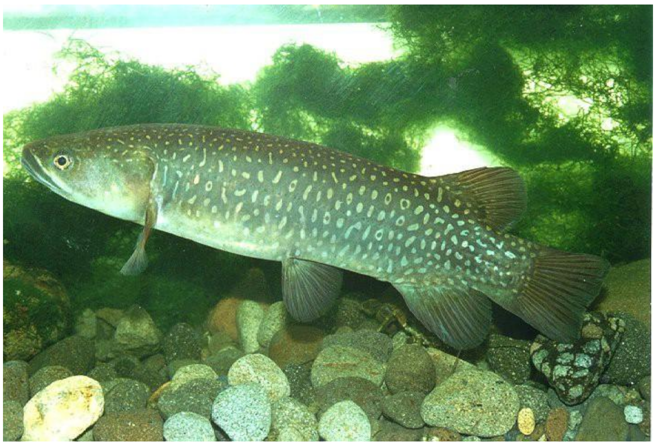
Whitebait Connection (WBC) freshwater discovery and monitoring handbook

(For MTSCT endorsed WBC coordinators)



A programme of the Mountains to Sea Conservation Trust (MTSCT)

Mountains To Sea Conservation Trust

Nga Maunga ki te Moana

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(Available on request)

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Cover Pictures: (the 'Whitebait catch' species)

1. Banded Kōkopu
2. Īnanga
3. Short-jawed Kōkopu
4. Koaro
5. Giant Kōkopu

Pictures from Stephen Moore

PART 1- INTRODUCTION

1.1 WELCOME TO THE WHITEBAIT CONNECTION

"It has been said that the day we successfully manage our freshwater resources, we would have solved all our land management issues in the process"

The way we use our land directly affects the health of our streams, rivers, estuaries, and the sea. It affects us all. By looking at the life in a stream, we can draw many conclusions, about the state of health of the stream and about the lands that surround it.

The name "Whitebait Connection" was chosen because these fish species connect us with the sea, through the streams and the rivers. And because of their distinctive habits, whitebait tell us how well we are managing these bodies of water and the surrounding lands.

Whitebait is a collective term describing the juvenile stage of six species of native freshwater fish that migrate in large, mixed shoals from the sea to freshwater rivers and streams during the spring season. The species include īnanga (*Galaxias maculatus*), banded Kōkopu (*Galaxias fasciatus*), koaro (*Galaxias brevipinnis*), giant Kōkopu (*Galaxias argentus*), shortjawed Kōkopu (*Galaxias postvectis*) and common smelt (*Retropinna retropinna*).

Schools and community groups that participate in the Whitebait Connection will also learn about freshwater bugs or macroinvertebrates, as they are known. The term invertebrate refers to life forms without spines. In this case they are basically insects whose larval stages occur in streams and rivers and that feed on algae, leaf litter or other invertebrates.

These creatures are not only indicators of water quality, (as some are more tolerant to pollution than others) but they also form the primary food source for our freshwater fish. The freshwater fish are also, in turn, on the menu of the kahawai and the kingfish that swim into the estuaries to feed. Our actions on land are linked to the water quality, to what life can be sustained by it, then to the whitebait, to the coastal fish stocks and even to the mighty marlin.

The Whitebait Connection offers concrete and specific ways in which ordinary people can come to understand and become involved in the future health of their local streams and rivers. It offers them a chance to be part of a greater legacy for us all, now and in the future.

Programme Contents:

The programme includes:

- this handbook;
- videos
- PowerPoint Presentations;

- freshwater bug and fish monitoring kits;
- catchment and habitat assessments;
- curriculum-integrated activities; and
- links to other programmes nationally and globally.

The Whitebait Connection Stream and Catchment restoration programme was developed with the support of the Department of Conservation — Northland Conservancy.

Our Vision

Our vision for this programme is:

• to get schools, tangata whenua and community groups actively involved in stream and catchment restoration throughout New Zealand;

• To provide ongoing support for all participating groups and schools, creating links to similar programmes operating nationally and globally;

• To provide a better understanding of the distribution and the abundance of whitebait and other freshwater fish species in New Zealand; and

• to strengthen the relationship between the Department of Conservation, schools, community groups and tangata whenua.

This manual will show you how:

• to carry out meaningful investigations into the state of health of your local catchment

• to feel the pulse of life in your streams and rivers through water bug (macroinvertebrate) surveys, freshwater fish and habitat assessment

• to use the clues that these activities will provide to take the first steps in restoring your catchment

• to get help or more inspiration via a comprehensive network of contacts and links.

If at any stage you encounter words or phrases you are unfamiliar with, please refer to the glossary section on page 96.

Our approach

The Whitebait Connection focuses on a biological/ecological approach. We look at all the life forms and their relationships in and around a stream. We investigate living things like types of water bugs, species of freshwater fish and the abundance of plants in a particular catchment.

Information gained will assist us all in managing our land and natural resources more appropriately. It will provide a legacy to those seeking to better the planet and set new standards in our own areas. We have also included references and contacts for groups or individuals interested in the physical and chemical aspects of water monitoring.

The technical methods in this manual have been primarily developed for stream and rivers but are also useful for lakes and wetlands as explained in Part 5.

Note: This programme and its manuals are designed for WBC delivery with community groups, tangata whenua and schools. Documents referring to programme background, umbrella organisation structure, coordinator training requirements, health and safety information, curriculum and other school specific issues can be found in the following documents:

- WBC Teacher Handbook 2020
- WBC Coordinator Handbook 2022

This manual can be implemented more easily in the field by using:

- The WBC coordinator field guide 2023 (found in Appendix A of this manual).

1.2 VALUES OF FRESHWATER – A KEY CONCEPT

Fresh water is New Zealand's most valuable natural asset. It is vital to the agricultural and horticultural products that we export. The scenic beauty and recreational opportunities offered by our lakes, rivers and wetlands are major attractions for tourists and locals alike. The productive, recreational, cultural, and spiritual uses of fresh water lie at the core of our identity as New Zealanders.

As our population grows and our land use intensifies, New Zealanders are becoming increasingly aware of the need to be more sophisticated about the way we manage this precious resource.

- Ministry for the Environment MfE Fresh start for freshwater

The NZ freshwater reforms are co-led by the Ministry for the Environment (MfE) and the Ministry for Primary Industries (MPI). The Government has initiated reform in freshwater management to address:

- deteriorating water quality in some areas
- water demand outstripping supply in some areas
- the need to balance different interests and values in water, as not all values and expectations can be met in all places at all times
- the interests of iwi/Māori in fresh water
- the need for more robust information on what we are putting into our water and how much water is available to use.

There is no doubt this will not be an overnight fix. Many, often conflicting, values need to be balanced. Local government offices around the country are supporting the formation of localised catchment management groups in their region that are made up of many different local stakeholders. It is the task of these groups to work together collaboratively to decide on water quality and quantity limits going into the future. If the group can reach a consensus, they can then make their recommendations to the council to approve and legislate. The limits set by the group must, at the very least, ensure that water quality stays the same as it is currently – but they can also choose to work towards improving water quality – set the limits higher. With the intensification of dairy and many other land uses in New Zealand, the job of setting and managing water quality standards becomes increasingly difficult. That is one reason why community engagement, freshwater advocacy, and conservation work such as the Whitebait Connection becomes extremely important at this point in time.

Cultural connections to freshwater in NZ

In Aotearoa we are fortunate enough to be able to add another dimension to water. As water was seen as a great source and sustainer of life; a vital link and a messenger; so also, was it seen as being able to "bite back", wreak vengeance, havoc, flooding and in the worst cases dry up.

Our Māori culture incorporates spiritual realms for the different degrees of purity or impurity of water, and this is significant. The water cycle and this awareness and knowledge base are born of a thousand years of experience.

He Timatanga

Waiora

Waiora is the purest form of water. It is the spiritual and physical expression of Ranginui, the sky father in his longed-for embrace with Papatūānuku, the earth. Pure water is termed Te Waiora a Tane, and to the Māori it contains the source of life and well being. Waiora is used in sacred rituals to purify and to sanctify. The rain is waiora, contact with Papatūānuku gives it its purity as water for human consumption.

Water can remain pure, as waiora, only if its contact with humans is protected by (-) appropriate ritual prayers. Waiora has the potential to give life, sustain wellbeing and counteract evil. At particular wahi tapu (sacred sites), the sacredness of the prayers and the purity of the water reinforce each other. But if one is damaged, then so too is the other. At Waitaiki, Arahura, the mauri of the river, the mauri of the pounamu (greenstone) and the mauri of the Kai Tahu, the tangata whenua, are inextricably linked.

Waimāori

Water becomes waimāori when it comes into unprotected contact with humans. It becomes waimāori in contrast to waiora because it is normal, usual or ordinary and has no longer any particularly sacred associations. Waimāori is the term used to describe water running freely, or unrestrained, or to describe water which is clear or lucid. Waimāori has a mauri that is generally benevolent and can be controlled by ritual.

Waikino

As with other terms describing water, waikino has both spiritual and temporal meanings. In the temporal sense waikino is the term used to describe water, which is rushing rapidly through a Gorge, or water where there are large boulders or submerged snags, giving the water potential to cause harm to humans. In the spiritual sense, waikino is water, which has been polluted or debased, spoiled or corrupted.

In waikino the mauri has been altered so that the supernatural forces are non-selective and can cause harm to anyone. Despite protests and warnings of the potential danger, sewage ponds were constructed at Whaingaroa (Raglan) on the site of one of the lairs of the guardian taniwha Te Atai o Rongo. That site is now considered debased and as a consequence the people there believe that the guardian mauri of Te Atai o Rongo has the potential to cause ill fortune or calamity, as does the waikino of that place.

Waimate

Waimate means water that has lost its mauri, or life force. It is dead, damaged or polluted water, which has lost its power to rejuvenate itself or other living things. Waimate, like waikino, also has the potential to cause ill fortune, contamination or distress to the mauri of other living or spiritual things, including people, their kaimoana or their agriculture. The subtle differences between waikino and waimate seem to be based on the continued existence of a mauri (albeit damaged) in the former, and its total loss in the latter.

The waters of the Manukau have been described as waimate because of extensive industrial contamination and sewage pollution. Waimate has also a geographical meaning, it denotes sluggish water, a backwater to a mainstream or tide, but in this sense waimate retains its mauri.

Waitai

Waitai is the name used to describe the sea, the surf, or the tide. Waitai has another meaning, rough, angry or boisterous, like the surf or the surge of the tide. The term waitai is used to distinguish seawater from fresh water (waimāori). Although Māori people did not fully comprehend the water cycle as taught in the elementary science syllabus, particularly the cycle of evaporation and precipitation, waitai is water that has returned to Tangaroa in the natural process of generation, degradation and rejuvenation. Such a notion does not seem to be antithetical to modern science.

Edward M. K. Douglas

1.3 THE WHITEBAIT CONNECTION – GETTING STARTED

Levels of Investigation

The Whitebait Connection catchment monitoring and assessment programme consists of three main elements of stream assessment:

1) **Physical habitat** focussing on catchments and physical parameters that govern stream type and condition.

2) **Instream biota** looking at the different types of freshwater flora and fauna and influences on them.

3) **Water quality** parameters which measure abiotic factors that contribute to stream health.

Site investigations are used within each element of assessment to measure the health of the stream reach being surveyed. Site investigations can be used to gauge overall stream condition if the selected sites are a reasonable representation of the stream system.

There are 3 main elements of Stream Assessment

Physical Habitat Parameters - Part 2

Check out Catchment Scale Conditons

Identify Hydrology and Stream Morphology

Look at the Riparian Vegetation

Assess Instream habitat

Instream Biota - Part 3

Sample the Macroinvertebrate Fauna at your site

Survey the Fish Fauna

Assess Instream macrophytes

Water Quality - Part 4

Measure stream pH

What are Dissolved oxygen levels

Water Clarity & flow

Assess stream Temperature

Nutrients

What is the water Conductivity

PART 2- PHYSICAL HABITAT PARAMETERS

The character of a stream is the water and the physical, chemical and biological environment that the water flows under, over and permeates through. It is instrumental in determining the quality and quantity of habitat available to biological organisms. It also plays a large part in the stream's aesthetic and amenity values.

The term used to describe these elements is "physical habitat". This is the living space for all in-stream flora and fauna and provides a medium for survival including food resource, shelter, protection from predators, and habitat for eggs and oviposition. It is spatially and temporally dynamic. It is intrinsically linked to the surroundings by the water cycle, from the atmosphere to the oceans. The role of physical habitat is significant; therefore, its condition and characteristics are used as part of a suite of measures to assess the health of a waterway.

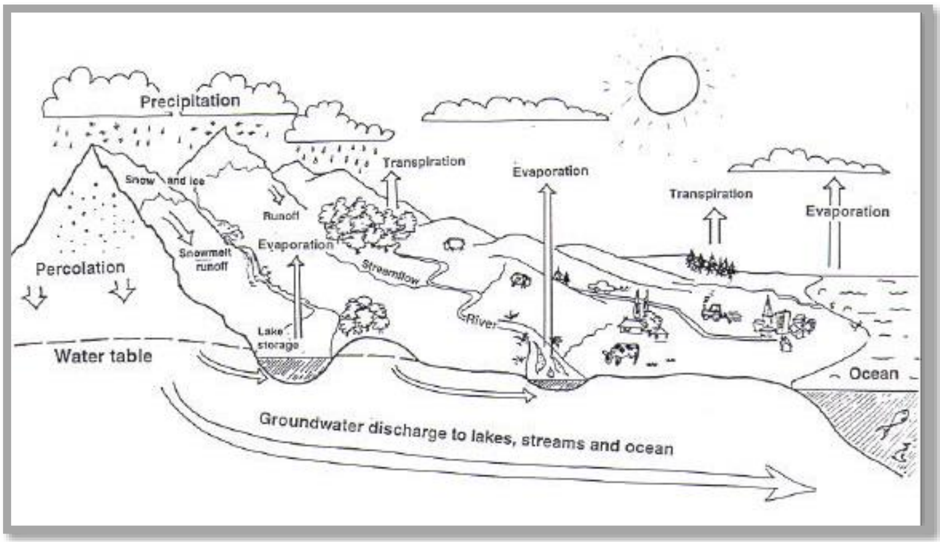
The following sections explore physical habitat parameters from the large, catchment-wide scale down to small, local scale measures.

2.1 CATCHMENTS – THE BIG PICTURE

2.1.1 THE WATER CYCLE

CLEAN, FRESH WATER is something most New Zealanders take for granted. In our homes particularly, we expect water to be available in limitless quantities whenever we need it. But if we begin thinking about water in a global context, it's not hard to appreciate just how fragile this resource is. All water is part of what's known as the "hydrologic cycle" which, in a simplified form looks like this:

The Water Cycle:



The cycle could begin, for example, with rain or snow, falling in a mountainous region. Snow may be trapped for various lengths of time in snowfields and glaciers before it melts. Rainwater may run into small streams, which flow down to lower altitudes. Small streams can merge to form larger streams, rivers and perhaps lakes, while other water might sink into the earth to become groundwater that sometimes reappears as springs.

Ancient water supplies still exist today trapped deep underground in natural rock basins or contained between various impermeable (nonporous) strata. Rain is also retained in the soil where plants take it up and a proportion is transferred back to the atmosphere via plant transpiration. Yet other water evaporates from surfaces such as rocks, standing water and leaves and goes directly back into the atmosphere. The fresh water flowing in streams and rivers eventually ends up in the sea. Groundwater and lake water also tend to move towards the sea, but much more slowly.

Major evaporation occurs from the vast area of the open ocean under the influence of global circulation patterns. Vast air masses move over the sea collecting water vapour and then move from areas of high to low pressure. When they meet any mountainous land mass the air is forced to rise, where it cools; any water in the air condenses into clouds and eventually rain ... and the cycle begins all over again.

2.1.2 WATER AS A RESOURCE

The moment water vapour condenses into liquid and falls as rain on to the land it becomes a usable resource. It can also be contaminated; both on its way down through the atmosphere and after it meets the land.

> ***"Of all the water on Earth, 97.2% is seawater. Of the remaining (fresh) water, 2.24% is trapped in ice caps. Groundwater accounts for 0.61% and lakes for just 0.009%. The atmosphere holds about 0.001%. All this means that the amount of water flowing in streams and rivers at any one time is an almost negligible 0.0001% of the Earth's water"***
>
> Figures from Allan 1995.

Whilst in almost all stages of the water/hydrological cycle occurring on land, water may be intercepted or extracted for human use, the proportion of the usable water at any given time is extremely small. The facts below will give you an idea:

Because our country is sparsely populated and its position, isolated in the middle of the ocean resulting in frequent rainfall, many parts of New Zealand seem to be disproportionately well off for fresh water. In addition, New Zealand's geological make-up has led to the formation of many lakes, which store large volumes of fresh water. Nevertheless, the uneven distribution of the population and rainfall means that even here we have water shortages and problems with water quality. In a global context our water crises are relatively minor, but we still cannot afford to take water resources for granted.

Ideally, we will:

- manage our catchments so that rainwater flows through to lakes, rivers and streams with minimal degradation; and
- look after the water once it is in lakes and watercourses.

The most serious pressures on our water environment, according to the 'State of the N.Z. Environment' report released by the Ministry for the Environment (1997) are:

a) From pastoral agriculture and cropping/horticulture:

• Sediment, animal waste and nutrient contamination of surface water by agricultural run-off;

• Flooding and erosion caused by the removal of deep-rooted vegetation;

• Nitrate contamination of groundwater;

•Loss of natural character and habitat quality of stream environments through drainage, channelisation/diversions, and the removal of riparian vegetation; and

• Invasion of plant and animal pests.

b) From urban areas:

• Increasing consumption of water;

• Sewage and stormwater discharges. Stormwater may pollute the receiving waterbody with sediment, toxic substances (e.g. heavy metals and hydrocarbons derived from motor vehicles). Contamination with human wastes may also occur when stormwater gets into and floods sewage systems. Stormwater quality is often similar to that of secondary-treated sewage;

> ***"…some lowland rivers are unsuitable for swimming because of faecal contamination from farm animals, poor water clarity, and nuisance algae growths. The stream water in some intensive dairy farming areas is in such poor condition that it may be unsafe even for livestock to drink. The lower reaches of some rivers are also polluted by discharges of industrial wastes, urban sewage and stormwater run-off".***
>
> The State of New Zealand's Environment, 1997

• The removal of riparian vegetation and destruction of aquatic habitat; and

• Flow fluctuations caused by reduction of infiltration and increasing the amount of solid surfaces. In cases of development, building structures and the surrounding services, tarmac etc, combined with the removal of the pre-existing soil types will completely alter the pathways and natural dispersal of water.

2.2 CATCHMENT SCALE CONDITIONS

2.2.1 WHAT DOES A CATCHMENT LOOK LIKE?

Key Facts:

- A **catchment** is a basin shaped area of land, bounded by natural features such as hills or mountains from which surface and sub-surface water flows into streams, rivers and wetlands. Water flows into and collects in the lowest areas in the landscape.

- A **catchment** is the area from which the water gets its life and sustenance. The amount of water carried by a stream, the shape of the channel, the fish, water bugs and plants, living in and around the stream, are all determined by its catchment.

- The **geology** of the catchment will influence many of its characteristics, from the stability of stream banks and streambeds to the natural pH of the water. pH is a scale used to denote alkaline or acid levels.

- No catchment is exactly like another. Each has a different size, shape, drainage pattern and features that are determined by natural processes, particularly geology and climate.

- The system of streams which transport water, sediment and other material from a catchment is called a **drainage network**.

- A **catchment** catches water as it falls to earth as precipitation (rainfall) and the drainage network channels the water from throughout the catchment to a common outlet. The outlet of a catchment is the mouth of the mainstream or river and this may be where it flows into another river or stream, or a place where it empties into a lake, estuary, wetland or ocean.

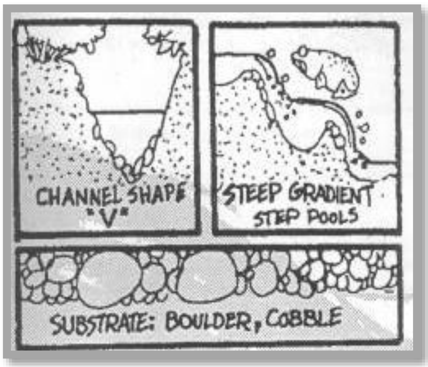
- The **size of catchments** may vary considerably. Catchments may be quite large such as that of the Waikato River, which begins in Tongariro National Park, includes most of the Waikato region and extends to the ocean just south of Auckland. Or they can consist of a myriad of small catchments like those that drain Mt Taranaki.

- **Tributaries** refer to small feeder streams that empty into larger streams or rivers. The catchments of tributaries are referred to as **sub-catchments**. Large catchments are often made up of many smaller sub-catchments. For example, the catchment of the Buller River contains eleven major sub-catchments. What happens in the smaller streams can affect the overall well-being of the main waterway.

- The **climate and its processes** have an enormous bearing on the land. Wind and flowing water erode and shape the land. Rocks are broken down into smaller pieces by the wear and tear and are transported in the flow of water. Fine materials move as sediment throughout the catchment. The soil that blankets the land was once rock and organic matter that has been transformed.

- **Soils** have different textures, mineral content, structure and drainage properties. The nature of the soils in a catchment plays a key role in the way water runs off the land and how likely that land is to erode.
- A stream is only as **healthy** as its surrounding catchment. Bad practices in any area of a catchment will have considerable impacts.
- **Everybody lives in a catchment**

2.2.2 HEADWATERS OF THE CATCHMENT



Streams begin their journey to the sea in the upper reaches of the catchment:

Some may appear briefly (**Overland flows**), and flow only during periods of intense rainfall;

Some are intermittent **(Ephemeral)**, flowing during the wetter seasons of the year; and

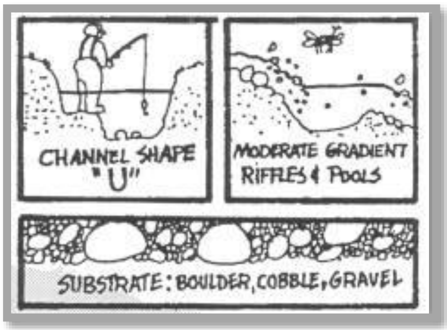
Others are more permanent **(Perennial)**, having year-round flow.

If the stream is on a steep gradient, it will be fast flowing and energetic. This energy permits it to carry large amounts of material and large pieces of rock and gravel which erode from the streambeds and banks. Rocks, pebbles and bedrock are characteristic substrates of fast flowing headwater streams. The rocks, pebbles and the moss etc, growing on them provide many habitats for aquatic macroinvertebrates, as well as good cover for fish. Coarse organic debris, especially larger woody debris, also provides habitat for stream life. In headwater streams that are not shaded by stream bank vegetation, attached algae and rooted aquatic plants produce most of the available food.

In the upper reaches, streams tend to be narrower and riparian vegetation almost completely covers the stream with its canopy. Very little sun reaches these points, so the water temperature remains cool throughout the year. Low light levels restrict algal growth, and upstream macroinvertebrate plant eaters (herbivores) rely mostly on food material from outside the stream, e.g. leaves, fruit, seeds, twigs and bark. In time this coarser material is made fine by physical abrasion and microbial activity. Macroinvertebrate "**collector-browsers**" tend to dominate in these upper reaches.

