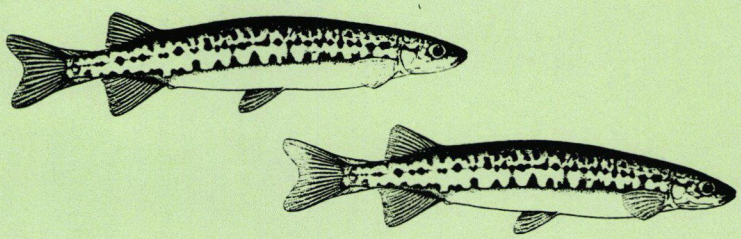
ENHANCEMENT OF WHITEBAIT HABITAT IN THE LOWER WAIAU RIVER

REPORT PREPARED FOR THE WAIAU RIVER WORKING PARTY
by:

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EXECUTIVE SUMMARY

An examination of whitebait samples from the Waiau River found that the fishery was dominated by juveniles of the common whitebait or inanga (*Galaxias maculatus*). Results of sampling in the lagoon area clearly showed that this species was the most abundant whitebait species. As normal for New Zealand rivers, sampling throughout the Waiau catchment found that inanga was restricted in distribution to lowland sections of the Waiau River.

ECNZ has indicated that it is prepared to support habitat enhancement of fisheries on land which it owns in the lower Waiau River valley, adjacent to the lagoon. This study recommends that any habitat enhancement should be focused upon *Galaxias maculatus*. But it is also recognised that eels and waterfowl would benefit from work done to enhance whitebait.

Field studies showed that shallow lagoons and ponded areas around the margins of the lagoon were favored micro-habitat for *Galaxias maculatus*. This fish had also moved considerable distances through areas that were only intermittently wet, in order to colonise shallow ponds lying in old river channels. In these habitats, inanga appears to have a competitive advantage.

It is suggested that the best way to enhance whitebait stocks in the Waiau Lagoon would be to create more shallow ponded habitat. However there are some difficulties with this approach. The major problem is that the soil type, even in the wettest areas of farmland purchased by ECNZ, is still a relatively light and free draining soil. The area has largely been built up by repeated deposits of flood borne sands and gravels.

It is impracticable to divert from the nearest water supply, the lower Holly Burn, to create a series of ponds across this area. To create permanent ponded areas in the pervious soils of the Waiau River delta requires that excavations be made below the water table. This is more costly than simply building contour dykes, as could be done on less pervious soils.

A worthwhile habitat enhancement project requires that a significant area of habitat be constructed. Constructed habitats should not detract from natural values. They must be practical and economic to construct and durable in the face of the repeated flood events to be expected in this area.

It is recommended that an existing series of former river channels, which lie close to or slightly below the water table through the area, be deepened to provide permanent ponding. In this way some 5.7 km of habitat could be constructed, plus one ponding area of 370 m^2. At present the length of habitat suitable for inanga is estimated at 320 m. Simply deepening the existing channels throughout their length will allow groundwater to be intercepted. This alone should provide the modest water flows which inanga require.

Based on a cost of $ 0.7 per cubic metre to move material with an excavator, the cost of the project would be within $ 30 000. Apart from the excavation there will be minor costs for supervision of the work. Other costs include replanting native vegetation and provision of educational and display material.

There will be an ongoing requirement to clear weeds and debris from the channels in succeeding years. Maintenance costs averaged at $ 5 000 - $ 10 000 per annum for a cleaning every 2-3 years have to be considered. There must also be provision for the farmer to run sheep only, on this area of the ECNZ lease. Excluding cattle will significantly reduce maintenance costs and will assist wetland vegetation regeneration.

Once the work has stabilised there should be an investigation of the densities of inanga that develop over summer in the canals. Based upon this information, gradual improvements to the design and thus the productivity of the system can then be considered.

This work will have significant implications for the design of wetland restoration projects around New Zealand.

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INTRODUCTION

Whitebait are the seagoing juveniles of small native freshwater fish in the genus *Galaxias*. Examination of a series of whitebait samples collected in spring 1993 from the Waiau River showed that 62% of 120 fish were the juveniles of *Galaxias maculatus*, the common whitebait or inanga. For a number of reasons, including their short life-cycle, and tolerance to both poor water quality and the effects of agricultural development, common whitebait are the species of obvious interest for any project to enhance whitebait production.

Common whitebait lay their eggs on stream margins flooded by spring tides or floods. After hatching when resubmerged, whitebait are washed downstream as larvae 7-8 mm long. Over the following spring they return to freshwater as whitebait, a much sought after delicacy, small transparent fish, 48-57 mm long. Those fish which escape the nets move into lowland freshwater habitats and grow to sexual maturity over summer. In autumn they return to the same stream margins used for spawning in previous years. After spawning most fish die, few survive a second year.

Whitebait fishing is a popular activity in the lower Waiau River. People come from the local community and from surprising distances throughout Southland to fish. The catch is usually minuscule and there is plenty of time to sit on the river bank developing theories as to why there are so few whitebait about. One obvious target is ECNZ and the effects of their "taking the water away". It is unlikely that this has in fact been the case. But as a public relations gesture, it could be relatively easy for ECNZ to do something about two of the (many) factors which control whitebait abundance; adult habitat and spawning habitat. The aim of this report is to examine the possibilities for providing a significant increase in the amount of whitebait habitat in the lower Waiau River.

The first requirement is to understand precisely where whitebait live in the Waiau River and what environmental factors are important to them.

