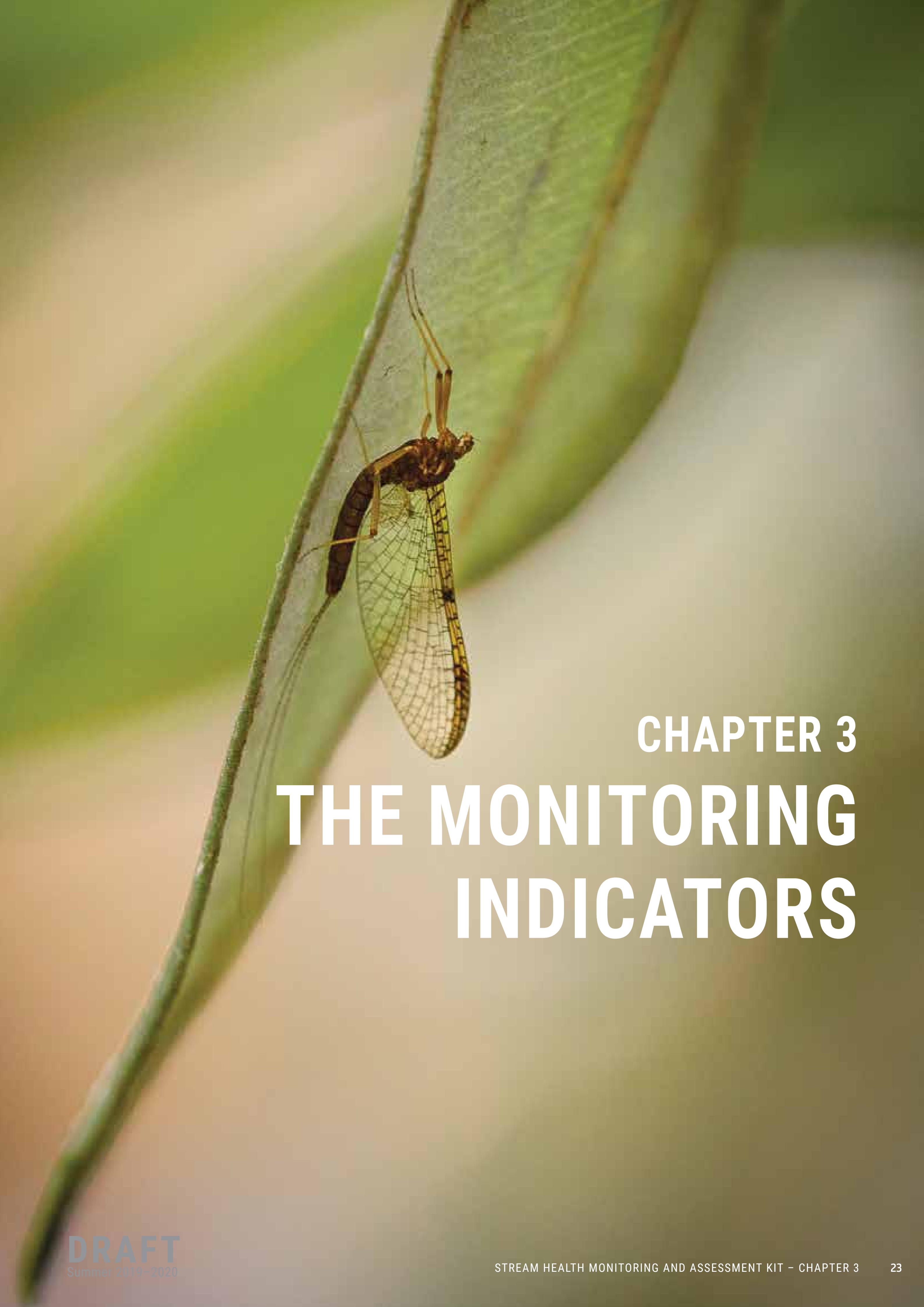

CHAPTER 3
THE MONITORING INDICATORS

CONTENTS

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INTRODUCTION

In this chapter, three categories of monitoring indicators are presented; water quality, stream life (aquatic plants and animals) and stream habitat.

Before you decide what to monitor, it is important to read through this section and understand what each indicator can tell you about the health of your stream.

Stream life and water quality differ in some important ways, and therefore tell us slightly different things about the health of a stream.

Water quality samples

- reflect conditions throughout the whole catchment: influenced by all the waters entering from different sources upstream
- a "snapshot" in time: may not capture a once-off pollutant spill, or extreme values that occur at a different time of day to your monitoring visits
- indicate what may be passed on to downstream waters (rivers, lakes, estuaries, the sea)

Stream life

- respond mainly to the habitat and water quality immediately around them
- can reflect conditions over weeks or months: influenced by conditions that occur when you are not there
- give a picture of overall stream health but it can be hard to know what is affecting them most (because they respond to a wide range of water quality and habitat conditions)

Monitoring water quality, stream life and stream habitat quality together gives the most complete picture of overall stream health, and each indicator helps you to understand or interpret the others. For a few indicators we have two levels (methods) of assessment.

