Volunteer River Monitoring Program
2020 Data Report

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Cover photograph of Friends of Scarborough Marsh volunteers courtesy of Betsy Barrett.

The VRMP, Wells NERR and Mousam and Kennebunk Rivers Alliance would like to recognize the contributions of John White. John was a passionate volunteer and advocate for the Kennebunk River and he will be sorely missed.

John White preparing for sampling the Kennebunk River with Betsy Smith

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Weskeag River Monitoring Project volunteers, 2020
(photo credit: Theo Pratt)

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Executive Summary

The Volunteer River Monitoring Program (VRMP) was started by the Maine Department of Environmental Protection (DEP) in 2009. The program began for two primary reasons. There were groups interested in water quality monitoring but lacked the resources to do it on their own. Other groups were monitoring on their own but, were all using different methods, data management systems, and quality assurance/quality control requirements. Thus, the VRMP was established to provide technical resources to watershed groups and a standardized approach with volunteer groups working under a Quality Assurance Project Plan. The VRMP further provides monitoring equipment, training, volunteer certification, data archiving, and an annual water quality report. In 2020, the VRMP began a pilot effort to collect data via the online ArGIS Survey123 app to allow for quicker and easier volunteer access to data.

Pleasant River
PRLT monitoring site

Despite the Covid-19 pandemic, seven watershed groups collected water quality data in river/stream and coastal watersheds throughout the State of Maine. These groups monitored Kennebunk River, Mousam River and their tributaries in south coastal Maine (York County); Presumpscot River and tributaries, Stroudwater River and Scarborough River tributaries in southern Maine (Cumberland County); Upper Androscoggin River and tributaries in western Maine (Oxford County); Lower Androscoggin River in mid-coast Maine (Androscoggin, Cumberland, Sagadahoc Counties); Kennebec River in central Maine (Kennebec, Sagadahoc counties); and Rockport Harbor and tributaries and Weskeag River in mid-coast Maine (Knox County). In 2020, the volunteers went above and beyond to contribute to water quality monitoring efforts expanding the range and scope of data collected in the state.

The VRMP annual report is divided into five chapters as follows:

1. 2020 monitoring overview, VRMP background, and Federal Clean Water Act - Maine's Water Classification overview
2. Explanation of water quality parameters
3. 2020 weather/flow data and water quality data requirements
4. Quality Assurance/Quality Control Program
5. 2020 River/Stream reports (attached as separate documents)

Chapter 1
Overview and Introduction

2020 Overview

The 2020 sampling season marked the twelfth year of the Volunteer River Monitoring Program (VRMP). Despite the Covid-19 pandemic, all seven watershed groups that had collected data the previous year collected data in 2020. To make the season happen, groups adjusted as necessary by modifying procedures to limit contact as much as possible, reducing monitoring seasons, reducing the number of monitoring sites and/or limiting new volunteers due to training requirements.

Seven volunteer river monitoring groups, comprised of 60 monitors, monitored 48 rivers and streams and one harbor. These groups represented a range of locations and watersheds. The Rockport Conservation Commission monitored Rockport Harbor and the freshwater streams draining to the harbor. Androscoggin River Watershed Council monitored the upper Androscoggin River and tributaries in western Maine. Friends of Merrymeeting Bay monitored the lower Androscoggin River and the lower Kennebec River. Presumpscot Regional Land Trust monitored the Presumpscot River and tributaries as well as Stroudwater River, located in the highly-developed area of southern Maine. The Kennebunk and Mousam rivers and tributaries, located in the southern and coastal area of the state, were monitored by the Mousam and Kennebunk Rivers Association with support of the Wells National Estuarine Research Reserve. The Weskeag River Monitoring Project sampled the tidal Weskeag River and tributaries. The Friends of Scarborough Marsh monitored tidal and nontidal tributaries to the Scarborough Marsh.

Monitoring groups covered an area of over 1000 square miles of river and stream watershed and collected a vast amount of data; a total of 700 sampling events were completed at 99 sites. Collected data parameters included water temperature, dissolved oxygen, specific conductance, bacteria, turbidity, chlorophyll and nutrients. Several groups participated in the pilot effort to collect data via the online ArGIS Survey123 app. Data entered into the online app was immediately available to groups to view in table, map, and graph form, allowing easier and quicker review, analysis, and sharing. While there are some kinks to work out with the data form and connection to the online database, overall this method seems a promising way to submit and have access to data collected by volunteers.

VRMP Background

The DEP is responsible for monitoring and assessing the State's waters. However, with limited State resources, it has long been recognized that there is value and a need for using volunteers for collecting water quality data. Therefore, there was interest in developing a statewide volunteer effort for streams and rivers, an effort similar to the very successful Lake Stewards of Maine-

Volunteer Lake Monitoring Program which has been in existence since 1971. In 2007, DEP commissioned a needs assessment and determined that there was widespread support for a volunteer river monitoring program. After determining where the program would be housed and how it would be organized, the VRMP was launched in 2009.

Prior to 2009, with no or limited DEP assistance, a number of hard-working river and stream watershed groups had already developed monitoring programs on their own for a variety of reasons. According to a needs assessment done for the DEP, these reasons included: an interest in land preservation, protecting endangered species, dam removal, opening clam flats, upgrading water classification, and obtaining water quality data. The VRMP brought some of the established groups and also new groups into the program.

There are challenges with volunteer groups working independently: they may employ diverse sampling or analyses methods; they may use different data management systems; and they may adhere to a variety of quality assurance/quality control requirements. Additionally, these groups may or may not have an approved quality assurance project plan. Also, for interested parties, centralized access to the results of most volunteer sampling had not been available.

The VRMP was formed as an organization to address these problems. The VRMP unifies a network of volunteer groups that participate in quality assured volunteer sampling. Volunteer sampling is governed by a program level Quality Assurance Project Plan (QAPP) which was created and is maintained by VRMP staff. Volunteer groups develop individual Sampling and Analysis Plans (SAPs) tailored to their specific project situation. To ensure consistent sampling and analysis methods, each SAP includes Standard Operating Procedures (SOPs) that detail equipment or techniques.

The creation of an approved generic QAPP and the support by VRMP staff makes it easier for interested groups to tackle the rigors of water quality monitoring with reduced difficulty and time associated with the development of QAPPs, SAPs, and SOPs.
The VRMP therefore:

1. Created and maintains a Quality Assurance Project Plan
2. Assists groups with writing Sampling and Analysis Plans
3. Maintains an equipment loan program
4. Provides annual training
5. Provides quality assurance/quality control of data and a centralized database
6. Produces an annual report

Overview of the Federal Clean Water Act and Maine's Classification System

A brief overview about water quality classification and criteria is provided here to give a better understanding of how volunteer monitoring fits into the bigger picture of protection and restoration of Maine's waters. For more details, we recommend the following website: www.maine.gov/dep/water/monitoring/classification/index.html.

In 1972, the Federal government passed the Clean Water Act which provides the overall framework for the protection and restoration of all waters of the United States. Included in the many requirements that States must implement, the Clean Water Act mandates that States establish a water quality standards program consisting of three parts: designated uses, criteria, and an anti-degradation statement.

The designated human and ecological uses reflect the goals for each water body and include: support of aquatic life, fishing (including fish consumption), recreation, drinking water, navigation, and hydropower. Narrative and numeric criteria consist of minimum requirements for parameters such as dissolved oxygen, bacteria, and the health of aquatic life communities that ensure that a water body attains its designated uses. The anti-degradation statement protects existing uses and high-quality waters by requiring that, when the actual quality of any classified water exceeds the minimum standards of the next highest classification, the higher water quality must be maintained and protected.

Maine defines uses for its water bodies through the Maine Water Classification Program. Each classification specifies the designated uses and water quality criteria (narrative and numeric) and may place specific restrictions on certain activities. Table 1 shows the classifications and associated designated uses for each class. Table 2 and Table 3 show the classifications and associated water quality criteria.

Maine has four water quality classes for rivers and streams: AA, A, B and C. Class AA waters are managed for their outstanding natural ecological, recreational, social, and scenic qualities. Direct discharge of wastewater, dams, and other significant human disturbances are prohibited. Class A waters are managed for high quality with limited human disturbance allowed; direct discharges are allowed but highly restricted. Physical and chemical characteristics should be similar to natural conditions. Class B waters are general purpose waters and are managed to attain good physical, chemical and biological water quality. Well treated discharges with ample dilution are allowed. Class C waters are managed to attain at least the swimmable-fishable goals of the federal Clean Water Act, including protection of spawning for indigenous fish species.

