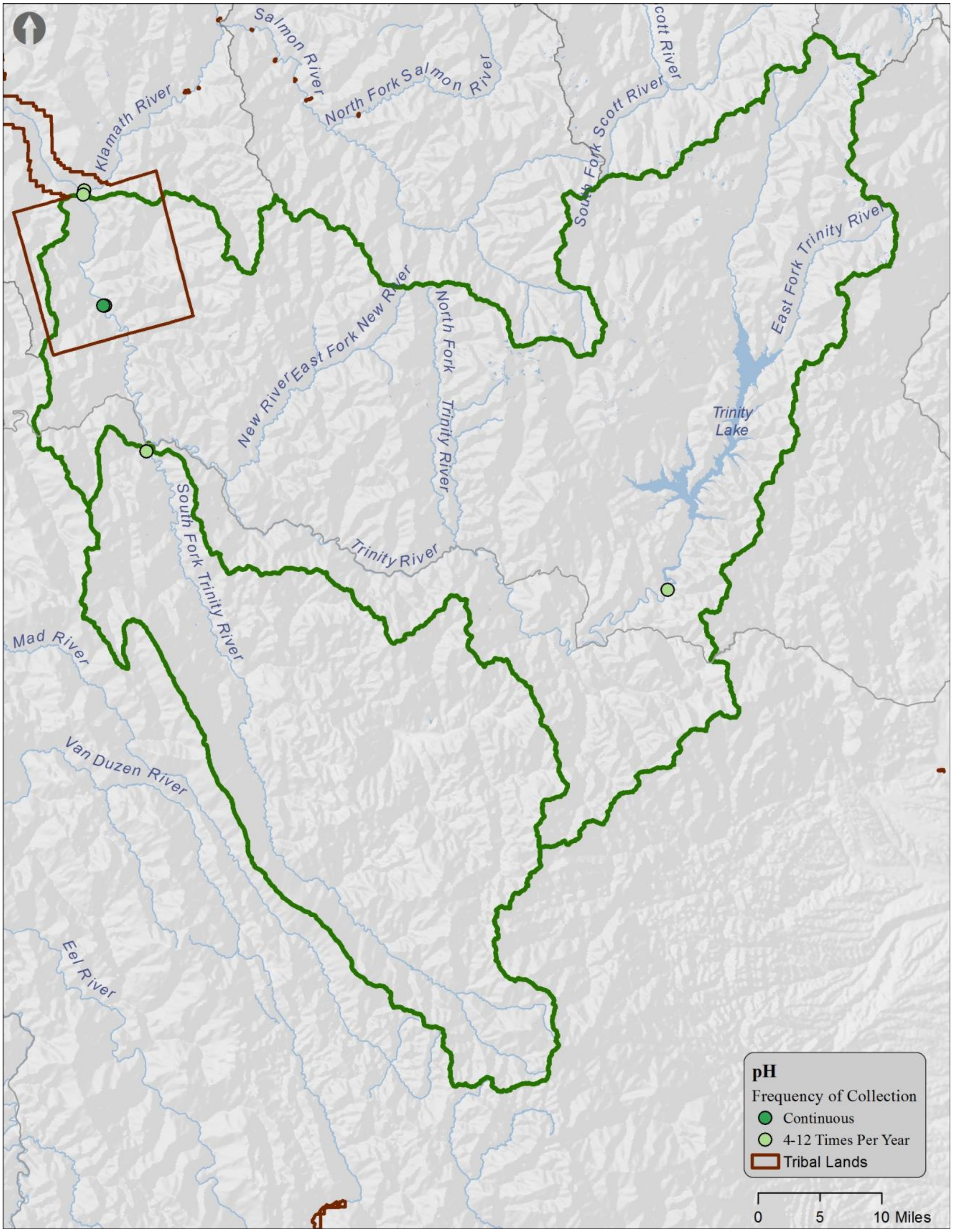


Figure 90: pH monitoring in the Trinity and South Fork Trinity River subbasins in 2014.

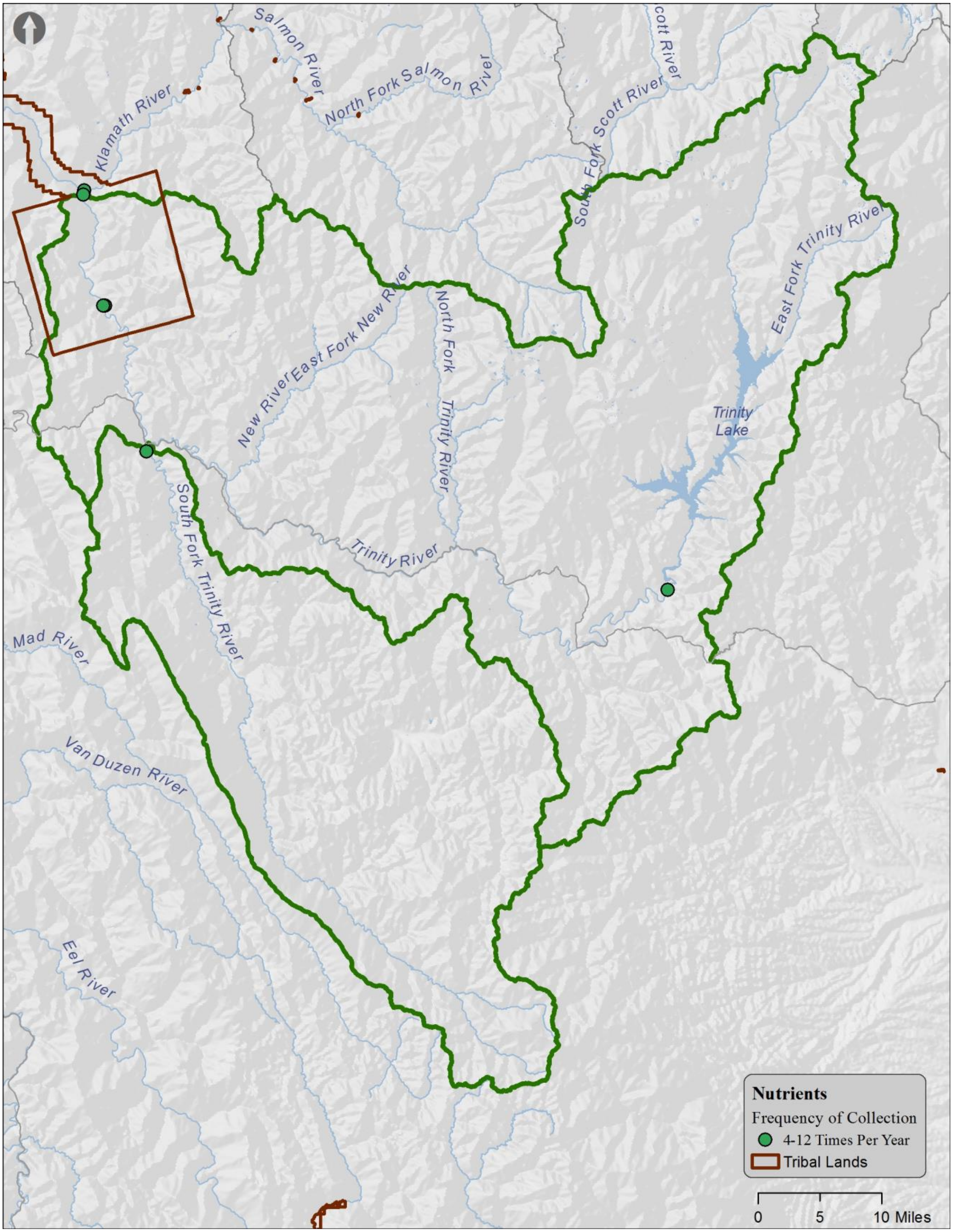


Figure 91: Nutrient monitoring in the Trinity and South Fork Trinity River subbasins in 2014.

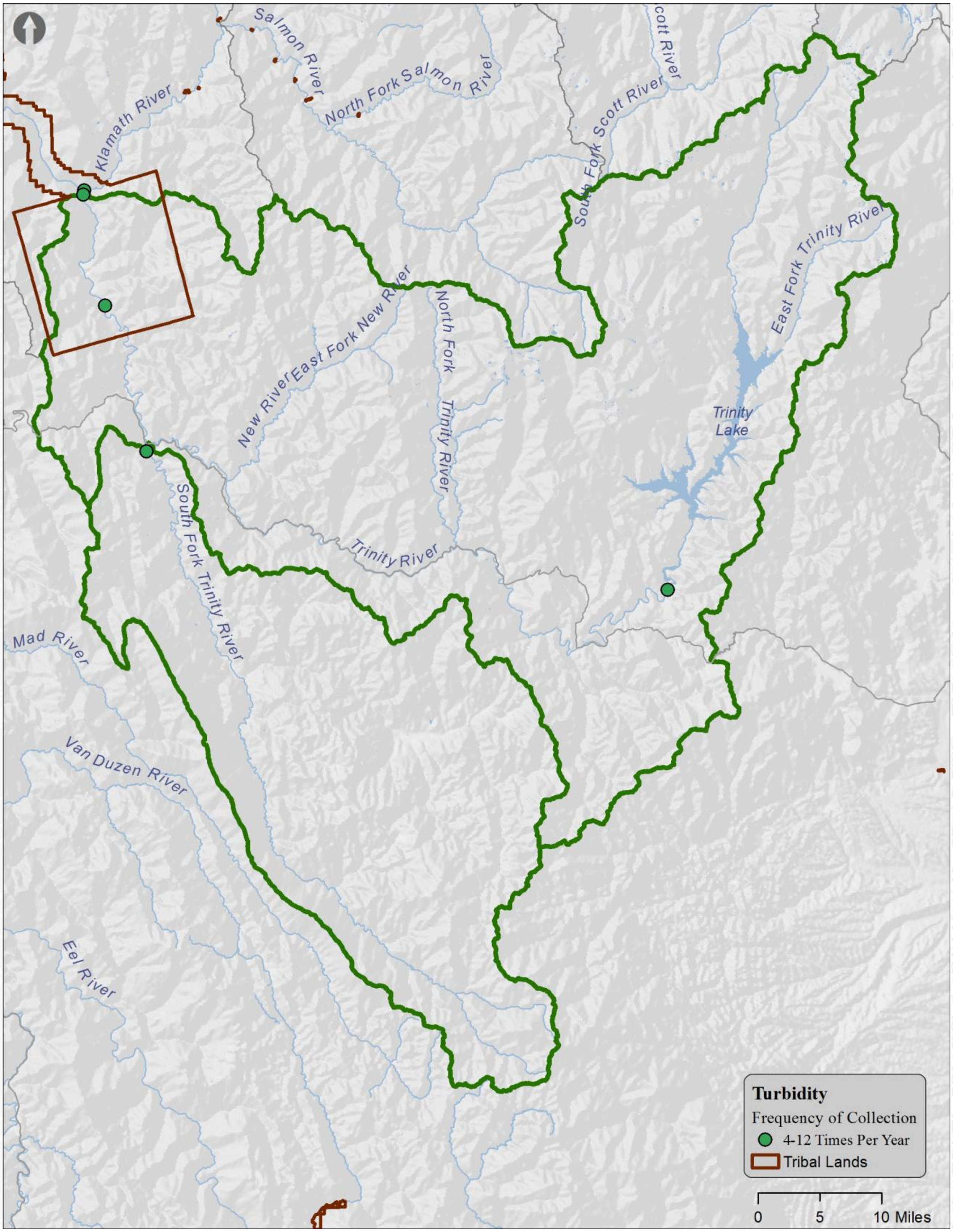


Figure 92: Turbidity monitoring in the Trinity and South Fork Trinity River subbasins in 2014.