Observations on the distribution of this fish were made as part of fisheries investigations in the Waiau River Catchment (Mitchell & Davis-Te Maire 1994, McDowall 1994). Inanga were found throughout the Waiau lagoon and in the lower river. Fresh run whitebait (in ones and twos), were seen in the Waiau above Tuatapere, after the river had been low and clear for a time. Inanga were even found at a surprising elevation in Saddle Creek, on the first river terrace. However the lagoon must be considered the centre of distribution of this species. Small inanga together with freshrun whitebait were common along the shallow vegetated margins along the northern shore of the eastern lagoon. Inanga were also abundant in a spring fed wetland on the West Bank (the Blue Hole), and numbers of fish were observed in the outlet channel draining into the river. This channel has since been found to be used by inanga as a spawning area (P. McClelland 1994).

But it was in small ponds and channels, intermittently connected to the lagoon by flow through rush and grass lined channels, that inanga were most abundant (Fig 1).

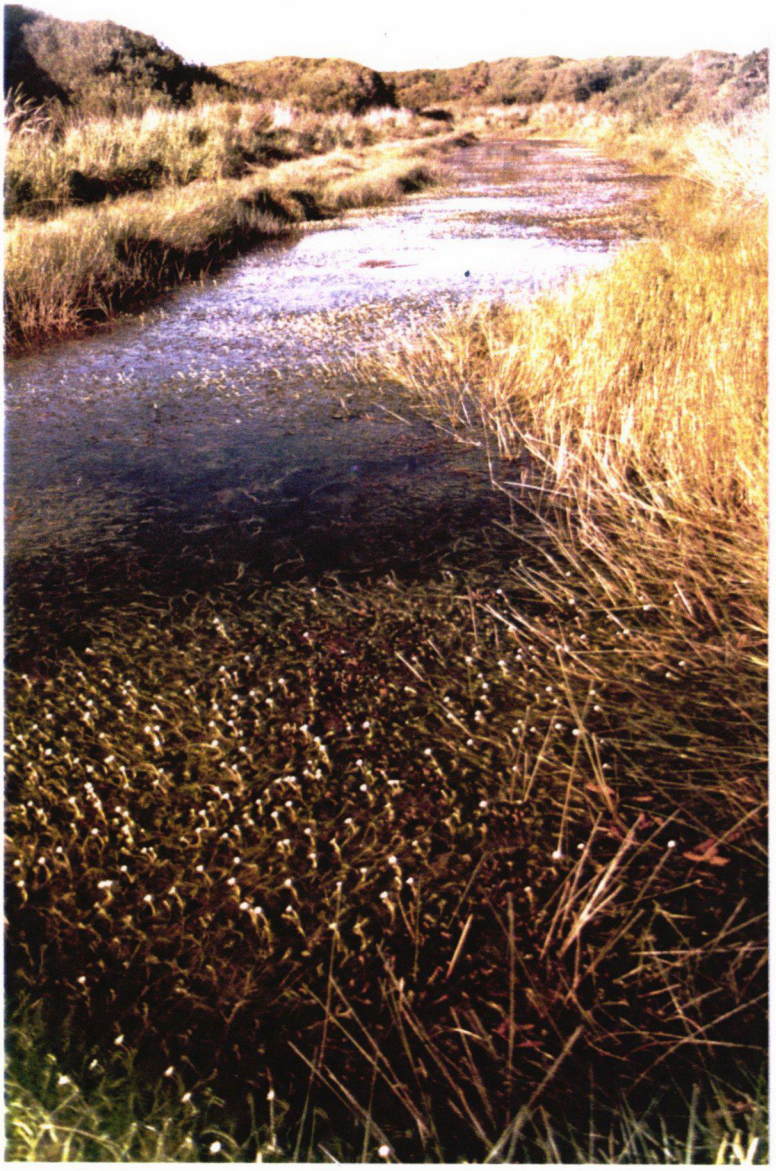


Fig 1. Site where the greatest concentration of inanga was found in the Waiau River - a cutoff stream channel

Large shoals of inanga appeared to dominate the fish community in this type of habitat, although longfinned and shortfinned eels were probably also common. McDowall and Eldon (1980) noted that inanga seek out temporary ponds and wetlands in Westland and commented on the risks implicit in this behaviour. Even the logistics of returning back to the tidal portion of the estuary for spawning in autumn would appear dependent upon flooding at the right time. Survival of the eggs may also be affected by autumn rainfall. In the Waikato River, dry autumns have been shown to be well correlated with poor whitebait catches the following spring (Stancliff et al 1988).

Development of agriculture in New Zealand has invariably been accompanied by a decline in the whitebait fishery. This was noted by McDowall (1968).

Farmers have worked over the lowlands, converting native forest and swamps into farmland. One of the major impacts upon whitebait from this process is the destabilisation of catchments by accelerated erosion rates. Conversion of native forest to farmland results in a change to stream ecology, dominated by the response to massive inputs of soil and the effects of opening the stream to the sun. If the land is relatively flat and thus less erosion prone, common whitebait will tend to persist in larger streams. The other kokopu species are much more sensitive and usually disappear.

Common whitebait appear to prefer small streams and swamps. These areas are disproportionately affected by farming; from trampling from stock (particularly cattle) and from attempts at drainage. Inanga can remain in the resulting drains, provided they hold permanent water and they are not too shallow. But in many cases these small streams eventually become only damp swales, with a dense growth of aquatic or marsh plants along the bottom. Eels can persist in the depths of mud formed by eroded topsoil, where there is some water flow, but the whitebait species are too sensitive to survive.

Larger waterways tend to be used by river control engineers as conduits to carry floodwaters away to the sea. There is seldom provision for fish habitat in the improved and straightened channel. Stopbanks and pumping stations often seal off the productive meanders and old stream channels which adult whitebait and many other native fish prefer. More habitat is lost.