Maine has three classes for the management of estuarine and marine waters: SA, SB and SC. SA waters are outstanding natural resources that receive minimal human impact, and are managed for the highest water quality of the three classes. No direct discharges of pollutants, including those from finfish aquaculture, are allowed in SA waters. SB waters are general purpose waters that are managed to attain good quality water. Well treated discharges of pollutants with ample dilution are allowed. SC waters are the lowest quality class, but must be fishable and swimmable and maintain the structure and function of the biological community. Well treated discharges of pollutants are allowed in SC waters.

Table 1: Classification and Designated Uses (rivers/streams and marine/estuarine)

Water Class	Designated Uses
Class AA	Drinking water supply, recreation in and on the water, fishing, agriculture, navigation and habitat for fish and other aquatic life.
Class A	Drinking water supply, recreation in and on the water, fishing, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation and habitat for fish and other aquatic life.
Class B	Drinking water supply, recreation in and on the water, fishing, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation and habitat for fish and other aquatic life.
Class C	Drinking water supply, recreation in and on the water, fishing, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation and habitat for fish and other aquatic life.
Class SA	Recreation in and on the water, fishing, aquaculture (excludes finfish), propagation and harvesting shellfish, navigation, habitat for fish and estuarine and marine life.
Class SB	Recreation in and on the water, fishing, aquaculture, propagation and harvesting shellfish, industrial process and cooling water supply, hydroelectric power generation, navigation, habitat for fish and estuarine and marine life
Class SC	Recreation in and on the water, fishing, aquaculture, propagation and restricted shellfish harvesting, industrial process and cooling water supply, hydroelectric power generation, navigation, and habitat for fish and estuarine and marine life.

Table 2: Classification and Water Quality Criteria (rivers/streams and marine/estuarine)

Water Class	Dissolved Oxygen Numeric Criteria	Habitat Narrative Criteria	Aquatic Life (Biological) Narrative Criteria[1]
Class AA	As naturally occurs	Free flowing and natural	No direct discharge of pollutants; as naturally occurs
Class A	7 ppm; 75% saturation (there are additional requirements for identified fish spawning areas)	Natural	As naturally occurs
Class B	7 ppm; 75% saturation (there are additional requirements for identified fish spawning areas)	Unimpaired	Discharges shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes to the resident biological community.
Class C	5 ppm; 60% saturation; 6.5 ppm (monthly average) at 22° and 24°F	Habitat for fish and other aquatic life	Discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.
Class SA	As naturally occurs		As naturally occurs
Class SB	Not less than 85% of saturation		Support all indigenous estuarine and marine species Discharge not to cause closure of shellfish beds
Class SC	Not less than 70% of saturation		Maintain structure and function of the resident biological community Support all indigenous species

[1] Numeric biocriteria in Maine rule Chapter 579; Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams.

Table 3: Classification and Bacteria Criteria

Waterbody Class	Bacteria Criteria[1, 2]
Fresh water	
Class AA	As naturally occurs, except that E. coli may not exceed a geometric mean of 64/100 ml over a 90-day interval or 236/100 ml in more than 10% of the samples in any 90-day interval.
Class A	As naturally occurs, except that E. coli may not exceed a geometric mean of 64/100 ml over a 90-day interval or 236/100 ml in more than 10% of the samples in any 90-day interval.
Class B	Between April 15th and October 31st *E. coli* may not exceed a geometric mean of 64/100mL over a 90-day interval or 236/100 ml in more than 10% of the samples in any 90-day interval.
Class C	April 15th – October 31st *E. coli* may not exceed a geometric mean of 100/100ml over a 90-day interval or 236/100ml in more than 10% of the samples in any 90-day interval.
Marine/Estuarine	
Class SA	As naturally occurs, except that the number of enterococcus bacteria may not exceed a geometric mean of 8/100ml in any 90-day interval or 54/100 ml in more than 10% of the samples in any 90-day interval.
Class SB	Between April 15th and October 31st , the number of Enterococcus may not exceed a geometric mean of 8/100mL in any 90-day interval or 54/100ml in more than 10% of the samples in any 90-day interval.
Class SC	Between April 15th and October 31st, the number of Enterococcus may not exceed a geometric mean of 14/100m in any 90-day interval or 94/100ml in more than 10% of the samples in any 90-day interval.

[1] Defined in 38 MRSA §466(2): "As naturally occurs" means conditions with essentially the same physical, chemical and biological characteristics as found in situations with similar habitats free of measurable effects of human activity."
[2] Bacteria standards were changed in 2018 [see L..D. 1298]

While the Water Classification Program establishes goals, designated uses, and criteria, it does not necessarily mean that a water body is actually attaining water quality conditions as defined in its assigned class. Another part of the Clean Water Act is Section 305(b) which requires that states assess the condition of their waters toward meeting designated uses and prepare a report biannually to Congress. This report is referred to as the 305(b) report or "Integrated Water Quality Monitoring and Assessment Report". "The "Integrated Report" utilizes water quality data collected by the DEP; other state, Federal, and tribal government agencies; volunteer water monitoring organizations; and other sources. The report provides a general overview of the conditions of Maine's waters and the appendices give the conditions of specific water bodies. The report also includes a list of "impaired water bodies". The report is available on the Maine DEP webpage: https://www.maine.gov/dep/water/monitoring/305b/index.html.

Chapter 2
Water Quality Monitoring

Why Monitor Certain Water Quality Parameters?

Water quality parameters commonly monitored to assess the quality of streams and rivers include dissolved oxygen (DO), biochemical oxygen demand (BOD), temperature, pH, alkalinity, suspended solids and turbidity, bacteria, and nutrients. Generally, all VRMP groups monitor DO, temperature, and conductivity. Additional parameters may be monitored depending on a number of factors including existing natural stream/river conditions, potential impacts, the group's monitoring objectives, and funding. For more information, see "Volume 2. A Citizen's Primer on Stream Ecology, Water Quality, Hydrology, and Fluvial Geomorphology (October 2010) on the VRMP website:
http://www.maine.gov/dep/water/monitoring/rivers_and_streams/vrmp/index.html.

Another good educational resource is the U. S. Environmental Protection Agency's "Volunteer Stream Monitoring: A Methods Manual" (USEPA, 1997), which can be found online at: http://www.epa.gov/sites/production/files/2015-06/documents/stream.pdf

Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)

One of the most important measures of water quality is dissolved oxygen – the amount of oxygen dissolved in the water. Oxygen in dissolved form is used by organisms living in the water to breathe. It is measured in milligrams/liter (mg/L) or parts per million (ppm). When measuring DO, percent saturation should also be recorded with the meter. When using DO chemical kits, percent saturation can be calculated if water temperature is known. Percent saturation provides a measure of the capacity for oxygen to cross gill membrane barriers and enter the bloodstream of organisms. Both DO and percent saturation are used to determine whether a water body is attaining its water quality class.

If oxygen is low, it stresses aquatic organisms, affecting their growth and reproduction and, if it becomes low enough, it may kill aquatic organisms. Levels less than 5 mg/L are generally considered stressful. Levels between 5-7 mg/L are stressful to some coldwater fish if the percent saturation is low. Greater than 7 mg/L is generally considered optimal for all aquatic life. Early life stages of certain coldwater fish require higher DO levels.

Oxygen enters rivers and streams in several ways:

- It diffuses from the atmosphere at the water surface
- It mixes with the atmosphere as water moves over dams, waterfalls, and riffles
- Algae and aquatic plants produce oxygen as a product of photosynthesis

Oxygen is used up through two processes:

- respiration
- decomposition of organic materials (i.e. leaves and other materials)

If there is an increase in organic loading (addition of organic material to a watershed), oxygen may be used up. Sources of loading include discharges, increased runoff, and increased plant (particularly algae) growth. More sophisticated sampling may warrant testing for BOD which estimates the amount of oxygen demanding substances in the water sample.