The headwaters of a river system are very important to the health of the entire river insofar as they are important areas of habitat for creatures, which provide food sources for life further downstream. Considering how the upper reaches are linked to the waters further down the catchment it is possible to predict how dams and weirs could restrict the distribution of food and the movement of aquatic animals.

2.2.3 MIDDLE CATCHMENT



By the middle reaches of the catchment some tributaries have entered the stream and added to the flow. The land is
generally, flatter here and the flow of the stream is slower.

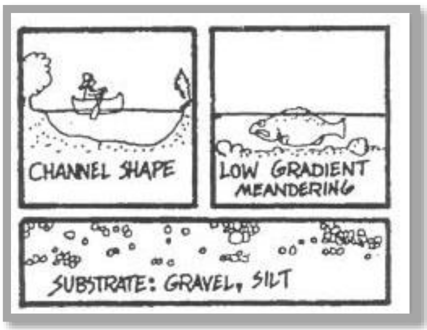
There are frequent shallow areas of faster moving water called riffles, where rocks break the surface. The deeper areas of water are called pools. The bottom substrate here is mostly composed of gravel and cobble.

The channel has widened into a 'U' shape and there is usually an associated floodplain (a flat area beside the stream bank). The stream regularly overflows onto this area, slows, and then dumps its load of sediment. The stream often flows across the floodplain in curves or meanders. Usually there is a combination of erosion on the outside edge of the bends, where the water flow is more rapid, and sedimentation (depositing sediment) on the inside edge where the water flow is slower.

In these middle reaches the canopy no longer reaches across the stream to shade the entire water surface. Here the sun is able to warm the water, raising water temperature throughout the day. Slower flows, together with the murkier water in these reaches may also increase the heat. Seasonal changes in water temperature are usually the greatest in this middle section.

Organic debris still falls into the stream from the riparian zone but as the amount of light increases, algae become an important part of the food base. The growth of periphytonic organisms (i.e. plants like algae found at the streambed) increases as the warmer temperature and slower flows favour them. Microscopic or tiny plankton are detectable too in upper, more well-lit layers of the water and as the nature of the food base is changed there is also a shift in the kind of life we will expect to find. "**Grazer and collector**" macroinvertebrates dominate this section of the stream.

2.2.4 LOWER CATCHMENT



Moving downstream to the stream's mouth, more tributaries have entered and further increased flow. The wider, deeper channel meanders through a flat floodplain and broad valley.

The stream travels very slowly and deposits the large quantities of sediment it has been carrying from further upstream. Although the water is unshaded, the murky water limits sunlight penetration, but some attached algae may grow in the shallows if stones or other suitable substrate are available. Fine particles may also replace organic debris and algae as the food source.

The communities of small aquatic organisms change again. "**Collector- filterer**" macroinvertebrates are more common in this stretch of the stream, where they filter out accumulated minute particles suspended in the water and gather fine particles that have settled to the river bottom.

In slower stream reaches, there is less spread of atmospheric oxygen in the surface water. This can cause even lower dissolved oxygen levels in the streambed sediments and slows down the breakdown of organic matter. Organisms that tolerate lower oxygen levels, and that prefer slower flowing water, are consequently more common in the lower section of the stream.

At its mouth, the stream or river empties into another body of water – a lake or estuary. Since it is often carrying un-deposited sediment, debris and other substances, it may damage these receiving water bodies. Estuaries are particularly sensitive environments and their role as a nursery for fish is easily disturbed.

2.2.5 STREAM ORDER

Streams are classified by their sizes:

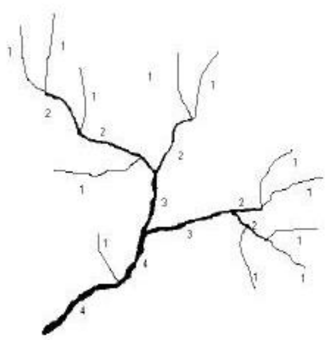
Zero order streams: These headwater streams are the smallest stream channels in the network. They do not typically appear on the 1:50,000 topographic maps so they are often overlooked. Zero order streams are important. They are ephemeral but account for a high proportion of the total channel length in a stream network. They represent the closest association between terrestrial and aquatic environments in that network (Storey et al. 2009)

First order streams: These streams are the next smallest streams in the catchment that have year-round flow (perennial). A zero- order stream becomes a first order stream at the point where it changes from being ephemeral to perennial.

Second order streams: These form when two, first order streams meet (confluence). They are larger streams still.

Third order streams: Formed when two, second order steams join, and so on…

Stream order only changes when two streams with the same classification meet. For example, when a first order stream meets a second order stream the resulting stream remains a second order stream. (See following diagram.)



2.2.6 WHAT DOES YOUR CATCHMENT LOOK LIKE?

Getting to know your catchment is an important step in the Whitebait Connection programme.

Learning about a stream and its catchment can be quite an adventure. As you investigate your catchment, you will discover information about its natural and cultural resources, history, its use (and abuse) by people and wildlife. Moreover, you will discover facts about the health of its waters.

Investigating it will enhance a sense of connection to the catchment and its watercourses. Since everything that happens in the catchment affects the stream in some way, by making a catchment inventory you will get the “inside line” on what’s really happening on the land that drains into your stream.

You will get raw data and be able to piece together how the various activities may be affecting it. The inventory process will help you better identify and design your stream monitoring objectives and give you some great experiences.

If you choose to work on a larger stream or river system, it will be best to focus on the sub-catchment that is in your ‘neighbourhood’. By combining your research and findings with other groups working upstream and downstream you may be able to create a more comprehensive picture of the “total” catchment.

Investigating your catchment in 3 steps:

1. **Identify** the boundaries of your catchment and make a working (base) map

First, find your stream on the topomaps website.

Go to: *www.topomap.co.nz*

Enter the Search tab and find the nearest local town.

With some local knowledge from here you should be able to find the latest topographical map of your stream. Alternatively, use the hard copy NZMS 260 Series topographical maps available from Land Information New Zealand. These maps have a scale 1:50,000 (2 centimetres on the map equals one kilometre on the ground)

Topomaps will give you an overview of:

a) The outlet point to the catchment. Look for the lowest elevation in your catchment and in most cases, this will be the mouth of the stream.
b) The route of the stream from its mouth to its tributaries.
c) The catchment boundaries - the boundary of the catchment will be located on the ridgeline above the smallest streams that drain into your stream.
d) The drainage basin - drawing a line along the ridges so that the ridgelines join will delineate the boundary of the drainage basin.

Get more detail on catchment shape, stream order, sediment yield, run off, rainfall and flood frequency from the NIWA webmodel WRENZ.

This is a water resources explorer for NZ and is a GIS-based web application that allows the user to display selected layers of water resource related spatial information on a map of New Zealand. You can also put the aerial map layer on the map to see what the different land uses are in your catchment.

E.g.1

Northland Regional Council Online Maps

Look at the Northland Regional Council maps. Find your stream by zooming in on the map. Click on the Environment layer in the layers tab and click on the distance stick in the tool tab. Measure.

E.g.2

Auckland Council GeoMaps

Look at the Auckland Council GeoMaps. Find your stream by zooming in on the map. Click on the Map views and turn on the Topo layer. Measure distance using the "Draw and Measure" option in Tools.

2. **Gather** all the other available information about your catchment.

Work out the length of your stream by laying a piece of wet string along its length on a topographical map. Use the scale on the map to calculate the length of the stream/s. (Remember to make scale adjustments if you change the size of the map when you photocopy.

Alternatively, some Regional Councils have web-based GIS maps that allow you to measure distances and therefore the length of the stream or distance inland using an aerial or topographical layer and a measuring tool. See examples in the text box.

Show the position and size of other surface water features, such as lakes and wetlands.

Trace out **roads and tracks,** the outline of **settlements, towns, cities** and **district boundaries**.

Pinpoint other features of significance on the map such as dams and historical sites. Include recent changes that have taken place in your catchment, such as new housing developments.

The Department of Conservation has maps that show areas of **special ecological value** and the distribution of flora and fauna. Some local councils have maps that show similar features, such as 'significant ecological sites', significant natural areas', and reserves.

The following catchment inventory sheet contains an extensive list of features that could be researched and added to the map. By building up this detailed picture of the catchment through observations, local knowledge and collaboration with government agencies and special interest groups, it will create a clearer understanding of the pressures and influences on your watercourse. Moreover, threats to its health can be anticipated. This will enable your group to select the most appropriate and useful site(s) to monitor depending upon your interests and purposes.

Go to:
http://wrenz.niwa.co.nz/webmodel

Go straight to the "Help" tab at the top of the opening page to discover how to use this application to find out more about your catchment.

It is always a good idea to make some photocopies of this catchment map once created. These copies will be working maps. You can label or mark the copies with different features, land uses or structures or make clear overlays to layer onto a base map. You should take one of the copies into the field to check some of the map's features and include a copy of your map in your field trip report.

3**. Get out there** and conduct a "field" assessment of the catchment.

You will need to write a summary of the disturbances to the watercourse, riparian zone, flood plain and wider catchment since settlement. List the current sources of potential and actual pollution on a catchment basis and in particular those upstream of your site.

Clues relating to the above may include dead upright trees in the water, unhealthy looking aquatic plants (pale green or covered in a brown furry coating). They may include bare banks, eroding banks, stock access to the water, increased sedimentation, drains and effluent pipes. You may detect unpleasant odours, unusual water coloration or clarity, black smelly sediment, surface scum or film, white sewage fungus, plenty of algae (either surface algal blooms or stream bottom filamentous algae). The land use catchment map you compile might become a very valuable resource for your local council, government agencies and community groups, and not just for your group. It could later form a "historical base map" upon which future changes can be plotted or overlaid.

Catchment Inventory Assessment Sheet

Discovering information about our catchment – the stream, the land surrounding it and the activities that may affect it.

Catchment Location

Catchment name ________________________ Topo, map number/s___________________________

Begins in______________________________ Flows through _________________________________

Ends in _______________________________ *(name town, district, region, etc.)*

Drains into_____________________________ *(name body of water e.g. lake or river)*

Catchment area _________ km2 Approx. length km__________ Width km_________________

Highest point ___________________________ Lowest point __________________________________

Climate

Average annual precipitation_________ mm Most precipitation occurs (months) ________________

Flood frequency (month/s, year/s)____

Coldest month of year ___________ Warmest month ____________ Yearly temp. range __________

Geology/Topography

Describe briefly the geological history that shaped your catchment ____________________________

____

Describe the physical characteristics of different reached of your catchment: ___________________

____

	Upper Reaches	Middle Reaches	Lower Reaches
Valley shape (‘V’, ‘U’ or wide flat U shape			
Gradient (steep, medium,gentle)			
Channel sinuosity (straight, meandering)			

Bottom substrate (cobble, gravel, etc)			

Predominant rock types present: igneous __ metamorphic_ _ sedimentary__

Name the most common type of rock:

Fish

Native species (circle if endangered or threatened) ____

____

Abundance ____

Introduced species (circle if presence threatens native species) ______________________________

____

Abundance ____

Any suspected barriers to fish migration?____

____

Wildlife

Native species (circle if endangered or threatened)____

____

Introduced species (circle if they should be threatened)_____________________________________

____

Key wildlife habitat areas____

____

Location of 'Protected Natural Areas'1 and/or 'Areas of Ecological Significance'2

____

____

Significance of these areas ____

____

1 Contact the Department of Conservation. 2 Contact your local council.

Historical

The earliest human inhabitants were ____________________________ Date ___________________

Reasons for settlement____

Describe the subsequent settlement of your catchment___________________________________

____

Significant cultural and historical features of your catchment_______________________________

____

Demographics

Population of your catchment ________________ Projected population in 10 years_____________

Population 10years ago___________ 50 years ago__________ 100 years ago______________

Land and Water Uses

Estimating the percentage of our catchment zoned for each land use and the activities that

are permitted:

Rural residential ____________% densities (average size of blocks) ____ ha.

Urban/suburban residential_______% densities (house per ha.)___________

Commercial ____________% __ light commercial __ heavy commercial

Industrial ____________% _ _ light industry _ _ heavy industry

Agricultural ___________% _ _ grazing _ _ crops ___ feedlots ___dairy __ Other (state)

Forestry _____________ % _ clear-cut ___ selective __ _ farm forestry

Quarrying/mining _______________ % type of activity________________________________

Parks/open spaces______________ % _ swimming ___ boating ___fishing_________ _ other

Other recreation _____________ % _ golf course_ skiing _______________________ _ o

Percent of the catchment that is: public land ____________ % public land______________ %

Percent of catchment covered with impervious surfaces______________%

Sources of domestic water supply for catchment residents __________________________________

Location of sewerage treatment plants (if any)____

Areas that rely on septic tanks____

Altered hydrology (dams, diversions, culverts, drained wetlands etc.):

Type of alteration	**Location Purpose**	**Water quality**

List any sources of pollutants____

Are they emanating (coming) from a single identifiable (point) source or diffused?

(spreading from somewhere else)____

2.3 HYDROLOGY & STREAM MORPHOLOGY

Stream hydrology and morphology are important considerations of physical habitat. They provide a description of the relationship between flowing water and the physical stream environment including the stream bed, the channel dimensions and wider catchment. Together these variables can be used to characterise the stream habitats available according to their width, flow regime, stability and connectivity to their surroundings.

2.3.1 CHANNEL WIDTH AND DEPTH

A bit of Background: The wetted channel width provides a measure of the available habitat to stream life. Studies have shown that channel width narrows with the removal of riparian vegetation and conversion to pasture (Davies-Colley 1997 – cited in Parkyn). Equally, when fenced and restored, the channel widens out again to the original. This is attributed to the replacement of pasture grasses (that hold the banks) with woody riparian plants that allow erosion during storm events. A wider channel provides more habitat for stream life.

Water depth is also an important factor of the stream habitat availability as it influences mesohabitats (See section 2.3.4), flow and temperature.

Measure it: A tape measure can be used to measure water width, perpendicular to stream flow at, at least 10, evenly spaced transects along your stream study reach. The reach surveyed should ideally be at least 20 times the average channel width with a minimum reach length of 50 metres.

Measure water depths at each transect of the 10 transects at 10%, 30%, 50%, 70% and 90% of the distance across the channel (i.e. make 5 depth measurements at each cross section). This will give you an average depth and, if plotted, these figures will give you approximate cross sections of the stream channel at each transect.

2.3.2 NATURAL FLOW REGIME

A bit of Background: The natural flow regime of a river or stream is the normal cycle of high, normal, and low flows that a watercourse might experience within an unmodified catchment. Changes to the natural flow regime in a stream reach can change its ecological character in several ways.

For example, an increase in water velocity due to an input of water from a stormwater pipe or increased stormwater run-off from a more developed catchment, may result in greater erosion of a stream channel and flood scour of habitats and macroinvertebrates. Conversely, retention of water by a dam may affect stream morphology through changes in sediment deposition or the natural run-riffle-pool structure. Straightening a stream and a concrete lining may help reduce floods but loss of meander pattern and natural substrate significantly reduces habitat opportunities.

Measure it: For the purposes of this manual, studies of natural flow regime, or departure from it, are visual assessments only, at both the desk-top level and in the field.

Desktop: During the information gathering exercise for Catchment conditions in Section 2.2, you may have made some measures of land use type in your catchment. Measure from an aerial the percentage of different land uses in the catchment. As a general rule of thumb the more 'hard surfaces" in a catchment, the more modification there is to natural flow regime.

In the field: Search your stream reach for stormwater inlet pipes. How many are there? What size are they? The more pipes and the greater their size, the more effect there will be on flow levels.

Similarly search for dams or places where there may be a water take from your stream reach.

In your stream reach try to determine the extent of channel modification. Tick which of the categories below your stream best fits into.

Channel type	Tick box that best suits your stream	Naturalness of flow regime
Natural channel with no modification		**High**
Natural channel, but flow patterns affected by a reduction in roughness elements (e.g. woody debris, or boulders)		
Channel not straightened or deepened, but upper banks widened to increase flood flow capacity		↓
Natural channel, but evidence of channel incision from flood flows		
Natural channel, but flow patterns affected by increase in roughness elements (e.g. excessive macrophyte growth)		
Flow patterns affected by artificial in-stream structure (e.g. ponding due to culvert, weir or unnatural debris)		
Channel straightened and/or deepened		**Low**

This assessment has been taken and simplified from the Stream Ecological Valuation (SEV) methodology (Storey *et al*. 2011). For some photographic examples of these channel types look at Figures 30 to 35 in the SEV User Guide.

A visual inspection of channel lining can also give an indication of flow regime. Smooth concrete will transport flows faster than a rough, natural channel with features such as logs and boulders. A concrete lining also completely removes the stream's natural connectivity to ground water. In your stream reach try to determine the dominant channel type. Tick which of the categories below your stream best fits into.

Type of channel lining	Tick box that best suits your stream	Naturalness of flow regime
Natural channel with no modification		**High**
Bed with unnatural loading of fine sediment		
Bank OR bed lined with permeable artificial lining (e.g. gabion baskets)		↓
Bank OR bed lined with impermeable artificial lining (e.g. concrete)		
Bank AND bed lined with permeable artificial lining		
Bank AND bed lined with impermeable artificial lining		**Low**

This assessment has been taken and simplified from the Stream Ecological Valuation (SEV) methodology (Storey *et al*. 2011). For some photographic examples of these channel lining types look at Figures 36 to 41 in the SEV User Guide referenced above.

2.3.3 FLOODPLAIN CONNECTIVITY

A bit of Background: Connectivity to its floodplain is an essential element of a healthy stream's ecosystem functioning. Floodplains play an important role in diffusing and retarding flood waters thus protecting the downstream habitats. They provide a place for deposition of sediment and dissolved nutrients carried in flood waters. This reduces contaminant loadings downstream. Some fish, such as eels, use flood events to access the floodplain for feeding. Other fish use floodplains and floods for spawning sites.

Measure it: A visual inspection will determine whether your stream still has a floodplain or access to it. Tick which of the categories below your stream best fits into.

Floodplain description	Tick box that best suits your stream	Connectivity to floodplain
Movement of flood flows onto and across the floodplain is not restricted by any artificial structures or modifications.		**High**
Floodplain present, but connectivity to the full floodplain is restricted by modification (e.g. stop banks or urban development).		
Floodplain present, but connectivity to the floodplain reduced by channel incision or bank widening so that most flood flows are unlikely to reach the floodplain.		
No hydrological connectivity with the floodplain as all flows are likely to be artificially contained within the channel.		**Low**

This assessment has been taken and simplified from the Stream Ecological Valuation (SEV) methodology (Storey *et al*. 2011). For some photographic examples of these floodplain types look at Figures 42 to 45 in the SEV User Guide referenced above.

2.3.4 MESOHABITATS

A bit of Background: Mesohabitats are defined as hydraulic habitats within a stream reach which are characterised by different mean water velocities and depths. These produce characteristic surface flow patterns. The commonest habitat types include riffles, rapids, runs (or glides), pools, backwaters, and cascades. They are determined by the local channel slope, shape, structure, flow depth, and mean water velocity. For example, stepped pool-run-rapid sequences occur in steep streams, whereas pool-riffle-run sequences characterise low gradient streams.

Rapid – shallow to moderate depth, swift flow and strong currents, surface broken with white water

Riffle – shallow depth, moderate to fast water velocity, with mixed currents, surface rippled but unbroken.

Pool – deep, slow flowing with a smooth water surface, usually where the stream widens and/or deepens.

Run – habitat in between that of riffle/rapid and pool, slow–moderate depth and water

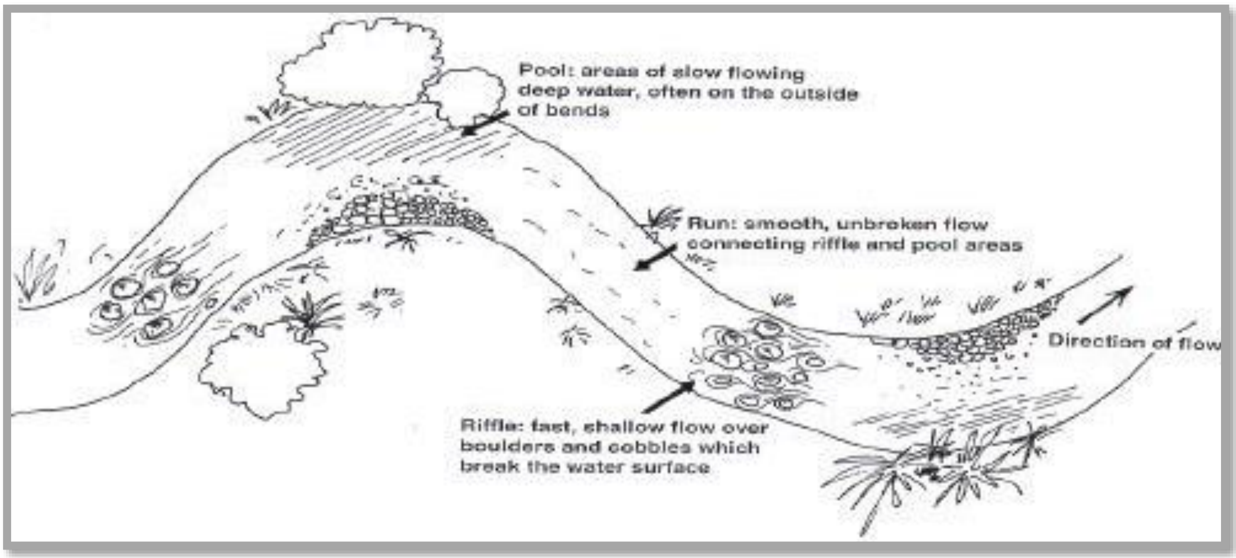
velocity, uniform–slightly variable current, surface unbroken, smooth–rippled.

Backwater – slow or no flow zone away from the main flowing channel that is a surface flow dead-end; although flow could downwell or upwell from the groundwater zone.

Taken from Harding *et al.,* 2009

Riffles are important for aerating the water and providing habitat for many of the more sensitive invertebrates. Streams that have several pools and riffles are able to support more life and greater variety of species than those that do not vary much in their character. Slower flowing streams without riffles may provide habitat diversity through bends, creating areas with different depths and current speed.

Measure it: Draw your own diagram illustrating the run–riffle–pool sequence in your stream like the example below:



2.3.5 BANK EROSION AND CONDITION

A bit of Background: Stream banks naturally erode, particularly on bends. However, changes in adjacent land areas can cause a stream to become unstable, resulting in continuous erosion along its channel. Such changes include increased run-off from impervious (hard) surfaces and piped 'streams', stock access, or direct interference such as straightening or channelling the stream. Steep banks are generally more likely to collapse and suffer from erosion than are gently sloping banks. Streams with banks in poor condition will often have poor instream habitat and introduce sediment into the stream.

The soil on banks is held in place by plant roots. Deep root systems offer greatest bank protection but shallow root mats also protect the surface of the bank against the abrasive effects of water. The more diverse the plant community on the banks the better. Young plants, which grow and reproduce rapidly, are better than old plants. The depth of plant root systems becomes more important as height and slope of the stream bank increases.

Measure it: Make a note of the amount of erosion on the banks of your stream and the likely causes. What percentage of the channel banks has signs of slumping, undercut banks or general erosion?

