Foreword

Flow Guidelines for Instream Values provides a long-overdue guide for resource managers on how to set minimum flows and other flow requirements in rivers. Drawn-out disputes on low flows, such as those on the Rakaia Water Conservation Order and the Whanganui River minimum flows, have been a feature of resource management in New Zealand over the last 20 years.

For the first time we have a consistent approach to this issue. I am sure that these guidelines will make the establishment of instream flow requirements in New Zealand easier in the future.

During the development of the guidelines the Ministry sought the views of a wide range of water managers through workshops and a submission process. An advisory group, consisting of a group of senior water managers with a wide range of views on this issue, advised the Ministry on the scope, content and philosophy of the guidelines. The advisory group achieved consensus on the guidelines. Submissions to a draft were positive, as was feedback from workshop participants. I am pleased that there is a large consensus and support for these guidelines.

Although these guidelines use the most up-to-date information and techniques, there are gaps. Areas requiring further research have been identified. I am particularly concerned that we could not provide more guidance on simple methods for setting flows in small streams.

These guidelines need to be used in the broader context of resource management and in particular of regional plans. In the future, we will provide guidance on other aspects of water management, such as procedures for identifying instream values and guidelines on water allocation methods.

I commend these guidelines to every resource manager and look forward to seeing the benefits of their use.

Hon Simon Upton
MINISTER FOR THE ENVIRONMENT

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Also, thanks to the organisations that made a financial contribution to the preparation and publication of these guidelines: Electricity Corporation of New Zealand, Auckland Regional Council and the Department of Conservation.

Executive Summary

Rivers - a matter of flow

Rivers are intimately tied in with our history and what it means to be a New Zealander. Our economic well-being depends on rivers, for example being crucial for power generation, industry and farming, as do many of our recreational and aesthetic values. Maori have, and still do depend on riverine food sources (mahinga kai), and have a strong spiritual ethos surrounding rivers.

Because rivers are so important, New Zealanders can become passionate about them. They arouse high emotions and conflict. For example, the setting of minimum flows for the Wanganui River was before the Environmental Court for close to 18 months and generated a pile of evidence 10 metres high.

Under the Resource Management Act (RM Act), regional councils are the primary water management agencies, and are often faced with making contentious water management decisions. Regional councils have responsibilities for setting river flow and water levels, and deciding on the flow regimes put in place to try and manage and allocate water resources. Ultimately, the objective of water managers is to set flow regimes that will maintain certain values identified in a river system. Thus, the setting of flow regimes is often the point at which interested parties representing instream values and out-of-stream uses meet head-on.

For some time there has been a strong need for a consistent process for determining flow regimes, one that the various communities of interest perceive to be fair, accessible, and transparent. *Flow Guidelines for Instream Values* provides this process for determining instream values within the wider context of water allocation.

Unique Rivers and Values, Unique Issues and Solutions

Each part of a river system is unique with its own set of environments and associated animals and plants. Likewise, each river comes complete with unique instream values, out-of-stream uses, and historical and social context. This in turn means that the management regime implemented must reflect the requirements of that particular river.

Because each river system is unique, these guidelines cannot set any general "rules of thumb", nor can any "magic numbers" be provided.

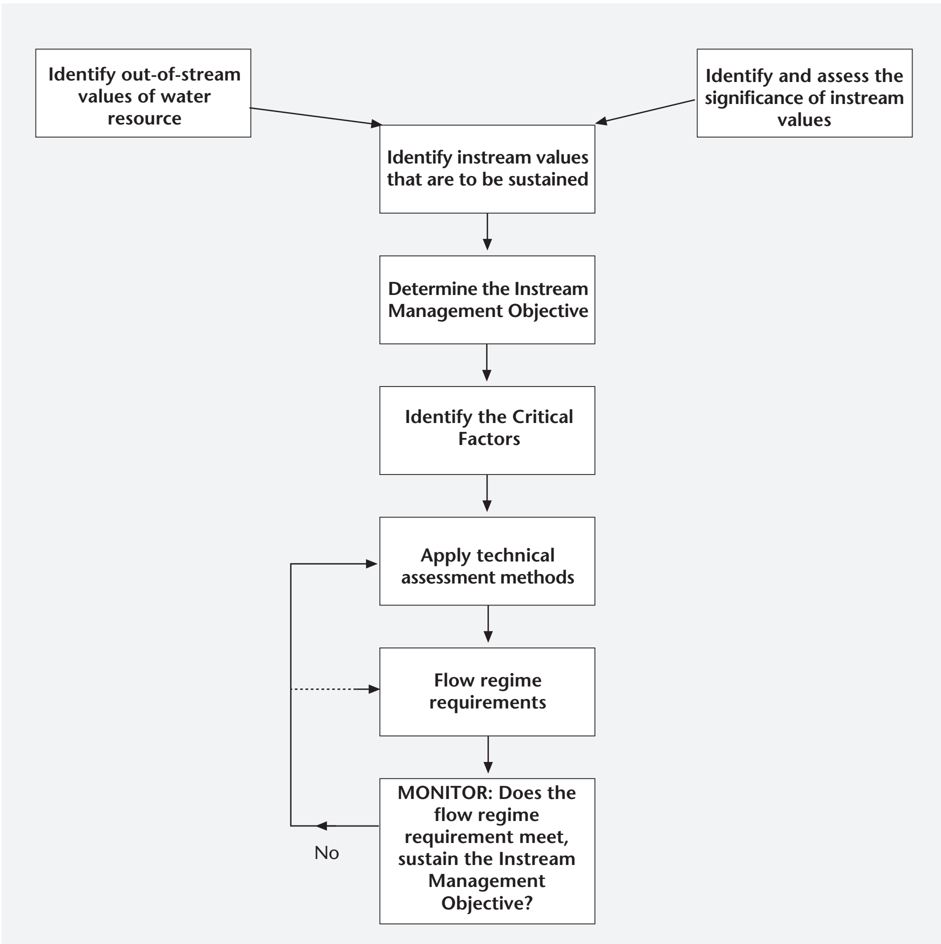
Instream values include those associated with the river's natural environment, its traditional uses for Maori, and its recreational and aesthetic values. Examples of out-of-stream uses include abstraction, diversion of water from or into a river, damming, and changing land-use patterns (for example, by urbanisation or converting pasture into pines).

The individuality and complexity of each river system highlights the importance of decision-makers setting clear and appropriate policy goals. In other words, determining as far as possible what the community wants from its river. Only then will it be possible to set a flow regime that both sustains the values of the river and meets the needs of its community in a way that accords with the RM Act.

A Common Process

The guidelines outline a practical and commonsensical *process* for setting a flow regime in a river. They present a range of options that decision-makers and others can use, whilst recognising that methods used will need to vary on a case-by-case basis. The process is summarised immediately below and is reflected in the structure of the document's two volumes.

Decision-making process recommended in these guidelines



Structure of Guidelines

Volume A explains basic principles of hydrology and hydraulics. Instream values are defined and discussed as: Ecological values, Landscape Values, Recreation Values, and Maori customary and traditional instream water values. It sets out the process by which flow requirements for instream values are determined, and given practical effect through plans, consents, and water conservation orders.

Technical methods available for deriving flow regime requirements are summarised in the latter part of Volume A. A more detailed discussion of these technical methods makes up Volume B.

Who Benefits From These Guidelines

The guidelines are an attempt to provide a mechanism or framework that all interested parties can use. Thus, a range of groups and agencies will benefit:

- **Decision makers in regional councils**, by assisting in:
  - preparing and reviewing policy statements and plans;
  - identifying and assessing instream values that may be present in a river system;
  - determining objectives and policies promoting the sustainable management of instream values;
  - better understanding Maori values, by setting out "typical" instream values that iwi may consider important. However, each iwi or hapu may well have different and specific values associated with waterways they use;
  - identifying appropriate methods to monitor the state of the instream values and the effects of activities which alter flow regimes; and
  - understanding the uses and limitations of the range of flow regimes available.
- **Water resource users** involved in statutory processes under the RM Act, by:
  - providing information on how an activity might effect a stream or river;
  - assisting in the preparation of assessment of environmental effects in applications for a resource consent; and
  - assisting with the preparation of submissions to, or comments on, policy statements or plans.

- **Iwi** by providing up-to-date information that enables participation in this process.
- **Interested parties** (environmental groups, for example), by providing up-to-date information that enables participation in this process.

Issues Outside the Scope of these Guidelines

There are a number of issues that the guidelines do not address. Resolving conflict between instream and out-of-stream use is outside the scope of these guidelines. Conflict resolution has to occur, for each case, using mechanisms such as Part II of the RM Act, regional plans and policy statements.

Gaps in the research means that little guidance can be given for some issues, for example simple methods for setting flows in small streams. Most of the modelling work and research in New Zealand has been done on large rivers, and recent work suggests that small rivers and streams may have particularly high ecological values. Models developed for large rivers may not apply to small streams.

Another issue that the guidelines do not effectively address is flow variability. Although the document presents a strong case for why flow variability may be crucial, especially for biological instream values, little guidance can be given. This is simply because the necessary data does not yet exist in New Zealand.

A Note on Developing these Guidelines

The Ministry decided on a working-group approach for this project, to ensure they meet the needs of the people who will use these guidelines. Ten people from outside the Ministry for the Environment with a perspective and ability in water management issues developed the project's terms of reference, assisted in selecting consultants, and reviewed drafts of the document. The working group comprised representatives from regional and district councils, the farming sector, iwi, the Department of Conservation (DoC), industry and environmental groups. The Ministry recognises the valuable contribution, in some instances financial, of these people and their organisations.

These guidelines represent the most up-to-date guidance possible on setting flow regimes to sustain instream values. In five years they will be reviewed to assess their usefulness, identify where changes are needed, and to incorporate new research findings.

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1 Background and Structure of the Guidelines

1.1 Background

Setting flow regimes in rivers is one of the most contentious water management issues in New Zealand. Low flow issues are frequently heard by the Environment Court, and the two longest Environment Court Hearings in New Zealand were on low flows.

These guidelines set out a process for setting a flow regime in a river. The document does not recommend any "magic numbers" or "rules of thumb". There are none. In setting flow regimes water managers need to follow a clearly defined process. The guidelines aim to provide this.

The guidelines should be used in the context of a "holistic" approach to river management. It is assumed that users of the guidelines have already determined that flow management is the critical issue that needs to be addressed.

1.2 Purpose

These guidelines provide a way of objectively establishing the flows needed to sustain instream values. They do not attempt to resolve the competition between instream values and out-of-stream uses. This competition must be resolved on a case by case basis, using the following to guide the decision; Part II of the Resource Management Act 1991 (RM Act),: Regional Policy Statements, Regional Plans and consultation with communities of interest.

In addition to setting out a process for identifying instream values, these guidelines provide a comprehensive discussion of the techniques available for setting flow regimes. This is the first time in New Zealand that a discussion of all the relevant techniques has been incorporated into one document.

1.3 Process used to develop the guidelines

These guidelines have been developed through an "advisory group" process. The group assisted in setting the Terms of Reference for this project and reviewed early drafts of the guidelines. This group comprised ten people with a range of perspectives on instream flow values and issues.

In addition, the guidelines have been discussed at a workshop for hydrologists. Key sections of the guidelines have also been reviewed by relevant experts outside the Ministry for the Environment.

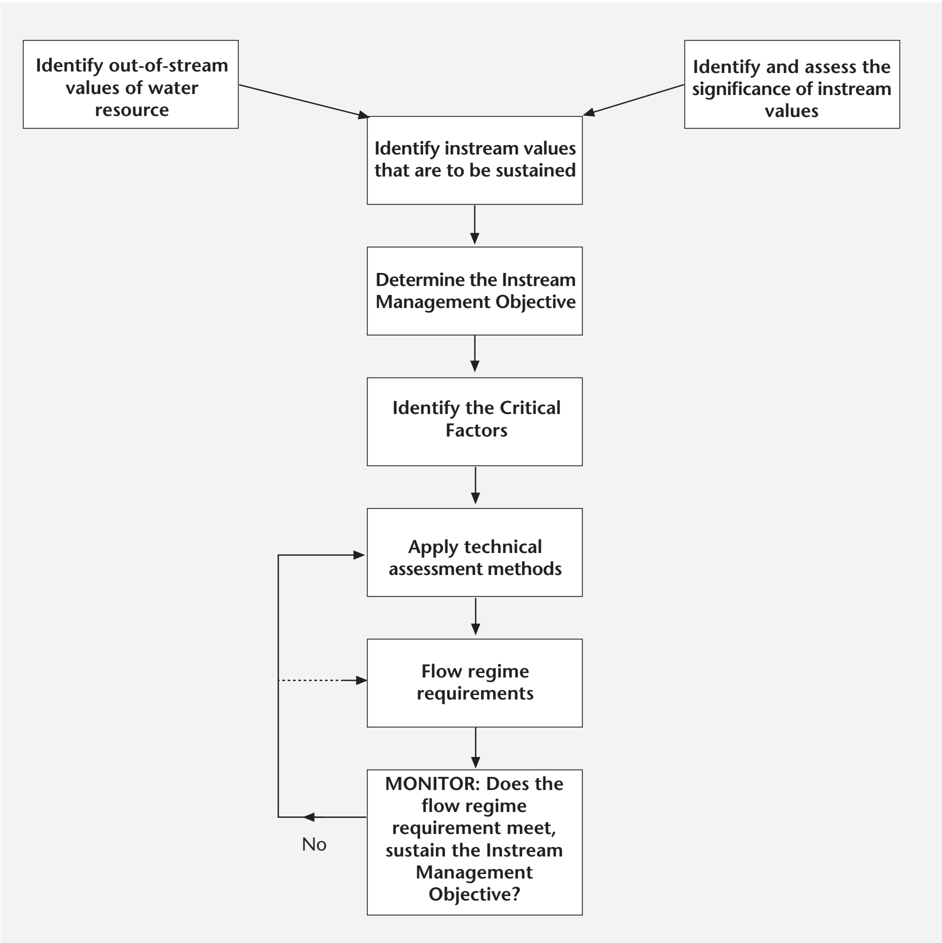
The Ministry called for submissions on the guidelines. In general the submissions were supportive of the guidelines. Several submissions identified two important issues that have not been addressed in this version of the guidelines:

- Setting flow regimes on small streams. Ideally, easily applied “rules of thumb” are needed for setting flows on small streams. At present there is not enough information to develop these “rules of thumb”, and primary research is needed on the hydrology and ecology of small streams.
- Identifying instream values and their significance. Submissions pointed out that there are a number of practical and conceptual difficulties with identifying instream values. Over the next few years, the Ministry will be developing a framework and guidelines for river management that will assist water managers identify instream ecological values and their significance. The framework and guidelines will address many of the issues raised by submitters.

1.4 Approach suggested in these guidelines

The recommended process for setting flow regimes in rivers is set out in Figure 1. The key part of the process is setting an ***Instream Management Objective***. This must be set before the technical assessment methods are applied.

Fig 1: Decision-making process recommended in these guidelines



Many technical methods are suited to particular types of objectives, for example, sustaining a specific type of habitat. These guidelines provide assistance in selecting the most appropriate method for a particular situation.

The technical assessment methods produce a ***Flow Regime Requirement,*** which is a flow regime that will sustain the Instream Management Objective. The flow regime requirement may be an annual minimum flow, or it may be a certain flow at a particular time of the day.

Users of these guidelines

The people most likely to use these guidelines are:

- Water managers, decision makers in regional councils.
- Water resource users and their consultants for information on possible effects of an activity, and to assist with participation in the statutory process.
- Tangata whenua; the guidelines identify "typical" values iwi may consider important, but in no way supersede the need to consult. Iwi will use the guidelines to assist with participation in the statutory process.
- Interested parties to assist with participation in the statutory process.

1.5 Myths these guidelines seek to dispel

These guidelines seek to dispel three common myths that have developed around minimum flow issues. First, that sophisticated methods have replaced traditional hydrological methods, such as the one-in-five-year low flow. This is not so. Sophisticated methods are best in certain situations whereas the traditional methods are applicable in others.

Second, that changes to flow regimes on “big rivers” are somehow much more important than changes to flow regimes on small rivers, therefore proposed changes to flow regimes on big rivers need much more work and more sophisticated assessment techniques. This is not necessarily the case. Simple techniques may be perfectly adequate for big rivers and in some cases very sophisticated techniques may be needed for small streams. In addition, small streams can have very high habitat values - in some cases the ecological values of small streams may exceed those of mainstem rivers.

Third, there is a perception amongst some water managers that a flow regime for one river becomes a precedent for flow regimes on other rivers. This is not the case. Different rivers need different flow regimes to support their instream values. Flow regimes need to be set for each river. However, it maybe appropriate to set a certain flow regime for a group of rivers that have similar physical characteristics.

1.6 Maori and landscape values

Water managers seem to be having difficulty understanding and addressing Maori and landscape values. In these guidelines there is an extensive discussion of Maori and landscape values. The Ministry hopes that this discussion will have wide applicability and will assist water managers to address a range of water-related landscape and Maori issues, including flow management issues.

1.7 Structure of these guidelines

It is acknowledged that the document is very big. Flows for instream values is a "big", complex issue about which there is a lot of information which is needed to make good decisions.

There are two volumes to these guidelines:

Volume A: The Guidelines

Volume B: Technical Background to Guidelines

Volume A (referred to as "the guidelines" throughout this document) has four parts. The structure is set out in Figure 20. Fold out this diagram and use it as a "map" to assist you to navigate this document. Also on the top of each page is the current chapter title to assist readers navigate this document.

Part 1 of **Volume A: The Guidelines** covers the basic principles of hydrology and hydraulics. An understanding of these basic principles is needed before the concepts in the RM Act can be applied.

In **Part 2** the instream values are defined and discussed. Part 2 comprises a discussion of Part II of the RM Act and an application of the matters in Part II to rivers.

In **Part 3** the concepts of hydrology and hydraulics are brought together with the instream values and the overall approach for managing flows is described. The means for implementing the approach, such as plans and consents, is discussed in this part of the guidelines.

Part 4 discusses techniques for setting flows for instream values. The guidelines relate these techniques to the overall approach developed in Part 3. Part 4 only summarises the techniques. Further detail of these is provided in **Volume B: Technical Background to Guidelines.**

1.8 Monitoring these guidelines

The Ministry for the Environment will monitor the effect and usefulness of these guidelines. Monitoring will be done in the following ways:

- Analysing plans and assessing whether or not the guidelines have been used.
- Undertaking specific investigations on resource consents.
- Reviewing the guidelines in five years' time. As part of the review process workshops will be held with relevant groups to assess the usefulness of the guidelines and identify changes that are needed.

Glossary of Terms

Abstraction	Removing water from the river system (including removal of groundwater)
Ash Free Dry Mass	The weight of a substance after incineration at very high temperatures to burn off all the organic material
Augmentation	Increasing (flow)
Base flow	Flow sustained by groundwater inflow
Base Flow Index (BFI)	Indicates overall flow variability
Bryophyte	Moss or liverwort
Catchment	The land area that contributes the river's flow
Coefficient of variation (CV)	A measure of the variability of the flow regime
Detritus	Dead organic material
Dissolved oxygen	Oxygen dissolved in the water
Diurnal	Daily
Diversion	Addition of water into the river system
Ephemeral	Short-lived
Evapotranspiration	Removal of water through plants
Flood flow	Periods of high river flow
Flow regime	A description of flow magnitude over time
Flow regime type classification	Classifying the flow regime based on the source of flow
Geomorphology	Study of the physical features of the earth's surface
Heterotrophs	Organisms which obtain energy from consumption of other dead or living organic matter
Histogram	A bar-graph of the average flow over a period

Hydraulic	Water depth, velocity and width of the surface of the water
Hydrograph	Graph of flow in a river over time
Hydrology	The scientific discipline used to describe flow regimes
Idiosyncratic	Variable - individualised, eccentric
Infiltration	Water entering the river system through the surrounding catchment soil - depends on permeability of the soil
Instream management objective	The objective and policy which promote the sustainable management of an instream value
Instream values	The values identified in a river system
Invertebrates	All animals without backbones
Kaitiakitanga	The exercise of guardianship, including the ethic of guardianship
Low flow	Periods of reduced river flow
Macrophytes	Large vascular, rooted plants and bryophytes
Mahinga kai	Food sources
Mauri	Life force; no direct translation to English
Morphology	Study of form and shape
Non-linear	Not simple or uniform (i.e. not a straight line relationship)
Out-of-stream values	Values associated with the use of water outside of the river system. These values are frequently associated with an economic value
Periphyton	Non-vascular plants forming crusts, films or filamentous mats in the river
pH	A measure of acidity and alkalinity. A value of 7 is neutral

Precipitation	Rain, snow, hail etc.
Reach	A stretch of river with similar characteristics, often defined by upstream and downstream tributaries, or significant geological controls, or bed controls
Riffle	Shallow part of river where water flows brokenly
Riparian	River margins
River typing	Classifying a river based on physical and ecological factors, such as the flow regime and channel form
Substrata	The material that makes up the bed of rivers, e.g. boulders, sand and silts
Tangata whenua	Maori - People (family) of the land
Taonga	Anything that contributes to the intellectual, physical and spiritual well-being of an iwi
Temporal	Relating to time
Truncated recession	Where a natural slow reduction in flow is halted (by abstraction or diversion) over a short period of time.
Wai tapu/Wai taonga	Sites of special spiritual significance

Acronyms & Abbreviations

AEP	Annual exceedance probability
ANZECC	Australia and New Zealand Environment Conservation Council
BFI	Base Flow Index
DO	Dissolved oxygen
DoC	Department of Conservation
DOFLO	A model that predicts the dissolved oxygen content in streams at different flows
ECNZ	Electricity Corporation of New Zealand Limited
FRE3	Average annual frequency at which flows exceed three times the median
IFIM	Instream Flow Incremental Methodology
LAC	Limits of Acceptable Change
NIWA	National Institute of Water and Atmospheric Research
NZCPS	New Zealand Coastal Policy Statement
RM Act	Resource Management Act 1991
ROS	Recreation Opportunity Spectrum
WSCA	Water and Soil Conservation Act 1967
WUA	Weighted Useable Area

2.0 Introduction

Of key concern to water managers, iwi, recreationalists, conservationists and the general public are the "instream values" of our rivers. In these guidelines instream values are defined to include:

- Ecological values
- Aesthetic (including recreation and landscape)
- Maori cultural and traditional values.

Water in rivers can be used for a variety of purposes that may impact on the instream values. Activities which impact on instream values include:

- Abstraction
- Diversion of water from or into a river
- Damming
- Change in land use, which can affect river flows, for example urbanisation or converting pasture to pines.

A key part of managing water resources is determining the flows needed to sustain instream values. These guidelines provide a methodology for determining flow regimes that will sustain instream values. These guidelines also provide information on the technical methods available for determining flow regimes.

The Ministry for the Environment has prepared the guidelines for the following reasons:

- The Ministry was concerned that water managers were using a range of technical methods to set flow regimes in rivers. Some of these methods were being used in a way that may not meet the requirements of the RM Act. The Ministry wishes to see methods used in a way that is compatible with the purpose and principles of the RM Act.
- There is now a large amount of information on methods for setting low flows, but this information has existed in technical reports and has not been compiled into a single, user-friendly document. The guidelines are a compilation of the existing information.
- There appears to be a communication gap between planners and the technical experts involved in water management issues. These guidelines aim to provide information that will assist communication between the planners and technical specialists.

- Submissions to *Principles and Priorities for the Development of Guidelines and Standards* (Ministry for the Environment, 1995), identified flow guidelines as a high priority.
- The Government's *Environment 2010 Strategy,* released in September 1995, sets out environmental priorities for New Zealand. A priority of the strategy is:

  Establishing Guidelines and standards that maintain the biophysical "bottom line" need of water quantity and quality.
- Flow management issues have a history of bitter and acrimonious debate. The Ministry for the Environment hopes that through these guidelines, future debates will be better informed and managed than in the past.

2.1 History of flow requirement issues

The impacts of abstractions and diversions of rivers and streams date back to some of the earliest European development in New Zealand, such as the granting of "mining privileges" in central Otago during the gold rush era. From the time of European settlement to the 1970s there was little regard for the instream value of water. Rivers were dammed, flows altered and in a number of cases the entire flows of rivers were diverted, for example, rivers and streams draining the volcanic ring-plain in the central North Island, and some South Island rivers such as the Tekapo.

Under the Water and Soil Conservation Act 1967 (WSCA) all rights to natural water were conferred on the Crown so that, with certain exceptions, any taking, use, damming or diversion of natural water became subject to Water Rights granted by Regional Water Boards. WSCA had a "multiple use" philosophy and there were no specific criteria against which to assess Water Right Applications. In the absence of other specific statutory criteria, the Court of Appeal developed a balancing test as a commonsense and practical means for making water allocation decisions[1] . In practice, this concept involved an attempt to meet, to some extent, all competing demands in respect of a particular body of water.

Ultimately, it became apparent that the Act's emphasis on multiple uses gave no guarantee for passive instream use against consumptive or developmental uses of water. Development interests which could be easily quantified often outweighed environmental interests which were difficult to value[2] . As a consequence of increasing public concern about the loss of instream values through damming and diversion, in 1981 Parliament amended the WSCA.

1 *Kim v MOWD [1982] 1 NZLR 319*

2 *See for example Royal Forest and Bird Protection Society v Bay of Plenty Regional Water Board (1978) 6 NZTPA 361*

The 1981 amendment added certain instream values into the long title of the WSCA. In addition, the WSCA created the water conservation order, which is a mechanism which could protect waters from use and development. As part of the 1981 amendment, Parliament took the unusual step of stating the specific object of the amendment as follows:

> *The object of this Act is to recognise and sustain the amenity afforded by waters in their natural state*.

But despite this amendment, conflicts over the use of water continued. During the 1980s minimum flow issues were some of the most protracted and bitterly fought resource conflicts in New Zealand. For example, the two longest planning tribunal hearings in New Zealand's history were about setting minimum flows in the Rakaia and Whanganui Rivers. These issues and numerous other ones have led New Zealand scientists to develop considerable expertise in determining flow requirements. This expertise forms the basis of this document.

The RM Act has repealed the WSCA along with many others. It introduced the concept of "sustainable management" and sets out principles by which resources should be managed. The RM Act is a significant step away from the "multiple use" philosophy of the WSCA.

Under the RM Act, regional councils are the primary water management agencies and have responsibility for allocating water and setting flow regimes. Regional councils have a range of mechanisms such as regional policy statements, regional plans and water conservation orders which they may use in their management of rivers, and in dealing with issues of flow requirements.

2.2 Purposes of the guidelines

These guidelines have three main purposes:

- **Consistency:** A range of different methods and techniques have been used by regional councils for determining flow requirements for river systems, and there has been little consistency between councils. A purpose of this document is to provide a consistent framework that can be used throughout the country. This does not mean that the same method should be used throughout the country. Rather the *most appropriate* methods should be selected for a particular location.

- **Information:** Water managers have lacked readily accessible information on the effects of altering the flow regimes of rivers, in particular the effects on aquatic communities. Information on the technical methods for defining flow regime has also been lacking. The purpose of these guidelines is to provide an up-to-date summary of available information.
- **Understanding:** Another purpose of these guidelines is to assist water managers to increase their understanding of the methods for setting flow regimes, their use and limitations.

These guidelines will assist decision makers in regional councils with:

- Identifying and assessing the type of instream values that may be present in a river system
- Determining objectives and policies which promote the sustainable management of instream values
- Determining appropriate techniques and methods to use in assessing the flow requirements needed to sustain the instream values
- Identifying appropriate methods to monitor the state of the instream values and the effects of activities which alter flow regimes.

For water resource users involved in statutory processes under the RM Act, the purpose of these guidelines is to:

- Provide information on the effects an activity might have on a river or stream
- Assist with the preparation of assessment of environmental effects in an application for a resource consent
- Assist with the preparation of submissions to, or comments on, policy statements or plans.

For tangata whenua, these guidelines set out “typical” instream values that iwi may consider important. It is acknowledged that each iwi and hapu has different and specific values associated with their waterways. The Ministry for the Environment strongly recommends that water managers consult with tangata whenua to determine the specific instream values for a particular river system. However, there are generic values, such as mahinga kai, that apply across New Zealand and can usefully be discussed in this document.

For interested parties, such as environmental groups, these guidelines seek to provide information that will assist individuals to participate in the statutory process.

It is not the purpose of these guidelines to resolve the competition between instream and out-of-stream uses. These guidelines provide a means of assessing instream values, which can then be considered alongside the merit of out-of-stream uses. The competition between the uses must be considered case by case.

2.3 Limitations of these guidelines

These guidelines have a number of limitations. First, they only cover instream values. They do not address out-of-stream values and how to allocate water. They do not cover methods for resolving conflicts between out-of-stream use and instream values. These conflicts must be resolved case by case, taking account of the particular instream values and out-of-stream uses, and using Part II of the RM Act to guide the decision.

Second, these guidelines cover flows only in relation to instream values. Flows are only one of the components of water management that need to be considered by water managers. To sustain certain values, such as ecological values, other factors may need to be considered, for example riparian management or land use practices.

Third, the guidelines do not adequately cover flow variability. They present a state-of-the-art discussion on the need for flow variability, but adequate scientific understanding to provide accurate guidance on the variation in flows needed to sustain instream values, particularly ecological ones, does not exist in New Zealand. Further research is needed in this area.

Fourth, they do not adequately cover small streams. Most of the research on the effects of flow regimes on instream values has been undertaken on larger rivers. Similarly, most flow data is collected on large rivers. Small streams can have very high ecological values, especially in terms of native fish.

On small streams it may not be cost-effective to undertake detailed investigations, such as habitat modelling. Ideally, easily applied “rules of thumb” are needed for small streams. More research is needed on small streams to develop these “rules of thumb”. Research needs to focus on: (1) methods for transferring hydrological records from larger streams on to small streams; and (2) the ecological functioning of small streams.

Fifth, these guidelines do not deal with all river management issues - they only cover flow-related issues. It is assumed that users of these guidelines have already determined that flow management is a critical issue that needs to be addressed.

Sixth, river typing tools need to be developed. Limited use of the concept of "river types" is made in these guidelines. By using the river typing approach it may be possible to transfer information easily from one river to another of a similar type. This would reduce the need to collect information for every new situation. The typing concept is not well developed in New Zealand and further work is needed. The Ministry for the Environment is currently undertaking work in this area with a small group of regional councils and the Department of Conservation.
This work will be completed for the review of the guidelines, in five years' time.

2.4 Process used to develop the guidelines

In accordance with the process set out in *Principles and Processes for Developing Guidelines and Standards* (Ministry for the Environment, 1995), an advisory group was appointed to assist with the development of these guidelines. The Flow Requirements Advisory Group comprised ten people from outside the Ministry for the Environment with a range of expertise in water management issues. The Advisory Group assisted the Ministry for the Environment to develop the terms of reference for this project, assisted with the selection of consultants and reviewed drafts of the guidelines.