Water temperature and altitude affect dissolved oxygen levels. Cold water holds more oxygen than warm water, and water holds less oxygen at higher altitudes. The most stressful period is the summer months because water temperature is highest, and flows tend to be lowest. Over a 24-hour period, lowest DO values occur in early morning and highest values late in the day. This is due to daily plant photosynthesis-respiration cycles and is the reason some early morning samples should be collected. In highly productive streams, there can be significant swings in dissolved oxygen over the course of a day.

Temperature

Temperature is a critical parameter affecting aquatic life and, along with DO, is one of the most important to monitor. Besides its effects on dissolved oxygen, temperature affects biological activity (e.g. metabolism of individual organisms). Aquatic organisms depend on certain temperature ranges for their optimal health. Both fish and macroinvertebrates are sensitive to temperature and will move within the stream to more favorable conditions if possible.

If organisms are exposed to temperatures outside their optimal range for a prolonged period, they can be stressed or die. Stress can alter their susceptibility to disease or toxins and affect reproduction. For fish, there are two kinds of limiting temperatures – the maximum temperature for short exposures, and a weekly average temperature that varies according to the time of year and life cycle of the species. For more information about fish species requirements, see Table 4-2- Maximum average temperatures for growth and short term maximum temperatures for selected fish in "Volume 2. A Citizen's Primer on Stream Ecology, Water Quality, Hydrology, and Fluvial Geomorphology" referenced above.

A number of human activities can affect temperature. These activities include removal of stream bank vegetation, impoundments, discharges, and stormwater runoff (e.g. runoff from heated surfaces such as parking lots, roads, and other sources).

Conductivity

Conductivity is a measure of water's ability to carry an electrical current and is directly related to the dissolved ions (charged particles) present in the water. Dissolved ions in water originate from the geology of the area as well as from human sources such as wastewater discharges and stormwater runoff. Conductivity is affected by temperature – the warmer the water, the higher the conductivity. For this reason, conductivity is generally reported as specific conductivity. Specific conductivity is conductivity that is adjusted to what the reading would be at a temperature of 25˚ Celsius. Conductivity and specific conductivity are measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µs/cm).

Conductivity is useful as a general measure of stream water quality and can be used to track down many kinds of pollution sources. The values for Maine undisturbed rivers and streams are generally low (30-50 µs/cm). Values significantly greater than 100 µs/cm may indicate that there is a potential pollution problem. Some degraded urban streams having serious pollution problems can have conductance values in the 300-400 µs/cm range or much higher.

There has been a growing concern in the Northeastern United States about potentially significant increases in chloride concentrations in freshwater surface and groundwater supplies, primarily originating from winter road and parking lot safety maintenance (salting) activities (Kausal et al., 2005; Mullaney et.al., 2009). Though conductivity is not a direct measure of chloride concentrations, high chloride concentrations are frequently associated with high conductance measurements, thereby making conductivity a valuable screening tool for this type of problem.

pH

pH is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0. The pH scale measures the logarithmic concentration of hydrogen (H+) and hydroxide (OH-) ions which make up water. When both types of ions are in equal concentration, the pH is 7.0 or neutral. Below 7.0, the water is acidic, and when the pH is above 7.0, the water is alkaline or basic. Since the scale is logarithmic, a drop in the pH by 1.0 unit is equivalent to a 10-fold increase in acidity.

Maine water quality standards allow a pH range of 6.0 to 8.5 for all freshwater quality classes (AA, A, B and C). pH outside this range reduces the diversity of aquatic organisms because it stresses the physiological system of most organisms and can reduce reproduction success. Low pH can also allow toxic elements (e.g. aluminum) to become available for uptake by aquatic organisms. pH is generally not measured by volunteers in part due to the difficulty of accurately measuring it. pH may be affected by acid rain/snowmelt, local geology, inputs from natural organic acids from the decomposition of organic matter, photosynthesis and respiration of aquatic plants, and certain wastewater discharges.

Alkalinity

Alkalinity is a measure of the capacity of water to neutralize acids and is also known as the buffering capacity. It is due primarily to the presence of naturally variable bicarbonate (HCO_3), carbonate (CO_3^{-2}), and hydroxide (OH^-) ions; bicarbonate is the major form. Sources of alkalinity include rocks and soils, salts, algal activity, and even certain wastewater discharges.
In Maine, there are wide natural variations due to the depth and type of soil material in a watershed. Alkalinity results are typically reported as milligrams per liter of calcium carbonate (mg/L $CaCO_3$). Rivers with alkalinity values less than 10 milligrams per liter (mg/L) are considered poorly buffered. Measuring alkalinity is important in determining a river's ability to neutralize acidic pollution from rainfall, acid deposition (polluted rain and snow), and other pollutants that may affect the strength of acids in a stream.

Sediment Pollution

Streams and rivers naturally transport sediments (sand, silt, or clay) through their systems. Excess sediments, usually resulting from human activities done carelessly, may enter into and become suspended, transported, and deposited within streams and rivers. These excess sediments can cause a number of harmful effects:

- reduce visibility which interferes with fishes ability to feed
- raise water temperature (suspended particles absorb more heat)
- damage fish and aquatic insect gills
- block sunlight, which impairs photosynthesis
- carry nutrients and toxics adsorbed to sediment particles
- fill in natural gravel-stone habitat areas – eliminating habitat areas and suffocating eggs

Total Solids, Total Suspended Solids and Suspended Sediment Concentration

"Total solids" is a measure of dissolved solids plus suspended and settable solids in water. In stream water, dissolved solids consist of calcium, chlorides, nitrates, phosphates, iron, sulfur, and other ion particles as well as humics and tannins that will pass through a filter with very small pores. "Suspended solids" include: sand, silt, and clay particles; plankton; algae; fine organic debris; and other particulate matter. "Total suspended solids" (TSS) and "suspended sediment concentration" (SSC) are measurements of suspended sediments (e.g., soil particles, sands, clays) originating both from outside and within a stream. The analytical methods for TSS and SSC differ. TSS data are obtained by several methods, most of which involve measuring the dry weight of sediment from a known volume of a subsample of the original sample. SSC data are obtained by measuring the dry weight of all the sediment from a known volume of a water-sediment mixture (sample).

Total solids, total suspended solids, and suspended sediment concentration monitoring is done by collecting water samples that are analyzed by a certified lab. Results are measured in milligrams per liter (mg/L) or parts per million (ppm).

Turbidity and Transparency

Turbidity is a measure of the degree to which material suspended in water decreases the passage of light. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, and other decaying vegetation. Turbidity can be useful for monitoring the effects of runoff from construction, agricultural activities, logging activity, discharges, and other sources. Turbidity is generally measured by using a turbidity meter with values reported in nephelometric turbidity units or NTUs. During significant rainstorm (runoff events), turbidity can increase significantly (e.g. > 100 NTU), especially if substantial erosion is occurring in the watershed.

Transparency is strongly correlated to turbidity. It may be measured using a transparency tube. This is a 120-centimeter tube that has a black and white disk at the bottom of the tube. The tube is filled with the water sample and then water is slowly drained out until the disk is visible.

Sources of total solids, suspended solids/sediments, and turbidity include: in-stream erosion, waste discharges, and soil erosion from human activities and land use in the watershed (e.g. construction projects, bare soil on residential lots, logging, agricultural activities, and polluted urban stormwater runoff including eroded soil and winter sand).

Bacteria

Many types of pathogenic (disease causing) viruses, bacteria, and protozoans can be present in surface waters that are contaminated by fecal matter. When people drink, swim in, or eat shellfish from contaminated or untreated water, they can potentially become ill. Since it is not possible to test for all the possible pathogens present, members of two bacteria groups – *Escherichia coli* and enterococci – are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. USEPA recommends *E. coli* as the best indicator of health risk from water contact in recreational waters. Enterococci are distinguished by their ability to survive in salt water and are recommended as the best indicator of health risk in salt water used for recreation. Fecal coliform are used for testing shellfish areas.

Some sources of bacteria and pathogenic organisms include malfunctioning septic systems, overboard discharge systems, combined sewer overflows, discharges from boats, improperly stored animal manure, wildlife, pet waste, and publicly owned treatment works (POTWs) that are not working properly. POTWs are heavily regulated and usually do a good job of treating and disinfecting wastewater. Bacteria can increase after a rain event due to run-off from farmland, urban areas, and lawns of pet owners as well as from naturally occurring local wildlife sources.