6.0 Standard Monitoring Protocols

A review of contributing organizations' Standard Monitoring Protocols is underway by the Regional Water Quality Control Board.

7.0 Quality Assurance / Quality Control

The Klamath Basin Water Quality Monitoring Plan will employ quality assurance (QA)/quality control (QC) procedures and data sharing protocols consistent with both the Regional Surface Water Ambient Monitoring Program (SWAMP) and Oregon Department of Environmental Quality (ODEQ). A review of the procedures is underway by the Regional Water Quality Control Board.

8.0 Next Steps

The Klamath Basin Monitoring Program, in cooperation with its members, has developed a coordinated water quality monitoring plan, outlined by this document. This document represents Phase 1 of the Basin-wide coordinated water quality monitoring effort. Specifically, phase one of the Klamath Basin Water Quality Monitoring Plan consists of; 1) review existing efforts conducted by organizations within the basin, development of monitoring goals and objectives, 2) identification of a monitoring network based upon existing legacy sites that best address the beneficial uses within each subbasin, 3) implementation of comparable Quality Assurance and Quality Control (QA/ QC) using multistate (Oregon and California) guidelines, 4) identification of consistent Standard Operating Procedures, and 5) development of a sustainable monitoring framework that addresses both long and short-term water quality data needs.

In phase two, it is recommended that the established monitoring network be evaluated annually (Appendix III). The Technical Review Committee (TRC) will review water quality data and evaluate the relevance or applicability of sites or parameters on a location by location basis and offer recommendations that best support the monitoring needs and requirements necessary to answer management questions and support beneficial uses. The TRC will make recommendations for incorporating measures that are coupled with available funding, including the addition of sites and parameters that may be added to the monitoring network. This may also include the implementation of special studies identified by the TRC (Chapter 8), as well as identified gaps in monitoring by region (Chapter 5 and Chapter 8.2). Additionally, as the funding for monitoring grows, it is anticipated that funds for supporting the KBMP organizational staff will grow as well. A proposal outlining the step-wise approach toward a fully staffed KBMP organization is outlined in the report, *Support for Long-Term Water Quality Monitoring Plan Implementation*.

8.1 Special Studies

Significance and Criteria for Adopting Special Studies:

Special Studies are an important component of the baseline monitoring identified by the Klamath Basin Water Quality Monitoring Plan. The special studies provide targeted research into key water quality issues. Special studies are defined projects that will help improve monitoring measurements or the interpretation of monitoring data, in particular by elucidating cause-effect relationships. The criteria for adopting special studies, developed by a subgroup of the Steering Committee, are as follows:

1) Consistent with the Klamath Basin Water Quality Monitoring Plan Goals and Objectives

2) Address identified gap in current monitoring

3) Address identified affected beneficial uses by examining the toxicity or degradation of water quality at a regional or local level.

Process for adopting Special Studies:

For a detailed description of the special study adoption process, see Appendix IV.

Priority Special Studies:

The below is a list of special studies have been identified by the Steering Committee and Water Quality Work Subcommittee as key water quality issues facing the Klamath Basin.

Spatial and Temporal Variation of Total Suspended Sediment Concentrations

Author: Andrew Stubblefield
Humboldt State University, Watershed Management

One topic that should receive consideration for a special study is the variability of water quality at different locations within a river cross section and the variability of concentrations over time. The methodology of the current version of the Klamath Basin Water Quality Monitoring Plan and current monitoring efforts rely on the assumption that grab samples taken from wading depths within the Klamath River are representative of the entire river. It is also assumed that the water quality samples taken at a given sampling time are representative of longer time periods. Loading estimates are then generated for the long time periods (1 wk – 1 month) between sampling trips. The effect of these assumptions on the accuracy and precision of load estimates has not been determined. Standard methods developed by the USGS would suggest the use of isokinetic methods (i.e. Equal Width Increment sampling) to account for spatial variability with depth, flow velocity and position within the river's meander pattern (Wilde, 2008). The second assumption is that the sediment concentration at a given time is representative of longer time frames. Turbidity measurement on smaller rivers suggests dramatic increases in sediment concentrations responding to storm events (Stubblefield, 2009). This would be dampened somewhat on a larger river but could still be significant. A single peak flooding event could represent a major fraction of sediment loading for a year. To the extent that spatial and temporal variability are present on the Klamath River they could lead to over or underestimations of sediment loading, perhaps leading to erroneous conclusions about sources of sediment and trends in sediment loading over time.

References Cited:

Stubblefield, A.P., J.E. Reuter, C.R. Goldman. 2009. Sediment budget for subalpine watersheds, Lake Tahoe California, USA. Catena 76: 163-172.

Wilde, F.D., ed., 2008, Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, accessed 12/2009 at http://pubs.water.usgs.gov/twri9A6/

Benthic biomass (periphyton) in the Trinity, Salmon and Klamath Rivers

Author: Peggy Wilzbach
Humboldt State University, California Cooperative Fish Research Unit

Benthic algae, along with nonliving organic carbon from a variety of sources, represent the primary energy source at the base of riverine food webs. The algae are found on virtually all organic and inorganic surfaces within rivers. They usually occur in association with a complex assemblage of organisms including bacteria, fungi, and microzoans, embedded within a polysaccharide matrix that is secreted by the organisms themselves; collectively, this assemblage is referred to as biofilm or periphyton. The photosynthetic activity of benthic algae provides oxygen for aerobic organisms in the ecosystem, and the carbon fixed by the algae provides food resources for herbivorous invertebrates and fishes. In addition, benthic algae remove nutrients from the water column, attenuate the current and stabilize sediments, and provide habitat for other organisms. Positioned at the interface of the physical-chemical environment and biological communities, benthic algae provide a useful indicator of water quality. They are sessile organisms, have rapid production rates and very short life cycles, and these attributes make them valuable indicators of current environmental conditions and short-term impacts. Algal assemblages are taxonomically rich, with taxa exhibiting different ranges of sensitivities and tolerances. Algal assemblages are sensitive to some pollutants, such as herbicides, that may not visibly affect other aquatic assemblages, or that may affect other organisms only at higher concentrations. Periphyton biomass provides an index of ecosystem productivity.

The objective of a benthic algae monitoring program is to provide information to assess general river ecosystem condition that can be related to invertebrate and fish community composition and abundance, as well as to nutrient conditions. Monitoring frequency and level of analysis can be easily scaled to the time and resources available, ranging from a simple, baseflow assessment of periphyton biomass and relative coverage of filamentous and non-filamentous algae on sampled substrates, to a full taxonomic analysis of algal assemblages at seasonal or flow-dependent intervals. Generic determination of diatoms present would allow assessment of the contribution of Klamath River reservoir sources to downstream periphyton assemblages, as well as estimation of metrics that are used to detect impairment of ecological conditions.

Fish disease and periphyton links to water quality

Author: Jerri Bartholomew
Oregon State University, Microbiology

Severe infection by the myxozoan parasite *Ceratomyxa shasta* has been a primary contributor to the declining numbers of juvenile Klamath River salmon and subsequent negative impacts on later adult returns. *Ceratomyxa shasta* has a complex life cycle, involving an invertebrate (polychaete worm) host as well as salmon. Salmon in the Klamath River have evolved with *C. shasta* and are relatively resistant to infection compared to salmon from rivers where the parasite is absent, thus the current severity of ceratomyxosis in these fish suggests a shift in the host:parasite balance.

Research conducted by OSU and the US Fish and Wildlife Service (USFWS) have identified a stretch of the river in which high parasite densities and large numbers of infected invertebrate hosts for the parasite result in severe disease and high mortality, thus providing a target for management actions. Potential management actions considered have the goal of: 1) reducing invertebrate host populations in the selected Klamath River reach, 2) reducing the effects of the parasite on juvenile salmon, 3) disrupting the life cycle of the parasite and 4) decreasing salmon exposure/Increasing salmon resistance. Research to test the feasibility of the highest priority management actions is being conducted by the Fish Health workgroup.

For more information:
http://microbiology.science.oregonstate.edu/Klamath River salmon

Estuary water quality monitoring

Author: Ken Fetcho
Yurok Tribal Environmental Program, Assistant Director

Typically estuaries form a fraction of the watershed area, yet it is critical nursery habitat for salmonids and other species. While one study has shown enhanced growth rates and return rates for steelhead (*Oncorthynchus mykiss*)in seasonally closed estuaries (Bond et. al. 2008), the rearing conditions in the Klamath River Estuary (estuary) may actually be detrimental to rearing outmigrants.

In the Klamath Basin the estuarine hydrology, morphology, and mouth closure dynamics during the summer low-flow conditions are currently poorly understood in the context on impending dam removal and its effect on estuarine habitat. Operation of dams and water diversions on the Klamath and Trinity Rivers affect mouth closure dynamics and water quality in the estuary. Estuarine water temperature is linked to salinity, upstream hydrology, and periods of mouth closure because when the estuary mouth is open, denser, cooler salt water from the ocean generates a salt wedge that moves up and down the estuary with tidal fluctuation (Horne and Goldman 1994, Wallace 1998, Hiner 2006). The salt wedge results in thermal stratification of the estuary with cooler, high salinity ocean waters remaining near the estuary bottom, and warmer, low salinity river water located near the surface. During low-flow conditions, the estuary has been observed to close completely and isolates the estuary from the ocean. The estuary closure reduces the size of the salt water wedge, decreases overall salinity, and increases water temperatures (Hiner 2006). There are additional concern that the water quality conditions may impair growth, including the critical thermal maxima for outmigrating salmonids. The objective is to characterize and evaluate the water quality conditions in the Estuary on a continuous basis by monitoring temperature, dissolved oxygen, pH, salinity, and specific conductivity. Another objective will be to characterize and evaluate the nutrient conditions of the Estuary by collecting bi-weekly grab samples. Grab samples will be analyzed for Total Phosphorus, Ortho-Phosphate, Nitrate, Nitrite, Total Nitrogen, Biological Oxygen Demand (BOD), Ammonia, Chlorophyll-a, Pheophytin, Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), Total Suspended Solids (TSS), Volatile Suspended Solids (VSS) and Alkalinity. To address nuisance algae blooms, phytoplankton samples will be collected on a bi-monthly basis in the Middle and Lower Estuary sites. Better understandings of the hydrologic and thermal dynamics of the estuary are necessary to improve the estuary's function as a critical nursery habitat.

Genetic analyses of cyanobacterial blooms

Author: Theo Dreher,
Oregon State University, Microbiology

A prominent expression of the unhealthy state of the Klamath Watershed is the prevalence of cyanobacterial blooms. In Upper Klamath Lake, these put at risk the survival of endangered sucker fish as a result of extreme pH and anoxic conditions, and possibly also due to microcystin toxicity. In Copco and Iron Gate Reservoirs and the downstream stretches of the Klamath River, the microcystin toxin produced by *Microcystis*-dominated blooms is a public health concern. Genetic techniques for studying the population structure of cyanobacterial blooms have recently begun to be applied to the Klamath cyanobacterial blooms. They have utility in identifying strain differences that can be exploited to track issues such as the presence of toxic and non-toxic strains of *Microcystis*, population changes during and between seasons, or the extent to which populations are closely related throughout the watershed due to movement down the river. Rapidly advancing technologies, particularly those involving DNA sequencing, are transforming the possibilities for genetic analysis, offering unprecedented resolution in identifying cyanobacteria in relatively large numbers of samples.