The Flow Requirements Advisory Group comprised:

- Ken Becker (Auckland Regional Council)
- Keith Chapple (Royal Forest and Bird Protection Society)
- Andrew Fenemor (Tasman District Council)
- Russell Howie (ECNZ)
- Murray McLea (Wellington Regional Council)
- Philip McKendry (Farmer, Canterbury)
- Donald Scott (New Zealand Fish and Game Council)
- Chris Shenton (Whanganui River Iwi)
- Marcus Simons (DoC)
- Paul Waaka (Ngai Tahu and Canterbury Regional Council).

Members of the Advisory Group attended as individuals with a perspective on, and interest in, water management. They were not representing any organisation that they may have affiliation to. The Advisory Group process was open and throughout the process members of the Group consulted widely.

The Ministry called for submissions on the guidelines. Overall, the guidelines were positively received. Most submitters felt they will be very useful and commended the Ministry for putting them together.

Apart from some points of clarification, the major changes to the guidelines have been to reformat the text to make it more user friendly and consistent with the process described in Figure 1.

Some submitters felt that the production of a summary document, which would outline the major issues that must be considered when setting instream flow regimes, would be very useful. The Ministry has prepared such a document, which has been inserted at the beginning of the guidelines, and will also be produced as a separate pamphlet.

There was a call from some of the submitters for further guidance on identifying values and setting instream management objectives for ecological and recreational values. It is not the role of these guidelines to provide the level of detail requested by the submitters. To provide the guidance requested, a comprehensive suite of guidelines is needed. The National Agenda for Sustainable Water Management (NASWM) will provide the framework for developing the necessary guidelines.

An additional area that submitters felt needs clarification is the resolution of conflict between the flow regimes required for different instream values, and between instream and out-of-stream values. The Ministry will hold a workshop for exchanging experience in setting instream flow regimes and resolving conflict between values. This will provide valuable input into the next version of these guidelines.

In general, the opinion of the guidelines was that they provide useful guidance on how to identify instream values and establish the flows required to sustain these. It was also generally agreed that the guidelines would be even more useful in association with other guidelines. This guidance can be developed under NASWM.

Part 1: Hydrology and Hydraulics

This part of the guidelines explains the fundamental physical process in rivers. The definition of "river" includes streams and creeks. Understanding the physical processes in rivers is essential to assessing the likely impact of an activity on instream values. In particular, it is necessary to have a basic understanding of hydrology and hydraulics. These terms are used throughout these guidelines.

- **Hydrology** is the scientific discipline that is used to describe flow regimes. Throughout the guidelines hydrological terms are used, such as the seven-day annual average low flow.
- **Hydraulics** refers to water depth, velocity and width of the surface of the water. It is the change in hydraulics that affects instream values, not hydrological changes. The *hydraulics* change as the flow regime changes, but the relationship is not linear. Therefore, in establishing the effect of an activity on instream values it is necessary to focus on changes to the hydraulic conditions, not just changes to the river hydrology.

This part comprises two chapters. Chapter 3 explains the basic principles of river systems, including the hydrology and hydraulics. Chapter 4 describes how activities change flow regimes and hydraulic characteristics. Please refer to the Structure of this Document, on the last page of this Volume.

3 Basic Principles of River Systems

This chapter discusses the principles of river systems. It begins with a discussion of the variables that influence the character of rivers, such as climate and geology and then discusses flow regimes and hydraulics.

3.1 Variables controlling river systems

See Volume B, Section 3.2.

A river is the product of a range of variables operating over different spatial and temporal scales. These guidelines use a hierarchical model (Figure 2) to arrange these variables. Higher order variables control lower variables, and not the reverse. There are strong interactions between variables within the same hierarchical level. For the sake of simplicity, not all the variables or their interactions have been shown. The hierarchical model has regional scale, catchment scale and reach scale variables.

3.1.1 Regional-scale variables

Geology, climate, human activities

The use of the term "region" in these guidelines, is an area of broadly similar climate and geological conditions, not a "region" as in the boundary of a regional council.

Variables which affect river systems at the regional scale are climatic and geological factors that act over large geographic areas (10 to 100 km^2 or greater). These variables provide the fundamental setting for the physical conditions in the river. Regional-scale variables are generally stable over time frames of 1,000 years or more.

3.1.1.1 Geology

Geology refers to the underlying rock type and the tectonic movement. Geology determines relief and source of sediment over large spatial and temporal scales and determines catchment morphology through its influence on these variables.

3.1.1.2 Climate

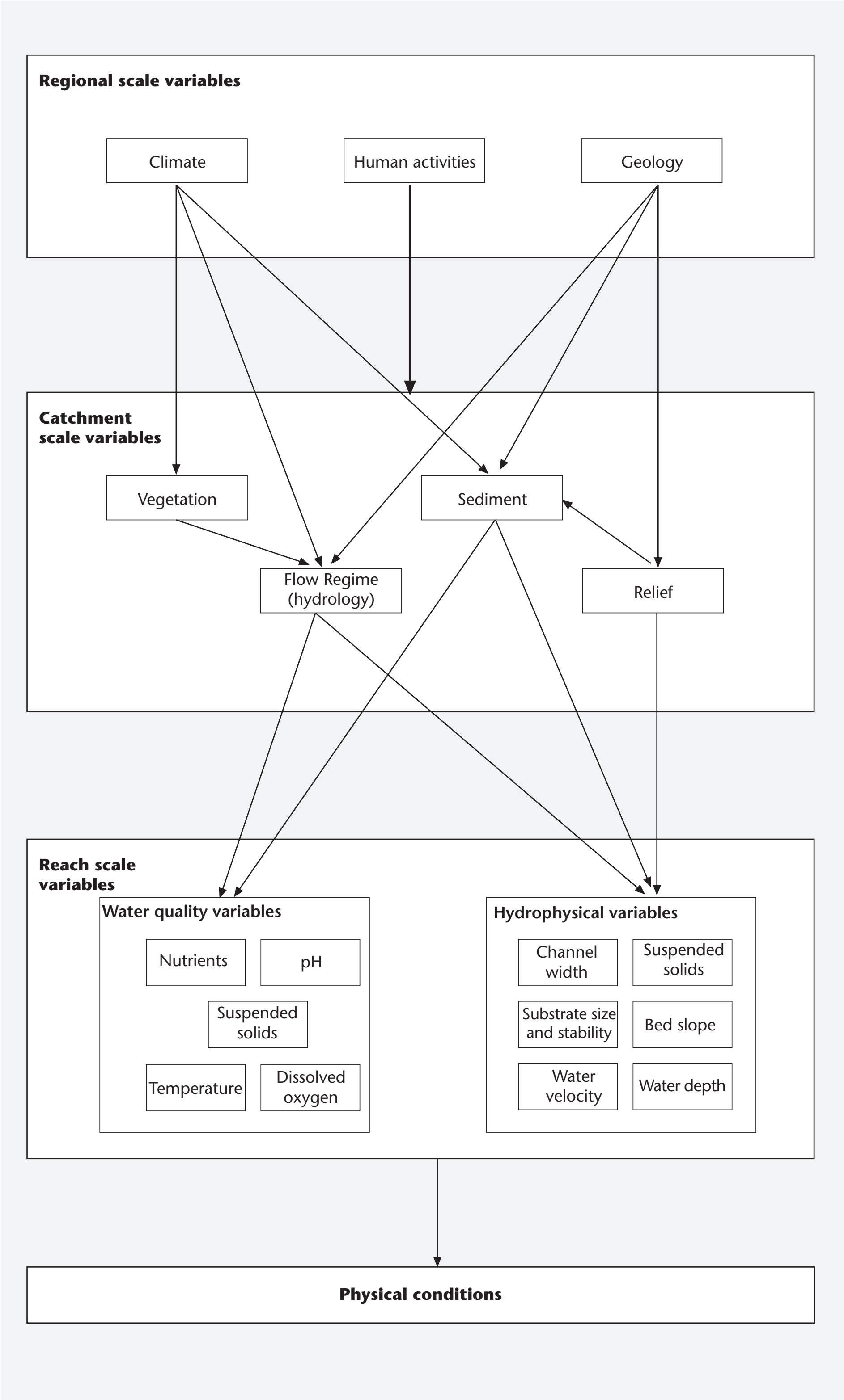
Climatic conditions control temperature, evaporation and precipitation. Over large spatial and temporal scales, climate is the fundamental determinant of the flow regime.

3.1.1.3 Human activities

See Volume B, Section 4.2

Regional scale variables can also include human activities. For example, agricultural land-use practices are often consistent over a regional area based on soil type and climatic conditions and which cover a number of catchments. Human activities also act at the smaller scales described below. Human activities and their effects on rivers therefore need to be considered at each scale at which they occur, e.g. catchment or reach.

Fig 2: Important variables affecting physical conditions in rivers



3.1.2 Catchment-scale variables

Flow regime, vegetation, relief, sediment supply.

The catchment area of a river is the land area which contributes to its flow. Catchments are highly variable in size and complexity and may be made up of many smaller catchments.

Catchment-scale variables refer to factors which affect catchment-wide processes. These processes are constrained at the higher level by geology and climate. Spatial scales are in the order of 10 to 100 of km^2, and time frames of 10 to 1,000 years. The variables include physical factors such as flow regime (hydrology), vegetation, relief and sediment supply.

Catchment-scale variables are more sensitive to change than regional-scale variables. Human activities can impact dramatically on them, particularly through land-use. Other activities which can affect catchment-scale variables are damming and diversion which can influence flow regime and sediment supply. Variables may be changed very rapidly (e.g. land-use changes, erosion events leading to change in sediment supply) and recovery of original conditions may require timeframes at the catchment scale (i.e. 10 to 1,000 years).

3.1.3 Reach-scale variables

Water velocity, depth, width, bed slope, erosion and deposition, substrate size, suspended solids, nutrients, pH, dissolved oxygen, temperature.

A reach may comprise "riffle and pool" sequences and may be a few hundred metres or several kilometres, depending on the nature of the river. At the reach scale, river width, valley width, slope of the river, flow regime and substrate are generally similar. Reaches are often defined by upstream and downstream tributaries or significant controls at the landscape scale such as gorges or bed controls such as a rapid.

The reach is normally the scale that water managers are most interested in. Many reach-scale variables are sensitive to changes in flows and are of importance to biota.

Within a reach there are a number of smaller scale variables. To anticipate the effects of changes to flow regimes it is necessary to understand these smaller variables:

- The river meander is, in many rivers, a clearly identifiable scale. At a meander scale many rivers exhibit the classic riffle and pool structure. Ecological conditions vary significantly from riffles to pools.
- At a smaller scale, ecological conditions vary even more, with certain animals occupying very specific niches.

- The particle scale (a smaller scale again) is important when considering sediment transport processes at larger scales and ecological functions such as habitat for plants and animals (including invertebrates) in the river.

The key point is that reach-scale variables comprise smaller scale variables, operating at scales from the individual particle (i.e. millimetres perhaps persisting for from hours to days) to the reach itself (which will persist at the catchment scale). When considering the effects of a change in flow regimes, it is important to bear in mind the range of scales at which different processes operate and how processes operating at one scale may become significant at another. For example, a change to the types of particles being carried in a river (particle scale) may result in a change to ecological conditions throughout the entire river system (catchment scale).

Physical factors which vary at the reach scale include chemical variables (including dissolved oxygen, pH, nutrients and toxic substances) and hydro-physical variables (water velocity, suspended solids, substrate size and stability, bed slope, depth, channel width). Some reach scale variables, such as substrate stability, persist for days to weeks. Other variables, such as dissolved oxygen or nutrient concentrations, vary daily over the length of a reach. When modelling or monitoring the effects of a change of flow regime it is important to choose the appropriate scale. For example, dissolved oxygen may vary diurnally and may need to be monitored at specific times.

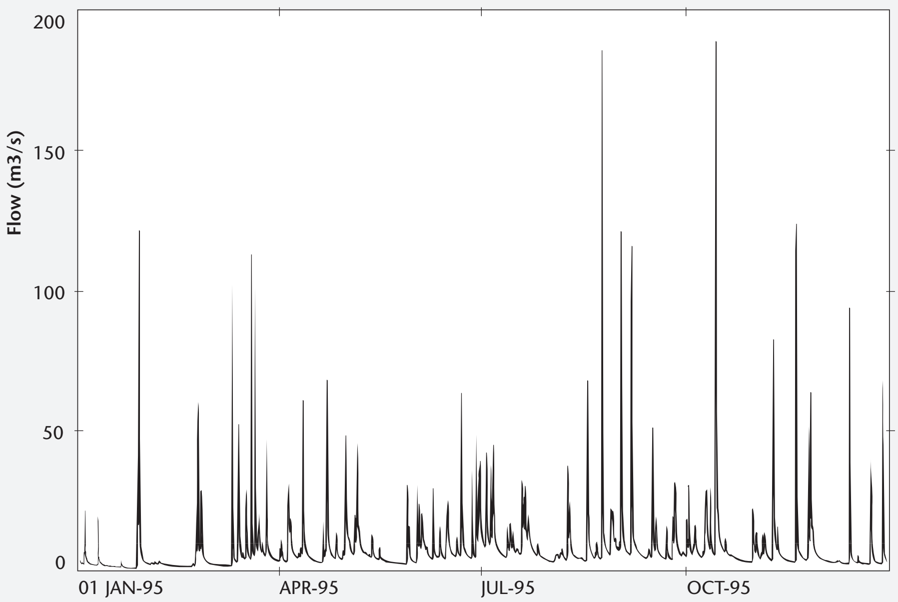
See Volume B, Sections 3.2, 3.3 and 3.4

3.1.4 Flow regime

The term "flow regime" refers to the way in which the flow varies daily or seasonally. The flow regime defines much of the character of the river, how frequently it floods and whether it is subject to prolonged periods of low flow, or even periods of no flow. Flow regime influences the physical conditions (depth, velocity, width) which support the instream values. It also determines the potential out-of-stream use of the resource for such activities as water supply, irrigation or generating hydroelectricity.

The concept of a flow regime is best illustrated by graphs of the flow in a river over time called "hydrographs" (Figure 3). Hydrographs contain two significant features: "Flood flows" and "Low flows".

Fig 3: Hydrograph for the Hutt River at the Kaitoke flow recorder site for 1995



3.1.4.1 Flood flows

"Flood flows" are periods of high river flow. They are generated by the runoff of rainfall from the surface of the catchment and by rapid sub-surface flow through the upper soil layers occurring quickly in response to rainfall in the catchment. In some catchments snow melt contributes to flood flows.

The term "flood" is a relative one. It is used to describe a flow that is above normal and is of importance to a particular aspect of the river.

See Volume B, Section 1.2.

For example, a flow that scours algae from a river bed may be small, compared with a 100-year flood - both are floods but are of very different size and significance. An ecologist may be interested in a flood that scours algae, but a flood engineer probably would not be interested in a flood of this size.

In many New Zealand rivers, floods have a critical influence on the shape of the channel. During floods, for example, the shingle in river beds is moved and the shape of the river bed can be changed. At low flows, the depth, velocity and width - the factors controlling many instream values - are a product of the effects of floods on the shape of the river channel.

3.1.4.2 Base flow and low flow

During a rainfall event a proportion of water is assumed to run off overland or through upper soil layers and to contribute to flood flow. The remainder moves into the ground and is stored temporarily as groundwater. Ground water flows into or out of river channels, depending on the nature of the river.

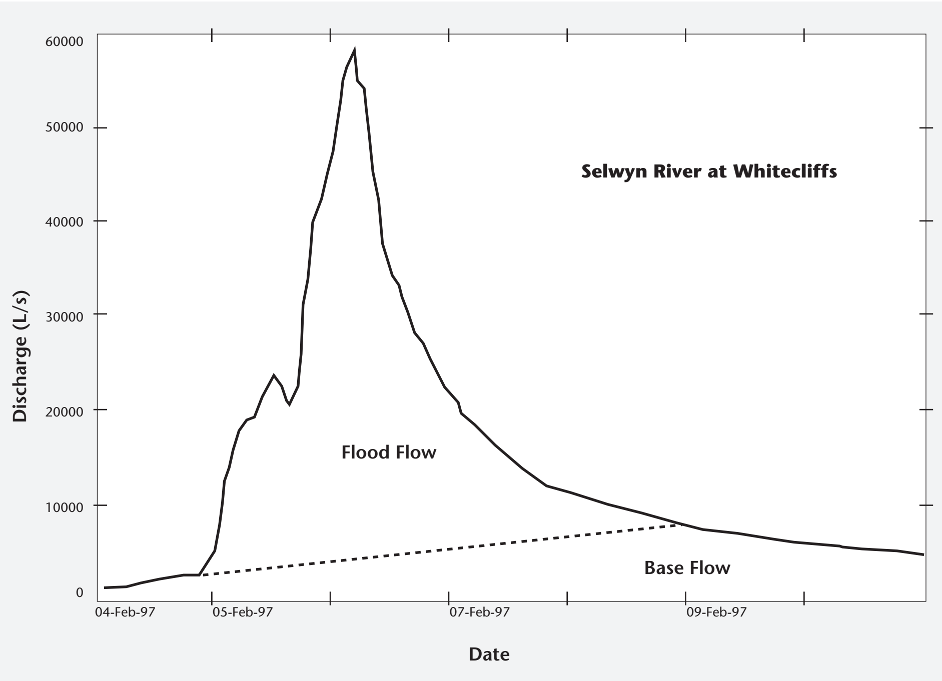
Flow sustained by groundwater inflows is the “base flow” component of a hydrograph. In most New Zealand rivers base flow conditions are the norm and floods are a rare exception from the normal conditions (see Figure 4).

The size of the base flow depends on:

- The size of the catchment, topography, land use and vegetation.
- Rainfall patterns, i.e. catchments with rainfall that is spread throughout the year tend to have higher base flows than catchments with uneven rainfall.
- Evapotranspiration.
- Catchment hydrogeology - the water storage capacity of the catchment. Some catchments have high water storage (aquifers) whereas others have small storage capacity (no aquifers).
- Water storages - lakes, dams, glaciers (snow melt).
- Human activities, such as extraction of groundwater, creation of artificial lakes and urbanisation resulting in an increase in hard surfaces.

Flood flow and base flow are conventionally separated on a hydrograph by a line extending from the foot of the rising limb of the hydrograph to the foot of the falling limb, shown in Figure 4 below. In practice there is no clear separation between flood flow and base flow water and a somewhat arbitrary approach to separating out the base flow is usually adopted.

Fig 4: Hydrograph showing the conventional separation of flood flow from base flow (Selwyn River).



See Volume B, Section 1.4.

"Low flows" are periods of reduced river flow. During low flows water in the river is generally from groundwater sources, lakes or glacier melt. The term "low flow" is a relative one and is used in different ways by different users of rivers. For example, a low flow for a canoeist may be quite different to a low flow for an angler.

3.2 Important characteristics of flow regimes

The important characteristics of the flow regimes when considering the effect of activities on instream values are:

- seasonal aspects, including low flow periods
- frequency and duration of low flows
- frequency and magnitude of floods
- "average" flow conditions.

For resource management, the important characteristics of flow regimes are illustrated by hydrological statistics. Hydrological statistics which are useful in considering flow regime requirements are summarised in Table 1.

Table 1: Summary of hydrological statistics

Statistic	Description
Low flow frequency	Frequency of flows of a given magnitude, usually expressed as an exceedance for a period of time. For example five-year seven-day low flow is the lowest weekly mean flow which occurs, on average, once in five years.
Flood flow frequency	Frequency of floods of given magnitude. Usually expressed as an annual exceedance probability (AEP). For example a flood with a 20% AEP has a 20% chance of occurrence in any year.
Flow duration curve	Frequency that flows of a given magnitude are equalled or exceeded. Usually expressed as a proportion of the time that a flow is equalled or exceeded. The range of flow magnitude is a measure of flow variability.
Monthly flow histogram	A bar-graph of the average flow for each month of the year constructed from the entire flow record. The monthly flow provides an indication of seasonal variation in average flow and identifies low flow periods.
Specific discharge	Average flow rate per unit of catchment area. It can be calculated for flows of certain frequencies e.g., five-year, seven-day specific discharge. Provides an area-scaled measure of the total volume of flow generated from the catchment.

3.3 Generating hydrological statistics

Hydrological statistics for flow regimes are best determined from historic flow records. Records that have been kept over longer periods and are more statistically reliable. Useful hydrological statistics can be determined from flow records of approximately five years or more. There are approximately 500 river flow recording sites in New Zealand for which flow records of useful length exist (Volume B, Section 1.3).

Where flow records do not exist or are insufficient to calculate flow statistics, hydrological techniques may be needed to evaluate important flow statistics

See Volume B, Sections 1.3 and 1.4.

3.4 Hydraulic conditions

Understanding how a change to a flow regime affects instream values requires an understanding of hydraulics. Hydraulics are altered by a change in flow, and in turn the change in hydraulics leads to changes in the instream values, for example, the depth of water for canoeing.

Hydraulic conditions (depth, width) are determined by the interaction of the velocity channel cross-section geometry with flow. The relationship between flow and the hydraulic conditions is complex and non-linear. For a particular cross-section, the hydraulic conditions depend on:

- channel hydraulic roughness
- channel morphology, comprising slope and channel geometry.

The effects of a change in flow regime are difficult to predict without detailed calculations. The most effective ways to predict effects on hydraulic conditions from a change to a flow regime is to use hydraulic computer models. These models are a key tool in a water manager's tool kit, but their use is limited to certain conditions. For example, current models cannot provide an accurate information on the type of standing wave that different flow regimes may produce on a rapid.

See Volume B, Section 3.

3.5 Assessing hydraulic conditions

There are two principal methods for assessing hydraulic conditions:

- Estimation by calculation
- Direct observation at different river flows.

Estimation by calculation requires surveys of channel slope and cross-section of the river reach. The survey detail necessary depends on the accuracy required and the variability of the channel cross-section and slope over the particular reach.

Hydraulic conditions at river cross-sections can be measured for a range of flows. The complexity of this type of exercise should reflect the final use of the data.

See Volume B, Section 1.4.

3.6 Types of rivers

In these guidelines broad categories or types of rivers that have similar flow and channel shape characteristics have been identified. River typing is in its infancy in New Zealand but is a promising means by which generic rules can be developed for certain river types. Currently, these guidelines are only able to offer very limited guidance on the different types of rivers. Information is available to use the typing approach to provide only a broad indication of how activities change flow regimes and hydraulics in different types of rivers.

See Volume B, Section 2.2.

In this section, rivers are typed according to their (i) flow regime and (ii) their channel form. This information is used in the following chapter to assess the way different activities, such as damming and diversion, affect flow regimes and river channels.

3.6.1 Flow regime types

One of the aims of the typing system is to help highlight differences in flow regime and the relationships of these to all components of the river system. The source of flow reflects geological factors such as soil type, catchment relief and existence of significant lake storages or springs and climate factors, including precipitation and evapotranspiration which determine flow regime.

The flow regime type classifications developed are:

- lake-fed or spring-fed
- low-relief country
- inland hill country
- non-glacial mountain
- glacial mountain.

It is acknowledged that classifying flow regime based on the source of flow will be coarse and considerable variation in flow regime may exist within a classification. For example:

- The flow regimes of inland mountain catchments vary considerably between the east and west coasts of the South Island. This can be explained by differences in precipitation, with West Coast catchments receiving more regular rainfall which reduces the variability in their flow regimes.
- The category low-relief country covers a wide range of different geological and climatic regions and will therefore show wide differences in flow regimes. An important variable determining flow regime in low relief country may be vegetation, with differences in land use and therefore vegetation causing significant differences in flood and low flows between adjacent catchments with similar geology and climate.

Many rivers will exhibit a flow regime which is a combination of the classifications presented here. The dominant source of flow, and therefore the flow regime classifications, may also change along the length of the river. For example, a lake-fed river will begin to exhibit different characteristics when flow from inflow tributaries overshadows the lake's influence on the flow regime.

It is possible to make general statements about the flow regime based on the source of flow (Table 2). Figure 5 shows a hydrograph over a period of one year for the example flow regime types.

The monthly flow histograms presented in Table 2 indicate the seasonal variation for different flow regime types. Flow duration curves provide a measure of the range of variation in flow. The flow duration curves presented in Figure 5 show flow as a percentage of median flow. In general, flow regime variability, from most stable to most variable, is: lake or spring, low relief country, inland hill country, non-glacial mountain and glacial mountain.

Table 2: Flow regime classified by source of flow

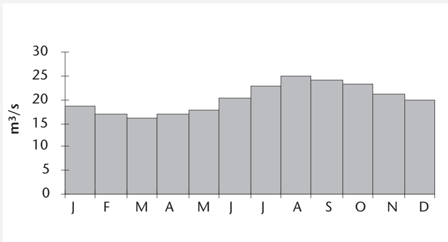
Flow Regime Type	Flow regime description	Example monthly flow histogram (mean monthly discharge)
Lake or spring	Relatively constant flow regime. Floods and droughts make only small changes in flow, and flow changes slowly due to damping effect of storage. Seasonal variability when inflows to lake or groundwater storage are seasonally influenced.	 The Kaituna River flows out of Lake Rotoiti in the Bay of Plenty region. Catchment area at the Taaheke flow recording site is 634 km^2.

Table 2: Flow regime classified by source of flow continued

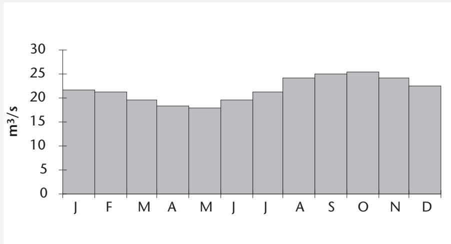
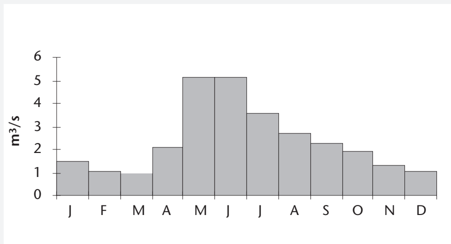
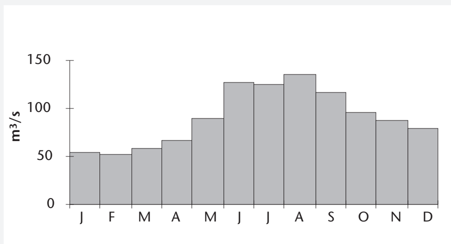
Flow Regime Type	Flow regime description	Example monthly flow histogram (mean monthly discharge)
Low relief country	A seasonal trend occurs, with higher flows in winter due to increased precipitation and reduced evapotranspiration. Flood peaks tend to be smaller, compared with mean flows, than in mountain-fed rivers. This has important implications for channel morphology and ecological communities. Geological conditions can be very important. For example, highly permeable soils such as in the central North Island's volcanic plateau are able to sustain very high base flows and absorb high rainfall rates, therefore damping flood flows. This gives rise to relatively stable flow regimes. Where soils have a lower infiltration capacity, base flows are often sustained by surface storages such as wetlands. These catchments are likely to yield much reduced low flows during dry periods and therefore less stable flow regimes.	 The Rangitaiki River is in the Bay of Plenty region. At the Murupara flow recording site it drains a 184 km^2 catchment. It is an example of a catchment with highly permeable volcanic soils.  The Waihopai River is in the Southland region. At the Kennington flow recording site it drains a 152 km^2 catchment. This catchment has reduced low flows during dry periods.
Inland hill country	Moderately variable flow regime. Floods and droughts cause large changes in flow. Response to rainfall and drought conditions is rapid. The regime has a strong seasonal trend with long periods of low flows during summer and relatively high flows during winter and spring when rainfall is often highest.	 The Motu River is in the east of the Bay of Plenty region. At the Houpoto flow recording site it drains a 1393 km^2 catchment.

Table 2: Flow regime classified by source of flow continued

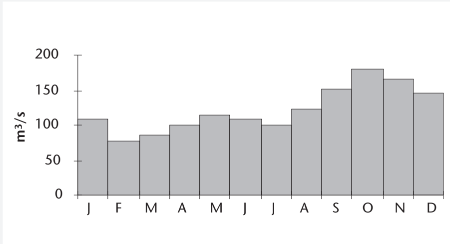
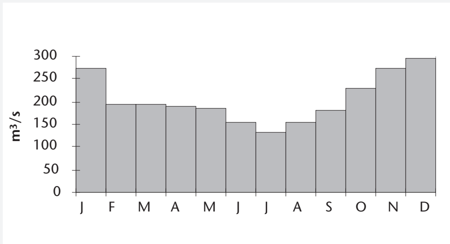
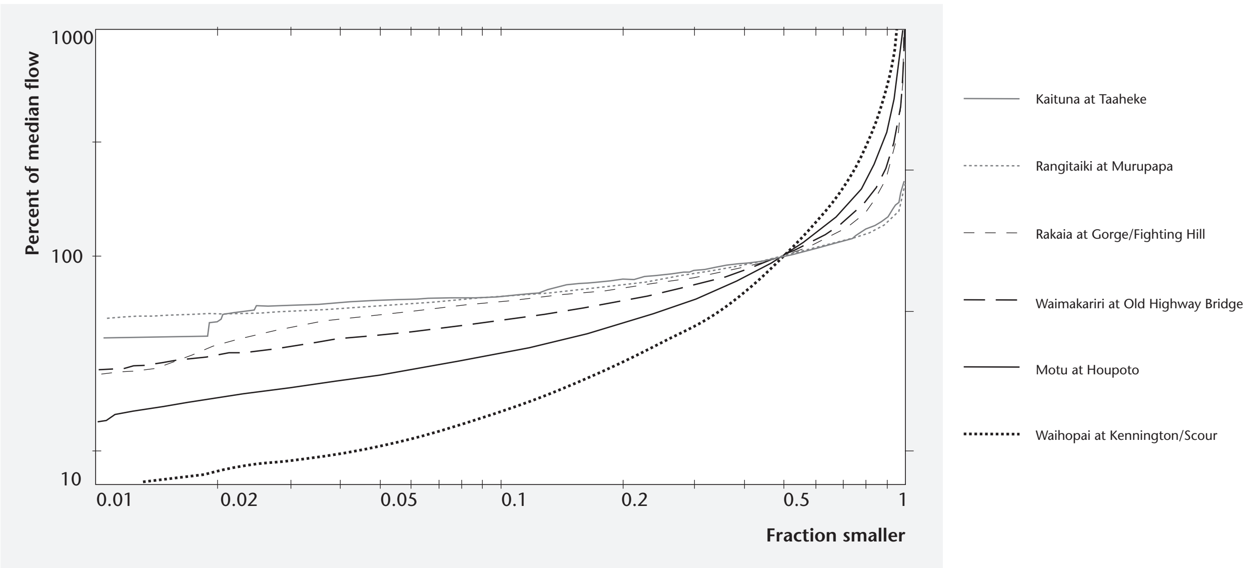
Flow Regime Type	Flow regime description	Example monthly flow histogram (mean monthly discharge)
Non-glacial mountain	Relatively variable flow regime. Floods and droughts cause large changes in flow. Response to rainfall and drought conditions is rapid. Strong seasonal trend in regime with low flows during autumn, winter and summer and relatively high flows during spring and early summer due to snow melt.	 The Waimakariri River is in the Canterbury region. At the Old State Highway flow recording site it drains a 3210 km² catchment.
Glacial mountain	Very variable flow regime. Floods and droughts cause large changes in flow. Response to rainfall and drought conditions is rapid. However base flows are sustained in summer due to glacier melt water. Strong seasonal trend in regime with low flows during winter in particular due to a high proportion of precipitation being stored as snow. Relatively high flows during spring and summer due to snow melt.	 The Rakaia River is in the Canterbury region. At the Gorge flow recording site it drains a 2560 km² catchment.