Nutrients

Nutrients important in stream and river ecosystems include cations [calcium (Ca^{+2}), sodium (Na^{+2}), potassium (K^{+1}), magnesium (Mg^{+2}) and chloride (Cl^{-1})] and anions [sulfate (SO_4^{-2}), nitrate (NO_3^{-1}), and phosphate (PO_4^{-3})]. These elements are sometimes referred to as nutrients because in small to moderate amounts, they are essential for healthy aquatic life. A nutrient that is the least abundant relative to a plant's need for it is called the limiting nutrient. Limiting nutrients limit the growth and reproduction of organisms. Phosphorus is usually the primary limiting nutrient for algal growth in freshwater while nitrogen is usually limiting for algae growth in marine waters.

The presence of algae and other aquatic plants in stream ecosystems is a natural condition, especially when adequate sunlight is available. When extra phosphorus from human activities enters freshwater, it may, given the right conditions (e.g., adequate sunlight), fuel excess growth of algae and aquatic plants. In some extreme cases, decomposition of dead algae and plants by bacteria, and the low dissolved oxygen levels resulting from this unnatural amount of decomposition, can stress aquatic communities (e.g. fish, macroinvertebrates).

There are many sources of phosphorus, both natural and human. Phosphorus enters freshwaters from activities such as:

- agricultural sites (e.g. eroding soil, chemical fertilizer, manure, organic matter)
- residential sites (e.g. eroding soil, chemical fertilizer, manure, organic matter)
- urban development (e.g. eroding soil, runoff from roads & parking lots)
- waste discharges (e.g. untreated or treated wastewater and sewage)

Monitoring phosphorus is challenging because it involves measuring very low concentrations by a qualified lab. Less sensitive methods should only be used to screen potential problem areas.

Nitrogen occurs in various forms (NH_3, NO_2, NO_3, TKN) and, in excess amounts, can cause significant water quality problems. It can cause excess growth of algae and dissolved oxygen problems as described above for phosphorus. High levels of ammonia (NH_3) can be toxic to some fish including trout. Excess nitrogen enters freshwaters from human activities such as:

- agricultural sites (e.g. chemical fertilizer, manure, organic matter)
- residential development (e.g. lawn fertilizer, pet waste, failing septic systems)
- urban development (e.g. chemical fertilizer) and
- waste discharges (e.g. untreated or treated wastewater and sewage)

Chapter 3
2020 Monitoring Data

Weather Data for 2020

The following information was obtained from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service Annual Climate Report. Information for spring, summer and fall 2020 was extracted and summarized for the Gray, Maine station. For more details and stations, see the National Weather Service website (www.weather.gov).

Frequent stormy weather was observed in the first part of spring. A new storm system would bring rain or wintry weather just about every week. Nearly 2 inches of rain fell on April 2 and 3. A week later another significant storm brought rain changing to a heavy wet snow on April 9. Although only accumulating to 6 inches, this very sticky snow brought down trees and power lines. A few days later another storm dropped more than an inch of rain on April 13. Although there were a few mild days, most days were cool with showers and even some snowflakes continuing late into the spring. In fact, on May 9 rain changed to snow with more than an inch measured. This was the first-time measurable snow has been observed in May during the 25-year history of observations at the national weather service office in Gray.

Suddenly in mid-May the frequent stormy weather ended and the precipitation shut off. Barely any rain fell again for more than a month causing the rapid onset of drought conditions in the area. Temperatures during this period were frequently warm during the day and cool at night. While there were a few hot days in late May, the temperature fell all the way to 37 degrees on June 1. The first consistently hot stretch of weather came in mid-June when the temperature warmed to near 90 degrees from June 18 through 20. The warmest was 92 on June 20. As the temperature and humidity began to climb toward the end of June, finally some drought relief arrived. From June 28 through 30 nearly 5 inches of rain fell. Until these drought relieving rains, Gray was enduring its driest period on record for this time of year. Such consistently dry weather was unprecedented for the spring which is typically the rainiest time of year.

Frequent showers and thunderstorms in July kept the drought from worsening, at least for the first half of the month. Later in July the heat and humidity became more common. While there were no extremely hot periods, the humid weather often led to warm nights as well. The hottest temperature was 91 degrees on July 19 and 20. The summer heat and humidity continued into August. One exception was on August 4 when tropical storm Isaias moved over the region. Less than half an inch of rain was observed as this moved through, but it was accompanied by some stronger wind gusts. It wasn`t until a cold front on August 15 that the summer heat finally ended. Although there were a few more hot days in late summer and early fall, the persistent summer heat was over.

Almost an inch of rain fell on August 29, but this would be the last significant rainfall for a while as drought conditions returned for September. There were often warm days and occasionally cool nights. The coolest was in mid-September when the temperature dropped into the 30s for 4 straight nights. Finally, after more than 4 weeks of dry weather a storm system brought nearly an inch of rain on September 30. This began a shift in the weather pattern with more frequent storminess returning. Frequent frontal systems brought a topsy turvy temperature pattern with occasional warmth replaced by cold. The next significant storm brought nearly 2 inches of rain on October 13. Just a few days later another storm brought nearly 2 more inches of rain on October 16 and 17. More consistent cold weather at the end of the month brought the first snowflakes just before Halloween.

The average temperature for the year was 47.7 degrees which was 2.0 degrees above normal. The warmest year was in 2010 when the average temperature was 48.9 degrees. The coolest was 45.1 degrees in 1997. The following table lists the average temperatures for each month of 2020 including departures from normal.

Average Temperatures (˚F) by Month in 2020

Month	Maximum	Minimum	Average
January	33.7 (+4.3)	18.7 (+6.1)	26.2 (+5.2)
February	35.2 (+1.7)	18.4 (+2.5)	26.8 (+2.1)
March	44.9 (+3.0)	27.5 (+3.5)	36.2 (+3.3)
April	50.1 (-3.5)	33.5 (-1.4)	41.8 (-2.5)
May	65.2 (+0.1)	42.9 (-1.8)	54.0 (-0.9)
June	75.6 (+1.6)	55.9 (+1.8)	65.8 (+1.7)
July	79.9 (+0.8)	62.9 (+3.2)	71.4 (+2.0)
August	78.6 (+0.1)	60.3 (+1.6)	69.4 (+0.8)
September	70.8 (+0.8)	51.4 (+0.7)	61.1 (+0.7)
October	56.4 (-1.6)	40.7 (+0.6)	48.5 (-0.6)
November	50.2 (+4.3)	32.5 (+1.5)	41.3 (+2.8)
December	36.7 (+1.9)	23.6 (+3.8)	30.2 (+2.9)
Annual	56.6 (+1.9)	38.7 (+1.9)	47.7 (+2.0)