2.4 INSTREAM HABITAT

The in-stream habitat is defined as the area below the vegetated bank and on or in the streambed that is submerged below water. The streambed provides habitat for many aquatic organisms. It provides a site for the deposition and incubation for their eggs, the source of their food and refuge from predators, floods and droughts.

The physical character of the streambed has an important effect on the habitat quality for algae, invertebrates and fish and it determines the quantity and quality of refugia from floods and predators. The suitability of substrate for different species depends on the dominant particle size, the range of substrate sizes, the degree of packing and compactness and the availability of interstitial spaces for refuge (Gordon et al. 2004).

There is a significant range of instream habitat assessment parameters that could be measured. However, for simplification in this handbook, three key parameters have been chosen to help characterise in-stream habitat condition.

2.4.1 SUBSTRATE PARTICLE SIZE

A bit of Background: Stream-bed particle size varies naturally from one stream to another, and can be predicted with knowledge of geology, climate, topography, and position in the stream network (Harding et al. 2009).

Substrate varies depending on position in the catchment. Boulders typically dominate in the headwaters of catchments and substrate size decreases downstream. Near river mouths the substrate is usually composed of gravels, silt and sand. The relative size and range of substrate is also often controlled by catchment conditions (e.g., climate and geology). For example, streams from catchments with igneous or metamorphic geology (e.g., granite) are likely to have larger substrate particles than comparable streams from catchments dominated by more easily fractured sandstones or mudstones (Harding et al. 2009).

Extra reading: Where do Fish Want to Live

Stream-bed particle size has a strong influence on the biological community in streams. Stream beds dominated by boulders and cobble support a greater abundance and diversity of macroinvertebrates than those dominated by fine sediments.

Cobbles and boulders also provide good habitat for native fish who are mostly benthic (bottom dwelling) in habit and use the streambed for shelter, foraging, and nesting. Sediment deposition in a cobble stream can therefore degrade fish habitat.

Measure it: The following method for stream-bed particle size evaluation, known as the Wolman walk, has been adapted from SHAP (Harding et al. 2009) by Parkyn et al. 2010 and is included below.

1. Lay tape measures across your stream reach at 6 positions including 2 riffles, 2 runs, and 2 pools.

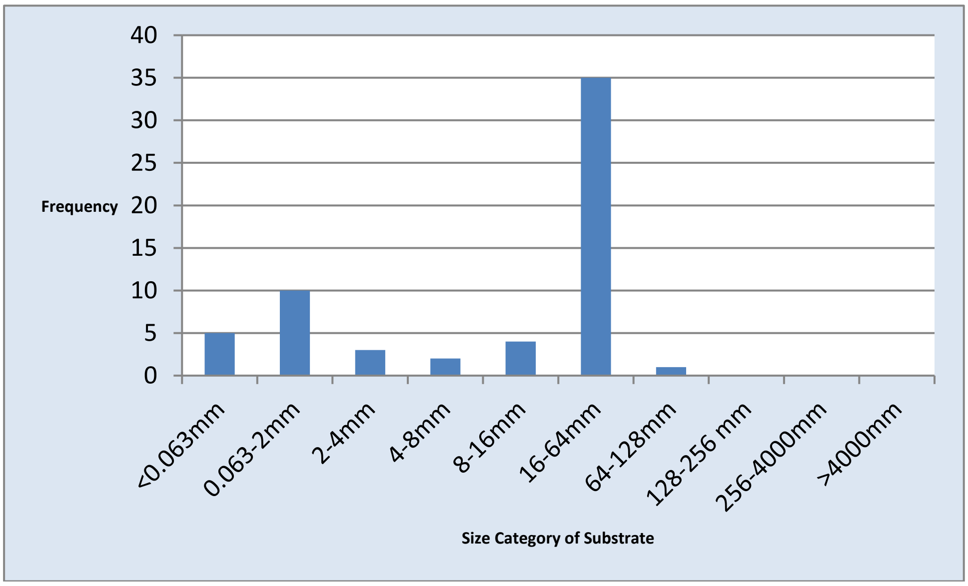
2. At each cross section, randomly select 10 particles while wading across the stream. To achieve random selection, pick up the particle immediately in front of your boot at each step across the stream. If the particles are completely covered in a layer of fine sediment (i.e. the first particle touched is sediment and not the larger particle beneath), and if you are able to pick the sediment up without pinching finger tips together (to avoid overemphasising transient fine deposits of silt/sand), then record that particle as silt or sand.

3. Measure the length of each particle's second-longest axis using a "Wolman stick" (see link below), and then assign it to one of the categories in Table 1.

4. Data can be reported by plotting the 60 different readings in a cumulative frequency graph, to show the distribution of particle size in your stream reach.

Table 1: *Size classes for the gravelometer or "Wolman stick".*

Size category	Category name	Size category	Category name
<0.063mm	Silt, mud	16-64mm	Large gravel
0.063-2mm	Sand	64-128mm	Small cobble
2-4mm	Small gravel	128-256 mm	Large cobble
4-8mm	Small medium gravel	256-4000mm	Boulder
8-16mm	Medium large gravel	>4000mm	Bedrock



Example of a frequency graph for a hypothetical stream with a gravel substrate

For some photographic examples of the Wolman stick look at Figures 6 to 9 in the SEV User Guide.

2.4.2 SUBSTRATE EMBEDDEDNESS

A bit of Background: This is the extent to which rocks (gravel, cobble, and boulders) are buried or surrounded by fine sediment. Rocks may become smothered when large-scale sediment inputs occur upstream. Reduced stream flow may in turn speed up deposition. As rocks become embedded there is less space between and under rocks for colonisation and the stream community will become dominated by groups such as worms and midges.

Measure it: Look for how much of the streambed is buried by silt or fine sediment. Observations of embeddedness should be taken in the middle of rocky/cobbled areas. Reaching into the stream and unplugging a few rocks is a good way to estimate the covered depth if it is difficult to estimate by sight alone.

2.4.3 ORGANIC MATTER ABUNDANCE

A bit of Background: The input of organic matter (e.g. leaves, wood) into the stream from external sources, coupled with in-stream production by plants and algae via photosynthesis, is an important driver of biological production in a watercourse. The amount of organic matter on the stream bed is a good indicator of the food and nutrients available to stream life. It can also provide good cover for macroinvertebrate and fish fauna.

The presence of riparian vegetation has a strong influence on the amount of organic matter in a stream as this is the main source of that input. Organic matter is also determined by seasonal leaf litter inputs and the flow characteristics of the stream in terms of how well it retains the organic material. Streams may become over-retentive if they are clogged with aquatic plants or rubbish. Conversely, they may become under-retentive if the stream has very high flows, has been straightened and has no boulders, woody debris etc. for material to be held back by.

Measure it: Use the method provided in protocol 2 of the SHAP (Harding et al. 2009).

Select a representative riffle, run and pool and at each of these mesohabitats:

- Visually estimate the percentage of the wetted bed with wood and leaf packs, including trees, branches and roots.
- Calculate the average proportion of the streambed where organic matter is present.
- Note down any features of the stream that may affect retentiveness.

2.5 RIPARIAN VEGETATION

A bit of Background: There is a strong inter-dependence between streams and their riparian vegetation. The riparian vegetation zone along the banks of a stream serves as a buffer to pollutants entering the stream from runoff; controls erosion; provides shade to reduce water temperature; provides habitat; and contributes nutrients in the form of plant matter such as leaves and twigs to the stream. Grasses and small shrubs next to the stream also provide escape cover or refuge for fish and places for eggs of both fish and invertebrate fauna.

Streams in urban settings often have little or no riparian vegetation. These areas are often 'cleaned up' during the construction of parking areas, housing or roading and never restored afterwards. In this way the effectiveness of the riparian zone is diminished as vegetation is removed, and the width reduced. Similarly, a stream may have good riparian vegetation but not be connected to it because it is piped or culverted.

Measure it: Carry out a visual inspection of the riparian vegetation along the stream reach. Tick the box in the table below for the vegetation type that most suits. Vegetation cover may vary along the reach. If so, estimate the proportion of the reach banks that is covered by the different vegetation types.

Vegetation type	Tick box that best suits your stream	Intactness of riparian vegetation
Mature indigenous vegetation with diverse canopy and understorey		**High**
Regenerating indigenous vegetation in late stage of succession		
Natural, diverse wetland vegetation on banks		
Mature native trees, but damaged understorey		
Mature exotic trees (e.g. Willows and plantation forest)		
Low diversity regenerating bush with stock excluded OR tall exotic shrubs (> 2m)		
Mature flax, long grasses and sedges		
Low diversity regenerating bush with stock access OR **Early-stage restoration planting OR Short exotic shrubs (< 2m) OR Immature plantation forest**		
Mainly long grasses (not grazed or mown)		
Grazed wetlands		
Mainly short grasses (grazed or mown)		
Disturbed bare soil or artificial surfaces		**Low**

This assessment has been taken and simplified from the Stream Ecological Valuation (SEV) methodology (Storey *et al*. 2011). For some photographic examples of these channel types look at Figures 41 to 57 in the above referenced SEV User Guide.

For an overview of riparian vegetation cover, before going into the field look at your stream on WRENZ with the satellite layer switched on and record how much of the stream banks have good cover. Figures 62 to 65 in the SEV user guide (referenced above) give you an idea of the different degrees of vegetation cover you might record.

PART 3- INSTREAM BIOTA

There are three main biotic components of a stream ecosystem. These are invertebrate fauna, fish fauna and plants (macrophytes). The integrity of these components is key to the healthy functioning of a stream. This part of the handbook looks at each of these three elements in detail and how they can be used as biological indicators of stream health.

3.1 BENTHIC MACROINVERTEBRATES

A bit of Background: If you turn over a few rocks in a shallow, fast flowing section of any New Zealand stream you will soon notice movement. Small, dark, insect-like shapes scuttling for cover. You may well also discover some of the surprisingly large numbers of the mayfly, stonefly, caddisfly or dobsonfly groups. These insects are in their larval (juvenile) stages and are just a few of more than 100 species widely distributed around the country. In addition to insects, you may find crustaceans, snails, worms and leeches in stony or weedy stream habitats. Collectively these creatures are known as "invertebrates," (animals without backbones).

Invertebrates are a vital part of the freshwater ecosystem. They include grazers, plant shredders, filterers and predators. Many of them feed on plant matter (algae, leaf litter and aquatic "weeds") and in turn they provide the most important food source to almost all the freshwater fish found in New Zealand. Without the invertebrates there would be none of the native eels, bullies or "whitebait" species and no introduced trout, salmon or perch in our freshwater habitats. Further, without any of the above we would have less kahawai, kingfish and marlin.

Invertebrate species have very different tolerances to stream habitat degradation, e.g. raised water temperature, increased siltation, lower dissolved oxygen levels. Species assemblage changes when these sorts of conditions occur. Therefore, sampling the macroinvertebrate community in your stream reach and knowing their tolerance levels will tell a great deal about the "state of health" of the water body.

Three of the most abundant orders (groups) of stream insect are Ephemeroptera (mayflies). Plecoptera (stoneflies) and Trichoptera (caddisflies). These are also the most sensitive groups. They are collectively known as ‘EPT’ taxa. The presence of many invertebrate species indicates clean water, cool temperatures and generally natural conditions. A stream which has a low diversity of invertebrate life is likely to have some habitat issues.

Sample it: There are standardised protocols for sampling wadeable streams described in Stark et al. (2001). The protocols distinguish different sampling techniques for hard-bottomed and soft-bottomed streams. This separation reflects significant differences in the morphology and community composition of these respective stream types and recognises that different methods are required if sample collection and processing are to be effective (Stark et al. 2001).

A hard-bottomed stream is one where the substrate is dominated by particles of gravel size or greater (i.e., <50% of the bed is made up of sand/silt). Riffle habitats are normally common in these streams, reflecting a reasonable stream gradient.

In contrast, soft-bottomed streams are usually low-gradient, and dominated by glide/pool habitats. Gravel, cobble and boulder substrates are rare or absent in these streams and sand/silt/mud/clay dominate the streambed. Macrophytes often dominate in unshaded reaches, whereas soft-bottomed streams in forested areas often have accumulations of woody debris that form stable, productive habitat for macroinvertebrates.

Work out whether your stream is hard or soft-bottomed and then select the correct sampling method.

3.1.1 SOFT-BOTTOMED STREAMS

Equipment:

- Kick sampling net (mesh size of 250 µm)
- Bucket
- White tray for sorting
- “Bug box”,
- ID sheets,
- Score sheets,
- Bug handling tools, including “bug sucker”, forceps
- Magnifying glass
- Suitable footwear.

Methodology:

1. Ensure that the sampling net and bucket are clean.

2. Sample a unit effort of 0.3 m^2 of woody debris, bank margins or aquatic macrophytes using the following procedures. Avoid dredging the net along the bottom in mud or sand and avoid leaves and algae if possible. Avoid hard (stony) substrates.

Woody Debris – Select submerged and partially decayed woody debris (50-250 mm diameter preferred). Place over the mouth of the net. Pour water over the wood while brushing it gently by hand to remove organisms. Larger pieces may be sampled in situ by brushing the log while holding the net directly below it. Each 1-metre section of woody debris has a sample area of about 0.3 m^2.

Bank Margins – Locate an area of bank with good structure and aggressively jab the net into the bank for a distance of 1-metre to dislodge organisms, followed by 2-3 cleaning sweeps to collect organisms in the water column. Each sample unit is about 0.3 m^2.

Macrophytes – Sweep the net through macrophyte beds for a distance of 1-metre to dislodge organisms, followed by 2-3 cleaning sweeps to collect organisms in the water column. Each sample unit is about 0.3 m2.

3. Repeat Step 2 at 10 locations while moving progressively upstream. This makes a total sample size of 3m^2. Remove sample material to the white tray. Select substrates to be sampled in proportion to their prevalence along a 50 - 100 m reach of stream. Record the reach length and the proportion of the sample taken from each substrate type (e.g., 50% wood, 25% banks, 25% macrophytes). After the 10th unit effort, wash or pick all animals off the net. The tray should now contain one entire sample comprising material dislodged from 3 m^2 of substrate.

You could split this sample between a few trays, so it is easier to look at the bugs and examine what you have found.

3.1.2 HARD-BOTTOMED STREAMS

Equipment:

- As for soft-bottomed streams

Methodology:

1. Ensure that the sampling net and bucket are clean.

2. Select the appropriate habitat (e.g., riffle).

3. Sample beginning at the downstream end of the reach and proceed across and upstream.

4. Select an area of substrate (0.1 - 0.2 m2) to sample with a natural flow that will direct organisms into the net. Place the net on the streambed and step into the sampling area immediately upstream of the net, disturb the substrate under your feet by kicking to dislodge the upper layer of cobbles or gravel and to scrape the underlying bed. The area disturbed should extend no further than 0.5 metres upstream from the net. Remove the material from the net into the tray.

5. Repeat Step 4 at several different locations within a 50 m stream reach and covering a variety of velocity regimes until a total area of 0.6 – 1.0 m2 of riffle habitat has been sampled. Transfer this material to a white tray. Wash or pick all animals off the net.

6. Rinse and remove any unwanted large debris items (e.g., stones, sticks, leaves) that may limit space in the tray and viewing the bugs.

7. Be aware that conditions at the time of sampling, such as higher than usual flows, may influence the results and interpretation. Also record observations of fish or other fauna and make sure you note down the method of sampling, i.e., kick or sweep.

Identification Guides:

Wai Care Invertebrate Field Guide

Manaaki Whenua Land Care Freshwater Invertebrate Guide

NIWA Macroinvertebrate Identification Guide

Note: There are some additional issues to consider when collecting samples in a stream.

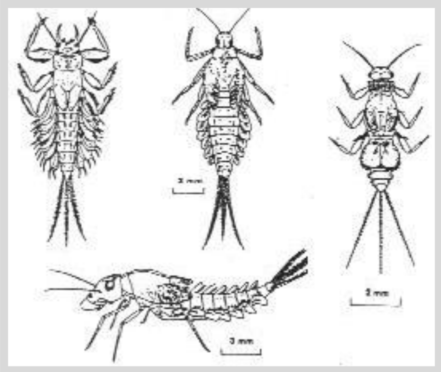
- Only sample stream sections that are safe to wade in. As a rule of thumb do not get into water deeper than your thigh.
- Do not sample when the river is above normal flows.
- Do not sample a stream within around 3 weeks of a large flood flow. There is likely to have been some habitat scour and loss of macroinvertebrates to downstream environments. It will take this period of time for habitat and fauna assemblages to restabilise.

3.1.3 IDENTIFICATION OF MACROINVERTEBRATES

Use the laminated ID chart in the bug box for initial identification.

There are also several guides for identification for New Zealand benthic macroinvertebrates available online that can be used to familiarise yourself with the insect groups. The Waicare link is particularly recommended.

There is a 'mystery' box into which you place the insects you are not sure about. The mystery box has four compartments, each compartment correlates to the basic four major groups of invertebrates.



Mayfly Larva

3.1.4 WHAT THE MACROINVERTEBRATE ASSEMBLAGE TELLS US

At the simplest level, the overall health of the stream can be gauged by seeing what is present or absent in the sample. This is known as a **qualitative** method, because it doesn't consider the number of bugs.

To detect more subtle effects on the stream, more precise sampling and detailed sorting is needed. Keys and photos will be needed to help identify bugs. While most of the bugs can be identified in the field and released back to the stream, this quantitative method may require taking mystery bugs back to the lab for identification.

For a more precise idea of stream health some of the following indices may be used. They are relatively simple to calculate, and each provides some useful information about the stream. Using several different indices provides a more complete understanding of the health of the stream.

Taxa Richness

Count the number of taxa (families) in the whole sample and record on a data sheet. Numbers usually increase with larger samples. The species richness, or total number of species, provides important information about the variety of the bug population in the stream. Knowing that there are caddisflies in your stream is useful information but knowing there are three different families (taxa) of caddisflies is even more useful.

The greater the species richness, the larger the variety of the bug population. In general, streams with a larger range of bugs are considered healthier than those with fewer. However, some organic pollution (excess nutrients from silage pits or animal wastes from a stock crossing) sometimes increases the number of species, especially in high altitude streams that are naturally low in species diversity and number of individuals.

EPT Richness

Count the total number of EPT taxa (Ephemeroptera - mayflies, Plecoptera - stoneflies, and Trichoptera - caddisflies) in the sample.

The EPT richness, or number of mayfly, stonefly, and caddisfly species, provides important information about your stream because these creatures are generally more sensitive to pollution. EPT numbers usually drop with pollution, although some mayflies and caddisflies tolerate some pollution (the bug box pictures show two exceptionally tolerant ones).

Many species of midges, sand flies, crustaceans, aquatic worms and snails tolerate more pollution, and tend to move into habitats vacated by mayflies, stoneflies and caddisflies when areas become polluted. This shift tends to simplify and destabilise the structure of the bug community and reduces the biological soundness of the stream ecosystem.

Although EPT richness values above 12 are considered good, some naturally unproductive high-altitude streams may have lower EPT numbers and yet be pristine.

EPT Richness	Stream Quality Assessment
More than 15 families/genera	Excellent
12-15 families	Good
8-12 families	Fair
Less than 8 families	Poor

Sequential Comparison Index (SCI)

Measures of relative abundance provide information on the make-up of the community. A community composed of many different types of bugs will score higher values. A stream community that supports a wide diversity of invertebrates is considered healthy and will be more stable.

Add up the number of different types of organisms and the total number of organisms, then calculate the diversity index:

$$\text{SCI} = \frac{\text{Number of different types of bugs in sample}}{\text{Total number of bugs in sample}}$$

This index shows the variety and relative abundance of bugs. People unfamiliar with identification of invertebrates use this measure easily. The index is based on the idea of runs. A new run begins each time an invertebrate picked from a sample is different from any already picked. The boxes in the tally sheet are simply ticked as each new kind of bug is identified. Compare your sequential comparison index with the table below:

SCI Value	Stream Rating
1 - 0.9	Excellent
0.89 – 0.6	Good

0.59 to 0.3	Fair
0.29 to 0.0	Poor

Pollution Tolerance Index (PTI)

Multiply the number of types of organisms in each tolerance level by the tolerance value for that level (4,3,2 or 1). These levels are shown on the lid of the bug box.

For example, in a sample that contains mayflies (4), stoneflies (4), caddisflies (3) and some diptera (1), the calculation would be:

2 x 4 (2 different types of organisms each with tolerance scores of 4)

+ 1 x3 (1 type of organism with a tolerance score of 3)

+ 1 x 1 (1 type of organism with a tolerance score of 1)

Pollution Tolerance Index (PTI) = 8 + 3 + 1 = 12

The Pollution Tolerance Index is based on the concept of indicator organisms and tolerance levels. Indicator organisms are sensitive to water quality changes and respond in predictable ways to changes in their environment. By their presence or absence, they indicate something about water quality. This procedure can be used to detect a relatively coarse level of degradation in stream quality.

Compare the index value with the scale below:

PTI Value	Stream Rating
23 and above	Excellent
17 - 22	Good
11 - 16	Fair
10 or less	Poor

Macroinvertebrate Community Index

Most regional councils use a more detailed version of the PTI called the Macroinvertebrate Community Index (MCI) for freshwater biological monitoring. It was designed to assess organic enrichment in streams and rivers and works by using macroinvertebrates as indicator species and linking their presence/absence with low/high levels of organic loading. The indicator species are assigned a score, and this is weighted according to their particular sensitivity to organic pollution. There are different scores assigned to indicator species depending on whether you are sampling hard or soft-bottomed streams.

The MCI and number of EPT taxa are of particular use for rapid bio-assessment protocols in lowland streams (Boothroyd and Stark 2000).

The MCI is calculated from presence-absence data as follows.

$$\mathbf{MCI = 20 \sum a_i / \mathit{S}}$$

where S = the total number of taxa in the sample, and a_i is the tolerance value for the ith taxon.

So, in practice you would add all the scores together of the taxa in your sample, divide this by the total number of taxa in the sample and then multiply this by 20 to get the MCI score.