Fig 5: Flow duration curves for examples of flow regime types



3.6.2 River channel types

A channel type can be defined on the basis of channel geometry. A useful classification for setting flow regimes can be based on the low flow channel geometry. Rivers with different channel geometry exhibit different hydraulic changes with equivalent changes in flow. In the following chapter the concept of channel types is used to generalise about how a change in flow regime will affect hydraulic parameters.

The low flow geometry of rivers can be divided into three principal types:

- Single thread uniform channels
- Single thread non-uniform channels
- Braided channels.

See Volume B, Section 2.2.

These forms are explained in Table 3 below.

Table 3: Channel type characterised by channel geometry

Channel Type	Important Features
Single thread uniform	Self-formed channels: fine sediment size, low width-to-depth cross- section ratio, low slope. Constrained channels: uniform cross-section may exist at high bed slopes where geological conditions allow.
Single non thread uniform cross- section	Cross-section caused by bars of bed material or exposed bedrock sills to form riffle-pool structure at low flows. Formed in a wide range of sediment sizes and bed slopes.
Braided	Multiple thread channels. Gravel channel material. Non-uniform channel cross-section caused by bars giving rise to riffle-pool structure at low flows. High bed slope.

4. Effects of Activities on Flow Regimes

This chapter discusses the effects of activities on flow regimes. Four broad categories of activities affect flow regimes:

- *Abstraction of surface and ground water:* Abstraction of surface and ground water affects the low flow part of the flow regime. Where surface water and ground water are closely linked hydraulically, abstractions of ground water can reduce river flows. In general, abstractions do not affect the frequency and magnitude of flood flows. Low-flow frequency and duration is increased and low flows are further reduced by abstractions.
- *Damming of water:* Damming can alter the entire flow regime of a river. In general controlled discharge rates from dams reduce flow variability. The occurrence of extreme low flows is reduced. Flood flows are reduced by the storage capacity of the dam.
- *Diversion of water into a river*: "Diversion" is used in these guidelines to mean the diversion of water into a river. Diversions affect low flows by increasing the flow rate, reducing the frequency of flows below a given magnitude and reducing the duration that low flows of a given magnitude occur.
- *Changes in the land use in the river catchment*: Changes in land use can change the entire flow regime. For example, increased vegetative coverage by forestry can reduce low flows and flood flows, urbanisation can increase flood flows.

Summary of the effects of activities on flow regime

Abstraction	Increase in frequency and magnitude of low flows
Diversion into rivers	Increased base and low flows
Damming	Reduction in frequency and magnitude of flood flows, and more constant base flows
Change in land use	Change in flood flows and low flows

4.1 Selecting appropriate hydrological statistics

The effects of activities on flow regime is best described by analysing hydrological statistics. The hydrological statistics required to adequately assess changes in flow regime will depend on the activity and the instream values being considered. For example:

- In some rivers white-water rafting may only occur when flows are above average. The relevant flow statistics may show the increased duration of below-average flows caused by an activity. In cases where flows can be controlled over a small time scale, say hours, the flow statistic that may be of interest to white-water rafters is the amount of time that flows are below average during daylight hours.
- For ecological values, low flows may be important or the number of freshes (small floods) over the time of year when algal growth is most significant.

See Volume A, Table 5, Vol B, Section 1.2

The key point is no one flow statistic will suit every situation. Different flow statistics should be derived for different situations. In Part 4 of these guidelines (Table 5) the most appropriate flow statistics to use in a particular situation are suggested.

4.1.1 Scale of change in flow regime

Flow regimes may be changed over a range of spatial scales by an activity, depending on its location in the catchment and its scale. For example, a small abstraction from a side tributary of a large river may cause a significant reduction in that reach but may become less significant as the tributary joins the main stem of the river. However, a large dam in the upper reaches of a catchment or the cumulative impact of a series of abstractions may cause a significant change in flow in the entire length of river downstream.

4.1.2 Assessing changes of hydrological statistics

Where flow records have been kept for five years or more, hydrologists can produce a wide range of useful flow statistics relatively easily. The effect of out-of-stream use of the water resource by abstraction, damming or diversion can be simulated by modifying the flow record to take into account the activity, and recalculating the flow statistics for the modified record.

Where flow records do not exist or are insufficient to calculate flow statistics, a hydrological assessment may need to synthesise a record to evaluate important flow statistics and assess the change in the flow regime caused by out-of-stream uses. (Section 3.3). Alternatively, regional methods and consideration of source of flow can be used to derive flow statistics and assess the effect of out-of-stream use of water on flow statistics. These methods will be less accurate than using a real or synthesised flow record, but they are less complex to apply.

Assessment of the effect of change in land use on flow regime is complex. Techniques include the use of results of existing research on the hydrological effects of land use change, hydrological models, and trend analysis of flow records for catchments where land use has already partly changed. This area requires ongoing research before standard approaches to assessment of change in flow regime could be defined.

See Volume A, Sections 3.3, 3.4.

4.2 Hydro-physical changes

Changes in flow regime result in changes in the frequency and duration of flows of a given size and therefore the frequency and duration of certain hydro-physical conditions. Damming and diversion of a large proportion of natural river flow can significantly alter the flow and sediment regime of a river. In such situations, there may also be morphological change which will permanently alter channel geometry and consequently the hydraulic conditions.

The river type classification can be used to provide some guidance on the hydraulic and morphological effects that may occur for different activities. This is summarised in Table 4.

4.2.1 Assessing changes of hydraulic conditions

Changes in hydraulic conditions can be assessed from a knowledge of flow regime changes and using the methods discussed in Section 3.5.

See Volume A, Section 3.5.

Table 4: Hydraulic and morphological effects of activities for different river types

Flow Regime Type	Channel Type		
	Single thread uniform cross-section	**Single thread uniform cross-section**	**Braided**
Lake or spring	**Abstraction** Results in greater reduction in depth relative to width at low flow. Constant abstraction may result in near permanent change in depth due to flow stability. **Damming** Channel type (morphology) unlikely to change with reduction in floods. **Diversion** Channel type change to non-uniform channel possible with increased flows.	**Abstraction** Abstraction results in greater reduction in width relative to depth at low flow. Constant abstraction may result in near permanent change in width due to flow stability. **Damming** Channel type (morphology) unlikely to change with reduction in floods. **Diversion** Increased channel instability possible with increased flows.	**Abstraction** Abstraction results in greater reduction in width relative to depth at low flow and reduction in channel braids. Constant abstraction may result in near permanent change in width and number of braids due to flow stability. **Damming** Channel type (morphology) may change with reduction in floods and sediment supply to single thread form. **Diversion** Increased channel instability possible with increased flows.
Low relief country	As above.	As above.	NA
Glacial mountain	**Abstraction** Reduction in depth relatively greater than reduction in width at low flow. Variable flow regime means effect of abstraction varies relative to natural flow. **Damming** Channel type unlikely to change with reduction in floods. **Diversion** Channel type change to non-uniform channel is possible with increased flows.	**Abstraction** Abstraction results in greater reduction in width relative to depth at low flow. Variable flow regime means effect of abstraction varies relative to natural flow. **Damming** Channel type (morphology) unlikely to change with reduction in floods but may be more stable. **Diversion** Channel type change to braided channel or more unstable meandering channel possible with increased flows.	**Abstraction** Abstraction results in greater reduction in width relative to depth at low flow and reduction in channel braids. Variable flow regime means effect of abstraction varies relative to natural flow. **Damming** Channel type (morphology) likely to change to single thread form with reduction in floods. **Diversion** Increased channel instability possible with increased flows.
Non-glacial mountain	As above	As above	As above
Inland hill country	As above	As above	As above

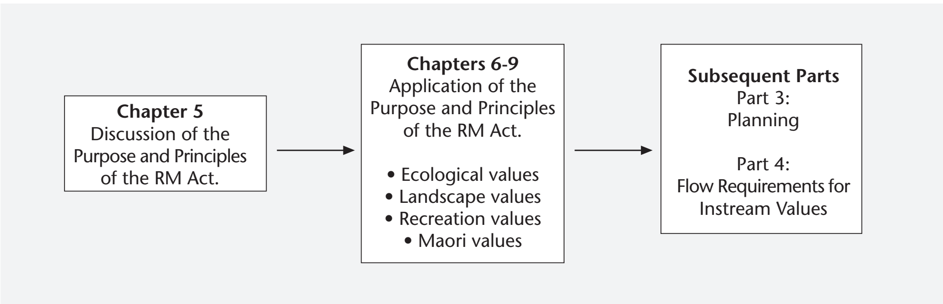
(NA = This channel type is unlikely to exist in conjunction with the flow regime indicated.)

Part 2: Instream Values

This Part of these guidelines considers Part II of the Resource Management Act 1991 (RM Act). It is from Part II that (i) the instream values are determined and (ii) the weightings that should be given to particular values are determined. Figure 6 shows the approach this Part 2 takes to applying the Purpose and Principles of the RM Act to the instream values.

The approach adopted in these guidelines is that sections 6 and 7 of the RM Act guide the application of section 5 to a particular issue. The Part II matters can be divided into four main sets of values: ecological, landscape, recreation and Maori. There are significant overlaps between these values.

Fig 6: Structure of Part 2 of these guidelines and relationship with Parts 3 and 4.



5. Purpose and Principles of the Resource Management Act

5.1 Introduction

In the late 1980s, the Ministry for the Environment undertook a comprehensive review of the major laws governing natural and physical resources in New Zealand. Discussion papers were published, hundreds of submissions were received, and regional discussion meetings and huis were held. The resulting Resource Management Act 1991 (RM Act) consolidates the previously fragmented and often ad hoc legislative framework dealing with the use of resources. It repealed more than 75 statutes and amended more than 150 others.

5.2 Section 5 : Purpose of the RM Act

Section 5(1) of the RM Act succinctly states:

> *The purpose of this Act is to promote the sustainable management of natural and physical resources.*

The concept of "sustainable management" is a multi-dimensional one, and a definition is provided in section 5(2) of the Act:

In this Act, 'sustainable management' means managing the use, development, and protection of natural and physical resources in a way, or at rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while —

> (a) *Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> (b) *Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> (c) *Avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

The definition provides the key to the Act, spelling out the end that is sought through the implementation of the Act's principles, processes and instruments. It describes a goal towards which those exercising functions under the Act must aspire and which underpins all functions and powers exercised under it.

The section 5(2) definition of sustainable management comprises a number of difficult elements whose interrelationships have been the subject of much debate. There are many views on the meaning of sustainable management. These guidelines do not attempt to present all of them. The guidelines' interpretation of section 5 is anchored in case law to date and presents a statement of principles drawn from the Act to provide guidelines for setting instream flow requirements for rivers. The interpretation provided in this document cannot outweigh guidance provided by the Environment Court (formerly the Planning Tribunal) and the other courts. For a more detailed appreciation of the intricacies of the elements of section 5 and their interrelationships, specific case law should be consulted.

Generally, "sustainable management" means managing the use, development and protection of natural and physical resources. It requires that such management be undertaken in such a way that it secures the matters referred to in subparagraphs (a), (b) and (c).

Of course, the natural and physical resources are not being managed or used in a vacuum. They are being used by people, and the view of resource use will largely be an anthropocentric one. People are enabled to provide for their well-being. The subparagraphs provide a more ecological viewpoint, but not entirely so.

5.2.1 Section 5(2)(a)

> *(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;*

Section 5(2)(a) provides for sustaining the potential of resources to meet the reasonably foreseeable needs of future generations. This gives the maintenance of resources a people-centred slant.

It is the potential of natural and physical resources which must be sustained, not the resource itself. On a long time scale, there may be few current uses which would impact upon the potential of river resources. Although diversions, pollution and growing stands of plantation forestry all impact upon the availability of river flows in the short to medium term, on an inter-generational time scale, diversions may be altered, pollution eliminated and trees felled.

The requirement to sustain the potential of resources only for the "reasonably foreseeable" needs of future generations is an important qualifier. It is not essential to sustain resources to meet all possible needs of future generations, although the distinction between those needs which can be termed reasonably foreseeable and those which are not is uncertain. Although the concept of "reasonable foreseeability" is familiar to lawyers, it is usually applied with hindsight to a set of completed actions. Forward-looking foreseeability is a less certain concept.

This subsection also requires a focus on the needs of future generations which may be expected to be at least similar to those of the present generation. However, the Environment Court has pointed out that a failure of the present generation to use (or value) a resource does not mean that the resource should not be protected for future generations (Re*: the Mohaka River National Water Conservation Order)*.

Furthermore, it may be expected that it will be easier to anticipate future needs in the short term than in the longer term. This suggests a preference for reversible impacts, so that a changing perception of future needs may be accommodated at an appropriate future time.

5.2.2 Section 5(2)(b)

(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems;

Paragraph (b) provides for sustaining the life-supporting capacity of resources. To a certain extent, section 5(2)(b) overlaps with subsections 5(2)(a) and (c). For instance, although subsection (2)(b) is not explicitly concerned with meeting the needs of future generations (like subsection (2)(a)), it does incidentally serve that purpose. Similarly, by safeguarding the life-supporting capacity of air, water, soil and ecosystems, some adverse effects of an activity on the environment are avoided. Section 5(2)(b) does, however, provide the clearest mechanism by which to protect natural and physical resources for their own sake, and not simply for their utility to humans. In this way, section 5(2)(b) is reinforced by section 7(d) which provides that any person exercising functions and powers under the Act must have particular regard to the intrinsic values of ecosystems.

"Life-supporting capacity" has a wide range of possible meanings. Broadly speaking, however, there are two basic approaches to its interpretation.

On the one hand, any diminution of the life-supporting capacity, be it the removal of a single species or a single organism, detracts from that capacity and thereby fails to meet the requirements of section 5(2)(b). If section 5(2)(b) were construed strictly, little in the way of human activity could take place.

The alternative interpretation of section 5(2)(b) takes a broader approach where diminution in the life-supporting capacity of a resource or ecosystem may be acceptable. A judgment is called for about the scope of the ecosystem in question, and some changes to this ecosystem may be considered not to compromise its "life-supporting capacity". Inherent in this approach is the concept that there is some threshold of change, beyond which the "life-supporting capacity" is compromised.

Other sections in the Act support a broad interpretation of section 5(2)(b). For instance, section 5(2)(c) makes provision for avoiding, remedying, or mitigating adverse effects of activities on the environment. One such adverse effect which might be remedied or mitigated could be the diminution of the life-supporting capacity of a resource. A diminution in the life-supporting capacity of an ecosystem or a resource might be permissible if it were compensated for elsewhere in the ecosystem, or in a nearby environment. Such a situation raises questions about the types of compensation acceptable from an ecological and human viewpoint. Factors such as the degree of modification which has already occurred to that particular ecosystem type will need to be considered.

Furthermore, section 107 seems to allow the granting of a resource consent in a situation where the life-supporting capacity of an ecosystem or a resource has been diminished. Section 107(1) provides that a consent authority shall not grant a discharge permit or a coastal permit allowing certain discharges which are likely to cause specified effects including significant adverse effects on aquatic life.

If the broader approach is accepted, a continuum of further possibilities exists, ranging from subsistence to optimum populations. Determining the protective coverage of section 5(2)(b) will require decision-makers to determine the “context” of an application. The “context” constitutes the particular environment and/or ecosystem which will be affected by the resource consent application. In some cases, reductions in life-supporting capacity can be viewed at an inter-catchment level, with mitigation of an effect in River A taking place in River B. In other situations, a single catchment will need to be considered in isolation, and in yet others, particular reaches of river may be of such significance or sensitivity as to warrant separate consideration.

Once this first decision relating to scale is made, the effect on the life-supporting capacity of the ecosystem may be determined by evaluating the impact upon each species in the environment or ecosystem, and the relevant importance of each organism or species. Different species’ sensitivities to change, as well as the flow-on effects of a reduction in a particular species, must be weighed. The duration of an adverse effect may limit or increase its impact upon the life-supporting capacity of the ecosystem. Natural variation in the life-supporting capacity of the ecosystem in question is also an important factor and the decision-maker will need to consider the irreversibility of a reduction in the life-supporting capacity of the resource or ecosystem and the significance of that ecosystem type. The cumulative impact of changes in flow in conjunction with other uses of or effects on the river must also be assessed.

Inevitably, interpreting section 5(2)(b) in the context of river low flow requirements will require risk analysis and assessment. Complete data sets will not always, if ever, be available. In such a situation decision-makers need to take a precautionary approach, particularly where the life-supporting capacity of a resource or ecosystem may be diminished in the long term as a result of their decision.

Uncertainty regarding the effects of an activity can arise from a number of different circumstances such as the absence of information, inconclusive information, or disputed information. Where there is reason to believe that an activity is likely have significant adverse effects, even when there is no conclusive evidence to prove a causal relationship between the activity and its effect, the precautionary approach should be applied.

In the case of flow management, this may mean applying safety factors to calculations or careful monitoring of the flow set to identify effects.

5.2.3 Section 5(2)(c)

> *(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment*

Section 5(2)(c) deals with adverse environmental effects of activities. This subsection recognises that adverse effects will sometimes occur; and that in some cases remedying or mitigating these effects will be appropriate. The wide definition of "environment" to include "people and communities" and "social, economic, aesthetic and cultural conditions" means that adverse effects on the social, economic and cultural dimensions of people's lives must also be avoided, mitigated or remedied. This may provide a tension between avoiding effects on natural resources and ecosystems and avoiding effects on aspects of human activities.

5.2.4 "While"

The relationship between the first part of section 5(2) and the subparagraphs is fixed by the use of the word "while". Whether the two parts are evenly balanced, or whether the first part has some priority over the subparagraphs is determined by the meaning of "while" which links the two functions. There has been much academic discussion of the meaning of this key word. The Board of Inquiry into the New Zealand Coastal Policy Statement concluded that:

> *(a), (b) and (c) are three specific objectives (or constraints) which must be pursued (or applied) while people and communities are being enabled to provide for (these things mentioned). The requirements of (a), (b) and (c) are cumulative - all must be observed.*

5.3 Sections 6-8 : Principles of the RM Act

While section 5 is the most important section of the RM Act and central to the Act's intent, it does not alone determine the substantive direction of the Act. Sections 6-8, the principles, are also part of the guiding ethos of the Act and give substance to the purpose. Each of the principles in sections 6-8 begins in the same manner:

> *In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall …*

Sections 6-8 set out a hierarchy of mandatory considerations in achieving the purpose of the Act. Section 6 sets out matters of national importance which must be "recognised and provided for" in the exercise of functions and powers under the RM Act. Section 7 sets out various other matters to which "particular regard" must be had in exercising functions and powers under the Act, and section 8 provides that the principles of the Treaty of Waitangi must be taken into account by persons exercising functions and powers under the Act.

"Matters of national importance" were used in one of the RM Act's predecessors, the Town and Country Planning Act 1977. Under that Act, it was recognised that where matters of national importance compete amongst themselves, it is for the planning authority to undertake a balancing exercise (*North Taranaki Environment Protection Association v The Governor-General* [1982] 1 NZLR 312). Where in a particular case matters of national importance conflict, the significance of the conflicting interest must be weighed in light of the facts of the particular case (*Environmental Defence Society v Mangonui County Council* [1989] 3 NZLR 257). These principles may also be applied to section 6 and section 7 to resolve any conflict between the matters set out each of these sections.

5.3.1 Section 6(a)

> *(a) The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development:*

Section 6(a) is not an end or an objective on its own but is an accessory to the principal purpose of sustainable management (*NZ Rail v Marlborough District Council* (HC) [1994] NZRMA 70).

When assessing what natural character there is in a particular riverine environment, the presence of human-made structures and modifications will not necessarily remove the natural character (Re: *National Water Conservation (Mataura) Order* C32/90).

In some cases, a flow which is sufficient to protect ecological elements, such as the life-supporting capacity of the river, may not be adequate to address other components of natural character such as landscape, aesthetics and physical characteristics.

5.3.2 Section 6(b)

(b) The protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development:

What constitutes an outstanding landscape is not set out in the Act. Some help may be gleaned from other sources; for instance a river must have "outstanding" features to qualify for a National Water Conservation Order under the Water and Soil Conservation Act and as a result, this term has been discussed by the Planning Tribunal in relation to the Rakaia, Ahuriri, Mohaka and Mataura Rivers.

5.3.3 Section 6(c)

(c) The protection of areas of significant indigenous vegetation and significant habitat of indigenous fauna:

Although commonly this section is discussed in relation to land-based resources, river environments can provide significant habitats for indigenous fauna, and may also contain areas of significant indigenous vegetation.

5.3.4 Section 6(d)

(d) The maintenance and enhancement of public access to and along the coastal marine area, lakes, and rivers:

Setting flow requirements may well impact upon public access to river environments, in both spatial and temporal terms.

5.3.5 Section 6(e)

(e) The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga.

Section 6(e) establishes the relationship of Maori and their customs and traditions with their ancestral lands, waters, sites, waahi tapu and other taonga as a matter of national importance. As yet there has been little case law on these issues, but decisions under the Town and Country Planning Act 1976 also have relevance to section 6(e).

The provision has three elements:

- an **active relationship** between Maori and taonga waters of ancestral importance
- that it is **Maori customary principles and practices** that are relevant to assessment of that relationship and the actions to be taken to recognise and provide for it
- the notion of **taonga value** applied to the waters, sites etc.

5.3.6 Section 7(a)

(a) Kaitiakitanga

Section 7(a) requires decision-makers to have particular regard to kaitiakitanga. The Act presently defines kaitiakitanga as the exercise of guardianship. In relation to a resource, kaitiakitanga includes the ethic of stewardship based on the nature of the resource itself.

Under present case law, kaitiakitanga is an obligation that can be exercised by any resource manager acting under the Act, including local authority decision-makers. Maori strongly assert, however, that the obligations of kaitiaki can only be discharged by the tangata whenua. An amendment has been proposed to the Act in the Resource Management Amendment Bill No, 3, which, if passed, would refine this definition, limiting kaitiakitanga to:

> *The exercise of guardianship by the tangata whenua of an area in accordance with tikanga Maori in relation to natural and physical resources; and includes the ethic of stewardship based on the nature of the resource itself.*

Regional policy statements have responded to the section 7(a) duty as a basis for expressing iwi preferences for the protection of a given resource. As these preferences will vary in each case, consultation with kaitiaki duly appointed by the iwi for this purpose is a practical means of obtaining the information needed.

5.3.7 Section 7(b)

(b) The efficient use and development of natural and physical resources

Decision-makers must also have particular regard to the efficient use and development of natural and physical resources under section 7(b). This section looks to the larger picture, and should not be limited to a narrow focus on efficiency of a particular activity or the "best use" of a particular resource.

5.3.8 Section 7(c)

(c) The maintenance and enhancement of amenity values

Section 7(c) requires those exercising functions and powers under the Act to have particular regard to the maintenance and enhancement of amenity values. "Amenity values" is defined in section 2 of the Act as "those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes".

Setting flow requirements for rivers can have an obvious and direct impact upon the amenity values of the river environments. In cases where there are no significant ecological values to protect, the public perception of a river as a "wild river" may take on increasing significance.

5.3.9 Section 7(d)

(d) Intrinsic values of ecosystems

Persons exercising functions and powers under the RM Act must also have particular regard to the intrinsic values of ecosystems (section 7(d)). "Ecosystem" is not defined in the Act, but guidance as to its meaning may be gleaned from a definition provided by section 2 of the Environment Act 1986: *"any system of interacting terrestrial or aquatic organisms within their natural and physical environment."*.

"Intrinsic values" is defined in section 2 of the Act. In relation to ecosystems, intrinsic values means:

Those aspects of ecosystems and their constituent parts which have value in their own right, including -

(a) their biological and genetic diversity; and

(b) the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience.

The definition of an ecosystem, together with the term "intrinsic values" will require assessments upon which decision-makers make their judgements.

5.3.10 Section 7(e)

(e) Recognition and protection of the heritage values of sites, buildings, places, or areas

Section 7(e) provides that persons exercising functions and powers under the Act must have particular regard to the heritage values of sites, buildings, places or areas. Although this concept generally relates to dry land, there are rivers in New Zealand which have sites of historical value which would be affected by changes in flows.

5.3.11 Section 7(f)

(f) Maintenance and enhancement of the quality of the environment

"Maintenance" suggests that the present quality of the environment continues and is not downgraded. "Enhancement" suggests an improvement in the present quality. It would be possible for a flow to be set higher than existing levels with the intention of enhancing the environment.

5.3.12 Section 7(g)

(g) Any finite characteristics of natural and physical resources

A water resource is arguably infinite in that actions taken this year will not necessarily impact upon its availability or quality in the years to come. Nonetheless, on a short-term or annual basis, a river system, although renewable, will demonstrate some finite characteristics, to which decision-makers must have particular regard.

5.3.13 Section 7(h)

(h) The protection of the habitat of trout and salmon

The focus is not on trout and salmon themselves, but rather on the protection of their habitats. This may serve the incidental purpose of protecting other species.

5.3.14 Section 8

Section 8 requires decision-makers to take into account the principles of the Treaty of Waitangi. The duty to "take into account" has been determined by the Courts as requiring more than a passing reference, instead impacting on the discretion of the decision-maker. The duty implies an obligation to consider the principles of the Treaty and weigh them against other factors, effecting a balance between the matters in making a decision.

Several statements of Treaty principles have been produced. Amongst those principles identified in Court of Appeal and Waitangi Tribunal cases are:

The Essential Bargain: The cession by Maori to the Crown of the right to make laws for good governance was in exchange for the obligation to protect Maori rangatiratanga.

Kawanatanga: The Crown has the right to make laws for the good governance of the nation. The Treaty does not authorise unreasonable restrictions of the Crown's right to govern.

Rangatiratanga: Maori were to retain rights to exercise rangatiratanga over important resources. Rangatiratanga denotes the mana to possess taonga resources but also to manage and control them in accordance with Maori customs and cultural preferences.

Partnership: The Treaty requires a partnership and the duty to act reasonably and with utmost good faith. The needs of both Maori and the wider community must be met, which will require compromises on both sides. The courtesy of early consultation is a partnership responsibility.

Active Protection: The Treaty duty is not merely passive, but extends to active protection of Maori interests in the use of their resources and other guaranteed taonga to the fullest extent practicable.

The Waitangi Tribunal has recognised that the exercise of rangatiratanga over a river impacts on both its use and its preservation. Rangatiratanga may be manifested in the ability to take food or other cultural materials from the river and its environs for cultural sustenance, and to act in accordance with the dictates of the spiritual relationship in the preservation of the resource.

These guidelines can only provide the barest starting point for consideration of the principles of the Treaty and their application to the management of water. Other sources for guidance include decisions of the Court of Appeal, the reports of the Waitangi Tribunal, and statements agreed between iwi and local authorities in regional and district policy and planning. As the public interests and the Maori customary values and practices appropriate to the exercise of rangatiratanga in any given circumstance will vary on the facts, decision-maker must consult with local tangata whenua to gain information on what they are and how they apply in different cases.

5.4 Summary: Instream values

For river instream values, the matters in the Purpose and Principles of the RM Act can be grouped into four categories:

- Ecological values
- Landscape values
- Recreational values
- Maori values.

The following chapters discuss how these four categories values are derived from the Purpose and Principles of the RM Act and describe the values themselves.

There can be considerable overlap between these four values. For example, mahinga kai relates to ecological values as does angling, a recreational value. Therefore, these four categories of values should not be considered in isolation of each other.

Ecological values, such as trout and blue duck, and recreational values such as white water rafting are well known, and are not discussed in detail in the chapter. But landscape, and Maori values have not been as well understood by many water managers. For these reasons, landscape and Maori values are discussed in greater detail than ecological and recreational values.

6. Ecological Values

See also Volume B, Chapter 6.

In these guidelines the term "ecological values" refers to the value of all vegetation and fauna that may be present within a river system. Ecological values have been at the centre of many water management issues, for example salmon in the Rakaia River and blue duck in the Upper Whanganui River.

6.1 Relevant RM Act matters

The matters in Part II of the RM Act that relate directly to ecological values are:

- Section 5(2)(b): The life-supporting capacity of water and ecosystems.
- Section 6(c): Significant habitats of fauna.
- Section 7(d): Intrinsic values of ecosystems.
- Section 7(f): Maintenance and enhancement of the quality of the environment.
- Section 7(h): The protection of the habitat of trout and salmon.

Many other matters are relevant to ecological values, including section 5(2)-cultural, economic and social wellbeing, 6(a)-natural character, 6(b)-landscapes, 6(e)-relationship of Maori with their toanga, 7(a)-kaitiakitanga, 7(c)-amenity values, 7(g)-finite characteristics of natural resources.

6.2 Approach to "life-supporting capacity"

Section 5(2)(b) of the RM Act, requires that it is necessary to safeguard the "life-supporting capacity" of water and ecosystems. As discussed in Chapter 5, the term "life-supporting capacity" has a range of possible meanings. A restrictive interpretation may be taken where no reduction of the life-supporting capacity of a river is allowed; to the broader pragmatic approach, where it is acknowledged that any activity which alters the flow regime of a river will have an effect on the life-supporting capacity of a river's ecosystem.

These guidelines adopt the broader, pragmatic approach to life supporting capacity.

In determining the "life-supporting capacity" for a river, water managers must determine:

- "what life is it determined will be supported?" and
- "to what level will the life-supporting capacity for that life/species be safeguarded?"

In determining the "life-supporting capacity" of a river there are a number of possibilities. For example:

- The existing or previous "historic" life-supporting capacity of the river could be maintained.
- A particular life form or species could be targeted and maintained at either optimal or subsistence levels. This approach has been used in many water management issues in New Zealand. For example, in the Rakaia River, flows were set to sustain the salmon fishery. When targeting species, water managers need to take account of the full range of requirements that species need, including passage throughout a river system for fish, habitat issues, such as food supply and space to live.