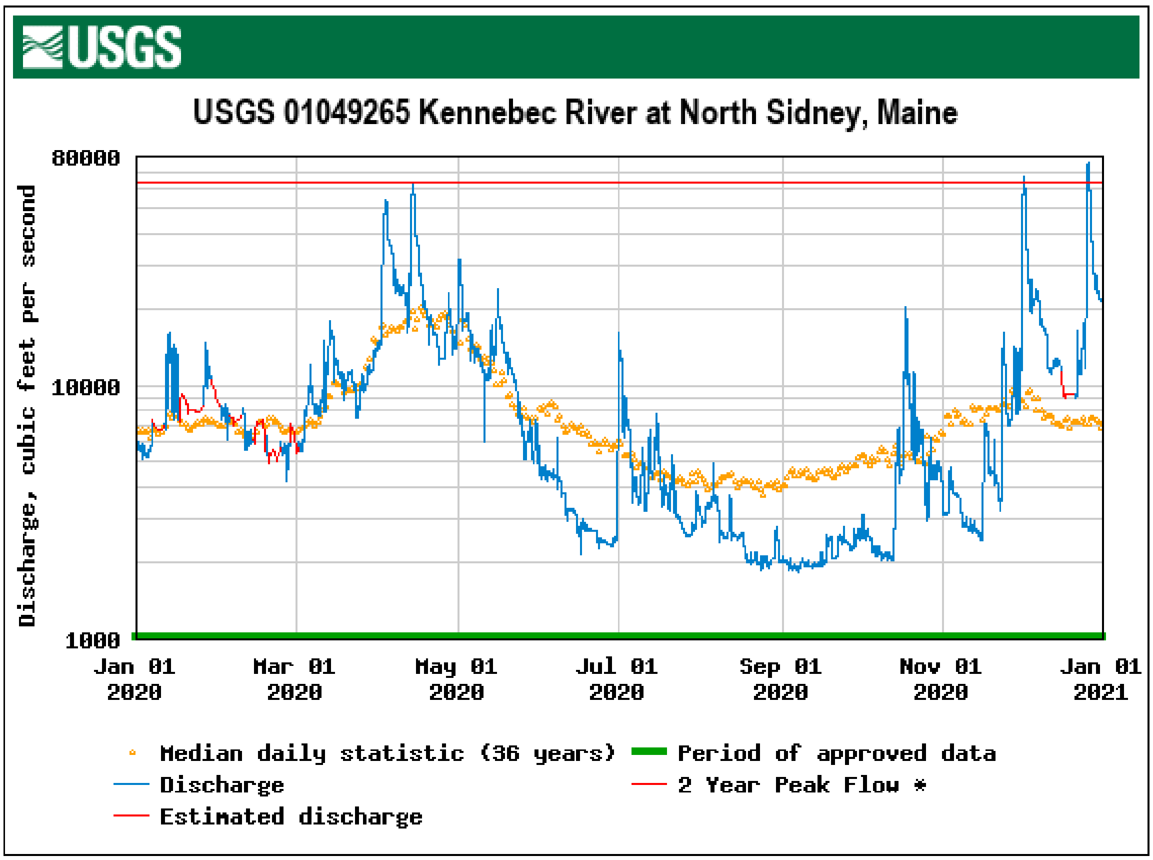
A total of 48.16 inches of precipitation fell which was 2.06 inches below normal. The heaviest precipitation fell at the end of June when 4.89 inches of rain fell from June 28 through 30. The driest year on record was in 2001 when only 34.77 inches was recorded. The following table lists the precipitation and snowfall amounts for each month of 2020 including departures from normal.

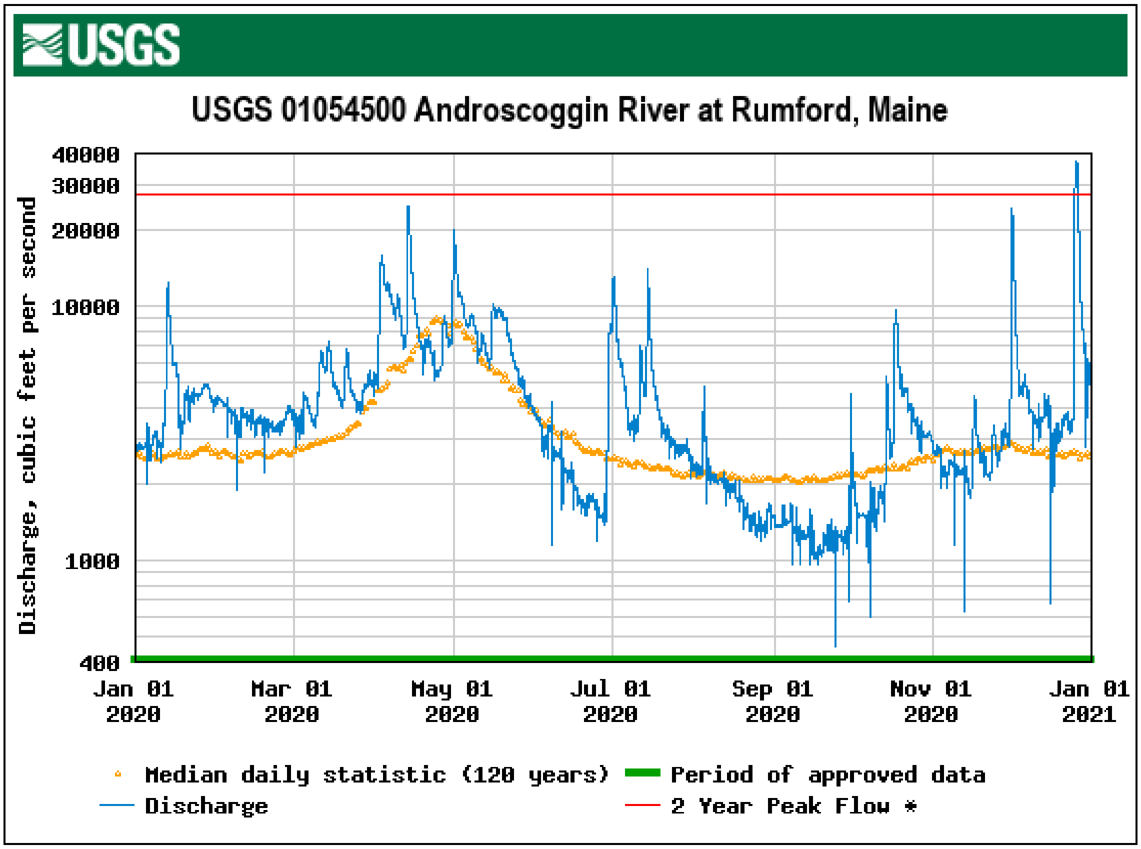
Monthly Precipitation and Snowfall Totals for 2020

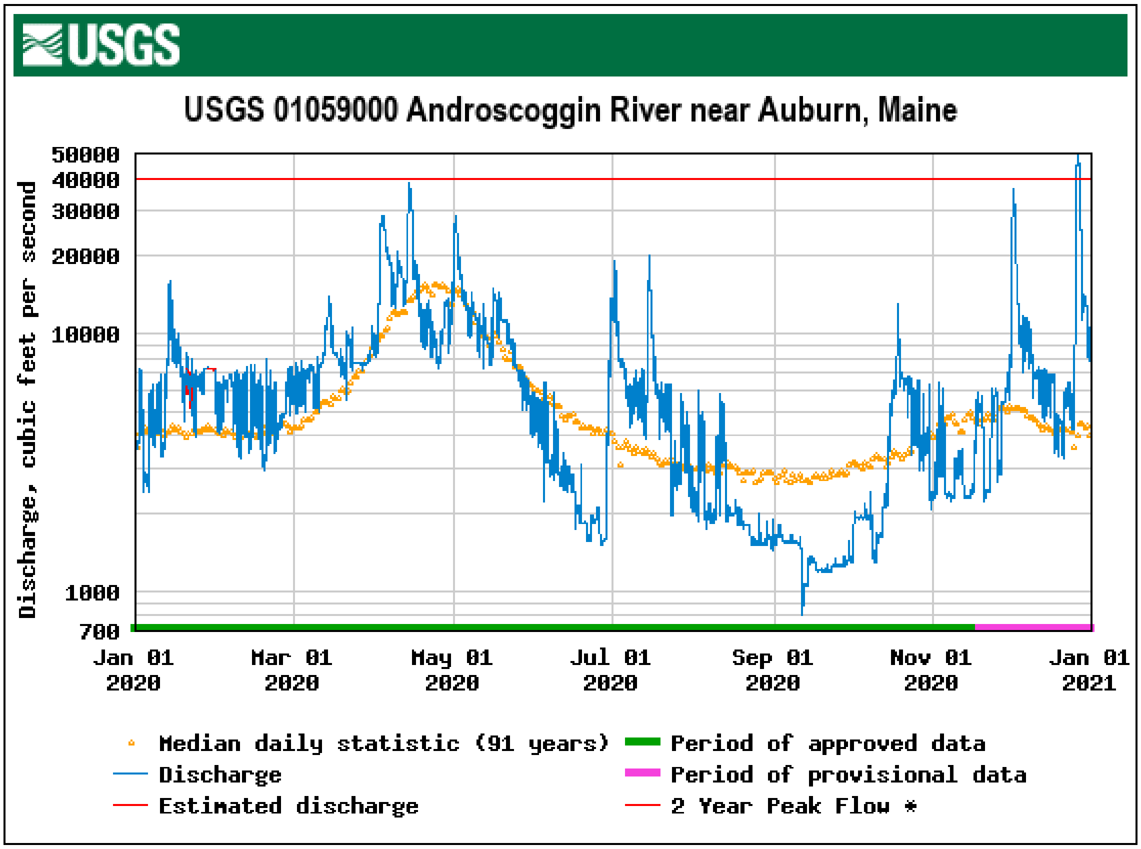
Month	Precipitation	Snowfall	Notes
January	3.27 (-0.26)	17.5 (-3.7)	
February	3.57 (+0.26)	13.4 (-3.1)	
March	2.39 (-1.78)	8.2 (-11.7)	
April	5.61 (+1.23)	6.8 (+2.0)	
May	2.54 (-1.36)	1.1 (+1.1)	Snowiest