Early observers recorded that whitebait tended to penetrate into all waters, even the most impermanent ponds and streams. McDowall & Eldon (1980) saw this behaviour in Westland and commented on the losses of fish possible if the resulting summer was dry. What has been less closely considered is why whitebait should take the risks implicit in colonising these types of habitat.

Thus there are probably selective advantages in this behaviour. Temporary bodies of water can often be very productive. Minerals and nutrients oxidised by exposure to atmospheric oxygen are soluble and readily available to plants and bacteria. New food chains are often very simple and thus there can often be a considerable surplus of production available to feed fish. Copepods and ostracods, plus insects such as waterboatmen, midge and mosquito larvae may become very abundant. In addition to this high productivity, the water temperature in shallow coastal ponds can become

higher than nearby, deeper, flowing water. Growth of cold-blooded animals such as fish can vary directly with the temperature. Obviously the reproductive output of large, well fed fish will be much greater than small underfed specimens. Feeding trials with inanga have in fact shown this (Mitchell in prep).

Scaleless fish such as common whitebait and eels, capable of respiring atmospheric oxygen through their skins, are well adapted to penetrating through small, intermittent stream flows to colonise ponds and marshlands. Most native freshwater fishes are generalised invertebrate predators and feed on identical food items. Inanga faces particular competition from smelt, a faster swimming, midwater shoaling fish with many of the same attributes as inanga. Sampling in the Waiau estuary showed that smelt were common and occupied the main water body. In contrast inanga were less abundant and tended to be restricted to shallow embayments and margins, particularly in areas covered by overhanging rushes. But inanga have advantages over smelt. Smelt have fragile, easily dislodged scales and could be expected to be excluded by the screen of plant stems and debris through which inanga apparently travel when seeking out ponds temporarily connected with the mainstream. Therefore if inanga can get into these productive areas they have less competition than out in the estuary.

On the basis of many years of observation and research into the habitats of inanga, it is possible to define with reasonable precision the sort of habitats in which inanga can be expected to be abundant:

Inanga are usually found close to the coast. They prefer water less than 1 m. deep. The substrate type can range from mud through sand to gravels. Water velocities are usually low, 0.3 m/sec or less. Often inanga will be caught right against the margins, hiding amongst plants and overhanging vegetation, particularly where flows are faster. Undisturbed feeding shoals can be observed moving across open shallow areas but they dart back into cover or deeper water at the approach of any potential predator.

Small channelised lowland streams that have developed a good bank cover of overhanging rushes and sedges are often productive habitats for this fish. The water depth, substrate and velocity is appropriate. Owing to pastoral development the productivity of the water can be high. But where dense growths of submerged aquatic plants are present, environmental conditions can become more extreme. Daily fluctuations in oxygen and temperature in these situations may be less suitable for fish. Therefore the narrow, linear nature of drains, strongly influenced and shaded by overhanging terrestrial vegetation has apparent advantages over open ponded areas.

Rather than bemoaning the losses to whitebait stocks due to land development, it may be possible to utilise the same methods that have caused the losses, in a constructive manner. Modern excavation machinery is capable of moving large amounts of material cheaply and with great precision. Instead of relying upon fortuitous circumstance to provide whitebait habitat as a result of farm drainage, it is suggested that habitat be deliberately created by the same methods.

The major aim of this report is to recommend practical designs for excavations on ECNZ land in the lower Waiau, intended to provide whitebait habitat. This will be the first time that whitebait habitat has ever been deliberately constructed. If there is more

adult habitat then there will be more whitebait larvae produced. Although there are many other variables which affect survival before the whitebait return to freshwater, without adult habitat there can be no option of increasing whitebait numbers on a sustainable basis. Creating more wetland habitat has benefits for other fishes such as eels and also for waterfowl. Previous habitat creation by the Fish and Game Council has primarily been for waterfowl, whitebait have benefited indirectly. But management activities for these species, including water level manipulations and the construction of water retention weirs, may result in less advantage for whitebait than an area dedicated to this fish.

Another point to be considered is the likely ongoing maintenance costs for the habitat creation project. Estuaries and flood plains are geologically unstable places. This fact must be recognised at the design stage. Floods always have the potential to dramatically reorganise any works or structures in the area. In addition to considering stability of any structures that may be created, the unceasing process of vegetation succession must be allowed for. Excavators may have to return to the area periodically.

Control of landuse activities, particularly grazing, in the land owned by both ECNZ and DoC, suitable for this habitat enhancement project, is a further part of planning for maintenance.

AIMS

1. **To examine the potential for providing a significant increase in the amount of whitebait habitat in the lower Waiau River.**

2. **To recommend designs and consider costings for excavations on ECNZ and DoC land in the lower Waiau, deliberately intended to provide whitebait habitat.**

3. **To estimate the likely ongoing maintenance costs for a whitebait habitat area.**

METHODS

Preliminary investigation of the suitability of the lowlying farmland owned by ECNZ adjacent to the Waiau lagoon began in November 1993. Fish samples were collected in the Hollyburn, in the lagoon and from shallow embayments extending off the lagoon into the farmland. The area was walked over in company with M. Rodway and M. Sutton of the Southland Regional Fish and Game Council and the potential for a whitebait habitat enhancement project was discussed. It was obvious that the soil type was unsuitable for pond construction. Flooding across the land has deposited a sandy soil interlaced with river gravels.

In August 1994 a more detailed investigation of levels and potential ponding sites was made by M. Sutton. It was found that significant excavations and water diversion would be required to create any ponds constructed above the water table.

