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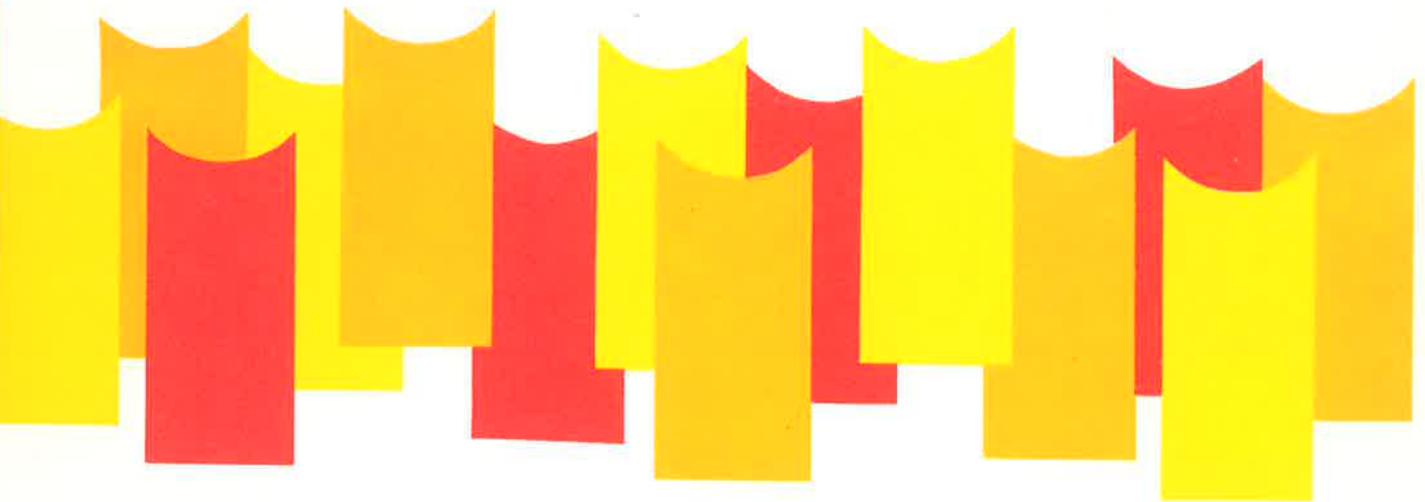
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NO 6

SUGGESTIONS FOR DEVELOPING FLOW

RECOMMENDATIONS FOR IN-STREAM

USES OF NEW ZEALAND STREAMS



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**SUGGESTIONS FOR DEVELOPING FLOW
RECOMMENDATIONS FOR IN-STREAM
USES OF NEW ZEALAND STREAMS**

**(A REPORT TO THE
NATIONAL WATER AND SOIL
CONSERVATION ORGANISATION)**

by

J C FRASER

WELLINGTON 1978

SUGGESTIONS FOR DEVELOPING FLOW RECOMMENDATIONS FOR IN-STREAM USES OF NEW ZEALAND STREAMS

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Australia

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ABSTRACT

This report was written in response to a request by the Water Resources Council, which has been concerned at the inadequacy of information available on the habitat requirements of freshwater fish as a basis for management decisions. The report carried out an assessment of the extent and nature of the research programme on freshwater fish habitat requirements which is necessary to provide a sound basis for management decisions on river alterations. The resources which would be needed for such a programme are outlined. A full description of a suggested investigation programme leading to quantification of flow requirements for New Zealand streams with emphasis on fish is included as an appendix to the report.

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FOREWORD

As a result of a survey carried out in 1976 by the Water Quality Research Committee of the Water Resources Council, it became apparent that there was insufficient information relating to the habitat requirements of fish in New Zealand rivers on which to base sound water resource management decisions. Furthermore, there appeared to be no study programme underway to remedy this deficiency, even though regional water boards and other authorities had urgent need for such information.

The Water Resources Council, after consideration of these findings, requested at its meeting of 16 July 1977 that two reports be prepared:

- a) a critical review of the current state of knowledge of the environmental requirements of New Zealand freshwater fish;
- b) an assessment of the extent and nature of the research programme which could be necessary to supplement the review findings to provide a sound basis for management decisions, and the resources which would be needed for such a programme.