VISUAL CLARITY

Why is it important?

Visual clarity is a measure of underwater visibility in streams. It reflects the concentrations of fine sediment, algae, and other particles suspended in the water. Reduced visual clarity can harm aquatic animals and river birds who rely on sight to find prey and avoid predators, and swimmers who may not see underwater hazards. Reduced clarity also means less light getting through the water to the stream bed where plants need it for photosynthesis. The fine sediment that causes low visual clarity may clog the gills of fish and benthic macroinvertebrates.

How is it measured and reported?

Visual clarity is measured using a clarity tube or black disc, which both measure the distance through water that a human eye can see a black object. The results are reported in metres. The measurement value to be reported is the average of two measurements, the distance at which a black disc disappears from sight and the distance at which it reappears. Most streams are best assessed by viewing a black disc in the stream through an underwater periscope. This equipment works well down to about 0.1 m (10 cm) visibility. If your stream is very turbid (<0.5 m visibility), the clarity tube is preferred because it is more precise and safer (no wading required). Visual clarity is strongly influenced by streamflow, and so is very changeable and should be measured on every visit (e.g. monthly).

What does it tell us?

Low visual clarity (cloudy water) usually tells us that fine sediment such as clay and silt particles are getting into the stream. Human activities in the stream catchment (such as earthworks or livestock grazing) can greatly increase the amount of fine sediment that enters the stream. Low visual clarity is often accompanied by faecal contamination, nutrients and other contaminants, so it may also indicate that levels of these contaminants are high.

WATER TEMPERATURE

Why is it important?

Aquatic animals struggle to live in warm water. In New Zealand, benthic macroinvertebrates cannot live in water warmer than about 22 °C, and few aquatic animals can survive above 30 °C. This is because they are used to living in well-shaded forested streams, and they are not used to the high afternoon temperatures that occur where that tree cover is gone. So, small streams without much shading usually have only a few species of aquatic animals.

Water temperature also affects many of the physical and chemical characteristics in streams. Warmer water holds less oxygen than colder water and increases the sensitivity of aquatic animals to toxins and diseases (two reasons why aquatic animals die in warm water), and increases the rate of chemical reactions and biological processes such as photosynthesis.

How is it measured and reported?

Single measurements of temperature are made with a thermometer. We recommend measuring water temperature at the same time of day on each monitoring visit, and always recording the time that you measure. This is because water temperature fluctuates over the day, reaching a minimum near dawn and maximum in the afternoon. A single temperature measurement may not be very informative. A series of measurements over time will show how stream water temperature changes with weather and season, and allow you to compare your stream with others.

However, even a series of measurements may not show the extreme temperatures that cause stress on aquatic life. For that, you need to measure at mid-afternoon on the hottest days - days with clear sun during late summer when stream flows tend to be lowest. Temperature loggers are often used to capture the full range of water temperatures that occur over a day and during the hottest days. Temperature loggers are set to measure temperature at regular intervals (usually every 15 to 30 minutes) for a set period of time (usually weeks or months).

What does it tell us?

Many human activities can change water temperatures, including:

- discharging warm water from thermal power stations
- releasing water from dams (releasing bottom water can reduce downstream temperatures, releasing surface water can increase them)
- removing shade trees and shrubs from riparian areas
- changing water levels by abstraction or diversion of water for irrigation, and
- connecting paved surfaces to streams via stormwater pipes.

CONDUCTIVITY

Why is it important?

Conductivity is a measure of how well the water can conduct an electrical current. Conductivity increases with increasing salt content (salts such as chloride, bicarbonate, sodium, calcium,) and increasing temperature.

Each stream tends to have a relatively consistent range of conductivity. Once you know this range, you can use it as a baseline to compare with each conductivity measurement. A large increase in conductivity (if the water level has not changed much) might indicate that a discharge or some other source of pollution has entered a stream.

The dissolved salts measured by conductivity usually do not have a direct effect on stream life until they reach levels found in brackish water or seawater (greater than about 5,000 μS/cm).

How is it measured and reported?

Conductivity is measured using a conductivity meter and is reported in microSiemens per centimetre (μS/cm) (the opposite of electrical resistance). Because conductivity is higher at warmer temperatures, the displayed value is adjusted to what conductivity would be at 25 °C. Conductivity measurements are most useful when collected many times over a long period. Recording the typical range of values at different times of year and during different stream flow conditions allows you to notice any unusual changes outside of this range.

What does it tell us?

Conductivity is often used in water quality studies as a quick indication of the level of salt content (including nutrient "salts") in the water. One particular use is detecting intrusion of seawater or geothermal water, since both of these have much higher conductivity than stream water. If you are looking for inanga spawning areas, this can help you locate the end of the "saltwater wedge" where inanga usually spawn.