A site visit was held on 26/8/94 together with representatives from Southland Regional Fish and Game Council, ECNZ, and the Department of Conservation. Professor R. Kirk, an expert on river morphology and coastal processes was also present. On this visit a basic concept of working within old stream channels, at present at or close to the water table, was decided.

Discussions were held with owner/operators of excavators, regarding the quantity of material that could be shifted and likely costings. Methods for creating ponded areas quickly and easily were also discussed.

Aerial photographs of the area (1:6500) were obtained from the Southland Regional Council and the location of sites suitable for habitat construction identified. Using a scale ruler the approximate lengths of these areas were estimated. Based on a generalised channel profile generated by standard operation of an excavator fitted with a drain cleaning bucket, the approximate volume of excavations needed to create ponding in the easy sites was then calculated.

Estimated total costs were calculated based on a cost around $0.7 per cubic metre of material excavated.

RESULTS

It was agreed that the most cost effective approach to providing inanga habitat would be to deepen the existing network of old stream channels, which traverse both the farmland and the DoC owned land which lies to the east of the ECNZ property. Owing to sediment collection in these low points during floods, the buildup of vegetation, stock accelerated erosion of the banks and to draining attempts over the years, the majority of these channels are now at or only slightly below the water table. More recent channels on DoC land closer to the present river bed are deeper, sections support inanga at present.

An excavator could be used to simply deepen the channels, to provide the narrow, riparian margin dominated type of habitat favored by inanga. Leaving short lengths of the old channel bottom between cleared sections of 100 m. in length, would assist in maintaining the height of the water table and would also provide the "screen" to exclude entry of competitors such as smelt.

Some of these old channels extend into the estuary (Fig 2), where they dewater completely at low tide. In these areas the machine could be worked along the margins, adjacent to the bank , piling excavated fill around the perimeter of the cutting, to produce low weirs that would assist the backing up of water upstream. Fish would have ready access into the channels at high tide. In these areas the narrow width of the excavated channels would not significantly reduce the area of tidal flat (which has other values). Juvenile flounder and other fishes and invertebrates could be expected to reside in these excavations, moving out to feed on the tidal flats at full tide.



Fig 2. Tidal section of the Waiau River lagoon
- this area largely dewaters every low tide

Aerial photographs (scale 1:6500), provided by the Southland Regional Council, show the old stream channels clearly (Fig 3). Those lengths it is considered could be most economically cleared have been marked out and are outlined and numbered. Table 1 then lists the lengths of each channel to be excavated. It is estimated that a total length of around 5,700 m. of habitat could be provided for inanga, plus a ponding area of 370 m^2, more than an order of magnitude increase on the present estimated 320 m. of habitat.

A survey by Southland Regional fish and Game Council staff found that there were only two, rather limited areas where more intensive excavations could be made. These are on the banks of the Hollyburn (4 & 5, Table 1). Site 1 may be suitable for an impoundment area owing to groundwater flows and contour.

Table 1: Estimated lengths of channel suitable for excavation.

Channel number	Length (m.)	Length for double cut
1	65	(368 m^2 ponding area)
2	228	228
3	150	85
4		1144
5		163
6	423	423
7	910	136
8	169	
9	683	
10	195	90
11	90	90
12	403	130
13	208	208
14	150	90
15	150	
16	143	

Naturally the old stream channels are not perfectly uniform in cross section. Channels may be quite narrow, when the surrounding ground is more elevated. Then there are areas where the channels spread out. This variability suggests that the proposed excavations could be of two basic types. Where the ground is higher and the channel narrow, the excavator could make a simple channel, one scoop wide (two-three metres wide), in the basin of the old channel (Fig 4). These channels, cut by moving the minimum of material, would ensure continuity between the second basic type of channel.

In low lying areas it is proposed that larger areas be excavated. Assuming a machine between 11-12 tonnes is employed for the task, the radius of swing will be between 6-7 metres. Working along the margin between firm ground and the intended wetland and laying the spoil in the tracks of the machine, a channel 4-5 metres wide could be cut. By working along both sides of larger areas, ponding areas up to 9-10 metres wide

could be constructed. Where the old channel is even wider it is recommended that an island be left in the centre of the two marginal cuts (Fig 5). Stock will be unlikely to gain access onto these islands which will then function as refuges.

Forming islands will present a number of management options. They will function as sites for waterfowl nesting. Freed from grazing, vegetation regeneration and succession will begin. This process could be assisted by planting appropriate native plants. And finally, the islands would provide whitebait spawning sites, freed from the risks associated with grazing livestock on whitebait spawning grounds (Mitchell 1991).

P. McClelland, B. Rance and L. Chadderton, DoC (Southland Conservancy), have prepared a list a native plants they consider suitable and appropriate for revegetation on the areas protected from grazing. These plants are listed in Table 2.

Table 2 Plants suitable for revegetation on the lower Waiau River.