At the request of the Water Resources Council, Mr J C Fraser, Chairman of the Environment Protection Authority of Victoria, visited New Zealand in October 1977 to assist in the preparation of these documents. In the light of his knowledge and experience relating to similar programmes overseas, Mr Fraser prepared this report on:

"Suggestions for developing flow recommendations for in-stream uses of New Zealand Streams". He also assisted Water and Soil Division staff in the preparation of the "Review of the habitat requirements of fish in New Zealand rivers", which is to be published as a Water and Soil Technical Publication by mid 1978.

The Water Resources Council requested, at its meeting of 15 February 1978, that a small working group should be established to investigate the level and manner in which the programme proposed by Mr Fraser should be implemented. In doing so the working group will take a broad overview of the need for research on the habitat requirements of freshwater fish, and the resources which are, or can be made, available in New Zealand to carry out this research. The report prepared by Mr Fraser will undoubtedly be a valuable basis for discussion by the working group.

Comments and suggestions relating to this report would be welcomed from interested parties. Communications should be addressed to the Director, Water and Soil Conservation Organisation, P.O. Box 12-041, WELLINGTON NORTH; ATTENTION: Dr M E U Taylor.



B W SPOONER

Chairman,
Water Resources Council.

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INTRODUCTION

The National Water and Soil Conservation Organisation has asked that I consider the draft information review on the aquatic habitat requirements of fresh water fisheries which has been prepared by your staff and to advise on its completeness and the merits of the information collected under the various section headings. I was also to comment on responses from other agencies, on the usefulness of criteria and any major deficiencies in available information.

Through participation in discussions with your staff, the ad hoc advisory group and written comments on the drafts of the information review and the summary document I have contributed to the points mentioned above.

Our discussions have highlighted the need for development of a process for producing flow recommendations and this report is directed primarily to this point.

In setting forth my thoughts on this subject it should be understood by the reader that my exposure to the problem in New Zealand is limited and any suggestions contained herein should be weighed in that light. Their practicality for application in the New Zealand situation must be judged by those responsible for solving the problem.

THE PROBLEM

Fundamentally the problem is an inability on the part of the government family of agencies to arrive at substantiated recommendations for protection of fish and other in-stream uses in relation to flow (discharge).

A statutory requirement exists to consider the needs of fish in the planning and allocation of water supplies but an acceptable basis for doing so is not available to the planners and decision makers. At the same time the development of New Zealand rivers for hydro-electric power, irrigation, etc., proceeds and competition between uses of water is increasing. The decision makers and planners need answers and recommendations that will stand up under challenge and that can be obtained in a timely fashion at reasonable cost.

The desire has been expressed to have answers immediately by using existing criteria from overseas or some rule-of-thumb, cook book or other expedient measure.

THE PROBLEM OF USING QUICK OR EXPEDIENT MEASURES

First, any expedient or quick measure not founded on known requirements of the aquatic organisms or other in-stream uses involved will fail to produce satisfactory results and

therefore will stimulate rather than resolve controversy.

Formulae or "cook books" to solve the problem do not exist although many useful criteria and guidelines have been developed overseas in the United States, Canada and England. Probably most, if not all, of the overseas criteria would be applicable to New Zealand trout and salmon streams but such an assumption would undoubtedly be challenged if applied. Certainly no, or very few, such criteria exist for the native species of New Zealand. It would be my view that validation of the overseas criteria for salmonids should be undertaken before using them extensively on New Zealand streams.

A rule-of-thumb approach (using a percentage of natural flows) such as the so-called "Montana method" might have to be used on an interim or emergency basis until a better method can be developed. If used it should be recognised by all concerned that it is strictly a temporary expediency and that development of a more substantiated procedure is underway.

Any such rule-of-thumb should be developed through consultation with the various governmental agencies who may be involved in or responsible for its implementation so there is a significant breadth of agency acceptance.

As a modification of the "Montana method" and a starting point towards adoption of an interim or emergency rule-of-thumb I suggest the following for consideration:

Optimum or Suitable Flow*	-100%	of the average flow for each month of record		
Acceptable Flow*	-75-99%	"	"	"
Poor-Fair Flow	-30-74%	"	"	"
Unacceptable	-29% or less	"	"	"

*Plus flushing or attraction flows when needed.