Part II of the RM Act allows for both approaches. For example:

- Section 6(a) directs water managers to preserve the natural character of rivers. In some cases preserving the natural character may mean maintaining the historic life-supporting capacity, in others it may mean targeting specific species which are the key to the "natural character".
- Section 6(c) of the RM Act also specifically directs water managers "to recognise and provide for the protection of significant indigenous vegetation and significant habitat of indigenous fauna". In practical terms this means that certain vegetation and fauna can be targeted.
- Section 7(h) requires that decision makers "have particular regard to" the protection of the habitat of trout and salmon. Thus, the needs of trout and salmon can be targeted.

For ecological values the critical sections of Part II of the RM Act are generally 6(c) and 7(h). It should be noted that obligation to "recognise and provide for" (section 6) is greater than the requirement "to have particular regard to" (section 7). The RM Act makes it clear that the protection of indigenous species and habitats is given more importance than the habitat of trout and salmon.

6.3 Identification of instream ecological values

There are three main aspects to ecological values:

- Fish passage: It is important for fish to have unrestricted passage through rivers. Passage is particularly important for native fish, many of which spend part of their life-cycle in the oceans, and return to freshwater as whitebait. Passage is a component of “habitat”.
- Habitat, in terms of food producing areas, water quality and space to live.
- Breeding areas, for example, riparian areas used by birds as nesting sites, or spawning and nursery areas for fish.

The following are sources of information for instream ecological values:

- Fish and Game Councils, which should have information on important trout and salmon fishing areas and spawning areas.
- Department of Conservation: DoC has information on the occurrence and abundance of native fish and indigenous bird species.
- Regional councils hold a range of information on aquatic resources in the region.
- District and city councils: In some cases, district and city councils may hold information on ecological values of waterways.
- Iwi: Information from iwi sources is discussed in Chapter 9 in this part of the guidelines.

7. Landscape Values

Landscape values have been a significant consideration in certain decisions on flow management in New Zealand rivers. For example, landscape values have been important issues in a number of Water Conservation Order hearings, including the Buller and the Mohaka.

7.1 Relevant RM Act sections

The Part II matters that are directly relevant to landscape values are:

- Section 6(a): Natural character
- Section 6(b): Outstanding natural features and landscapes
- Section 7(c): Amenity values
- Section 7(d): Intrinsic values of ecosystems.

The remainder of sections 6, 7 and 8 can be considered to be at least indirectly relevant to landscape values.

7.2 The dimensions of landscape values

Landscape is not defined in the RM Act. In a recent paper to the World Planning Congress in Auckland, the Hon. Simon Upton, Minister for the Environment, suggested that :

> *… landscape is simply a collection of natural and physical resources viewed according to a particular personal and cultural value set. Its make-up is determined by history, by the legal and institutional arrangements that govern land ownership, and importantly, by the ethic landowners bring to land stewardship. As with amenity in an urban context, perceptions of landscape quality vary across time, across cultures and amongst various sectors of society. [September 1996]*

In this view, landscape has both a physical and a perceptual side. It reflects an evolution in our understanding of landscape - from a narrow and simplistic view of landscape as scenery, to an in-depth appreciation of landscape as a complex *physical* and *perceptual* entity of fundamental importance to society. The emphasis has moved from the visual, through the aesthetic, to the experiential.

As with all landscapes and natural features, rivers must be managed to reflect a wider understanding of the internal ecological dynamics, the extraordinary complexity of human responses, and the inextricable links between us, our actions and our environment.

To succeed in this, there must be an appreciation of what makes up landscape and how this relates to Part II of the RM Act. These interconnections are discussed here under the headings of *The Physical Landscape* and *The Perceptual Landscape*. The "physical landscape" relates to values in their own right, whereas the "perceptual landscape" relates to the human values placed on a landscape.

7.2.1 The physical landscape

The physical landscape relates strongly to sections 6(a), natural character, 6(b), outstanding natural features and landscapes and 7(d), intrinsic values. The physical landscape is the expression of a complex interplay between physical, biological and cultural processes. Each area has its own unique character and identity which reflects the particular mix and emphasis of the processes that formed it. It has its own unique combination of climate, rocks, soil, water, vegetation, fauna and human artefact. Landscape character is a quality of all landscapes - urban, rural and wilderness.

7.2.1.1 Natural character (RM Act section 6(a))

Natural character will be a significant quality of the physical landscape in unmodified areas. Natural character is not defined in the RM Act. Generally, natural character is seen as a continuum, from high to low.

A landscape or river with high natural character is not necessarily a pristine, unmodified environment but rather a place or feature where the influence of nature substantially dominates the influence of humans. This equates to a non-specialist's understanding of natural character. A river with high natural character is one with a predominance of natural elements, patterns and processes. A river's natural character will be dependent upon the presence of features such as rock outcrops, water, vegetation, and fish, and an absence of artificial structures and artefacts. The natural elements should occur in natural patterns. For example, river meanders, braids, riffles and pools, falls and gorges, varied bank profiles and riparian vegetation all occurring with a distinctive natural aspect. The presence of natural elements occurring in unnatural patterns, e.g. as a result of channelling, will reduce or remove natural character.

To be sustainable, the natural elements and patterns must be underpinned by natural processes. It is the natural processes that sustain the patterns and elements, which in turn sustain the natural character.

7.2.1.2 Rivers as natural features (RM Act section 6(b))

Natural features are not defined in the Act; however, a useful approach could be to take it to mean "distinct and spatially restricted parts of the landscape such as rock outcrops, bush remnants, lakes and rivers, or components of the landscape such as a geomorphological feature". Natural features are often experienced from beyond their boundaries, e.g. a river viewed from its banks or surrounding valley. By contrast, landscapes are spatially extensive places that are usually experienced from within. Using this definition many sections of rivers are clearly natural features set in a wider landscape context.

7.2.1.3 Intrinsic value of ecosystems (RM Act section 7(d))

There is clearly an extensive overlap between natural character and the intrinsic values of ecosystems. Processes are fundamental to ecosystem values and rivers are particularly dynamic landscape features. The ecological interconnections between rivers and their catchments and the consequences on their flow dynamics are issues of significance. For example, regular flood flows may have the benefit of removing vegetation from instream gravel banks, particularly in braided rivers. They may also cause bank erosion ultimately leading to cut-off meanders which themselves develop into valuable - if ephemeral - wetland adjuncts to the river ecosystem. Adequate and timely low flows may be essential to migrating fish and so on.

7.2.2 The perceptual landscape

The perceptual landscape is a more elusive concept than the physical landscape. Each river takes on landscape values when it is perceived or experienced. These values are subjective. Individuals, the community, or society may place particular values on a river. Inevitably, a range of "landscape" values are ascribed to any river. How each individual experiences the river - whether they make some specific use of it, and whether they enjoy their experience - will reflect their expectations, aspirations and prior experience. It may evoke pleasure and invitation, belonging or alienation, hopes or fears. Variables such as weather, knowledge, familiarity and the disposition of the viewer will all play their part in how people respond. Nonetheless, having made the point that each individual's response will be unique and may vary over time, it is also true that many people share broadly similar responses.

It is necessary to consider this complex and interconnected set of values when assessing landscape. For the purpose of these guidelines, they are grouped under the convenient titles[3] of Natural Values, Legibility, Ephemeral and Aesthetic values. Additional to these are the values, frequently referred to as "spiritual", that are particular to tangata whenua, and the wider shared values reflected through art, literature and popular culture.

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3 *These values were identified in the Canterbury Regional Council Landscape Assessment, 1993, prepared by Boffa Miskell Limited and Lucas Associates*

7.2.2.1 Natural values in landscape

The ecology of an area is generally expressed in the landscape. Consequently the health and ecological sustainability of an area will have an effect on our perception and experience. For example, the difference between a crystal-clear brook and a turbid, scummy stream. The outward appearance of a river may well reflect the fundamental inner workings, or "ecology" of the place. All natural values influence the perception and experience of landscape. They add depth and meaning. While this is derived from the physical entity of land, water and air, it is in some meaningful sense separate. Blue duck present on a river is of scientific value but the sight of a family of blue duck negotiating rapids may give immense aesthetic pleasure.

This value is strongly interwoven with natural character and with intrinsic values of ecosystems.

7.2.2.2 Legibility values in landscape

Legibility is the information and meaning a landscape or natural feature conveys. This may be information that sheds light on past natural processes, such as glaciation or erosion, or it may give meaning to historical events and activities which in some instances help define society in time and place. Rivers are often highly expressive of their formation, particularly where this can be experienced in their wider landscape context - for example, the spectacular terracing of many glacial mountain rivers. They have also been a focus for human activity providing food, passage, boundaries, crossing points and spiritual sustenance. This "cultural history" may be expressed in extant physical features.

Rivers may also be expressive of landscapes elsewhere. For example, during very dry, hot "nor-west" conditions on the Canterbury Plains, the major rivers can be in flood following heavy rain and snow melt in the mountains. They act as a connection between the two landscapes, contributing to a wider "sense of place".

An understanding and appreciation of legibility values will influence many people's appreciation of pleasantness, aesthetic coherence, and cultural and recreational attributes and therefore is linked to amenity values. There may also be a strong linkage to heritage values (section 7(e) of the RM Act).

7.2.2.3 Aesthetic values in landscape

The RM Act makes reference to aesthetic coherence and aesthetic values but does not define the terms[4]. A useful working definition of aesthetics is:

> *pertaining to the quality of human perceptual experience (including sight, sound, smell, touch, taste and movement) evoked by phenomena or elements or configurations of elements in the environment.*

In other words, aesthetic values are determined by the landscape's physical and natural properties coupled with the cultural values of the person experiencing the landscape. Although each individual will have different perceptions of landscapes there are also many similarities within Pakeha appreciation of beauty and meaning.

Terms used to explain the aesthetic qualities of landscape include vividness and coherence. A vivid landscape is a striking landscape that remains long in the memory. A coherent landscape is one that visually "hangs together". Unity and harmony convey similar meanings. There is likely to be considerable agreement that the forest and gorge parts of the Motu River are beautiful. Words like "breathtaking" and "spectacular" might be applied to Huka Falls. Some of the reaches of eastern South Island rivers such as the Rakaia and Waimakariri may be described as bleak, stark, wild and barren. There are probably many similarities in the views on which river landscapes are picturesque, serene, wild, scenic and so on. This suggests that it is feasible to obtain some measure of agreement on what is aesthetically special and why.

Wild and scenic qualities have received considerable attention due to the Water Conservation Order provisions.

Wild	*(of scenery) having conspicuously desolate appearance* *Concise Oxford Dictionary*
Scenic	*having fine natural scenery* *Concise Oxford Dictionary*
Scenery	*general appearance of natural features of a district picturesque features of landscape* *Concise Oxford Dictionary*

4 *The term aesthetic coherence is used in the definition of 'Amenity Values'; section 2, RM Act*
The term aesthetic values occurs in the Fourth Schedule section 2(d) of the RM Act

“Wild” in relation to rivers may be interpreted as the raw, untamed power of natural waters. If the “picturesque” definition of scenery given above is valid, then the terms “wild” and “scenic” are at opposite ends of a wide spectrum. “Wild” refers to the raw, fearsome nature of a white-water river such as the Lower Shotover. “Scenic” refers to the tranquil and picturesque, such as the River Avon meandering through Hagley Park in Christchurch. When prescribing attributes to rivers it must always be remembered that rivers are dynamic and the most tranquil can change into a fearsome torrent in certain circumstances.

7.2.2.4 Ephemeral values in landscape

Ephemeral values (values that are shortlived, occur occasionally) can make a significant contribution to the values attached to a river at a particular time. Some events such as reflections of rainbows or exceptional sunsets may occur randomly and rarely. Other ephemeral events, such as the presence of a concentration of wildlife, flood flows, or the icing over of a water body may be regular and characteristic events. Where these occur they may add to the value of a place.

7.2.2.5 Maori values in landscape

Maori perspectives on land and water can be distinct from those of the Pakeha. They are of increasing influence on the way all New Zealanders view their environment. The spiritual significance of place and the interconnectedness of people and land are increasingly strong influences on our perception of place. The significance that Maori give to rivers, adds depth and meaning to the river landscape.

7.2.2.6 Popular shared landscape values

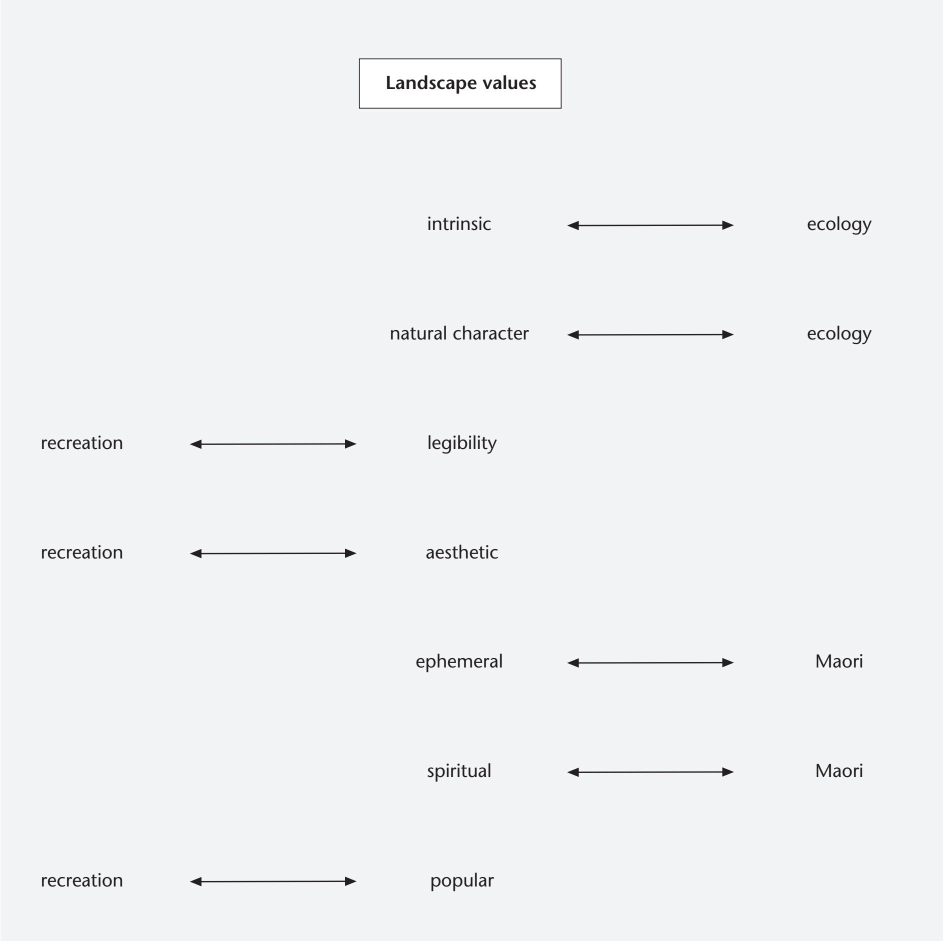
Some landscapes and natural features take on added value because of their popularity and importance to the general public. This may be reflected through writing or painting, or through tourism and recreation interests for example. These values are likely to incorporate several of the values described above. If large numbers of people have access to a site then arguably it may be of greater value, for example scenic viewing of the Buller River from the State Highway, or a local swimming hole close to a settlement. The contrary argument is that the absence of people increases the worth of a place, for its sense of peace and solitude.

There is a strong overlap between these popular values and what the RM Act includes within amenity values in section 7(c).

7.3 Overlaps with other instream values

There are significant overlaps between landscape values and other instream values. Figure 7 illustrates the major overlaps.

Fig 7: Landscape values and major overlaps with other instream values



7.4 Identification of landscape values

Based on this discussion of landscape and associated concepts, it is clear that the following range of landscape values may be affected by physical instream changes:

- Intrinsic values - including geology, plant life, wildlife.
- Natural character - incorporating natural elements, aspect and processes.
- Legibility - expressive of formation, heritage, and sense of place.
- Aesthetic values - wild, scenic.
- Ephemeral values - regularly recurring events.
- Spiritual values - particularly values held by tangata whenua.
- Popular values - related to use, enjoyment and community attitudes.

Although these values overlap and are inextricably interwoven, they are used in these guidelines to provide a checklist and a set of questions that can be used to assess the significance of landscape values. Rather than rely on an all-embracing landscape view this "questions and checklist approach" provide a more targeted basis for assessing instream management objectives and potential landscape effects.

The Box below contains a set of questions that can assist water managers identify whether landscape values are likely to be significant on a particular river. If the answer to any of the questions is "yes", a more detailed landscape assessment may be carried. Table 5 provides an example of the kind of output from a more detailed study.

Questions for assessing the importance of landscape values

1. Is the river ecologically significant? Adequate biological data are usually available to assess this.
2. Is the river largely unmodified, retaining its natural character and quality?
3. Are there outstanding natural features such as a waterfall or a geopreservation site?
4. Does the river pass through an outstanding landscape? If so, does that landscape contribute to the quality of the river and vice versa?
5. Is the river highly expressive of its formation and does it have a "strong sense of place"?
6. Does the river have historical or heritage importance?
7. Does the river have a high aesthetic quality - is it wild or scenic?
8. Are there regularly recurring events that are widely valued?
9. Is the river of spiritual importance?
10. Is the river heavily used and widely appreciated as a recreation resource?
11. Does the river occur in literature or painting?
12. Is the river highly visible from a significant location(s) e.g. state highway, township?

Table 5: Summary landscape assessment sheet for a fictional river

Reach	Landscape Values							Comments
	Intrinsic Character	Natural	Legibility	Aesthetic	Ephemeral	Spiritual	Popular	
1 Above dam	✔	✔						Unaffected by proposed flow changes
								Dam
2 Below dam	✔	✔					✔	Single thread channel with public access
3 1-3 km below dam			✔					Oxbows and terracing - adjacent wetlands
4 3 km below dam			✔	✔				Historic crossing point with very attractive rock outcrops - settlement adjacent.

8. Recreational Values

See also Volume B, Chapter 9

Recreational values have been debated extensively in Water Conservation Order Hearings, for example, in the Buller and Kawarau Water Conservation Orders. The Water Conservation Order process provided a great deal of useful information on what constitutes "recreational values" for rivers.

8.1 Relevant RM Act sections

The following sections of the RM Act relate directly to recreational values:

- Section 5(c): 'Environment' is defined to include 'amenity values', which in turn is defined to specifically include 'recreation attributes' (section.2(1)).
- Section 6(d): Access.
- Section 7(c): Amenity values.

8.2 Range of recreational values

Common instream recreational values can be grouped into four categories:

- Those that involve floating or paddling down a river - rafting, kayaking, tubing, pack floating, dinghy drifting, drift diving, etc
- Consumptive activities - angling, whitebaiting, etc
- Site-specific activities - swimming, paddling, etc.
- Motorised activities - jet boating, jet skis, etc.

There is a wide range of recreational values that need to be considered in addition to the "common" recreational values. Therefore a rigid definition of recreation, such as "canoeing" or "white-water rafting", is not appropriate in all cases.

Issues that the water manager needs to consider when identifying instream recreational values include:

- Social aspects: There is the need to understand the motivational factors which influence recreationalists to use or visit resources for recreation, to understand how the nature of the resource best caters for the experiences sought, and how social interactions within the resource affect users' satisfaction with the experience they are seeking.
- Family or whanau groups are more likely to be encountered when describing recreation within the Maori culture, where recreation may partly serve to help preserve cultural identity and to help define and strengthen kinship bonds (Matunga, 1995).

- For many cultural groupings, such as Maori, a wide variety of other nuances are likely to be encountered. For example, the work-leisure dichotomy may become blurred. This may be especially relevant in rural communities, or where food is gathered from a resource such as a river.

8.3 Identifying recreational instream values

Information sources that can provide information on instream recreation values are as follows:

- Recreation groups and local recreation associations.
- Local authority and DoC planning staff.
- Site specific surveys.
- The former National Water and Soil Conservation Organisation publications, specifically the national river survey (Egarr et al., 1981). This survey was conducted in 1981, has not been updated and may well be out of date.
- Planning tribunal reports: Water Conservation Orders, consent hearings.
- Department of Conservation: Conservation Management Strategies, reserve management plans, recreation or visitor strategies, Recreation Opportunity Spectrum analyses, consultant reports.
- Regional, district or city councils: Recreation strategies, reserve management plans, resource consent studies, policy statements, consultant reports, community directories.
- New Zealand Canoeing Association, NZ Jet Boat Association, etc (other recreation associations may be found where local authority community directories are available).
- Iwi Management Strategies (some regions only).
- Fish and Game Councils: National angler surveys and site specific studies.
- New Zealand Tourism Board (occasional surveys).
- Universities: Outdoor Recreation in New Zealand Bibliography (Lincoln and DoC, 1995), theses, dissertations, papers, etc.
- The Hillary Commission for Sport, Fitness and Leisure (Life in New Zealand Study, 1991).
- New Zealand Tourism Industry Association, or Regional Tourism Organisation (addresses available through the NZ Tourism Board).
- New Zealand Water Safety Council (database of river deaths, some related to recreation).

- Water Recreation Regulations 1979, Harbours Act 1950, harbour masters, Ministry of Transport.
- Commercially published guide books (angling, kayaking, tramping, etc).
- Tourism promotional.
- Independent studies carried out by development agencies.

Measuring the "significance" of a waterway for recreation is problematic. There is no clear indicator which tells us whether a resource is highly significant or not. A commonly used method for assessing "significance" is in terms of locally, regionally, nationally or internationally significant:

- An internationally significant river would offer some characteristic that attracted interest or use from outside the country (and may therefore be a valuable resource for tourism). There is often a feature that is unique, rare or unusual at an international level.
- For assessing national significance, useful methods have been developed for Water Conservation Orders hearings. An approach to nationally significant could be based on the "disappointment factor". A well-informed recreational visitor to an "outstanding" waterway (see Water Conservation Orders for such waterways as the Kawarau and Buller) is very rarely "disappointed" (that is, they know what to expect, and the waterway consistently delivers). Thus, if a resource that consistently satisfies a set of expectations is changed in some way, then the level of disappointment is likely to be extreme. This differs from a resource which rarely meets expectations (that is, it is highly variable or seldom reaches a minimum standard).
- A regionally/locally significant river may offer an opportunity that is common nationally, and use is generally only from the regional/local area.

It should be noted, however, that a waterway in some relatively rare state (e.g. flooding) may offer several special recreation opportunities (such as flood rafting or kayaking, or river surfing (using surf boards on standing waves), or it may only be raftable in flood conditions, for example). If an expectation exists that this opportunity may occur only occasionally, then the rare situation may also be very highly valued.

Generally speaking, a river of high significance will have a reliable flow pattern. It may show a consistent flow all year, or highly predictable seasonal flow patterns. The Motu River, for example, has a moderately variable seasonal flow regime, but that variation is predictable and the river is considered nationally significant. Likewise, the Rakaia has a very variable flow regime, and yet it is a highly significant fishery, as the presence of fish is predictable at recognised times of the year.

The river that offers a predictable experience of an appropriate type will be highly regarded, and users will be more willing to invest time and money to travel some distance to it (that is, they are unlikely to be disappointed by the resource). A natural result of this understanding is the "Travel Cost Method" of resource valuation. This tool of economic evaluation assumes that the more costs a person is willing to incur through travelling to a resource, the more they value it. Several case studies can be accessed (Kerr, 1987). The method is best applied to remote resources and has some limitations. Contingent Valuation techniques may also be applied ("willingness to pay"). The appropriateness of both these systems should be assessed by natural resource economists or recreation planners.

The means to assess significance requires an understanding of several factors, including:

- Who the users are and where do they come from?
- What do they do on the river (it may be an event, in which case the origin of the entrants could be checked, or a commercial activity)?
- From where did they learn about the opportunity?
- Where else they can undertake the same or similar activity (where are the alternatives, where would they go if this opportunity did not exist and would that alternative offer a similar experience)?
- What specifically attracts the users? (Note, the context of the river may be important, not just its flow regime. This is best exemplified by wilderness rivers *(Motu), or rivers with significant histories (Whanganui).*)

Some data for assessing significance may be borrowed from any existing Recreation Opportunity Spectrum (ROS) analysis carried out by DoC or a local authority (Volume B, Section 8.1). This should be treated with caution, however, as the process is not designed to identify significance. The system identifies types of recreation opportunities within a study area, and may identify where a recreation opportunity is locally or regionally rare.

Answers to the above questions may also be gained by direct survey, use of existing information (as above) or by interviews. It may also be necessary to survey the wider population of a district or region to assess the level of latent demand for the resource. Latent demand is expressed by those who would wish to use the resource but currently do not or can not, or for whom the resource has "existence value". Here the perceived value is not a result of use, but is inferred through the knowledge of others' use, the opportunity for use, or the mere existence of the resource. Existence value may be very high for nationally or internationally significant resources (consider the Colorado where the waiting list to raft the river may span over a decade).

Conversely, a resource that is used locally may still be highly significant. An alternative may be found locally or regionally, but any cost incurred in travelling to an alternative may preclude the activity. This would include especially the use of swimming pools in rivers, particularly when located near a population node or institution (marae, outdoor education school, etc).

Where it is important to have a clear understanding of "significance", the use of professional surveyors and recreation planners is advisable.

In water conservation order hearings, it is clear that much weight is given to studies carried out on a national or regional basis, and certainly any relevant study undertaken prior to the order being applied for has high standing, (Buller River WCO, 1996; Teirney, 1982). Although, again, the concept of identifying what is "outstanding" is a different exercise to identifying impacts on less significant waterways, the focus on achieving an accurate representation of the significance of use of the waterway is directly relevant.

There is anecdotal evidence of user groups attempting to encourage greater use of a waterway during a survey period to increase user counts when resource protection is sought. This in itself indicates a high value is placed upon the resource, but in any case, absolutely accurate use figures are not always necessary (and are seldom achievable anyway, considering the many access points a river may have, and the unwillingness of many commercial operators to reveal commercially significant customer information). In the Planning Tribunal's (now Environment Court) *Report and Recommendation of the Inquiry into the National Water Conservation Order for the Buller River* (1996) it was stated several times that user numbers alone do not indicate the significance of a waterway for recreation.

For example, page 56:

> *A further point to be made about numbers is that while rivers such as the Shotover River and Kawarau River in Central Otago have considerably larger numbers of people rafting them on an annual basis, this is because they are in close proximity to one of New Zealand's premier tourist centres, namely Queenstown. This, so it was asserted and we agree, is not necessarily determinative of the question whether the rafting feature of a water body such as the one we are now considering is outstanding in a national context.*

Context, again, is significant, but the measures of context may also be affected by the existence of a proposal to alter the flow regime of a waterway. This is discussed further in Volume B, Chapter 9, by looking at the contextual factors affecting specific recreation activities.

8.4 References

Matunga, H. 1995. Maori participation in outdoor recreation. In Devlin, P.J. et al Outdoor Recreation in New Zealand, DoC and Lincoln University, Wellington.

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Kerr, G.N. 1987. An introduction to the travel cost method of demand estimation. In Kerr G.N. and Sharp B.M.H (eds) Valuing the environment: economic theory and applications. Studies in resource Management No.2. CRM, Lincoln University. Pp 123-134

Buller River WCO. 1996. Report and recommendation

Teirney, L..D. *et al*, 1982. National Angling Survey, MAF and New Zealand Acclimatisation Societies, Wellington.

9. Maori customary and traditional instream water values

See also Volume B, Chapter 11.

The purpose of this section is to provide general information on the range of values and use interests likely to be raised by Maori in discussions on the protection of their instream values within minimum flow regimes. It is intended as a starting point for decision-makers in approaching these matters and must be backed by robust liaison and discussion with tangata whenua local to the river resources in question. It is not a substitute for detailed consultation with iwi on their values and priorities and their application to any specific water management issue or case.

9.1 Relevant RM Act sections

Part II of the RM Act makes provision for Maori interests to be factored into resource management decisions in three ways:

- Section 6(e) sets out the relationship of Maori and their culture and traditions with their ancestral lands, waters, sites, waahi tapu and other taonga as a matter of national importance.
- Section 7(a) provides that persons exercising functions and powers under the RM Act must have particular regard to kaitiakitanga. The definition of this term in section 2 of the RM Act may be amended by the Resource Management Bill to mean the exercise of guardianship by tangata whenua in accordance with tikanga Maori.
- Section 8 specifically directs attention to the principles of the Treaty of Waitangi which all persons exercising functions and powers under the Act must take into account.

9.2 Overview: Maori water values - Waitangi Tribunal cases

Several Waitangi Tribunal cases provide information on Maori values in water which decision-makers can access for guidance on these issues. Principles emerging from those cases include:

(i) Fresh water is the life-giving gift of the Gods and is also used to bless and to heal. Maori separated water streams according to their uses, different sources being used for cooking, drinking and cleaning, amongst other uses. Mixing of waters used for different purposes is prohibited by Maori custom. *Manukau Report*

(ii) The Maori conception of rivers is holistic and the rights that therefore flow from the exercise of rangatiratanga over rivers will reflect this holistic ecosystem view. The taonga value of water extends to the water itself, and the resources contained within the river and its environs. Rangatiratanga pertaining to a river may include interests in development uses of the water. *Te Ika Whenua Report*

(iii) In the traditional Maori conception, it is irrelevant to consider whether effluent or human waste can be treated in scientific terms to be virtually pure before discharge into rivers. There is a need for much greater awareness of the mental and spiritual concepts of Maori in relation to water and its food resources by non-Maori who share the resources or are charged with their protection. *Motunui-Waitara Report*

(iv) The spiritual and cultural significance of a river resource to Maori can only be determined by the tangata whenua who have traditional rights over the river. It cannot be assessed in any other way. *Kaituna Report*

(v) Environmental consultation with iwi is a significant aspect of the Partnership duty under the Treaty. *Ngai Tahu Report*

Maori are likely to seek to maintain the properties of the water that are necessary to sustain customary uses, ranging from ceremonial use of the most pure spring waters through to ecosystem support for species significant for mahinga kai purposes. The range of values and uses likely to be raised by Maori in this context are discussed in more detail below.

9.3 The Maori world view: integrating spiritual, intellectual and physical well-being

In Maori creation belief, divine force was issued from Io-matua-kore (the Creator) into the domains of the children of Papatuanuku and Ranginui, forests, sea, air etc, thereby imbuing the elements of the natural world with life principle or mauri. In ideological terms, mauri represents the essence that binds the physical and spiritual elements of all things together, generating and upholding all life.