Ecological Role	Common name	Scientific name
Low cover	flax	*Phormium tenax*
	toe toe	*Cortaderia richardii*
	giant sedge	*Carex secta*
	red tussock	*Chionochloa rubra*
Primary shelter	mutton bird scrub	*Olearia angustifolia*
	tree daisy	*Senecio reinoldii*
	salt-marsh ribbonwood	*Plagianthus divericatus*
	mingimingi	*Coprosma propinqua*
	koromiko	*Hebe salcifolia*
Scrub/forest	cabbage tree	*Cordyline australis*
	kohuhu	*Pittosporum tenifolium*
	tarata	*Pittosporum eugenoides*
	ribbonwood	*Plagianthus betulinus*
	manuka	*Kunzia ericoides*
	kowhai	*Sophora microphylla*
Berries for wildlife	wineberry	*Aristotelia serrata*
	three-finger	*Pseudopanax colensoi var. ternatus*
	karamu	*Coprosma lucida*
	broadleaf	*Griselinia littoralis*
	tree fuchsia	*Fuchsia excorticata*
Dominant trees	silver beech	*Nothofagus menziesii*
	kaihikatea	*Podocarpus dacrydiodes*
	rimu	*Dacrydium cupressinum*

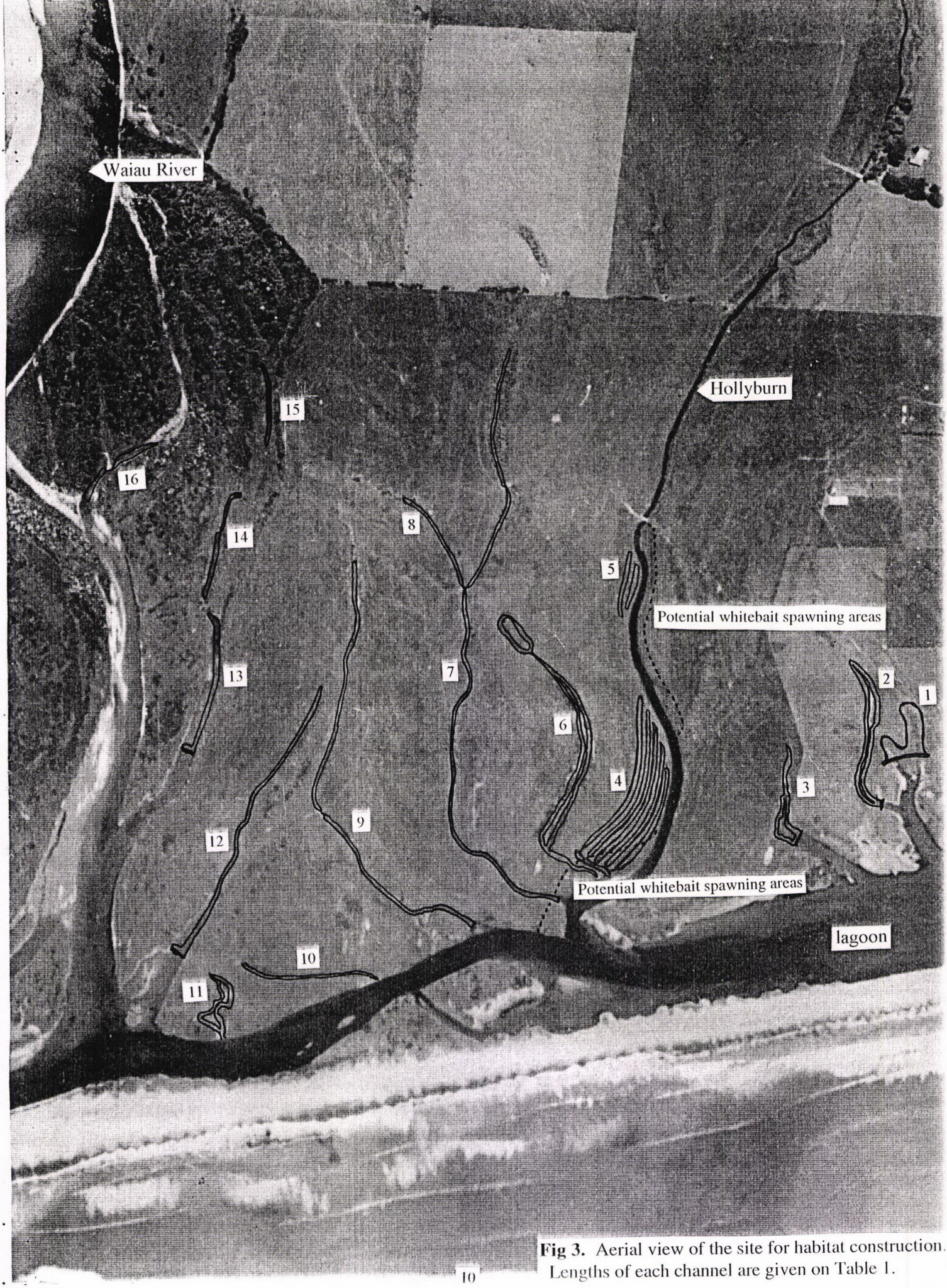


Fig 3. Aerial view of the site for habitat construction. Lengths of each channel are given on Table 1.