Interpretation of MCI scores taken from Boothroyd and Stark 2000 are shown below:

Quality	Interpretation	MCI score
Excellent	Clean water	>120
Good	Doubtful quality or possible mild pollution	100-119
Fair	Probable moderate pollution	80-99
Poor	Probable severe pollution	<80

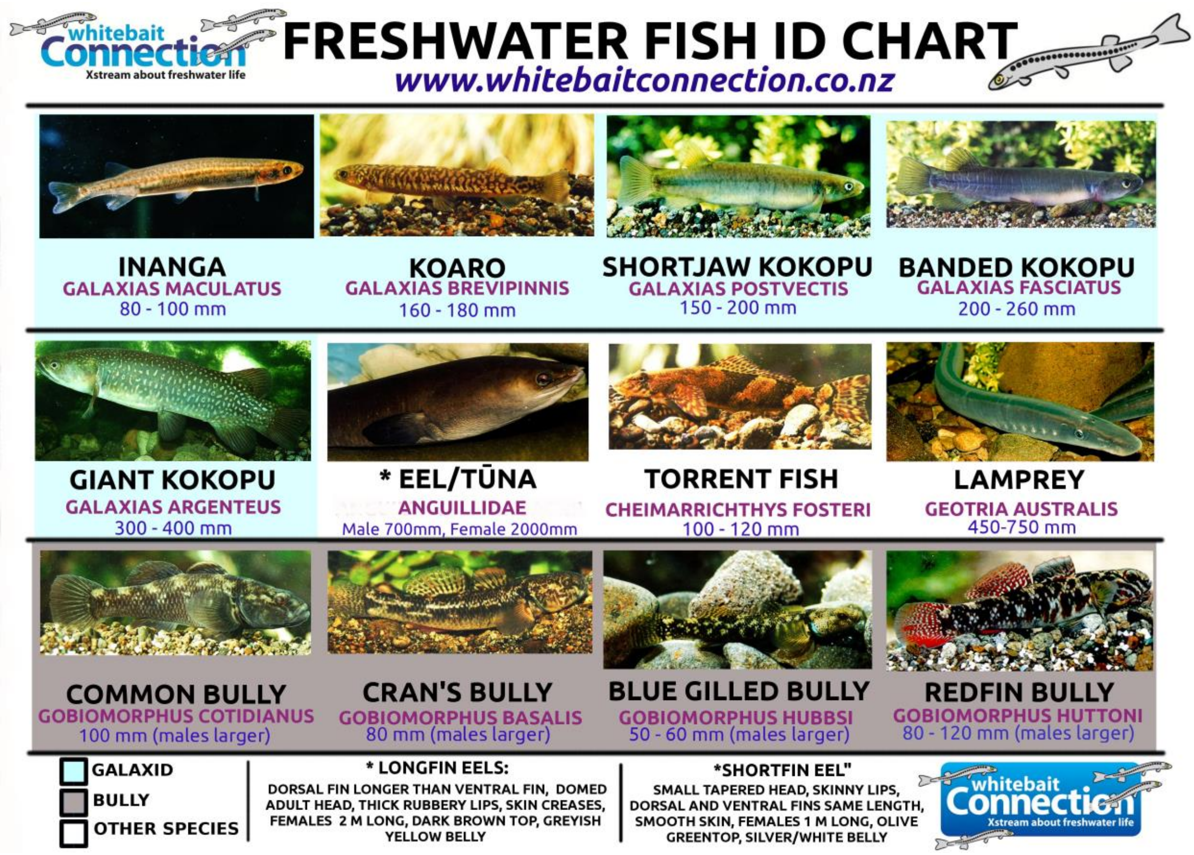
The Waicare Invertebrate Field guide (linked above) is the resource most likely to be used with this handbook and this simplifies the MCI scores slightly to cover the main families and just the hard-bottomed scores for indicator species. This is sufficient for this programme, but it is good to know that there are another set of scores out there also for soft-bottomed streams.

3.2 FRESHWATER FISH

New Zealand has a rich diversity of freshwater environments with abundant rivers, streams, lakes and wetlands. New Zealand has at least thirty-five native species of fish, yet they are little known to most of us who perhaps could name not more than a couple. Many people still believe our streams and rivers to be void of *any* fish life apart from eels, whitebait and the introduced species of trout.

Some of the reasons why so they are unknown are that native fish are relatively small, secretive and nocturnal. Also, half of our fish species spend some part of their lives at sea, which means they need easy passage to get to and from their freshwater habitats.

New Zealand's geographic location as an isolated set of islands in the middle of the South Pacific, is partly responsible for producing some of our extraordinary native freshwater fish species. Today it is known that 31 of them are not found anywhere else in the world and are endemic (found in only this locale) to New Zealand.



One of the Whitebait Connection fish identification resources showing a few of the commonly found native species

3.2.1 DISTRIBUTION OF FISH IN NEW ZEALAND

NIWA, the National Institute of Water and Atmospheric Research, is a Crown Research Institute established in 1992. It operates as a stand-alone company and carries out research for the benefit of New Zealand on our water and atmosphere environments.

NIWA has recently completed a major survey on the distribution of native fish in New Zealand. Staff at NIWA, regional councils, consultancies, Fish and Game NZ and the Department of Conservation (DOC) have surveyed habitat used by fish in New Zealand streams and rivers over the past 15 years. They have built up a large database of observations from this. This is known as the New Zealand Freshwater Fish Database.

Data on more than 21 000 fish have been collected from over 5000 locations throughout New Zealand. By comparing fish presence with the physical characteristics of the locations, NIWA graphed 'habitat suitability curves'. Understanding the habitat requirements of each species can inform decisions about water management.

The following findings were made (information taken from the NIWA website):

- Eels were the most widespread species, found in about half of the rivers surveyed.

- Upland and bluegill bully were the most abundant widespread species, followed by eels, brown trout, and common bully, all with more than 1200 individuals being caught.
- Three fish were left out of the study – giant bully, black flounder, and shortjaw kōkopu – because they caught fewer than five of each of these species.
- Habitat preferences:
  - Rapid/riffle – torrentfish, bluegill bullies, kōaro, alpine galaxias, and upland longjaw galaxias
  - Run – juvenile eels, trout, and some galaxiid and bully species
  - Pool – adult eels, lamprey, various juvenile galaxiid species, and adult kōkopu.

This information contributes to decision making in relation to aquatic restoration, biodiversity planning and management of the range of activities that alter stream habitat and water allocation.

3.2.2 WHAT SORT OF FISH SHOULD BE PRESENT IN YOUR STREAM?

You have already gathered a lot of information about your stream e.g. the catchment of your stream (Section 2.1), the stream order (Section 2.2.5), distance inland (Section 2.2.6), its physical habitat values (Section 2.3 & 2.4) and the macroinvertebrate fauna (Section 3.1). All this information helps to predict what fish might be present in your stream. Review the fish habitat sheet also at:

To make some more site-specific predictions, there are some excellent tools on the NIWA website or reports written by NIWA that can help you work out what fish you might expect in your stream.

Use NIWAs Fish finder to discover the distribution of all New Zealand's native fish and see from these maps whether they may occur in your stream:

Look at this report produced by NIWA. This is a technical report but does contain useful distribution maps and information at the back of the document that could be helpful P.21-49.

3.2.3 WHAT SORT OF FISH ARE PRESENT IN YOUR STREAM?

Having predicted what fish might be in your stream you can set about researching what fish actually are in your stream. This can be done, first at a desk-top level then actually out in the field.

3.2.3.1 AN INTRODUCTION TO THE FRESHWATER FISH DATABASE (FFDB)

The desk top part of your survey could investigate whether there have been any surveys already completed on your stream in the past. The best source of information for that is the New Zealand Freshwater Fish Database (NZFFD). This contains over 30,000 records of the occurrence of freshwater fish throughout New Zealand and its main offshore islands. Data are recorded on a standardised card in the field and then submitted to a database manager for quality control. The data has been collected and contributed voluntarily by a wide variety of entities including staff from NIWA, the Department of Conservation, Regional Councils, environmental consultants, Universities, Fish and Game Councils, other Crown Research Institutes, schools and members of the public.

The data collected includes the location of sample sites, the fish species present, information on their abundance and size, sampling methods and a physical description of each site. This information is freely available to the public, but you do need to register. You can use the database to find your stream and see if there are any fish records for it from past surveys. The user guide provides a step-by-step approach to accessing the data and using the Fish Assistant software.

Use NIWAs Freshwater fish database to find records of any surveys that may have taken place in your stream.

It is important to review the assistant software for this database and gain a good understanding of it to get good search results.

3.2.3.2 FISH SAMPLING METHODS

With the desk top work complete, it is time to go out into the field to collect your own fish data as part of your investigations. There are three main fish sampling methods – backpack electrofishing, trapping and spotlighting. The Whitebait Connection programme uses the spotlighting technique, but the other options are also described in brief:

Electric fishing

Professional researchers often use electric fishing to assess freshwater fish populations. Electric fishing uses a portable generator to pass an electrical circuit through the water to stun the fish within the immediate vicinity of a handheld electrode. This renders them easier to catch for study purposes. Because of the possible dangers inherent in a combination of electricity and water, electric fishing operators need to be licensed and qualified.

Advantages: It is a fast and effective way of sampling the fish fauna.

Disadvantages: All personnel undertaking electrofishing must have completed an EFM training course and have current workplace first aid certificates; it is an expensive form of sampling as it requires at least 3 operators to undertake effectively; there is a danger element to humans, livestock and the fish.

Netting

Catching fish species in nets (fyke nets, Killwell nets and Gee minnow traps), set along the stream reach overnight, is a viable option. Place the nets in suitable sections of the reach where they can be securley attached to the bank. The opening of the nets should be parallel with the flow of water. Place the opening of the fyke net downstream so it does not collect lots of debris in it. Traps do not generally ned to be baited. The fish will usually enter them out of being inquisitive.

Advantages: Netting is relatively safe and can be carried out by a wide range of age groups; it can be carried out in normal working hours but does need a return trip the next day.

Disadvantages: The nets can be subject to damage by vandal; possible theft of nets; they are subject to damage or loss by flooding; some native fish species are “escape artists”, they are really skilled in getting out; and some fish are at high risk of predation if caught in a net with their main predator!

Spotlighting

Spotlighting involves shining a powerful spotlight into the stream reach at night and recording what species are seen. Spotlighting is a sampling technique particularly suitable for wadeable streams in New Zealand because many freshwater fish species are benthic (bottom-dwelling) and nocturnal. A stream, apparently devoid of any fish life during the day, is suddenly full of activity. The fish are seemingly mesmerized by the light and sometimes are so amazed by it; they can actually be touched!

Advantages: In many ways, this method is by far to be preferred to all the others. It is fairly rapid to undertake, it needs little equipment, and it is a largely non-invasive technique.

Disadvantages: Catching the fish to obtain accurate length measures is very time consuming. It is recommended that operators visually estimate fish size by placing them in defined species size categories and regularly capture and measure some fish during surveys to ‘calibrate’ and record their ‘visual estimate error’. It is impaired by visibility of the water and it is conducted outside of normal working hours.

Spotlight Fishing Protocol

Equipment:
Net
spotlight with battery
torch
a bucket
a clear plastic container
Fish identification guide recording sheet

1. Mark a 150-m reach of the stream. Separate it into 10 subsections of 15-m length. Mark sections during the day and begin spotlighting 45 minutes after dark.

2. Walk beside the stream, if possible, shine the spotlight 1–2 m ahead, and sweep from bank to bank. Identify and count all fish. Estimate size, capturing the occasional fish to calibrate estimate. To capture a fish, good teamwork will be required. The spotlight operator will try and herd the fish (with a stick or second net) towards the person with the first net, rather than attempt to scoop or “catch” the fish.

3. Once the fish are in the net, empty it very carefully into a bucket, or into a clear plastic container containing water. Clear plastic containers will enable you to have a good look at the catch to assist in identification. As with water bug surveys, start downstream and work up so you are always working in previously undisturbed water. **Tip:** Take your time and get your 'eye in'. This is something most people get very good at in a relatively short time.

Identify, count and measure (total length) all fish species caught in your surveyed stream reach. An online key to identify New Zealand fish species is available at:

NIWA Atlas of NZ Freshwater Fishes

Survey Timing

All the sampling methods above can under-represent certain of the fish species for one reason or another, associated with their technique. However, there are also some issues that should be considered in the timing of the survey that can cause variability in the results. If they cannot be avoided, they may at least offer an explanation as to why some species may not be present in your survey. These have been cited from *New Zealand Freshwater Fish Sampling Protocols, Part 1 – Wadeable Rivers & Streams (*Joy, David, Lake; 2013*)*

- In general surveys for State of the Environment type monitoring (an inventory of what is present) should not take place between May 1 and November 30. Generally, fish become less active and less susceptible to capture when temperatures are low.
- Avoid fishing during or immediately after rainfall events or bed moving high flows. During such periods fish can either be displaced from the survey area or may burrow further into the substrate cover, thus reducing fish capture efficiency and causing unnecessary data variability. For example, the Waikato Regional Council imposes a two-week stand-down period for any biological sampling following bed disturbing flows.
- Generally, the optimal time for fishing and minimising variance is when flows are at or close to base flow and stable.
- Avoid sampling during full moon phases when spotlighting as fish tend to become more skittish.
- Do not deploy any nets or traps if heavy rain is forecast for the catchment over the following 24 hours.

Also note that most of the fish species migrate within the stream during certain times of year, although all of their behaviour is not fully understood.

The banded Kōkopu for example, have a time in autumn when they can be found in the middle and lower reaches. Most of the remainder of the year you may find them mainly in the upper reaches or upper tributaries in forested areas.

Eels are also quite mobile in the stream system, with a general pattern of small elvers (baby eels) travelling up through the stream and maturing in the middle and upper catchment areas. Later, at a certain stage of their adult life, eels form great migrations downstream and out to sea for their journey to the spawning grounds, which are believed to be somewhere near Tonga.

3.2.3.3 HOW INTACT IS YOUR STREAM FISH FAUNA - WHAT SPECIES ARE MISSING?

Having worked out what fish ***should*** be present in your stream and which fish ***are*** actually present, it will be possible to see which species are missing. If one or more of the species that should be present is either absent or scarce, it is likely there is a problem. The next section discusses the sorts of issues that may reduce the fish fauna in your stream.

Note that some fish such as the giant and shortjaw Kōkopu are naturally rare, while others such as torrentfish and bluegill bullies are only present in specific micro-habitats which may not be present. However, if the more common species are missing then this would trigger you to look at reasons why.

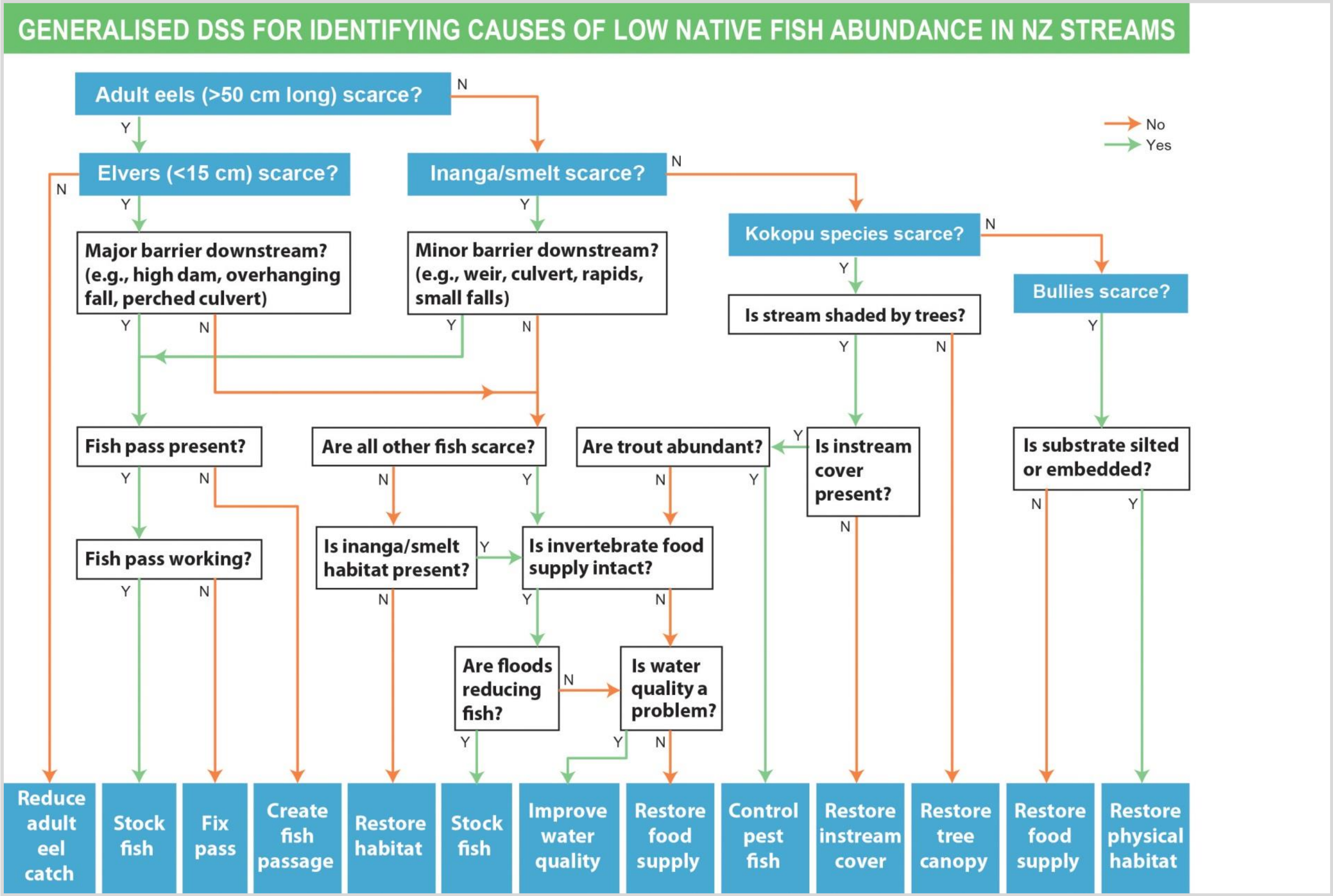
3.2.4 WHAT SORTS OF THREATS ARE THERE TO THE FISH IN YOUR STREAM?

Fish are at the top of the food chain in freshwater systems. Because of this they have suffered more than most and focusing on freshwater fish species is a very good way to learn about the whole stream system. It is a sad fact that in New Zealand we have lost much of the abundance and productivity that was once a feature of our freshwater systems. Over the past century, species populations have been steadily reduced by water pollution, overfishing, human interference with stream habitats and by introductions of exotic fish.

Declining numbers of freshwater fish are commonly the result of one or more of the following:

1. Poor recruitment – blockages to fish passage
2. Habitat loss
3. Biotic limitations – e.g. food resources, pest fish

One or more of these three factors may be at play in your stream catchment and be having an effect on your stream. These factors may reduce some species but not others. The diagram on the following page is taken from the NIWA website and shows a generalised species-specific decision support system (DSS) to help identify the main causes of low native fish abundance in NZ streams. It also provides the response to the management response to these issues.



Source NIWA website

3.2.4.1 POOR RECRUITMENT

Recruitment is a measure of the number of new juvenile fish reaching a habitat so they can sustain a population there.

An unusually high proportion of our native fish are diadromous. This means that they undergo migrations between fresh and salt water as a necessary part of their lifecycle.

- Species such as eels, mullet, freshwater flounder grow to adulthood in freshwater and then migrate downriver to breed in the sea.
- Galaxiids, smelt and bullies breed in freshwater with their juveniles travelling downriver to develop at sea.
- Only the lamprey breeds and develops in freshwater streams and spends its entire adult life at sea.

Because these diadromous species all need to migrate upriver from the sea at some stage, they are vulnerable to barriers created by falls, chutes, dams, weirs, and perched culverts. This is one of the most significant causes of the decline in freshwater fish populations in New Zealand.

They also vary widely in their ability to swim upriver. Some species (e.g. eels, banded Kōkopu, redfin bully, koaro) can easily climb vertical wet/moist rock faces of dams or waterfalls. This allows them to move much higher up the catchment. Other species cannot climb (e.g. īnanga, smelt, mullet) and are restricted to lowland, coastal streams. Consequently, the geographical distributions of the species vary widely within rivers and are greatly affected by both altitude and distance from the sea.

If climbing species are absent from your site, there is likely to be a barrier to the upstream migration of the juveniles downstream. Check your site's altitude and distance upriver from the sea using the information you gathered about your catchment (Section 2.2.6). Have you already identified any barriers to fish passage in these initial investigations?

Fish passage can be reinstated by several management options including lowering perched culverts to bed-level, constructing fish ramps up to a perched barrier, hanging rope from a culvert, a fish pass taking the fish around an obstacle and slowing flows through a culvert using baffles.

3.2.4.2 HABITAT LOSS

Changes to habitat can cause fish to be totally absent or present only in small populations in a stream. Part 2 of this handbook discusses the different habitat parameters in a stream. Of relevance particularly to fish are changes to water flow, vegetation cover, substrate and water quality:

Water flow

Physical features such as rapids, riffles, pools, water depth and velocity all provide habitat for fish. If these elements change, then these fish habitats may be lost or altered to be unsuitable.

Faster flows caused by loss of vegetation in a catchment, channelisation for flood management or stormwater from impermeable catchments will all increase runoff with consequent losses in habitat from flash floods, bank/habitat erosion and siltation.

Smaller flows caused by dams, abstractions or land use changes upstream will reduce the wetted area of the stream and water velocities, all affecting fish habitat in pools, runs and riffles.

Vegetation cover

Vegetation cover is also a very important habitat requirement for fish in New Zealand. There are different types of habitat that it can provide:

- Shade from an overhead tree canopy - important for koaro and the kōkopu species;
- Instream plants - important for īnanga; and
- Instream features such as a hole created by large woody debris - important for eels and kōkopu.

If a type of cover is lacking, one or more of the species that depend on it will be absent or scarce, even though physical habitat is otherwise suitable.

Poor water quality

Finally, if suitable water flows and cover are both present, and recruitment is not a problem, the absence of fish may be due to poor water quality.

Summer water temperatures may be too high for some fish or the pH or oxygen levels may be too low. This may be due to natural features e.g. sluggish flows in a higher order stream; geology that affects the pH of water locally; or man-made pollution e.g. chemical spills and discharges. Recolonisation will occur naturally after pollution events, but it can take years.

3.2.4.3 BIOLOGICAL LIMITATIONS

There are also biological limitations that can affect the populations of fish in a stream.

Food supply

Invertebrate fauna are a critical food resource for native fish and so if they are limited, perhaps due to heavy siltation, pollution or excessive algal growth instream, fish abundance will also decline. An invertebrate community that is diverse and comprises high densities of large insect larvae such as mayflies and caddisflies is an indication of good food supply for fish. One which has low diversity and is dominated by snails, for example, is a poorer food source.

Invertebrate communities can be improved by improving habitat through riparian planting, reducing sources of sedimentation, and identifying any sources of pollution.

Pest fish

The introduction of large, northern hemisphere, predatory, fish species like trout, perch and catfish to New Zealand, has had a significant impact on the native fish fauna. These pest fish can reduce the abundance of native fish through competition, predation and aggressive behavior. The main issues that pest fish can cause are:

Niwa have produced an article on pest fish that is useful as an introduction.

- Stirring up sediment and making the water murky
- Increasing nutrient levels and algal concentrations
- Contributing to erosion
- Feeding on and removing aquatic plants
- Preying on invertebrates, native fish and their eggs
- Competing with native species

Unfortunately, Northland with its subtropical climate is proving to be a new home for a number of aquarium fish, carelessly and sometimes illegally released by their keepers. Mosquito fish *Gambusia affinis,* for example are being blamed worldwide for damaging native fish populations by eating their eggs and young. *Gambusia's* breeding potential has been estimated to expand from a population of 7000 to 120,000 in only five months!

Other pest fish include perch (*Perca fluviatilis)*, caudo (*Phalloceras caudimaculatus)*, grass carp (*Ctenopharyngodon idella)*, rudd (*Scardinius erythrophtalmus)*, tench (*Tinca tinca)*, European carp (*Cyprinus carpio)*, goldfish (*Carassius auratus)*, brown bullhead catfish (*Ameiurus nebulosus).*

As a general rule, if juvenile trout are present, galaxiids are likely to be scarce; if gambusia are present, and the stream is shallow and still (i.e., a pool habitat predominates), īnanga and smelt will be scarce.

Perhaps some of the most threatening of these species are catfish, gambusia, koi carp and rudd.

If you catch or observe any of the above pest fish in your catchment, please notify your Whitebait Connection coordinator or the Department of Conservation.