The Maori world view does not separate spiritual aspects from the physical practices of resource management. Features of the natural environment are imbued with a spiritual force in addition to being valued for their economic use and contribution to cultural and social cohesion. This integration of spiritual and secular resource values is reflected in Maori ethics of:

- spiritual continuity
- responsibilities to present and future generations
- tribal and individual identity
- shared community history
- inter-generational transfer of cultural values; and
- physical health and sustenance.

In the Maori conception, all elements of the natural environment (including people) possess a life force, and all forms of life are related. The interconnectedness of all things means that the welfare of any part of the environment will directly impact on the welfare of the people. For example, the heath and well-being of the resources of a river catchment will impact on the spiritual, social and physical heath and well-being of the iwi. A water body with a healthy mauri will sustain healthy ecosystems, support cultural uses and mahinga kai, and be a source of pride and identity to the people.

Fig 8: Maori and non-Maori associations with water.

Non-Maori	Maori
Scenery	
Recreation	
Amenity	
Nature	
Landscape	
Cleanliness	
Beauty	
Power	
Health	
Spirituality	
Food	
Identity	
Tradition	
	Mana

Attributes straddling the mid-point are equally important to Maori and non-Maori.
Adapted from Taylor and Patrick, 1987

9.3.1 Spiritual continuity and the protection of mauri

Water has a special place in Maori conceptions about natural resources as a gift from the Atua and the ancestors, and a pure and uncontaminated source of life-giving vitality to ecological resources and the communities they support. The primary objective of Maori environmental management is to maintain the integrity of the connective life force. Resource use and allocation decisions are measured against this objective.

Although the focus for Maori is the maintenance and enhancement of mauri, rather than the physical stock of a resource or ecosystem, this life - essence can be tangibly represented in terms of elements of the physical health of a river ecosystem. In addition to intangible qualities that are associated with the spiritual presence of the river, elements of physical health which reflect and enhance mauri include:

- Water quality, e.g. clarity
- Life-supporting capacity and ecosystem robustness
- Abundance, depth and velocity of flow
- Continuity of flow from the mountain source of a river to the sea
- Fitness for cultural usage; and
- Productive capacity.

Maori conceive that each waterway carries its own mauri, guarded by separate spiritual guardians and tribal caretakers and having its own status or mana. The mixing of waters by unnatural means, the mixing of waters from different sources with separate mauri, or discharges of "used" waters or wastes to living waters that supply food, are prohibited in the Maori conception. These activities are considered to degrade the mauri of the waters and may also offend the mana of different iwi who hold traditional rights and responsibilities with respect to the different waterways.

Mauri represented by the physical properties of a water resource is an extinguishable value. It can be defiled by poor resource practice which results in the water resource no longer being considered fit for the particular human uses for which it is valued. Damaging the mauri of a river will affect its productivity and the food and other materials sourced from it.

Restoring the ecological and spiritual integrity of degraded waterways is a very significant principle in modern Maori resource management, given the extensive environmental degradation that has occurred. Restorative action, including replenishing minimum flow levels and habitat restoration, will be seen as a priority, particularly with respect to resources of high original ecological or cultural value.

The mauri of a water resource is protected through application of a complex system of specific cultural and spiritual practices, customs and rules that were developed to manage and control the interactions of people and the natural world, commonly called tikanga. Primary institutions of this nature include the practices associated with the rites of kaitiaki, tapu and rahui (temporary prohibitions). The result sought from application of these practices is sustainable management of the resource to ensure that such resources are maintained as appropriate to present and future community needs.

9.3.2 Taonga

Taonga has been defined by the Waitangi Tribunal as referring to anything, tangible or intangible, that contributes to the intellectual, physical and spiritual well-being of an iwi. Clearly, there is a spectrum of values inherent in the concept, and priorities between those values will need to be determined on a case-by-case basis. Amongst other matters, the factors which may be relevant to assessing the taonga value of a river ecosystem or its parts may include:

- The traditional genealogical, historical, economic or cultural significance of the resource to the iwi
- The present-day contribution of that river ecosystem or certain reaches as sources of cultural materials or as a site for cultural activities
- The present-day scarcity or abundance of alternative resources within the catchment or tribal territory
- The urgency of need for remedial or restorative action to replenish or maintain the mauri of the resource.

For example, it is likely that high degrees of protection will be sought for water habitats with critical environmental features, like wetlands, or breeding and migratory habitats for threatened or otherwise highly significant species. High degrees of protection will also be sought for places of special historical, social or cultural importance.

It is important to recognise that a river's significance to iwi will also depend on locality, i.e. location within whanau or hapu territory. If resources are scarce locally, they will be considered highly significant regardless of their occurrence within another iwi territory elsewhere.

9.3.3 Identity and inter-generational transfer of cultural values

> *Water and associated resources confirm life to man, and thereby form a basis for identification, belonging, mana. Taylor and Patrick (1987)*

Maori social identity flows in cultural terms from the relationship of iwi, hapu and whanau with their natural environment. This is demonstrated in the practice of mihi, whereby individuals introduce themselves in relation to the natural markers of their tribal territory - their ancestral mountains, the rivers that flow from those mountains, and the lands surrounding them.

These cultural associations are as significant today as they were traditionally, expressing and affirming the kinship relationship between present generations and their ancestral forebears and cultural antecedents. They bridge the metaphysical elements of the gods and legendary ancestral characters with more recent historical events and important tribal figures.

Preserving the integrity of waterways that are valued for such associations is an important aspect of the responsibilities of kaitiaki. The significance of such waterways continues to be recounted in order to preserve tribal history and pass on cultural identity and values to future generations. Waterways will carry a variety of such associations with respect to iwi and hapu identity and historical values. Amongst the values likely to be identified are:

- The role of particular waterways in unique tribal creation stories
- The role of those waterways in historical accounts
- The proximity of important waahi tapu, settlement or other historical sites in or adjacent to specific waterways
- The use of waterways as access routes, transport courses, or trailways; and
- The value of waterways as traditional sources of mahinga kai food and other cultural materials.

9.3.4 Kaitiakitanga

The term kaitiakitanga derives from the verb tiaki. In a natural resource context, the term incorporates notions of guarding, keeping, preserving, fostering, sheltering and watching over resources. Kaitiaki are the agents of this preservation and guardianship.

See also Volume A, Section 5.3.6.

Kaitiakitanga denotes the responsibility of specific appointed iwi representatives to carry out particular functions, to keep and guard iwi interests and taonga resources. The obligations of kaitiaki include enforcement of the practices of tikanga, or those customary practices established to nourish and control the relationship between people and the natural world.

Kaitiaki may be human or non-human. Where they are human, kaitiaki are *persons sanctioned by inherited rights and responsibility or by election and instruction by tribal elders and authorities* (Ngaati te Ata 2.2.3). Kaitiaki are accountable back to the iwi, and care must be taken to ensure appropriate communication processes are established between iwi and decision-makers to avoid interfering in representation and accountability processes.

The responsibilities of kaitiaki can only be discharged by outcomes which sustain the spiritual and physical integrity of the resources and their relationship with the people, so that the resources and the cultural values they support are passed down to future generations.

Given that objective, Maori are likely to measure the effectiveness of opportunities provided for the exercise of kaitiakitanga against the environmental outcomes that are achieved. Those outcomes will be represented by physical resource health and opportunities for continuing cultural usage according to iwi customary preferences and priorities.

9.3.5 Classification of water according to cultural purpose

Maori apply a variety of classifications for water according to its source, physical and spiritual state, and consequent fitness for particular uses. Each class of water is accorded a taonga value, cherished for its contribution to the well-being of the people associated with it.

9.3.5.1 Vital fluid of life of Papatuanuku

In the Maori conception, Papatuanuku (Mother Earth) is the nurturer of life, creating and supplying a web of biological support systems for her children, including people, flora and fauna. Water is representative of a life-giving essence, with waterways serving as alimentary canals, supplying nourishment to her and, through her, to all living things.

All things must pass through Papatuanuku, returning through her in the birth-death-regeneration cycle. As part of that, Papatuanuku is the medium through which wastes must pass to be cleansed of impurities. Waterways act as agents for Papatuanuku in this context, expressing the kinship connection that Maori believe people enjoy with the divine forces operating in the environment. Waterways also have an important role in the absorption of waste by Papatuanuku, not as a receiving environment but as a nourishing and diluting agent for the Earth.

Maori are likely to have several expectations for decision-makers responding to these beliefs in the context of a minimum flow regime. First, that sufficient allocations will be made for the ecological purposes of water as a part of the overall natural land-water ecosystems. Second, that steps will be taken to reflect the value of the natural character of the rivers, their passage through the land, and the minimising of diversion, damming and other artificial activities which alter the natural flow between water and land environments.

9.3.5.2 Wai tapu and wai taonga

In addition to the religious and historical associations identified above, Maori imbue certain water sources with a special character depending on its spiritual status or usage. Water may be considered to be tapu, or sacred, because of its properties in relation to other water, tapu places or objects, and its close association with the gods. In other instances, water bodies will have special taonga value because of special uses that are not restricted by the prohibitions of tapu. Examples of tapu or taonga waters may include:

- dwelling places for taniwha or protective guardian spirits
- burial places
- safe repositories for precious artefacts or cultural items (e.g. stones or other items regarded as invested with or representing the mauri of the place)
- healing, spiritual cleansing, or baptismal waters

- river headwaters, waterfalls or water passing over rapids
- hot springs or waipuna (pure spring sources used for ritual ceremonial purposes)
- sources of pounamu (greenstone), ochre, paru (mud) or other significant cultural taonga.

The tapu or taonga status of such waterways is dependent on the preservation of their purity and the avoidance of unprotected contact with humans. Flow courses and levels are a significant part of the maintenance of the properties of such water ways.

Maori are likely to seek absolute protection of waterways with tapu status, and to protect the quality and quantity of waters whose uses are of special taonga value. Those waters will need to be identified in discussions with tangata whenua to ensure their significance is reflected in decisions within the flow regime. In some instances, decision-makers will need to be sensitive to iwi concerns about identifying the precise location or nature of some tapu or taonga sites, as a part of guarding against encroachment or degradation.

9.3.5.3 Mahinga kai

Mahinga kai has been literally translated as “food works”. The terms refers to the production and gathering of food and other natural resources, such as raranga (weaving) materials or other cultural materials. Mahinga kai resources are significant to iwi for more than their sustenance of physical life, health and well-being, cultural artworks, or their economic use value as trade items. A range of other cultural associations also apply.

The ability to provide hospitality to visitors is a primary cultural tenet of Maori society, reflecting on the status, economic power, reputation and social standing of the host people. The abundance of the food able to be supplied by hosts to visiting people signifies the wealth and mana of the iwi, and their success as rangatira and kaitiaki in preserving their local resources and cultural traditions. In most instances, individual iwi are known for special local foods that represent part of their tribal identity and association with the lands and waters of their traditional territory. Those species have a value which cannot be replaced by substitutes.

In the modern context, participation in mahinga kai activities is an important expression of cultural continuity, and a means of experiencing collective activity as a coherent social group. Food and cultural materials gathering is governed by cultural practices that express the ethics of Maori conceptions of the environment and the rights and obligations of people under that conception. Continuation of these practices is a important means of passing those cultural values down to children and grandchildren, ensuring their survival through the generations.

Waterways yield mahinga kai resources directly, provide the ecosystem support for mahinga kai species (e.g. food sources for utilised species), and nourish and replenish other highly significant mahinga kai environments, including forests and coastal areas. The availability of sufficient quantities of clean fresh water for these purposes is essential to the maintenance of mahinga kai resources and their related cultural values. Amongst other possible priorities, special value will be placed by tangata whenua on waterways that:

- are significant habitats for important food species and materials such as eels, watercress, flax, etc
- afford breeding and migratory environments for those species and the species they feed on, e.g. wetlands and lagoons
- have long-standing use histories for whanau, hapu and iwi
- deserve priority protection by virtue of their physical properties, either as robust ecosystems or degraded mahinga kai environments needing restoration.

As with all other cultural values and uses discussed in this section, the protection of instream mahinga kai values will require resource managers to consult with local iwi to establish the locations and species that are particularly significant for them, and explore the variety of options that will assist in ensuring these values are adequately protected.

9.4 Identifying Maori values

The values that Maori are likely to want to see addressed in flow management issues are:

- Mahinga kai, food sources
- Mauri, the "life-force" of the water
- Waahi tapu, sites of special spiritual significance.

9.5 References

Taylor and Patrick. 1987. Looking at water through different eyes - The Maori Perspective *Soil & Water* Summer p22.

Part 3: Planning

This Part comprises two chapters. Chapter 10 sets out the detail of the fundamental approach we recommend for establishing flow requirements for instream values. Chapter 11 discusses how this approach can be given effect through plans, consents and Water Conservation Orders.

See also Volume A, Chapter 5.

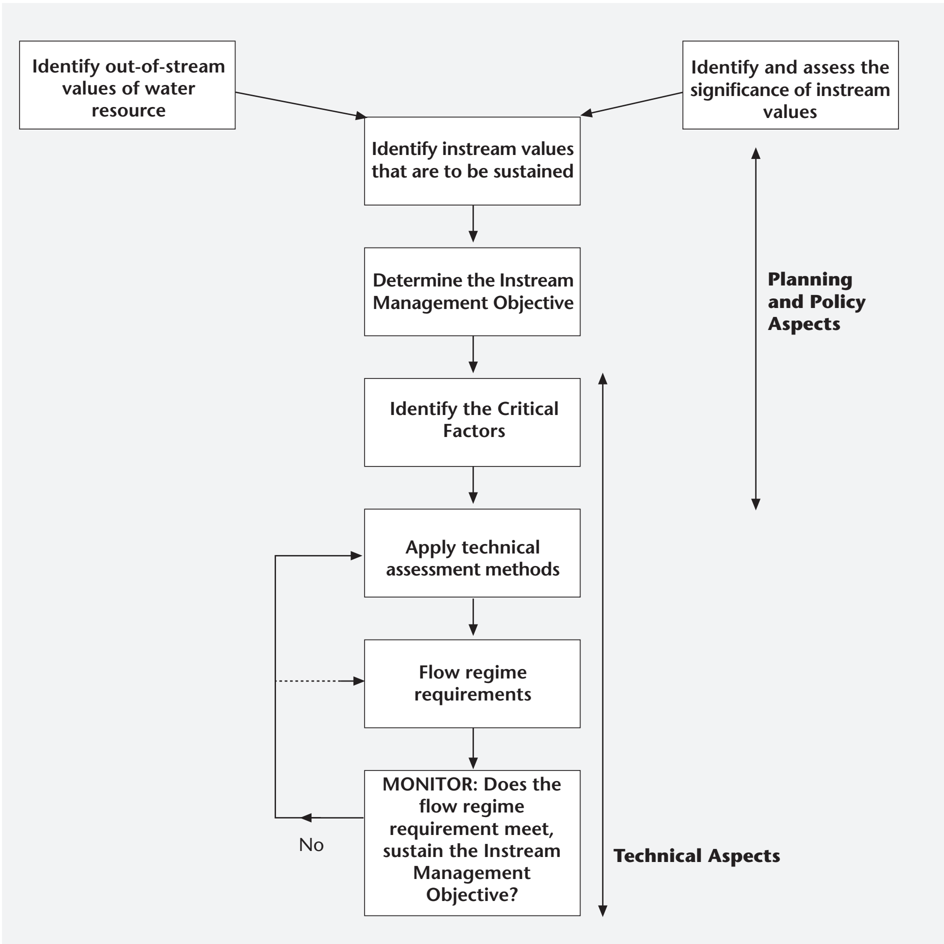
10. Approach Used in the Guidelines: Instream Management Objectives

For more information on how the approach used in the guidelines conforms with the RM Act See Volume A, Chapter 5.

This chapter describes the approach we recommend for establishing flow requirements. The approach is ideally suited to the development of plans, but it can also be used for setting conditions on consents when no plan exists.

The approach is set out in Figure 9. The following sections describe the components of the approach.

Fig 9: Summary of the approach to managing instream values taken in the guidelines



10.1 Identify and assess the significance of instream values

The first step in the approach is to identify the instream values. As discussed in previous chapters these fall into four broad categories, in accordance with Part II of the RM Act:

- Ecological
- Landscape
- Recreation
- Maori.

When assessing the significance of these values, water managers:

- Must refer to Part II of the RM Act in order to determine significant values and priorities.
- Must refer to any other relevant statutory provisions, such as national policy statements, regional policy statements, regional plans or Water Conservation Orders, which may also identify the significance of a particular instream value.
- Should consult with relevant communities of interest, such as local community groups, environmental interest groups, recreational user groups and tangata whenua, and with relevant statutory bodies such as the Department of Conservation. These groups have information that will assist the water manager identify and assess the significance of instream values.

10.2 Identify the instream values that are to be sustained

The second step is to establish what values are to be sustained. This involves a decision as to how these resources are going to be shared. These guidelines do not address the value of water for out-of-stream uses. What follows is the process for determining the flow regime required to promote the sustainable management of instream values.

Generally, different flow regimes are required to sustain different instream values. In some cases the flow requirements of an instream value may conflict with other values. For example, the flow regime required to sustain recreational rafting may conflict with the flow regime required to sustain native fish species.

In situations where instream values have conflicting flow regime requirements, water managers need to establish which values take prominence. Water managers also need to consider the level of protection given to each value, i.e. the level of risk. To define which values take precedence and acceptable levels of risk, water managers need to refer to: Part II of the RM Act; previous chapters of these guidelines, which describe instream values; any relevant planning documents, such as regional policy statements; regional water plans; and Water Conservation Orders.

Water managers need to establish:

- The relative significance of instream values.
- The acceptable level of risk that these values will not be sustained.

10.3 Determine the Instream Management Objective

The third step is to establish the Instream Management Objective, that is, the values that are to be sustained. The Instream Management Objective must be sufficiently well defined that a flow regime (i.e. a description of flow magnitude over time) can be derived from the objective. The Instream Management Objective must also specify the level of protection to be afforded to the instream values.

Setting the Instream Management Objective may involve deciding on the relative importance of different, competing instream values. These decisions must be made case by case. In some situations, if the most sensitive instream values are protected, most other values will be sustained.

The following are possible examples of an Instream Management Objective:

- Optimise habitat conditions for an indigenous species.
- Maintain the existing available habitat for (e.g. trout or native fish).
- Provide a percentage reduction in habitat area.
- Maintain the existing recreation values.
- Maintain a raftable flow for not less than 30 days of the summer.

The Instream Management Objective is likely to be couched in different terms depending on the target audience. We suggest a hierarchical model, with increasing detail at lower levels in the hierarchy. At the political level (higher hierarchical level) the Instream Management Objective may be a broad, encompassing statement, but at the technical level (a lower level) the Instream Management Objective needs to be tightly defined and very specific, for example:

- At the political level the Instream Management Objective may be "to maintain sufficient water quality to sustain a high quality trout fishery".
- The Instream Management Objective that a scientist may work to, in order to protect a trout fishery, may be to ensure that a specific temperature is not exceeded.

There may be uncertainty about the flow requirements of instream values. When making decisions on the flow regime requirement of instream values, the Instream Management Objective should be based on the flow regime most likely to sustain the instream values. This would constitute taking the precautionary approach. Effectively, this constitutes erring on the side of caution when uncertainty is involved.

Objectives and policies which seek to sustain instream values are referred to in these guidelines as the Instream Management Objective.

The level to which an instream value is supported by the Instream Management Objective is defined by the Level of Protection.

See Volume B, Section 12.3.2.

10.3.1 Types of Instream Management Objective

In these guidelines, Instream Management Objectives are divided into two categories:

- **Maintenance of instream values (status quo)**. This is a low-risk approach to managing instream resources. It seeks to avoid changes that enhance one instream value at the expense of others. It provides all existing instream values with an existing level of protection.

The status quo does not necessary mean the current situation, which may be the consequence of diversion or abstraction. It refers to the naturally occurring values.

- **Protection of targeted instream values.** This may be a reduction in, or an optimisation of, flow conditions for a specific instream value(s) which has been identified and targeted. This management objective must consider the relative significance to be given to each of the instream values.

Values that have been lost as a consequence of previous management regimes could be selected as an Instream Management Objective; this means that enhancement is an option.

The two categories reflect:

- The **technical assessment methods** that are currently available. These fall into two broad categories: techniques that seek to maintain current conditions and techniques that enable water managers to target the needs of certain values.
- **Statutory requirements**: As discussed in previous chapters, targeting the requirements of certain values can be consistent with the Purpose and Principles of the RM Act.

In general, Instream Management Objectives that protect targeted instream values will require greater consultation and consideration of options than maintaining the status quo. Similarly, the derivation of Flow Regime Requirements for Instream Management Objectives which seek to protect targeted instream values will generally require greater technical assessments.

See Volume B, Sections 12.1.2, 12.2.2, 12.3.2.

10.4 Identify critical factors and determine the Flow Regime Requirement

After establishing the Instream Management Objective, the next step is to define the flow regime required to support the objective. In these guidelines, this is called the Flow Regime Requirement.

See Volume B, Section 6.4

Part of developing the flow regime is identifying the parameters that are critical to sustaining the Instream Management, for example, habitat area or certain water quality parameters. These "critical factors" will vary depending on the situation.

> The flow regime required to achieve the Instream Management Objective is referred to as the "Flow Regime Requirement".

See Volume B, Chapters 7, 8 and Sections 12.1.3, 12.3.

The flow regime requirement may have a number of dimensions, such as the size of minimum flows, and timing of flow releases, including duration, frequency and seasonal requirements. Techniques for determining the Flow Regime Requirements are discussed in broad terms in Part 4 of these guidelines and are discussed in greater detail in Volume B, Chapter 7 and Chapter 8.

Using the terminology developed in these guidelines, an adverse effect occurs when the flow regime requirement is not met.

> An adverse effect occurs when an activity prevents the Flow Regime Requirement being met.

10.5 Aspects to consider when setting Instream Management Objectives and Flow Regime Requirements

The following aspects need to be considered when setting Instream Management Objectives and developing Flow Regime Requirements:

- Remedial and mitigation measures; using other means than just flows to achieve an instream management objective.
- The scale and magnitude of a potential effect.
- Reversibility issues.

10.5.1 Remedying and mitigating

Section 5(2)(c) in the RM Act recognises that in certain circumstances it may be appropriate to remedy or mitigate adverse effects. Examples of remedying and mitigation measures include:

- In some situations around New Zealand, riparian vegetation has been planted to reduce water temperatures and remedy the adverse effects of reducing flows.
- In the Clutha River, a reach downstream of the Clyde Dam was deepened to give a water depth of at least one metre and a width of 60 metres between the Clyde Dam and Roxburgh. This depth and width was sufficient to ensure that the instream values in this reach were sustained.
- In the Waitaki Scheme, habitat for black stilt was re-created and enhanced in another area of the Upper Waitaki Catchment because power development reduced wetland habitat in the catchment of the Waitaki River.

From a risk and certainty perspective, there is a hierarchy of **avoid, remedy, mitigate,** although there is no legal hierarchy. For technical reasons, avoiding an effect will provide the certainty that the instream value will not be adversely impacted, i.e. **avoid** is generally associated with a higher level of certainty than **remedy** and **mitigate**. The choice of methodology will depend on the importance of the value, the certainty of the outcome, and the level of protection desired.

See Volume A, Sections 12.4, 13.5.1 Volume B, Chapter 12.

10.5.2 Scale and magnitude aspects

In setting Instream Management Objectives and developing Flow Regime Requirements, the concept of scale and magnitude must be considered. There are two aspects to scale:

- The **area** over which the flow regime, and therefore the physical conditions supporting instream values, will be changed.
- The **magnitude** of the effect on instream values.

10.5.2.1 Area over which the flow regime will be changed

Different activities will affect flow regime over different areal extents depending on location and type of activity. For example, a large dam in the upper head waters of a river may change the natural flow regime over the entire length of the river downstream of the dam. The scale of the change in a flow regime in this instance is large. A small abstraction on a side tributary, on the other hand, would cause only a small change in the flow regime. This abstraction may affect the flow regime in the tributary but may be insignificant downstream of the tributary's confluence with the main branch of the river.

10.5.2.2 Magnitude of the effect on instream values

Changes in flow regime may affect the ability of the river to support instream values to a varying extent. For example abstractions may reduce flows in only a small portion of the river system, but this may be a critical reach for fish spawning and the effect of the activity may therefore be transferred throughout the catchment. Similarly a small areal scale effect may cause a large scale effect if it impacts a critical river reach for a recreational activity.

10.5.3 Reversibility of any adverse effects on the instream values

Section 5(2)(a) of the RM Act provides for sustaining the potential of resources to meet the reasonably foreseeable needs of future generations.
It is the **potential** of the resource and not the resource itself which must be maintained.

It is reasonable to assume that a flow regime can be returned or restored in any river system, and therefore over time physical conditions that have been altered may be able to be returned in a river. The future viability of some instream values such as ecological values, however may require the maintenance of a particular flow regime to be sustained over time. For example an activity may alter the physical conditions of a river system in a way which compromises the viability of an endangered indigenous species. The effects of such an activity may be irreversible. The sensitivity of a particular instream value to the change in flow regime and the duration of any potential adverse effect must therefore be considered in assessing potential reversibility of potential adverse effects.

Section 5(2)(a) refers also to the concept of "reasonable foreseeability" or the time scale within which it is considered appropriate to sustain the potential of the resource. It is therefore important to consider not only the reversibility of the adverse effects of any activity on an instream value, but also the timescale over which such reversibility is considered to be acceptable. For example, the effects of large scale infrastructure such as the construction of a hydro-electric dam may be considered reversible over an inter-generational timescale, but over a shorter timeframe it is unlikely that a dam would be removed. The adverse effects of such an activity may therefore be considered to be less reversible than, for example, an abstraction.

It is possible that there may be a "political" aspect to reversing adverse effects on instream values, because this may require readjustment of community expectations on the use of the water as a resource. It is important to include the community in this decision-making. This will ensure that identified instream values are considered, and that the purpose of the instream management objective is well understood by interested parties.

11. Application of the Guidelines

The RM Act provides several statutory instruments to manage instream values. Part V provides for standards, policy statements and plans, Part VI for resource consents, and Part IX for Water Conservation Orders.

As discussed in Chapter 8, the ideal approach to managing flow regimes is to derive *Instream Management Objectives* and *Flow Regime Requirements* before flow regimes are changed. These Objectives and Requirements could be set in the following:

- National policy statements and environmental standards
- Regional policy statements and regional plans
- Water Conservation Orders.

11.1 National policy statements and plans

At the time of publishing these guidelines, only one National Policy Statement had been prepared, the New Zealand Coastal Policy Statement (NZCPS). This is not directly relevant to the issue of flow management in rivers. No national environmental standards have been developed.

11.2 Regional policy statements and plans

Under the RM Act, each regional council is required to prepare and implement a regional policy statement (RPS). An RPS provides an overview of the resource management issues, and sets objectives, policies and methods to achieve integrated resource management within a region.

Regional councils can prepare regional plans to carry out their functions specified under section 30(1)(e) of the Act. Regional Plans focus on specific resource issues and contain a greater level of detail than RPSs.

These guidelines will assist regional councils in the preparation and review of policy statements and plans. In particular, these guidelines outline the matters to be considered in developing Instream Management Objectives and associated Flow Regime Requirements.

Instream Management Objectives may be expressed in objectives and policies contained in a regional policy statement or plan. Flow Regime Requirements such as maximum or minimum levels or rates of abstraction of flows, could be expressed as a rule in a regional plan.

The First Schedule of the RM Act sets out the statutory procedures to be followed in the development of regional policy statements and plans. An important part of this procedure is consultation with those that have an interest, or role, in the management of the instream water resource.

11.2.1 Section 32

Section 32 of the RM Act is also to be considered before developing Instream Management Objectives and Flow Regime Requirements for regional policy statements and plans. This requires that, prior to adopting objectives, policies, rules, or other methods, a council must have regard to:

- The extent that the provisions are necessary
- Other means by which to achieve the purpose of the Act; and
- The efficiency and effectiveness of the provisions relative to other procedures.

For a fuller analysis of the obligations imposed by section 32, refer to Ministry for the Environment : *Section 32 - A Guide to Good Practice* (1993).

11.3 Water Conservation Orders

The Act provides for any person to apply to the Minister for the Environment for the making of a Water Conservation Order.

Regional councils or other organisations could use these guidelines to assess the appropriateness of a Water Conservation Order on a particular water body. The guidelines could assist in establishing the provisions contained with any Order granted. A Water Conservation Order should be seen as another statutory provision identifying Instream Management Objectives and Flow Regime Requirements for a river system.

11.4 Resource consent applications

Section 14 of the Act requires that no person may take, use, dam or divert any freshwater water unless:

- Expressly allowed by a rule in a regional plan, proposed regional plan or a resource consent.
- The water is required to be taken for an individual's reasonable domestic needs.
- The water is required for the reasonable needs of an individual's animals for drinking water, and the taking or use does not or is not likely to have an adverse effect on the environment.
- The water is required for fire-fighting purposes.

A resource consent application should satisfy the requirements of section 88 of the Act. These guidelines should assist applicants identify the types of instream values that may be affected by a proposed activity.

When assessing an application for resource consent, section 104 of the Act must be considered. This requires that any actual or potential effects of a proposed activity on the environment and any relevant objectives, policies, rules and other provisions specified in policy statements, plans and conservation orders be considered in the assessment of an application. Such provisions may include Instream Management Objectives and Flow Regime Requirements.

11.4.1 Where Instream Management Objectives and Flow Regime Requirements are established

Where Instream Management Objectives and Flow Regime Requirements have been established through a policy statement or plan, consent authorities can assess the effects of any proposed activity against these provisions. Where the effects meet the Flow Regime Requirement, the activity would be considered acceptable. Where the effect of the activity does not meet the Flow Regime Requirement, councils may be able to use the policy statement or plan to make decisions on remedying or mitigating the effects (Figure 10).

11.4.2 Where there are no existing Instream Management Objectives or Flow Regime Requirements

It is not practical, nor realistic, for every stream to have Instream Management Objectives and Flow Regime Requirements. Where no Instream Management Objectives and Flow Regime Requirements have been developed, the approach set out in Chapter 8 and summarised in Figure 11, is used.

If the effects of a proposed activity do not compromise the flow regime required to maintain the instream values at the existing level of protection (i.e. maintain the status quo for instream values), the effect of the activity is not considered to be adverse.

If a reduction in currently existing instream values is considered to be acceptable, the decision to allow the activity is analogous to setting an Instream Management Objective that allows a set reduction in the level of the status quo. The flow regime which results from the activity is analogous to the consequential Flow Regime Requirement.