Conductivity can also tell us something about where the stream water has come from. High-conductivity streams typically have more input of groundwater, with longer underground flow paths, than low-conductivity streams.

In general, however, conductivity is hard to interpret on its own, and is normally used to support other information. For example, high conductivity may be a factor explaining high growth of periphyton (algae) in a stream, but you need to confirm that all other conditions (e.g. light, temperature, streamflow) are suitable for growth and have recorded high periphyton cover there.

NITRATE

Why is it important?

Nitrogen is an important nutrient supporting plant growth. Nitrogen in soil and water is cycled through several different forms, including ammonia/ammonium (NH_3/NH_{4+}), nitrate (NO_{3}-), nitrite (NO_2^-) and organic nitrogen. Nitrate dissolves easily in water and can easily pass through soils, particularly during heavy rainfall. Once in a stream it can be readily used by plants and algae for growth and even moderate concentrations can cause plants and algae to grow to nuisance levels. However, the effects depend on various other factors, such as phosphate (the other important growth nutrient), light, flood frequency, etc. High nitrate concentrations can also be toxic to aquatic animals, and to human health. High nitrate concentrations in drinking water have been linked to a blood disorder in infants called blue baby syndrome.

How is it measured and reported?

Nitrate concentration is usually measured using “colorimetric” methods, where chemicals added to a water sample react with the nitrate to form a colour. The intensity of the colour shows the concentration of nitrate. Professional laboratories measure the colour intensity (actually, the amount of light absorbed by the sample) using an instrument called a photometer or colorimeter. In SHMAK you read the colour intensity by eye using a colour comparator, so the SHMAK method unfortunately is less accurate than professional methods.

Nitrate concentrations are usually reported in mg/L, which is the same as g/m³ or ppm (parts per million). Normally it is “mg/L nitrate-nitrogen” (or “mg/L NO_3-N”), but sometimes you might see “mg/L nitrate” instead. The difference is that mg/L nitrate-nitrogen measures only the nitrogen atom whereas mg/L nitrate measures the whole nitrate molecule, which is heavier. 1 mg/L nitrate-nitrogen is the same as 4.42 mg/L nitrate.

What does it tell us?

In agricultural catchments, high nitrate concentrations in streams typically result from nitrogen fertilisers and livestock that excrete large amounts of nitrogen in their urine. Near homes and residential areas, high nitrate can also indicate overflows or leakage from sewage pipes or septic tanks, or or it can be found in stormwater inputs. Apart from toxic effects, the main concern with high nitrate in streams is its effect on stimulating periphyton (algae) or macrophyte (aquatic plant) growth. But because nitrogen can cycle between different forms, it is hard to predict the effects of nitrate without also knowing how much nitrogen is in the water in other forms (e.g. ammonium or organic forms). High nitrogen suggests that nuisance growths of periphyton or macrophytes might occur, but other factors, such as low light, low phosphorus, low temperature and/or frequent floods, may prevent nuisance growths. To get a complete picture of nitrogen in your stream, we recommend sending a water sample to a professional lab for ammonium, nitrate, nitrite and total nitrogen analysis.

PHOSPHATE

Why is it important?

Phosphorus is an essential growth nutrient for plants. In water, phosphorus occurs as phosphate (PO_4^{3-}) which has both organic forms (derived from plants and animals) and inorganic forms (derived from rock). Most phosphate enters streams attached to soil particles, some of which settle on streambeds. While it is attached to this sediment, the phosphate is not immediately available as a nutrient for plants and algae. However, over time and in the right conditions it can be released from the sediment as dissolved phosphate, which can be taken up by growing algae and aquatic plants. Even at very low concentrations phosphate can stimulate plant growth.

How is it measured and reported?

Like nitrate, phosphate concentration is normally measured using a colorimetric method. When a chemical is added to the water sample, it reacts with phosphate to form a blue colour and the intensity of this colour is measured using a photometer or colorimeter. Like a professional lab, the SHMAK kit uses a colorimeter (called a phosphate checker), but it is less accurate than a professional colorimeter, especially at low concentrations.

Phosphate concentration is normally reported in mg/L, which is the same as g/m³ or ppm (parts per million). Because phosphate concentrations in streams are often very low, you often see ppb (parts per billion) too. Parts per billion is 1000 times greater, i.e. 1 ppm = 1000 ppb.