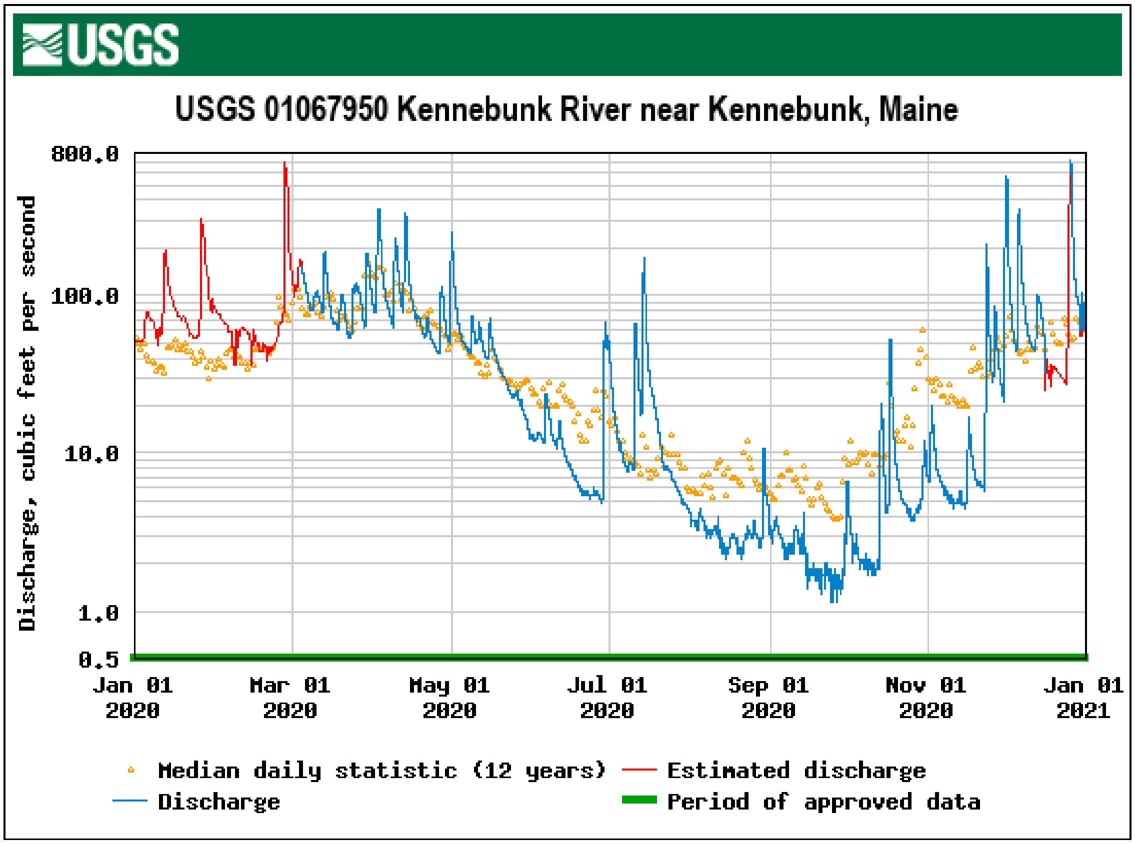
June	5.39 (+1.09)	0.0	
July	5.20 (+0.90)	0.0	
August	2.24 (-1.35)	0.0	
September	1.15 (-3.04)	0.0	
October	4.86 (-0.28)	T (-0.1)	
November	6.73 (+1.38)	0.1 (-2.9)	
December	5.21 (+1.15)	18.8 (+0.5)	
Annual	48.16 (-2.06)	65.9 (-17.9)	

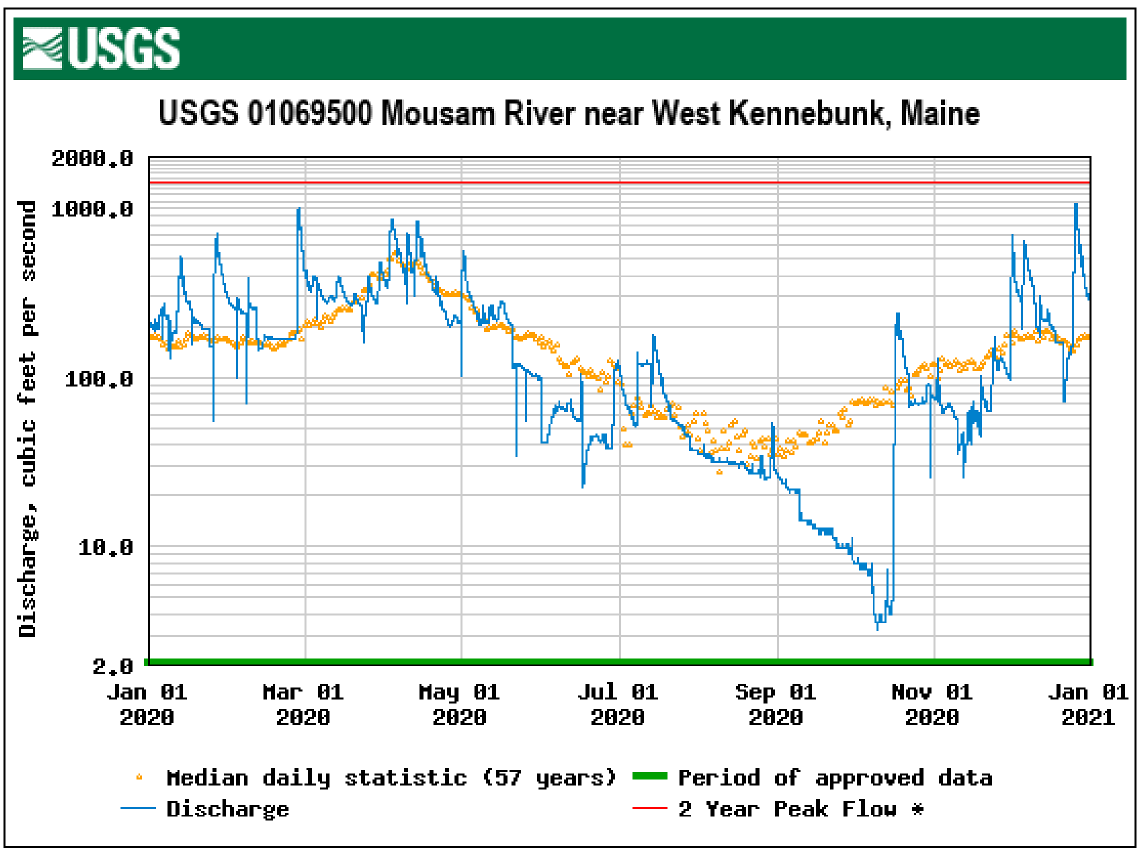
The following graphs depict the recorded discharge on rivers where there are USGS river monitoring stations and which are of interest to VRMP groups.