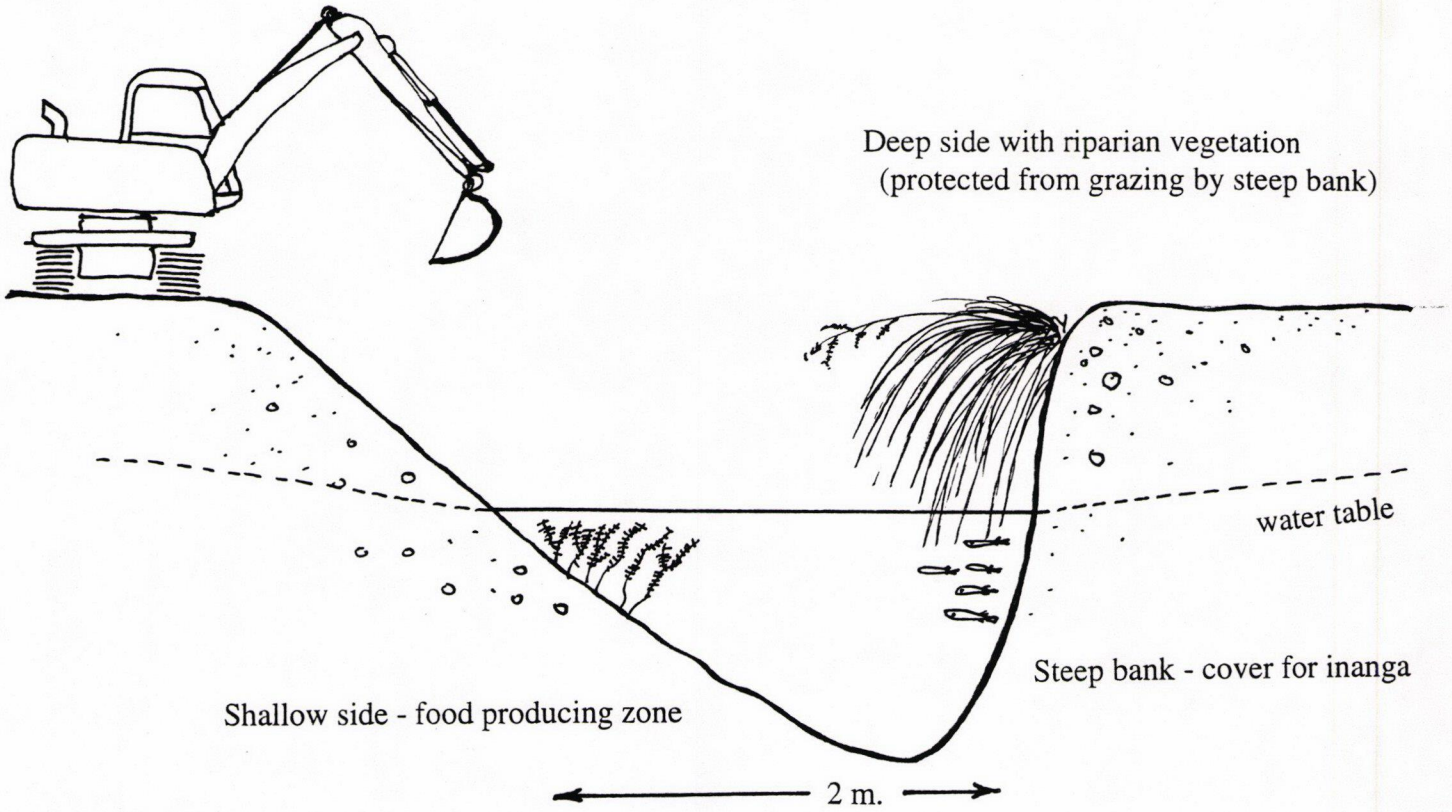


Fig 4. Form of simple channel cut using an excavator

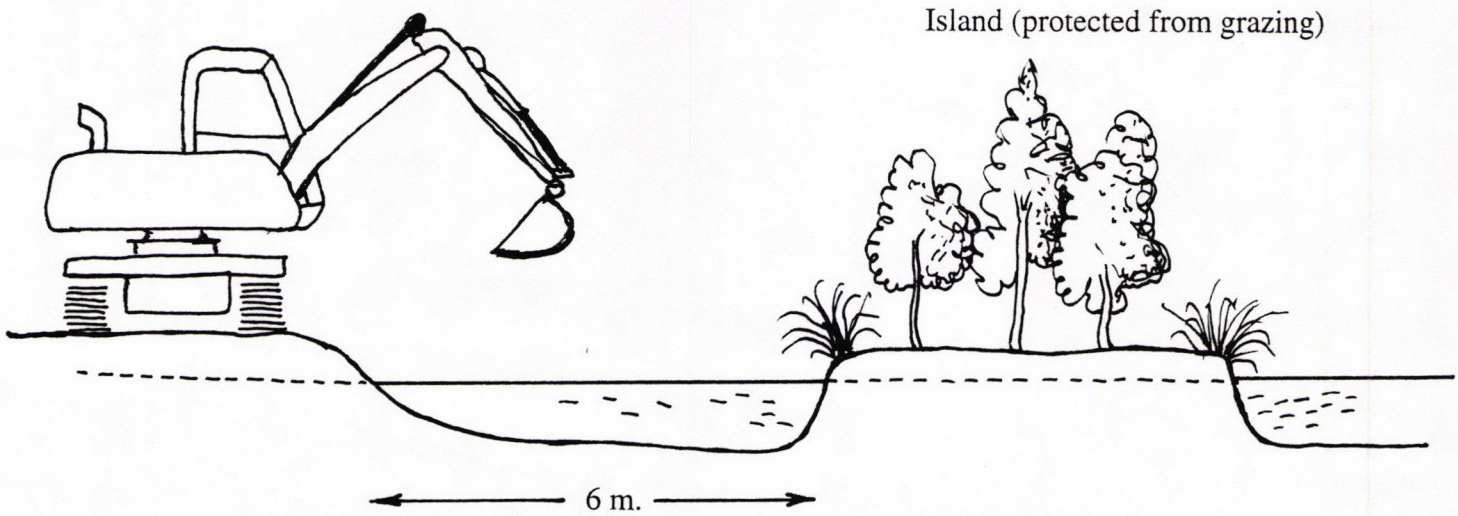


Fig 5. Enlargements on lowlying ground, including formation of islands

The restoration of riparian vegetation is considered a very important advocacy issue for the Department of Conservation. Native species are particularly recommended for enhancing aesthetic and ecological values in more stable riparian environments such as the lower Waiau River. Planting could be done as a work scheme or using the local Conservation Corps. The DoC native plant nursery at Te Anau is an obvious facility for propagating the genetically appropriate plant material required. A contract for the regeneration work, administered by a professional botanist or a landscape architect is suggested.