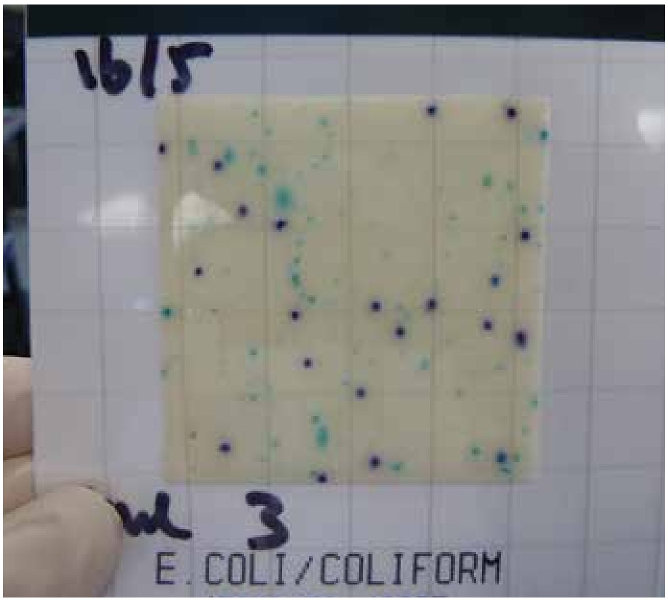
The Hanna Instruments phosphate checker in SHMAK shows phosphate concentration as mg/L phosphate, but most professionals report it as mg/L phosphate-P. The difference is that mg/L phosphate-P measures only the phosphorus atom whereas mg/L phosphate measures the whole phosphorus molecule, which is heavier. Multiplying your colorimeter results by 0.326 will convert them from phosphate to phosphate-P, so you can compare them directly with most professional lab results. 1 mg/L phosphate is the same as 0.326 mg/L phosphate-P.

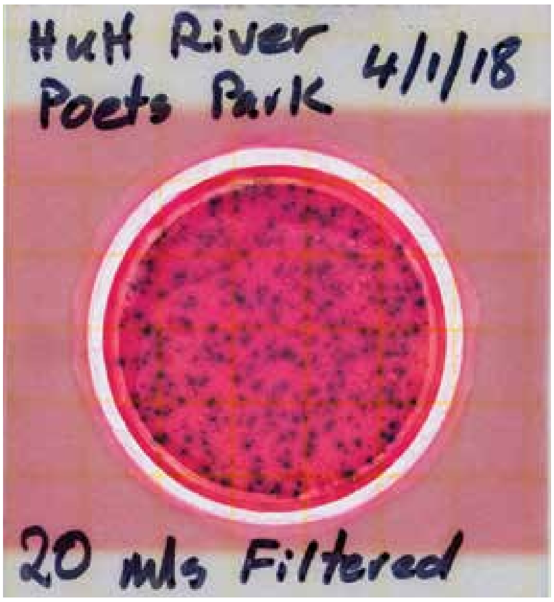
Measuring dissolved phosphate is challenging because in most New Zealand streams it is present in very low concentrations (< 0.01 mg/L).

What does it tell us?

High phosphate concentrations can indicate high levels of soil erosion and/or use of phosphate fertiliser in the catchment. In urban environments high phosphate concentrations can result from wastewater and stormwater inputs, runoff from commercial cleaning or from phosphate fertilisation of gardens and playing fields.

The main concern with phosphate in fresh water is its effect on stimulating algal or aquatic plant growth. However, it is hard to predict these effects from the amount of dissolved phosphate in a water sample, as sediment-bound phosphate (which is difficult for volunteers to measure) may also contribute to plant growth. Even if all the phosphorus is measured, it still may not be easy to predict effects on aquatic plant growth for the same reasons as described for nitrate. To get a more complete picture of phosphate in your stream, we recommend sending a water sample to a professional lab to analyse for phosphate (typically referred to as dissolved reactive phosphorus) and total phosphorus.





E. coli BACTERIA

Why are they important?

Faecal microorganisms come from humans and warm-blooded animals such as farm animals, pets, birds and pest mammals. They can enter streams in a variety of ways including discharge or leakage of sewage, animals defecating in the water, or runoff from grazed pastures. Drinking, swimming or eating certain foods (e.g., shellfish) from water contaminated with faecal matter can make you sick from taking in human faecal pathogens such as *Campylobacter* or *Cryptosporidium*. The bacteria *Escherichia coli* (*E. coli*), found in the intestines of warm-blooded animals, is used as an indicator for faecal contamination. The common strains of *E. coli* are not harmful themselves, but indicate that harmful pathogens may be present.

How are they measured and reported?

E. coli in water is reported as "colony forming units" (cfu) in 100 mL of sample water. Each colony on a growth plate represents a single *E. coli* cell, or a clump of cells, that has multiplied many times and become visible to the human eye. *E. coli* can be grown and counted on a Select *E. coli* Count Plate (SEC plate). The colour of the colonies depends on what brand of growth plate you use. The growth media on these plates contains a combination of nutrients and colour-producing chemicals that make *E. coli* colonies appear purple-blue (MCM media) or blue (Petrifilm™). Coliform bacteria that are not *E. coli* appear green (MCM media) or pink/magenta (Petrifilm™).

What do they tell us?

