Chapter 5: Development and Implementation of a Monitoring Program

Read this chapter…

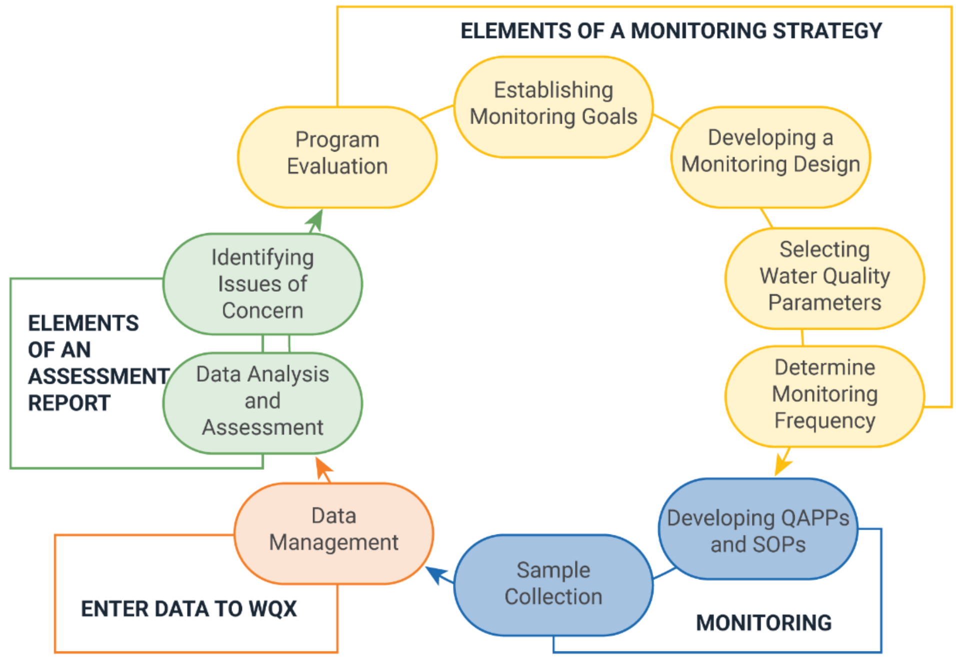
- To learn what a Monitoring Strategy is and about its role in a water quality program.
- For an overview of how to implement a water quality monitoring program.
- To identify water quality parameters to monitor.
- To learn the importance of QAPPs and SOPs.
- To learn about collecting, managing, and analyzing data and conducting program evaluations.

Chapter highlights:

- Table of water quality parameters used to assess designated uses.
- Content from EPA's water quality parameter factsheets.
- Options for documenting assessment processes and participating in How's My Waterway.

This chapter is designed to help Tribes establish and implement a water quality monitoring program (monitoring program). Conducting a monitoring program is a key component of a Tribe's overall water quality program and is an ongoing and iterative process (Figure 8). An effective monitoring program consists of several activities: developing water quality goals and a monitoring design to inform those goals; monitoring water quality parameters; managing, analyzing, and assessing data; and evaluating the effectiveness of the program. Tribes revisit each of these activities as they learn from and expand their monitoring program. Together, these activities make up the components of a Section 106 Monitoring Strategy (Figure 8).

Figure 8. Monitoring program cycle



QAPPs: Quality Assurance Project Plans
SOPs: Standard Operating Procedures
WQX: Water Quality Exchange

Monitoring Strategy

A Monitoring Strategy is a long-term plan for meeting water resource goals. The document includes current and future monitoring plans and incorporates a timeline for implementation including milestones to accomplish tribal monitoring goals. The Monitoring Strategy is comprehensive in scope, serving all water quality management goals and decision needs. It includes all tribal waters and all waterbody types (for example, streams, rivers, lakes, Great Lakes, reservoirs, estuaries, coastal areas, wetlands, and ground water). The Monitoring Strategy also identifies the technical issues and resource needs that are current impediments to a Tribe's monitoring program. Where possible, a Monitoring Strategy will document plans and needed resources such as field and lab equipment, for filling current gaps and weaknesses in a monitoring program. A Monitoring Strategy can also help continuity in a program (when staff change) and may be useful as a communication tool for other programs, management, and the community. Tribes should review their Monitoring Strategy annually and revise the document to incorporate program changes. Tribes should submit their Monitoring Strategy for EPA review at least every 5 years.

Additional information and examples to assist Tribes in developing Monitoring Strategies can be found in the *Developing a Tribal Water Quality Program Monitoring Strategy* supplement. Figure 8 also identifies the components that contribute to the three grant programmatic deliverables described in Chapter 6: Programmatic Reporting Requirements.

Establishing Monitoring Goals

The primary purpose of a water quality monitoring program is to determine if the physical, chemical, and biological conditions of tribal waters support tribal water quality monitoring goals. Tribes can base their monitoring goals on historic knowledge, Indigenous Knowledge, and data they collect on or near tribal waters. The monitoring goals, documented in the Tribe's Monitoring Strategy, help determine the direction of the program and may evolve over time. Monitoring goals are one aspect of the program goals referenced in Chapter 4: Program Development.

Monitoring goals will vary given geography, environmental conditions, history, values, and program objectives. Tribes may want to consider the uses of tribal waters and include special cultural uses when developing monitoring goals. Additionally, Tribes may seek elder and community input, and use Indigenous Knowledge to help prioritize goals.

Defining Monitoring Goals

The Monitoring Strategy includes descriptions of the goals and the data needed to determine if the water meets the corresponding goal. For example, if a goal is to determine whether the water is safe for swimming, the Monitoring Strategy will include monitoring for pathogen indicators in waters used for swimming. It may also include who will use the data and how the data will be used to inform decision making for the Tribe and external partners where necessary.

EPA identifies five basic questions for a monitoring program to address. Tribes do not need to answer all the questions immediately but may want to keep them in mind when developing their monitoring goals and use them to help guide the direction of their monitoring program. The questions are:

1. **What is the overall water quality of the waterbodies?** The Tribe determines the extent to which tribal waters meet the program goals. These may include the objectives of the CWA; attainment of any applicable water quality standards (WQS) and designated uses; protection and propagation of balanced populations of fish, shellfish, and wildlife; water quality; protection of ecosystem health; maintenance of pristine waters; or protection of public health. Indigenous Knowledge can make important contributions to defining tribal water quality goals.
2. **To what extent is water quality changing over time?** The Tribe monitors to understand if and how water quality has changed over time. This may help identify areas of concern and determine whether the program's protection or restoration activities are working. Indigenous Knowledge may be very useful for this evaluation.
3. **What areas need protection, what are the problem areas?** The Tribe identifies high-quality, pristine waters that need protection from degradation and waters that have water quality problems to address. If WQS are in place (EPA-approved or tribal), the Tribe uses them to identify impaired or problem areas. If no WQS are in place, the Tribe uses proxies to determine impairment (such as WQS from neighboring Tribes or states, regional thresholds, and EPA's nationally recommended *Water Quality Criteria* where applicable for waterbody types).
4. **What level of protection do these areas need?** Current monitoring results combined with historical water quality information help the Tribe develop appropriate levels of protection for tribal waters and create WQS or other thresholds to evaluate monitoring results. These thresholds serve as a guide for developing plans to reduce pollution entering tribal waters. For example, a Tribe that has established water quality goals could use monitoring results to

determine which waterbodies are not meeting the goals and identify which management strategies for nonpoint sources (NPS) are most appropriate.

5. **How are clean water projects and programs addressing tribal goals?** Tribes with established water quality programs regularly reflect on program accomplishments and determine how the program supports water quality goals. The Tribe can then consider any program adjustments necessary to help accomplish the goals.

Hoopa Valley Tribe: Example in Setting and Assessing Goals

The Hoopa Valley Tribe uses Section 106 funding to support their goal of protecting tribal cultural needs and the community drinking water supply, the Trinity River.

The Trinity River bisects the lush valley that is home to the Hoopa Valley Indian Reservation in Northern California and is the community's sole source of drinking water. The Hupa people have used it since time immemorial for ceremonial bathing, sacred world renewal ceremonies, and the Tribe's boat dance ceremony, which is conducted to heal the Earth.

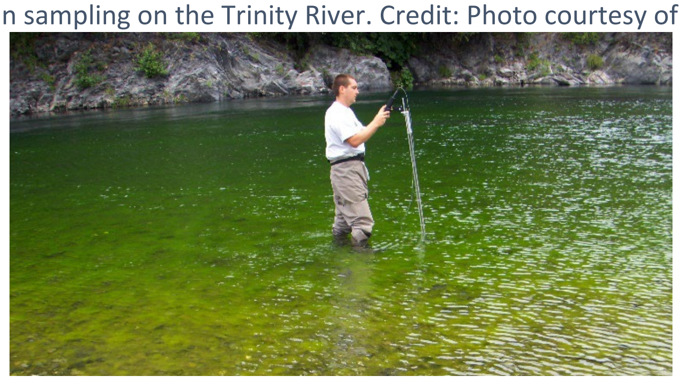
Hoopa's Tribal Environmental Protection Agency (TEPA) is the department delegated with safeguarding the reservation's natural resources and water quality. From approximately 2010 to 2020, exceptional drought has exacerbated other related climate change-induced stressors such as elevated water temperatures and low water flows in the Trinity River and its tributaries. These conditions have caused a substantial increase of cyanotoxins in the free-flowing river, increasing risks to the Tribe's drinking water system. Additionally, the cyanotoxins present a potential hazard to those who have contact through recreational and ceremonial uses.

TEPA uses Section 106 funding for sampling activities necessary to identify toxic cyanotoxin levels in the Tribe's drinking water source. During low flows and high river temperature conditions, TEPA monitors for blue-green algae (BGA) concentrations utilizing a multiparameter sonde. TEPA also tests water samples weekly for microcystin using Eurofins Abraxis test strips, and biweekly, using nutrient and BGA samples. A lab also analyzes these samples for cyanotoxin concentrations. In addition to these sampling activities, TEPA works with the Tribe's Public Utilities District (PUD) to implement a treatment plan that is effective in combating and eliminating BGA toxins from the Tribe's drinking water source.