Fig 10: Assessment of effects for resource consent applications where Instream Management Objectives and Flow Regime Requirements are established in policy documents or plans

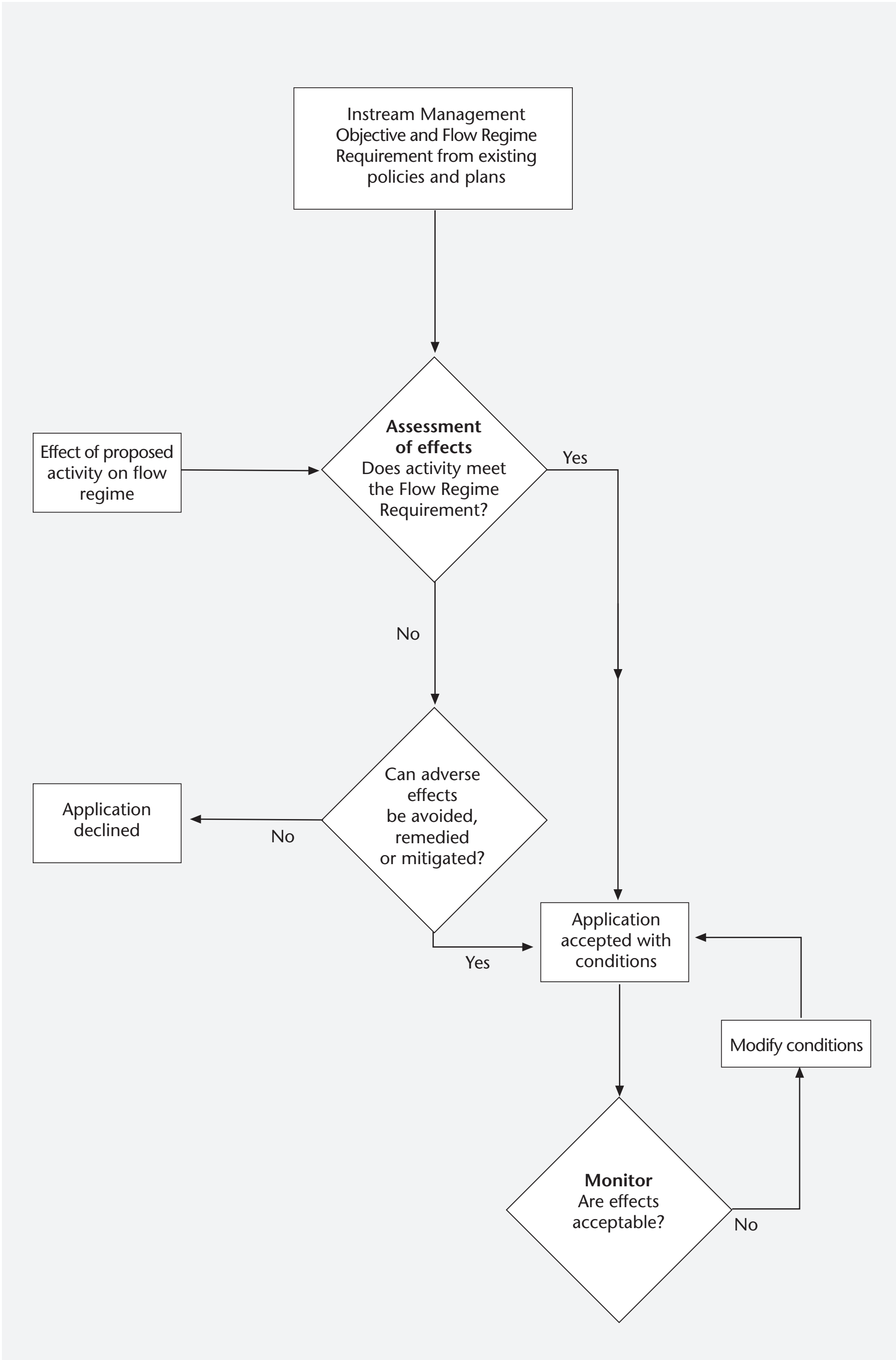
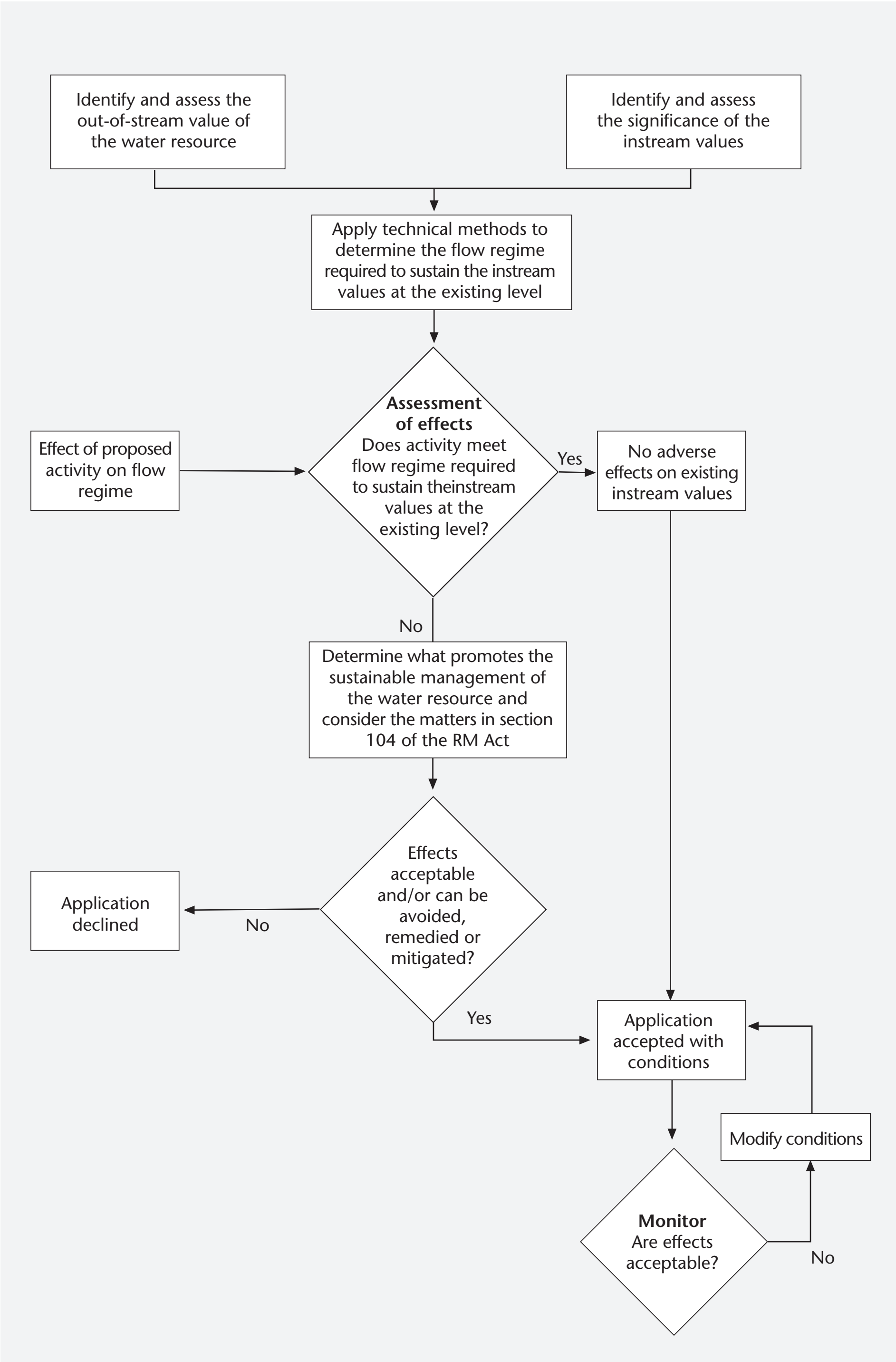


Fig 11: Summary of decision process for assessing applications where there is no existing Instream Management Objective

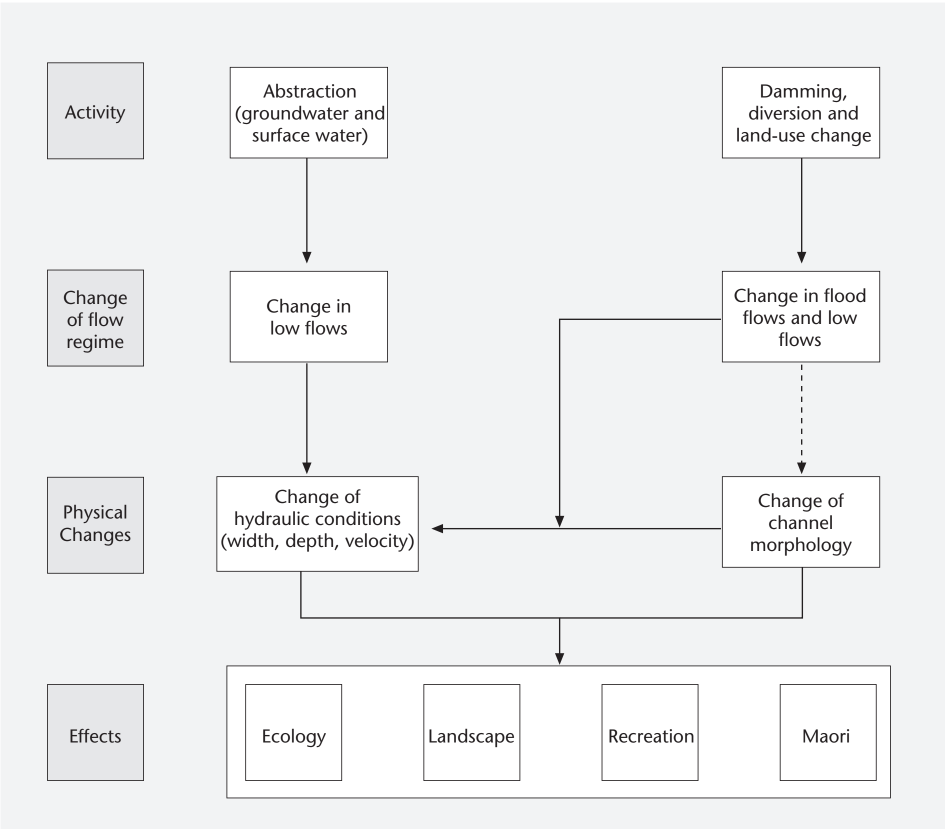


Part 4: Flow Regime Requirements for Instream Values

This part of these guidelines covers the technical methods available for deriving flow regime requirements. The cause and effect relationship between an activity and the effect on an instream value is set out in Figure 12. An activity, such as abstraction, causes a change to the flow regime, for example, changes to flood flows or low flows. The change in flow causes a change in the hydraulic conditions, which leads to effects on instream values. Volume B contains detailed discussion on how changes to flow regimes affect ecological, recreation and landscape values.

The key to managing rivers sustainably is to ensure the Instream Management Objective is sustained, i.e. particular sets of values are maintained. To maintain the instream values, it is necessary to define the parameters that are critical to maintaining the instream values and a Flow Regime Requirement needs to be set. Technical methods are used to set the Flow Regime Requirement.

Fig 12: Effects of activities on instream values

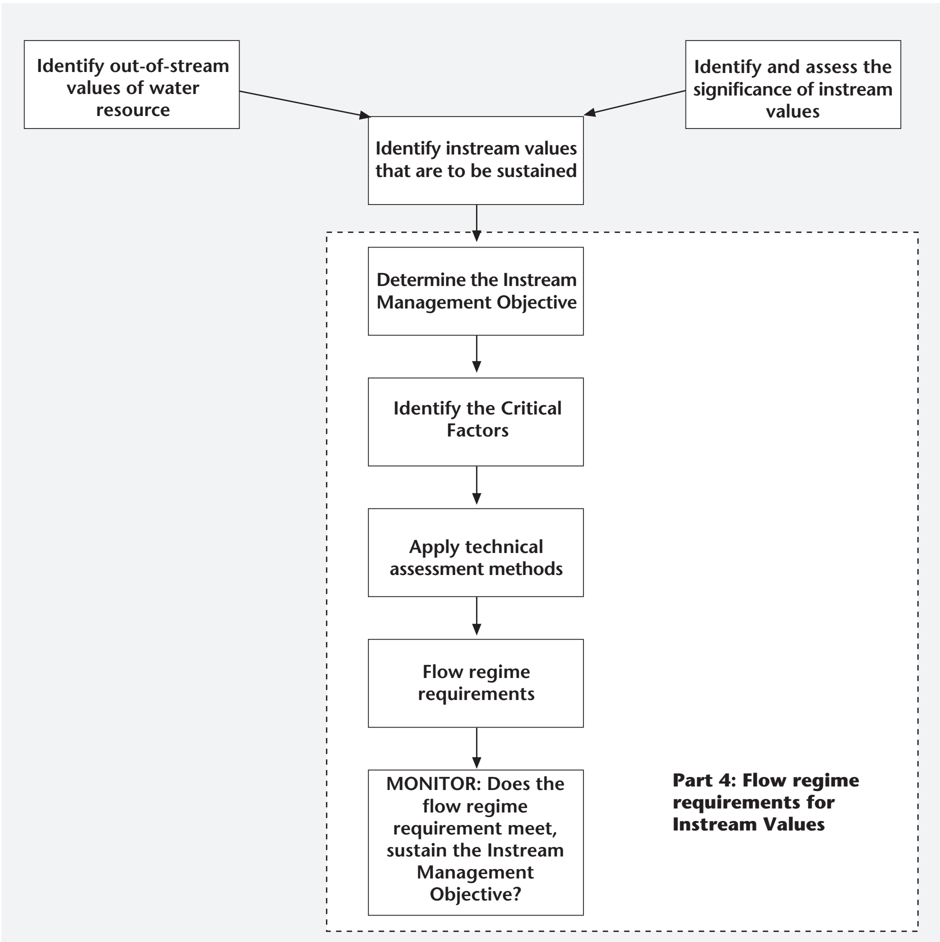


The first four chapters in this Part of the guidelines cover the setting of flow regime requirements for ecological values, Maori values, recreation values and landscape values. The fifth chapter discusses monitoring.

The structure of each chapter in this Part of the guidelines matches the process for setting flow regimes (Figure 13). First, Instream Management Objectives are discussed. Second, methods for identifying critical parameters are outlined. The technical methods are outlined and methods for avoiding, remedying and mitigating adverse effects are discussed. Each chapter also contains a section on monitoring.

This Part of the guidelines introduces and overviews the technical methods. Volume B provides more detailed information on these methods. Worked examples and Case Studies are also provided in Volume B. The relevant sections of Volume B are identified in the margins of the text.

Fig 13: Decision-making process recommended in these guidelines



12. Flow Regime Requirements for Instream Ecological Values

This Chapter discusses methods for establishing a flow regime requirement that will sustain ecological values. Guidance is provided on the critical parameters that may need to be addressed.

Ecological communities in rivers are adapted to certain ranges in physical conditions (i.e. hydraulic conditions and water quality) in response to the natural variation in flow regimes. Because of the diversity and flexibility of most aquatic organisms, there is probably no sharp cut-off where a flow regime will not support a particular community. Rather, the ecological effects of change in flow regime is a continuum along which a decision must be made.

The minimum flow is often the most important part of assessing flow regime requirements for ecological values. Minimum flows can be an ecological "bottleneck" and can strongly influence the nature of the ecological values in a river.

The understanding of how ecological communities in rivers are affected by changes in flow is not complete. The decision process presented here can only provide limited guidance. Experience and case studies, local conditions and public expectations should also contribute to the approach to ecological assessments.

12.1 Instream Management Objectives and levels of protection

An assessment of flow regime requirements for instream ecological values must begin by setting the Instream Management Objective. In determining this it is necessary to identify:

- The species and habitats of value.
- The level to which these species and habitats are to be protected. Levels of protection are inherent in an Instream Management Objective. Highly valued trout or salmon fisheries may merit higher levels of protection than average or poor fisheries. Headwater streams that contain rare species and habitats may merit more protection than streams that contain more common species and habitats.

Instream Management Objectives for ecological values can be divided into the same two categories discussed earlier (Section 10.3.1):

- **Maintenance of existing ecological conditions (status quo).** This is low risk and does not require identification of specific target biota which have to be maintained. It seeks to avoid changes in flow regime that enhance a species at the expense of other species.
- **Protection of target biota.** This may be a reduction in conditions or optimised conditions for target biota. This approach can be taken when target biota have been identified.

There are three main components that define flow regime's ability to support an ecological community:

- **Flow variability**: Variations in flow are important ecologically and provide processes such as flushing of accumulated accumulations of sediment, algae and detritus.
- **Water quality:** The flow is a significant determinant of water quality parameters such as dissolved oxygen, nutrients, pH and toxic contaminants.
- **Habitat (space and food producing area):** Many river biota have preferences for certain ranges of water depth and velocity, i.e. hydraulic habitat. Flow, interacting with the river's morphology (cross-section and slope), determines this available hydraulic habitat.

12.2 Critical parameters

These importance of the parameters varies depending on the site specific circumstances. This section provides tests to assist water managers determine which parameters are likely to be most relevant in a particular situation.

Th critical parameters of a flow regime for sustaining ecological values are:

- **Flow variability**, to fulfil species requirements for flow variation.
- A **minimum flow**, to fulfil:
  - **water quality** requirements
  - **habitat** requirements.

In some cases two minimum flows will be derived: one for water quality, and the other for habitat. The larger of these two flows should be adopted to ensure that the objective is met.

In certain situations the closure of the river mouth will be a critical parameter. River mouth closure is treated as a "special case" in this section.

There are three components to a Flow Regime Requirement for ecological values:

- Flow variability
- A minimum flow for water quality
- A minimum flow for habitat purposes requirements

In certain circumstances, a flow regime will need to be set for river mouth closure purposes.

12.2.1 Flow variability

To date water managers have rarely considered flow variability when setting flow regimes. The normal practice has been to set minimum flows and without considering of the duration of low flow.

There has been little research on the effect of increases in duration and frequency of low flows on instream ecological communities. The lack of information necessitates a cautious approach to this issue.

The likely effect of reduced flow variability in gravel and cobble rivers is an increase in periphyton biomass which can then have flow-on effects to the ecosystem (Volume B, Chapter 6). This effect is likely to be more pronounced where nutrient concentrations are high. Some guidance in assessing when this issue may be important is discussed in the box below.

The effects of a lack of flow variability may be able to be mitigated by flow sharing (e.g. 70 percent of the flow is retained for instream uses and 30 percent for out-of-stream use) when flows fall below a certain threshold. Abstraction rates are usually very small in relation to flow magnitudes required to produce flushing flows, i.e. flow variability that is significant from an ecological perspective. Flow sharing may have little relevance for ecological values where the level of abstraction is small compared to flushing flows.

Tests for the need to consider flow variability when assessing minimum flow requirement:

- For larger rivers, will the proposed activity induce average water depths of less than 0.6 m, average velocities of less than 0.7 $m.s^{-1}$, and periods of constant low flows of greater than five weeks? This combination of conditions is likely to result in the excessive build-up of plant biomass (particularly in gravel/cobble bed streams).
- A "test" to determine whether there is a risk of a change in the existing ecological community as a result of a proposed activity is provided by the hydrological statistic FRE_3. This is discussed in Volume B, Section 1.2.1.

See Volume B, Section 1.2. and Chapter 6.

Special case - streams that dry up (ephemeral streams)

Out-of-stream use of water resources in ephemeral streams may result in increased frequency and duration of dry periods. There is a lack of scientific information on how increased dry periods may affect the biota in ephemeral streams. As a consequence there are no minimum flow assessment methods for ephemeral streams. Most ephemeral streams, however, contain invertebrates and some contain fish species. Ephemeral streams can be important as sources of water for wetland areas.

The issues associated with out-of-stream water use from ephemeral streams are best approached by establishing the aquatic values that the stream supports, developing instream management objectives and assessing the effect activities such as allocation and land use have on the frequency and duration of dry periods. Pay particular attention to:

- The re-colonisation capability of the species present
- The rate of reduction of flows to dry conditions and the capability of species such as fish to move to other habitats
- The increased length of river dried up
- Loss of habitat of rare and endangered species.

12.2.2 Water quality

When setting flow regime requirements, water quality may need to be considered when:

- There will be increased water temperature due to reduction in flow.
- There are nutrient, organic matter and toxic contaminant inputs from point source discharges.
- Nutrient enrichment from non-point sources occurs, associated with high plant biomass.

See Volume A, Section 3.2.2. Volume B, Section 7.4

Water quality assessment methods are discussed in Volume B, Section 7.4. Levels of protection are determined by the standard of water quality required to meet the ecological objectives. Minimum flows are set at levels which will achieve these water quality standards.

Tests for the need to consider water quality when assessing minimum flow requirements:

- Is maximum temperature greater than 19°C? The maximum acceptable temperature may be higher than this depending on the instream management objective and the target species (see discussion on change in depth in Volume B, Chapter 6). In some situations stream temperatures may naturally rise above 19°C.
- Could a substance which is already being discharged become toxic with reduced dilution?
- Will the proposed activity induce average water depths of less than 0.6 m, average velocities of less than 0.7 $m.s^{-1}$, and periods of constant low flows of greater than five weeks, and is point or non-point enrichment present? This combination of conditions is likely to result in the excessive build-up of plant biomass (particularly in gravel/cobble bed streams).
- Could there be point source enrichment (and the associated periphyton/macrophyte proliferation) after dilution under the reduced flows? Will total inorganic nitrogen exceeds 100-300 mg m^{-3} and dissolved reactive phosphorus exceeds 15-30 mg m^{-3} (refer to the MfE Water Quality guidelines No. 1)? Non-point source enrichment will be likely if more than 40% of a catchment is intensively developed for agriculture (particularly in the near river regions of the valley bottom). A good, and rapid, water quality indicator of likely diffuse source enrichment is whether stream water conductivity exceeds 150 mS cm^{-1}.

Note: Most of the research used to develop these tests was undertaken in streams that are large enough to be waded. The "tests" need to be applied with caution to small streams. It should be noted that small streams can provide very important habitat for native fish and for juvenile salmonoids

See Volume B, Chapter 6.

12.2.3 Habitat

Habitat assessment methods are used to determine a flow that provides the necessary hydraulic conditions (width, depth and velocity) for (i) space for organisms to live and (ii) food producing area. Habitat is usually a critically important aspect to consider when developing flow regime requirements because changes to flow regimes invariably impact on habitat, although the degree of impact depends on the river type and the change to the flow regime.

Tests for where minimum flow requirement assessments should consider habitat requirements.

- **Will average velocity be less than 0.3 m/s?** An average velocity of greater than 0.3 m/s provides for most stream life. Velocities lower than this are unsuitable for a number of fish species and allow the development of nuisance periphyton growth. (The development of nuisance levels of periphyton also depends on nutrient status).
- **Will depths in pools be less than 0.4 m?** Water depths in pools greater than 0.4 m provides habitat for adult brown trout.
- **Will shallow areas be lost?** Sufficient areas of shallow water (0.05-0.3 m) may need to be retained for juvenile and native fish. Shallow areas also provide habitat for most stream invertebrates.

See Volume B, Sections 7.2.3, 7.3.

12.2.4 River mouth closure

River mouth closure is a critical parameter than can affect the ecological values of the estuaries and ecological values throughout the entire catchment, as a consequence of altering fish passage from the sea into the river system. The mouths of many rivers in New Zealand can be closed when deposition of beach material by waves exceeds the rivers' ability to erode this material to maintain an open mouth.

See Volume B, Sections 3.4, 5.3, 6.5

The time distribution between river mouth opening or closure is the river mouth opening regime.

The steps in the process of assessing when river mouth closure is likely to be a "critical parameter" and needs to be considered as part of a Flow Regime Requirement, are as follows:

- Categorise the river mouth, into large or small river and large or small lagoon
- Use Table 6 to assess how the change to the flow will change the river mouth opening regime.
- Carry out further detailed studies, if the river mouth opening regime is sensitive to changes in the flow regime.
- Consider whether a flow regime requirement needs to be set for the river mouth opening regime.

Table 6: Flow regime changes with the greatest potential to impact on particular categories of river mouths

River mouth Category	River mouth under natural regime	Reduction in:	Likely effect
Large river, small lagoon	Always open	Low flow	May cause closures, if reduction in low flow is very large.
Large river, small lagoon	Sometimes closed	Low flow	Increased frequency and duration of closure
Large river, large lagoon	Sometimes closed	Low flow	Increased duration of closure
Small river, small lagoon	Often closed	Flood frequency	Reduced frequency of opening
Small river, large lagoon	Often closed	Low flows and flood flows	Increased duration of closure

12.3 Technical methods

The following are commonly used technical methods for setting flow regimes:

- Historic flow methods.
- Hydraulic methods.
- Habitat assessment methods (e.g. Instream flow incremental methodology - IFIM).
- Water quality modelling.
- Regional methods.

The underlying concepts behind these methods are summarised in Table 7 below and explained in detail in Volume B, Chapter 7.

See Volume B, Chapter 7.

The choice of technical assessment methods is influenced by the Instream Management Objective for ecological values and the identification of the "critical parameters". The following sections provide an overview of the use and limitations of the various methods.

Table 7: Minimum flow assessment methods

Historic flow methods	These set minimum flows based on historic low flows. They assume that the existing ecological community will continue to be maintained by flows which have been experienced in the past. Increasing levels of protection are offered by setting minimum flows at historically more frequent low flow levels (e.g. a 1-in-5-year low flow provides a higher level of protection than a 1-in-10-year low flow).
Hydraulic methods	These set minimum flows based on maintaining the value of some hydraulic parameter, usually wetted perimeter. They assume is that a "full" channel will sustain the ecological community.
Habitat assessment methods	These methods provide assessments of the available hydraulic habitat for a target species at different minimum flows. They assume that an ecological community will be sustained provided there is sufficient habitat. Levels of protection are therefore specified by available habitat for a target species.
Water quality modelling	A range of methods exists for estimating likely impacts on water quality of changes to flow regimes, such as temperature and dissolved oxygen modelling.
Regional methods	Regional methods are an extension of the above methods. A regional method aims to set a minimum flow for several similar rivers in a region or sub-region, based on a predetermined level of habitat availability or water quality criteria.

12.3.1 Historic flow methods

Historic flow methods are the simplest technical methods to apply. They are appropriate for situations where the Instream Management Objective for ecological values is to maintain the existing ecological community (i.e. maintain the status quo). The level of protection can be varied, for example, a 1:10 or 1:5-year low flow can be chosen, but the level of protection is difficult to define for the following reasons:

- *Effects of sustained reductions in habitat*: It is difficult to establish what the effect on an ecosystem will be of a sustained 1:10-year low flow, when in the past 1:10-year low flows have occurred occasionally and effects of the reduction in habitat may not have had time to become measurable.
- *Water quality issues:* Historic methods imply that water quality is taken into account because these methods set minimum flows that the ecological community has experienced in the past. This may not be the case, because flows that occurred historically may have been associated with water quality problems, but the low flow conditions may not have lasted long enough for the problems to become readily apparent. Water quality should also be considered when historic methods are used.

- *Lower flows than those recorded*: Historic flow methods are unable to provide information on whether the ecological community is able to be supported at minimum flows that are lower than recorded low flows. Historic flow methods will therefore tend to result in a "naturally occurring" low flow (e.g. 1:5-year) rather than resulting in a flow that meets the specific physical requirements of the biota.

Some water managers believe that a historic flow set in one part of the country becomes a precedent. This view is not correct. Different regions and types of rivers will require different historic flows to meet ecological Instream Management Objectives, depending on the hydraulic conditions of the river. For example, in some rivers a 1:10 low flow may meet the ecological objectives; in others, anything less than average annual low flow may not meet the same ecological objectives.

On some rivers in New Zealand, water managers have used historic methods developed overseas, for example, the Montana method and the Yorkshire method. These are regional methods and were developed for stream and flow regime types in Montana and Nebraska, and in Yorkshire. The methods may have little relevance to the types of streams in New Zealand and may produce a Flow Regime Requirement that will not achieve the Instream Management Objective.

See Volume B, Section 7.3.1.

12.3.2 Hydraulic methods

Hydraulic methods produce minimum flows that are related only to a hydraulic parameter, usually the wetted perimeter of the channel (Volume B, Section 7.2.2). These methods maintain water in the channel without considering habitat requirements in terms of depth and velocity with the aim of maximising out-of-stream use. Hydraulic methods therefore do not relate to Instream Management Objectives for ecological values and they are not recommended for assessing minimum flow requirements.

See Volume B, Section 7.3.2.

12.3.3 Habitat assessment methods (IFIM)

Habitat assessment methods are most suited to situations where the instream management objective and level of protection is set for a target species and its habitat. In New Zealand, Instream Flow Incremental Methodology (IFIM) has been used in a number of situations and is well suited to the physical and ecological characteristics of New Zealand rivers.

IFIM enables water managers to quantify habitat availability for natural and modified flow regimes for a particular target species. In suitable conditions, IFIM is the most accurate method for establishing a low flow that meets the Instream Management Objective, provided that the Instream Management Objective relates to a target species and habitat.

IFIM is the most expensive habitat method to apply. It is most suited to situations where the instream values and the water resource values are high.

IFIM provides an estimate of the amount of habitat available at different flows. The water manager needs to decide what an acceptable amount of habitat is - IFIM does not do this. Thus, IFIM does not decide the minimum flow. It is the Instream Management Objectives that determines what the minimum flow should be - IFIM only provides information for implementing the Instream Management Objective.

It is important to consider all aspects of the aquatic ecosystem when applying IFIM. In particular:

- Sufficient habitat needs to be provided for all the life stages of the target species
- The requirements of all life stages of the food sources of the target species needs to be met.
- Water quality also needs to be considered - IFIM does not address water quality issues.

Before contemplating whether IFIM will assist in setting a minimum flow for habitat purposes, water managers need to be aware of the physical limitations of the model. An expert should be consulted on this. The main limitations include:

- The model works best in laminar flow conditions. This is because hydraulic conditions (width, depth velocity) will be similar in long reaches of the river. The model will not work well in very turbulent streams because the hydraulic equations used in the model do not apply to these conditions.
- Calibration of the model may be difficult in very small streams. This is because the monitoring equipment, such as current (velocity) meters, are too large to provide accurate information of conditions at a particular location in a small stream.
- Idiosyncratic behaviour of fish: The habitat preferences of native fish are not well understood. While preference curves have been developed for native fish, there is debate among the scientific community about the validity of these. Some experts suggest that native fish are very idiosyncratic in their choice of habitat and we do not understand all of these indosyncracies. Native fish preference curves should be used with caution.
- For trout it is important to consider which aspect of their life cycle is critical to ensure a successful fishery. In some cases, modelling may be carried out in the location where fishing occurs (adult stage); in other situations, spawning areas may be modelled.

In many cases in New Zealand, IFIM has been used together with arbitrary rules of thumb, such as:

- Reducing habitat to two-thirds of that at the annual average minimum flow, or;
- Reducing the available habitat so that the river remains above the top 15 percentile for habitat, when compared with rivers from the "100 rivers" study.