Overfishing

Large eels may be scarce if they have been overfished. From the 1960s, commercial catches of eels have risen steadily. "*In 1975, eels were the most valuable fish export after rock lobsters. Five years later, they were the fifth most valuable finfish export. This big increase in fishing effort led to significant stock reductions in some areas, with a marked decline in the average size of the eels caught*" (source DoC website).

Not enough is known about the quantity, quality, and sustainability of the eel fishery – including the fact that short fin and long fin eels are often harvested as one despite the latter being classed as threatened. This is highlighted in a report in June 2013, about longfin eel from the Parliamentary Commissioner for the Environment. This has been welcomed by the Ministry for Primary Industries (MPI) and the Department of Conservation (DOC) who are both committed to understanding more about data on longfin eels.

Disease

In other countries, disease and parasite infections can result in a sudden and dramatic decline in the abundance of vulnerable fish species. However, these have not been reported for native fish in New Zealand rivers to date, so they are unlikely to account for a reduction in fish abundance.

3.2.5 ADDITIONAL INFORMATION ABOUT ĪNANGA

Lifecycle of the whitebait species – the migratory galaxiids

What are whitebait?

Of the more than 20 known New Zealand species of the family galaxiidae just five have a migratory sea going whitebait stage. These are the familiar īnanga (*Galaxias maculatus*) which provide the mainstay of the whitebait fishery and the four larger more spectacular looking kōkopu species which include banded(*G. fasciatus*) , giant (*G. argenteus*) and shortjaw kōkopu (*G. postvectis*)and the koaro (*G. brevipinnis*) . Other non-migratory galaxiids include 5 species of mudfish (see O'Brien and Dunn 2007), and around a dozen more fish (some yet to be formally described) including a suite of species unique to eastern and southern South Island (e.g see McDowall 2010)**.**

The 5 migratory whitebait species, except for the banded kōkopu currently listed as "not threatened", are declining and "At Risk" (Allibone et al 2010). The fundamental problems are habitat loss and degradation and blockages to migration pathways between the sea and freshwater habitats. The whitebait species lifecycle requirement to utilise and have free access to freshwater and marine environments is perfect for demonstrating the "Mountains to the Sea" concept of integrated catchment management and the "Whitebait Connection".

Īnanga are the smallest of the whitebait species and as adults reach about 10cm; they are also the most short-lived at typically 1-2 years, while the kōkopu's and koaro range from about 20- 50cm long and may live 10 to 20 years . Īnanga live in low gradient waterways nearer the coast and are a more day active- open water shoaling species while the others may penetrate long distances inland are more nocturnal, cryptic and associated with cover.

Spawning on the land?

All the whitebait species spawn on riparian margins and have larvae which rear at sea before returning to freshwater environments as whitebait to grow to adulthood. However, the īnanga differs from the other 4 whitebait species in that it relies on the water level changes induced by spring tides to allow egg deposition and hatching out of larvae (e.g see McDowall and Charteris 2006). The other species spawn on the flooded margins of typical adult habitat during flood or fresh events and rely on subsequent freshes/floods to inundate eggs and promote hatching before the larvae migrate out to sea.

Therefore, before hatching, the sensitive eggs of all of the whitebait species are exposed for several weeks to a variety of potential impacts. These include egg losses from predation by natural predators (e.g eels, bullies), bacterial or fungal infections and environmental stressors such as droughts or floods. Human induced impacts range from stock trampling īnanga eggs deposited on stream banks in lowland catchments to riparian vegetation removal at kōkopu spawning sites at higher elevations.

Whatever the whitebait species, from īnanga to giant kōkopu it makes sense to identify and protect the spawning areas to optimise egg deposition and subsequent egg survival. Native riparian vegetation, intact bank structure, good water quality and natural flow/ water height regimes provide optimum conditions for spawning and successful egg development and hatching. These conditions will also maintain the productive capacity of adult and sub- adult habitats. Fish passage is also a prerequisite to allow migrating whitebait access to spawning grounds and upstream habitats.

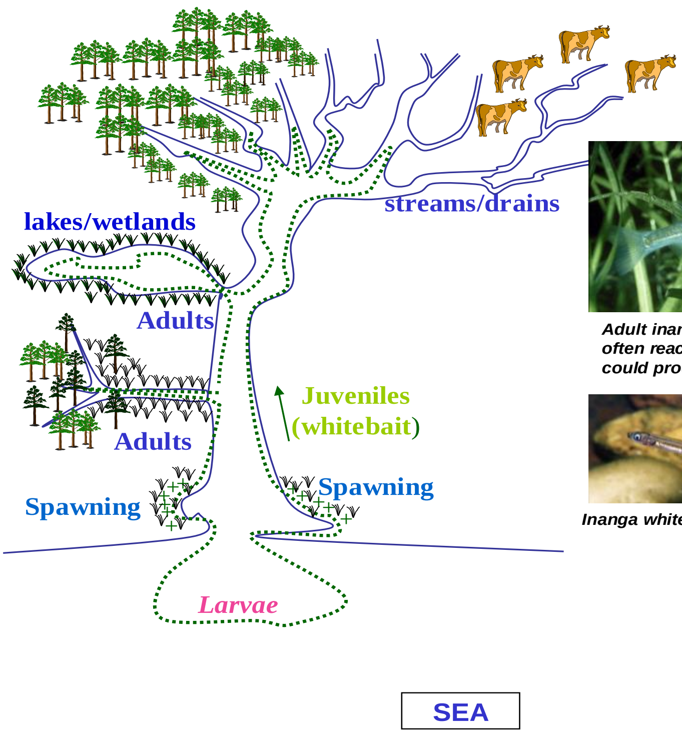
Bob McDowall's (1990) book 'New Zealand freshwater fishes" provides a good overview of the all the whitebait species and their habitat requirements and more recent scientific literature is summarised in McDowall (2010). "Ikawai" (McDowall 2011) provides a detailed Māori perspective on the whitebait and other freshwater fish species. The New Zealand Whitebait Book McDowall (1984) adds a further perspective on the history of the whitebait fishery and fascinating anecdotes on the fish and fishery.

Background on Īnanga Ecology

The īnanga occurs throughout New Zealand and is the most abundant of the 5 whitebait species inhabiting coastal rivers, streams, lakes and wetlands. Īnanga whitebait make up about 95% of the whitebait catch and are a NZ icon and taonga with their long history of cultural importance as food to Māori and Pakeha and the associated NZ whitebaiting culture. Īnanga also have significant commercial importance for the fishery they support, which is governed by whitebait fishing regulations administered by DOC. Īnanga are important in the food chain as a source of food for many animals e.g eels, trout, kahawai, flounders and piscivorous birds such as herons and terns. There is an extensive literature (see bibliography) on the species ecology and its habitat requirements. McDowall's classic book New Zealand Freshwater Fishes (1990) provides an excellent overview. "Ikawai" **(**McDowall 2011)

As an inhabitant of lowland waterways already subject to extensive modification from agricultural and urban development, there is great opportunity to partner landowners, iwi, schools, community and environmental groups, Councils and others to protect and restore īnanga habitat –both the adult habitat and especially the critical spawning habitat located in the tidal reaches of waterways.

Lifecycle of inanga



Adult inanga are an attractive fish and often reach about 10cm. The fish pictured could produce up to 10,000 eggs

Inanga whitebait about 50mm long

The life history of the īnanga variously involves: adult life in freshwater and estuaries with movement between them; autumn spawning of adults on riparian margins within spring tide influence; hatching of eggs after about 2- 4 weeks and the larvae being transported to and living in the sea for about 6 months then returning to freshwater in the springtime as the familiar īnanga whitebait (about 50mm long). Adult īnanga live usually for 1-2 years and there is general recognition that the lack of suitable spawning habitat is a fundamental bottleneck that limits the population (McDowall 1990). Īnanga whitebait have the least capability to climb and surmount obstacles of the five whitebait species (e.g. Doehring 2009). Enabling passage for īnanga and other fish by addressing blockages caused by poorly designed and positioned culverts, tidegates, floodgates and other barriers is another effective īnanga conservation tool being employed by DOC and Councils (e.g. Boubee et al 2000).

Ecology of Īnanga Spawning

Imagine rivers flowing intensely white from immense quantities of īnanga milt (sperm) expressed during spawning-these were the accounts of the early writers and observers of īnanga spawning. "Cowfish" was another name ascribed to īnanga because of this effect. Occasionally large-scale spawning is evident today but more typically it is on a smaller scale (Figure 1) because of the scale of habitat loss and changes generally evident in the lower catchments of New Zealand rivers.

Figure 1: Milt drifting in Poorman Stream Nelson

Figure 2: Īnanga eggs amongst rootlets and stems

A detailed account of īnanga spawning and summary of relevant literature can be found in McDowall (1990) and McDowall and Charteris (2006)) with a regional analysis of spawning locations and their characteristics set out in Taylor et al (1992) and Taylor (2002).

Īnanga spawning may occur from as early as January to as late as June, but the peak months are March – May, with April the overall peak. At big spawning sites tens or hundreds of thousands of mature fish congregate in the tidal reaches of rivers during the spring tide cycle. Their bellies are distended and silvery/white with eggs and milt which may express freely if the fish are caught and handled. Often spawning is concentrated a few days after the new moon or full moon tide. Spawning is also often concentrated around the upstream limit of a wedge of saline water that pushes up under the freshwater layer. Eggs and sperm are deposited near the top of the highest spring tide level amongst the inundated vegetation- sometimes in a real spawning frenzy audible from some distance away. The presence of predators such as herons and eels are often a good clue to what is going on as the spawning īnanga make easy prey in the shallow margins. The eggs must remain moist until they hatch when inundated by the next cycle of spring tides. Because egg development is temperature dependent hatching may vary from 2-4 weeks. If the spring tide is not high enough to re-immerse the eggs hatching can be delayed which may be for up to 48 days.

Īnanga will spawn amongst a variety of vegetation types which may include various mixtures of introduced pasture grasses and herbs, native grasses, rushes, flax and larger shrubs and trees. The plants that eggs are deposited amongst are adapted to freshwater influence and spawning in saline adapted vegetation is very rare. Fundamentally, the vegetation whether it is native or exotic, needs to trap sufficient moisture at its root base to ensure īnanga eggs remain moist until they hatch when inundated by the next cycle of spring tides. Typical plants associated with spawning are listed in from Richardson and Taylor 2004. Exotic grasses dominate most spawning sites surveyed in New Zealand (Taylor 2002) and can provide excellent spawning habitat because they can trap high levels of humidity at their root bases where the īnanga eggs accumulate (see picture) sticking to the fine rootlets and stems. Taller and denser patches of vegetation tend to be preferred because of the extra protection they afford to eggs by shading and trapping of moisture. Eggs may also be deposited on and amongst accumulations of dead leaves and stems in moist shady environments.

The same sites may be used for spawning for many years, however, sometimes sites are abandoned and often without obvious reasons. It has been noted, however, that when rank pasture grasses are allowed to regenerate over many years to become exceptionally thick and tall, īnanga spawning within these sites may stop (e.g Taylor 2002) probably on account of them becoming too thick for fish to easily penetrate into.

Gently sloping stream banks are subject to extensive submergence when inundated (see Fig. below) and provide large easily accessed areas for egg deposition, while steep banks limit the area of suitable habitat available. Re-contouring artificially over- steepened banks to more gentle gradients has been used successfully to improve spawning habitat by some councils (e.g see Taylor and McMurtrie 2004). Where banks are steep and collapsed then the optimum pockets of habitat that are flatter in gradient with thick vegetation are prime areas for spawning (e.g. see Richardson and Taylor 2004).

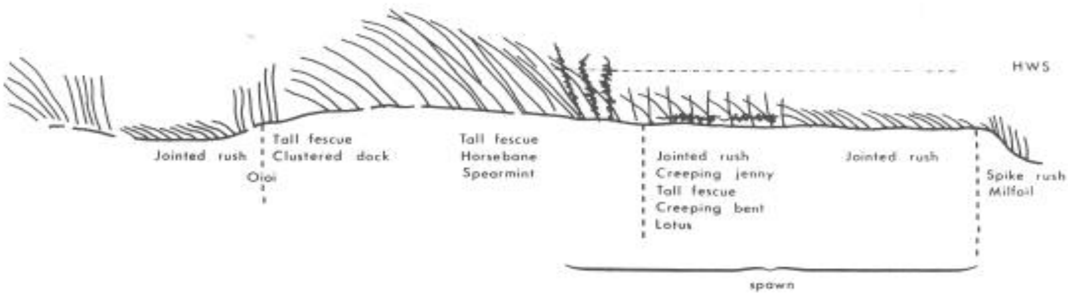


Figure 3 - The diagram shows how spawning on a low gradient site in the Grey River covers an extended area (Taylor et al 1992)

The requirement for shading of eggs means that the bank of the river receiving the least sun is most often utilised for spawning. Research has shown that egg mortality may increase by 95% when exposed to sunlight (e.g. Hickford and Schiel 2011). Deciduous introduced trees such as willows may generate extensive leaf fall which smothers eggs and reduces survival, it also suppresses the growth of other lower stature vegetation that better optimises spawning success.

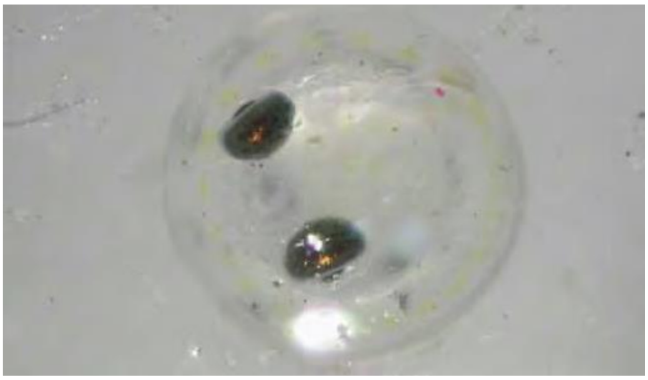


Figure 4: A well-developed īnanga embryo (about 1.2 mm) the most vulnerable phase of the lifecycle (from Taylor 2005).

The vulnerability of īnanga eggs deposited on stream margins has long been recognised- notably the impact of stock grazing and trampling (e.g McDowall 1984) and fencing out stock remains the primary measure to protect spawning grounds. Other adverse impacts on eggs include activities such as riparian vegetation clearance, weed invasion, mowing, pollution, sedimentation, over-steepening of banks, human trampling and the deposition of rubbish or other material. Besides these unwelcome impacts the eggs also face predation by a range of predators including mice, crabs and fish such as bullies and eels (Baker 2006), īnanga have also been found to cannibalise their own eggs at times!

Figure 5: When submerged at spring tide this small site supported high densities of eggs especially amongst the more rank grass (arrows)

Finding Īnanga Spawning

Before you go searching for spawning fish or īnanga eggs check for existing information

Don't assume that your site of interest has not been surveyed before, the landowner(s), Conservation Department, NIWA (and previously MAF) District and Regional Councils, iwi, community groups and researchers may have conducted surveys there in the past or hold important knowledge about the site. Councils or DOC may have undertaken or commissioned survey work and hold spawning survey data. Approaching these contact points might save you a lot of time in figuring out which places you might best target in finding spawning grounds. Some Councils may also hold detailed data on spring tide water level heights that may help in locating the most likely elevations for egg deposition (e.g Sykes 2012). Currently there is also research into GIS tools to model and map likely īnanga spawning sites which may become a tool that is more generally available in the future. Other useful information on native fish distribution and occurrence can be found on the NIWA national freshwater fish database (for which a log in and password will need to be obtained – see www.niwa.co.nz)

Comprehensive entry of data from spawning surveys into the National īnanga spawning database ceased in about 2002 so there is a significant amount of data that is not currently accessible through this source. A national summary of īnanga spawning surveys up until 1999 can be found in Taylor (2002) and more detailed analysis of South Island surveys between 1988-1990 can be found in Taylor et al (1992).

A new īnanga spawning database is currently being designed, including data sheets for collecting spawning information and saltwater wedge information. The new database will be managed by NIWA and eventually be updated with data from previous surveys and be accessible online to interrogate and enter data. It is expected to be available by end 2014.

When the new datasheet design is finalised, it should be used to collect spawning information in a systematic way for inclusion into the new national database format. In the interim the old īnanga spawning datasheet can be used (Appendix 1). If information on saltwater wedge location is collected then it can be entered into the draft tidal wedge survey field sheet currently under development (Appendix 2).

Gaining site access

Ensure that you have landowner permission to the proposed survey site or across any land to access the site before you undertake survey work. Get details of property boundaries and be aware that land ownership on the margins and beds of waterways can be complex so that careful checking is needed to establish ownership. Besides the need to get permission to proposed survey sites it is also advisable to let adjacent landowners know that survey work is proposed.

Health and Safety

An assessment of potential site hazards needs to be undertaken so that they can be managed. Establishing what these are will require consultation with the landowner and their specific requirements for managing health and safety risks on their property. Some hazards may relate to the use of the site by stock – e.g., working around stock, and electric fences. The proximity of deep water presents drowning risks especially working on steep banks and the potential presence of deep, soft mud and boggy areas also requires care to avoid becoming stuck or submerged in these areas. Wearing of a lifejacket may be advisable in such situations. If boats, kayaks or other watercraft are used for access then lifejackets and other safety equipment will be mandatory. Likewise, if the survey is to involve children, students, community groups or others unfamiliar with working around freshwater, then appropriate levels of adult supervision and other precautions would need to be taken in accordance with the levels of risk. In addition, compliance with company or agency health and safety requirements for working in and around waters will be a mandatory requirement. For example, working in pairs and notification of whereabouts and expected departure and arrival times back at home base.

Searching for īnanga spawning grounds

The two main methods for locating īnanga spawning grounds are: 1) egg searches and 2) surveys for spawning fish. The goal of both types of survey is to find the deposited eggs and evaluate the size and significance of the spawning site and consider what is needed to protect it. Useful guidance on finding eggs and spawning fish can be found in Richardson and Taylor (2002), Mitchell and Eldon (1991) and in the 'Locating īnanga spawning sites" guide recently produced by Mike Hickford (2012) of Canterbury University Marine Ecology Research Group (MERG). Copies of this guide are available from MERG. Information has been extracted from these sources in developing this advice.

1. **Egg searches**

Egg searches should target low tide so that the eggs which are deposited near the upper most level of the spring tide can be more easily found. Care needs to be taken not to trample eggs in the process of searching! Sometimes it is easier to stand in the water while inspecting banks- this reduces bending and kneeling effort. Searching requires the pulling back of vegetation to check for eggs accumulated at the soil base or sticking to stems.

The best time to search for eggs is from March – May, with April the peak month usually. Egg laying occurs over several days just after the new or full moon (sometimes both) and 2-3 days after the highest of the spring tides. Tide tables provide information on tide heights and the spring tides while moon phase and can be checked in various tidal and lunar calendars (e.g. see here).

Prior to searching locating maximum water level on the spring tide

To increase the chances of finding eggs it is strongly advised that the site is visited prior to egg searching. This needs to occur during the spring tide cycle to determine the maximum water level height as a reference point to start egg searching. The spring tide level needs to be marked using something easily seen such as fluorescent flag tape attached to a tent peg or some other kind of marker. It needs to remain if inundated by water, disturbed by stock or subject to strong wind. A line of debris (sticks, leaves etc) deposited at the top of the spring tide level is another cue to look at as a reference to what bank height to search for eggs. Eggs usually are in a band a few centimetres below the maximum spring tide level. As mentioned previously checking for existing information on spawning at the site is another obvious way of helping to narrow down the area to be searched.

Establishing the upstream limit of saltwater

Where rivers meet the sea saltwater gets pushed upstream underneath a surface layer of freshwater as the tide comes in. Around the upstream limit of the saltwater wedge īnanga often choose to spawn-they don't spawn in saltwater but in the freshwater layer. A conductivity meter can be used to determine the salinity level at prospective survey sites. This is usually done from a boat with a series of conductivity readings taken from the surface to bottom of the channel to find the upstream limit of saltwater. Saltwater, being heavier, sits hard against the deepest part of the riverbed. Use of a conductivity meter is by no means essential- it is an expensive item of equipment and requires some training to use it; Council or DOC staff are more likely to have access to such equipment and they may be able to assist. Bank and submerged aquatic plants can provide good indicators of freshwater influence.

Bank Vegetation as a salinity indicator: The presence of saltwater tolerant plants such as sea rush, jointed rush, three square rush and Batchelor's button would indicate that spawning was most unlikely so search upstream from these looking for freshwater tolerant plants. While about 50 plant species are known to support spawning there are some in particular to look for- rank pasture grasses (highly favoured for spawning), cow parsley, creeping bent, twitch and Edgar's and common rush. The thick aerial root mats of these plants provide the humid environment suitable for keeping eggs alive and healthy.

Submerged aquatic vegetation: Look for non salt tolerant freshwater aquatic plants such as *Elodea (Canadian pondweed), Myriophyllum* (milfoil) and *Potamogeton's* –such as *P. cheesmanii or P. Crispus* and other freshwater dependent species (*see* here).

The presence of crab burrows penetrating big areas of banks is also a usually reasonable indicator that conditions are too saline for spawning so look for where the crab burrows (Fig. 6) are limited to the lower levels of the channel as an additional indicator of where to start looking for eggs.

Figure 6. Mud crab (*Helice crassa*) and burrow

Figure 7. Īnanga -belly distended with spawn

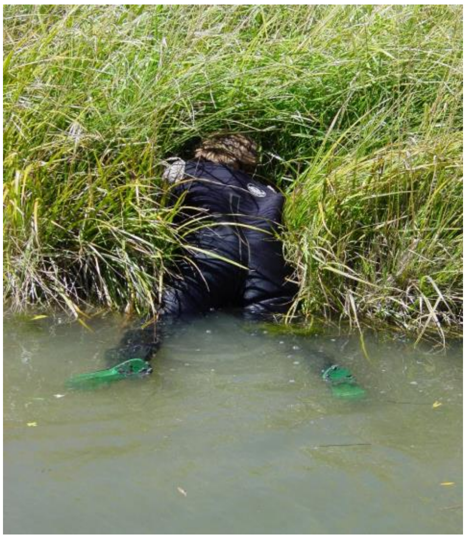
While the upstream limit of saline water is a good location to begin the search for īnanga eggs- they may occur upstream or downstream of this point depending on local site conditions – such as suitability of vegetation, bank contours and stock access. So there is usually no way to avoid expending significant effort to locate eggs, but targeting your effort should minimise this. Usually there will be defined pockets of spawning with many metres between these, but sometimes especially in large rivers, a site may extend continuously for 50 metres or more.

Targeting optimum locations for eggs

As described earlier, *shaded stream banks* are usually preferred for spawning- because the shade allows soil to remain more damp- so target these areas and avoid, dry sandy soil which is unsuitable. Besides locating freshwater tolerant plants as a general indicator of suitability for spawning look for clumps of longer vegetation which maintain moisture levels and at the same time are easy for the fish to wriggle into and amongst- (Fig. 5). Dr Mike Hickford (2012) noted highly favoured plants were tall fescue (*Schedonorus phoenix*), creeping bent (*Agrostis stolonifera*) and Edgar's rush (*Juncus edgariae*). Areas where the bank contour shelves more gently, where smaller tributary streams enter the mainstem and ungrazed patches of bank are other potential hot spots to look for eggs (e.g see Mitchell and Eldon 1991). If areas are particularly damp then these may be avoided by īnanga for spawning and from Mitchell and Eldon's observations included smartweed (*Polygonum decipiens*), Marsh seedbox (*Ludwigia palustris*) and *toad rush (Juncus bufonius)*. Click here for identification.