TEPA also uses Section 106 funding to analyze current data about cyanotoxins, informs the community about associated health risks, updates tribal members and decision makers on the causes and effects of cyanotoxins in the watershed, and provides potential remedial options.

In 2006, EPA approved the Hoopa Tribe's nutrient criteria for the neighboring Klamath River and set standards for cyanobacteria and associated toxins for the protection of recreational users. The Hoopa Tribe is preparing a similar plan of action for the Trinity River to address cyanotoxin occurrences and develop standards that are protective of recreational uses and cultural practices. The Tribe's program will assist in developing this new regulatory framework to protect water quality on the sacred Trinity River.

Figure 9. Cyanotoxin sampling on the Trinity River. Credit: Photo courtesy of Hoopa Valley Tribe



Collecting Existing Information

As a first step, each Tribe may consider collecting as much existing information as possible about all the waterbodies on the reservation to inform the monitoring program goals. (Information about identifying basic tribal water resources and tribal water quality needs is in Chapter 4: Program Development.) Tribes can find information in historical environmental data and can supplement it with existing tribal, state, and federal data found on EPA's *How's My Waterway* application. Additionally, Tribes can use maps, aerial photos, Indigenous Knowledge, and reports to support the quantitative information. As Tribes collect existing information, the Tribe can identify information gaps and fill those gaps through their monitoring program. To find additional existing data resources, examples can be found in the *Listening to Watersheds* document.

Developing a Monitoring Design

A monitoring design is developed to address the monitoring goals the Tribe has identified. The monitoring design should include:

- Priority areas for monitoring.
- Waterbodies monitored.
- Uses to assess.
- Parameters to monitor.
- Frequency and timing of monitoring.
- Sampling design.

Priority areas: When Tribes are prioritizing areas for addressing water quality problems, they should consider all aspects of influence on the waterbody. Cultural significance, biological and ecological factors, partner buy-in on the project, the cost and feasibility of possible solutions, and tribal members' concerns are all factors which contribute to prioritizing areas in the monitoring design. For instance, Tribes may want to consider prioritizing the protection of a high-quality water resource that is vulnerable to threats by NPS pollution. Preventing pollution is often more cost-effective than restoring impaired waterbodies.

Waterbodies differ in topography, degree of surrounding urbanization, and land use which can impact the waterbody's susceptibility to pollution. Tribes may want to consider prioritizing more vulnerable waters for monitoring. For instance, if a source water assessment shows that ground water sources are vulnerable to contamination, monitoring and protection of wellhead areas may be prioritized.

Waterbodies Monitored: Each waterbody type outlined in the Monitoring Strategy may need a unique sampling design to effectively assess for tribal monitoring goals and designated uses. For example, lakes may require depth profile sampling and large rivers may require samples collected from equal width increments across the width of the stream to be representative of the water quality at that station. For more information see the Source Water Protection section in Chapter 7: Program Expansion – Additional Activities.

Tribal Goals or Designated Uses: As part of developing a monitoring design, Tribes identify designated uses for the waterbodies they plan to monitor. Designated uses are the goals for the waterbody and can be used by Tribes with or without WQS. Both tribal goals and designated uses will help a Tribe determine the parameters to monitor, how to assess the locations, and sampling design(s) to implement.

Parameters to Monitor: The Tribe's monitoring design will identify which water quality parameters to sample and how often to sample. More information on sampling for common parameters is in the Determine Monitoring Frequency section of this chapter.

Frequency and Timing of Monitoring: The frequency of monitoring is determined by tribal water quality goals. For example, if a Tribe is interested in measuring pathogen exceedances for swimming and recreational waters, monitoring frequency and times should align with the tribal thresholds or WQS and the times of year those locations are used for recreation. The monitoring frequency should support the amount of data needed to perform assessments of the waters to achieve tribal monitoring goals (for example, 5 samples in 30 days to calculate a geomean).

Sampling Design: A sampling design is the type of monitoring approach the Tribe will implement to successfully meet their monitoring goals. Depending on the number of waters on tribal lands, a Tribe may be able to conduct a census to monitor and assess all waters every year. This sampling design type can address all tribal goals when paired appropriately with sample collection method, location, frequency, parameters, and spatial scale. Where Tribes have many water resources, they may consider other monitoring designs to evaluate their designated uses. Table 5 shows four types of sampling designs that Tribes can use to achieve water quality monitoring goals: targeted, fixed-site, statistical, and census. Furthermore, Tribes may choose to focus on one watershed or a subset of watersheds each year, known as the rotating basin approach.

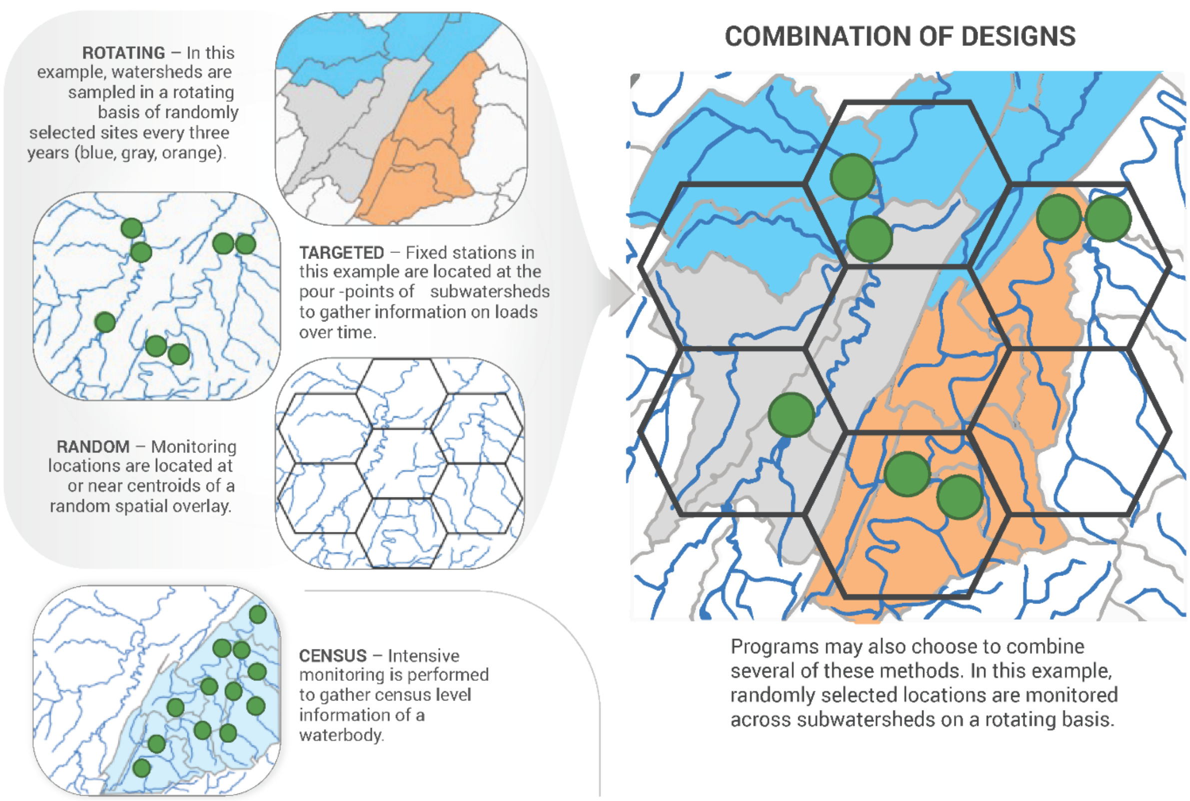
Table 5. Sampling design summary

Sampling Design Type	Strengths	Products	Limitations
Targeted	In-depth collection of data for area(s) of interest.	• Decisions about individual assessment units. • Local action plan like total maximum daily loads (TMDLs). • Effect of permitted discharges.	Generates site specific data with limited ability to extrapolate beyond sample location.
Fixed-site	Long-term, routine water quality data supports site-specific trends like flow and flux at a basin outlet.	• Historical record of water quality trends. • Loads (or amounts) of key parameters like nutrients.	Not designed to represent trends beyond specific monitoring locations.
Statistical	Cost-effective, statistically representative method for assessing condition of a broad population and tracking changes over time.	• Broad, unbiased assessments of status and trends across multiple scales. • Analysis of patterns in stressor-response relationships.	Not designed for localized site assessments, except for the sites sampled.

Sampling Design Type	Strengths	Products	Limitations
Census	Monitor and assess all waterbodies every year — common when Tribes have limited water resources.	• A complete assessment of status and trends within waterbodies.	Potentially expensive and resource intensive.

A mix of sampling designs may be useful to inform various aspects of water quality. As shown in Figure 10, Tribes can pair statistical surveys (representative sampling) with a rotating basin survey approach to better predict local water quality conditions and determine overall condition. This can inform the need for a targeted sample design to assess specific areas, determine impairments, and identify possible sources.

Figure 10. An example of how multiple sampling designs can be used together to inform water quality protection and restoration



Updating Monitoring Designs

As water quality programs grow and program priorities change, monitoring designs should be updated to better represent the Tribe's monitoring goals. Additionally, Tribes may choose to include effectiveness monitoring in their monitoring design to track water quality improvement, evaluate the success of water quality restoration projects where applicable, and consider whether they need to modify restoration projects.

The Tribe's Monitoring Strategy may include multiple sampling designs to allow for flexibility in shaping monitoring to the different waterbodies and waterbody goals.

Confederated Salish and Kootenai Tribes

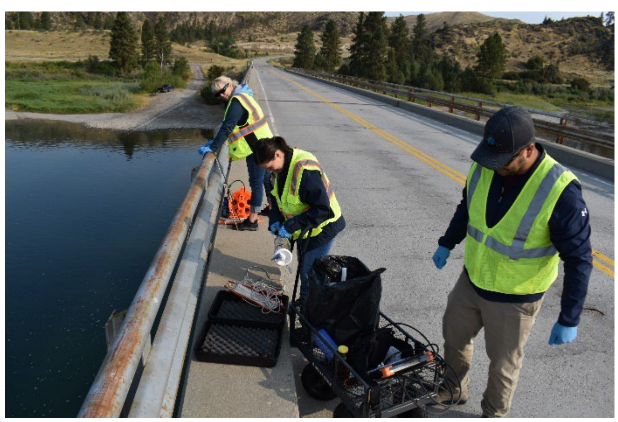
The Flathead Indian Reservation is the native homeland of the Confederated Salish and Kootenai Tribes (CSKT). The Kootenai, the Salish, and the Pend d'Oreille peoples comprise the Tribes of the Flathead Reservation.