High concentrations of *E. coli* bacteria suggest that pathogenic microorganisms might also be present in your stream and swimming or water sports may be a health risk. *E. coli*, together with rubbish, periphyton and visual clarity, measures the overall 'swimmability' of fresh water.

Sources of faecal contamination could be humans (e.g. leaking septic tanks or sewers), livestock, waterfowl or, in urban areas, pet waste. The risk of human pathogens differs between these different sources. For example, the risk from cattle faeces is roughly similar to human sewage, while the risk from bird faeces is likely to be lower. Further investigation will be needed to work out the most likely source of the *E. coli* you measured, and the health risk it represents. Your local regional council or organisations like ESR (the Institute of Environmental Science and Research) may be able to help with this.

PERIPHYTON

Why is it important?

Periphyton refers to communities of algae and cyanobacteria attached to the sediment surface or to aquatic plants. Periphyton varies from thin slippery films to thick mats or long filaments in many shades of green and brown.

Periphyton plays an important role in stream ecosystems by providing a food source for macroinvertebrates. But too much periphyton causes problems. Thick growths look ugly, spoil recreational activities such as swimming and fishing, and can clog water intakes and filters. They can also smother habitat for macroinvertebrates and strip oxygen from the water at night, which harms macroinvertebrates and fish. One type of periphyton (a cyanobacteria or "toxic algae" called *Microcoleus*) can taint drinking water with a musty odour and even produce toxins that have killed dogs.

How is it measured and reported?

In SHMAK, you can choose between two methods for estimating periphyton coverage, depending on the time available and your equipment. The results are reported as the percentage of the stream bed covered by periphyton in a certain area.

The stone method (SHMAK Level 1)

Examine 10–20 stones, one at a time

- Doesn't require equipment
- Quick

The viewer method (SHMAK Level 2)

View 10–20 areas of stream bed

- Covers a larger area
- Provides a more accurate estimate of periphyton cover across your whole site

Because periphyton growth changes a lot over time, it is best to monitor it every time you visit the site (ideally monthly) so you can calculate average growth. Monitoring periphyton at the same time as water quality is useful because periphyton responds to water quality (especially nutrients and temperature). The most important information about periphyton is its maximum growth: how much periphyton accumulates when conditions are ideal (e.g., stable flows, plenty of sunshine, and warm temperatures – conditions that are most likely to occur in late summer).

What does it tell us?

Most small New Zealand streams have little obvious periphyton, because they are naturally shaded and the periphyton is quickly eaten by benthic macroinvertebrates. Blooms of nuisance periphyton are usually a symptom of a system stressed by factors such as nutrient enrichment, high light (from removal of bankside vegetation) and high temperatures (that increase algal growth rates and stress some invertebrate grazers). If enough light is reaching the stream bed, nutrient levels tend to be the main factor limiting periphyton growth. This means that an increase in nutrients can cause periphyton growth to reach nuisance levels (provided floods are not frequent and the stream has a stony bed on which periphyton can easily grow).

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MACROPHYTES

Why are they important?

Macrophytes are large aquatic plants, often (but not always) with leaves and roots. In muddy or sandy-bottom streams they are normally the main type of aquatic plant (whereas periphyton is the main plant type in stony-bottom streams). Macrophytes produce oxygen, provide refuge for fish and substrate for benthic macroinvertebrates and contribute to nutrient cycling. However, too much macrophyte growth can impact on human values by affecting swimming or fishing, causing flooding, clogging water intakes, depleting dissolved oxygen levels, smothering the stream bed and causing fine sediment to settle on the stream bed. Some macrophytes, such as oxygen weed, are classed as invasive (or noxious) weeds because they quickly invade new areas and form large dense beds that choke waterways and exclude other plant and animal species.

How are they measured and reported?

There are two macrophyte indices:

- The "macrophyte water surface cover index" estimates the amount of water surface area occupied by macrophytes
- The "macrophyte clogginess index" estimates the percentage of the water volume that is occupied by macrophytes.

Macrophytes are reported as the average cover of macrophytes at your site (as a percentage).

Since macrophytes require some soft sediment (sand or mud) they are typically assessed in soft-bottom streams only. However, some species can be rooted in the stream bank and grow across the water surface in smaller hard-bottom streams.

Macrophytes can be monitored once per year in summer, when their growth is at its peak. But monitoring also in spring and autumn, provides more information, which can be helpful.

What do they tell us?

The amount of macrophyte cover in a stream tells us how suitable the conditions for growth are. These conditions include the amount of light, flood frequency, flow velocity, and nutrient concentrations in the water and sediments. Nuisance growths of aquatic macrophytes are generally most common in unshaded, nutrient-rich lowland streams. Nutrient runoff from the land, as well as inputs from sewage and stormwater discharges, can promote macrophyte growth. Increasing stream lighting to >30% of full sun, (e.g., by removing riparian vegetation), will typically result in nuisance growths. Conversely, restoring riparian forest can limit growths of pest species while enabling shade-tolerant native species to survive.