These have been used as Instream Management Objectives. There are concerns that these rules of thumb have little basis. They have not been developed through a rigorous, consultative process and the principles on which they are based are questioned. The Ministry recommends that these rules of thumb are not used and that water managers use IFIM only after a clear Instream Management Objective has been set.

See Volume B, Sections 7.2.3.3, 7.3.3.

12.3.4 Water quality methods

There is a range of water quality methods available for assessing the impacts of a change in flow regime on water quality parameters. The methods range from simple dilution calculations to complex models for predicting dissolved oxygen and temperature regimes. Water quality methods that have been used in New Zealand are outlined in Volume B. Application of temperature and dissolved oxygen modelling techniques are described in the worked examples section of Volume B.

See Volume B, Section 7.4, and Chapter 12.

12.3.5 Regional methods

Regional methods are applications of technical methods to all rivers in a specified area. These methods are useful for setting minimum flows for rivers in an area where rivers have similar character (shape and flow regime), and specific management objectives and levels of protection have been set for the area. The river types provide a conceptual basis for developing these methods.

Regional methods can produce robust rules of thumb based on flow statistics, similar to the Montana and Yorkshire methods. These rules of thumb may relate hydraulic habitat (derived using IFIM) or water quality parameters (e.g. dissolved oxygen) to hydrological statistics, such as the 1:5-year low flow. Once developed, the methods are easy to apply because the necessary hydrological statistics are straight forward to generate.

Regional methods are complex to formulate and usually require expert assistance. Regional methods for habitat and water quality management are presented in the Case Studies section in Volume B.

See Volume B, Section 7.5 and Chapter 12.

12.4 Remedying and mitigating effects on ecological values

Ecological values are usually affected when changes in physical conditions cause a series of ecological changes and consequent "flow-on" effects to the ecosystem. The adverse effects of activities can be avoided by restricting or stopping the activity to ensure that the Flow Regime Requirement is met, for example, stopping abstraction when the minimum flow is reached.

There are, however, circumstances in which it may be appropriate to remedy or mitigate the adverse effects of activities. The difference between avoiding, remedying and mitigating adverse effects are not clearly defined. For example, the effects of reduced flow variability downstream of a dam may be able to be overcome by periodically releasing flows from the dam. The periodic release of flows of a given magnitude may provide a flushing flow which removes excess periphyton and sediment from the channel. In this case, although the accumulation of periphyton and sediment is an adverse effect, it is remedied or mitigated by the flushing flow.

Ways of mitigating and remedying effects can be divided into two categories:

- Instream measures (including riparian planting on the reach affected by an abstraction).
- Out-of-stream measures, for example, measures taken to enhance conditions in another catchment.

See Volume B, Chapter 6.

Ways of remedying and mitigating the effects of changes to river mouth closure are also discussed in this section.

12.4.1 Instream measures

Table 8 provides a range of instream measures for remedying or mitigating the effects of changes in flow regimes. An example of an instream measure is the reduction of water temperature. On small streams, water temperature can be more effectively managed by stream shading than by setting minimum flows.

Mitigation measures do not obviate the need for a Flow Regime Requirement, but a mitigation or remedy measure can, in some circumstances, mean that a lower flow can be set whilst ensuring that the Instream Management Objective is met. For example, where stream shading is used to reduce water temperature, a minimum flow may still be required to fulfil habitat requirements and meet the Instream Management Objective for ecological values.

See Volume B, Section 12.3.

Table 8: Remedy and Mitigation measures for different physical changes

Physical change causing adverse effect	Remedy/mitigation measure
Reduction in flow variability	Flow sharing below a flow threshold. Release flows from dams.
Water temperature	Riparian shading.
Nutrient, organic and toxic contaminant concentration	Reduction in point source inputs of nutrients, organic and toxic substances. Riparian shading to reduce plant growth.

12.4.2 Out-of-stream measures

Off-set or out-of-stream mitigation is a method used to achieve an Instream Management Objective. This approach involves payment to mitigate the effects of the activity, for example by creating an alternative habitat to compensate for that lost. This method was applied in the Waitaki Valley to create and enhance wetland habitat to replace that which was lost through the Waitaki hydro-power development.

In the past some activities have effectively dried up river channels, thereby removing life-supporting capacity of the river system. In one or two instances in New Zealand these effects have been mitigated by the enhancement of conditions in an adjacent catchment. Due to the complexity of the functioning of ecological systems, predicting ecological responses to out-of-stream measures can be considered to be risky. These measures could therefore only be considered when:

- A very specific ecological value is identified and a management objective for that value is identified and agreed to.
- A thorough investigation of the proposed mitigation measures has established that the objective can be met by enhancing conditions in an another area, or in an adjacent river catchment, with a high level of certainty.

See Volume B, Section 12.4.3

12.4.3 River mouth closure: Remedying effects by artificial opening

One way of remedying the effects of changes to river mouth opening regimes, caused by changes to flow regimes, is to artificially open the river mouth. Many river mouths are managed by being opened before lagoon levels get high enough for the process to occur naturally. This requires taking advantage of particular conditions: low wave action or a reasonably high lagoon level. The opportunities for these artificial openings are affected by the flow regime in much the same way as the occurrence of natural openings, so that the categorisation into "large" and "small" rivers, on the basis of how often and in what conditions they are open or closed to the sea, should be made in terms of the artificial regime rather than the natural one. This means, for example, that a river that needs occasional bulldozing to be kept open will be more expensive and difficult to maintain if low and base flows are reduced.

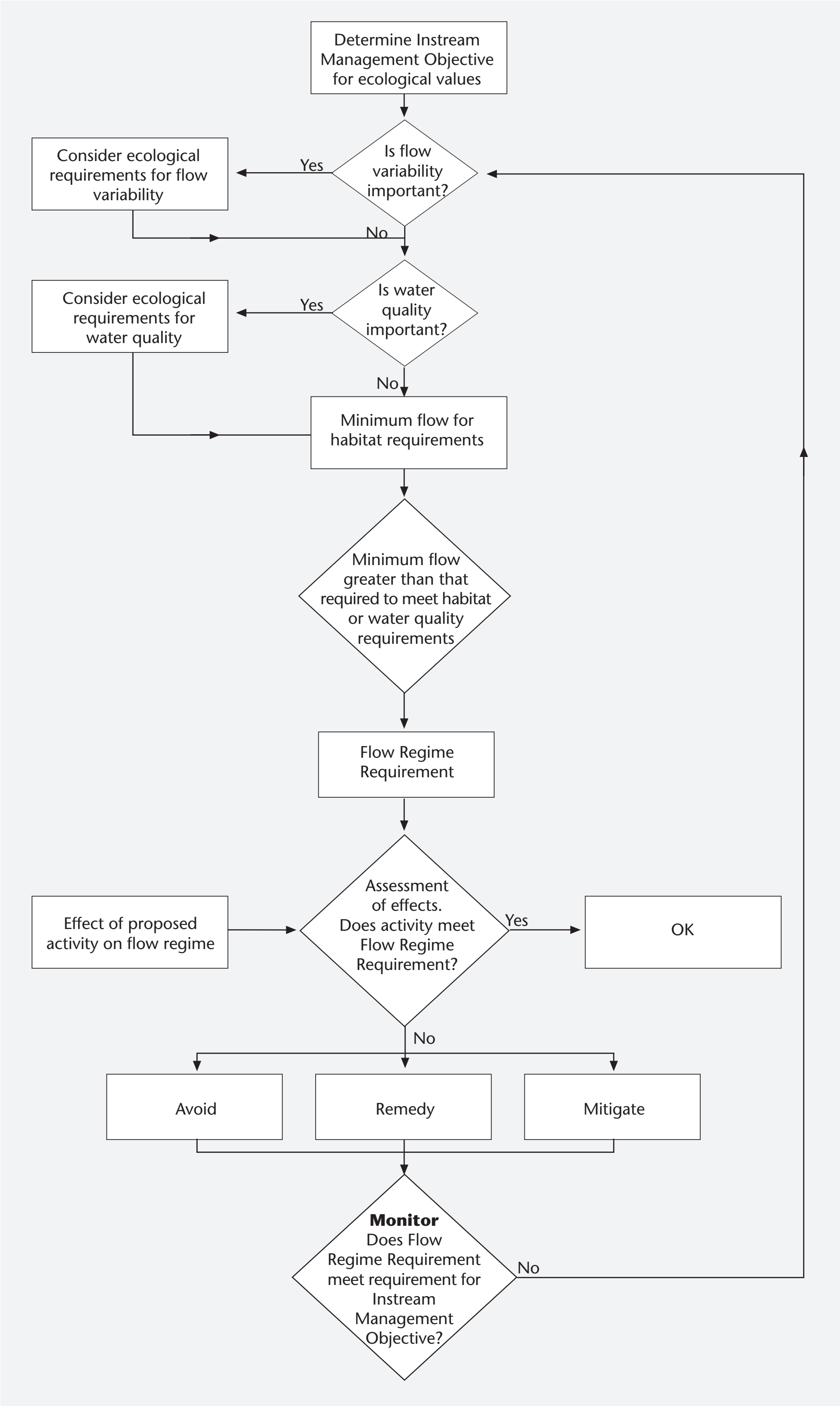
12.5 Summary: Process for setting flow regime requirements for ecological values

There are three main components to developing a flow regime for instream ecological values:

- Water quality
- Habitat space
- Flow variability.

The decision process for determining flow requirements for instream ecological values is summarised in Figure 14 below.

Fig 14: Flow regime requirement assessment for instream ecological values



13. Flow Regime Requirements for Maori Instream Values

Earlier sections of these guidelines describe Maori values as they apply to water in general and instream flows in particular. This chapter identifies the types of issues that Maori may wish to have included in Instream Management Objectives and methods for setting Flow Regime Requirements for these issues.

When determining the appropriate flow regimes for Maori values it is necessary to acknowledge that:

- Iwi patterns of usage vary throughout a catchment
- Iwi have an interest in the whole water body from its source to the sea
- Many mahinga kai species are migratory, therefore, the whole catchment needs to be considered, not just the sites where Maori gather mahinga kai
- Iwi harvest different species in different locations and at different times of the year.

See Volume B, Chapter 11.

13.1 Instream management objectives

To set instream management objectives for Maori values and uses, water managers need to establish dialogue with iwi on (i) the uses of different reaches of water bodies and (ii) the ideological values that are relevant to those uses.

Each iwi will have various uses and values associated with different reaches of rivers but there is likely to be some commonality between iwi. These commonalities are set out in the box below and are discussed in the remainder of this Chapter.

Values that iwi are likely to want included in an Instream Management Objective are:

Mauri

- The mauri of water bodies and their productive capacity will be protected and, where necessary, degraded water bodies will be restored.
- The quality and quantity of water in all waterways will be sufficient to provide for the healthy functioning of associated ecosystems.

Mahinga kai

- Flows will be adequate for mahinga kai.
- Flows will be adequate to allow access to mahinga kai.

- Where instream flows relate to the condition of wetlands, special effort is taken to ensure that wetlands are protected for mahinga kai purposes and as a kohanga of native fish species.
- Activities associated with the change of flow regimes, such as water takes, will not adversely impact on mahinga kai.
- Upstream and downstream passage of mahinga kai species will be maintained.

Waahi tapu

- Flows will protect waahi tapu.
- Methods used to protect waahi tapu will protect and accommodate tikanga Maori.

In some cases, Iwi may prefer direct representation in decision-making and management activities rather than "consultation", i.e. the **process** of setting the Instream Management Objective may be very important to iwi. In the decision-making process, the following are objectives that iwi may wish to achieve:

- Iwi rangatiratanga over water bodies within their rohe will be re-established.
- Iwi will be able to discharge their kaitiaki and manaakitanga responsibilities.

There will be greater surety that Maori beliefs, values and uses will be protected and enhanced if Maori have a direct say in developments that affect the water resource.

13.2 Critical parameters

This section outlines the critical parameters for the following Maori instream values:

- Mauri
- Mahinga kai
- Waahi tapu.

13.2.1 Mauri

Mauri is essential to sustaining the productive capacity of the environment. There are several aspects to mauri, including:

- The intangible qualities that are associated with the spiritual presence of the river
- The aesthetic qualities of the river
- The physical qualities of the river which can be depicted in terms of the quantity, quality, depth and velocity of flow
- The value of the river to iwi, as a source of water, mahinga kai and its use in activities such as burials and rituals.

To determine the flow required to sustain the mauri in an acceptable state, decision-makers need to give iwi the opportunity to:

- Explain the flow regime needed to protect the mauri.
- Identify the values that will be affected if the mauri is threatened, for example, mahinga kai.

When formulating Instream Management Objectives and identifying priorities for restoration, it is essential that iwi are responsible for identifying those water bodies or reaches of water bodies that need remedial or restorative action to maintain or replenish the mauri, or one particularly important to retaining mauri.

Iwi must be involved in site investigations to observe the river under various flow conditions.

Although scientists can translate iwi concerns on sediment movement, the needs of mahinga kai and river mouth dynamics to specific flow requirements, only the iwi, as the kaitiaki, can confirm if a particular river flow is sufficient to meet the metaphysical aspects of mauri.

Particular issues relating to mauri that water managers need to consider are as follows:

- **Water Quality**: Contamination of a water body will diminish its mauri. Sometimes water quality issues will need to be addressed as part of the flow regime requirements.

- **The "moods" of the river.** To protect the "moods" of the river, flow variability needs to address:
    - The daily, seasonal and yearly variations
    - Low flows and flood flows, and
    - Minimum flow requirements.
- **River mouth closure:** In some parts of the country, river mouth closure is a significant issue.
- **Respect for the water body:** An important aspect of mauri is demonstrating respect for the water body. An example of respect can be the restoration of degraded sections a river. Iwi participation in enhancement projects provides a practical means of demonstrating respect for the water body.
- **Augmentation:** It is important to explain augmentation in terms of mauri. Each water body has its own mauri that is unique to that water body and it is distinct from the mauri of another water body. Mixing of waters from two different sources can have both spiritual and physical ramifications. Damaging the mauri will have an impact on the productivity of the water body and mahinga kai will be affected.

  The mixing of waters from one source with another damages the mauri of the river. Further it is seen as an insult to the iwi involved, who are the kaitiaki of these resources. Iwi must be consulted whenever a proposal involves the mixing of water from two different sources as it is essential that the effects of the diversion (and augmentation) on the mauri of the water bodies are determined.

See Volume A, Sections 12.2.4; Volume B, Section 3.4, 5.3, 6.5, case studies

A flow regime for mauri must address:

- **Water quality**, because water quality is a critical component of mauri
- **Water quantity,** because mauri can be diminished by reduced flows.
- **Flow variability** to protect the "moods" of the river.
- **Flow variability** to protect normal river processes, such as sediment movement and river mouth closure.
- **Mixing** of waters from different rivers.

13.2.2 Mahinga kai

One of the most prized resources taken from water bodies is mahinga kai. Mahinga kai were used for subsistence, cultural and economic purposes. The welfare of the iwi depended, and today still depends, on ensuring that mahinga kai are managed on a sustainable basis. This is the role of the iwi as kaitiaki of the resource.

Where the maintenance and enhancement of mahinga kai is the instream management objective, iwi must be given the opportunity to identify those waterways or reaches of the water that are significant.

The critical parameters relating to mahinga kai that water managers need to consider are:

- Habitat, in terms of food production and passage.
- River mouth openings (a specific aspect of passage).
- Water quality
- Physical access to the river.

See Volume A, Chapter 12.2.4

Flows to provide habitat for mahinga kai: Once iwi have identified the mahinga kai species that are of importance, scientists can identify the needs of each species and the flow regime that optimises the conditions needed by each species.

Flows for upstream and downstream passage: Scientific tools are available to establish flows that facilitate fish passage. An eel fishery will be sustainable only if at least part of the population can complete all parts of its life cycle. Downstream migration is an important issue. Eels migrating downstream follow the dominant flow of water. If the greater flow is in fact a diversion or an off-take from the river, eels will follow that flow and be lost to the system.

Eels (heke) move in the autumn and the movement is greatest at the last phase of the moon. It is important that at these times the greater flow, and the direction in which the heke travels, is the river flow.

Flows to maintain water quality: Water quality is important for maintaining mahinga kai species.

See Volume A, Section 12.2.4; Volume B: Sections 3.4, 5.3,6.5 and case studies

Flows to maintain lake and river mouth openings: To enable migratory species to move between the river and the sea it is essential that the river mouth is open.

Physical access to the areas where mahinga kai are located: Human access to the river needs to be maintained.

Flow regime requirements for **mahinga kai** need to address:

- A minimum flow for **habitat,** including **fish passage.**
- A minimum flow to maintain **water quality.**
- Flow to maintain **river mouth openings**
- **Access** to the areas in which mahinga kai are located.

To set flow regime requirements for mahinga kai, water managers need information on:

- The particular rivers and lakes that have special significance as mahinga kai
- The reasons a particular water body or reach of a water body is of significance, for example:
  - the mahinga kai species that are of greatest significance to iwi
  - the areas prized as kohanga, providing spawning areas for fish and breeding sites for birds
  - the areas where cultural materials, such as raupo and paru, are sourced
- The reaches of waterways that were important sources on mahinga kai but which in recent decades have been adversely affected by water management practices.

13.2.3 Waahi tapu

In the management of natural and physical resources, decision-makers need to ensure that waahi tapu are accorded respect because of the tapu associated with them. Waahi tapu are any place or feature that has special significance to whanau, hapu or iwi. Waahi tapu are not restricted to burial sites and include areas associated with landscape, areas where sacred activities took place, pa sites and places associated with the birth of, or ceremony involving, ancestors.

To set flow regimes for **waahi tapu** water managers need to:

- identify waahi tapu located in, or adjacent to, water bodies that may be affected by changes to the flow regime of the water body
- identify the nature and scale of the effects of flow regulation, including flood ranges, design flood levels etc
- identify the controls necessary to ensure that waahi tapu are protected.

The management of waahi tapu is complex. Iwi and decision-makers will be involved in the process of developing systems for:

- identifying and recording sites of significance to iwi
- advising councils of the location or approximate location of waahi tapu.

From the perspective of iwi, one of the most significant issues is the need to ensure the protection of sensitive information. This will require decision-makers to develop, with iwi, systems and processes that protect the specific location and nature of waahi tapu. Such systems may include:

- restrictions on access to the information
- excluding the public from aspects of the hearing process.

13.2.4 Remedying and mitigating the adverse effects of flow regulation

An adverse effect may result when the flow regime will not adequately protect all the instream values and uses that have been identified by iwi. It is likely that some values will be protected while others will not. In these instances it is for iwi and decision-makers to identify appropriate strategies for mitigating and remedying the adverse effects. Examples of actions that could remedy or mitigate the adverse effects on instream Maori values include:

(a) Re-establishing flows in rivers or stretches of the river that have previously been de-watered as a result of damming, diverting or abstracting water.

(b) The provision of fish passage through either:
- The installation of fish passes such as the native fish passes that have been installed on a number of hydro installations in both the North and South Island.
- The release of water from hydro structures at key stages of the life cycle of migratory fish species. For example, to facilitate eel passage downstream, releases of water may be required during certain phases of the moon in autumn.

(c) Re-establishing or creating habitats appropriate for mahinga kai. This could see the council undertaking the restorative work or alternatively iwi could be funded to undertake the work. It could also entail the acquisition of land to habitats suitable for mahinga kai.

(d) Putting in place a flow regime that incorporates flushing flows. For example the regime for the Lower Waiau River, in addition to the minimum flow of 12-16 cumecs, will have flushing flows of 35 cumecs and, if necessary to ensure an open river mouth, flows of 150 cumecs in spring and autumn.

(e) Committing to the improvement of water quality in water bodies where iwi have identified degradation of water quality as a particular issue.

(f) Where the effects on iwi beliefs, values and uses is unknown or unclear, developing:

- A research programme, jointly with iwi, to ascertain the likely effect and scale of the effect and means of remedying or mitigating the effect[5] ; and
- A monitoring programme, involving iwi, to monitor the effects on iwi beliefs, values and uses that are of greatest concern to iwi.

(g) Supporting research that is designed to increase the understanding of:

- The habitat requirements, breeding habits and appropriate harvesting methods of native fisheries, mahinga kai plants and wildlife;
- The traditional and contemporary relationship between iwi and mahinga kai resources, identifying appropriate means of enhancing this relationship.

(h) Supporting programmes and activities for promoting, restoring and enhancing the social, cultural and economic relationship of iwi with the water bodies and their associated resources, within their rohe.

It is the responsibility of decision-makers to consult with iwi to explore the variety of options for remedying and mitigating the effects of flow regulation on cultural values and uses.

13.3 Summary: Flow Regime Requirements for Maori instream values

Where the flow regime is likely to generate a particular effect on Maori, it is for Maori to provide information on:

- whether it is an adverse effect
- whether the effect is worth tolerating given the possible benefits to other sectors of the community.

The process by which iwi will be involved in setting flow regimes is explained below and is summarised in Figure 15.

1. If decision-makers and iwi collect the types of information set out in this chapter, they will have prepared an inventory of values and uses including but not limited to:
   - mahinga kai species and habitats
   - sites from which cultural materials are harvested
   - trails providing access to water bodies
   - traditional uses of water bodies or reaches of water bodies

5 *An example is the Te Waiau Mahika Kai Trust which is being funded to research the downstream migration of eels from the Waiau Catchment and to identify means of addressing the problems of downstream migration.*

- kohanga for fish and birds
- landscapes and landforms of significance
- waahi tapu.

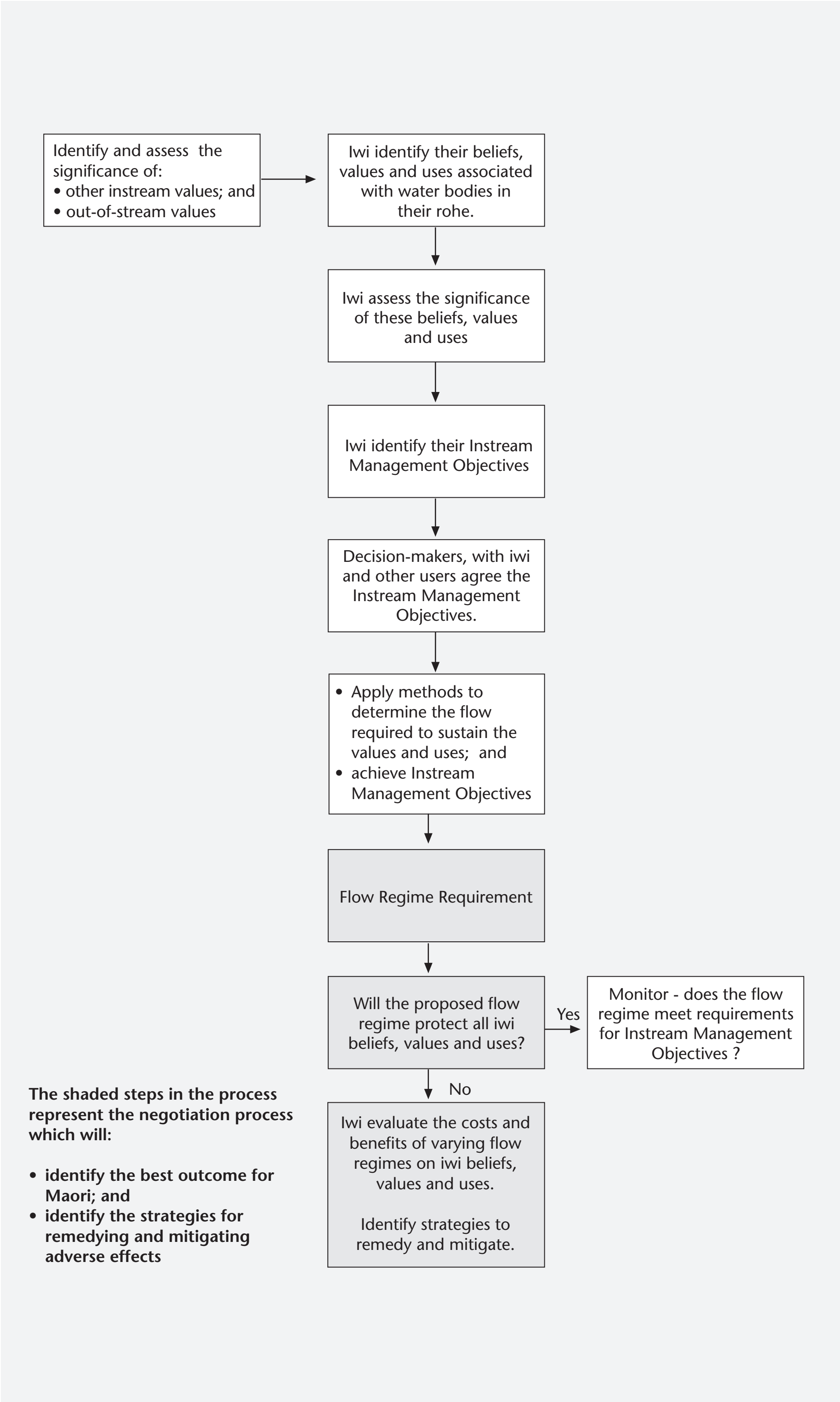
2. Iwi, using the inventory as a basis, can undertake an assessment of the relative importance of the values and uses of different water bodies within their rohe.
3. Having identified the values and assessed their significance, iwi will be able to formulate their Instream Management Objectives. These can then be incorporated with other Instream Management Objectives.
4. Once decision-makers are advised of the values and the Instream Management Objectives they can assist iwi through the application of technical methods to determine the Flow Regime Requirements needed to protect each of these values.
5. When advised of the flows needed to protect their instream values in a particular water body, iwi can evaluate the level of effect on identified values and uses under different flow scenarios, leading to a ranking, in cultural terms, of the suitability of each scenario.
6. Once the flow regime has been agreed, decision-makers and iwi can identify strategies for remedying or mitigating the adverse effects that flow regulation is likely to create.

This process will ensure iwi participation in determining the appropriate flow regime for a water body. It is equally important for iwi to be involved in the wider management of the water resources within their rohe.

Participation in water management is the means by which iwi are able to discharge their kaitiaki responsibilities. The onus is on decision-makers to:

- identify and implement practical ways in which iwi can exercise their rangatiratanga
- determine with iwi the practical means by which iwi are able to discharge their responsibilities as kaitiaki of the water bodies within their rohe, for example by:
  - developing enhancement programmes that involve iwi to have a hands-on operational role
  - commissioning iwi to undertake research or assist with research projects
  - commissioning iwi to document the values and uses or water bodies and
  - designing and implementing monitoring programmes that provide iwi with opportunities to participate.

Fig 15: Flow Regime Requirements for Maori instream values



14. Flow Regime Requirements for Landscape Values

Earlier sections of these guidelines define landscape values as they apply to instream flow requirements and identify how landscape values overlap and interweave with Maori, ecological and recreation values. This chapter suggests questions that water managers can ask to determine when to incorporate landscape values into Instream Management Objectives. It then provides guidance on how to determine flow regime requirements that will support the instream management objectives.

It will be clear from earlier chapters that the task of determining flow regime requirements for landscape values is fraught with difficulty due to the complexity of natural flow regimes. Flow variability, landscape diversity, reach-by-reach differences and a range of values coming under the "landscape umbrella" all result in the need for a reach-by-reach assessment. Because landscape values are largely based on perceptions it is not possible to be as precise as with other values.

No widely accepted landscape evaluation techniques exist for flow management issues. The bulk of investigations, both in New Zealand and overseas, have focused on scenic assessment and, although they may give a good indication of aesthetic values, they may miss out on other important aspects of landscape. Generally they give little weight to the natural flow regime dynamics and have a general perspective, failing to focus on instream values. Better landscape techniques need to be developed.

See Volume B, Chapters 8 and 9.

Several of the effects on landscape values may also relate to ecological, recreation and Maori values. These aspects of landscape may be adequately addressed through the methods set out elsewhere in these guidelines. In particular this is likely to be true of intrinsic values and spiritual values covered by ecological and Maori values respectively.

14.1 Instream Management Objectives

To set an instream Management Objective for landscape values, it is necessary to identify:

- What landscape values are present.
- Where on the river they occur.

See Volume A, Chapter 7.

The methods used to achieve this will depend on the significance of the river and the landscape.

As discussed earlier, several of the landscape values are interwoven with ecological, recreation and Maori values. These aspects of landscape may be adequately addressed through the methods set out elsewhere on these guidelines. In particular this is likely to be true of intrinsic values and spiritual values covered by ecological and Maori values respectively.

See Volume B, Chapter 10.

14.2 Identify critical parameters

Once the location and type of landscape values have been identified, the critical aspects that the regime needs to address can be identified. For each river reach it is necessary to identify the likely flow regime required to sustain the identified landscape Instream Management Objectives.

The landscape values can be addressed in matrix form with detailed flow requirements on one axis and locations and reaches on the other. For each reach an estimate can be made of acceptable flow regime changes given the existing landscape values. From these results a flow regime requirement can be set. For example, using the fictional river, it may be estimated that a minor (say 20 percent) loss of flow in Reach 4 will result in a loss of the wild qualities of the river and this will be important during the natural low flow period which coincides with the period of greatest public use. This threshold may be more constraining than the estimated need for flows elsewhere in the system, for example in Reach 2 where the picturesque qualities of the river would be retained following an estimated 40 percent reduction in low flows.

If the priority landscape requirement(s) is more restrictive than any ecological, recreational or Maori requirements, further detailed investigations would be necessary. Again, the importance of the river and the range of landscape requirements will determine whether only the first priority Reach needs to be addressed in detail, or whether several reaches should be studied. In some instances different reaches maybe affected at discrete times of the year.

Landscape values on rivers with the following characteristics may be particularly sensitive to changes in flow regimes:

- If the river's natural flows display little variation, the potential for landscape values to be adversely affected by flow modifications will generally be greater than in rivers with high natural flow variability.
- Flow modifications are likely to be most apparent where there are shelving river banks (Volume B, Section 10.3.3).

See Volume B, Section 10.3.3

If the natural flow regime is likely to be changed, it can be anticipated that landscape priorities are likely to occur either close to the flow modification (downstream unmodified tributaries will 'damp' any flow change effects) or in areas or at places where the river is highly valued or experienced by large numbers of people.

14.3 Technical methods

Having identified one or more places along the river where flow changes are most sensitive because of their potential effects on specified landscape values, decision-makers will have to confirm preliminary predictions with detailed studies. At this stage expert advice is essential.

As discussed in the introduction to this chapter, technical methods for identifying flow regimes to sustain landscape values are poorly developed. A technical investigation is likely to involve two aspects:

- Obtaining a factual record illustrating instream differences during the natural flow regime, either as a graphic, still photograph or video.
- Evaluation either by expert opinion or public perception study.