By "average flow for each month of record" is meant the average of the flows for a particular month for the years of record.

I should note that the above suggested rule-of-thumb schedule would not create normal or necessarily ideal conditions even in the "Optimum or Suitable Flow" category. It could result in reducing the peak or flood flows which in some streams may be important to maintaining the normal ecosystem.

SUGGESTIONS FOR SOLUTION TO THE PROBLEM

Attached and included as a part of this report the reader will find an appendix entitled "Suggested Investigation Programme Leading to Quantification of Flow Requirements for

New Zealand Streams with Emphasis on Fish". My following comments relate to those suggestions.

If we accept the premise that many overseas criteria exist for determining fish — water flow needs and that many of them are probably applicable to New Zealand salmon and trout streams then a process geared to use of such criteria would hold the best prospect of producing satisfactory results in a short time.

As the use of such overseas criteria would probably be challenged in part or in whole as to their applicability to New Zealand trout and salmon streams then it may be wise to engage in a brief field programme designed to ratify or validate the criteria under local conditions. Certainly the criteria would not be applicable to the native species of fish. Therefore I have suggested a "Ratification Programme" be carried out for an initial period of two years to check the criteria for salmon and trout. This same programme would also start developing appropriate criteria for the important New Zealand native species. The programme of developing criteria for native species would probably have to be continued beyond year two.

Actual work of making flow recommendations (based on the needs of fish or other uses) could then begin in year three with a fair degree of assurance that the overseas criteria are, or are not, applicable to New Zealand conditions.

I see the need for three other programmes which should be initiated before actual determination of stream flow recommendations commences. One is a fish resource inventory programme designed to yield data on numbers or population magnitude and distribution for the more important streams in New Zealand. Such information is presently scarce or non-existent. It is inevitable that justification of flow releases to the decision makers will require an explanation of resource magnitude. This means that a programme of inventorying fish populations and their distribution should be initiated on a substantial scale at the earliest possible date. If commenced in year one it could be producing useful data on the priority streams by years three and four. It would, of course, have to continue beyond that time to cover other streams and to add to previous data where needed.

A programme of prioritising the approach to determining flow recommendations would be desirable. Obviously, flow recommendations for all of the streams of New Zealand cannot be made simultaneously or even in a two or three year period. Field data must be gathered and analysed, all of which takes time if done properly. Consequently, the work should be related to a prepared priority schedule developed as a result of carefully considered inputs from hydro-power, irrigation, water right and other planning programmes as well as input from the fisheries and recreat-

ion interests on the more important streams. This prioritising programme could be largely carried out in year one with further work in year two so that by year three the flow recommendation programme could commence with a specific and agreed upon priority of work. Updating of the priority schedule would be a continuing but not an especially time consuming task after year two.