Water resources on the Flathead Indian Reservation are extensive and varied. The Reservation is located within the lower portion of the Flathead River watershed in western Montana. Approximately 1,317,399 acres lie within its exterior boundaries. There are approximately 76,155 acres of major waterbodies. This includes approximately 65,086 acres of the south half of Flathead Lake. Additionally, the boundaries of the Reservation contain more than 1,200 miles of irrigation canals and 17 reservoirs. Extensive wetland complexes are associated with these systems and over 10,000 individual pothole wetlands comprise the glacial pothole complex of the Mission Valley. Over 4,000 miles of streams and approximately 103,133 National Wetland Inventory wetland acres make up the steam complex across the Reservation.

CSKT performs routine surface water quality sampling (Figure 11) within seven sub-basins on the Reservation. Along with physical parameters, CSKT also collects samples that they ship to a laboratory for analysis 182 miles away. Due to the rural status of Montana, the only location to drop off samples is on the northern half of the Reservation. This shipping issue limits the amount of time the field crew can spend collecting samples and make the same day shipping time requirements.

Due to the size of the Reservation, the number of sites that CSKT can sample within a working day is limited. The Tribe not only samples sites that are within the Water Quality Program but also the Non-Point Source Program restoration projects. A typical sampling day for the program is to have the vehicles and equipment ready by early morning, drive to the sites, and collect samples. The samples must be at the shipping company by early afternoon, or they will not ship that day. The ability to collect samples and make the shipping deadline dictates the Water Quality Program's sampling plan.

Figure 11. CSKT performing water quality sampling. Credit: Photo courtesy of CSKT



Conducting Special Studies

Tribes may need to conduct special studies, a type of targeted monitoring, if through their routine monitoring they identify areas of particular concern or interest that their routine monitoring does not fully address. As areas of interest arise, Tribes should consider monitoring to identify the source of impacts to a waterbody, such as new construction. Tribes may need to perform special studies to track best management plan progress, determine loads for TMDLs, and identify pollution sources. They should ensure existing project elements such as the QAPP, lab protocols, sampling design, and Monitoring Strategy support special study designs.

Selecting Water Quality Parameters

The monitoring design identifies the parameters the Tribe plans to monitor to assess water quality and meet monitoring goals. "Parameters" are properties of water quality. For use in this guidance, the terms analytes, characteristics, and constituents are synonymous with parameters.

Table 6 highlights common and additional parameters Tribes monitor to assess their tribal goals or designated uses. The common parameters provide basic information about the aquatic environment and are usually less costly than more lab intensive parameters. Additional parameters may include waterbody-specific pollutants, ambient and sediment toxicity, health of organisms, and nutrients. This distinction may be useful when selecting parameters to monitor.

Adding or replacing parameters may also provide a more complete picture of water quality. As Tribes analyze their monitoring data, they may partner with their EPA regional office, neighboring Tribes, neighboring states, and appropriate federal agencies to help identify supplemental parameters. In some cases, Tribes might consider reducing or eliminating monitoring parameters at sites where data indicate there is no water pollution problem for the sampled parameter. However, Tribes should consider the impact to long-term data records on parameters of interest when reducing or eliminating monitoring parameters, and consider when to revisit those parameters to ensure there continue to be no water pollution problems.

Table 6. Common and additional parameters to assess tribal goals or designated uses

Parameters	Aquatic Life	Recreation	Drinking Water Source	Fish/Shellfish Consumption
Common Parameters	• Dissolved oxygen (DO). • Temperature. • Conductivity. • pH. • Nutrients (total phosphorus (TP), total nitrogen (TN)). • Turbidity. • Biological communities. • Secchi depth. • Habitat assessment.	• Pathogen (*E. coli*, enterococci). • Turbidity. • Secchi depth. • Harmful algal blooms (HABs), algal toxins.	• Metals. • Pathogens. • Total dissolved solids (TDS), total suspended solids (TSS). • Nutrients. • Salinity. • HABs, algal toxins.	Fish tissue contaminant levels for: • Mercury. • Polychlorinated biphenyls (PCBs). • Polycyclic aromatic hydrocarbons (PAHs). • Legacy pesticides.
Additional Parameters	• Flow. • Sediment toxicity. • Eutrophic condition in lakes. • Nutrients (NH_3, DIN, DIP, PO_4). • Chlorophyll *a*. • Pesticides. • TSS. • Emerging contaminants. • Floristic quality. • Metals. • Ions (Ca, Cl, Mg, Na, K, SO_4). • Continuous (high frequency sensor) monitoring.	• Nuisance plant growth. • Aesthetics. • Hazardous chemicals.	• Flow. • Volatile organic carbons (VOCs). • Pesticides. • Emerging contaminants.	• DDT. • Chlordane. • Select Per- and polyfluoroalkyl substances (PFAS), Perfluorooctanoic acid (PFOA). • Emerging contaminants. • Metals.

Top 15 Parameters Reported by Tribes

Reflective of results at the release of this guidance

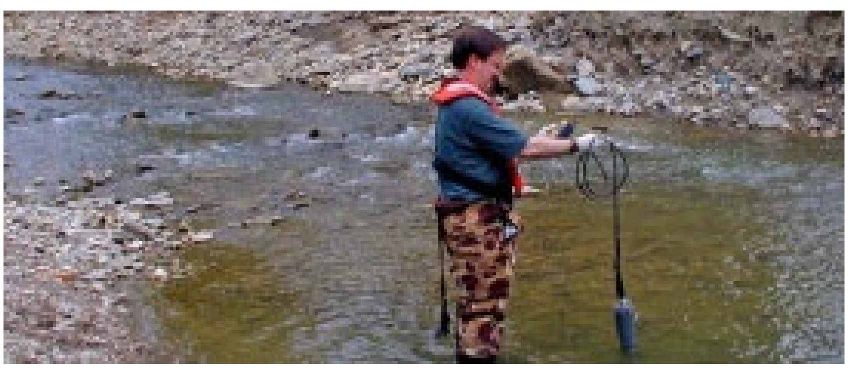
1. Water temperature.
2. DO.
3. pH.
4. Turbidity.
5. Specific conductance/conductivity.
6. Salinity.
7. TSS.
8. Air temperature.
9. Fecal coliform.
10. Flow.
11. *E. coli*.
12. Phosphorus.
13. Nitrogen.
14. Benthic macroinvertebrates.
15. Fish assemblage.

The following sections provide information on how and why Tribes sample the most common parameters. Factsheets for each parameter are available on EPA's *Factsheets on Water Quality Parameters* website.

Water Temperature

Water temperature influences the majority of physical, biological, chemical, and ecosystem processes in aquatic environments. Altered stream temperature is a significant cause of water quality impairment in the United States and influences other water quality parameters. Measuring temperature helps to understand the magnitude and variability of temperature fluctuations and anticipate the consequences for water quality and ecosystem health (Figure 12).

Figure 12. Measuring temperature in the field. Credit: Photo courtesy of USGS



In general, increased water temperature can result in:

- Decreased DO available to aquatic life.
- Increased solubility of metals and other toxins in water.

- Possible increased toxicity of some substances to aquatic organisms.
- Algal blooms, which typically occur during the summer season or periods of unusually warm temperatures.

Dissolved Oxygen

DO is an important parameter of the overall biological health of a waterbody and is required for a waterbody to support aquatic life. It is generally measured in the field along with water temperature, turbidity (clarity), specific conductance, and pH using a water quality probe. This information is then assessed against thresholds or WQS to determine whether the water is fit for aquatic life.

DO affects fish health and sensitivities vary by species. A high DO is needed to be “supportive” of fish spawning, growth, and activity. Different levels of DO are required to support aquatic life depending on the species present and their stages of life (such as spawning, larvae). Trout, for example, require a high DO, while carp can survive in lower DO conditions. Among the macroinvertebrates, many immature insects require a high DO content, while other species, such as aquatic worms and snails, can tolerate lower DO concentrations. Hypoxic (low DO concentration) or anoxic (virtually no DO) conditions do not support fish or macroinvertebrate populations.

pH

pH is an important parameter of chemical, physical, and biological changes in a waterbody and plays a critical role in chemical processes in natural waters. pH values are on a scale from 0 to 14, with 7.0 considered neutral. Solutions with a pH below 7.0 are considered acidic, and those with a pH above 7.0 are considered basic. The pH scale is logarithmic, meaning that every one-unit change represents a ten-fold change in pH. In other words, pH 6.0 is ten times more acidic than pH 7.0; pH 5.0 is one hundred times mores acidic than pH 7.0.

pH is a key factor in water chemistry and toxicity. A change in pH can alter the concentrations and forms of toxic chemicals in water. Metals such as aluminum, lead, mercury, copper, and arsenic are generally more soluble at a lower pH. Therefore, higher concentrations can be absorbed into the tissues of organisms, rendering these metals more toxic to aquatic life. In more basic waters (pH > 8.5), the conversion of the nontoxic form of ammonia to the toxic form is increased.

pH also plays a key role in aquatic health by affecting biochemical processes and the metabolism of aquatic organisms. Generally, if water is too acidic or too basic, damage can occur to an organism’s gills, exoskeleton, fins, and other critical components. Of particular concern are pH-sensitive macroinvertebrates (small organisms without a backbone), fish eggs (most fish eggs cannot hatch at a pH less than 5), and juvenile fish. Organisms vary in the pH ranges they can tolerate. Furthermore, even though an organism itself may tolerate a more extreme pH, its food source may not.

Turbidity

Turbidity and TSS are different ways to measure similar water quality characteristics. Turbidity is the clarity of the water and TSS is the concentration of suspended particles, which include soil particles (clay, silt, organic matter), algae, and microscopic organisms.