How and what to look for when egg searching

Keep in mind the factors that are likely to indicate good īnanga spawning habitat. If a reconnaissance visit to establish spring tide height was made target your egg searches of the bank vegetation near this height. Usually, it will be below the maximum spring tide height as eggs tend to be deposited as the tide begins to fall again after the spring tide has peaked. Figure 2 shows a close up of īnanga eggs which are 1.2mm diameter; the only other eggs of similar appearance are those of slugs which are typically 2-3 mm in diameter, more oval and opaquer. Also, as īnanga eggs develop they will show the larval fish growing inside which should be visible with a strong hand lens. The vegetation needs to be forcefully pulled apart so that you expose the bases of the plant stems and rootlets at ground level. Look carefully as if eggs are present in low densities they may be easily overlooked. Eggs may also be attached higher up on stems and sometimes may be deposited in looser plant litter and leaves. Rubber gloves may be advisable when searching in locations where there is sharp debris, rubbish or the chance of faecal contamination. Waders or gumboots are advisable.



Getting down to it for a close look!

Recording spawning site survey information

Getting an accurate record of the site surveyed and location of spawning areas is very important. A new NIWA national īnanga spawning database and datasheets are currently under development. In the meantime, the old īnanga spawning survey form and draft tidal wedge datasheet (Appendix 2) can be used to record information which can then be transferred to the new database when it goes online. Waterproof paper is advisable. Important information to record is the time of the survey, the tidal and lunar cycle, the location and extent of the surveyed area (a handheld GPS is useful) including its general features as also shown on a site sketch map. A cross sectional drawing of the contour of the bank at the site is also helpful information to record. Likewise, photographs are valuable to supplement this information. Marking spawning areas with flags before photographing them is an excellent way to definitively record their location.

Photographs of plants (or plant samples) can be referred to botanical experts for checking their identification if needed. An estimate of the density of eggs found (e.g number in a 10cm-by-10cm area), their stage of development and the vegetation type they were associated with in the context of the general site is important additional information to gather. Also record observations on the condition of the site including such things as the presence of invasive weeds, the degree of livestock access, water quality, bank condition, tide gates or flood gates presence, birds and other fauna present- this information will assist in evaluating any potential future management and protection options for the site.

2. Surveys for spawning fish

This type of survey takes place on the spring tide during its peak and targets finding adult īnanga undertaking the act of spawning. It uses the cues as set out above to find optimal spawning habitat, but the focus is primarily a visual one to spot large aggregations of adult īnanga spawning on the stream margins. The fish often are moving downstream in large numbers (Fig. 8) to the spawning grounds, their movement is steady and if fish are able to be caught the distended silvery bellies (Fig. 7) will confirm the presence of ripe spawn.

Figure 8. A spawning aggregation moves upstream

Techniques

Stealthily move along the bank, wearing a good pair of Polaroid sunglasses to aid your vision for seeing into the water. Look for large schools of fish and follow them if you can safely. Typically, the aggregations of fish will coalesce into larger groups which will push into shallow water amongst the vegetation where it is suitable for spawning. The activity of wriggling and splashing as spawning īnanga come out of the water causes a reasonable amount of noise – so listen for a spattering noise as a cue for locating fish. It is also very common to see herons and occasionally bittern perched on stream edges targeting spawning fish. Likewise, eels and trout target spawning fish so look at for them and listen for the low frequency “choff choff” noise made by feeding eels as another cue to home in on as an indicator of spawning taking place.

Usually it is 10- 15 minutes after the peak of the spring tide that fish spawn and the milky sperm from larger aggregations of fish will discolour the water (Figure 1). As the water recedes further, milt continues to drain from streamside vegetation and trapped amongst the vegetation it is common to find dead or dying spawned out fish (Fig. 9). The location of the spawning ground needs to be marked so that a detailed egg search can be carried out on the low tide. Data to be recorded during surveys for spawning fish and guidance on interpreting your observations of spawning behaviour are set out in the datasheet (Appendix 1).

3. National Īnanga Spawning Programme (NISP)

Te Kaupapa Mātauranga Toene Inanga ā-Motu /The National Īnanga Spawning Programme (NISP) was created in 2016 by the Whitebait Connection (WBC) and offers opportunities for local decision-making, community involvement, freshwater research, and monitoring, to give understanding and inspire and empower community into action. The NISP provides a comprehensive set of resources created to support teachers, students and community to learn more about īnanga and how to find, monitor and restore their spawning grounds. The NISP was designed to be delivered alongside the Whitebait Connection's Investigating Freshwater Inquiry Framework that has stages of learning and links to suggested teaching and learning experiences which support inquiry into freshwater environments. The NISP is designed to be used in all levels of the curriculum by teachers and environmental educators but can also be offered as a stand-alone resource for groups wanting to get stuck in and needing expertise advice. The NISP resources can be found here.

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Appendix 1: Side 1 of datasheet for recording īnanga spawning and egg search information (NIWA design)

CONSERVATION TE PAPA ATAWHAI

INANGA SPAWNING SURVEY

Instructions on how to complete this form are provided on the back.

NIWA *Taihoro Nukurangi*

SITE LOCATION DATA			Number:
Survey date	Map sheet No. NZMS(260/1)	Easting:	Northing:
Surveyors' name:	Contact address:	Survey agency:	Catchment No. (if known)
Catchment name:		Surveyed bank length (m):	
Locality:			
Extent of survey:			
SURVEY SITE DATA			
Were eggs found or spawning observed? Eggs / Spawning / Both / Neither	Has spawning previously occurred at this location? (Yes / No / Unknown)	Is there a culvert or tidegate which impedes inanga passage at high water (Yes / No / Unknown)	Is the saltwater limit downstream of the site? (Yes / No / Unknown)
Time spawning first observed	Time spawning commenced (if known)	Time spawning ceased (if known)	Time of high water at site
Spawning was observed on the (New moon / Full moon / Unknown) spring tides	Approximate area of spawning site (m²)	Distance (m) from spawning site to upstream limit of saltwater	Peak spawning activity index (1-6) 1, 2, 3, 4, 5, 6
LAND USE, TENURE, VEGETATION, AND IMPACTS			
Land Tenure Private / DOC / Leased / Other	Lot number and Deposited Plan No.	Name/Address of landowner:	
Predominant land use Urban / Wasteland / Reserve / Industrial / Recreational / Pastoral / Other	Spawning vegetation code numbers (key overleaf)		
	Grasses	Herbs	Native vegetation
Nature and extent of perceived threats to spawning			
SPAWNING SITE SKETCH			
Notes:			

Return to: M J Taylor, NIWA, PO Box 8602, Riccarton, Christchurch

Appendix 1: Side 2 of datasheet for recording īnanga spawning and egg search information (NIWA design)

GUIDELINES FOR COMPLETING THE INANGA SPAWNING SURVEY FORM

It's not expected for everyone to have the knowledge or experience to completely fill in the survey form, but your best effort is certainly appreciated. On this precept, if you are not sure about filling in a section, please don't guess. Leave the appropriate section blank, and jot your thoughts down in the notes section at the base of the form. The waterproof field guide "How to locate and protect whitebait spawning grounds", published by MAF Fisheries, is an invaluable aid for locating and evaluating spawning grounds.

Number: A space for entering your own classification code or record number.

Map sheet Number: Cross out either the old inch to the mile map series (NZMS 1) or the metric 1:50000 (NZMS 260) series. Please give the full grid reference.

Catchment number: As published in Catchments of New Zealand, issued by the Soil Conservation and Rivers Control Council.

Surveyed bank length: The length of river course systematically surveyed.

Extent of survey: A brief description of the extent of the area surveyed. Eg. From main road bridge to estuary mouth.

Time spawning commenced: The time spawning actually started, which is <u>not</u> necessarily the time spawning was first observed.

Spawning Activity Index: Enter the most applicable level of spawning activity when spawning is at its peak.

1. Prespawning shoaling. Tight shoals of ripe strippable fish swimming parallel to the bank. These fish often intrude into very shallow water, often (but not always) at locations where they spawn on subsequent tides. Prespawning shoaling takes place usually when the tide is rising or at its peak. Spawning cues (milt production, or splashing) are not associated with prespawning shoaling behaviour.
2. Just detectable spawning involving less than 200 fish. No milt detectable in the water, and spawning barely audible.
3. Spawning associated with 200-1000 fish, slight water discolouration by milt. Spawning audible between 5-10 metres away.
4. Spawning audible from about 10 m away, with definite water discolouration in the shallows, but no discolouration in flowing water. Large shoals (1000-3000) of spent fish may be seen leaving the area.
5. Intense spawning activity involving 3000 to 10000 fish, audible from some distance, with strong discolouration of both standing and flowing water.
6. Shoals of 10,000's of spent fish observed leaving area. Conspicuous, intense, noisy spawning causing extensive water discolouration by milt downstream of the spawning site.

Spawning vegetation code numbers:

List, in order of predominance, plants in the vicinity where spawning occurred. The codes which pertain to the most prevalent vegetation should be underlined, and a ring should be drawn around the code numbers representing vegetation upon which inanga eggs were directly attached. For example, if eggs were found on the grass Yorkshire fog in a community dominated by tall fescue, with some carex, buttercup, and clover, then this would be coded:
Grasses <u>1</u>, ④ Herbs 4,2 Native Vege 2. If you are unsure of the identity of a plant, code it as 'unknown' in the meantime. You may wish to take a sample from the site to get it identified by an expert. If you are confident that there is spawning site plant other than those listed present, then state its identity in the notes.

Vegetation codes:

Grasses:
1. Tall fescue
2. Creeping bent
3. Chewings fescue
4. Yorkshire fog
5. Mercer grass
6. Perennial ryegrass
7. Swamp millet
8. Other, specify
9. Unknown

Native: Vegetation:
1. Toetoe (Toitoi)
2. Cutty grass (carex)
3. Niggerhead
4. Wiwi (NZ rush)
5. Jointed rush
6. Oioi (jointed wire rush)
7. Spike Rush
8. Umbrella sedge
9. Raupo
10. Flax
11. Other, specify
12. Unknown

Herbs:
1. Lotus
2. Clover
3. Musk
4. Buttercup
5. Plantain
6. Water celery
7. Moss
8. Creeping Jenny
9. Mint
10. Selfheal
11. Yarrow
12. Wandering Jew
13. Cow parsley
14. Twitch
15. Other, specify
16. Unknown

Nature and extent of perceived threats to spawning:

A brief note on actual or impending damage to the spawning site. Eg. stock grazing and/or trampling, pollution, flooding, grass mowing etc.

Spawning site sketch:

A quick sketch of the spawning site(s) or area surveyed in relation to the water course, and possibly a 'side-on' drawing of the bank profile, depicting the relationship between the eggs, the surrounding vegetation, and the slope of the stream bank to the waters edge.

Photographs:

If you like, you can paste photographs on this side of the form.

Appendix 2: side 1 of new draft datasheet for recording tidal wedge survey data (NIWA and collaborators)

Tidal Wedge Survey Field Sheet

Metadata

Waterway name:	Catchment name:
Date (DD/MM/YY):	Observer's names:
Nearest standard port:	Predicted time of high tide (HH:MM):
Current local atmospheric pressure (hPa):	Observed time of high tide (HH:MM):
Any impediments to tidal flow? (if yes, provide details) Unknown / No / Yes:	Flow condition: Low / Normal / High / Unknown

Spawning data (also fill out the Spawning Survey Field Sheet if evidence of spawning is observed)

Did this survey include a search for evidence of inanga spawning: No / Yes	
What was observed? Eggs / Spawning / Both / Neither	Has spawning been recorded in this waterway previously? Unknown / No / Yes

Salinity data

Observed location of toe of tidal wedge: Easting (NZTM): Northing (NZTM):

#	Waypoint	Time (HH:MM)	Easting (NZTM)	Northing (NZTM)	Channel L/Centre/R	Depth (m)	Salinity (ppt) Bottom	Mid-water	Surface
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

Supporting documents

Photo filenames:

Appendix 2: side 2 of new draft datasheet for recording tidal wedge survey data (NIWA and collaborators)

Sketch of site

Notes for observers

Metadata

Waterway name: name of the waterway that was surveyed
Catchment name: as published in Catchments of New Zealand (1956)
Date: date on which the field component of the survey was completed
Observer's names: for verification of survey results
Nearest Standard (or Secondary) port: see www.linz.govt.nz for lists of Standard and associated Secondary ports
Predicted time of high tides at nearest port: see www.linz.govt.nz for tidal predictions at the nearest port
Current local atmospheric pressure: atmospheric air pressure can dramatically alter local tidal amplitude
Observed time of high water at survey site: time that you observed water levels to peak at the survey site
Any impediments to tidal flow: is there a culvert, tide gate, sand bar etc that impedes tidal flow?
Flow conditions: is the waterway obviously above or below normal flow conditions?

Spawning data

Did this survey include a search for evidence of inanga spawning? Did you actively search for eggs or observe spawning?
What was observed? Eggs found, spawning observed, both or neither
Has spawning been recorded in this waterway previously? Is there any record of previous spawning in this waterway?

Salinity data

Observed location of toe of tidal wedge: from the data set collected, where is the upstream limit of the tidal wedge

Enter the following data for each location where you measure the salinity:
Time: time that the measurement was completed
Easting: longitude of the measurement site from GPS using the NZTM coordinate system
Northing: latitude of the measurement site from GPS using the NZTM coordinate system
Channel: Indicate where in the channel the salinity measurement was taken
Depth: How deep was the water at the site where the salinity measurement was taken?
Salinity: What was the salinity at the bottom, in mid-water and at the surface?

3.3 PERIPHYTON & INSTREAM MACROPHYTES

3.3.1 PERIPHYTON

A bit of Background: Periphyton are sessile (stationary) freshwater organisms that are attached to, and grow on, surfaces on the stream bed, i.e. rocks, sand, wood and macrophytes (instream plants). They mainly comprise algae but can also be bacteria and fungi. Periphyton can take two general forms:

- microscopic, single-cell algae forming thin layers on stream substrates (i.e., diatoms). These are more common in fast-flowing, higher gradient streams with lower light levels.
- macroalgae that develop as filaments, sheets or mats. These are more common in in low-gradient, open streams with higher light levels.

Periphyton is an important part of the food chain. It is a primary producer that photosynthesizes and is one of the main food sources for stream fauna such as macroinvertebrates (e.g. snails, mayflies, caddisflies, midges), which in turn are fed upon by fish and birds.

Since algae require light to photosynthesize and grow, light levels are the primary factor controlling periphyton abundance. It is also regulated to a lesser extent by stream flow and scour regime (which can dislodge it), nutrients, temperature, and grazing.

In high light conditions, sluggish, low-gradient streams with no riparian cover and run-off from a pastoral catchment, nuisance growths of periphyton are likely to develop as mats or sheets across the stream bed and make the habitat unsuitable for many sensitive invertebrate species. Conversely, in higher-gradient, fast flowing, shaded streams in a forested catchment, a thin covering of microscopic algae may be present on the rocky substrate providing a good food resource for resident macroinvertebrates.

Measure it: To monitor periphyton in your stream reach, you could use the periphyton cover rapid assessment method of Collier et al. (2007b). The form is provided below. This method assesses periphyton cover across 5 evenly spaced transects at the reach scale (50–100 m). These could be the same as the substrate measurement transects (Section 2.4.1). The methodology below has been taken from Parkyn *et al*. 2010.

- Begin at the downstream transect. For each transect, assess periphyton cover in a 10 cm diameter circle at 5 evenly spaced sampling points across the transect (i.e., at 10, 30, 50, 70 and 90% of the width).
- Assess periphyton on whatever substrate occurs at each point (i.e., cobbles, sand, wood, macrophytes). Record the percentage cover of upper surface for the different periphyton categories (which are based on mat thickness or filament length and colour; Table 5.5).
- Repeat for all five transects. Calculate a mean % cover for each periphyton category across the 5 transects.

Assess periphyton during the growing season (summer and autumn when plant biomass peaks) under base flow conditions and at least 3 weeks after a high flow event.

Data sheet for periphyton rapid assessment.

Stream name: **Date:**

Transect #:

Thickness category	Colour category	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Mean % cover
Thin mat/film **(<0.5mmthick)**	N/A						
Medium mat **(0.5-3mm thick)**	Green						
	Light brown						
	Black/dark brown						
Thick mat **(>3mm thick)**	Green/light brown						
	Black/dark brown						
Short filaments **(≤ 2 mm long)**	Green						
	Brown/reddish						
Long filaments **(>2cm long)**	Green						
	Brown/reddish						
Submerged bryophytes	NA						
Iron bacteria growths	NA						

3.3.2 INSTREAM MACROPHYTES

In-stream macrophytes are the plants that grow in the water, either attached to the stream bed and emergent or they are free-floating. Macrophytes have several beneficial effects for stream ecosystems. They provide habitat and cover for invertebrates and fish; a surface for algae and bacteria to grow on; they can slow water flows thus encouraging sediment deposition; and their roots help to stabilise the streambed.

Similar to periphyton, because in-stream macrophytes are primary producers and photosynthesise, they are strongly controlled by light availability. Small, forested streams typically have a low abundance of in-stream plants and may just support mosses (bryophytes). A larger, slow flowing stream with no riparian vegetation in farmland can have a high density of plant growth – especially competitive, exotic species. At these high levels they can be detrimental to stream life and smother benthic habitats, reduce stream biodiversity and impede water flow. The photosynthesis–respiration cycle of dense beds of macrophytes can also cause wide fluctuations in dissolved oxygen and pH.

Since it is light driven, macrophyte abundance peaks in spring and summer time when day lengths are longer and light intensities are higher. Slower flows and fewer scouring less floods also enhance macrophyte growth.

Other factors that affect macrophyte growth are the availability of nutrients and inorganic carbon, competition from introduced species and herbivory.

PART 4- WATER QUALITY

4.1 THE IMPORTANCE OF WATER QUALITY

Water quality is an important aspect of stream health and assessment. Rivers and streams are diverse environments supporting native plants, fish and insects. They also provide important sources of water for people, industry and irrigation. Clean water is vital for both ecosystems and the economy.

A contamination of fresh water can have wide ranging effects all the way through the associated ecosystem. A river can only be as healthy as the streams that feed into it so any action to clean up a small stream can have effects all the way downstream to the sea. Pollution, sediment, flow levels and surrounding land use are a few of the elements that will have an effect on water quality.

4.2 HOW IS WATER QUALITY MANAGED?

Managing water quality and aquatic life is a high priority in New Zealand. At the highest level, the recent National Policy Statement for Freshwater Management (NPSFM) 2020 came into effect on 3 September 2020.

It recognises freshwater management as a nationally significant issue requiring central government direction. The NPSFM sets a standard national requirement to ensure there are clear limits to govern the allocation of water and management of water quality. The NPSFM will help drive national consistency in local Resource Management Act (RMA) planning and decision-making while allowing for an appropriate level of regional flexibility. This will support improved freshwater management in New Zealand.

The NPS can be viewed in full here

Click here to link to more information on the NRWQN

The RMA requires local authorities to amend regional policy statements, proposed regional policy statements, plans, proposed plans, and variations to give effect to the provisions in the NPSFM. This will ensure that all these documents promote and regulate the sustainable management of each region's water resources.

Baseline levels and water quality trends can be monitored at sites across New Zealand by referencing The National River Water Quality Network (NRWQN). The NRWQN provides reliable scientific information on many important physical, chemical, and biological characteristics of a selection of the nation’s river waters. The NRWQN consists of 77 sites on 35 rivers that are fairly evenly distributed over the two main islands of New Zealand.

4.3 WHAT ARE SOME OF THE WATER QUALITY PARAMETERS?

Water quality tests can give clues to what the likely sources of pollution are and where contamination might have come from. Water quality tests can include the following:

4.3.1 WATER TEMPERATURE

A bit of Background: Measuring water temperature is very simple and is a very important factor in water quality. Most creatures can survive in water temperatures ranging between 10 degrees Celsius and 25 degrees Celsius. If the temperature rises or falls outside that range, the creatures may die or move away.

The influence of temperature on water quality is significant. Many of the physical, chemical and biological characteristics of streams are directly affected by temperature. Temperature influences:

- the amount of oxygen that can be dissolved in the water
- the rate of growth by algae and larger water plants.
- the sensitivity of organisms to toxic wastes, parasites and diseases.
- the structure of aquatic communities.

Several things determine water temperature in a stream but the most important are weather, season, shading, water depth and inflows from other sources.

Test it: Spot temperature readings are simple to make with thermometers. Alcohol (rather than mercury) thermometers are most suitable for field use.

Because stream water temperature varies significantly throughout the day, a spot temperature reading of the maximum temperature on a clear sunny day in the mid-to-late afternoon is best. To avoid localised high-temperature bias, take the temperature reading in the shade and in flowing water.

4.3.2 DISSOLVED OXYGEN

A bit of Background: Dissolved oxygen (DO) refers to the small amount of oxygen gas dissolved in the water. Dissolved oxygen is vital for life in freshwater environments. Low levels of DO directly affect fish, macroinvertebrates, micro-organisms and plants all of whom depend on it for the process of respiration, i.e. to breathe. High levels of DO may indicate anoxic (too much respiration) or eutrophic (too much productivity) conditions. This can be similarly harmful for stream life and its healthy functioning.

The DO level is a useful general indicator of water quality. Low levels of dissolved oxygen can indicate the presence of certain pollutants, particularly organic matter. When pollutants such as sewage effluent, milk, decaying aquatic vegetation and animal manures enter a stream, they break down very quickly. This decomposition by micro-organisms uses a lot of oxygen. In some extreme cases it could mean that all the oxygen might be removed from the water, killing all the creatures living in it.

Flow levels can also affect DO levels. In low flow conditions, e.g., during a drought or if there are several water takes from a stream, the DO levels may be lowered. This is especially so if surface water agitation is reduced by loss of riffles (through less water), or the water temperature increases (because it is shallower and colder water can hold more oxygen). Conversely, a flood in a stream can increase DO levels by increasing agitation and flow from turbulent waters. This effect is only temporary though because, once the flood recedes, there will be high levels of organic debris left behind. This gets broken down by bacteria which uses up oxygen and can cause lower DO levels that may last for days or even weeks.

Test it: Place a dissolved oxygen (DO) probe in gently flowing water – ideally at the downstream end of a pool. Ensure the DO meter is calibrated before use according to manufacturer's instructions. Allow the value to stabilise and record DO % saturation and water temperature. A reading as close to dawn as possible provides a measure of the minimum DO saturation in-stream, and a reading in the late afternoon provides a measure of the maximum DO concentration in-stream.

If you don't have access to a DO meter, there are some simple visual observations that you can make that can assess likely DO levels in your stream. This assessment has been taken and simplified from the Stream Ecological Valuation (SEV) methodology (Storey *et al*. 2011). Tick the box which best describes the indicators of oxygen reducing processes that are present in your stream reach.