Inanga prefer water between 0-1.0 m. deep. Favored refuges are under overhanging vegetation where the bank is steep sided and the water slow-flowing. Feeding shoals will move into shallower, more open water. The channel dug by an excavator is of lunate form, steepest on the side away from the machine (Fig 4). Provided that cattle are excluded from the area, this channel form, cut 1m below the water table, together with the overhanging marginal vegetation that will regenerate naturally, would produce quite suitable habitat for whitebait without any especial effort.

The cross-sectional area of the first basic channel type, the 2 m. wide by 1 m. deep cut has been estimated at 1.4 m^2. It has been estimated from the aerial photograph that some 2422 m. of channel would be excavated by a single cut only.

The distance suitable for a double channel, cut from both sides, has been estimated to be 2787 m. (Table 1). As overlapping scoops of the blade will probably be necessary, involving shifting some material twice, a channel about 6 m. wide could be dug in swampy ground. Allowing for a 1 m. water depth, perhaps 12 m^2 would have to be excavated in profile from these sites (Fig 6). It is estimated the total amount of material that could easily be excavated to create a significant amount of habitat for inanga is therefore:

$2\,787 \times 12 + 2\,422 \times 1.4 = 36\,835\ m^3$

At a rate of $0.7 per cubic metre, this results in a cost estimate of around $26000 for this work. Finally there is thought to be an area (1), where a ponding area of 370 m^2 could be constructed by building a 65 m long, low retaining wall.

Allowing for contingencies, transport costs and time spent doing a good job, it appears that for a cost under $30000, a significant increase in the amount of inanga habitat in the lower Waiau could be created.

In the absence of any significant riparian shading it is thought that the channels will probably require cleaning out every 2-3 years. Maintenance work would always have to be scheduled for the wintertime, when there are very few inanga in the area. Although the time required and hence the cost of simply cleaning the channel would obviously be less than for excavation in the first instance, there will still be significant ongoing costs. The cost of cleaning could be from $15000 to $30000, or $5000 to $10000 per annum. On the other hand, with good riparian shading and exclusion of cattle, it may eventuate that cleaning is required much less often

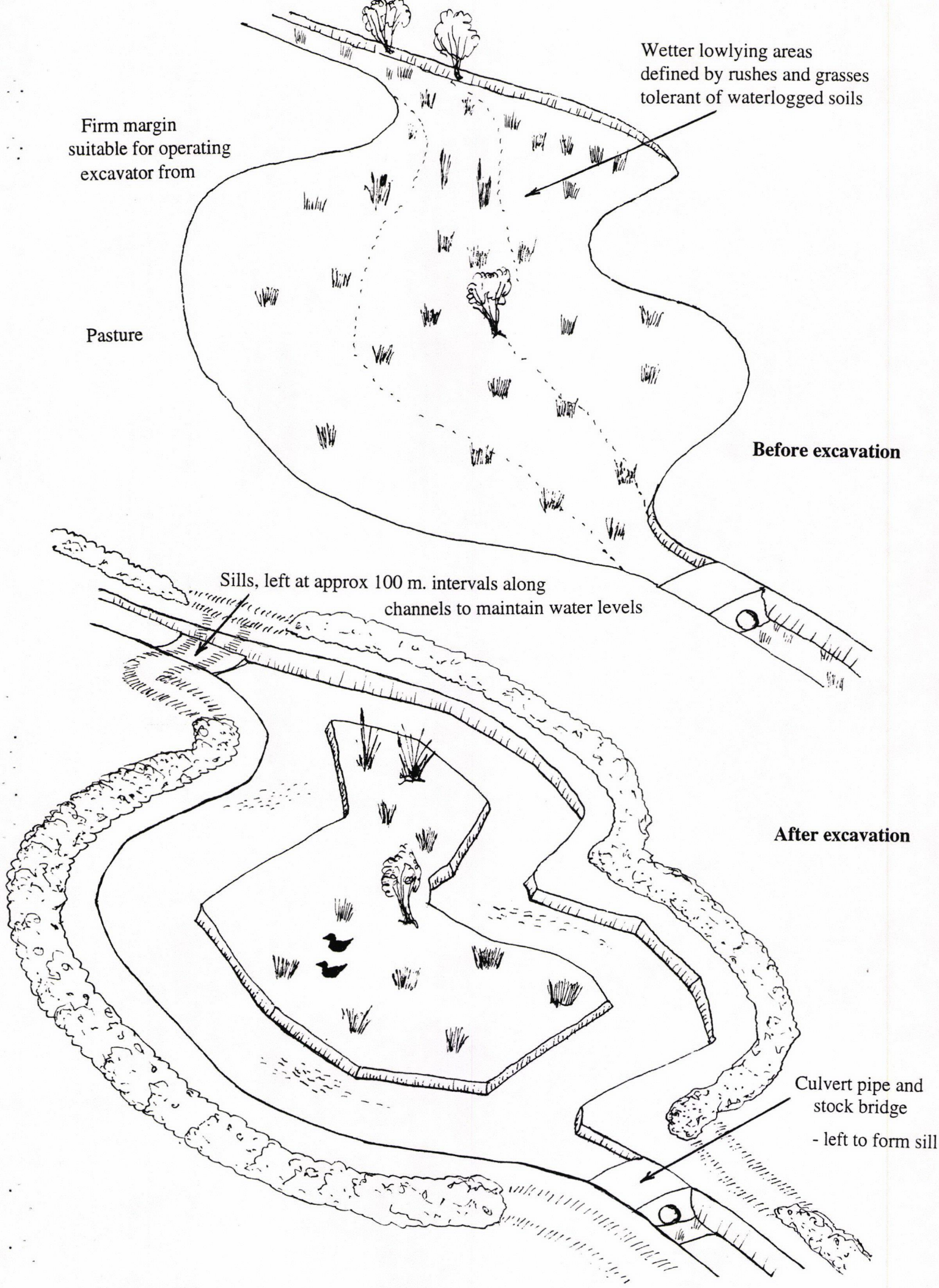


Fig 6. Stylised diagram of excavation pattern to optimise pondage and wildlife values in lowlying areas.