An increase in turbidity or suspended solids can also negatively affect aquatic health by:

- Clogging fish gills or the filter-feeding systems of other aquatic animals.
- Hindering visibility, making it difficult for predators to find prey.

- Decreasing light penetration into water and thereby the ability of submerged aquatic plants to photosynthesize, reducing biomass and growth rates of aquatic plants.
- Reducing fish resistance to disease.
- Altering egg and larval development.

Changes in turbidity can also affect other water quality parameters; increased turbidity is likely to be accompanied by the following:

- Higher temperature and reduced DO due to increased heat absorption of the water.
- Reduced DO due to decreased light penetration into the water and an associated decrease in photosynthesis by aquatic plants.

Suspended solids contributing to turbidity can affect water chemistry and microbiology. The particles can adsorb (take up on their surfaces) pollutants, including nutrients, metals, and organic compounds. If the particles settle on the bottom of the waterbody, then the pollutants settle with them. If bottom sediments are subsequently disturbed and resuspended, the aquatic community can be exposed to any adsorbed toxins or nutrients.

E. coli or Enterococci

Water samples are collected to measure *E. coli* to make sure water is safe for public recreation, such as swimming, fishing, or canoeing. *E. coli* is considered a parameter organism, used to identify fecal contamination in freshwater and indicate the possible presence of disease-causing bacteria and viruses (pathogens). Individuals that swim or come into contact with water containing elevated levels of *E. coli* and other fecal parameter organisms such as enterococci are at an increased risk of getting sick because of potential exposure to fecal pathogens. Common symptoms of ingesting a pathogenic strain of *E. coli* include vomiting and diarrhea. High numbers of *E. coli* (and other) bacteria may contribute to cloudy water, unpleasant odors, and increased oxygen demand (which may reduce levels of DO in the water).

E. coli concentrations may be linked with other parameters such as high TSS and turbidity concentrations because the bacteria tend to be found with particles. *E. coli* concentrations may also be linked with high phosphorus, nitrate, and biological oxygen demand (BOD) concentrations.

Nutrients

Excess (or elevated) nutrients is among the most common water pollution problems affecting waterbodies in the United States. High nutrient concentrations resulting from human activities can diminish ecosystem health. Excess nutrients in a waterbody can lead to excess biological growth (eutrophication) and HABs. In freshwater, HABs are often caused by cyanobacteria (for example, blue-green algae) and may have negative effects on humans and ecosystems.

Certain types of cyanobacteria can produce toxins that are harmful to humans and animals through recreational exposure or through consumption of drinking water. Toxins can also work their way into the aquatic and terrestrial food webs and potentially harm animals and humans. Additionally, algal blooms can lead to hypoxia, or low DO in the water, either through algal respiration or consumption of oxygen by decomposers when the algae die off. Persistently low DO can harm sensitive aquatic animals, resulting in chronic stress or even mortality.

Nutrient concentrations are highly variable in waterbodies across the United States. To interpret monitoring data, it is helpful to be familiar with typical nutrient concentrations for healthy and disturbed waterbodies in the area. When nutrient concentrations are higher than an aquatic system's natural background concentrations, the water has most likely been affected by urban or agricultural activities, including both point source and NPS contributions.

Metals

It is important to measure metals because all metals can be toxic at high concentrations, even those that are nutritionally essential for sustaining life in aquatic ecosystems in small amounts (such as copper and manganese). Metal toxicity negatively affects the health of aquatic organisms. For example, metal toxicity:

- Decreases abundance and diversity of species.
- Changes reproduction, juvenile growth, and behavior.
- Causes spinal abnormalities, gill damage, and death.

In a waterbody, metals are either dissolved or in particulate form. Dissolved metals are small enough to pass through a 0.45 micron (µm) filter and are more easily absorbed by organisms. Metals can bind to particulates such as clay, sand, or organic matter. Particulate metals are larger and typically less bioavailable than dissolved metals, but organisms can still uptake particulate metals through their gut.

Over time, dissolved and particulate metals in the water can build up in the tissue of fish and other aquatic organisms. This process, called bioaccumulation, occurs when an organism absorbs or uptakes metals more quickly than their body can eliminate them.

Biomagnification of some metals (such as mercury) can also occur in an aquatic ecosystem. Biomagnification occurs when concentrations of metals increase from transfer up through the food chain as larger organisms feed on many smaller organisms who have each bioaccumulated metals in their bodies. Biomagnification and bioaccumulation can cause concentrations of metals in larger aquatic organisms to be toxic to humans, and to the birds and other wildlife, that consume them.

Macroinvertebrates

Insects are the most common macroinvertebrates in aquatic systems, living in water as nymphs or larvae until they reach their adult stages. Common insects in aquatic systems include dragonflies, caddisflies, stoneflies, beetles, midges, and mayflies. Others, such as aquatic worms, leeches, and small crustaceans (crayfish and fairy shrimp), live entirely in water. Most species live in the bottom sediments of the waterbody or attached to rocks, vegetation, logs, and sticks.

Lifespans range from a few weeks to several years. Macroinvertebrates are most frequently used for biological monitoring, or "biomonitoring," because of their prevalence in aquatic habitats and their differing sensitivities to chemical pollution and physical disturbances. Biomonitoring is the use of organisms to assess the overall quality of their environment or habitat. Because they generally have limited mobility and cannot escape pollution, macroinvertebrates better reflect the long-term water quality of a site compared to a single sample of chemical constituents that only provides a snapshot in time. Table 7 shows examples of generalized pollution sensitivity (tolerant or intolerant of pollution) for several common macroinvertebrates.

Table 7. Examples of macroinvertebrates and their pollution sensitivity levels

Macroinvertebrate	Pollution Sensitivity
Stonefly	Intolerant
Mayfly	Intolerant
Crayfish	Range
Leech	Tolerant
Aquatic worm	Tolerant

Source: Maine Department of Education *Outdoor Learning Opportunities: Macroinvertebrates*.

Knowing the typical variety and abundance of macroinvertebrates in a healthy waterbody in a region can help when evaluating waterbodies for signs of poor ecosystem health. Generally, healthy waterbodies support a diverse population of macroinvertebrates. Samples yielding only pollution tolerant species, a low abundance of organisms, or very little diversity (primarily one or two species) might indicate a degraded waterbody. Figure 13 shows an example of a mayfly, a type of pollution sensitive macroinvertebrate.

Figure 13. The mayfly, a type of insect, under the view of a microscope. Credit: Photo courtesy of USGS

Basic Habitat Information

Healthy and intact habitat is critical for supporting biological communities, protecting water quality, and preserving the overall ecological integrity of aquatic ecosystems. Fish, insects, and other organisms find food and shelter near and in streams, lakes, and wetlands. Vegetation growing in the riparian zone provides shade, stabilizes sediment, and can filter pollutants before they enter the waterbody.

Alterations to the physical structure of the habitat surrounding waterbodies can negatively impact instream physical characteristics, water chemistry, and aquatic communities. Specifically, if vegetation in the riparian zone is removed, runoff of sediment into the stream can increase. As a result, stream embeddedness (the amount of sediment covering “substrate,” or bottom material) changes as excess sediment fills pools and reduces the available substrate for fish and other aquatic organisms to shelter. The water chemistry may also change as the excess sediment alters turbidity and pH levels. These changes affect the potential for the habitat to support the aquatic community.

Habitat assessments help determine whether alterations to the riparian zone or instream features may negatively impact water quality and aquatic communities. Rapid Bioassessment Protocols (RBPs) is a popular, efficient, and cost-effective method to assess habitat. Evaluating changes in the condition of habitat parameters helps anticipate potential effects on the aquatic ecosystem, provides clues toward sources of degradation, and can inform restoration projects and waterbody management strategies.

Determine Monitoring Frequency

When determining the monitoring frequency for each parameter, consider factors such as cost, time, resources, accessibility of monitoring site(s), seasonal flows and conditions, and the desired level of confidence in the data and the decision it supports. Waterbody conditions change over the course of a day, from season to season, and from year to year. These changes can be the result of natural variability or human activities. *Listening to Watersheds* contains some general information that will help in deciding when and how often to collect monitoring samples.

Fort Belknap Indian Community Water Quality Program Development – Lake Monitoring Training

The Fort Belknap Indian Community (FBIC) Water Quality (WQ) Program strives to incorporate and implement new methodologies and strategies that ensure the water quality of their tribal waters remains healthy, supports designated uses, and protects tribal members from harmful levels of pollution. To further this on-going effort, the WQ Program partnered with EPA and the USGS, resulting in a successful experience that gave FBIC more insight on the future direction of their WQ Program.

The FBIC WQ Program first reached out to USGS in June 2018 for guidance on lake monitoring. This led to a joint funding agreement using Section 106 grant funds and a working relationship.

The WQ Program gained momentum to develop tribal WQS. They first needed to collect water quality data. Several reservoirs and ponds on the reservation have limited recreational uses. For this project, they selected two highly used recreational reservoirs: Snake Butte Reservoir and Strike Reservoir. The WQ Program and USGS then coordinated a training on lake monitoring, which included:

- Vertical profiling.
- Photic zones measurements.
- Water samples:
    - Nutrients – assessing the N:P ratio and harmful algal blooms.
    - *E. coli* – using the on-site filtering and dilution method.
- Cyanobacteria.
- Fish tissue.
- Quality control (QC) samples – replicate data.
- Collected parameters with a multiparameter sonde.
- Chlorophyll *a* sample demonstration.
- Depth readings.

The WQ Program discovered new monitoring concepts to support future monitoring goals for their tribal reservoirs. They also discovered more information to investigate. They developed a fish tissue collection project for the Snake Butte Reservoir and Strike Reservoir, including an analysis for mercury, selenium, and arsenic. They also initiated an *E.coli* sampling project with the local Aaniiih Nakoda College laboratory. This greatly increased the opportunity to collect more water samples from both reservoirs in May, July, and September, and supported their goal to develop tribal WQS.