It is proposed to conduct annual cyanobacterial population analysis using water collection splits from samples that are collected as part of the routine monitoring at sites ranging from Upper Klamath Lake through Iron Gate Reservoir and just below the dam (collections currently organized by PacifiCorp) and the downstream reaches of the Klamath River (collections currently organized by the Karuk and Yurok Tribes). Monthly sample collections will be archived and analyzed for the DNA sequences of two strain-distinguishing genetic targets (ITS and *cpcBA*) and for the *mcy* toxin biosynthetic genes of *Microcystis*. The results will provide a comprehensive database of strain differences and similarities between times and sites. The resulting information could answer questions such as: (a) are bloom changes, such as recently increased prevalence of *Microcystis* in Upper Klamath Lake, due to changes in the proportions of existing strains or due to importation of strains?; (b) can correlations be found between increased proportions of non-toxic as opposed to toxic *Microcystis* and environmental conditions, which might lead to options for managing blooms to decreased levels of toxicity?; (c) is microcystin toxicity in the lower reaches of the Klamath River primarily the result of continual delivery of *Microcystis* from the upstream reservoirs or due to locally endemic *Microcystis*?

Other potential Special Studies Identified by the KBMP Members were also identified. The process for adopting Special Studies is outlined in Appendix IV.

- Effects of legacy toxins and pesticides (mercury, dioxin, organophosphate)
- Emerging contaminants (pharmaceuticals, antibiotics)
- Inner gravel dissolved oxygen below Iron Gate Dam during spawning
- Sampling first flush for organics accumulated on channel bed in the mainstem
- Climate change related impacts to snow pack, precipitation frequency and other factors that may affect the basin
- Develop an early warning sign process that may aid in the identification of future TMDL issues
- Effects of post-fire sediment input
- Effects of wetland restoration of Upper Klamath Lake on water quality
- Effects of fire on stream temperature
- Understanding the dynamics of BGA blooms in UKL and reservoirs throughout the Basin

8.2 Gap Analysis

At the second KBMP meeting in Yreka (April 8-9, 2008), KBMP participants developed a map of the water quality sampling locations within the Klamath Basin for the 2008 season. Through the use of subbasin maps and parameter tables, KBMP participants added to the information collected prior to the meeting. Following the map analysis, one representative from each subbasin reported to the large group the gaps in monitoring activities they and others working in the subbasin had identified. Table 13 is the product of that exercise.

Table 14: Water quality monitoring parameter gaps by subbasin.

Subbasin	Parameter
Williamson, Sprague, and Upper Klamath Lake	Nutrients Loading
Williamson, Sprague, and Upper Klamath Lake	Phytoplankton Interaction
Lost	Bacteria
Lost	Algae
Lost	Nutrients
Lost	Water Chemistry*
Shasta	Bacteria
Shasta	Sediment
Scott	Algae
Scott	Water Chemistry*
Salmon	Bacteria
Salmon	Algae
Salmon	Sediment
Salmon	Invertebrates
Middle Klamath (Seiad Valley to Orleans & Seiad Valley to Weitchpec)	Algae / Periphyton
Middle Klamath (Seiad Valley to Johnsons Riffle)	Invertebrates
Middle Klamath (Seiad Valley to Orleans)	Nutrients
Middle Klamath	Sediment
Middle Klamath (Seiad Valley to Orleans)	Water Chemistry*
Middle Klamath (Seiad Valley to Orleans)	SONDE
Lower Klamath (Estuary)	Bacteria
Lower Klamath	Sediment
Lower Klamath (Estuary)	Atmospheric

Trinity / SF Trinity	Bacteria
Trinity / SF Trinity	Algae
Trinity / SF Trinity	Invertebrates

*Water chemistry – pH, DO, conductivity, temperature

Additional gaps in monitoring were identified based on the data available at the time of analysis.

The following are a list of identified gaps in monitoring:

- Sites vacated by the NCRWQCB in the Trinity, Shasta, Scott, and Klamath River mainstem
- Sediment monitoring in the Trinity / SF Trinity
- Monitoring to capture salmonid rearing, spawning and upstream migration, with emphasis on identified refugia
- Regular monitoring in the Upper Klamath Subbasin's reservoirs for cyanotoxins (microsystin as well as anatoxin, and cylindrospermopsin) is recommended from May until late fall (e.g. October to November) to assess potential public health threats due to the presence of these toxins (being added in 2016).

8.3 Future Monitoring in the Klamath Basin

Future monitoring is planned by various entities throughout the Klamath Basin including non-profits, private and federal entities. As the NCRWQCB monitoring locations come offline, entities throughout the Basin may collaborate to fill the monitoring needs. Currently, additional monitoring is planned by Riverkeeper in the Shasta subbasin, specifically above Dwinnell dam to fill the monitoring gap left by the NCRWQCB. The Quartz Valley Indian Reservation (QVIR) plans additional sites on Moffitt Creek and on East Fork before the confluence with the South Fork Scott River.

Also as part of the Action Plan goals for identified TMDLs throughout the Basin, compliance and trend monitoring plans are under development. The purpose of compliance and trend monitoring plans are to determine, on a watershed scale, if water quality standards are being met, and to track progress toward meeting water quality standards (NCRWQCB, 2009). A compliance and trend monitoring plan has been developed for the Scott subbasin and a similar plan is under development of the Shasta subbasin. Compliance and trend monitoring within these regions are conducted by private, tribal and federal entities. Both the ODEQ and the NCRWQCB compliance and trend monitoring locations shall be included in the Klamath Basin Water Quality Monitoring Plan soon as the compliance and trend monitoring plans become available. *Additionally, monitoring plans submitted by designated management agencies under the California and Oregon TMDL shall be evaluated for inclusion in the Plan.*

The U.S. Forester Service is working with the NCRWQCB on developing a sediment, temperature, and shade monitoring plan as part of the TMDL requirements and timber harvest waiver. The monitoring effort shall focus on small tributaries on Forest Service land. Currently, the Forest Service land occupies approximately 50% of the Basin. This plan may aid in addressing sediment concerns identified by KBMP the Middle, Lower, Shasta, and Salmon subbasins.

References

Barbiero, R.P., and J. Kann. 1994. The importance of benthic resrutment to the population development of Aphanizomenon flos-aquae and internal loading in a shallow lake. J. PlanktonRes. 16: 1581-1588.

Bond, M. H., S. A. Hayes, C. V. Hanson, and R. B. MacFarlane. 2008. Marine survival of steelhead (*Oncorhynchusmykiss*) enhanced by a seasonally closed estuary. Can. J. Fish. Aquat. Sci 65:2242–2252

California Climate Change Center (CCCC). 2006. Our Changing Climate: Assessing the Risks to California, Summary Report.

California Department of Fish and Game (CDFG). 2004. September 2002 Klamath River Fish-Kill: Final Analysis of Contributing Factors and Impacts. Northern California-North Coast Region. 173pp.

Carlson, Ken, T. Hamaker, D. Shelton 2009. Analysis of Microcystin in Resident Fish Tissues in the Vicinity of the Klamath Hydroelectric Project: Preliminary 2008 Results. Technical Memorandum prepared for PacifiCorp.

De la Fuente, J. and P. A. Haessig, 1993, Salmon Sub-Basin Sediment Analysis, USDA – Forest Service, Klamath National Forest.

Elder, D., B. Olson, A. Olson, J. Villeponteaux, and P. Brucker. 2002. Salmon River Subbasin Restoration Strategy: Steps to recovery and conservation of aquatic resources. Prepared by Klamath National Forest and Salmon River Restoration Council for the Klamath River Basin Fisheries Restoration Task Force. Yreka, CA. 74 pp.

FERC (Federal Energy Regulatory Commission). 2007. Final Environmental Impact Statement for hydropower license. Klamath Hydroelectric Project (FERC Project No. 2082−027).

Foott J.S, T. Martinez, R. Harmon, K. True, B. McCasland, C. Glace, and R. Engle. 2003. Juvenile Chinook health monitoring in the Trinity River, Klamath River, and Estuary. June−August 2001. FY2001 Investigational Report. U. S. Fish and Wildlife Service, California- Nevada Fish Health Center, Anderson, CA.

Gearheart, R. A., J.K. Anderson, M.G. Forbes, M. Osburn, and D. Oros. 1995. Watershed strategies for improving water quality in Upper Klamath Lake, Oregon. Humbolt State University.

Hallett, S.L., R.A. Ray, C.N. Hurst, R.A. Holt, G.R. Buckles, S.D. Atkinson and J.L. Bartholomew. 2012. Density of the waterborne parasite, Ceratomyxa shasta, and its biological effects on salmon. Applied and Environmental Microbiology 78:3724-3731.

Hoopa Valley Tribe Environmental Protection Agency (Hoopa TEPA). 2008. Water Quality Control Plan Hoopa Valley Indian Reservation. Hoopa, CA.

Horne A. J. and C. R. Goldman. 1994. Limnology. Second edition. McGraw-Hill Inc.: New York.

Jordan M. S. 2012. Hydraulic predictors and seasonal distribution of Manayunkia speciosa density in the Klamath River, CA, with implications for ceratomyxosis, a disease of salmon and trout. MS Thesis, Departments of Water Resources Science, and Microbiology, Oregon State University, Corvallis Oregon.

Kann, J. 2007. Toxic Cyanobacteria Results for Copco/Iron Gate Reservoirs: October 29-30, 2007. Technical Memorandum prepared for Karuk Tribe. Orleans, CA.

Kann, J., and E. Asarian. 2007. Nutrient budgets and phytoplankton trends in Iron Gate and Copco reservoirs, California, May 2005 – May 2006. Final technical report to the State Water Resources Control Board, Sacramento, California.

Kann, J. and S. Corum. 2007. Summary of 2006 Toxic microcystin aeruginosa trends in Copco and Iron Gate Reservoirs, CA. Technical Memorandum Prepared for the Karuk Tribe of California, Orleans, CA.

Kann, J. 2006. *Microcystis aeruginosa* occurrence in the Klamath River system for southern Oregon and northern California. Technical Memorandum.

Kann, J. and S. Corum. 2006. Summary of 2005 Toxic Microcystis aeruginosa Trends in Copco and Iron Gate Reservoirs on the Klamath River, CA. Aquatic Ecosystem Sciences, Ashland Oregon and the Karuk Tribe DNR, Orleans, CA.

Kann, J. and E. Asarian. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005 - May 2006. Final Technical Report to the State Water Resources Control Board, Sacramento, California.

Kann, J. and E. Asarian. 2005. 2002 Nutrient and hydrologic loading to Iron Gate and Copco reservoirs, California. Prepared by Kier Associates and Aquatic Ecosystem Sciences for the Yurok Tribe Environmental Program, Klamath, California.

Kann, J. and W. Walker. 2001**.** Nutrient and hydrologic loading to Upper Klamath Lake, Oregon 1991-1998. Prepared for the Bureau of Reclamation, Klamath Falls, Oregon.