Status		Tick box that best suits your stream	DO levels
Optimal	No anaerobic sediment No odours or bubbling when sediment disturbed Little or no macrophyte biomass (summer), or no areas of slow flow, low shade and soft substrate (winter)		**High**
Sub-optimal	No anaerobic sediment Some bubbling when sediments are disturbed, but no odour Moderate macrophyte biomass (summer), or moderate areas of slow flow, low shade and soft substrate (winter)		
Marginal	Small patches of anaerobic sediment Some bubbling and sulphide odour when sediments are disturbed Some sewage fungus may be present Dense macrophyte biomass (summer), or no areas of slow flow, low shade and soft substrate (winter)		
Poor	Much black anaerobic sediment Extensive bubbling with sulphide odour when sediments disturbed Surface scums present Abundant sewage fungus may be present		**Low**

4.3.3 PH

A bit of Background: The pH test for water is a measure of how acidic or alkaline (basic) the water is on a scale of 0 to 14. Pure water has a neutral pH and is 7 on the pH scale. pH measurements below 7 indicate the water is acidic. pH from 7 to 14 indicates the water is alkaline.

Animals and plants in streams are adapted to certain ranges of pH. Creatures prefer pH levels between 6.5 and 9 and changes in pH outside the normal range of a water body will cause more sensitive species to die as it changes other aspects of the water chemistry or the creature's biochemistry.

A pH of below 4 or above 11.5 is sufficient to kill all fish in the water. There is a gradation of effect up to these extremes remembering that for every one unit change on the pH scale, there is approximately a ten-fold change in how acidic or alkaline the sample is.

Using the universal indicator paper to measure pH

Test it: pH is routinely measured in streams using a glass electrode with the measurements preferably being made in the stream rather than in water samples transported back to a laboratory. A simpler, but coarser, method of measuring pH involves using universal indicator paper dipped into the stream for approximating pH according to colour.

4.4.4 WATER CLARITY

A bit of Background: New Zealand has some of the clearest water in the world. The quality of our water contributes significantly to our economy, particularly through tourism. Visual clarity is such a fundamental attribute of waters that it is specifically included in the Resource Management Act 1991 because it affects the recreational quality of water and how people perceive it.

Water clarity is an indirect measurement of the amount of suspended solids in water. In New Zealand it is the preferred method for assessing water turbidity (or 'murkiness'). In other words, high water clarity means low turbidity and vice versa.

As erosion occurs within a catchment, tiny particles of clays, silts or small organic particles are washed into waterways. These particles can be held in the water current and are called suspended solids. The faster the water is moving the more suspended solids it can carry. If soils enter the stream in unnatural quantities, the whole system is quickly thrown out of balance.

Soil type in the catchment can affect water clarity. For example, streams in catchments with clay soils are likely to have much lower water clarity naturally than streams in sandy catchments. Measuring the increase in suspended solids murkiness in a stream following rainfall is one way of assessing catchment condition.

Visual clarity of waters is an important attribute affecting habitat for aquatic life as well as recreational safety and amenity value of waters.

Suspended material restricts light passing through the water column. Reduced light limits natural and healthy plant growth, which in turn affects the aquatic life relying on those plants for food. Higher levels of sediment lead to habitat destruction or direct effects on the stream life in the following ways:

- Where there is less light penetrating the water, there will be less photosynthesis (the process where light is converted into "food energy" by plants with a by-product being oxygen) and this reduces the level of oxygen in the water.

- The water becomes warmer because suspended materials absorb heat from the sun. This also decreases the amount of oxygen present in the water (cold water can hold more oxygen). Shaded waterways are therefore less affected.

- Sediments settling out of the water column may cover bottom dwelling creatures or the places where they would ordinarily live. The gill-structure of many aquatic creatures is easily clogged by sediments. This reduces their ability to take up oxygen.

- Poor water clarity has direct effects on fish and birds that rely on their sense of vision to find and catch their prey.

- Turbid waters may indicate the presence of contaminants, such as paint in solution or absorbed into sediment particles. These contaminants may directly result in (acutely) toxic effects on aquatic life or build up over time, and result in longer term (chronic) toxicity.

Test it: A clarity tube can be used to monitor gross changes in turbid waters. They are not recommended for robust scientific monitoring purposes, but they can be used by community groups.

Whitebait connection staff with students using the visual clarity tube.

One design of the clarity tube consists of an optically clear acrylic tube for containing the water sample. A 20-mm diameter black semicircle (disk) is fixed onto a magnet so that it is centred in the tube. The tube is filled with a water sample from the stream and held horizontally while observing the black disc target. The disc can be slid along inside the tube using another magnet on the outside.

Move the black disk away from you until it disappears. Note this distance. Then slowly move the disk along the tube back towards you until it re-appears. Note this distance too. On the outside of the tube: read the distance measured from the front of the disk to the clear viewing end.

Repeat to obtain at least two further readings. Get another person to take a reading if possible. Before each reading, gently agitate the water column to ensure that any sediment stays in suspension. (Don't shake so hard that lots of bubbles are produced in the water, because these will reduce the sighting distance.) Take the average of all the readings to obtain the average clarity.

The clarity tube visibility approximates the black disc visibility at low clarity (<0.5 m). However, visual ranges of importance in waters are often greater than can be measured accurately by the clarity tube. For example, the Ministry for the Environment recommend a minimum of 1.6 m black disc visibility for bathing safety. It is recommended that regional councils monitor visual clarity by the black disc method rather than by clarity tube.

4.4.5 WATER VELOCITY

A bit of Background: The water velocity of your stream influences a number of factors. These include water temperature, the concentration of dissolved oxygen and turbidity. Stream velocities are influenced by catchment scale features such as geology, soil type, slope and cover. Rainfall levels also influence flows and there is usually a noticeable difference between flow rates in summer and winter.

The average velocity of flow is an important factor in determining which particular plants and animals will be able to live in a stream reach. Sensitive stream organisms are generally unable to tolerate velocities less than 0.1m/s due to reduced oxygenation of the water. Slow moving water also tends to heat up more, making it worse.

Shaded rocky-bottomed streams are less affected by low flows. Moderate to fast flow rates (0.3 to 0.7 m/s) are preferred by most macroinvertebrates and speeds greater than 0.3 m/s prevent rooted water plants from reaching nuisance levels.

Test it: A simple way to measure velocity is to use the “ruler method” (see Harding et al., 2009).

1. Measure the water depth twice at the fastest point on a cross section using a flat-bladed metal ruler.
2. For the first measurement, position the ruler parallel to the current and record the depth (d1)
3. For the second measurement, turn the blade so that it is perpendicular to the current and a ‘bow wave’ forms on the upstream face of the ruler. Record the depth at the top of this bow wave (d2)
4. The difference between these two measurements (d2-d1) can be used to calculate velocity within 10% of flow meter readings.
5. Note that if the difference is less than 2mm then the usefulness of the method is compromised. In this sort of instance then measure the distance a floating particle travels in a fixed time period (e.g. use 10 seconds).

4.4.6 NUTRIENTS

A bit of Background: A nutrient is a chemical that an organism needs to live and grow, and which must be taken in from its environment. Nutrients in streams are used for growth by aquatic plants, periphyton, and microbes (bacteria, fungi).

The two primary nutrients in water are nitrogen (N) and phosphorus (P). They occur both as dissolved forms (NO3-, NH4+ and PO43-) and bound in dissolved or particulate organic molecules (e.g., amino acids). The dissolved ionic forms are most biologically available for organisms, and these are readily taken up and used by stream plants.

In pristine/natural stream waters, nitrogen occurs at low concentrations and at growth-limiting levels. It comes from decaying plant material and other organic matter. Phosphorus also occurs naturally at low, growth limiting concentrations. It comes from the weathering of rocks and decay of leaf litter or other organic matter.

Human activities can result in external inputs of nutrients entering streams (e.g. fertiliser leachate/runoff, industrial wastewater, urban stormwater and sewage discharges). These are often at high concentrations and can stimulate nuisance growths of aquatic plants, periphyton, and microbes.

These inputs can be from point sources (e.g., pipes, drains) or diffuse sources (e.g., groundwater seepage, runoff).

When nitrogen or phosphorus levels exceed normal levels in a stream, the balance in the ecosystem is lost and excessive plant growth takes place. This is a process called eutrophication and can cause problems such as algal blooms and growths. This is further exacerbated when these plants die, as oxygen is used in their decay. Lower oxygen levels reduce the diversity of macroinvertebrates that the stream can support and in extreme cases can kill fish.

Test it: Water samples can be collected for nutrient analysis and assessed in a lab. The water sample should be collected in containers provided by the lab, and by using a grab to take the sample from the centre of the stream channel during a period of stable river flow. Store the water sample chilled during transport to the laboratory. Samples should be processed within 24 hours of collection or frozen to be analysed later. You can also ask your local council for help measuring nutrients in water samples.

4.4.7 CONDUCTIVITY

A bit of Background: Conductivity is the ability to conduct electricity. Water conducts electricity because it contains dissolved solids that carry electrical charges. Therefore, measuring the conductivity of the water indirectly measures the amount of substances such as calcium, bicarbonate, nitrogen, phosphorus, iron, or sulphur dissolved in water, i.e. the amount of Total Dissolved Solids (TDS) in the water.

This is important as a water quality measure because most streams have a fairly constant range of conductivity under normal circumstances. Consequently, if a significant change in conductivity is detected then this can be an indicator that a discharge or some other source of pollution has entered the water.

Conductivity can be affected by many factors. Examples include:

- The addition of freshwater lowers conductivity. Rainwater has low conductivity as it is very pure and has not picked up minerals from the land yet. It increases water levels and dilutes mineral concentrations.
- It follows on that during low flow conditions in summer and autumn, the dissolved solids are more concentrated as there has been no rain to dilute these effects. Conductivity levels are higher at these times.
- Conductivity is affected by temperature: the warmer the water, the higher the conductivity.
- Soil and rocks release dissolved solids into the waters that flow through or over them. Therefore, the geology of a certain area will determine the conductivity.
- Salt water has a high conductivity as it is so full of salts. In coastal streams or estuaries where salt water and freshwater mix, conductivity levels are higher.

Raised levels of dissolved minerals may affect how suitable the stream water is for some uses, such as drinking water and protecting ecosystems. Some species of aquatic plants and animals tolerate only a small range in the number of dissolved solids in water and they begin to disappear if levels rise.

Some species of macroinvertebrates are very sensitive to metal ion concentration and may be used as indicators for the presence of these ions.

Test it: A conductivity meter is used to measure conductivity. It applies voltage between two electrodes. The drop in voltage between the two electrodes is used to measure the resistance in the water. This is converted into conductivity. The conductivity meter is placed in the water and allowed to stabilise before a reading is taken.

Conductivity is measured with a meter in milli siemens per metre units (mSm-1). The natural conductivity of fresh water varies from very low values (less than 3.0 mSm-1) to very high values 25 or more mSm-1), which may be unsuitable for irrigation. The average for New Zealand rivers is 8.5 mSm-1.

4.4.8 OTHER TESTS

A bit of Background: Some water quality tests measure micro-organisms in the water to ensure water is safe for swimming or shellfish collecting. Faecal microbes that can cause disease in humans are some such micro-organisms and high levels of faecal material can indicate the possible presence of these bugs. Faecal contamination is normally monitored using “indicator” microbes that are universally present in the faeces of warm-blooded animals (including people). These are the bacterium *Escherichia coli* (in freshwaters) and the *Enterococci* group (in marine waters).

Toxicants are other elements that can affect water quality. Discharges to the environment from industry, agriculture, or urban environments can often contain toxicants that can cause adverse effects on aquatic communities in the receiving water environments. Examples of toxicants include heavy metals (mining, urban stormwater, geothermal, timber treatment), pesticides and herbicides (agriculture, horticulture), and polycyclic aromatic hydrocarbons (PAHs) (urban stormwater).

Test it: This section on ‘other tests’ are measures that are in specialist areas and practical advice for collecting samples that test for these parameters are not covered by this document.

4.4.8 STREAM HEALTH MONITORING AND ASSESSMENT KIT (SHMAK)

A bit of Background: NIWA’s Stream Health Monitoring Assessment Kit (SHMAK) gives land owners, iwi, school and community groups simple, scientifically-sound tools and resources to monitor the ecological health of New Zealand’s streams. SHMAK kits include equipment for testing most of the parameters mentioned above as well other measures of stream health. You can find out more about SHMAK and order kits here. Video resources for using the SHMAK kit can be found here.

4.4.9 ENVIRONMENTAL DNA (EDNA)

A bit of Background: Environmental DNA, or eDNA, refers to all the tiny traces of genetic material that is left behind as living things pass through water or soil. By collecting up discarded DNA and sequencing it, we can get a picture of the plants and animals in a local area. Once it is shed into the water, eDNA sticks around for a few hours to a few days. The time depends on whether it is in freshwater, marine water, stagnant water, the exposure to sun, and so on. Other material that's in the environment can also break eDNA down.

Environmental DNA is a new and powerful tool and can be a way to scan environments quickly to detect change. It has the advantages of being non-destructive and doesn't require animal capture. Wilderlabs compact and easy-to-use eDNA kits require no specialised training or equipment and are ideal for a range of applications including biosecurity, conservation, environmental resource management and education. The on-site processing and preservation system avoids the need to keep samples cold or transport bulky equipment, and the samples can be posted to the Wilderlab laboratory in Wellington for processing. A range of highly sensitive DNA tests are available, from targeted single-species detection to multi-species sequencing services. Wilderlabs eDNA kits can be purchased online on the Wilderlabs website.

PART 5: OTHER TYPES OF FRESHWATER ENVIRONMENTS

Lakes and Wetlands

The monitoring methods described in this handbook have been developed specifically for monitoring stream and river environments. However, the key concepts of the WBC programme transfer to investigation of other types of freshwater environments as well. Streams, rivers, lakes and wetlands are all important parts of a catchment system and are often linked in many ways e.g. collective effects on water quality in a catchment area, connected aquifers, historical links with water passage and species (such as dune lake Galaxiids).

Monitoring of wetland and lake environments is an important aspect of catchment management; it alerts us to potential problems and helps us measure the success of any management efforts. WBC coordinators are often working in these environments too such as the unique Kai Iwi dune lakes in Northland. Much of the WBC monitoring equipment can still be used in a lake or wetland environment to engage community and highlight what is special and unique about lakes (e.g. trapping dune lake Galaxiids or Mudfish with gee minnow traps or testing conductivity, clarity and pH with the SHMAK equipment) but the monitoring methods should not be used to determine lake 'health'.

Two tools have recently been developed for monitoring New Zealand lakes. These are the *Protocol For Monitoring Lake Trophic Levels And Assessing Trends In Trophic State* (Burns et al 2000), and development of a method for using submerged aquatic macrophytes to assess lake condition, called LakeSPI (Clayton et al 2002). This snapshot survey identifies what lakes are currently being monitored by regional councils around New Zealand, the type of monitoring and how it is being undertaken. MfE have found that the recently developed protocols for assessing trophic state (TLI) and lake condition (LakeSPI) are being widely adopted around the country.

PART 6: TAKING ACTION FOR FRESHWATER – HINTS, TIPS AND IDEAS

"Tell me and I'll forget; show me and I may remember; involve me and I'll ***understand****"*

Whilst the engagement of community in the WBC programme is the setting of foundations on which to build deeper understanding of the economic, environmental and cultural dynamics at work within a catchment; using this understanding to initiate positive behaviour change and build motivation to act for freshwater conservation, is the most important part of the WBC programme and the vision that inspired its creation.

Partnerships are often the best way to achieve conservation results. Where communities become involved in conservation activities with agencies, experience shows a host of benefits.

Action might be planned in partnership (e.g. between DOC and WBC) before community engagement even starts e.g. linking community into existing catchment management plans. Alternatively, the WBC programme may be the catalyst for change where the community are charged with deciding on what action they will take. It may also be a combination of both e.g. linking community in with existing plans but also encouraging them to take their own self-directed action. Either way – it is all good!

Ideas for taking action:

- Forming a stream care group
- Joining an existing stream or catchment care group
- Applying for funding for fencing or planting projects
- Fencing
- Planting – self-initiated or joining a community planting day
- Waterway clean ups
- Propagating seedlings for riparian planting
- Reduce use of non-biodegradable plastic bags
- Improving fish passage
- Identify, restore and protect whitebait spawning habitat
- Water conservation initiatives e.g. fixing leaky taps, doing a school water audit

- Installing rain guards / filters
- Restore wetlands
- Cycle to school to reduce vehicle pollution which ends up in storm water runoff
- Weed removal
- Translocation of eels
- Raise awareness in the community about the impacts of:
    - Overstocking
    - Over fertilizing
    - Farm intensification
    - Stock in waterways
    - Nutrient overloading
    - Clearance of wetland
    - Clearance of hillside vegetation
    - Spread of pests

And many more…

Helpful resources:

Stream Restoration for Aquatic Invertebrates

Landcare Wetland Restoration Handbook

A Guide to Restoring Īnanga Habitat

PART 7 - WHITEBAIT CONNECTION COORDINATOR STREAM MONITORING GEAR LIST

Whitebait Connection Northland Freshwater Investigation Kit care guidelines and equipment list – Updated January 2023

WBC MISSION STATEMENT

To foster understanding of life sustaining capacities of aquatic eco-systems, by engaging school children, teachers, parents and the wider community, in an ecological and largely outdoor practical inquiry about streams and catchments and to encourage and facilitate any restorative actions that may result from that enquiry.

This set of equipment is to be used in support of the above mission statement eg. *research projects and monitoring programmes, school field trips, community days.*

All equipment purchased by the Mountains To Sea Conservation Trust remains property of the Trust.

WBC environmental care kaupapa always applies:

- **Look and learn only!**
- Leave the environment in the same state or better state than you found it.

USE AND CARE GUIDELINES

- **Safety -** Mountains to Sea Conservation Trust Health and Safety Policy must be followed for use of equipment. See WBC Coordinators Manual section 3 for H&S reporting forms, RAMS and first aid information. **Check, Clean, Dry** – always ensure equipment is free of any plant, animal or fungal life between waterways. Best practise is to CHECK, CLEAN, DRY all equipment between waterways. CHECK for plant fragments and pests. CLEAN using detergent (5% dishwash) or salt water (sea strength or 5% salt) until completely soaked through. DRY completely to kill freshwater pests.
- **Storage** in dry place, rinse any salt water off equipment, ensure laminated sheets are dried before storage (as they stick together). Store in safe, lockable location.
- **Maintenance** including sewing up loose canvas on scoop nets, riveting scoop net handles can be carried out as needed.
- Please check WBC Coordinators Manual for more information on equipment and monitoring protocols
- Let the WBC National Coordinator know asap if any breakages or loss of equipment occurs before attempting to replace.

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
Scoop Nets 	6	You could buy and supply the frames for these to a canvas maker (available at most hunting or fishing shops. You will need to buy the mesh from Sefar Filter Specialists Ltd. Aukland. It needs to be a specific mesh size: 500microns. Premade nets can be purchased from an Australian supplier Australian Entomological Supplies here. However, they are of a lesser quality.	$56.01 for the mesh for one net. $34.95 for the net frame. $40.97 for the labour to get the mesh changed on a net frame supplied. $106.95 to get a company to make the net frame from scratch and to sew on the mesh *Total works out to be $131.93 per net if the frame is supplied or $162.96 per net if frame not supplied.* **$791.58 for a set of six nets.** $64.40 each from Australian Entomological Supplies **$386.40 total for a set of 6 + postage**
Minnow Traps 1/8" Mesh	6	For catching smaller fish. These can be ordered from Wild Habit. Here is the link.	$80 for each trap **Total of $480 for 6 + postage**

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
			
Fyke net/Hinaki 	1	Fyke nets can be ordered from the Australian supplier TL Net making here. We usually order NZ protocol sampling fyke nets, Standard, 5 metre wing, 60 cm drop. However, any of the NZ protocol nets are good depending on the site being surveyed. These nets have excluders to prevent smaller fish from being eaten by tuna. Although 1 fyke net is required for school programme delivery you will require 6 nets if using them for monitoring following standard protocols.	**$155.00 per net + postage**
Orange Ball	1	We usually just use a brightly coloured plastic	$2 for a ball or orange

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
		ball for the flow test – you may already have one lying around or just pick one up from a $2 shop. You can also measure flow using a metal ruler as described in the coordinator handbook.	
1-Metre-Long Metal Ruler 	1	For measuring velocity and depth can be found at Warehouse Stationery. Link	**$50 from Warehouse Stationery**
Wolman or Particle Size Stick or Chart) 	1	Used for habitat assessment – categorising streambed particle size. You can make these yourself by charting the different measurements on a laminated sheet (or using the SHMAK kit one) or etching them onto a ruler or aluminium stick as in the original 'Wolman Stick'.	Cost of stick or printing and laminating an A4 piece of paper.