Figure 14. FBIC WQ Program conducting lake monitoring. Credit: Photo courtesy of FBIC

Developing QAPPs and SOPs

Developing QAPPs

A QAPP is a written document that outlines the procedures the Tribe will follow to meet the monitoring program goals and ensure sufficient quality of the samples collected and analyzed, how the data are stored and managed, and the reports produced. The QAPP outlines the technical and quality aspects of a project (for example, monitoring data collection, detection limits, analytical methods, data management, data analysis, reporting) and provides a blueprint for obtaining the type and quality of environmental data and information needed. Any EPA-funded project that includes the collection and analysis of data must have an EPA-approved QAPP before any monitoring activities may begin (2 CFR 1500.12).

The QAPP must include data quality objectives (DQOs).

DQOs are the qualitative and quantitative statements that:

- Clarify monitoring goals.
- Define the appropriate type of data to meet the goals.
- Specify tolerable levels of potential decision errors that Tribes will use as the basis for establishing the quality and quantity of data they need to support decisions.

Data validation procedures should also be included in the QAPP. Chapter 4 of EPA's *The Volunteer Monitor's Guide to Quality Assurance Project Plans* and EPA's *Managing the Quality of Environmental Data in EPA Region 9* document contain further information on data validation and QAPPs. Data should be validated according to tribal program procedures before submission to EPA.

Additionally, QAPPs may include data quality indicators (DQIs). DQIs are an entity, process, or community whose characteristics show the presence of specific environmental conditions. DQIs are based on the DQOs and are meant to help assess the sufficiency of using a particular dataset for a particular purpose. There are six DQIs:

- **Accuracy** – A measure of confidence that describes how close a measurement is to its true value. It is a combination of systemic errors associated with bias and random errors associated with precision, or imprecision.
- **Bias** – A systemic error in a method or measurement system that can affect all results. It is coupled with precision to determine data accuracy.
- **Comparability** – The degree to which data can be compared directly to similar studies.
- **Completeness** – Comparison between the amounts of usable data collected versus the amount of data called for in the sampling plan. This is measured as a target percentage of valid results obtained compared to the total number of samples taken for a parameter.
- **Precision** – An assessment of the degree that two or more replicate measurements are in agreement. It is coupled with bias to determine data accuracy.
- **Representativeness** – The extent to which measurements characterize the true environmental condition or population at the time a sample was collected.

EPA has guidance for developing QAPPs for all types of monitoring programs, from a simple volunteer monitoring initiative to established state programs. Some additional tools include EPA's:

- *Requirements for Quality Assurance Project Plans*.
- *Guidance for Quality Assurance Project Plans*.
- *Quality Assurance Project Plan Development Tool*.

More information on DQIs can be found in *Listening to Watersheds* and Tribes can contact their EPA regional office and Quality Assurance (QA) Manager for more information on developing a QAPP. EPA's *Guidance for Data Quality Objectives Process* contains more information on DQOs and DQIs.

QAPPs for Ground Water Monitoring

Because of regional variations in geology and hydrology, there are multiple methods for ground water monitoring. By establishing a comprehensive ground water QAPP with field, sampling, lab, and assessment protocols, Tribes can effectively sample wells for contaminants such as metals, volatile organic compounds, and nutrients. Research into past land use as well as hydrogeological surveys of the area will supply knowledge regarding the characteristics of aquifers as well as potential sources of contamination. Sound data collection will help Tribes develop the foundation they need to determine their ground water protection needs. Additional information on eligible ground water sampling activities is in Chapter 4: Program Development.

EPA Review and Approval of QAPPs

The Tribe will submit the QAPP to the EPA regional Project Officer who will then forward it to the appropriate EPA regional staff for review and approval (EPA Order 5360.1 A2). QAPPS should be submitted to EPA approximately 60 days before the start of the sampling activity to ensure it is approved prior to sampling. Once EPA has approved the QAPP, the Tribe can begin implementing their tribal water quality monitoring program. Monitoring activities must be described in the approved QAPP.

Over time, Tribes may need to modify or refine their water quality monitoring program to address new water quality issues or concerns. If changes to the QAPP are needed, contact the EPA Project Officer to determine if the changes are substantive, requiring a revision to the QAPP, or non-substantive. Non-substantive changes can be documented in the QAPP as a pen and ink change but must be noted in the progress report. A Tribe may have several QAPPs covering different aspects of their monitoring program (for example, wetlands, surface water, and fish tissue). If the Tribe does not follow the procedures outlined in the QAPP, the quality of the data may not meet the tribal water quality expectations or be adequate for the analysis and assessment activities. The *Tribal Assessment Modules* on EPA's Ambient Water Monitoring and Assessment website includes additional information on QAPPs.

Developing SOPs

Once Tribes have determined the monitoring goals, sampling design, and parameters to collect as outlined in their QAPP, it will be important to document how the information collected will remain consistent through time. Tribes can document this information in SOPs, checklists, or other internal operation documents. Tribes develop SOPs to achieve consistency, uniformity, and program continuity when performing monitoring tasks. SOPs are particularly useful to maintain tribal program continuity through staff turnover. Some of the information that Tribes will develop and document includes proper procedures for:

- Sample collection: equipment needed, sampling plan, frequency, and timing for sample collection.
- Storage: bottle types and sizes, labels, refrigerator or freezer space, use of coolers.
- Preservation methods and holding times: ice (wet or dry), chemicals.
- Accessibility of sampling locations and permission to access locations.
- Tracking: databases, forms.
- Shipping: time needed to transport samples to the lab or shipping center, shipping drop off times, and the analytical lab's receiving days.
- Chain of custody: forms needed to ensure proper documentation for the handoff of samples.
- Data validation: ensuring the data are accurate (for example, no out-of-range data, decimals in the wrong place for a result value, or incorrect units associated with the result).
- QA: spikes, duplicates, blind samples.
- Analysis: the use of the data for assessment purposes.

In addition, the SOPs should document the maintenance of their equipment, including how the equipment is calibrated and used. SOPs may align with a field or laboratory manual and can help specify implementation of tasks, such as frequency of calibrating equipment. Tribes typically develop separate Field SOPs for monitoring equipment, including parameters they measure on-site using *in-situ* field instruments (for example, water temperature and stream flow). If the Tribe is performing sample analysis in its own laboratory, they will have lab SOPs describing their analytical and preparation methods and the level of precision and accuracy they can provide.

The *National Environmental Methods Index* database website may include many field and analytical methods. The website is searchable, useful for finding and comparing analytical and field methods for all phases of environmental monitoring.

Wetlands Monitoring

Because of their composition, wetlands are more complicated to monitor than most surface water bodies. A wetland monitoring program can consist of several components:

- Establishing the current condition of wetlands, including their extent and condition.
- Measuring the physical and chemical properties of the wetland, including pH, color, turbidity, DO, total phosphorus, and sediment/soil samples.
- Determining the hydrogeomorphic setting and function.
- Cataloguing biodiversity, the presence of rare or endangered species, and items of cultural significance.
- Inventorying potential local contamination sources, such as stormwater culverts and septic fields.

Tribes conducting wetlands monitoring can consult EPA Region 9's *Wetlands Quality Assurance Project Plan Guidance and Template*, which is designed to assist in documenting procedural and data requirements for projects involving environmental measurements and wetlands monitoring. For information on beginning a wetland monitoring program, refer to EPA's *Volunteer Monitoring Can Protect Wetlands* website to find "Volunteer Wetland Monitoring: An Introduction and Resource Guide" and other resources. Tribes can view EPA's *Wetlands Monitoring and Assessment* website and *Protecting Waters and Wetlands in Indian Country: A Guide for Developing Tribal Wetland Management Programs* for additional information.

Analyzing Monitoring Samples Using Outside Laboratories

Many water quality programs use outside laboratories to analyze water quality samples and provide taxonomy identification of biological samples. Outside laboratories are also used to complete QC checks such as verification of taxonomy on a subset of samples. The Tribe's QAPP should document how the laboratory will carry out these activities. It is helpful to communicate with laboratories on how each entity will track samples; how Tribes need to preserve, pack, and ship samples; the reporting limits the lab can meet and what corrective actions they will take if there are issues; and how and when laboratories will confirm sample receipt to ensure the samples are processed efficiently and accurately.

When tribal water quality programs are choosing a laboratory to analyze their water quality samples, consider providing the laboratory with a list of questions regarding the analyses they anticipate and talk directly with the laboratory manager. When developing a contract, factors to consider include: the specific period that the contract will cover, the scope of work (including materials the laboratory will furnish), terms for payment, a provision for giving both the Tribe and EPA the right to audit the laboratory, and other terms and conditions as required or recommended by the tribal water quality program. Programs will need to agree on documentation of analytical methods and turnaround time in advance. When contracting with a laboratory, the tribal water quality program will need to obtain a copy of the laboratory's QA/QC plan.

The tribal water quality program should consider requiring the lab supply the data in a format compatible with the Tribe's data management system or WQX. At a minimum, the data should be provided in an electronic data deliverable (such as an Excel or CSV file). Receiving data elements and results from the lab in a WQX-compatible format will reduce a Tribe's data management burden. EPA's *Water Quality Exchange Web Template Files* website contains WQX templates. EPA regional technical advisors or other Tribes in the region can help identify qualified labs in an area that may be able to provide sample analysis. See Chapter 6: Programmatic Reporting Requirements for more information on data reporting requirements.

Sample Collection

Sample collection methods will vary depending on the monitoring purpose, parameters collected, waterbody type, and geography. Details that are necessary to consider when planning a collection activity include:

- Planning out the full sampling season.
- Organizing field crew training and sampling QA checks.
- Evaluating the potential sites to be sampled.
- Procuring supplies and equipment suitable for sampling needs.
- Instrument cleaning and calibration.
- Creating a sampling plan to execute the collection of the samples.

For more information on how to plan out and execute sample collection, please see *USGS National Field Manual for the Collection of Water-Quality Data* and the *Manuals Used in the National Aquatic Resource Surveys*.

Data Management

Data management is the process of managing, storing, and maintaining monitoring results in a format that allows Tribes to use the data to make decisions about their water quality programs. Monitoring data results and metadata are most useful when they are in a format that Tribes can manipulate, summarize, and analyze. This section provides information on managing data, including how to compile useful datasets, store and manage data in an electronic format, validate data, and report the results.