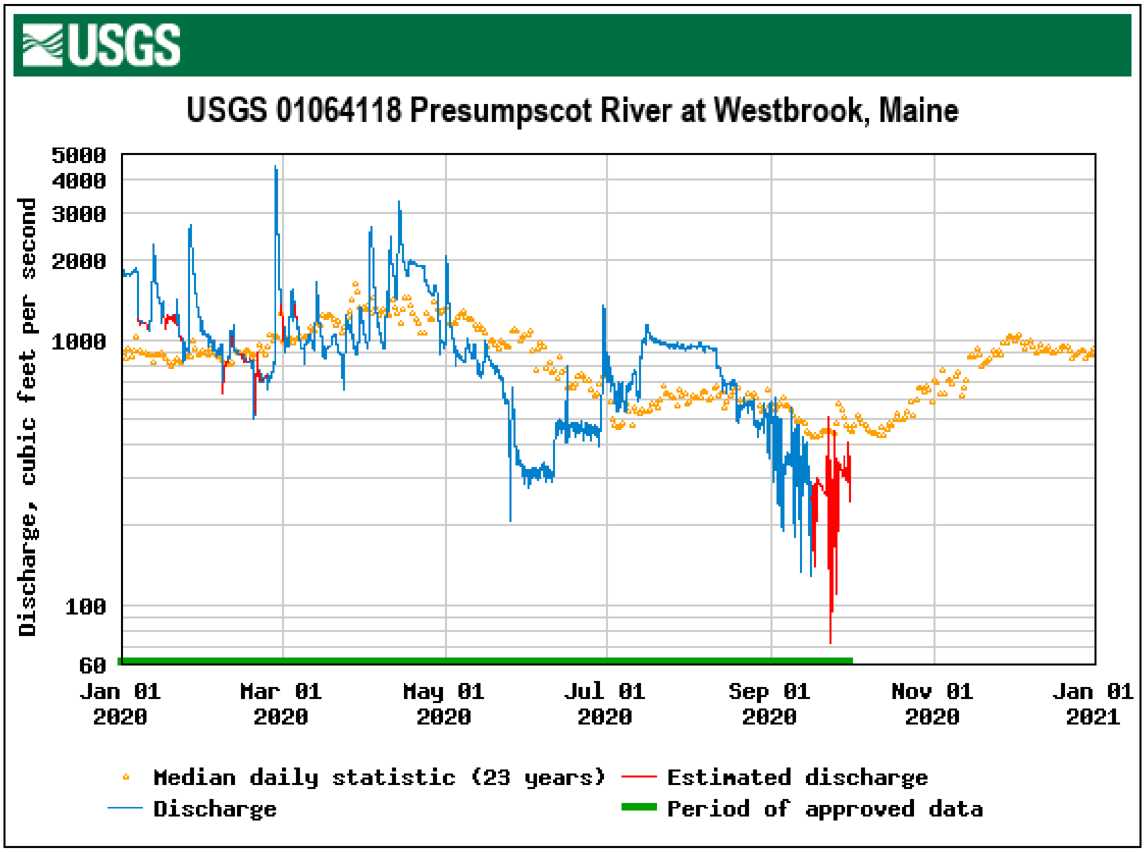



USGS
USGS 01054500 Androscoggin River at Rumford, Maine
Discharge, cubic feet per second
40000
30000
20000
10000
1000
400
Jan 01 2020
Mar 01 2020
May 01 2020
Jul 01 2020
Sep 01 2020
Nov 01 2020
Jan 01 2021
Median daily statistic (120 years)
Discharge
Period of approved data
2 Year Peak Flow *


USGS
USGS 01059000 Androscoggin River near Auburn, Maine
Discharge, cubic feet per second
50000
40000
30000
20000
10000
1000
700
Jan 01 2020
Mar 01 2020
May 01 2020
Jul 01 2020
Sep 01 2020
Nov 01 2020
Jan 01 2021
Median daily statistic (91 years)
Discharge
Estimated discharge
Period of approved data
Period of provisional data
2 Year Peak Flow *


USGS
USGS 01067950 Kennebunk River near Kennebunk, Maine
Discharge, cubic feet per second
800.0
100.0
10.0
1.0
0.5
Jan 01 2020
Mar 01 2020
May 01 2020
Jul 01 2020
Sep 01 2020
Nov 01 2020
Jan 01 2021
Median daily statistic (12 years)
Estimated discharge
Discharge
Period of approved data


USGS
USGS 01069500 Mousam River near West Kennebunk, Maine
Discharge, cubic feet per second
2000.0
1000.0
100.0
10.0
2.0
Jan 01 2020
Mar 01 2020
May 01 2020
Jul 01 2020
Sep 01 2020
Nov 01 2020
Jan 01 2021
Median daily statistic (57 years)
Period of approved data
Discharge
2 Year Peak Flow *



There were 15 days that recorded at least 1.00 inch of precipitation, 0.9 days more than normal. The following table lists the days which received at least 1.00 inch of precipitation in 2020.

Days with At Least 1.00 Inch of Precipitation in 2020

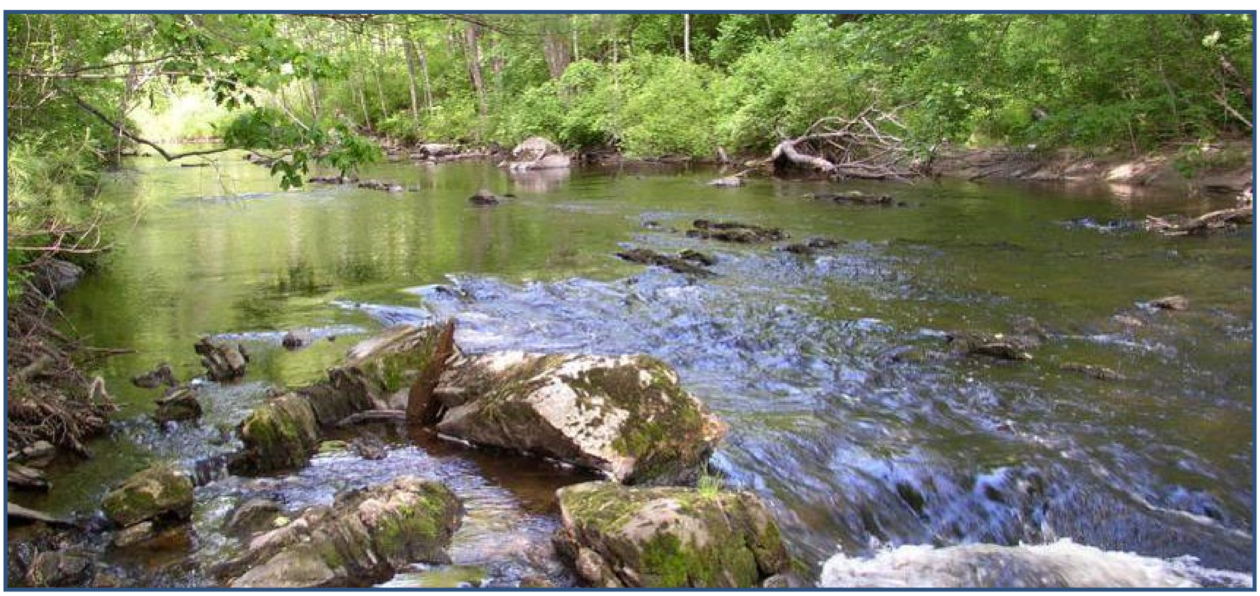
Day	Precipitation (in)	Day	Precipitation (in)
January 25	1.11	July 14	1.51
February 27	1.53	October 13	1.93
April 2	1.41	October 17	1.41
April 9	1.40	November 23	2.35
April 13	1.34	November 30	2.30
May 1	1.22	December 5	1.86
June 29	3.77	December 25	1.37
July 8	1.43		

Monitoring and Time of Day

To assess attainment of dissolved oxygen (DO) criteria within Maine's water quality standards, early morning monitoring may be necessary. DO values generally fluctuate depending on time of day with lowest values often occurring in early morning and the highest values late in the day. The fluctuation may be minimal or significant depending on a number of factors (e.g. streamflow, water temperature, and plant and algae growth). DO data collected during the early morning (between dawn and 8:00 AM) are therefore important for water quality monitoring purposes. Except as naturally occurs, if DO concentration falls below the applicable DO criteria at any time of day, this also signals non-attainment. For tidal waters where understanding the quality and influence of the freshwater is the goal, monitoring is recommended to occur on the low, outgoing tide. Ideally, monitoring should occur anytime this tide corresponds with early morning. Collecting water quality data at particular times of the day (e.g., very early in the morning, or at the low outgoing tide) can be difficult and inconvenient; however, it is encouraged whenever possible.

Bacteria Data

The River/Stream reports contain the bacteria data collected by the volunteer groups and the calculated geometric means. Geometric mean is a special average that indicates the central tendency of a set of numbers. Because very high or low values can skew the mean, geometric mean is used. The means were calculated for all the sites, regardless of the number of samples taken. To calculate a mean for regulatory purposes, at least six samples are required throughout the season (April 15th - October 31st) during a 90-day period and sampling effort is subject to review by DEP Division of Environmental Assessment staff.