The two macrophyte indices indicate impact on stream flow, recreational use and ecological health. High macrophyte cover can harm aquatic animals by reducing dissolved oxygen during the night when they respire; measuring minimum dissolved oxygen (typically near dawn) can help determine if this is occurring.

BENTHIC MACROINVERTEBRATES

Why are they important?

Benthic macroinvertebrates are animals that live at the bottom (benthic) of streams and lakes, are large enough to be seen with the naked eye (macro) and lack a backbone (invertebrate). We often call them stream bugs for short. In fresh waters, they consist of the immature stages of many insects such flies, mayflies, caddisflies, stoneflies, beetles and damselflies. As well as insects, there are also crustaceans (e.g. kōura/crayfish and shrimps), snails, worms and leeches. Stream bugs are a key part of stream food webs, feeding on periphyton, macrophytes, dead wood or each other. The aquatic larvae are an important food source for fish and the winged adults are often eaten by birds.

How are they measured and reported?

In the SHMAK, macroinvertebrates are sampled using a sieve or a kick-net as outlined below.

	SHMAK level 1	SHMAK level 2	SHMAK level 2
Stream type	Stony-bottom	Stony-bottom	Sandy/muddy-bottom
Equipment	Sieve	Kick-net	Kick-net
Method	Collect individual stones	Disturb the stream bed to dislodge macroinvertebrates	Jab vegetation, brush logs and wood
Advantages	Quicker than kick-net	More accurate	More accurate
Disadvantages	Misses some species	Time consuming	

After collecting, the different bug types are identified. Each type has a "tolerance score" from 1 to 10 that indicates how sensitive it is to water pollution or habitat degradation (10 means only found in healthy streams, 1 means often found in poor conditions). The different scores can be combined and reported in one or more macroinvertebrate health indices. One index commonly reported by professionals in the Macroinvertebrate Community Index (MCI).

What do they tell us?

Because the tolerance of each macroinvertebrate type to environmental impacts is well known, the particular variety of bugs present in a stream can tell you about environmental conditions there. However, it might not tell you which environmental factor is causing some bugs to be missing. Undertaking a habitat assessment and water quality measurements at the same time can help you work this out. Stream bugs live in streams for months or years so they reflect a range of habitat and water quality conditions over a long period of time, whereas water quality measurements measure only one type of impact at one point in time.

FISH

Why are they important?

Native fish are an important part of New Zealand's freshwater biodiversity. New Zealand has approximately 53 native species of freshwater fish (although the exact number of species is under review), most of which are endemic (found only in NZ). Most species are declining in numbers across the country and some are threatened with extinction.

Fish play an important role as top predators in healthy stream ecosystems. The species present and their abundance affects abundances of stream bugs and some ecosystem processes.

How are they measured and reported?

The three main sampling methods for estimating fish numbers in a stream are backpack electrofishing (pictured top left), trapping (with fyke nets or Gee minnow traps) and spotlighting. Spotlighting is the method recommended in the SHMAK because it requires the least specialised equipment.

Spotlighting (recommended in SHMAK):

Spotlighting is the method recommended in the SHMAK because it requires the least specialised equipment. Spotlighting involves shining a powerful spotlight into the stream reach at night and recording what species are seen. It is suitable for wadeable streams because many freshwater fish species are benthic (bottom-dwelling) and nocturnal (more active at night).

Trapping:

Trapping involves setting a fyke net or Gee minnow trap along the stream reach, leaving it out overnight and retrieving it the next morning. This method is a viable alternative option if working with a council or community organisation that can purchase the equipment.

Electrofishing:

Electro-fishing, which uses an electric current to temporarily stun fish so that they can be assessed, must be carried out by a trained professional.

Whichever method is used, the types and numbers of each species caught are usually recorded in the New Zealand Freshwater Fish Database. Fish surveys are best undertaken during the summer (December to March) as fish generally become less active when temperatures are low. The optimal time for sampling is when flows are stable and at (or close to) base flow. Sampling within 5 days after a flood is usually avoided.

Fish data are usually reported as simply a list of fish present (with their abundances and size range if measured). There is an index called the Fish Index of Biotic Integrity, which increases with more native fish species present and decreases with more pest fish present.

What do they tell us?

The range of native fish present can tell us about the habitat and water quality, both at your site and between your site and the sea. Also, because about a third of native species spend some part of their lives at sea, they need uninterrupted passage between the sea and their freshwater habitats to complete their life cycle. Therefore, species may be absent if there is:

- habitat loss (including loss of water, riparian vegetation, large instream features like boulders and wood, or infilling of the gaps between streambed cobble by fine sediment)
- a barrier to migration (e.g., culverts and dams)
- low dissolved oxygen levels
- high temperatures
- low food resources (benthic macroinvertebrates) or
- predatory introduced fish present.