Understanding Metadata and Compiling Useful Datasets

Metadata are "data about data" that include information about a specific water quality sample that provides context for the sampling activity. Metadata contain information about when, where, why, and how the Tribe collected a water quality sample. When monitoring, record the necessary metadata. For example:

- The location where each sample was collected, such as longitude and latitude and the waterbody name.
- The conditions at the time of collection: such as water temperature, flow, atmospheric conditions.
- The units for each parameter.
- Any replicate data, which are data from two or more samples collected at the same time.
- The date and time of sample collection.
- The reason the sample was collected: such as to determine if phosphorus threatens the waterbody.
- The sample and analytical methods used to collect and analyze the sample.
- The method's detection limit.

Recording metadata is valuable for three primary reasons:

1. Metadata are important for the immediate use of the data by the Tribe because it provides more information for making decisions.
2. With the necessary metadata, the Tribe can continue to use the data in the future while identifying changes to monitoring goals, determining restoration activities, and identifying sources of water quality pollution.
3. Metadata are valuable beyond the original collection purpose and data re-users (those who did not originally collect the data but are using them for a separate purpose) can determine if the samples are comparable and thus reusable for their environmental needs.

Certain metadata are required when collecting and reporting data to EPA as part of the Section 106 programmatic reporting requirements, discussed in more detail in Chapter 6: Programmatic Reporting Requirements. Templates and other resources are available on EPA's *Water Quality Data Upload with WQX* website to ensure Tribes include required metadata with their data submittal.

Developing Electronic Data Storage Capacity

Data should be stored so Tribes can easily organize, summarize, and manipulate the data. Electronic spreadsheets allow the Tribes to easily store data in tables where they can rearrange, sort, search, and perform calculations for analyses. Many spreadsheet-based software programs are commercially available for Tribes to use (for example, Microsoft Excel). Some of these programs also include tools (for example, graph-building, calculator, modeling functions) that help analyze, manipulate, and report data. Managing data in spreadsheets may be most appropriate for Tribes that are just beginning to monitor or that do not have large datasets (for example, few sampling locations, few parameters, infrequent monitoring).

Databases organize data in tables and can be set up to make interactions simple. Data entry screens ensure that data entry follows a structure and can automatically check user entries for correct data types (numbers versus text) or range of data (such as pH must be greater than 0 and less than 14). Although a database takes a considerable amount of time to set up, it can ultimately make it very easy to enter, store, retrieve, and report data, and to perform relationship queries. Microsoft Access and Oracle are examples of database programs. Managing data in a database makes more sense for larger, more complex datasets, such as those with many sampling locations, parameters, or frequent monitoring.

Geographic Information System (GIS) Software is a tool that can be used to display data in a map. GIS is a computer system for capturing, storing, manipulating, analyzing, and displaying data related to positions on the Earth's surface. This is equivalent to displaying a monitoring location's latitude and longitude measurements as a point on a map. These points, along with their results and metadata, create a set of map events for display and analysis.

Performing Data Validation

Data validation is the process of evaluating field, lab, and data management activities, organizations (such as labs), and personnel. This can include evaluating performance, such as sample collection techniques; systems, such as equipment and analytical procedures; and data quality, such as comparisons of actual data results with project quality goals. Examples of data validation procedures include:

- Reviewing field data sheets for completeness and accuracy before leaving the field.
- Ensuring entries copied from field data sheets into electronic spreadsheets are accurate.
- Examining unexpectedly high or low results (outliers) and investigating for possible issues.
- Checking calculations.
- Correcting errors such as decimal places in the wrong spot and incorrect units.
- Comparing project data to specific QA/QC criteria (DQOs and DQIs).
- Calculating precision and accuracy of instruments and placing this information in the metadata file.
- Reviewing QC sample results to ensure attainment of acceptance criteria (either established by the Tribe or defined in the laboratory's QA plan and SOPs).

As described in the section above on Developing SOPs, Tribes should consider documenting the data validation process so they can replicate the process each time data are validated.

Backing Up Electronic Data

Regularly backing up data ensures information is not completely lost if the Tribe ever has a computer failure, software problem, user error, or office damage. A Tribe can back up data in several ways, such as by copying the information to an external hard drive or backing up documents to a cloud service. Some computer systems include built-in backup tools. Tribes that collect water quality data using Section 106 funds must upload that data to WQX and can also use WQX as an off-site data repository backup.

Uploading Data to the Water Quality Exchange

Templates and guidance for submitting data into WQX are available on EPA's *Water Quality Data Upload with WQX* website. Once Tribes submit data to WQX, the data are available in the *Water Quality Portal*, a cooperative data service sponsored by the USGS, EPA, and the National Water Quality Monitoring Council (NWQMC). Metadata accompany each sampling result in the Water Quality Portal. Additional information on submitting information to WQX can be found in the *Tribal Data Management for WQX Submission* supplement.

Data reporting requirements are discussed further in Chapter 6: Programmatic Reporting Requirements.

Updating and Upgrading Electronic Data Systems

Manufacturers of hardware (such as computers and monitors) and software (such as spreadsheet and database programs) often develop new and improved products that, over time, might make the existing system obsolete. Periodically investing in new hardware and software products is necessary, and Tribes should build those costs into the work plan. The grant budget should account for the entire life-cycle of work and the associated tools and technology needed to ensure grant work plan activities can be accomplished. Tribes can regularly check manufacturers' websites or product centers to see if any upgrades are available. Many times, software manufacturers issue product upgrades or modifications free of charge.

As Tribes accumulate years of data and add more monitoring parameters, the amount of data they collect and store increases. Tribes may find their hardware and software tools no longer address all their data management needs. In this case, Tribes may consider upgrading to a more powerful computer with greater storage space, processing capacity, or a more powerful software package. Tribes may need to upgrade from a spreadsheet-based program to a database management system. When investing in new software, consider how best to transfer data from the existing system into a new software program.

Database management systems allow programs to easily import spreadsheets and verify that the transferred information is compatible with the new software. Data management procedures will naturally evolve when programs gain new software, hardware, parameters, or other significant updates. Tribes that plan to use Section 106 funds to upgrade computer systems may work with their EPA Project Officer to understand any budget proposals or modifications.

The Exchange Network grants are a funding source to leverage when updating and upgrading electronic data systems and are discussed further in Chapter 9: Other Funding Options. For additional information on data management, please see the *Tribal Data Management for WQX Submission* supplement.

Data Analysis and Assessment

Data analysis and assessment is the process of performing statistical summaries, assessing data against water quality thresholds or WQS, determining if waters are meeting designated uses, and describing water quality trends. These analyses identify whether tribal waters are meeting tribal goals for the waters and inform future water quality protection, preservation, and restoration practices. During data analysis, Tribes also evaluate whether they need additional data. *Listening to Watersheds* lists some typical ways in which Tribes analyze data, including:

- Status: comparing parameters against WQS or water quality thresholds that the Tribe establishes for a waterbody.
- Trends/changes over time: comparing parameter(s) at a site over time.

The *Tribal Assessment Modules* on EPA's Ambient Water Monitoring and Assessment website have more information on data validation, analysis, and assessment.

Documenting Assessment Processes

Preparing for data analysis begins with documenting a process to utilize the data to make water quality management decisions. The assessment process is the pinnacle of the water quality program because it is the process of evaluating monitoring results against thresholds or WQS and determining whether waters are meeting tribal goals.

Tribes will need to document how they can make decisions with small sample sizes, how conflicting parameter assessments contribute to overall water quality status decisions, the percent exceedances allowed while still meeting thresholds or WQS, and how other types of best professional judgements will be used during the assessment processes. By documenting assessment decision processes, Tribes can be confident that they are assessing and reporting data in a consistent way.

One way to document assessment processes is to develop an assessment methodology documenting how the current tribal staff perform assessments and how others can reproduce the results. Documenting the assessment process also ensures consistency in data interpretation from year to year and provides transparency to stakeholders. The assessment methodology should describe:

- How the Tribe will aggregate data and information relevant to tribal use assessments.
- The extent of the waters to which the decision is applicable.
- How the Tribe evaluates the suitability of the data or information for decision making.
- How the Tribe analyzes and interprets the data to make attainment or nonattainment decisions.

To start, the assessment methodology should include four common elements to inform the water quality decision processes:

1. The waterbodies monitored: assessment units (AUs).
    - AUs are the location of the decision and the extent to which it applies. For example, when a station is monitored, is the data representative of a single point in the stream or the water quality of a reach of the stream? AUs include monitoring locations, lengths of stream, and polygons (for example, lake, ocean, or wetland area).
    - To determine whether it is appropriate to represent decisions for a reach of stream, gather data to understand where water quality changes occur in the reach, evaluate mixing zones, consider point source and non-point source introductions along the waterbody, elevation, land use, and physical characteristics of the waterbody.
2. The number of results the Tribe needs to make a decision.
    - The goal is to collect enough samples to characterize the true environmental condition of the waterbody for the tribal goals being evaluated. Include in the assessment methodology if and how the data will be assessed in the event a sample size is not met. Consider the sample size needed to assess thresholds or WQS as well as the magnitude, duration, and frequency of the exceedances.
3. The decision criteria for determining attainment and nonattainment of the tribal use for the waterbody.
    - Decision criteria may include a 10 percent exceedance allowance of the threshold or WQS.
4. The thresholds or WQS the Tribe uses to assess each use.
    - Thresholds can typically be represented in a table containing each parameter sampled, the WQS or threshold, the use assessed, and any rules for assessing. For example, DO for aquatic life: 3 mg/L in the spring season with a 10 percent exceedance threshold.

EPA advises Tribes to revisit their assessment methodology as they grow their programs and expand it as necessary. Tribes with TAS for Section 303(d) will also have to include additional elements in their decision-making process and assessment methodology. Additional information regarding assessment methodologies can be found in EPA's *Consolidated Assessment and Listing Methodology*.

Performing Analyses

Once the Tribe determines how to perform the assessment, data analysis will begin with:

1. Identifying all data for use in analysis.
2. Compiling, running QA measures, and standardizing data and metadata.
3. Assessing data against thresholds or WQS.