Kann, J., and V.H. Smith. 1993. Chlorophyll as a predictor of elevated pH in a hypertrophic lake: Estimating the probability of exceeding critical values for fish success. Klamath Tribes Research Report. KT-93-02. The Klamath Tribes, Chiloquin, Oregon.

Karuk Tribe of California, Department of Natural Resources. 2002. Water quality monitoring report: water years 2000 & 2001 Klamath River mainstream.

Karuk Tribe of California, Department of Natural Resources. 2003. Water quality monitoring report: water years 2002 Klamath River mainstream.

Kier Associates. 2007. Comments on Klamath River Nutrient, Dissolved Oxygen, and Temperature TMDL Implementation Plan Workplan Outline for CA. Performed under contract to the Klamath Basin Tribal Water Quality Work Group with funding from the U.S. EPA. Kier Associates, Arcata, CA.

Klamath Basin Monitoring Program (KBMP). 2009. Support for Long-term Water Quality Monitoring Plan. Humboldt, Ca.

Laenen, A., and A.P. LeTourneau. 1996. Upper Klamath Basin Nutrient-Loading Study -Estimate of wind-induced resuspension of bed sediment during periods of low lake elevation. U.S. Gelogical Survey. Open-File Report 95-414. Portland, OR. 21:139-162.

National Resource Council. 2008. Hydrology, Ecology, and Fishes of the Klamath Basin. Washington, D. C. National Academies Press.

Nichols, K. and J. S. Foot. 2005. Health Monitoring of Juvenile Klamath River Chinook Salmon, FY 2004 Investigational Report. USFWS California-Nevada Fish Health Center, Red Bluff, CA.

North Coast Regional Water Quality Control Board (NCRWQCB). 2009. Draft Scott River Watershed Water Quality Compliance and Trend Monitoring Plan. Santa Rosa, CA.

North Coast Regional Water Quality Control Board (NCRWQCB). 2009. AIP Interim Measure 12: Water Quality Monitoring Activities Monitoring Year 2009. Santa Rosa, CA.

North Coast Regional Water Quality Control Board (NCRWQCB). 2008a. Staff Report for the Klamath River Total Maximum Daily Loads (TMDLs) and Action Plan Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California (Public Review Draft). Santa Rosa, CA.

North Coast Regional Water Quality Control Board (NCRWQCB). 2008b. Surface Water Ambient Monitoring Program, Summary Report for the North Coast Region for years 2000-2006.). Santa Rosa, CA.

North Coast Regional Water Quality Control Board (Regional Water Board). 2007. Water Quality Control Plan for the North Coast Region (Basin Plan). January 2007.

North Coast Regional Water Quality Control Board (NCRWQCB). 2006. Action Plan for the Shasta Watershed, Dissolved Oxygen and Temperature TMDLs. Santa Rosa, CA.

North Coast Regional Water Quality Control Board (NCRWQCB). 2005a. Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads. Santa Rosa, CA.

North Coast Regional Water Quality Control Board (NCRWQCB). 2005b. Salmon River, Siskiyou County, California – Total Maximum Daily Load for Temperature and Implementation Plan. Santa Rosa, CA.

Oregon Department of Environmental Quality. 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). ODEQ, Portland, OR.

Pacific Fishery Management Council (PFMC). 2007. *Review of 2006 Ocean Salmon Fisheries.* (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon.

PacifiCorp. 2006. Causes and Effects of Nutrient Conditions in the Upper Klamath River. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. November 2006. 77 pp.

Ray, A.R., R.A. Holt and J.L. Bartholomew. 2012. Relationship between temperature and C. shasta-induced mortality in Klamath River salmonids. Journal of Parasitology. 98:520-526.

Seaber, Paul F. Paul Kapinos, and George Knapp, 1987. Hydrologic Unit maps. United States Department of Interior, US Geological Survey, Water Supply Paper 2294, 63 pp.

Snyder, J. O. 1931. Salmon of the Klamath River, California. California Division of Fish and Game, Fish Bulletin No. 34. Sacramento, CA.

Stillwater Sciences. 2009. Dam Removal and Klamath River Water Quality: A Synthesis of the Current Conceptual Understanding and Assessment of Data Gaps. Technical Report. Prepared for State Coastal Conservecy, 1330 Broadway, 13th Floor, Oakland, CA 94612, 86 pp.

Stocking, R. W. and J. L. Bartholomew. 2007. Distribution and habitat characteristics of *Manayunkia speciosa* and infection prevalence with the parasite, *Ceratomyxa shasta*, in the Klamath River, OR-CA, USA. Journal of Parasitology 93:78-88

Stocking, R. W., R. A. Holt, J. S. Foott and J. L. Bartholomew. 2006. Spatial and Temporal Occurrence of the Salmonid Parasite *Ceratomyxa shasta* (Myxozoa) in the Oregon-California Klamath River Basin. Journal of Aquatic Animal Health. 18: 194-202.

Stocking, R. W., and J. L. Bartholomew. 2004. Assessing links between water quality, river health and Ceratomyxosis of salmonids in the Klamath River system. Department of Microbiology, Oregon State University, Corvallis, OR.

Tribal Water Quality Work Group (TWQCG). 2009. http://www.klamathwaterquality.com/ [Accessed July 2009].

U. S. Environmental Protection Administration (EPA). 2009. Clean Water Act, Watershed Academy http://www.epa.gov/watertrain/cwa/ [Accessed July 2009].

U. S. Environmental Protection Administration (EPA). 2008. Total Maximum Daily Loads Nitrogen and Biochemical Oxygen Demand to address Dissolved Oxygen and pH Impairments, Lost River, California.

U. S. Environmental Protection Administration (EPA). 2001. Trinity River Total Maximum Daily Load for Sediment.

Van Winkle, W., 1914, Quality of the surface waters in Oregon: U.S. Geological Survey Water Supply-Paper 363, 133 p.

Wetzel, R. G. 2001. Limnology. Lake and river ecosystems. Third edition. Academic Press: San Diego.

YTEP (Yurok Tribe Environmental Program). 2006. Klamath River Blue-Green Algae Bloom Report: Water Year 2005.

YTEP (Yurok Tribe Environmental Program). 2005. Water Year 2004 Report.

Yurok Tribal Environmental Program (YTEP). 2004. Water Quality Control Plan for the Yurok Indian Reservation. Klamath, CA.

Appendix I Answers to the "Big 5 Questions"

The formulation of the five "Five Big Questions" was generated during the April 8th and 9th, 2008 meeting in Yreka, California. The questions were forged out of a desire to understand the baseline water quality in each subbasin, both existing and over time.

The set of questions were as follows:

* What are the baseline trends?
* Does water quality support beneficial uses?
* How is the water quality affected by climate change?
* What are the effects of regulatory actions on water quality?
* What are the effects of land and water management actions on water quality?

A representative from each subbasin volunteered to address each of the five questions; the responses are as follows.

Williamson, Sprague, and Upper Klamath Lake
Response to Big 5 Questions –
Response by - Jessica Asbill (USBOR)

1. What are the baseline trends?

The Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) was released in May 2002.

2. Does water quality support beneficial uses?

Public Domestic Water Supply, Salmonid Fish Spawning (Trout), Private Domestic Water Supply, Salmonid Fish Rearing (Trout), Industrial Water Supply, Resident Fish and Aquatic Life, Irrigation, Wildlife and Hunting, Livestock Watering, Fishing, Boating, Water Contact Recreation, Hydro Power, Aesthetic Quality.

3. How is the water quality affected by climate change?

This question needs more research.

4. What are the effects of regulatory actions on water quality?

The Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) was released in May 2002.

5. What are the effects of land and water management actions on water quality?

Land ownership is predominantly private and United States Forest Service in the Upper Klamath Lake drainage, accounting for 42.3% and 53.4% of the land area, respectively. Crater Lake National Park makes up 3% of the land area. Nearly 1% of the area is National Wildlife Refuge. Land use in the Upper Klamath Lake drainage is predominantly forested (69.4%) and shrubland/grassland (13.7%). Agriculture (farming) and grazing occur on 5.5% of the drainage. Wetlands and water make up 6% and 3.7% of the surface area, respectively.

Lost
Response to Big 5 Questions –
Response by - Jessica Asbill (USBOR)

1. What are the baseline trends?

The NCRWQB is in the process of writing the California TMDL right now. ODEQ plans on writing the Oregon TMDL in the near future.

2. Does water quality support beneficial uses?

Yes. This is from the California Public Draft Review of the TMDL.

Rare, Threatened or Endangered Species
Agricultural Supply
Groundwater Recharge
Freshwater Replenishment
Migration of Aquatic Organisms
Non-Contact Recreation
Commercial & Sport Fishing
Warm Freshwater Habitat
Wildlife Habitat
Spawning and Reproduction

3. How is the water quality affected by climate change?

This question needs more research.

4. What are the effects of regulatory actions on water quality?

The NCRWQB is in the process of writing the California TMDL right now. ODEQ plans on writing the Oregon TMDL in the near future.

5. What are the effects of land and water management actions on water quality?

This is a very complex system with many components. The system from Clear Lake to Malone Dam is mostly canyon and forest. Below Malone Dam is mainly agriculture until the Lost River system enters the Klamath River at Strait's Drain. There are three protected refuges in this system: Clear Lake, Tule Lake, and Lower Klamath Refuge. Each refuge is managed differently and so each contributes differently. Another component is that water transfers to the Lost River from the Klamath River, and then to the Klamath River from the Lost River through the Lost River Diversion Channel. It depends on which system needs the water each day to which way it flows. In the winter the Lost River Diversion Channel usually flows from the Lost River to the Klamath River and in the summer it usually flows from the Klamath River to the Lost River.

Upper Klamath
Response to Big 5 Questions –
Response by - Mike Deas (Watercourse Engineering Inc.)

Upper Klamath (Link to Iron Gate Dam)

1. What are the baseline trends?

Short data series, maybe 6 to 8 years. System illustrates wide range of variability and longer data sets required. Many impacts over the last 100 or so years and parsing out individual effects is challenging. Big upstream contributing area…with Upper Klamath Lake (UKL) right at the top of this reach.

2. Does water quality support beneficial uses?

Yes. Agriculture, municipal, industrial, environmental, recreation (boating, hunting, fishing). Agriculture, municipal, and industrial uses are largely limited to the Link Dam to Keno Dam reach. Downstream of this reach fishing and recreation may be supported by water quality.

3. How is water quality affected by climate change?

Not quantified at this time. System is already warm – see Bartholow work.

4. What are the effects of regulatory actions on water quality?

A FERC Relicensing process is underway through this reach. A TMDL has been completed on the Lost River (there is a hydraulic connection between the Lost and Klamath Rivers). A TMDL is underway currently to assess the reach from Link Dam to the Pacific Ocean. ODEQ is responsible for water quality conditions in Oregon, NCRWQCB is responsible for California waters.

5. What are the effects of land and water management actions on water quality?

Considerable. In the upper basin, hypereutrophic UKL (impacted by land and water use upstream) provides a large source of nutrients and organic matter to downstream river reaches. Although small, municipal and industrial uses in the Klamath Falls area are contributors (to be addressed in TMDL). Federal Reclamation project activities, coupled with private irrigators produce agricultural return flow to the Klamath River. Impoundment by system reservoirs has changed the aquatic environment from riverine to more quiescent lake conditions, changing the water quality response of the river to upstream inflows borne out of UKL and other inputs to the system.