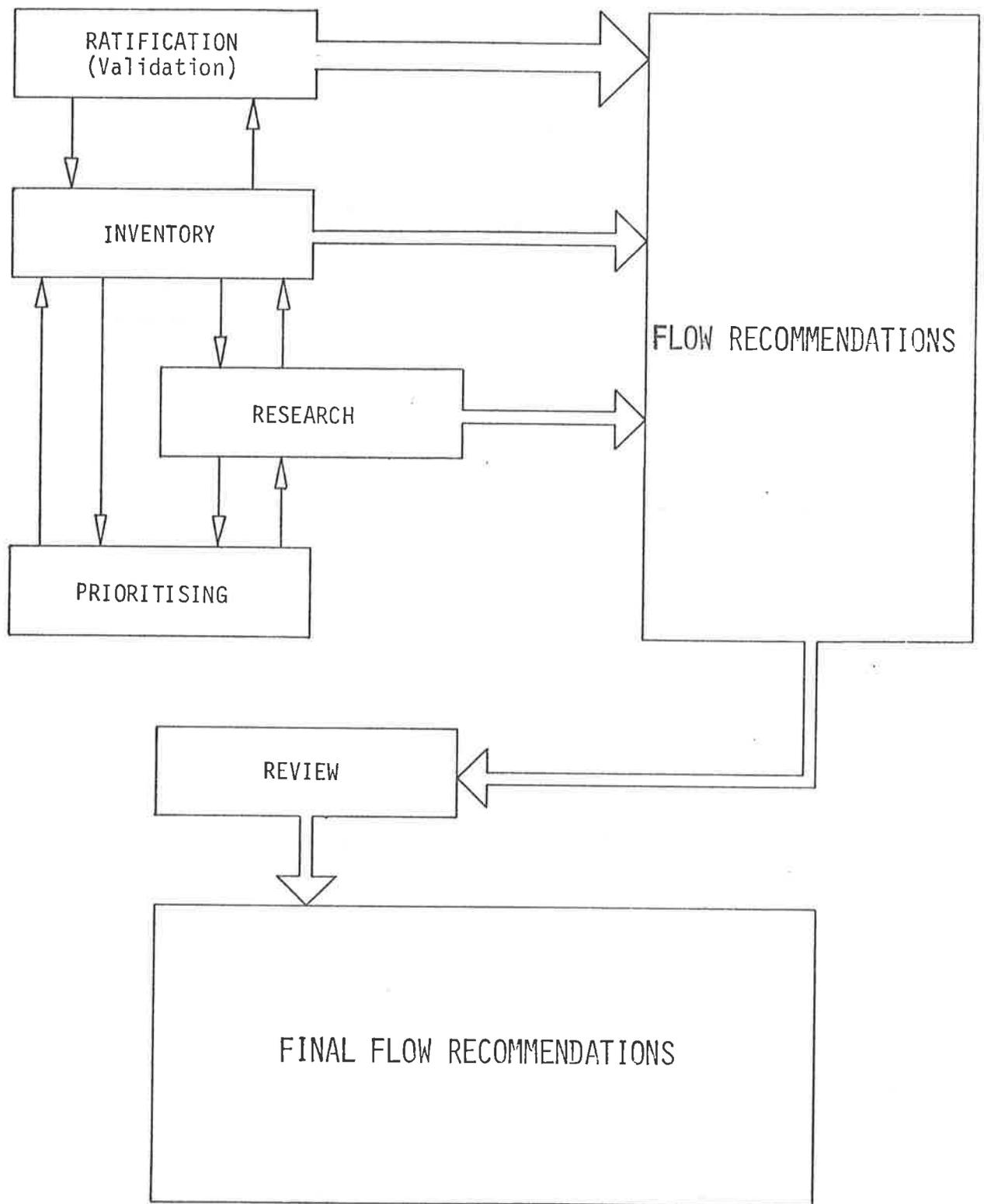
As the foregoing suggested programmes are proceeding, many gaps in scientific knowledge will become apparent and therefore an on-going research programme should be initiated as a supporting element. I would suggest a component type programme where very specific, time-limited studies with specific objectives be undertaken to supply information needed for better formulation of in-stream flow needs for fish and other uses. Care must be exercised that the research projects in this programme are strictly problem-oriented and are directly responsive to the needs of the flow recommendation programme.

Finally, I come to the Flow Recommendation Programme itself, which, of course, is the ultimate purpose of the whole exercise. Using the information supplied by the Ratification, Inventory, Prioritising and Research Programmes, overseas methods and criteria, and its own field data, this programme could commence in year three to produce stream flow recommendations and other recommendations for maintenance of fish resources and other in-stream values. I suggest an initial team consisting of four or five men (biologists, hydrologists, clerical, etc.). The leader and perhaps his principal assistant should commence work in year two so that they can get some familiarisation and preparatory work out of the way and thus be better prepared to commence work on flow recommendations at the beginning of year three.

I suggest also engaging the services of a consulting fresh water fisheries biologist from western United States who has had experience in using stream survey, transect and evaluation methods and who is experienced in the development and use of streamflow related criteria for salmonids. This would greatly influence the speed and efficiency of the programmes during the initial stages, especially the Ratification and Flow Recommendation Programmes. His services would be needed during the first three years of the programmes.

MANPOWER REQUIREMENTS

These programme suggestions are designed to be carried out with a minimum of personnel in as short a time span as possible but considerable effort will nevertheless be necessary. Reasonably reliable flow recommendations cannot be expected without significant effort. The manpower requirements and related factors of equipment, facilities,



CONCEPTUAL INTERRELATIONSHIPS OF SUGGESTED PROGRAMMES
FOR DETERMINING STREAM FLOW FOR NEW ZEALAND STREAMS

CONCEPTUAL TIMETABLE FOR SUGGESTED PROGRAMMES
RELATED TO STREAM FLOW DETERMINATION IN N.Z.