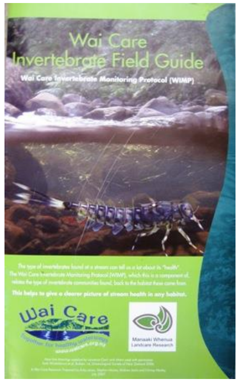
Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
White Trays 	6	You can pick these up from any plastics shop – you just need plain white basins. We use tote trays from Storage Box. Link	Approx. $12 each from Storage Box **Total of $72 for a set of 6**
Fish Measuring Tray with Ruler 	1	You can pick these up from any plastics shop – you just need plain small white basins with a plastic ruler glued in the bottom. An example of a product you may order/buy is the white tray from Storage Box Madesmart Bin Tall. You'll also need a 30cm clear ruler and some super glue to glue the ruler into the tray with.	**Tray is $27 from Storage Box** **Clear 30cm ruler** **Superglue**
Bug Sorting Trays	6	Buy the plastic 'tackle boxes' from any plastics shop, hunting and fishing shop or The Warehouse – they already have the compartments in them for bug sorting. Make sure the dividers are attached to the box or you	Approx $19.95 each **Total of $119.70 for a set of 6.**

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
		will have to glue them in yourself to make sure they don't end up falling out in the stream.	
Scoopers 	12	Start collecting all your laundry powder scoops as these are great for bug sorting	n/a
Pipettes 	6	These are good for bug sorting. They can be ordered from various online websites. Hobby land sells a pack of 10 for $3. Link	**$3 for a pack of 10** (you will need extras as these tend to get dirty and/or lost easily). Make sure to cut the end of the pipette with scissors to create a larger hole minimising damage to bugs.
Magnifying Glasses	6	These are essential for bug identification. You can usually purchase them at The Warehouse for $4 per unit.	You can usually purchase them at The Warehouse for $4 per unit. **Total of $24 for a set of 6**

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
			
Thermometer/ Conductivity Metre 	1	These meters are used for measuring both temperature and conductivity. They are included in the SHMAK kit. Additional metres can be ordered through NIWA by emailing Stuart.Escott@niwa.co.nz	Included in the SHMAK kit. **They an be purchased individually for $110.**
pH Testing Strips	1 pack	For pH testing. Can be purchased from most pet stores.	**$20 for a box of tests**

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
			
Small Fish Tank and Battery Powered Pump  	1	Very handy for viewing any fish caught in the field and keeping them for viewing for a few hours. These products can be purchased from most pet shops – see some examples here: 'Aqua One Battery Air Pump 250' & 'Aqua One/Pet One Multi Use Transport House' tank.	**Battery powered pump is $23** from Hollywood Fish Farms (Albany, Mount Roskill & Hamilton stores) **Tank is $23.95** from Kiwi Petz
Laminated WBC invertebrate ID Sheets	6	You can get these online on the WBC Google Drive or by request from the WBC National Coordinator info@whitebaitconnection.co.nz. They should be printed and placed back-to-back with the WBC fish ID sheet and laminated and then placed on the lid of the bug boxes (fish side up).	The cost of printing and laminating them

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
			
Laminated WBC Fish ID Sheets 	6	You can get these online on the WBC Google Drive or by request from the WBC National Coordinator info@whitebaitconnection.co.nz. They should be printed and placed back-to-back with the WBC invertebrate ID sheet and laminated and then placed on the lid of the bug boxes (fish side up).	The cost of printing and laminating them
Wai Care Invertebrate Field guides / monitoring protocol – WIMPS	7	You can get the most recent version of this resource here. We suggest printing and laminating 7 copies of them for your kit or requesting hard copies from Wai Care directly if they are still available.	The cost of printing and laminating them if WaiCare won't provide hard copies

Item Name:	**Amount Recommended for a WBC kit**	**What it's used for and Where to get it:**	**Cost:** **(All prices are approx and GST inclusive)**
			
Bright Cones 	4	To mark boundaries of study area – can also be used for marking 'Whitebait Run' area. We suggest retractable cones as they can be stored and transported easily. Here is an example from Mitre 10.	$23.73 **Total of $94.92 for four**
Clipboards	7	For use of the groups – one per group, and also one for the WBC Coordinator. It's often good to get 6 blue and one red – the red one being for the WBC coordinator. You can get these from various stores. Here is an example	$7 each from Warehouse Stationary **Total of $49 for seven**

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
		from Warehouse Stationery. Tie pens on to each clipboard.	
White Flexi Tub 	1	For putting fish into for students to view. Can be purchased from stores such as Mitre 10 and the Warehouse. Link Using a measuring tape, you can mark measurement points on the bottom of the bin in 10cm increments. This can be used for measuring tuna/eels.	**$11.78** from Mitre 10
Measuring Tape 	1	For measuring during the flow test and any other measuring required. Can be purchased from Supercheap Auto and other hardware stores. Link	**$29** from Supercheap Auto

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
White Bucket 	1	For holding fish, water or equipment. Can be purchased from hardware stores.	**$10 each**
NIWA SHMAK KIT:		Order these online through NIWA using this form. Orders can be emailed to Stuart at Stuart.Escott@niwa.co.nz	**$1250 for the SHMAK plus kit including a clarity tube + postage**
Hanna Phosphate Checker 	1	For testing Phosphate. An optional addition to the school delivery kit (may be more suitable for older students). Make sure to keep check of reagent expiry dates.	Included in the SHMAK plus kit. **Can be purchased individually for $110** through NIWA. **Reagents can be purchased for $16** through NIWA
Aquaspex Nitrate Testing Kit	1	For measuring Nitrate. An optional addition to the school delivery kit (may be more suitable for older students). Make sure to keep check of reagent expiry dates.	Included in the SHMAK plus kit. **Can be purchased individually for $90** through NIWA. Reagents can be purchased from Aquaspex. Deionised water may be needed for dilution with high test results. This can be purchased from Supercheap Auto for approximately $10.

Item Name:	**Amount Recommended for a WBC kit**	**What it's used for and Where to get it:**	**Cost:** **(All prices are approx and GST inclusive)**
			
Clarity Tube (with carry case, cap and magnet) 	1	For measuring water clarity. Included in the SHMAK kit or can be purchased individually through NIWA.	Included in the SHMAK kit. **Can be purchased individually for $180** through NIWA.
SHMAK Manual	1	Included in the SHMAK kit. Additional manuals can be purchased through NIWA	Included in the SHMAK KIT. **Additional manuals can be purchased for $34 each**
Miscellaneous		In the kit you also should have two pencils, small containers, tweezers, a small sieve, a ruler and a habitat assessment sheet which can be useful for different things	
Waterproof streamside box containing		20L fish bin with lid to keep the contents below in.	
Rubbish bags and gloves			
WBC brochures and stickers			

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
Dishwashing detergent and scrubbing brush.			
Copies of MTSCT Incident Report Sheet			
Copies of MTSCT Volunteer forms			
Fully equipped first aid kit 		Order from Industrial First Aid Supplies Ltd. sales@first-aid.co.nz the following products: 1 x first aid kit - Sports Kit B bag and contents for $54.00 1 x Telfa adhesive non-adherent pads (sterile) - 5cm x 7.5cm - 20's ($7.15) 1 x Non-woven swabs (NON-STERILE) - 10 x 10 - 100's ($5.15) 1 x Betadine Antiseptic Ointment ($5.99) 1 x HealthE antibacterial (hand sanitiser) gel - 375 mL pump ($8.00) 1 x Green Cross Instant Cold Pack (with cold pack sleeve) x 5 ($8.70) 1 x Sunsense Ultra Milk Lotion SPF 50+ - 250 mL ($19.75) 1 x Repel Insect Repellant Aerosol Spray - 100 mL ($14.99) 1 x Stingose Spray - 25 mL ($12.99) 1 x Carefree tampons - regular - 20's ($5.90)	**$142.62 from Industrial First Aid Supplies**

Item Name:	**Amount Recommended for a WBC kit**	**What it's used for and Where to get it:**	**Cost:** **(All prices are approx and GST inclusive)**
Throw rope  	1	For rescues/to throw to someone in water. To be carried at all times. Can be purchased from marine deals here	**$84.99 from marine deals plus $7.99 shipping**
Equipment to be provided by WBC coordinator			
Camera (phone)			
Printed version of site-specific RAF			
Printed version of pre-site RAF			
Laminated sheet of WBC coordinator emergency details		This includes coordinator emergency contact details and any medical information and required medication.	
Whistle			
Map of area (optional)			
Additional ID Books (optional)			
Gear cleaning bin and detergent (for onsite cleaning of equipment,			

Item Name:	Amount Recommended for a WBC kit	What it's used for and Where to get it:	Cost: (All prices are approx and GST inclusive)
gumboots)			
Cell phone (fully charged)			
Waders/gumboots		If you are to use waders we recommend ones made of neoprene material or if wearing pvc waders use a weight belt.	
Raincoat			
Worksheets to record data			
Laminated briefing checklist			

GLOSSARY

Algae — Any of various primitive, mostly aquatic, one or multi-celled, nonflowering plants that lack true stems, roots, and leaves, but usually contain chlorophyll. Algae convert carbon dioxide matter through photosynthesis and form the basis of the marine food chain. Common algae include dinoflagellates, diatoms, seaweeds and kelp.

algal bloom — A condition which occurs when excessive nutrients levels and other physical and chemical conditions help rapid growth of algae. Algal blooms may dissolve oxygen levels in the water.

alkalinity — Refers to the quantity and kinds of compounds present (usually bicarbonates, carbonates, and hydroxides) that collectively shift the pH below 7.

autotroph — Organisms which require their energy from the sunlight and nonliving materials

baseline study — Collecting data to document existing conditions and establish a database for planning or future comparisons (see impact analysis and trend analysis).

benthic — Living in or on the bottom of a body of water.

benthos — Collectively, all organisms living in, on, or near the bottom substrate in aquatic habitats (examples are oysters, clams, burrowing worms).

(BOD) — The quantity of largely organic, materials present in water samples as measured by a specific test. Although BOD is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act.

bioindicators — Organisms that are used to detect changes in environmental pollutant levels.

biota — The animals, plants, and microbes that live in a particular location or region.

buffer strip — A barrier of permanent vegetation, either forest or other vegetation, between waterways and land uses such as agriculture or urban development, designed to intercept and filter out pollution before it reaches the surface water resource.

carcinogenic — Potentially capable of causing cancer.

catchment area — The geographical area served by an institution.

(COD) — Quantitative measure of the strength of contamination by organic and inorganic carbon materials.

clinometer	Instrument for measuring angles of slope. Most geography departments have sets (if not try the maths department).
cold water fish	Fish such as trout salmon; preferred water temperature ranges between 7-18 degrees C (45-65 degrees F); cool water fish, such as striped bass, northern pike, and walleye, have a range between that of cold water and warm water fish.
coliform bacteria	See Faecal Coliform bacteria.
Colloidal	A suspension of finely divided particles in a dispersing medium; particles do not rapidly settle out of suspension and are not readily filtered.
colorimetry	Process of measuring the concentration of a known solution constituent by comparison with colours of standard solutions of that constituent.
(CSO)	A pipe that discharges water during storms from a sewer system that carries both sanitary wastewater and stormwater. The overflow occurs because the system does not have the capacity to transport, store, or treat the increased flow caused by stormwater run-off.
combine sewer system	A wastewater collection and treatment stem where domestic and industrial wastewater is combined with storm run-off. (Although such a system does provide treatment of stormwater, in practice, the systems may not be able to handle major storm flows. As a result, untreated discharges from combined sewer overflows may occur.)
contaminant	See Pollutant.
covariates	Explanatory variables, such as climate, hydrology, land use, or additional water quality variables, that change over time and could affect the water quality variables related to the primary pollutant(s) of concern or the use impairment being measured. Specific examples of explanatory variables are season, precipitation, stream flow, groundwater table depth, salinity, pH, animal units, cropping patterns, and impervious land surface.
critical area	Area or source of non point source pollutants identified in the project area as having the most significant impact on the impaired use of the receiving waters.
cumulative effects	The combined environmental impacts that occur over time and space from a series of similar or related individual actions, contaminants, or projects.
cyanobacteria	Photosynthetic bacteria; often referred to as blue-green algae.
decomposition	The breakdown of complex organic substances into more simple organic substances.

denitrification	Reduction of nitrate-yielding gaseous nitrogen.
deposition	The settling out of a soil particle or aggregate of particles from the water column.
designated use	A beneficial type of use established by a state for each water resource and specified in water quality standards, whether or not it is being achieved.
detritovores	Organisms that feed on fresh or partly decomposed dead organic matter; the term usually applies to detritus-feeders other than bacteria and fungi.
detritus	Fresh to partly decomposed organic matter.
disposal	Methods by which unwanted materials are relocated, contained, treated, or processed. Unless contaminants are converted to less harmful forms or removed from the material before disposal, they may be released again into the environment.
dissolved oxygen	The amount of oxygen present in the water column. More than five parts oxygen per million is considered healthy; below three is generally stressful to aquatic organisms
ecosystem	Interrelated and interdependent parts of biological system.
erosion	Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.
estuary	A coastal water resource where fresh water from rivers mixes with salt water from the ocean.
eutrophic	Usually refers to a nutrient-enriched, highly productive body of water.
eutrophication	A process by which a water body becomes rich in dissolved nutrients, often leading to algal blooms, low dissolved oxygen, and changes in community composition. Eutrophication occurs naturally, but can be accelerated by human activities that increase nutrient inputs to the water body.
facultative	Organisms that flourish in the presence of oxygen, but can also survive in the absence of oxygen, (in an anoxic environment).
anaerobes faecal coliform	Bacteria from the colons of warm-blooded animals which are released in faecal material. Specifically, this group comprises all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35 degrees Celsius.

feeding groups: Freshwater animals can be classified as shredders, browsers, predators and filters according to the nature of their food and the way they obtain it.

Shredders – are mainly large insect larvae, which chew up dead leaves. As a group they are relatively uncommon in our streams, compared with many other countries.
Browsers – consume fine particulate matter, algae and associated bacteria, fungi and slimes that are the main components of biological films on the surfaces of stones and plants. They are by far the largest and most diverse feeding group.
Predators – feed on other living animals.
Filterers – sieve food from the water using a range of devices, including snares, nets, brushes and filtering hairs.
Collector-browsers – macroinvertebrates, which don't restrain {as do?} collector-filterers.

geographic information systems (GIS) Computer programs linking features commonly seen on maps (such as roads, town boundaries, water bodies) with related information not usually presented on maps, such as type of road surface, population, type of agriculture, type of vegetation, or water quality information. A GIS is a unique information system in which individual observations can be spatially referenced to each other.

groundwater The water that occurs beneath the earth's surface between saturated soil and rock and that supplies wells and springs.

habitat A specific area in which a particular type of plant or animal lives.

hazardous Any solid, liquid, or gaseous substance which, because of its source or measurable characteristics, is classified under national law as hazardous and is subject to special handling, shipping, storage, and disposal needs.

impact analysis Monitoring activities that aim to determine adverse effects of a particular land use on a stream or river.

impaired water Surface and ground waters that are negatively impacted by pollution resulting in decreased water quality.

impervious surface A surface such as pavement that cannot be easily penetrated by water.

intermittent stream A watercourse that flows only at certain times of the year, conveying water from springs or surface sources; also, a watercourse that does not flow continuously, when water losses from evaporation or seepage exceed available stream flow.

lake A man-made impoundment or natural body freshwater of considerable size, whose open-water and deep-bottom zones (no light penetration to bottom) are large compared to the shallow water (shoreline) zone, which has light penetration to its bottom.

land use	The way land is developed and used in terms of the types of activities allowed (agriculture, residences, industries, etc.) and the sizes of buildings and structures permitted. Certain types of pollution problems are often associated with particular land uses, such as sedimentation from construction activities.
leachate	A solution or product obtained by leaching.
lentic	Still or standing (water)
limiting nutrient	The plant nutrient present in lowest concentration relative to need: limits growth such that addition of the limiting nutrient will stimulate additional growth.
load	The volume or mass of a substance; derived by multiplying the concentration by the flow rate over a specific period of time.
loading	The influx of pollutants to a selected water body.
lotic	Flowing (water)
macro - invertebrate	Invertebrates visible to the naked eye, such as insect larvae and crayfish.
macrophyte	A macroscopic (large) vascular plant; a multicellular aquatic plant, either free-floating or attached to a surface.
metabolic waste	Waste products formed as a result of metabolic processes.
metabolism	The chemical changes in living systems by which energy is provided for vital processes and activities and new materials are assimilated.
mineralization	The conversion of humus and soil organic matter into inorganic substances by microbial breakdown.
mitigation	Actions aimed at reducing the negative effects of a particular land use or activity.
mitigation bank	Habitat protection or improvement actions taken expressly for the purpose of compensating for unavoidable, necessary losses from specific future development actions.
natural community	A distinct and reoccurring assemblage of populations of plants, animals, bacteria, fungi, and viruses naturally associated with each other and their physical environment.
nitrate	A form of nitrogen which is readily available to plants as a nutrient. Generally, nitrate is the primary inorganic form of nitrogen in aquatic systems.

nitrification The oxidation of ammonia to nitrate and nitrite, yielding energy for decomposing organisms.

nitrogen An element which in living organisms is a component of protein structures.

nitrogen fixation The conversion of gaseous nitrogen to ammonia or nitrate.

non point source controls General phrase used to refer to all methods employed to control or reduce non point source pollution.

non point pollution(NPS) Pollution originating from run-off from diffuse areas (land surface or atmosphere) having to well-defined source.

nutrients Chemicals that are needed by plants and animals for growth (e. g., nitrogen, phosphorus). In water resources, if other physical and chemical conditions are optimal, excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae. Some nutrients can be toxic to animals at high concentrations.

oligotrophic Usually refers to a nutrient-poor body of water with low productivity.

oxygen demanding materials Materials such as food waste and dead plant or animal or animal tissue that use up dissolved oxygen in the water as they decompose through chemical or biological processes. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen consumed when a substance decays.

particulate matter Very small, separate particles composed organic or inorganic matter.

parts per million (ppm) A volume until of measurement; the number of parts of a substance in a million parts of another substance. (For example, 10 ppm nitrate in water means 10 parts of nitrate in a million parts of water.)

perennial stream A watercourse that flows throughout the year or most of the year (90 percent), in a well defined channel. (Same as a “live stream”.)

periphyton Small plants like algae, found at the bottom of streams (autotrophs)

pesticides Chemical materials that are used for the control of undesirable insects, diseases, vegetation, animals or other forms of life.

PET	Polyethylene terephthalate.
pH	The negative log of the hydrogen ion concentration (-log 10 [H+]); a measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The scale is 0-14.
phosphorus	An element essential to the growth and development of plants, but which, in excess, can cause unhealthy conditions that threaten aquatic animals in surface waters.
phytoplankton	Free-flowing microscopic aquatic organisms capable of photosynthesis.
plankton	Mostly microscopic (some are barely visible to the naked eye) aquatic organisms found in the lighted upper layers of the water column. Includes photosynthetic (phytoplankton) and heterotrophic (zooplankton) organisms.
point source	Any confirmed and discrete conveyance from which pollutants are or may be discharged. These include pipes, ditches, channels, tunnels, conduits, wells, container, and concentrated animal feeding operations.
point source pollution	Water pollution that is discharged from a discrete location such as a pipe, tank, pit, or ditch.
pollutant	A contamination that adversely alters the physical, chemical, or biological properties of the environment. The term includes nutrients, sediment, pathogens, toxic metals, carcinogens, oxygen demanding materials, and all other harmful substances. With reference to non point sources, the term is sometimes used to apply to contaminants released in low concentrations from many activities which collectively damage water quality over time.
protozoan	Single-celled, free living, animal-like micro-organisms that occur in aquatic environments.
reservoir	A constructed impoundment or natural body of freshwater of considerable size, whose open-water and deep-bottom zones (no light penetration to the bottom) are large compared to the shallow water (shoreline) zone, which has light penetration to the bottom.
restoration	The renewing or repairing of a natural system so that its functions and qualities can be compared to its original, unaltered state.
revetment	Facing of stone or other material either permanent or temporary, placed along the edge of a body of water to stabilise the bank and/or protect it from erosion.
riffle	Area of a stream or river characterised by a rocky substrate and turbulent, fast-moving, shallow water.

riparian	Relating to the bank or shoreline of a body of water.
river	A watercourse that flows at all times, receiving water from ground or surface water, for example, from other streams or rivers. The terms, ‘river’ and ‘stream’ are often interchangeable, depending on the size of the water resources and where it is.
Runoff (run-off)	Water that is not absorbed by soil and drains off the land into bodies of water, either in surface or substance flows.
salinity	The amount of dissolved salts in water, generally expressed in parts per thousand (ppt).
saprobe	An organism that feeds on non-living organic matter.
sediment	Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water.
sedimentation	Deposition of sediment.
siltation	The deposition or accumulation of fine soil particles.
source control	A practice, method, or technology used to reduce pollution from a source; for example, best management practices or end-pipe treatment.
species	A class of individuals having common attributes and designated by a common name; a particular kind of atomic nucleus, atom, molecule, or ion.
stadia rod	Graduated, upright rod used for measuring gradient, or elevation. Paint a wooden dowel or metal rod with alternating 15cm-long sections of red and white. Mark with black lines at 2.5cm intervals.
storm drain	A system of gutters, pipes, or ditches used to carry stormwater from surrounding lands to streams or lakes. In practice storm drains carry a variety of substances. Sediments, metals, bacteria, oil, and antifreeze enter the system through run-off, deliberate dumping, or accidental spills. This term also refers to the end of the pipe where the stormwater is discharged.
stormwater	Rainwater that runs off the land, (usually paved or compacted surfaces in urban or suburban areas) and is often routed into drainage systems in order to prevent flooding.
stratification	Division of an aquatic community into distinguishable layers on the basis of temperature.
stream	A watercourse that flows at all times, receiving water from groundwater and/or surface water supplies, such as other streams or rivers. The terms, ‘river’ and ‘stream’ are often used interchangeably. (see river.)

stream order Streams are often classified by size. First order – the smallest streams that have year round flow and no tributaries. Second order – formed when two first order streams meet. Third order – formed when two, Second order streams join, and so on. Stream order only changes when two streams with the same classification meet.

stream reach A section of stream used to evaluate overall stream condition or health. Each of these sections is called a stream reach. Reach boundaries may be defined by a topographic feature or other permanent structure, and are typically 50-100m in length.

submerged aquatic vegetation (SAV) Vegetation rooted in the substrate of a body of water (usually no deeper than 10 feet), that does not characteristically extend above the water surface and usually grows in associations or beds. It serves as nursery area for juveniles and supports adult populations of economically important seafood species. SAV beds also enhance water quality by reducing cloudiness and stabilising sediments. Also referred to as sea grass.

substrate The surface with which an organism is associated; often refers to lake or streambeds.

substrate sampling Sampling of streambeds to determine the percent of fine particle material and the percent of gravel.

suspended load Sediment that is transported by suspension in the water column of a stream or river.

suspended solids Organic and inorganic particles, such as solids from wastewater, sand, clay, and mud, that are suspended and carried in water.

sustainable use Conserved use of a resource such that it may be used in the present and by future generations.

swale A low place in an area of land, usually more moist and often having ranker vegetation than the adjacent higher land. Grassed swales are often used beside roads to act as a filter strip, removing pollutants from surface run-off.

thermal pollution A temperature rise in a body of water, sufficient to be harmful to the aquatic life.

thermo cline Zone of rapid temperature and density change in a stratified water body; marks the transition zone between the epilimnion and the hypolimnion. Also known as the metalimnion.

total alkalinity A measure of the titratable bases, primarily carbonate, bicarbonate, and hydroxide.

total suspended solids (TSS) The weight of particles that are suspended in water. Suspended solids in water reduce light penetration in the water column. They can clog the gills of fish and invertebrates and are often associated with toxic contaminants because organics and metals tend to bind to particles. (Differentiated from total dissolved solids by a standardised filtration process, where the dissolved portion passes through the filter.)

toxic, toxicant or toxin Poisonous, carcinogenic, or otherwise directly harmful to life. Refers to any substance or mixture which has the potential to cause death, disease, behavioural abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformities in organisms or their offspring. Organisms are vulnerable to toxicants either directly from the environment or indirectly by ingestion through food chains.

transport The movement of a soil particle, nutrient, or pesticide from its original position. This movement may occur in water or air currents. Nutrients and pesticides can be attached to soil particles or dissolved in water as they move.

trend analysis Comparing recently collected data with past or baseline data to detect changes in stream condition.

tributary A stream or river that flows into a large stream or river.

turbidity A measure of the amount of light intercepted by a given volume of water due to the presence of suspended and dissolved matter and microscopic biota. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity are harmful to aquatic life.

upstream/ downstream design A water quality monitoring design that uses two water quality monitoring sites. (One station is placed directly upstream from the area where the testing will be done and the second is placed directly downstream from that area.)

variable A water quality constituent (for example, total phosphorus pollutant concentration) or other measured factors (such as stream flow, rainfall).

warm water fish Prefer water temperatures ranging between 18-29 degrees C (65-85 degrees F); include fish such as small-mouth bass, large-mouth bass, and bluegill.

water management The practice of limiting the amount of water used in activities such as animal waste flushing systems or milking operations in order to reduce the amount of run-off and therefore, decrease the probability of polluting nearby surface water.

water quality standards Established limits of certain chemical, physical, and biological parameters in a water body, water quality standards are established for the different designated uses of a water body.

water table The depth or level below which the ground is saturated with water.

watershed The area of land from which rainfall (and/or snow melt) drains into a single point. Watersheds are also sometimes referred to as drainage basins or drainage areas. Ridges of higher ground generally form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

zooplankton Free-floating or weakly-swimming planktonic organisms not capable of photosynthesis.

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APPENDIX A – WBC COORDINATOR FIELD GUIDE

Available on request from WBC National coordinator (info@whitebaitconnection.co.nz) – this is a field guide based on the implementation of this manual.