To know what fish species are absent you will need to know what species should be there. Sampling a nearby reference site or checking the NZ Freshwater Fish Database (**https://nzffdms.niwa.co.nz/**) could help, but best would be to discuss with a fish expert, such as at your regional council.

CURRENT VELOCITY

Why is it important?

Current velocity is the speed at which the water moves in the stream, and is a key aspect of aquatic habitat. A fast current helps plants to take up nutrients and animals to take up dissolved oxygen from the water. And it brings more food to aquatic animals than a slow current. So fast-moving streams often contain a higher diversity of macroinvertebrates and fish than sluggish streams.

However, water velocity also exerts a direct force on plants and animals, so a very fast current can stop periphyton and macrophytes from reaching high abundances. High velocities during floods can flush out fish, dislodge stream macroinvertebrates and uproot macrophytes. Periphyton may be scoured off rocks during high velocities by the water itself, by abrasion of moving sediment (sand blasting) or by the rocks being rolled over.

How is it measured and reported?

Surface velocity can be measured from the rate that a floating object (e.g., an orange) moves along a measured length or section of stream.. It is best to measure in a run section where flow is fairly uniform and there are not many obstructions.

This method gives only a rough measure of average velocity because water moves at different speeds in different places: it is faster near the surface in midstream and slower near the stream bed and banks due to friction. Average velocity across the whole stream is normally about 86% of the surface velocity you measure, so you can calculate average velocity by multiplying by 0.86.

Professionals typically use a current meter to measure velocity at different depths then calculate average velocity from these.

Current velocity is reported as distance per unit time (e.g., metres per second or m/s).

What does it tell us?

Velocity can be multiplied by stream cross-sectional area to calculate streamflow (see "Streamflow" section opposite). Also, if you have measured velocity on every monitoring visit, it can be used on its own, or with water level, as a relative measure of streamflow. Velocity indicates the potential for material (e.g., rubbish) to be transported downstream.

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STREAMFLOW

Why is it important?

Streamflow (discharge) is the volume of water per unit time flowing past a point in the stream. It is a key measure of the size of the stream and of "state of flow" – how today's flow compares to the average.

The streamflow at the time of your monitoring visit is important for understanding the water quality on that day, as water quality depends strongly on streamflow. Therefore, it is important to estimate streamflow, or at least water level, on every monitoring visit.

The streamflow "regime" of a stream (median streamflow, mean streamflow and other statistics) describes how much a stream changes over time, usually in response to rainfall or snowmelt. A very changeable stream may be a more difficult habitat for aquatic plants and animals to live in than a more stable stream.

How is it measured and reported?

Water level measurements can provide a qualitative estimate of stream flow. Water level can be described as low, normal, slightly raised or high. If you are familiar with the stream, you can judge water level from your own experience. If you don't know the normal water level, then you can judge it in relation to perennial terrestrial plants and the stream banks. If the water is far below the perennial plants and the water is clearer than usual, the water level is low. If the stream is flooding over banks or over the roots of trees and shrubs, the water level is high.

Measuring streamflow (in m^3/s) gives more detailed information than estimating water level. For long-term monitoring sites, the best approach is usually to find a nearby site suitable for installing a staff gauge (similar to a vertical tape measure on a pole) to indicate water level on your stream visits. Water level can be converted to streamflow by developing and maintaining a rating curve.

Alternatively, you can estimate streamflow by measuring current velocity (see Current Velocity section) and cross-sectional area of the stream. Cross-sectional area is calculated by measuring water depths at 5-10 equally-spaced points across the stream channel and multiplying the average depth by the stream width.

Keep in mind that water level or streamflow measurements may collected (or estimated) by your regional council.

What does it tell us?

Streamflow on the day of (and 1-2 days before) your monitoring visit helps you to understand the water quality you measured that day, because most water quality indicators change with streamflow. For example, visual clarity is usually low at high streamflow and water is clear at low streamflow.

The streamflow in the days or weeks before your monitoring visit may help explain your results for periphyton, and may tell you whether it is a suitable time to sample macroinvertebrates.

STREAM HABITAT

Why is it important?

Stream habitat is defined as the whole stream environment including the stream bed, stream banks and land use in the immediate vicinity of the stream (riparian zone). It is formed by the interaction between several factors, including topography (shape of the land), geology, climate, and land-use.

The type and quality of this physical habitat have a significant influence on the stream plants and animals because each species needs a suitable "living space" to survive. Each species prefers different habitat conditions (e.g. some species prefer fast moving water, others quiet pools). Stream habitat provides:

- a place to live
- shelter from high flows
- protection from predators
- a place to lay eggs.

How is it measured and reported?

Stream habitat can be assessed several ways, ranging from visual observations to detailed measurements. In SHMAK we score eight different aspects of the stream bed, banks and riparian zone. Each aspect is assessed visually, by matching your site to descriptions that reflect a continuum of conditions from excellent to poor. This approach requires no equipment except a tape measure. Because stream habitat changes slowly under normal conditions, it only needs to be measured once per year. However, it is wise to re-assess after a large storm or new earthworks or construction activities.