PROGRAMMES	YEAR							
	1	2	3	4	5	6	7	
Ratification *	[shaded]		[shaded] NATIVE SPECIES [shaded]					
Fish Resource Inventory	[shaded]							
Stream Prioritising	[shaded]	[shaded]						
Flow Recommendation (application of criteria)		[shaded]	[shaded]			[shaded]	[shaded]	[shaded]
Research	[shaded]	[shaded]	[shaded]	[shaded]	[shaded]	[shaded]	[shaded]	

- * Involves validation of overseas criteria on salmonids and development of flow preference criteria for native species. The objective would be to complete the validation on salmonid criteria in years 1 and 2 but development of criteria for native species would probably have to be extended into years 3 to 5.

etc., would have to be worked out in detail. In the time frame in which I am working I can only provide preliminary thoughts on the minimum manpower strength needed. There would also be costs for counting stations, boats, vehicles, etc. My consideration of manpower requirements suggests:

- (1) **Ratification Programme** — one or two teams (preferably two) of five or six qualified persons each (biologists, hydrographers, assistants).
- (2) **Inventory Programme** — three to five teams of three to four persons each for intensive mark and recovery and electrofishing work in the first three years on priority streams and continuing effort by three teams after year three to confirm and up-date previous data and to develop data on other streams on the priority list.
- (3) **Prioritising Programme** — one or two individuals (fish biologists) for the first year and one in the second year with part time effort within the Flow Recommendation Programme in the third and subsequent years.
- (4) **Flow Recommendation Programme** — two to four teams of four or five individuals (biologists, hydrologists, clerical, etc.). (Availability of legal and other specialist assistance may be needed from time to time.)
- (5) **Research Programme** — manpower requirements undefined. This programme and its component projects would proceed only as specific research needs are identified and funded. Many of the projects could be carried out under time-limited contracts with universities, consultants, government agencies etc.
- (6) **Consulting Biologist** — should be experienced water project — flow requirement fisheries biologist from western United States (preferably Oregon, Washington, California, Montana, Wyoming or Idaho) where intensive flow recommendation and salmon and trout protection work has been done. His services would be needed during the first three years of the programme plan as I envision it.

CAUTIONS

- (1) Keep the programmes on a practical, problem-solving basis. Avoid "hobby horse" investigation or research work. Avoid involvement of programme personnel in other operations — keep their noses to the grindstone on the objective of developing good flow recommendations using good criteria.
- (2) A stream is a highly complex ecosystem and its productivity for fish is dependent upon many factors some of which are highly variable seasonally and from year

to year. The flow of water (or current), made up of depth, velocity and surface area is the key to river aquatic resources.

A common misconception is that flow or discharge can be substantially altered in volume or time without altering the ecosystem. Any change in the natural flow regime of a stream will have some effect on its productivity — it could be beneficial or detrimental in terms of the interests of man.

The problem is to identify these changes and relate them to the PREFERENCE NEEDS of the plants and animals inhabiting the system.

- (3) Another common fallacy is to assume that if you maintain conditions which simply prevent fish dying from dessication, excessive temperatures, etc., the fish population can be maintained.

Aquatic plants and animals in a stream have adapted over a long period of time to PREFERRED habitat conditions. They inhabit those areas where these preferred conditions occur MOST of the time and at such times when special life cycle functions are being carried out such as spawning.

The preferred conditions may not be present at all times. The organisms may be able to survive temporarily adverse conditions but they cannot maintain a viable population if such adverse conditions occur for lengthy periods or at critical times in their life cycle.

The key to developing criteria for determining flows is to quantify the PREFERRED conditions of the target species. This may mean that the preferred conditions for several associated or competing species might also have to be determined.

There is no substitute for a knowledge of the preferred habitat conditions of the principal species in the ecosystem, but time and availability of funds are seldom sufficient to carry out the desired studies. Therefore, some short cuts are often necessary while at the same time carrying out as much research as reasonably possible to build a better knowledge. For example, criteria have been developed for the preferred flow depths and velocities for spawning, holding, adult migration, etc., for the commercially valuable species of Pacific salmon. Quantifying all the habitat preferences and needs of an individual organism is theoretically possible but for practical purposes in relation to stream flows the following appear to be the most critical (not listed in order of importance):

- (a) Adult migration.
- (b) Spawning.
- (c) Egg incubation.
- (d) Holding.