Chapter 4
Quality Assurance/Quality Control

VRMP Quality Assurance Project Plan [QAPP], Sampling and Analysis Plans [SAPs], and Sampling Sites

The VRMP's network of volunteer groups monitor under quality-assured volunteer sampling as governed by:

(a) A program-level Quality Assurance Project Plan (QAPP)[1], which includes data quality objectives and Standard Operating Procedures (SOPs) for how to collect water samples and how to use various VRMP-approved water quality meters (Maine DEP, 2020), and;

(b) Individual Sampling and Analysis Plans (SAPs)[2] created by each volunteer group that tailor the program-level QAPP to their specific project situation and which are reviewed/approved by VRMP staff. A SAP provides specific information, including the group's goals and objectives. Project specific details include items such as detailed site location information and sampling logistics. They also include the parameters being monitored, and specific SOPs (or reference to the SOPs). Individual SAPs also allow flexibility for groups to adapt the design of the program to local situations, conditions, and available resources.

This VRMP report will not describe the details (e.g., sampling methods, sample sites), but they may be found in the documents just described. To view the QAPP, visit the VRMP website[1]. For a copy of a SAP, contact VRMP staff.

[1] Maine Department of Environmental Protection. March 2020. Maine Volunteer River Monitoring Program (VRMP) – Quality Assurance Project Plan (2019-2024). Available at https://www.maine.gov/dep/water/monitoring/rivers_and_streams/vrmp/qapp/index.htm.

[2] Sampling and Analysis Plans (SAPs) for individual VRMP groups, which include site descriptions and photographs, are available from the VRMP.

VRMP Quality Control Steps

The following bullets summarize the various QA/QC measures that are a part of the VRMP.

- Individual volunteers are evaluated on the adequacy of their sampling techniques and certified/recertified at annual volunteer training workshops.
- VMRP maintains and calibrates equipment lent to monitoring groups. The accuracy of monitoring equipment or techniques is tested as described in Table 3a of the Quality Assurance Project Plan (Maine DEP [QAPP], 2020).
- Monitors follow an approved SOP for each parameter monitored. Additionally, field calibration and/or accuracy determination procedures are performed for monitoring equipment that require it, as listed in Table 3a or in the instrument's specific SOP.
- For water samples requiring laboratory analyses, field duplicate samples are obtained for at least 10% of samples (i.e. 1 duplicate per 10 samples) collected per parameter (Table 3c of the Quality Assurance Project Plan).
- Sample bottles or containers, if used, are appropriately prepared (e.g. rinsed, sterilized) prior to sampling, by either a laboratory or the volunteer group according to approved SOPs.
- Laboratories that are used by member organizations must meet the criteria listed in Appendix 11 of the QAPP. The laboratories are expected to provide their own internal approach to quality control for each parameter being analyzed, and their testing should meet VRMP criteria outlined in Table 3a if the data are to be included in the VRMP's water quality database. Quality control data (Lab Reports) will be submitted by each laboratory to their patron volunteer monitoring groups who will, in turn, submit copies of this information to the VRMP. The volunteer group reviews the lab QA/QC data for potential problems first and informs the VRMP of any problems. The VRMP will also review the lab reports.
- Water quality data is reviewed according to procedures outlined in the next section.

VRMP Quality Assurance Review of Data

After water quality and associated data are submitted, the VRMP undertakes a thorough review of field forms (hard copies) and electronic spreadsheets to assess the accuracy of the information submitted. VRMP also reviews the data to determine whether QA/QC (quality assurance/quality control) measures stipulated in the VRMP QAPP were carried out by volunteers and labs.

The volunteer groups continue to make improvements each year with QA/QC procedures. Overall, volunteers are completing the field sheets much better and calibrating meters correctly. Problems seem to occur primarily with new monitors. They are sometimes not as attentive to calibrating meters correctly and recording calibration values. VRMP staff tries to perform QA/QC checks during the summer with new monitors. QA/QC issues the monitors need to pay attention to are:

- Make sure that all pertinent sections of the field sheet are filled in completely, including the QA/QC calibration section.
- Meters should be turned on for a minimum of 15-20 minutes prior to calibration
- Duplicate sampling should be done for 10% of samples collected for lab analysis.
- Zero dissolved oxygen tests should be done mid-season.

The following explains the steps taken to review the data and how problem data are handled:

1) VRMP water quality data are entered onto standard field forms. These VRMP datasheets include space for data elements that are entered into the VRMP database. This includes information on how samples were collected, sample location, equipment used, and other important notes or observations. The field form also includes a "QA/QC Check" section and chain of custody for the field form and lab samples.
2) Data are entered by the group's data manager into the online ArcGIS Survey123 app or a standardized spreadsheet template called a "pre-EDD" (Pre-electronic Data Deliverable).
3) The electronic data and hard copies of the datasheets are sent to the VRMP.
4) VRMP staff compares the group's datasheets and electronic files to ensure the records match. A review of field duplicate data and laboratory quality assurance information is also conducted as noted below in the tracking step.
5) When reviewing the data, VRMP staff identifies any problems and may enter specific comments in the VALIDATION_Comments field of the Pre-EDD or in the QA/QC Tracking spreadsheet housed on the DEP server.
6) VRMP staff review lab reports provided by labs that analyze samples. Review includes reviewing procedures such as whether holding times were met, field and lab duplicates and lab blanks-spikes. Data may be rejected by VRMP staff or may include a qualifier (such as holding time exceeded).
7) Some data may be excluded from the database. Reasons for possible exclusion are below.
    - Data values are outside the measurement range (detection limit) [3]

[3] See "Maine Volunteer River Monitoring Program (VRMP) Quality Assurance Program Plan (2020)" Table 3a-Quality objectives for commonly measured stream assessment parameters under the umbrella of the VRMP.

- Calibration value for the dissolved oxygen meter was not recorded and/or there was no indication on the datasheet that it was calibrated
- Calibration value for dissolved oxygen meter is outside the accepted calibration range [<97% or >103%]
- There was a Pre-EDD, but no hardcopy of the datasheet
- Samples for laboratory analyses did not adhere to handling requirements (e.g. did not use sterilized containers, did not get to lab on time, samples not kept cold)

8) Data are uploaded into the DEP's Environmental and Geographic Analysis Database (EGAD) database.

Maine DEP Use of VRMP Data

The VRMP was designed to provide support to volunteer organizations interested in collecting water quality data. The support includes equipment loan and maintenance, annual training on use of equipment, data management and an annual monitoring report. The VRMP has a Quality Assurance Project Plan and each volunteer group has a Sampling & Analysis Plan specific to their monitoring efforts. Data that passes VRMP QA/QC review is uploaded to DEP's database. Thus, all the data is stored electronically and is available for DEP use. Outside organizations or individuals may also obtain the data upon request.

While the data that VRMP affiliated groups gather is high quality, Maine DEP will decide how to use the data in decisions related to laws, enforcement, and other regulatory issues. In some cases, VRMP collected data will be viewed as primarily "advisory level data" since it may be difficult for DEP to defend the validity of volunteer collected data, regardless of the quality assurance steps that are in place.

In general, DEP uses data collected by DEP and quality assured data collected by affiliated groups to assess the water quality of the State's waters. This information is reported out in the 305(b) report, "Integrated Water Quality Monitoring and Assessment Report" that is completed biannually as required under the Clean Water Act. If impairment is identified, further action may be warranted.

Required River/Stream Monitoring Locations

Volunteers are advised that sampling should occur so that a flowing, well-mixed, representative sample is collected. If possible, volunteers should try to sample in the "center half of flow".

Volunteers may also employ a variety of techniques to obtain a well-mixed sample including wading into the stream, using an extension pole or sampling from a bridge/culvert.

Each of the VRMP sampling sites is documented, and VRMP staff visit the sites to approve and certify them. It is critical that volunteers consistently sample from the same location (whenever feasible and safe) to ensure comparability of data at that particular river or stream location.

Maine DEP River Codes that Correspond to Volunteer Group Site Code Names

The VRMP creates unique River Code IDs ("VRMP Site IDs") for each of the local volunteer group sites ("Organization Site Codes"). VRMP Site IDs can be found alongside volunteer Organization Site Codes in the Stream Reports data. For example, the Mousam-Kennebunk Alliance has a site named KB-05. The VRMP Site ID for this site is Kennebunk River-SKE148-VRMP. The "SKE148 is the unique identifier for the DEP database and "VRMP" identifies the site as a VRMP site. For simplicity, only volunteer Organization Site Codes were used in the figures (graphs) in this report.

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