Identifying all data for use in analysis: Monitoring data are not the only data that Tribes can use to evaluate the condition of tribal waterbodies. If available, Tribes can incorporate any other data into the analysis, such as the waterbody's geological characteristics, recreational advisories, fish consumption advisories, fish kills, and data from upstream and downstream Tribes or states. EPA maintains a number of online databases containing data related to water quality that may be used to supplement or support tribally collected data. For example: the *Water Quality Portal* contains hundreds of millions of results from around the country including data from Tribes, states, academia, USGS, nongovernmental organizations (NGOs) and more. EPA's *How's My Waterway* application provides a user-friendly way to view data from the Water Quality Portal collected on or near tribal lands as well as other information about nearby water quality. When Tribes use data from any secondary source in decision making, their QAPP needs to include a discussion of how they review the data and determine that the data are suitable for the intended purpose. In addition, Tribes can perform analyses using more than one year of data and may use external data sources to better understand trends in water quality and supplement data for low sample sizes.

Compiling, conducting QA measures, and standardizing data: The next step is compiling the data into one format for analysis. Specifically, Tribes might need to standardize parameter names, check data ranges, determine outliers, convert units, and compare methods for laboratory analysis.

Assessing data against thresholds or WQS: Once data is compiled into one format, Tribes can then compare each parameter against the corresponding WQS or threshold. Tribes with approved WQS will use them to perform assessments (see Chapter 8: Program Expansion – Regulatory Authorities for more information about WQS). Tribes without EPA-approved WQS use other thresholds, including tribally adopted WQS to determine whether tribal waters are meeting tribal water quality goals or designated uses. Tribes can adopt relevant thresholds from neighboring Tribes or states or use EPA's *National Recommended Water Quality Criteria Tables*. The thresholds chosen should align with their tribal designated uses and water quality goals.

Some thresholds or WQS have a multi-step assessment process. For example, to analyze zinc or nickel, a Tribe needs to collect and assess not only metals but water hardness. Multi-step assessments can be complex to analyze.

Compiling Water Quality Assessments

Once the Tribe compares the data against thresholds or WQS, the next step is to associate those outcomes to the tribal goals or designated uses for which they apply. As shown in Table 6, Tribes use many parameters to evaluate water quality and determine designated use support such as aquatic life use or fish consumption. In the assessment phase, Tribes will compile parameter analyses against thresholds or WQS to determine whether a designated use is being supported. For example, if *E. coli* values exceed the thresholds or WQS, the tribal goal/designated use of primary contact recreation is not supported.

Please see EPA's *Consolidated Assessment and Listing Methodology* and the *Tribal Assessment Modules* on EPA's Ambient Water Monitoring and Assessment website for more information on Water Quality Assessments including exercises to practice assessing data against thresholds and WQS.

Developing a Water Quality Assessment Report

First and foremost, Water Quality Assessments are for tribal use to communicate the status of water quality on tribal lands and secondarily for EPA.

The Water Quality Assessment Report commonly includes:

1. The Tribe's interests and goals for water quality.
2. A description of the work achieved.
3. Water quality status and trends.

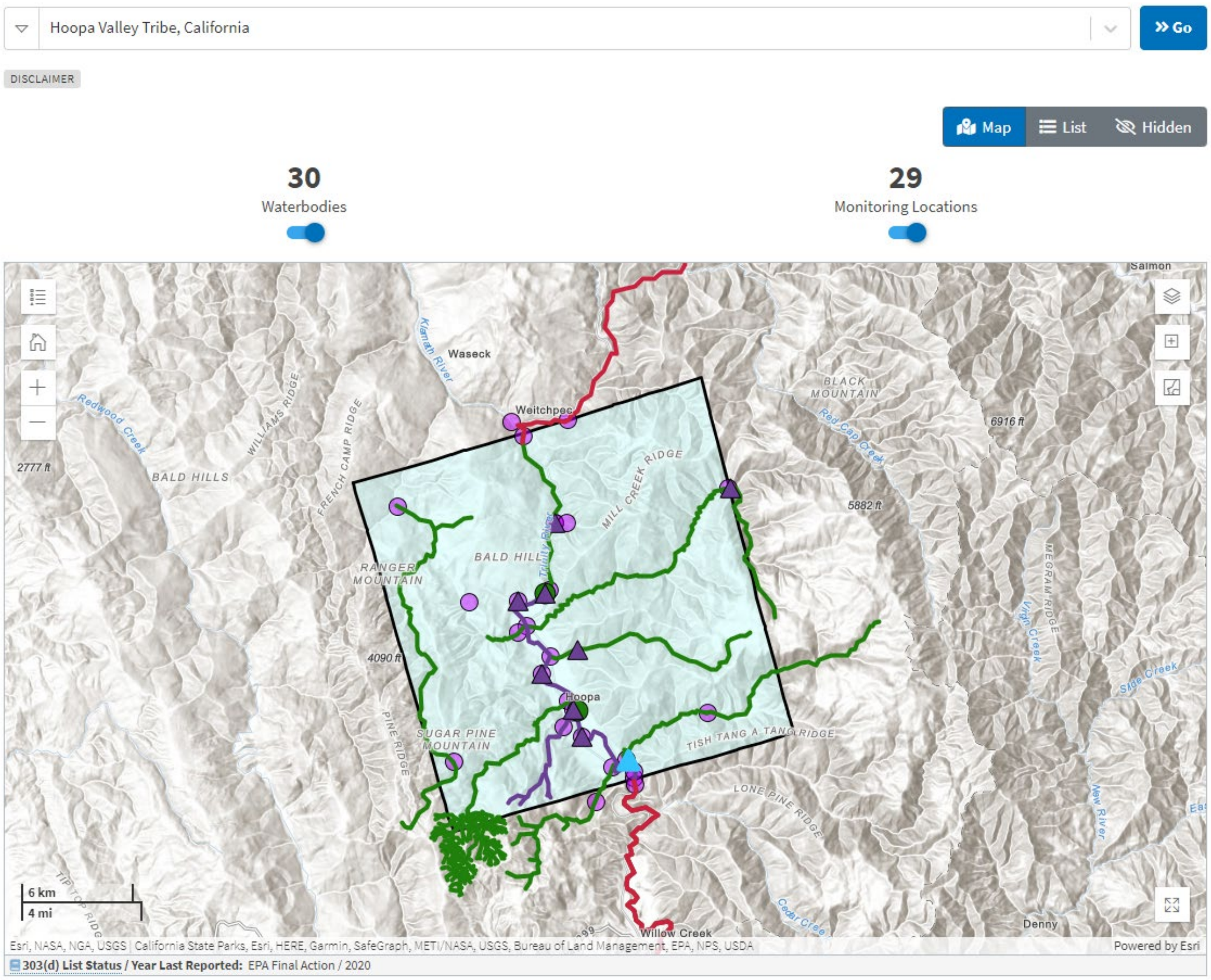
4. A discussion of how the results might inform future actions to help measure progress with meeting the tribal water quality monitoring goals and address water quality concerns.
5. Visual displays of results from analyses, such as in charts and graphs to present to the tribal community.

The Water Quality Assessment also serves as a grant deliverable and informs EPA about water quality on tribal lands. The Water Quality Assessment can include information such as evaluating program effectiveness, water quality improvements such as effectiveness monitoring, and identifying trends in water quality. Chapter 6: Programmatic Reporting Requirements has more information on Water Quality Assessment requirements.

Water Quality Assessments may lead to Tribes re-evaluating their water quality program and considering future enhancements. Tribes can review the Updating Monitoring Designs, Conducting Special Studies, and Monitoring Strategy sections of this chapter to adjust their monitoring design as the Tribe re-evaluates the water quality program to address new monitoring goals. Figure 8 shows the continuous process of learning, adjusting, and expansion of a monitoring program.

As an alternative to a written Water Quality Assessment, Tribes can choose to submit Water Quality Assessment decisions through the Assessment and TMDL Tracking and Implementation System (ATTAINS) and make these decisions available through How's My Waterway (Figure 15). ATTAINS provides a national platform for reporting tribal and state water quality decisions. This e-reporting process makes tribal decisions available, alongside decisions that states, and territories make, and shows a more complete picture of water quality across the nation. This e-reporting process not only helps inform EPA of water quality issues on tribal lands, but it also helps make tribal information more accessible in decision making by watershed partners. For more information on ATTAINS, including eligibility requirements and the new training schedule, Tribes can reach out to their EPA Project Officer, e-mail attains@epa.gov, or visit the *ATTAINS* website.

Figure 15. Snapshot of pages containing Tribal Water Quality Assessments in EPA's How's My Waterway application



Identifying Issues of Concern

Tribes may find water quality issues after performing Water Quality Assessments that need to be addressed. Several factors can contribute to water quality problems in surface water and ground water. Common pollutants and stressors that may impact a Tribe's water quality include:

- **Pesticides**: Pesticides are used in agriculture, animal feeding operations, and other activities. Many pesticides are toxic to animals and may bioaccumulate in the environment. Any pesticides used in or near surface waterbodies or aquifer recharge areas may lead to residues in water, fish, and shellfish. Sources of pesticides include crop and urban runoff. EPA's *About the Office of Chemical Safety and Pollution Prevention (OCSPP)* website and EPA's *Pesticides* website have more information about pesticides.
- **Salinity**: Salinity is a measure of the total salt content in water. Excess salinity can harm wildlife and the suitability of water for drinking. Agricultural irrigation can cause excess salinity. Urban and industrial uses can also cause salinity problems. Saltwater intrusion into fresh water sources

is a related problem that can occur where fresh and saltwater are in near proximity. Salinity measurements are often included in measurements of TDS.