- (e) Rearing or nursery areas.
 - (f) Food production and feeding.
 - (g) Spatial requirements.
 - (h) Juvenile migration.
 - (i) Water temperature – dissolved oxygen – chemistry.
 - (j) Sediment transport.
 - (k) Shelter.
 - (l) Species composition – competition.
 - (m) Use by man (e.g. angling success, harvestability).
- (4) The paucity of data on the habitat requirements (or preferences) of New Zealand native species of fish is particularly disturbing. Their importance from a commercial or sport angling standpoint is unknown to me but most certainly from the standpoint of their role as part of the ecosystem they are important and their habitat requirements should be quantified.
- (5) The decision makers should be supplied with stream flow recommendations designed or geared to maintaining the resource in a healthy, viable condition – they should NOT be provided with flow recommendations upon which the fish populations can barely survive or which reflect a reduction to “accommodate” abstraction or development. The accommodation or resolution of conflicts between in-stream flow needs and abstraction needs should be resolved in light of and after a knowledge of MAINTENANCE flows is available.
- (6) Good water management calls for determining in-stream flow needs BEFORE consumptive uses pre-empt available water supplies.
- (7) We do not manage our resources properly if we administer them only in reference to today’s needs. If our decisions are directed solely at stimulating today’s economy without thought for future generations we are not fulfilling our role as custodian of those resources. We have an obligation to future generations to save some of the attributes of this world for them – to leave some of the options of management open to them – to pass on

to them a habitat of similar diversity so that they can enjoy and profit by it as we have.

New Zealand rivers are world renowned for their beauty, their productivity for fish, and their service to man in many other ways. This and previous generations have enjoyed and profited by this great resource. Prudent management requires careful husbanding of this resource including its in-place values. This means ensuring that adequate flows are preserved. It means developing a system to provide a sound basis for decision making and it means an acceptance on the part of all involved that this is a needed action – just as needed as developing off-stream uses to bolster the present economy.

- (8) My appraisal is that there is an urgent need to provide greater input on in-stream flow needs to water resource planning in New Zealand. This will require the allocation of significant funds and a concerted effort. Without such action the water resource planning and decision making processes on water development projects will be incomplete and inadequate and will result in largely single-purpose, consumptive-use oriented decisions. This would be most unfortunate. The in-place values of many New Zealand streams are far too great to suffer from such inadequate attention.
- (9) In a situation such as presently seems to prevail in New Zealand, administrators may be inclined to look for ways to achieve a flow of information from a multitude of sources including local entities in order to save costs. I recommend against such an approach in this instance. The problem requires centralised, concerted effort by experts. They will have to draw upon information from local sources but the local entities (such as Acclimatisation Societies, Catchment Boards, etc.) usually would not have, nor could they develop the expertise in a reasonable time to produce substantiated recommendations on flow and other requirements of fish.

APPENDIX

SUGGESTED INVESTIGATIVE PROGRAMME LEADING TO QUANTIFICATION OF FLOW REQUIREMENTS FOR NEW ZEALAND STREAMS WITH EMPHASIS ON FISH