What does it tell us?

Stream habitat assessments tell us about various human activities that may have degraded stream habitat (e.g., the removal of riparian vegetation, causing stream bank erosion, increased sedimentation, and smothering of fish habitat). Poor habitat conditions could cause a greater impact on stream life than poor water quality. Therefore, assessing habitat as well as water quality is necessary to interpret the results of biological monitoring.

Identifying which habitat features could be affecting stream health will help you set goals for restoring stream health. Monitoring stream habitat over time can also help you evaluate the success of your restoration efforts.

STREAMBED COMPOSITION

Why is it important?

The composition of the streambed (the type and size of particles that make up the bed) has a strong influence on stream life. Streambeds made up mostly of boulders and cobbles provide hard surfaces that stream bugs need to crawl on or under. So, they support a greater range and higher numbers of stream bugs than beds made up of fine sediments like silt. Cobbles and boulders also provide good habitat for native fish, creating spaces where the fish can shelter, feed and nest. Fine sediment (sand and mud) deposited on a stony stream bed can smother the hard surfaces macroinvertebrates like, fill up the spaces that fish use and clog their gills.

How is it measured and reported?

The most common method to estimate streambed composition is the Wolman walk (SHMAK Level 2). Randomly selected streambed particles are picked up, measured and the different size classes counted. A quicker method is a visual assessment (SHMAK Level 1), which can be made by walking up and down your stream reach and estimating the proportion of the streambed composed of each the categories given. This gives a rougher estimate than the Wolman method.

Streambed composition typically changes slowly so only needs to be monitored annually, ideally at the same time as you collect your benthic macroinvertebrate sample. But it can be useful to re-assess after a large storm or new development in the catchment.

Streambed composition is reported as the percentage of the stream bed that is covered by different categories and size classes of particles. Streambed particles range from mud or sand (<2 mm) to boulders (>25 cm). The stream bed may also be covered by leaves, wood, macrophytes (aquatic plants), concrete or bedrock.

What does it tell us?

Streambed composition tells us what sort of aquatic life we could expect to see (provided water quality and flows are sufficient). It also tells us both about the natural setting of a stream (catchment geology and topography) and about human influences. Streams in steep headwaters, in catchments with hard rock types, and those experiencing frequent large floods usually have beds dominated by large particles (cobbles and boulders). Streams in lowland, low-gradient valleys, in catchments with soft sedimentary rocks and/or having floods tend to have beds of fine sediment. A covering or build-up of fine sediment can also indicate soil erosion in the catchment or stream banks made worse by human activities such as earthworks or farming.

RUBBISH

Why is it important?

The pollution of fresh waters by household and commercial waste is a growing concern.

Rubbish:

- makes streams unattractive
- can make them unsafe for recreation
  - broken glass or discarded appliances can be sharp or dangerous
  - discarded chemical containers can leak toxic contaminants
  - some types (e.g. soiled nappies) can spread human pathogens
- can harm wildlife
  - animals can become trapped, strangled, or may eat some items.

Much of the rubbish is eventually transported downstream to estuaries or out to sea where it continues to harm the environment and pollute beaches.

How is it measured and reported?

A simple visual assessment can be made by estimating the amount of different rubbish types in and around a stream reach. In this SHMAK Level 1 method, several aspects of rubbish are scored on a scale of 1 to 8 and summed to give a final score out of 40:

Overall amount of rubbish	8	7	6	5	4	3	2	1
Threat to aquatic life	8	7	6	5	4	3	2	1
Threat to human health	8	7	6	5	4	3	2	1
Amount coming from on-site dumping	8	7	6	5	4	3	2	1
Amount accumulating from upstream	8	7	6	5	4	3	2	1
Total	**Score out of 40**							

For a more comprehensive understanding of what rubbish is there and where it is coming from, the rubbish tally method is used. In this SHMAK Level 2 method, rubbish items are identified and counted by material type (e.g., glass, metal, plastic) and use (e.g., food wrappers, metal appliances). They can then be weighed, and are removed from the site.

We recommend assessing rubbish once per year, or once each season if you want to determine the rate that rubbish accumulates in your stream reach in different seasons.

What does it tell us?

Assessing rubbish in streams can tell us where littering or dumping is occurring, can raise awareness of rubbish issues and show where better waste management strategies are needed. Be aware that the rubbish may have been dropped upstream or elsewhere in the catchment, and carried to your site by rain or wind. Rubbish surveys using the tally method can be linked with nearby coastal surveys of beach litter to help estimate the types and amount of rubbish exported out to sea. If you completely remove all the rubbish at your site and revisit the site regularly, then you can work out the accumulation rate (number of pieces per day) from your data, and compare accumulation rates at different stream sites.