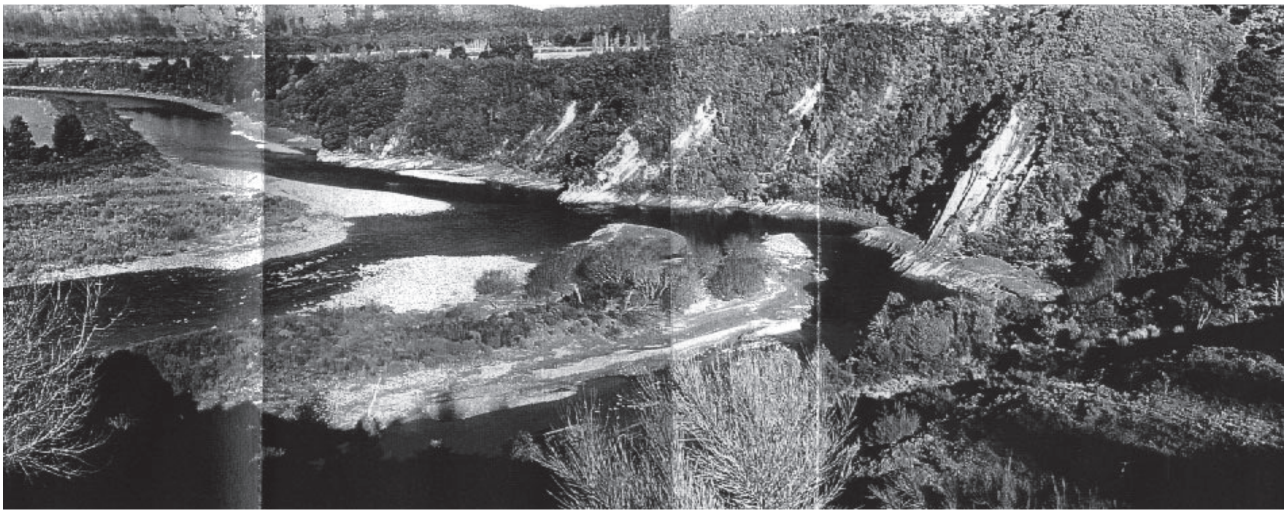
An example of these two steps is presented in Figure 16. In this example, a photographic record is used to illustrate the relationship between flows and the river landscape. Using this approach, decisions can be made on the flows needed to meet the landscape Instream Management Objective.

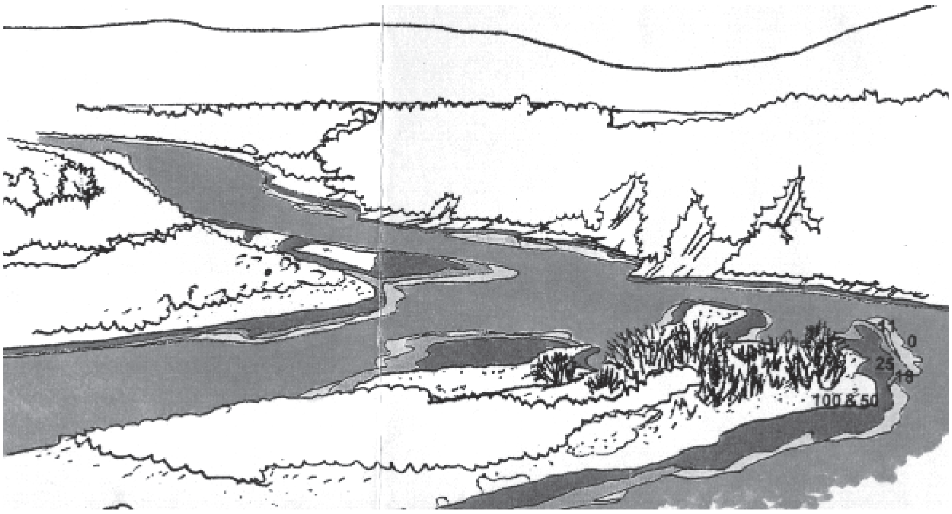
The same factual data could be used as a basis for studies of public perceptions and preferences. This will be a particularly appropriate approach if aesthetic and popular values have been identified.

As with any assessment or evaluation of largely qualatative issues, experience and judgement in choice of method and sophistication of techniques is crucial. In many cases the level of detail discussed in this section may not be justified. Where major rivers are concerned a detailed assessment of the full river, reach-by-reach, may be based on an understanding of the existing/natural flow regime and the diversity of "landscape" value that may be affected.

Fig 16: Landscape assessment from the Waiau River Resource Consents Process (courtesy ECNZ)

This illustration is taken from the Waiau River investigation report prepared by Boffa Miskell Limited for Electricity Corporation of New Zealand Limited and is reproduced with their permission.





Location	0 cumecs	11 cumecs	18 cumecs	25 cumecs	50 cumecs	100 cumecs
Mararoa Weir	0	11	18	25	50	100
Sunnyside	49.0	57.3	50.0	62.3	196.0	177.0
Clifden (river levels)	0.88mm	0.9m (estimated)	0.935m	1.07m	1.60m	1.48m
Tuatapere	71.0	91.4	66.0	92.0	202.0	181.0

Viewpoint 11	**Sunnyside**	
Naturalness	Fairly high. The river itself appears natural although exotic trees are dominant. The wider landscape is heavily modified farmland.	
Changes under different flows	In these photographs there is little difference between the 0 to 25 cumec flows. The 50 and 100 cumec flows do give the impression of a larger, faster flowing river.	
Effects of tributary flows	the flows measured at Sunnyside were:	
	Controlled Flow at Mararoa	**Flow at Sunnyside**
	0	49.0
	11	57.3
	18	50.0
	25	62.3
	50	196.0
	100	177.0
Water area differences	The increase in water area is very minor between zero and 25 cumec flows (5% ±). A further increase of 10% ± occurs with the 50/1 00 flows.	
Elements	The most apparent change is from a small river meandering through a rock and gravel bed in the 0-25 cumec flows while the 50/100 flows spread across the width of the bed.	
Users	This viewpoint required crossing an electrified fence although glimpses are possible along Sunnyside Road. There are a number of cribs on the opposite bank which suggests this is a popular fishing spot.	
Comments	Only those very familiar with the river would be aware of the differences between flows. The most likely people to use these reaches are anglers. Caution: the contribution of controlled weir flows of less than 25 cumecs	

14.4 Remedying and mitigating effects on landscape values

Landscape values will depend on various flow characteristics, such as variability or low flows. It may be possible, however, to remedy or mitigate adverse effects from a proposal in ways other than by meeting flow regime requirements. Landscape improvements to the riverbanks or in-river works to create pools or riffles for example might maintain aesthetic or popular values despite substantially reduced low flows. If this is possible, it will be necessary to consider the next priority area, as the revised low flows may have unacceptable consequences there. For example, it may have been possible to mitigate loss of aesthetic and popular values through in-river bed modification so that a flow reduction of 40 per cent is feasible rather than 10 per cent. This might result in the second priority location becoming critical. Here, less than a 20 per cent flow reduction may be required to maintain "wild" characteristics. If the adverse effects at this location cannot be mitigated, then a 20 per cent change to low flows would be the flow regime required to support the landscape values for that river. It may of course be possible to remedy and mitigate effects on second priority concerns and so on. The minimum acceptable flow regime will be one that retains all the significant landscape values either through flow management or through remedying and mitigating any adverse effects resulting from the flow regime modifications.

In some cases actions such as weed control may protect the landscape values. This would mainly apply to rivers with large, exposed shingle banks.

It may be possible to meet some landscape values through flow releases at certain times of the day. This type of solution would be applicable to rivers with high natural character on popular tourist routes. Tourist operators could be advised when flows were to be "just right" for landscape values and take tourists to the river at these times.

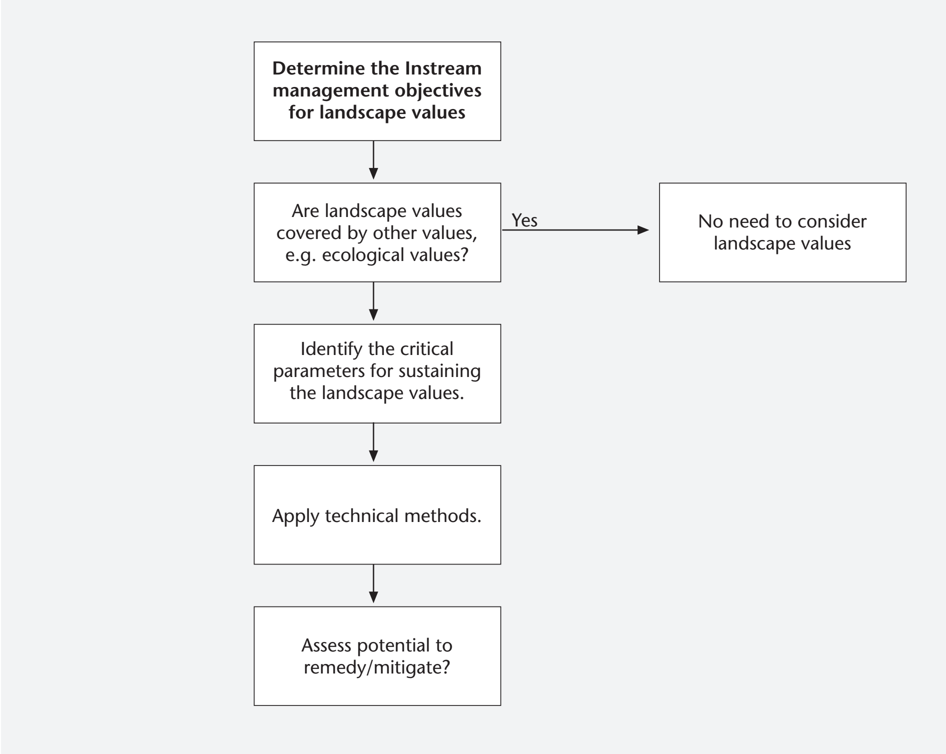
14.5 Summary: Process for setting Flow Regime Requirements for landscape values

Methods for setting Instream Management Objectives and Flow Regime Requirements for Landscape values are not well developed in New Zealand. Better methods are needed, given the importance of landscape values in flow management issues in New Zealand.

There are strong overlaps between landscape and other instream values. Flow regime requirements for these other values may ensure that landscape values are sustained.

The process for setting flow regime requirements for landscape values is set out in Figure 17 below.

Fig 17: Summary of decision-making process for landscape values



15. Flow Regime Requirements for Instream Recreation Values

This chapter describes approaches for establishing Instream Management Objectives for recreation and setting flow regime requirements.

It is difficult for any recreation planner to understand the resource requirements for all recreation activities on rivers; there are so many users, activities and subjective values, which all change over time. The information required to analyse resource requirements for river recreation are, however, generally quite accessible-from the users themselves. This chapter focuses on methods for obtaining recreation information in a systematic and targeted manner.

Some common recreation planning assessment tools are briefly described in Volume B, Chapter 8.

See Volume B, Chapter 8.

15.1 Instream Management Objectives

Options for setting Instream Management Objectives for recreation can be divided into two categories:

See Volume A, Chapter 8 for guidance on assessing instream values for recreation.

- **Maintaining the status quo recreation values:** Retaining the status quo would maintain all recreation activities at their existing level of availability and character, and this would infer that no user would register increased dissatisfaction. However, at least one recent survey (Booth et al, 1994) and the evidence tabled in many water conservation orders indicates that just the knowledge that a river is controlled may degrade, to some extent, the recreational experience (regardless of the effect on the flow regime). This should be kept in mind, particularly where the natural character of the river is perceived to be a key element of an experience.
- **Targeting certain activities at certain times:** A controlled flow regime may improve some recreational activities. River stretches may become swimmable, flows may be more predictable for kayaking and rafting, and new activities may become possible (such as fishing for salmon or rowing on a hydro lake or behind an irrigation dam).

See Volume B, Chapter 9.

15.2 Identify critical parameters

The critical parameters will vary from activity to activity. The critical parameters for the four categories of recreational values are as follows:

- **Paddling or floating activities**: Depth of passage and amount of white water, holes and waves. Certain waves may only exist under particular flow conditions.

- **Angling:** The critical parameters are discussed in *Chapter 12: Flow Regime Requirements for Instream Ecological Values*. It should be noted that optimal ecological conditions may not necessarily relate to optimal angling conditions. In some cases it will be necessary to identify critical parameters that relate directly to angling.
- **Swimming:** Critical parameters include depth, velocity and clarity.
- **Jet boating and other motorised activities:** Depth is a critical parameter

Clearly, hydraulic conditions (width, depth velocity) are critical parameters for a number of recreational activities. Table 9 gives guidance on the hydraulic parameters needed for most river-based recreation activities.

See Volume A, Chapter 8; Volume B, Section 8.1.

Quality recreation activities, however, are not confined to what would be considered ideal or even minimum conditions. It should be remembered that a quality recreation experience can be had in virtually any setting, i.e. it is important that water managers engage in dialogue with recreationalists. The information provided in these guidelines should not be used as a substitute for consultation with river users.

Table 9: Instream hydraulic conditions that will support various recreational activities (Amended from Mosley, M.P. 1983).

Activity	Water surface width m, depth m, velocity ms^{-1} requirements			Preferred Sediment Requirements	Preferred Other Requirements
	Minimum	Maximum	Preferred		
Paddling/ wading	W - D - V -	W - D 1.2 V 1.8	W - D 0.4-0.6 V <0.5	Sand and gravel preferred. Algal or silt coating undesirable No debris, broken glass etc.	Bacteriological and toxicant water quality standards to be met. Water temperature 15-25°C preferred. DxV product less than 1.0. Bottom visible. Easy access and sloping beach desirable
Angling/ wading	As above	As above	As Above	As above	As above, and/or fish habitat requirements Water temperature below 19°C is desirable, as trout stop feeding at higher temperatures.
Swimming	W 5.0 D 0.8 V -	W - D - V 1.0	W >10.0 D 1.5 V <0.3	As for paddling/wading.	As for padding/wading. Length of channel useable >50 m. For diving from bank, D $\geq$2.0 m
Tubing/ drift diving	W 5.0 D 0.3 V -	W - D - V -	W - D 0.8-1.5 V 1.0-2.0	As for paddling/wading. For "white-water" form of sport, as for rafting/canoeing.	No hazards-overhanging/submerged trees, etc. Bacteriological and toxicant water quality standards met. Bottom visible. Water temperature 10-25°C Access at top and bottom of reach to be travelled. Class 11 or 111 on international scale. (1 or 11 for drift diving). Obstacles can be portaged. Slots between rocks >1.0 m

Activity	Water surface width m, depth m, velocity ms^{-1} requirements			Preferred Sediment Requirements	Preferred Other Requirements
	Minimum	Maximum	Preferred		
White water rafting/ canoeing	W 7.5 D 0.2 V -	W - D - V 4.5	W >20.0 D 0.8-1.5 V 1.0-3.0	Presence of large boulders and bedrock outcrops to provide interest. Sediment on riffles of gravel size and not angular to minimise wear and tear.	As for tubing/drift diving except, Class II to IV on international scale. Slots between rocks >2 m.
Tramping* (riverbed routes)	W - D - V -	W - D 1.2 V 1.8	W - D - V -	Gravel bed desirable for easy travel. Algal or silt coating undesirable. Stable boulders, rock outcrops and small waterfalls desirable for interesting travel.	DxV product less than 1.0 on skewed gravel shoals for easy crossing, or footbridges available. River does not impinge on bluffs, to minimise need for river crossings, Floodplain or terrace surfaces present for easy travel. Water temperature >10°C. Bottom visible.
Angling (bank).	W - D - V -	W - D overbank V -	W as for fish D habitat V preferences	As for fish habitat preferences. No snags on stream bed.	As for fish habitat preferences, and: Easy access to and along bank. Stable (non-caving) bank.
Angling (boat).	W 7.5 D 0.3 V -	W - D - V 3.0	as for fish habitat preferences, and W >7.5 D 0.6-1.5 V <1.5	As for angling (bank)	As for fish habitat preferences. and/or As for boating (non-powered)
Boating (non-powered)/ rowing/ flat water canoeing.	W 7.5 (20.0 rowing) D 0.5 V -	W - D - V 1.5	W >20.0 D 0.6-1.5 V <0.5	Sand bed preferable. No snags on stream bed.	No snags in stream. Easy access to river No hazards - weirs, etc.
Sailing.	W 30.0 D 0.8 V -	W - D - V 0.5	W >60.0 D ~1.5 V ~0.0	As for boating (non-powered)	As for boating (non-powered).
Flatwater power-boating (low power).	W 7.5 D 0.6 V -	W - D - V 3.0	W >30.0 D ~1.5 V <1.5	As for boating (non-powered)	As for boating (non-powered).
Flatwater power-boating (high power)/ water skiing.	W 30.0 D 1.5 V -	W - D - V 4.5	W >90 D ~3.0 V <1.5	As for boating (non-powered)	As for boating (non-powered).
Jetboating.	W 5.0 D 0.1 V -	W - D - V 4.5	W >5.0 D >0.6 V <4.5	As for white water rafting.	Easy access to river. Minimum depth over riffles >0.2 m. No hazards - weirs, submerged piles, overhanging trees, etc. Bottom visible.
Camping (for water supply and washing bathing).	W 0.5 D 0.1 V -	W - D - V -	W - D - V -	As for paddling/wading.	As for paddling/wading.

* *Width, depth and velocity criteria for tramping in river gorges must be relaxed, when swimming across pools is expedient. The extreme form of this activity is pack floating, for which sport hydraulic criteria can hardly be set.*

See Volume B, Chapter 8.

15.3 Remedying and mitigating effects on recreational values

There are many examples in New Zealand where flow regimes are managed to continue to cater for recreation, albeit in an altered style. These include:

- Controlled releases of water for rafting and canoeing activities. This may result in congestion at these times, and removes the opportunity when water is not released. May be suitable for special events, such as kayak slalom courses. Timing is very important (there is no point in a release on a mid-winter weekday).
- The provision of alternative activities on the same waterway. This includes lake fisheries (large scale hydro, and small scale irrigation dams such as those in the Maniototo, Otago) and boat activities such as rowing, jet boating, skiing, on dam lakes.
- The provision of alternative activities in other locations, such as offering access to previously restricted areas. This is not common.
- Active river management to maintain activities. This includes digging swimming holes that fill due to altered flow regimes, lowering channels to maintain pooled water.

See Volume B, Chapter 9.

15.4 Summary: Process for setting flow regime requirements for recreation values

Figures 18 and 19 present two approaches to setting flow regime requirements for recreation values. The difference between the two is in the approach taken for early assessment of the acceptability of changes to the flow regime in rivers used for recreation. There is clearly a difference in the investment of time, money and effort between the two. It is necessary however, for resource managers used by recreationists, the response to acknowledge that to a proposed change in flow regime in a river will vary depending upon the type of change proposed.

Fig 18: Common methodology with reactive study (after announcement of proposal)

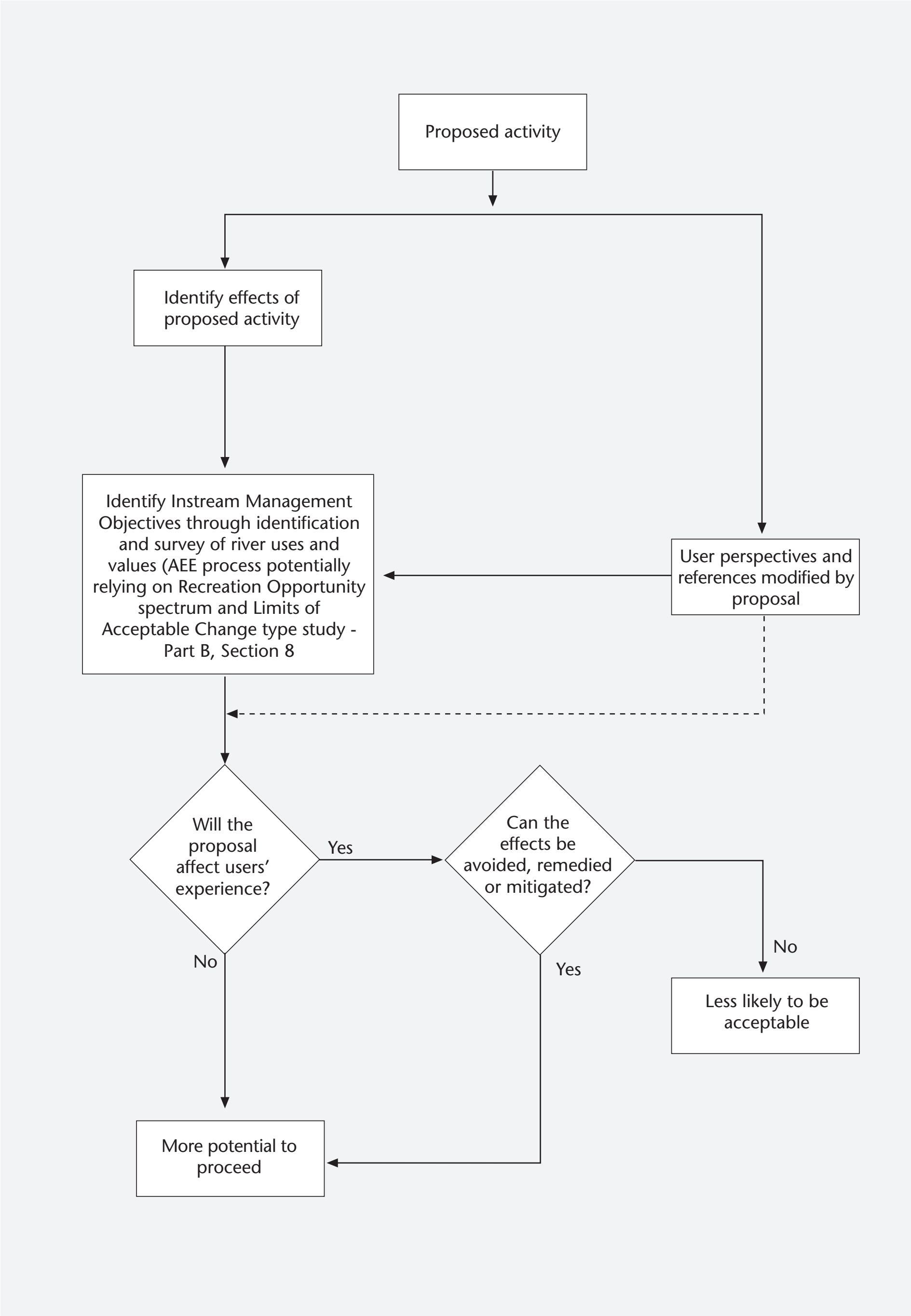
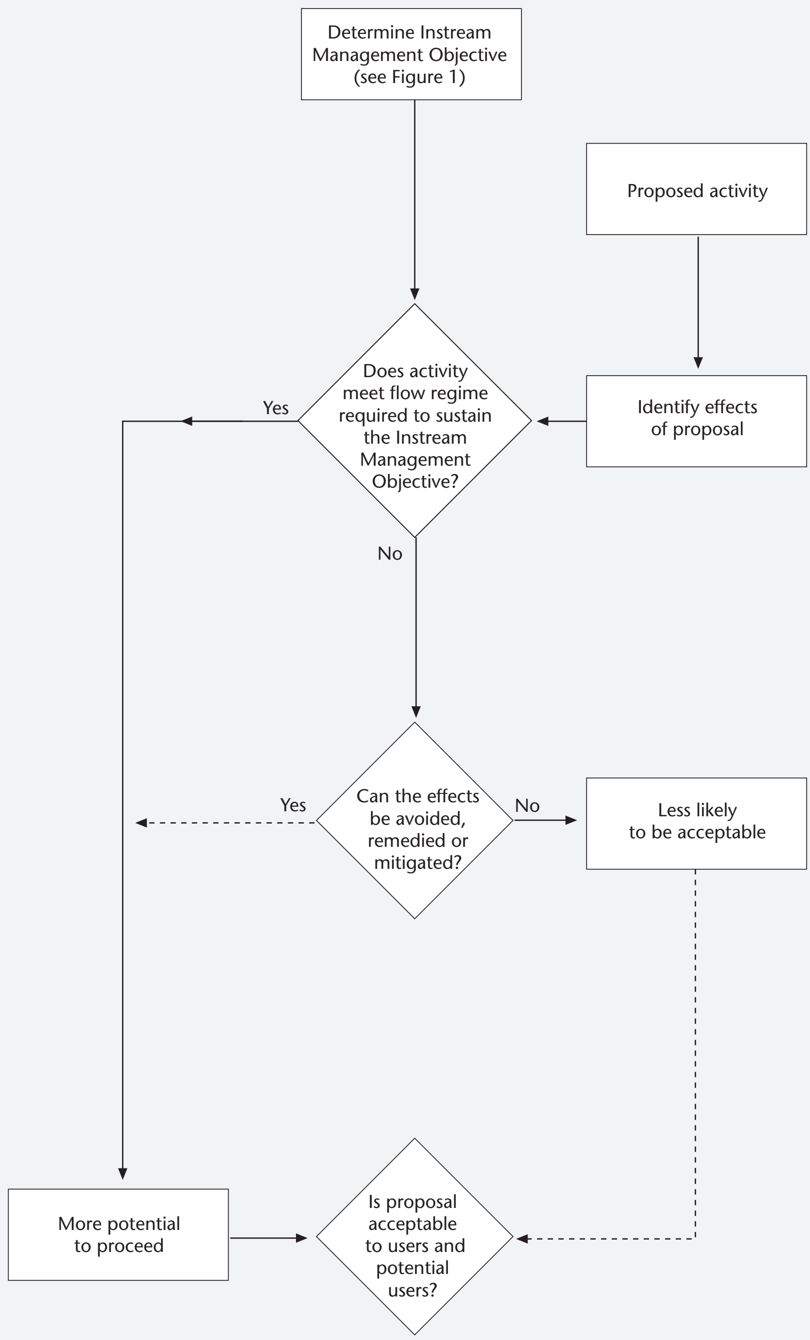


Fig 19: Ideal methodology with pre-study (before announcement of proposal)



15.5 References

Booth and Keys, 1994. Tongariro River Study. DoC, Taupo-Turangi and Tourism Resource Consultants.

Mosley, M.P. 1983. Flow requirements for recreation and wildlife in New Zealand rivers - A Review. *Journal of Hydrology (NZ)* Vol.22 No.2 152-174.)

16. Guidelines for Monitoring the Effects of Change of Flow Regimes

16.1 Types of monitoring

For the purposes of these guidelines two different types of monitoring are defined:

- Consent compliance monitoring
- State of the environment monitoring.

Conditions may be imposed on a resource consent to ensure compliance with any terms and conditions that may have been imposed. These guidelines do not discuss the monitoring compliance of consent conditions.

Section 35(2) of the RM Act gives regional councils a range of responsibilities for monitoring the state of the environment. In terms of these guidelines these section 35(2) responsibilities could be broadly categorised as:

- Monitoring the state of instream values in the region
- Monitoring the suitability of Instream Management Objectives
- Monitoring the effectiveness of Flow Regime Requirements in meeting Instream Management Objectives.

The discussion of monitoring in these guidelines is restricted to monitoring the effectiveness of Flow Regime Requirements (implemented by policy statements, plans or resource consents) in meeting Instream Management Objectives.

16.2 Ecological monitoring

The interaction of flow, physical conditions and ecological responses to changes in these is complex and impossible to predict with certainty. Most prediction of effects will have wide error boundaries. Where possible, allowance should be made in setting Flow Regime Requirements to "fine-tune" the consent conditions to more accurately attain the designated Instream Management Objectives in the context of local natural phenomena. Monitoring therefore seeks to provide information that can help refine the assessment of the Flow Regime Requirement. A philosophy for this monitoring is discussed below.

A chain of ecological responses to changes in flow may ultimately lead to habitat changes which are important to the Instream Management Objective. For example, an Instream Management Objective may be to provide for trout at some specified level. The changes in physical conditions which ultimately may prevent the attainment of this objective can be complex. Reduced flows and increased nutrient concentrations may increase periphyton biomass leading to reduced abundance of invertebrate species that are a food source for fish. Ultimately this may reduce fish abundance. The development of a bio-monitoring programme to monitor the effectiveness of Flow Regime Requirements in meeting Instream Management Objectives must therefore consider which ecological parameters should be monitored.

See Volume A, Chapter 6.

The overriding philosophy in planning a bio-monitoring programme should be that it is cost-effective but generates the information required to refine the Flow Regime Requirement. To achieve this a number of points should be followed:

- The Instream Management Objectives should be clearly defined.
- The Flow Regime Requirement should define the physical conditions (i.e. hydraulic and water quality) necessary to attain these objectives.
- The effects of natural changes in the habitat conditions over time should be documented and understood to allow correct interpretation of the monitoring results. This means that a number of habitat variables, as well as the biota, may need to be monitored.
- A suite of biological parameters should be used which relate closely to the management objectives and are good indicators of changes in the hydraulic and water quality processes of concern. These biological parameters may include measurements of water quality, plant biomass and species composition and animal biomass and species composition.
- Rapid field-assessment techniques may be appropriate for routine monitoring where no specific problems are expected or have been identified.
- A combination of rapid field-assessment and more quantitative sampling methods should be used where specific problems are expected or have been identified.

The frequency at which routine data is collected (possibly by rapid field assessment programmes) will vary depending on the Instream Management Objective and the rate of change in biological parameters. Monthly assessments will suffice for many requirements. Under such a regime, data can be grouped for periods where, say, abstraction is not occurring and compared with periods when abstraction is occurring.

There is no value in having a monitoring programme unless regular reviews of the data are carried out. It is imperative that there is regular (e.g. annual) reconciliation of measured effects with the Instream Management Objective. In carrying out such reviews, it is useful to not only assess whether the Instream Management Objectives are being met but also whether the monitoring frequency and sampling methods and parameters are still appropriate.

Where potential problems have been specifically identified, then more detailed, quantitative analysis may be required. This may include upstream-downstream sampling or bio-assays. This can be complemented with seasonal or annual quantitative sampling during "worst-case" periods or seasons if necessary.

16.3 Landscape monitoring

Monitoring will need to be tied closely to the landscape values that flow regime requirements are tailored to. This will determine frequency, timing and sophistication of monitoring. It is not logical for any monitoring process for landscape to follow the same procedure for setting the original instream flow regime requirements.

16.4 Recreation monitoring

Constant contact with users groups is essential. Periodic formal surveys may be adopted, although it is often equally beneficial to maintain close formal and informal communication with users and user groups to assess reactions to seasonal flow patterns, and the adoption of new recreational activities. For casual users, observational analysis and interviews (formal or informal) are necessary.