1. **Ratification Programme** – two years (designed to validate or develop criteria for New Zealand streams relating to preferred flows for specific life cycle activities of fish).
 - (1) Quantify for each species of salmonids:
 - (a) Adult migration (including migration stimulation).
 - (b) Holding or resting.
 - (c) Spawning.
 - (d) Egg incubation.
 - (e) Nursery or Rearing (food production and holding).
 - (f) Downstream migration of juveniles.
 - (g) Flushing.
 - (h) Shelter.
 - (i) Water temperature.
 - (2) Quantify for native species – years 1 through 5.
 - (a) Appropriate selected criteria factors for various species such as spawning, migration, temperature, requirements, etc. (This would result in development of flow preference criteria for the more important native species.)
 2. **Fish Resource Inventory Programme** – three years intensive work then continue at reduced level.
 - (1) Salmon – identify:
 - (a) Migration reaches.
 - (b) Holding areas.
 - (c) Spawning areas.
 - (d) Juvenile nursery areas (rearing areas).
 - (e) Areas of upstream and downstream losses (e.g. unscreened diversions, barriers to migration etc.).
 - (2) Trout – (each species).
 - (a) Residence vs migration areas.
 - (b) Holding – feeding areas.
 - (c) Spawning areas.
 - (d) Nursery areas.
 - (e) Production (develop an understanding of the productivity of the stream for trout – how good is the stream?).
 - (3) Native Species – (identify for significant life cycle stages).
 3. **Stream Prioritisation Programme**
 - (a) Resource value or importance (in-stream).
 - (b) Uniqueness or support of rare or endangered species.
 - (c) Development threat (hydro, irrigation, channelisation, etc.).
 4. **Flow Recommendation Programme** – Application of ratified (or developed) criteria from programme 1 to the priority streams (extent of coverage dependent upon size of crew).
 - (a) Development of flow needs based on criteria developed in Programme 1 for:
Salmon
Trout
Native Species.
 - (b) Identify areas of special concern needing full protection.
 - (c) Identify areas of low concern.
 5. **Research Programme** – made up of component research projects aimed at providing a flow of needed information on aquatic organism (including fish) habitat requirements. Each component to have well-defined objective and a specified time for completion.
- ### RATIFICATION (VALIDATION) PROGRAMME
- Recognising that rule-of-thumb approaches to quantifying flow requirements of fish are undesirable and recognising that criteria developed overseas may or may not be applicable to New Zealand streams and fishes a need exists to validate (or reject) the criteria developed overseas for quantifying the flow requirements of fish. Once this is done the ratified criteria could be used and new criteria could be developed for those found unsuitable to New Zealand conditions.
- Existing methods in western United States could form the basis for testing the criteria in New Zealand streams for salmonids. For example, the depth, velocity preferences of salmon and trout during spawning could be checked in New Zealand streams by using stream transect methods on actual spawning beds. Similar approaches could be used for adult migration, holding, egg incubation, juvenile migration flows, and food production flows.
- I suggest that one or two teams each consisting of five or six biologists and hydrologists with appropriate field and clerical assistance could do most of the validation work on salmonids in about two years. Their task would be to determine the validity of existing American stream flow fish preference

criteria under New Zealand conditions and to identify areas where new criteria or new methods must be developed and to do so where time permits.

The ratification (or validation) programme should be geared to produce results in two years with allowance for minor extensions in areas requiring a third year check.

It would be advisable to engage the services of a United States Biologist who is familiar with the methodologies involved as a consultant to the programme at least in its initial stages and then periodically including a final review period.

Upon completion of its validation work the team (and its developed expertise) could be transferred and applied to the Flow Recommendation Programme.

Since few, if any, habitat preference conditions related to flow have been developed for the New Zealand native species it poses a special problem. Work should commence on the important species as soon as possible. Hopefully sufficient knowledge could be developed in the two year Ratification Programme period to provide a reasonable basis for in-stream flow recommendation work on priority streams.

STREAM PRIORITISING PROGRAMME

Obviously the Flow Recommendation Programme cannot be applied to all the streams of New Zealand in a one or two year period following the Ratification Programme. A guess is that two to four teams could develop flow requirements for three to five major streams in two years. By increasing the number of teams a doubling of this accomplishment might be achieved but a declining efficiency factor (lack of experienced supervisors) with increased numbers of personnel in the first two years should be recognised.

Because of these limitations it would be advisable to apply the Flow Recommendation efforts to the more important (valuable) streams where development or abstraction is imminent and where answers on flow requirements are most urgent. This involves the development of a priority listing of streams needing attention and a time schedule of probable events for each stream. Such an analysis could be developed by one or two individuals in year one and completed in year two. Continuous updating and refining would be necessary thereafter.

Early input from this Prioritising Programme would be needed to the Flow Recommendation Programme — probably at the end of year one. Very early co-ordination between this Prioritising Programme and the Inventory Programme would be necessary because the Inventory Programme should also be geared to the priority needs and some early decisions would have to be made as to where the inventory efforts would best be concentrated.

Development of a priority listing will require planning schedule inputs from the water and hydro-electric developing agencies and inputs from fisheries agencies, water boards, acclimatisation societies, etc.