Butte

Butte subbasin primarily a closed subbasin, it is not included in analysis.

Shasta

Responses to the Big 5 Questions

Response by - Mike Deas (Watercourse Engineering Inc.) & Karen Mallroy (Shasta RCD)

1. What are the baseline trends?

Mike Deas (Watercourse Engineering Inc.)

Not enough data is in hand to identify clear trends in water quality – a long history of water resources development in the basin. TMDL has been completed and implementation plan in place. DFG Incidental Take Permit (ITP) is due to come on line in 2009. Key land and water acquisitions are being explored, but firm commitments will not occur until 2009.

2. Does water quality support beneficial uses?

Mike Deas (Watercourse Engineering Inc.)

Yes. Drinking water supplies, industrial uses, agricultural uses, and environmental uses.

3. How is water quality affected by climate change?

Mike Deas (Watercourse Engineering Inc.)

Not quantified at this time. System is already warm – see Bartholow work.
Being a spring creek (essentially), the Shasta River may be one of the more high value

tributaries to monitor and assess for baseline trends and assess climate change impacts

4. What are the effects of regulatory actions on water quality?
Mike Deas (Watercourse Engineering Inc.)

As noted above a TMDL is in place and the DFG ITP process is due to be implemented soon.

5. What are the effects of land and water management actions on water quality?
Mike Deas (Watercourse Engineering Inc.)

Notable. Water resources development has lead to depletion of stream in several reaches. Adjacent land use (largely agriculture) leads to return flows entering the Shasta River. The RCD is active in tailwater management, fencing, and other activities. Coupled with TMDL and ITP actions, progress is being made.

5. Effects of land and water management actions on water quality? –
Karen Mallroy (Shasta RCD)

Agricultural land and water management practices have had a significant impact on water quality, including raising temperature and nutrient levels. Projects that reduce ponding and warm water returns in the Shasta will continue to be a major focus for the RCD.

<u>Scott</u>
Responses to the Big 5 Questions
Response by - Stuart Farber (Timber Products Company) & Danielle Yokel (Siskiyou RCD) & Crystal Bowman (Quartz Valley Indian Reservation)

1. What are the baseline trends?
Stuart Farber (Timber Products Company)

I do not know of any data set or report that describes baseline trend for sediment, temperature or fish abundance or populations for the entire watershed? French Creek has a baseline trend for coarse sediment in pools. Some water temperature trends exist for reaches of the watershed back to 1997. Seems like a coordinated, scientifically rigorous approach is needed for at least the larger sub-basins, if not the entire watershed.

2. Does water quality support beneficial uses?
Stuart Farber (Timber Products Company)

Yes, sediment levels (both coarse and fine), water temperatures are supporting anadromous and native fish populations. Some species, coho, maybe be improving in some sub-basins like French Creek. A better link between water quality and beneficial uses needs to be established, especially with anadromous salmonids and native trout. Existing TMDL was not a scientifically rigorous process, and many links between land uses and water quality are unclear.

3. How is water quality affected by climate change?
Stuart Farber (Timber Products Company)

Water quality data and climate information exists for reaches of the Scott River and sub-basins back to the 1950's. This data is in reports available at the Department of Water Resources in Red Bluff. Some of this information is described in the 2001 water temperature report (Quigley et al 2001). The Scott River has experienced at least two or three warming (late 1970's, early 1990's) and cooling (early 1960's,early 1980's, late 1990's) periods since the 1950's, seems like the information would be helpful.

4. What are the effects of regulatory actions on water quality?
Stuart Farber (Timber Products Company)

None. Existing regulation has either been established under one-size-fits-all approaches by State wide agencies, regulations are designed for a watershed far away from the Scott River, so it fails at addressing local conditions. The existing TMDL was not a rigorous scientific effort, consequently its actions will not improve water quality, and actions that may improve water quality will not get emphasis or funding because of errors made in the original TMDL.

5. What are the effects of land and water management actions on water quality?
Stuart Farber (Timber Products Company)

The baseline trend of land management is not known in the watershed, along with the baseline of water quality information. If you had both, you could make some powerful observations about how the watershed works and how to improve water quality. But since neither data set exists, and no efforts are currently on-going to pursue this sort of information, it does not seem likely answers to the key questions in this watershed will ever be known. So the effects of land use on improving or degrading water quality is not likely to be known.

2. Does Water Quality support beneficial uses?
Danielle Yokel (Siskiyou RCD)

Yes, currently the Scott River supports domestic water supplies, recreation, agriculture, and fisheries both in the mainstem Scott River and Tributaries. Some locations on the Scott River mainstem and East Fork exceed water temperature thresholds quoted for anadromous salmonids, but juveniles have been documented rearing in thermal refugia. Siskiyou County Public Health should be contacted to see if they have any documented cases of water quality impacting recreation.

2. Does water quality support beneficial uses?
Crystal Bowman (Quartz Valley Indian Reservation)

Elevated surface water temperatures and increased sediment loads have impaired many designated used of the Scott River, including cold water fishery beneficial uses of migration, spawning, reproduction and early development (NCRWQCB Scott TMDL 2005.
E.coli monitoring in 2007 by the QV Tribe has indicated an exceedance to the USEPA Ambient Surface Waters levels and in 2008 an exceedance to the North Coast Basin Plan. This is a public health threat and is therefore not meeting the beneficial uses of recreation. Exceedances were document in both tributaries and the mainstem Scott. Sonde monitoring efforts by the Tribe in 2007 and 2008 indicate dissolved oxygen and pH Basin Plan requirements for salmonids are not being met in various locations on the mainstem Scott. This is directly related to consistently high levels of nitrogen (> 0.12 mg/l) detected on the mainstem Scott River and Shackleford Creek. Nutrients do not directly affect salmonids, but can impact them indirectly by stimulating the growth of algae and aquatic macrophytes to nuisance levels that can adversely impact water quality (dissolved oxygen and pH).

3. How is water quality affected by climate change?
Crystal Bowman (Quartz Valley Indian Reservation)

There is high demand for water resources in the Scott Valley. The river supports many families within as well as outside the community. Local ranchers have crop and livestock water irrigation needs, local Tribes have cultural and subsistence needs from the fishery and commercial fishermen depend on the Scott River for reproduction of the ocean fishery. And recreation of the wilderness is shared by people around the world.

So, what will happen to the Scott River watershed as our climate begins to change and become warm? Less water will be available to meet all the needs the watershed current has.
The agricultural community will require more groundwater wells to meet their existing needs as surface flows decrease. Increased withdrawls from the aquifer would lower the water table thereby decreasing the river depth, velocity and connectivity. The amount of solar radiation would increase causing increased water temp and perphytin growth resulting in high daytime pH and low nighttime DO. Lowering the water table would also impact forest health by weakening trees thereby making them more susceptible to disease and insect infestation. This would decrease the forest stand and thereby decrease the amount of pollutants a riparian stand can filter, the amount of sediment an upland forest can hold and increase direct solar radiation on the river. Macroinvertebrate assemblages would change and decrease in quantity due to the overall changing ecology. The needs of the Tribes and commercial fishermen will not be supported with decreasing surface flows and there is not a feasible mitigation that could replace the in-river fishery.

4. What are the effects of regulatory actions on water quality?
Crystal Bowman (Quartz Valley Indian Reservation)

Regulations to protect fish, water quality and specifically quantity in Scott Valley have been loosely monitored. As a result, their effect on improving both water quality and the fishery has been poor. Scott River adult Chinook data indicate a declining population despite extensive restoration projects and regulations.
However, recent requirements from the Scott TMDL implementation plan has led to priority changes for local restoration and monitoring groups. This regulatory action has promise of improving water quality and fish populations.

5. What are the effects of land and water management actions on water quality?
Crystal Bowman (Quartz Valley Indian Reservation)

Current land use activities (Scott TMDL 1-17):
• 1.timber harvest (private and public)
• 2.irrigated agriculture – 6% of watershed
• 3.livestock grazing
These land use activities have the potential to affect water quality through:
• 1.increased solar radiation
• 2.increased sediment loads
• 3.water extraction

• 4.loss of large woody debris
All of these impairments to water quality have been documented in the Scott TMDL the river has been listed as temperature and sediment impaired.

Agriculture and livestock grazing also have the ability to introduce nutrient and bacteria pollution. These parameters have been monitored in 2007 and 2008 monitoring will continue in the future to assess the extent of the pollution in a variety of water years. High levels of E.coli, TN and TP are concerning for both human and aquatic health respectively.

Salmon

Responses to the Big 5 Questions

Response by - Lyra Cressy (Salmon River Restoration Council)

1. What are the baseline trends?

Baseline trends on the Salmon River are hard to quantify. The Salmon River TMDL determined that loss of riparian shade that has resulted in elevation of stream temperatures above natural receiving water temperatures. Water temperatures range between nearly 0C in the winter to nearly 30C in the summer. Temperatures normally peak between the middle of July and the beginning of August. Cooling trends normally begin after the first week of August.

2. Does water quality support beneficial uses?

The primary beneficial uses on the Salmon River pertain to the anadromous salmonid fishery. The water quality conditions present in the Salmon River are not fully supportive of anadromous salmonid species. Water temperature is the primary concern. The Salmon River TMDL concluded that summer water temperatures on the Salmon are excessively hot for the support of salmonids, and that in increase in riparian shading is the best way to mitigate the problem.

3. How is water quality affected by climate change?

This question needs more research. Reduced winter snowpack, and the timing of the snow melt have definite consequences for summer water temperatures on the Salmon.

4. What are the effects of regulatory actions on water quality?

The Salmon River TMDL Implementation Plan requires that the USFS (the primary landowner on the Salmon River) take the actions necessary to bring the Salmon River into compliance with clean water standards.

5. What are the effects of land and water management actions on water quality?

The primary management actions associated with water quality on the Salmon River are mining, timber harvest, road building and fire management.
Disruptions in natural fire regimes by human intervention in suppression have influenced vegetation and sediment delivery patterns in the Salmon River sub basin.
Historic mining activities substantially altered the watershed, as demonstrated by dramatic effects on the landscape, vegetation, soil, and river structure. Lack of vegetation allows for greater amounts of solar radiation to reach the stream, raising stream temperatures.

<u>Middle Klamath</u>
Responses to the Big 5 Questions
Response by – Susan Corum (Karuk Tribe)

1. Baseline Trends

Increased water temperature, elevated nutrient levels, low dissolved oxygen, elevated pH, increased incidence of fish disease, an abundance of plant growth, high Chlorophyll-a levels, and high concentrations of toxigenic blue-green algae.

Copco and Iron Gate reservoirs are highly stratified during the growing season (May-October).

2. Does WQ support beneficial uses?

Impacted beneficial uses from water quality issues listed in 1:
Cold freshwater habitat
Rare, threatened or endangered species
Migration of aquatic organisms
Spawning, reproduction, and/or early development
Commercial and sport fishing
Cultural use and subsistence fishing
Contact and noncontact recreation
Wildlife habitat

3. Is WQ affected by climate change?

More info is needed.
If there is less snow pack and warmer temperatures in the future, then all issues listed in 1. will be intensified. This could have impacts on fish health, more algae blooms, shift run timing, etc.