- **Flow Alterations**: Activities such as dam construction and water withdrawals can alter natural water flow and threaten waterbodies. Reduced flows impair the ability of waterbodies to flush out nutrients and organic matter, thereby increasing contaminant concentrations. Additionally, lower water levels can affect aquatic species that require specific water levels and flow rates to survive. In contrast, problems such as degradation of river and stream bottoms, may also occur when water flow increases. Lack of riparian buffer and excess impervious surface without modern drainage techniques, such as bioretention ponds or green stormwater infrastructure, cause flow alterations, scouring of stream banks, and excess sedimentation. When rain falls on these surfaces and is directly routed to a river, it can cause rapid changes in flow volume and velocity. Additionally, impervious surfaces can limit ground water recharge, diminishing the quantity of ground water available for use, and increasing the cost of obtaining ground water.
- **Channelization**: Changes created by channelization and channel modification can harmfully alter waterbodies. Channel modifications alter the natural flow of water, as well as water temperature and sediment characteristics, which in turn can affect the water quality and wildlife in the waterbody.
- **Streambank Modification**: Lack of healthy vegetation buffers, channelization, and shoreline and streambank erosion can result in excessive sediment loads and increased turbidity and nutrient levels that can adversely affect aquatic vegetation, shellfish beds, and tidal flats.
- **Feedlots and Livestock Operations**: Animal waste can pose a significant threat to water quality. Oxygen-demanding substances such as aerobic bacteria, ammonia, nutrients (including nitrogen and phosphorus), solids, pathogens, and odorous compounds are common pollutants associated with animal waste. Manure is also a potential source of salts, trace metals, and, to a lesser extent, antibiotics, pesticides, and hormones. Animal waste and wastewater can enter waterbodies from spills or breaks of waste storage structures due to accidents or excessive rain.
- **Pastureland**: Overgrazing exposes soils, increases erosion, encourages invasion by undesirable plants, and reduces buildup of sediment on streambanks, wet meadows, and floodplains. This may result in nutrient runoff and sediment deposition in nearby waterways.
- **Irrigated Cropland:** Irrigation waters transported in open, unlined canals can seep into adjacent soils and carry soluble pollutants into ground or surface waters. Too much irrigation causes excess water to run off the land into surface waters or seep through the soil into the ground water. Irrigation waters can include pollutants such as sediment and organic solids, nutrients, including nitrogen and phosphorus, chemicals, metals, pesticides, salts, bacteria, viruses, and other microorganisms.
- **Land Disposal of Hazardous Waste**: While landfill units have safeguards, hazardous waste can still contaminate ground water if not properly treated before land disposal. Rain can also filter through hazardous waste and leach out hazardous chemicals into the ground water.
- **Municipal Discharges**: Wastewater is a potential source of pollution because it may contain organic and inorganic materials, especially if the wastewater is untreated or only partially treated. Discharged wastewater, particularly if untreated or partially treated, may increase excess nutrients in the receiving stream and can be a source of *E. coli*, enterococci, and other pathogens. EPA's *Office of Wastewater Management* (OWM) website has more information on wastewater management and municipal discharges.

- **Forestry**: Certain timber harvesting practices can disturb natural areas contributing to erosion, soil loss, and sedimentation. Forestry can also increase water flow through cleared sites and cause erosion along streambanks.
- **Mining**: Mining and mining waste can cause acid mine drainage, a metal-rich water formed by the chemical reaction between water and rocks containing sulfur-bearing minerals. Acid mine drainage is typical in areas where there is ore, or where coal mining activities have exposed rocks containing pyrite, which is a sulfur-bearing mineral. Even mineralized areas that have not been mined can have metal-rich drainage, which may be acidic. Mine drainage can contaminate drinking water and disrupt the growth and reproduction of aquatic plants and animals.

Monitoring Effectiveness of Protection and Restoration Activities

The goal of protection and restoration is to achieve quantifiable improvements in water quality. When designing and implementing water quality protection and restoration activities, the project plan should include measures and milestones to help determine whether the management measures are being completed and are addressing the water quality concerns. Consider short-term and long-term water quality measures as some parameters may change sooner than others. For example, riparian buffer zones and other stormwater management measures may reduce scouring and excess sedimentation before benthic macroinvertebrate community health improves. Consider that upstream stressors may limit the ability to demonstrate the effectiveness of a downstream best management practices (BMPs). It may be appropriate to update the QAPP and related documents to include the data requirements necessary to determine if the restoration activities are effective.

If the measures are not improving water quality as expected, then consider if:

- Management measures are being properly implemented by all responsible parties.
- There are other sources of the pollutant that the measures do not cover.
- There is a need to implement further special studies to evaluate effectiveness.

Program Evaluation

Program evaluations are important to ensure the program is still providing the information needed to advance and accomplish tribal goals. As Tribes accumulate monitoring data and perform assessments, it is necessary to evaluate whether the monitoring data are adequate to meet water quality goals. If the right data are not collected to meet water quality goals, Tribes may identify what additional information is needed and consider adjusting the monitoring program accordingly. If the Tribe wants to change an aspect of the water quality monitoring program, they will also need to update their QAPP and SOP documents and submit them to the EPA regional office for approval. EPA's *Developing a Tribal Water Quality Program Monitoring Strategy* supplement has more information on CWA goals.

Tribal Environmental Education and Outreach

Tribes may choose to provide information about the program to the community, including the results of the Water Quality Assessments. Water quality programs, particularly ones that involve voluntary activities, rely on active community involvement and public participation to succeed. A Tribe's community outreach and awareness program may include several topics related to the monitoring program, including information on waterbodies on the reservation, volunteer activities, human health concerns, management measures, pollution prevention, education, and general information. When conducting any public outreach activities, Tribes can reinforce the message with monitoring and assessment data. The community may be more likely to share concerns or understand accomplishments if they see quantitative data that support the claims.

Informed and involved members of the community are more likely to support the Tribe's efforts to protect the environment. For example, if a goal is to address leaching from septic systems, the water quality program may work closely with homeowners and small businesses that use septic systems (Chapter 7: Program Expansion – Additional Activities has more information on septic systems). Taking pictures of activities and events and posting on social media may help illustrate work being completed. Depending on the activities that the Tribe chooses to implement, they may target different groups of the population. For example, if the Tribe wants to prevent pesticides from entering surface water, they may work with farmers or gardeners in the community to implement a pesticide and fertilization management program.

Salt River Pima-Maricopa Outreach Example

The Salt River Pima-Maricopa Indian Community (SRPMIC) considers the education of Native youth one of their most important goals. The SRPMIC Environmental Protection & Natural Resources Division's Water Quality Program (WQP) organizes community events to engage youth in learning about the natural resources and wildlife around them, and how their protection is vital. Despite the tumultuous year of 2020, the WQP made continuous efforts toward their ambitious environmental education and outreach goals.

During 2020, the WQP conducted presentations for high school students to discuss what the WQP does on tribal land to protect their water resources. Students learned about the importance of water quality, how to sample, and saw firsthand the important work the WQP staff were doing.

Activities such as these raise environmental awareness and give youth an opportunity to see some of the career opportunities that exist within tribal governments. The SRPMIC's outreach goals emphasize the impact of engaging community members in environmental issues and the importance of training future generations to be good environmental stewards.

Additional methods that communities have used to raise public awareness about water quality issues include:

- Tours of restored or impaired waterbodies.
- Educational workshops on pollution, source water protection, and septic system management.
- Events and programs such as "adopt-a-river," river cleanup days, and volunteer monitoring networks.
- Brochures, flyers, and newsletters on pollution, source water protection, and septic system management.
- No-penalty hazardous waste collection programs.
- Solicitation of public input in developing a septic system management program.

The Tribe may have public participation requirements that apply to tribal law. Tribes should consult a tribal attorney general or equivalent officer to see if any tribal public participation requirements apply. Partnering with the community (including potentially regulated entities), watershed groups, and others will help the Tribe understand the community's perspective and may give the Tribe access to data and information to make their program more effective. In addition, including those affected by the quality of the reservation waters may build support for the standards development process.

Figure 16. The SRPMIC Young River People's Council leading a student activity. Credit: Photo courtesy of the SRPMIC

Volunteer Programs

Volunteers from the community may be able to help Tribes implement their program, allowing Tribes to devote funding to other program areas. Community members may also have ideas that help Tribes define their program's needs and priorities. Tribes may also encourage volunteer groups to form and independently conduct activities that will support their water quality program goals. Tribes may consider incorporating volunteer recruitment into community outreach efforts and use available resources, such as:

- Staff from neighboring water quality programs who can provide technical assistance. Some Tribes with established water quality programs have mentored Tribes developing new programs.
- Volunteers who can help carry out some of the activities in the work plan. Several water quality programs have used volunteers from the community, local high schools, tribally sponsored internship programs, community colleges, and university programs.

EPA's *Volunteer Monitoring* website has more information about volunteer monitoring programs.

Northern California Tribal Stream Team

The Northern California Tribal Stream Team facilitates water quality monitoring knowledge and equipment sharing among tribal environmental staff primarily in Mendocino, Lake, and Sonoma counties in Northern California. Participating Tribes take turns hosting the meetings. This collaborative group has helped maintain tribal water quality programs during times of staff turnover and equipment failures. The Stream Team also works with youth through schools and other science, technology, engineering, and math (STEM) programs, demonstrating modern monitoring and restoration techniques and connecting those concepts to Indigenous values and knowledge.

Figure 17. Northern California Tribal Stream Team meeting at the Hopland Band of Pomo Indians Reservation, May 2018. Credit: Photo courtesy of the Northern California Tribal Stream Team

Working in Partnership with Other Tribes and States

Collaborating with neighboring Tribes, states, and EPA is a sound environmental planning and management practice because they often share the same environmental problems. Working together to resolve these problems benefits everyone. The Tribe may also benefit from contacting other organizations in the watershed, including local governments and watershed organizations.

Depending on the types of activities a tribal water quality program conducts in the watershed, they may be able to support regulatory programs of neighboring Tribes and states. For example, the Penobscot Indian Nation shares their water quality monitoring data with the Maine Department of Environmental Protection not only for resource management and planning purposes but also Section 305(b) reporting to Congress, which Maine is required to perform as part of their Integrated 303(d)/305(b) Report.

In some cases, Tribes may want to work even more closely with neighboring Tribes and states regarding WQS on common waterbodies or modify and adopt the WQS of an adjacent Tribe or state. These options can be quick and cost-effective ways to establish WQS that are more likely to result in consistent upstream and downstream standards.

There are many opportunities for negotiation, agreement, and cooperation between Tribes and states that can benefit both parties. Usually, these agreements have focused on information exchanges such as those in Oklahoma's *Submitting Assessments or Water Quality Data to the State of Oklahoma for Inclusion in the Integrated Report: A Guide for Tribes* and transboundary coordination, much like agreements commonly reached between states. Some agreements have also allowed Tribes to access state resources such as training, to protect water resources.