INVENTORY PROGRAMME

As the pressures for development and abstraction on rivers increase the competition for the available water intensifies. The in-stream resources compete with abstraction and inevitably questions of comparative values on importance are raised. If a fish resource is involved the legitimate questions are:

- 1 How many fish?
- 2 How important?
- 3 Value? (Not necessarily in monetary terms.)

The importance and value questions can only be dealt with after the resource has been quantified to a reasonable degree.

An inventory of spawning runs is essential to evaluating salmon streams and consequently in evaluating their requirements for water. A river with a run of several thousand salmon deserves far greater attention and protection of in-stream flows than a river with a vestigial run and no potential for improvement.

Inventory data are important in prioritising the work of making stream flow recommendations.

Resident trout streams need to be evaluated more in terms of their importance as producers than in terms of actual numbers of residents or migrants. Electro-fishing methods for population sampling could be used as a means of estimating species composition, size distribution, standing crop, etc. From such data a rating system for trout streams could be developed based on relative production.

Salmon counts would probably necessitate establishment of some counting or capture stations at key locations combined with a mark and recovery programme.

An assessment and distribution mapping of native species should also be accomplished. Special attention should be given to species of commercial and sporting angling significance and to any rare or especially unique species whose preservation could have significance to future faunal representation.

Without reasonably good inventory data a programme to protect fisheries cannot be effective.

RESEARCH PROGRAMME

On-going research is an essential ingredient to a programme of protecting in-stream resources. But it should be kept separate

from the urgent programmes designed to give management decisions. It should be designed and controlled to provide a continuous supply of needed information to the management programmes (Ratification, Inventory, Prioritising and Flow Recommendation Programmes). The research needs of these management programmes should be continuously identified, prioritised and fed into the research programme which should be made responsive to and answerable to those needs. The Research Programme should not be carried out by the people involved in the Ratification, Inventory Prioritising or Flow Recommendation Programmes but it should be responsible to someone who also has responsibility for the overall conduct of these other programmes to ensure co-ordination and relevance of the Research Programme.

The following is a list of examples of the types of subjects which might be undertaken by this Research Programme.

- (a) In-stream invertebrate (food production) and flow relationships in New Zealand streams.
- (b) Microhabitat preferences of salmonids and native species (for each species and appropriate life stages) particularly in nursery areas.
- (c) Species interaction and competition in New Zealand streams.
- (d) Quantification of cover values.
- (e) The interaction of cover distribution, heat stress, low flow conditions and fish behaviour and production.
- (f) Temperature – flow relationships in New Zealand streams.
- (g) Effects of channelisation on aquatic resources.
- (h) Importance of streamside vegetation to fluvial resources including temperature, cover, erosion control, food production (energy flow).
- (i) Native species characteristics:
 - (1) Spawning times and requirements.
 - (2) Swimming endurance.
 - (3) Preferred depths, temperatures, conditions, etc.

(4) Shelter requirements.

(5) Food requirements.

- (j) Methodology development.
- (k) Quantitative relationships of flow reductions to fish production.
- (l) Spatial requirements of important species.
- (m) Comparative values of substrates in New Zealand streams (food production, spawning of fish, etc.).

FLOW RECOMMENDATION PROGRAMME

After the support programmes (Ratification, Inventory, Prioritising) have progressed sufficiently to provide a suitable base for developing actual flow recommendations then the principal effort of this entire exercise can begin.

I would envision two to four teams of four or five individuals each (biologists, hydrologists, clerical, etc.) could develop flow recommendations and fish protection recommendations on three to five or even more medium sized streams after the first year of field work. It would be necessary for these teams to do stream survey work using transect methods and acceptable habitat preference criteria for the species of fish involved before compiling defensible flow recommendations.

With time the personnel assigned to this programme would develop considerable expertise and the speed with which they could deal with individual streams would increase. Large rivers pose special problems and therefore it is not possible to estimate exactly how many streams can be treated by this programme in a year. In fact each stream poses a different set of problems to the survey team so some experience will be necessary before reasonable advance estimates of work accomplishment can be made.

The important aspect of this work is to obtain field data in a consistent manner with standardised, accepted methods by people trained in the task. As the programme teams increase their expertise the planners and decision makers will be more willing to accept their findings.