4. Regulatory actions for WQ

Currently, the TMDL for the Klamath is in development. It must be adopted by 2010. Concurrently, the Klamath Hydroelectric Project on the mid-Klamath is undergoing relicensing with FERC. As part of this, the Project is undergoing 401 certification process by both Oregon and California.

5. Effects of land and water management actions on WQ.

Klamath Hydroelectric Project alters water quality dynamics. Temperatures are cooler in spring and warmer in the summer. Nutrient dynamics are altered due to highly stratified reservoirs. Copco and Iron Gate Reservoirs provide habitat for toxic algae blooms.

Grazing reduces riparian vegetation yielding higher River temperatures.

Mining-Historic large-scale hydraulic mining and current suction dredge mining. Historic mining operations altered stream channels and eroded hillslopes. Current mining resuspends sediment and mercury in water column.

Roads-Unmaintained roads and culverts can cause debris torrents which add sediment to River affecting water temperature and fish habitat.

Forestry practices-Clear cuts, salvage logging, fire suppression, and enormous back burns impact water quality. When large areas are cut or catastrophic fires occur from poor forestry practices, watersheds are highly erosive.

Lower Klamath

Responses to the Big 5 Questions

Submitted the SAP for the Yurok Tribe Environmental Program

Trinity / SF Trinity
Responses to the Big 5 Questions
Response by – Mike Deas (Watercourse Engineering Inc.)

1. What are the baseline trends?

Basin is pretty consistent, with natural variability affected by impoundment (Trinity Reservoir) and extra-basin diversion at Lewiston Reservoir. ROD lays out a clear plan of action in the top 40 miles (down to the North Fork Trinity River), and the Trinity River Restoration Program (TRRP) is very active in research, monitoring, and resource management. Recent developments have included flows to encourage coarse sediment transport and bank restoration activities (but much work is going on). An unfortunate element of the TRRP is that it is largely restricted to the main stem down to the North Fork (and not in the tributaries). The Hoopa Valley Tribe has an active program on reservation lands collecting flow and temperature data in several tributaries. This is a large basin and more focus on the main stem downstream of the North Fork, and in tributary streams (particularly in the middle of the basin, including the South Fork Trinity River) would be useful.

2. Does water quality support beneficial uses?

Yes. Cold water is an important element of fisheries management in this stream. Trinity Reservoir has a large cold water pool and provides cold water to the Trinity River downstream of Lewiston Dam (supports anadromous fish in the river and in the hatchery). The river is largely oligotrophic (low productivity), particularly compared to the Klamath River. However, considerable benthic algal growth occasionally occurs in the lower river (reasons unknown). Beneficial uses include small agriculture, rural use (water supply), recreation, and upstream of Lewiston, large scale water supply, hydropower, recreation, and other uses in the Trinity Division of USBR.

3. How is water quality affected by climate change?

Not quantified at this time.

4. What are the effects of regulatory actions on water quality?

USBR Record of Decision, TRRP implemented (and ongoing) actions. Operations have been defined to meet NCRWQCB basin plan objectives. TRRP is active in temperature monitoring and management.

5. What are the effects of land and water management actions on water quality?

Impoundment and diversion play a major role in the basin. Historic forest practices and associated sediment yield are also deemed problematic throughout much of the water shed (more so upstream in the main stem Trinity River, but in many tributaries).

Appendix II Goals and Objectives SWAMP and ODEQ

SWAMP Goals and Objectives:

The Surface Water Ambient Monitoring Program (SWAMP) was proposed in a Report to the Legislature to integrate existing water quality monitoring activities of the State Water Resources Control Board and the Regional Water Quality Control Boards, and to coordinate with other monitoring programs. Related Water Code is contained in Sections 13160-13193.

SWAMP is a statewide monitoring effort designed to assess the conditions of surface waters throughout the state of California. The program is administered by the State Water Board. Responsibility for implementation of monitoring activities resides with the nine Regional Water Quality Control Boards that have jurisdiction over their specific geographical areas of the state.

SWAMP is intended to meet four goals as follows:

1. Create an ambient monitoring program that addresses all hydrologic units of the State using consistent and objective monitoring, sampling and analytical methods; consistent data quality assurance protocols; and centralized data management. This will be an umbrella program that monitors and interprets that data for each hydrologic unit at least one time every five years.

2. Document ambient water quality conditions in potentially clean and polluted areas. The scale for these assessments ranges from the site-specific to statewide.

3. Identify specific water quality problems preventing the SWRCB, RWQCB's, and the public from realizing beneficial uses of water in targeted watersheds.

4. Provide the data to evaluate the overall effectiveness of water quality regulatory programs in protecting beneficial uses of waters of the State.

Additionally, the SWAMP program is essential to the success of the Total Maximum Daily Load (TMDL) program. Extensive monitoring data and information on the quality of the waters of the State are the backbone of the TMDL program. A TMDL is a framework for assessing the condition of a watershed, evaluating the factors that contribute to identified water quality problems in the waterbody, and for developing a plan to restore healthy water quality conditions. The SWRCB's SWAMP program, once fully implemented, is intended to produce water quality data to improve RWQCB's abilities to list and delist 303(d) waters. Section 303(d) of the federal Clean Water Act requires states to identify waterbodies that are impaired, to identify the pollutant(s) or stressor(s) that are causing impairment, and to develop a plan (the TMDL) to attain and maintain desired water quality standards. An "impaired" waterbody is one that is not meeting water quality standards and/or not supporting the designated beneficial uses of the waterbody.

There are five general objectives of a TMDL:

1. To assess the condition of a waterbody, and determine/confirm cause(s) / source(s) of stress.

2. To quantify the sources of the pollutant or stressor.

3. To determine how much of a particular pollutant or stressor a waterbody can handle and still meet desired conditions.

4. To identify whether and how much the different sources need to be reduced in order to support desired conditions.

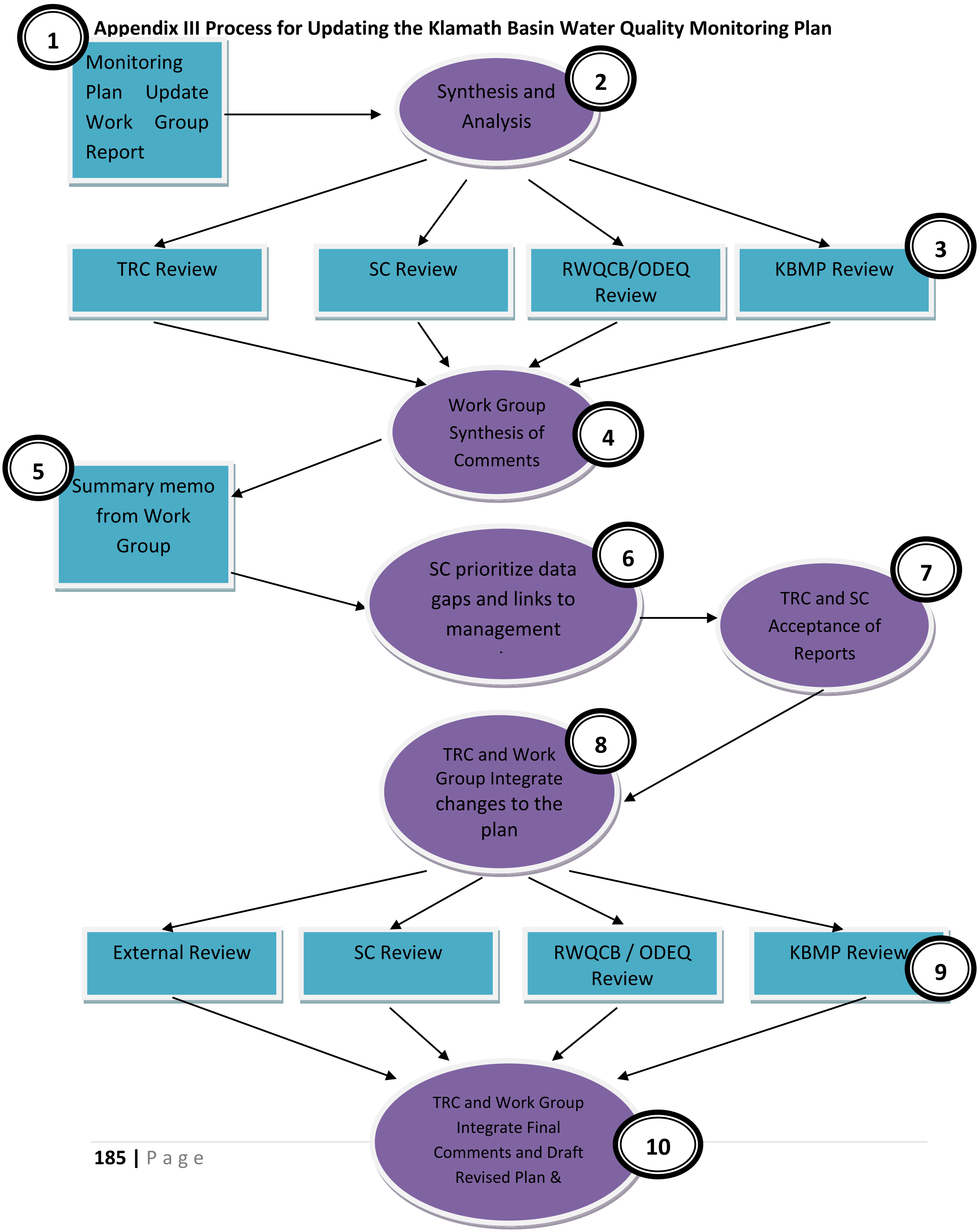
5. To develop a plan which, when implemented, will restore waterbody health.

Oregon Department of Environmental Quality

Goal and Strategy

The goal of DEQ's Nonpoint Source (NPS) Program is to prevent and eliminate water pollution from nonpoint sources of water pollution in all waterbodies in the state. DEQ's overall strategy is to further develop its own and other agencies' or individual's capabilities in each of the ten program areas listed below, emphasizing watershed protection and enhancement, voluntary stewardship, and partnerships between all watershed stakeholders.

Appendix III Process for Updating the Klamath Basin Water Quality Monitoring Plan



Steps referred to in the above process for updating the Klamath Basin Water Quality Monitoring Plan *(Adapted from the San Francisco Estuary Institute).*

1)

The Plan shall be evaluated annually. Data from the previous season shall be presented at the annual member meeting, accompanied by a group discussion. A work group shall be selected by the Technical Review Committee (TRC). The work group shall evaluate the current plan with an emphasis on comments from the group as well as data gaps, trend monitoring, tracking special studies, and evaluating the success of the Plan.

The success of the Plan is defined as the ability to achieve the goals and objectives outlined in the Plan, with an emphasis on tracking water quality conditions affecting sensitive beneficial uses.

2)

The work group shall evaluate and synthesize the previous season's data. The work group will also integrate changes in monitoring and update the monitoring network to best support the goals and objectives of the Plan. The work group shall propose recommendations for improving the Plan and prepare a report outlining suggestions and rational.

3)

The report shall be distributed to the TRC, Steering Committee (SC), KBMP members, regulatory agencies (RWQCB and ODEQ). The regulatory agencies shall evaluate the Plans effectiveness for meeting compliance and trend monitoring goals. The regulatory agencies shall prepare a report for the work group outlining necessary changes to meet regulatory goals. The Steering Committee and KBMP member shall also prepare suggestions for improving the Plan.