There will some additional costs; Time for Fish and Game Council staff to provide onsite supervision. Costs for constructing an information kiosk on the terrace on Fishermans Camp Road, overlooking the area. Costs for publicity materials and public participation.

DISCUSSION

Are there likely to be significant negative environmental impacts from the work proposed ?. Habitat construction within drains and wet areas should have a minimum impact upon the area of pasture available and leased for farming. Existing bridges could be retained for stock access and the sills formed by the culverts in these areas would assist in maintaining the height of the water table. Excavation should attempt to retain existing flax shelter belts and other native vegetation where possible.

If the work is carried over onto the DoC owned land, there is little native vegetation in that area that could be affected by the activities of the excavator. The area is presently largely overgrown with gorse, broom and blackberries. Cleaning some of the more permanent ponds may impact upon the eel population. Cleaning should be done in winter when there are few inanga present and the cool conditions give eels a good chance of slithering back into the water. By spring, the time when whitebait are moving into freshwater in large numbers, productivity in the channels should have largely recovered. Eventually of course there will be a net increase in the abundance of native fishes following the work.

If the excavations are continued down to the upper reaches of the tidal flats (Fig 2) there will be a conversion of a small proportion of the shallow flats to deeper water. Owing to the greater numbers of small fish which will shelter in these channels over low tide, predation pressures on the tidal flat *Harpacticoid* copepod community may increase. This impact would be difficult to detect.

Initially there will be a visual impact through the whole area from the lines of raw spoil. Spoil should be spread evenly so the excavator can work on top of it in future years, avoiding artificial hummocks and mounds. There is little saline intrusion, even down to the estuary. Therefore problems such as sulphide oxidation and the formation of acid soils in the spoil heaps will be avoided. In turn this implies that grasses will quite quickly colonise the spoil heaps. The organic component will be higher in subsequent maintenance cleanings. This material will thus remain visually intrusive for less time than material from the first excavations.

Previous effort on whitebait enhancement has concentrated on whitebait spawning habitat (Mitchell & Eldon 1991, Mitchell 1991, Mitchell 1992, Mitchell 1993, Mitchell 1994). This has been because these areas are very limited in extent. Protection of whitebait spawning grounds from the impacts of landuse is feasible within small budgets. Work done in the Waiau River on locating whitebait spawning grounds (McClelland 1994), has identified sites where spawning occurs, or is likely to occur. The dotted lines on Fig 3. indicate areas where whitebait may spawn on the eastern side of the Waiau Lagoon. In tandem with the proposed habitat enhancement it is

suggested that some protection be afforded to these areas. Restricting grazing to sheep only should ensure that grazing pressure is reduced to a minimum over the wetter autumn months when spawning effort peaks. The likely difficulty in maintaining fences in the unstable environment of the lower Waiau means that fencing may be a less effective technique for excluding stock than simply banning cattle, a more destructive and more aquatic animal.

As part of monitoring whitebait habitat, the extent and location of spawning grounds should be examined. Excavation of channels around spawning areas close to the lagoon, on low-lying ground could then both protect the spawning grounds from stock trampling and provide more habitat for whitebait. This could be done during a maintenance period at very little additional expense.

Following completion of the excavations it is recommended that the channels be monitored for the presence, abundance, growth and condition of inanga over the mid-late summer period. As this project is the first of it's kind in New Zealand, the information to be gained on the value of the most successful parts of the constructed habitats, will be most important for future projects. For example it would be valuable to know the best size and channel profile for inanga habitat. If the most cost-effective type of channel was known then future work could be more closely tailored to the requirements of the fish. Observations on long-term maintenance problems and requirements will also be very important.

There are other techniques for monitoring the value of these habitats for inanga. One method would be to make observations during the spawning season of the numbers of whitebait using the spawning areas (likely to be within the dotted sections on Fig 3). An alternative approach could be to monitor numbers of whitebait larvae leaving the channels over spring tides in autumn. This technique has already proven valuable for locating whitebait spawning grounds (Mitchell 1992). A design for a cheaply made fish plankton (ichthyoplankton) net would be a valuable tool for DoC field staff.

Finally, although it is subject to all the vagaries of conditions and survival in the sea, a watch should be kept on the whitebait catch from the Waiau River. The overall aim of this work is to enhance whitebait numbers, it would be gratifying if this could actually be shown to have occurred.

RECOMMENDATIONS

It is recommended that:

1. Inanga habitat be constructed in the most cost-effective manner, by excavating the series of old river channels present through both ECNZ and DoC land adjoining Waiau Lagoon.

2. That an understanding of an ongoing commitment to periodic maintenance of the artificial habitats is reached by ECNZ.

3. That the populations of inanga which develop in the various sections of artificial habitat be studied. Knowledge of the optimum design for inanga habitat would be valuable, not only if future extensions are planned at this site, but for further work around New Zealand.

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