4 & 5)

The work group shall review suggested changes to the Plan and prepare a memo detailing the suggested alteration to the Plan.

6)

The SC shall evaluate the suggested changes to the Plan in light of funding and prioritize changes to the Plan and prepare a report.

7)

The TRC and SC review and discuss the report.

8)

The work group, based on the recommendations of the report, shall make changes to the Plan. The TRC shall review the changes and approve the Plan for dissemination.

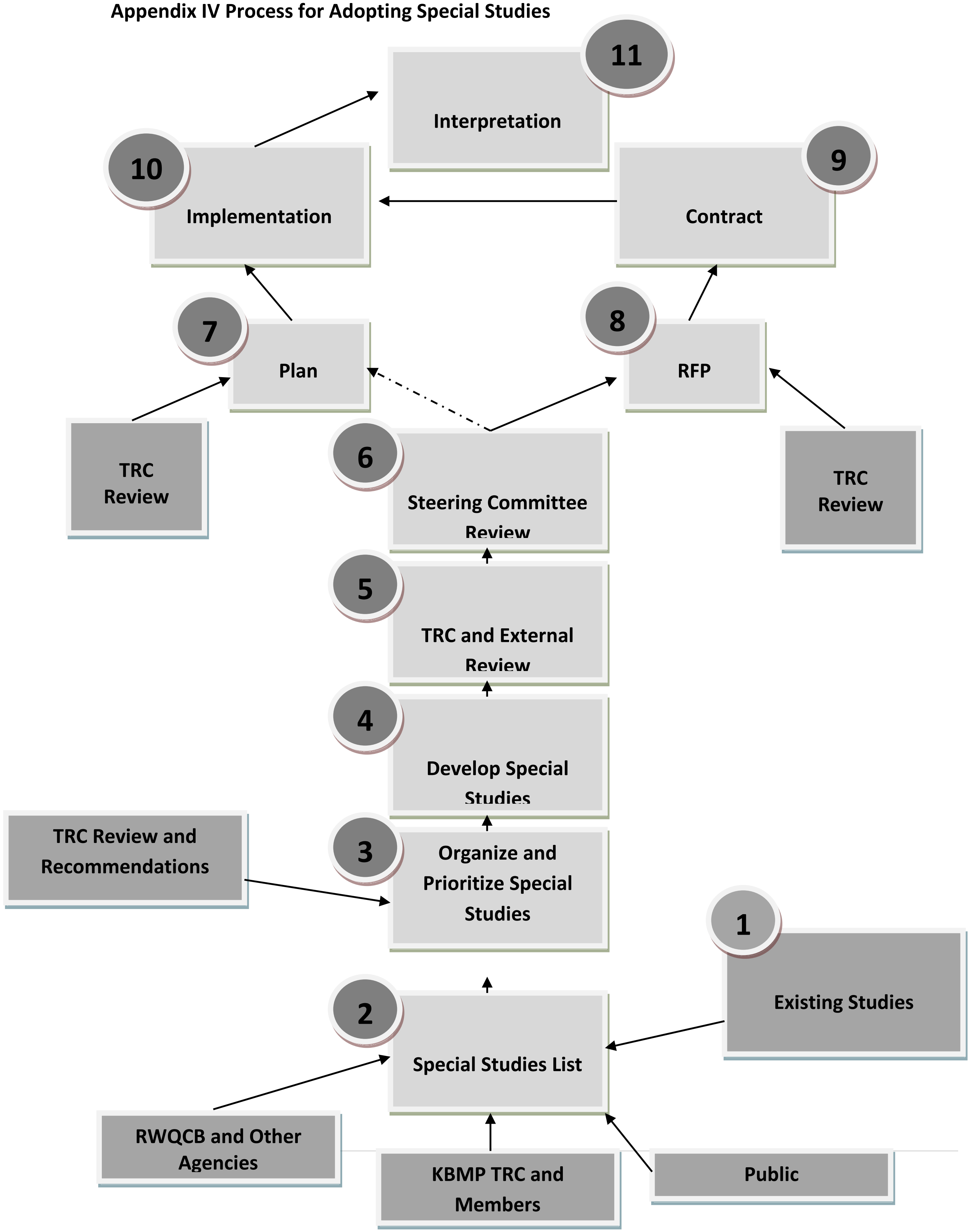
9)

The plan shall be distributed to an external review entity, the SC, members of the KBMP, and regulatory agencies (RWQCB and ODEQ).

10)

The work group shall integrated any remaining comments and draft the final version of the Plan.

Appendix IV Process for Adopting Special Studies



Steps referred to in the above Special Study Implementation Process flow chart *(Adapted from the San Francisco Estuary Institute)*

1)

There are four main sources for input for potential special studies. These potential special studies could arise from a variety of activities, such as data interpretation, observations during field work, review of relevant literature, existing studies, TMDL implementation goals and the public. At this beginning stage, there need be no formal write-up. The (Technical Review Committee AKA Water Quality Subcommittee) TRC maintains a raw list of ideas for further consideration.

2)

Potential special studies shall be posted on the KBMP website to maintain transparency during the selection process. Along with the list of potential special studies the criteria for selection shall be included.

3)

At this point, the TRC should take the lead in organizing, evaluating, and prioritizing the raw list of Study topics. The TRC should be actively involved in this process, which should include the following steps:

- TRC will solicit any needed additional information from submitters
- TRC will have a preliminary, open-ended discussion of topics
- TRC will sort topics into those that might be included in the baseline monitoring (need successive measurements over time), approached as Pilot Studies (need methods development or proof of concept work), or implemented as Special Studies (focused and bounded questions)
- TRC will separately rank each topic on specific criteria:
    - overall relevance to objectives and management questions
    - the appropriate level of scientific detail needed to address the topic
    - technical issues that need to be resolved prior to implementation
    - probable level of effort and cost
    - need for outside expertise

- TRC will solicit the RWQCB's views on the degree to which each topic responds to Program objectives and the current management questions
- TRC will meet together to discuss each topic, using the criteria listed above as guidance of developing a prioritized list of topics.

On a case by case basis, TRC will determine whether to apply these criteria in a subjective or a more formal quantitative fashion, documenting the factors that entered into their decision.

4)

Based on the prioritized list of possible topics, TRC will prepare a set of more formal descriptions of concepts or issues. These will form the basis for Pilot and Special Studies in the coming year and in subsequent years. These concepts need not correspond one-to-one with individual topics on the list developed in Step 3. Instead, these concepts may incorporate more than one topic or may use one or more topics as a starting point.

An integral part of each study concept should be a statement of its relationship to the Program objectives and the current management questions. Further, each should also include a description of the anticipated duration, a tentative budget for the study, and decision points regarding when the study should be considered complete and/or included in the Klamath Basin Water Quality Monitoring Plan.

5)

The TRC will provide an independent review of the studies developed in Step 4. The goal of this step is to prepare background information that will help the Steering Committee's decision making in Step 6. The TRC should evaluate each Study concept in detail, identifying potential benefits and pitfalls, evaluating and improving tentative budget estimates, and soliciting specific information needs from individual members of the Steering Committee. In particular, the TRC will ensure that each potential special study includes a conceptual model of the problem and specific aspects of study design such as site selection and sampling frequency.

6)

In this step, the Steering Committee will select a certain number of studies to include in the Program plan. The Steering Committee will consider information provided by the TRC. The final decision will be based on consensus.

7 & 8)

The dashed arrow indicated that funding is not currently available for integration of studies directly into the Klamath Basin Water Quality Monitoring Plan; as a result all studies will be put out for bid. Each proposed study should include concise statement of objectives, milestones, deliverables, expected budget, and evaluation criteria. Where particular technical methods must be used, these should be specified. In particular, TRC should give careful consideration to whether the desired work can be performed within the budget and time constraints. Final drafts of the plans/RFPs will be reviewed and approved by the Steering Committee.

9 & 10)

At this point, Studies will be integrated with the KBMP's normal contracting and implementation process. TRC will monitor the progress of all special studies and report on their progress to Steering Committee at least quarterly.

11)

Following implementation, results of the special studies should be evaluated. In particular, the Steering Committee, with input from TRC, should make explicit decisions about whether and how special studies should be incorporated into the Klamath Basin Water Quality Monitoring Plan. External scientific review may be solicited as necessary.

Appendix V Designated Beneficial Uses

The list provided below regarding beneficial water uses which follows is Section 13050(f) of California's Porter-Cologne Water Quality Control Act, states:

"Beneficial uses of the waters of the state that may be protected against water quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves."

- Municipal and Domestic Supply (MUN) - Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
- Agricultural Supply (AGR) - Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
- Industrial Service Supply (IND) - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.
- Industrial Process Supply (PROC) - Uses of water for industrial activities that depend primarily on water quality.
- Groundwater Recharge (GWR) - Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.
- Freshwater Replenishment (FRSH) - Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity).
- Navigation (NAV) - Uses of water for shipping, travel, or other transportation by private, military or commercial vessels.
- Hydropower Generation (POW) - Uses of water for hydropower generation.
- Water Contact Recreation (REC-1) - Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white-water activities, fishing, or use of natural hot springs.
- Non-Contact Water Recreation (REC-2) - Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

- Commercial and Sport Fishing (COMM) - Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.
- Aquaculture (AQUA) - Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.
- Warm Freshwater Habitat (WARM) - Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
- Cold Freshwater Habitat (COLD) - Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
- Inland Saline Water Habitat (SAL) - Uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates.
- Estuarine Habitat (EST) - Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).
- Marine Habitat (MAR) - Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).
- Wildlife Habitat (WILD) - Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
- Preservation of Areas of Special Biological Significance (BIOL) - Includes marine life refuges, ecological reserves and designated areas of special biological significance, such as areas where kelp propagation and maintenance are features of the marine environment requiring special protection.
- Rare, Threatened, or Endangered Species (RARE) - Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.
- Migration of Aquatic Organisms (MIGR) - Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

- Spawning, Reproduction, and/or Early Development (SPWN) - Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.
- Shellfish Harvesting (SHELL) - Uses of water that support habitats suitable for the collection of filter feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.
- * Ceremonial and Cultural Water Use (CUL) – Defined as the traditional use of a river, stream, reach or lake for cultural purposes by members of the tribal community; such uses involves immersion, provision and adequate flows for ceremonial purposes, and suitable water-temperature for ensuring the presence and consumption of anadromous salmonids for ceremonial purposes.
- * Wild and Scenic (W&S)- Provides for scenic, fisheries, wildlife and recreational purposes.
- ** Subsistence Fishing (FISH)- Fishing by the Tribal communities for the purposes of subsisting.

(* Adapted from the Hoopa Valley Tribe Water Quality Control Plan 2002)
(** Adapted from the North Coast Regional Water Quality Control Board, 2008. Preliminary Review Draft Klamath River TMDL)

Table 15: Existing and potential beneficial uses (California).

Beneficial Use Existing (E) or Potential (P)		Middle Klamath River HA							Lower Klamath River HA	
		Ukonom HSA	Happy Camp HSA	Seiad Valley HSA	Beaver Creek HSA	Hornbrook HSA	Iron Gate HSA	Copco Lake HSA	Klamath Glen HSA	Orleans HSA
Agricultural Supply	**(AGR)**	E	E	E	E	E	P	E	E	E
Aquaculture	**(AQUA)**	P	P	P	P	P	E	E	P	P
Preservation of Areas of Special Biological Significance	**(ASBS)**									
Cold Freshwater Habitat	**(COLD)**	E	E	E	E	E	E	E	E	E
Commercial and Sport Fishing	**(COMM)**	E	E	E	E	E	E	E	E	E
Native American Culture	**(CUL)**	E	E	E					E	E
Estuarine Habitat	**(EST)**								E	
Flood Peak Attenuation/Flood Water Storage	**(FLD)**									
Freshwater Replenishment	**(FRSH)**	E	E	E	E	E	P	P	P	P
Groundwater Recharge	**(GWR)**	E	E	E	E	E	E	E	E	E
Industrial Service Supply	**(IND)**	E	E	E	E	E	P	E	P	E
Marine Habitat	**(MAR)**								E	
Migration of Aquatic Organisms	**(MIGR)**	E	E	E	E	E	E	E	E	E
Municipal and Domestic Supply	**(MUN)**	E	E	E	E	E	P	E	E	E
Navigation	**(NAV)**	E	E	E	E	E			E	E
Hydropower Generation	**(POW)**	E	E	E	E	E	E	E	E	E
Industrial Process Supply	**(PRO)**	P	P	P	P	P	E	E	P	P
Rare, Threatened, or Endangered Species	**(RARE)**	E	E	E	E	E	E	E	E	E
Water Contact Recreation	**(REC1)**	E	E	E	E	E	E	E	E	E
Non-Contact Water Recreation	**(REC2)**	E	E	E	E	E	E	E	E	E
Inland Saline Water Habitat	**(SAL)**									
Shellfish Harvesting	**(SHELL)**						E		E	P
Spawning, Reproduction, and/or Early Development	**(SPWN)**	E	E	E	E	E	E	E	E	E
Warm Freshwater Habitat	**(WARM)**	E	E	E	E	E	E	E	E	E
Wetland Habitat	**(WET)**									
Wildlife Habitat	**(WILD)**	E	E	E	E	E	E	E	E	E
Water Quality Enhancement	**(WQE)**									

Beneficial Use Existing (E) or Potential (P)		Shasta Valley HA			Scott River HA		Salmon River HA			
		Shasta River & Tributaries	Lake Shastina	Lake Shastina Tributaries	Scott Bar HSA	Scott Valley HSA	Lower Salmon HSA	Wooley Creek HSA	Sawyers Bar HSA	Cecilville HSA
Agricultural Supply	(AGR)	E	E	E	E	E	E	P	E	E
Aquaculture	(AQUA)	E	P	P	P	E	P	P	P	P
Preservation of Areas of Special Biological Significance	(ASBS)									
Cold Freshwater Habitat	(COLD)	E	E	E	E	E	E	E	E	E
Commercial and Sport Fishing	(COMM)	E		E	E	E	E	E	E	E
Native American Culture	(CUL)						E	E		
Estuarine Habitat	(EST)									
Flood Peak Attenuation/Flood Water Storage	(FLD)									
Freshwater Replenishment	(FRSH)	P	P	P	P	P	P	P	P	P
Groundwater Recharge	(GWR)	E	E	E	E	E	E	E	E	E
Industrial Service Supply	(IND)	E	P	E	E	E	E	E	E	E
Marine Habitat	(MAR)									
Migration of Aquatic Organisms	(MIGR)	E	P	E	E	E	E	E	E	E
Municipal and Domestic Supply	(MUN)	E	P	E	E	E	E	E	E	E
Navigation	(NAV)	E	E	E	E	E		E		
Hydropower Generation	(POW)	E	E	E	E	E	E	E	E	E
Industrial Process Supply	(PRO)	P		P	E	E	P	P	P	P
Rare, Threatened, or Endangered Species	(RARE)	E			E	E	E	E	E	E
Water Contact Recreation	(REC1)	E	E	P	E	E	E	E	E	E
Non-Contact Water Recreation	(REC2)	E	E	E	E	E	E	E	E	E
Inland Saline Water Habitat	(SAL)									
Shellfish Harvesting	(SHELL)						P	P	P	P
Spawning, Reproduction, and/or Early Development	(SPWN)	E		E	E	E	E	E	E	E
Warm Freshwater Habitat	(WARM)	E	E	E						
Wetland Habitat	(WET)									
Wildlife Habitat	(WILD)	E	E	E	E	E	E	E	E	E
Water Quality Enhancement	(WQE)									

Beneficial Use Existing (E) or Potential (P)		Lower Trinity River Hydrologic Area					Middle Trinity Hydrologic Area		
		Hoopa Hydrologic Subarea	Willow Creek Hydrologic Subarea	Burnt Ranch Hydrologic Subarea	New River Hydrologic Subarea	Helena Hydrologic Subarea	Ewing Reservoir	Douglas City Hydrologic Subarea	Weaver Creek Hydrologic Subarea
Agricultural Supply	(AGR)	E	E	E	E	E		E	E
Aquaculture	(AQUA)	P	P	E	P	P	P	P	E
Preservation of Areas of Special Biological Significance	(ASBS)								
Cold Freshwater Habitat	(COLD)	E	E	E	E	E	E	E	E
Commercial and Sport Fishing	(COMM)	E	E	E	E	E	E	E	E
Native American Culture	(CUL)	E							
Estuarine Habitat	(EST)								
Flood Peak Attenuation/Flood Water Storage	(FLD)								
Freshwater Replenishment	(FRSH)	P	P	P	P	P	P	P	P
Groundwater Recharge	(GWR)	E	E	E	E	E	P	E	E
Industrial Service Supply	(IND)	E	E	E	E	E	P	E	E
Marine Habitat	(MAR)								
Migration of Aquatic Organisms	(MIGR)	E	E	E	E	E		E	E
Municipal and Domestic Supply	(MUN)	E	E	E	E	E	E	E	E
Navigation	(NAV)	E	E	E	E	E		E	E
Hydropower Generation	(POW)	E	E	E	E	E		E	E
Industrial Process Supply	(PRO)	P	E	P	P	P		P	P
Rare, Threatened, or Endangered Species	(RARE)	E	E	E	E	E	E	E	E
Water Contact Recreation	(REC1)	E	E	E	E	E	E	E	E
Non-Contact Water Recreation	(REC2)	E	E	E	E	E	E	E	E
Inland Saline Water Habitat	(SAL)								
Shellfish Harvesting	(SHELL)	P	P	P	P	P			
Spawning, Reproduction, and/or Early Development	(SPWN)	E	E	E	E	E		E	E
Warm Freshwater Habitat	(WARM)						E		
Wetland Habitat	(WET)								
Wildlife Habitat	(WILD)	E	E	E	E	E	E	E	E
Water Quality Enhancement	(WQE)								

Beneficial Use Existing (E) or Potential (P)		Upper Trinity River Hydrologic Area			South Fork Trinity River Hydrologic Area				
		Trinity Lake (formerly Clair Engle Lake)	Lewiston Reservoir	Trinity River	Grouse Creek Hydrologic Subarea	Hyampom Hydrologic Subarea	Forest Glen Hydrologic Subarea	Corral Creek Hydrologic Subarea	Hayfork Valley Hydrologic Subarea
Agricultural Supply	(AGR)	E	E	E	E	E	E	E	E
Aquaculture	(AQUA)	P	E	E	P	P	P	P	P
Preservation of Areas of Special Biological Significance	(ASBS)								
Cold Freshwater Habitat	(COLD)	E	E	E	E	E	E	E	E
Commercial and Sport Fishing	(COMM)	E	E	E	E	E	E	E	E
Native American Culture	(CUL)								
Estuarine Habitat	(EST)								
Flood Peak Attenuation/Flood Water Storage	(FLD)								
Freshwater Replenishment	(FRSH)	E	P	P	P	P	P	P	E
Groundwater Recharge	(GWR)	E	E	E	E	E	E	E	E
Industrial Service Supply	(IND)	E	P	P	E	E	E	E	E
Marine Habitat	(MAR)								
Migration of Aquatic Organisms	(MIGR)	P	P	E	E	E	E	E	E
Municipal and Domestic Supply	(MUN)	E	E	E	E	E	E	E	E
Navigation	(NAV)	E	E	E	E	E	E	E	E
Hydropower Generation	(POW)	E	E	E	E	E	E	E	E
Industrial Process Supply	(PRO)	E	E	P	P	E	P	P	P
Rare, Threatened, or Endangered Species	(RARE)	E	E	E	E	E	E	E	E
Water Contact Recreation	(REC1)	E	E	E	E	P	P	E	
Non-Contact Water Recreation	(REC2)	E	E	E	E	E	E	E	E
Inland Saline Water Habitat	(SAL)								
Shellfish Harvesting	(SHELL)								
Spawning, Reproduction, and/or Early Development	(SPWN)	E	E	E	E	E	E	E	E
Warm Freshwater Habitat	(WARM)	E	P						
Wetland Habitat	(WET)								
Wildlife Habitat	(WILD)	E	E	E	E	E	E	E	E
Water Quality Enhancement	(WQE)								

Beneficial Use Existing (E) or Potential (P)		Butte Valley HA				Lost River HA			
		Macdoel-Dorris HSA	Meiss Lake	Bray HSA	Tennant HSA	Mount Dome HSA	Tule Lake HSA	Clear Lake HSA	Boles HSA
Agricultural Supply	**(AGR)**	E	E	E	E	E	E	E	E
Aquaculture	**(AQUA)**	P	P	P	P	P	P	P	P
Preservation of Areas of Special Biological Significance	**(ASBS)**								
Cold Freshwater Habitat	**(COLD)**	E	E		E	E	P	E	E
Commercial and Sport Fishing	**(COMM)**	E		E	P	P	E	E	E
Native American Culture	**(CUL)**								
Estuarine Habitat	**(EST)**								
Flood Peak Attenuation/Flood Water Storage	**(FLD)**								
Freshwater Replenishment	**(FRSH)**	P	P		P	P	P	P	P
Groundwater Recharge	**(GWR)**	E	P	E	E	P	P	E	P
Industrial Service Supply	**(IND)**	P	P		P	P	P	P	P
Marine Habitat	**(MAR)**								
Migration of Aquatic Organisms	**(MIGR)**	E		E	E	E	E	E	E
Municipal and Domestic Supply	**(MUN)**	E	E	E	E	P	P	P	P
Navigation	**(NAV)**		E		E	E	E	E	E
Hydropower Generation	**(POW)**				E	E	E	E	E
Industrial Process Supply	**(PRO)**	E		P	P	P		P	P
Rare, Threatened, or Endangered Species	**(RARE)**	E		E	P	E	E	E	E
Water Contact Recreation	**(REC1)**							P	
Non-Contact Water Recreation	**(REC2)**	E	E	E	E	E	E	E	E
Inland Saline Water Habitat	**(SAL)**								
Shellfish Harvesting	**(SHELL)**							P	P
Spawning, Reproduction, and/or Early Development	**(SPWN)**	E		E	E	E	E	E	E
Warm Freshwater Habitat	**(WARM)**	E	E	E	P	E	E	E	E
Wetland Habitat	**(WET)**								
Wildlife Habitat	**(WILD)**	E	E	E	E	E	E	E	E
Water Quality Enhancement	**(WQE)**								