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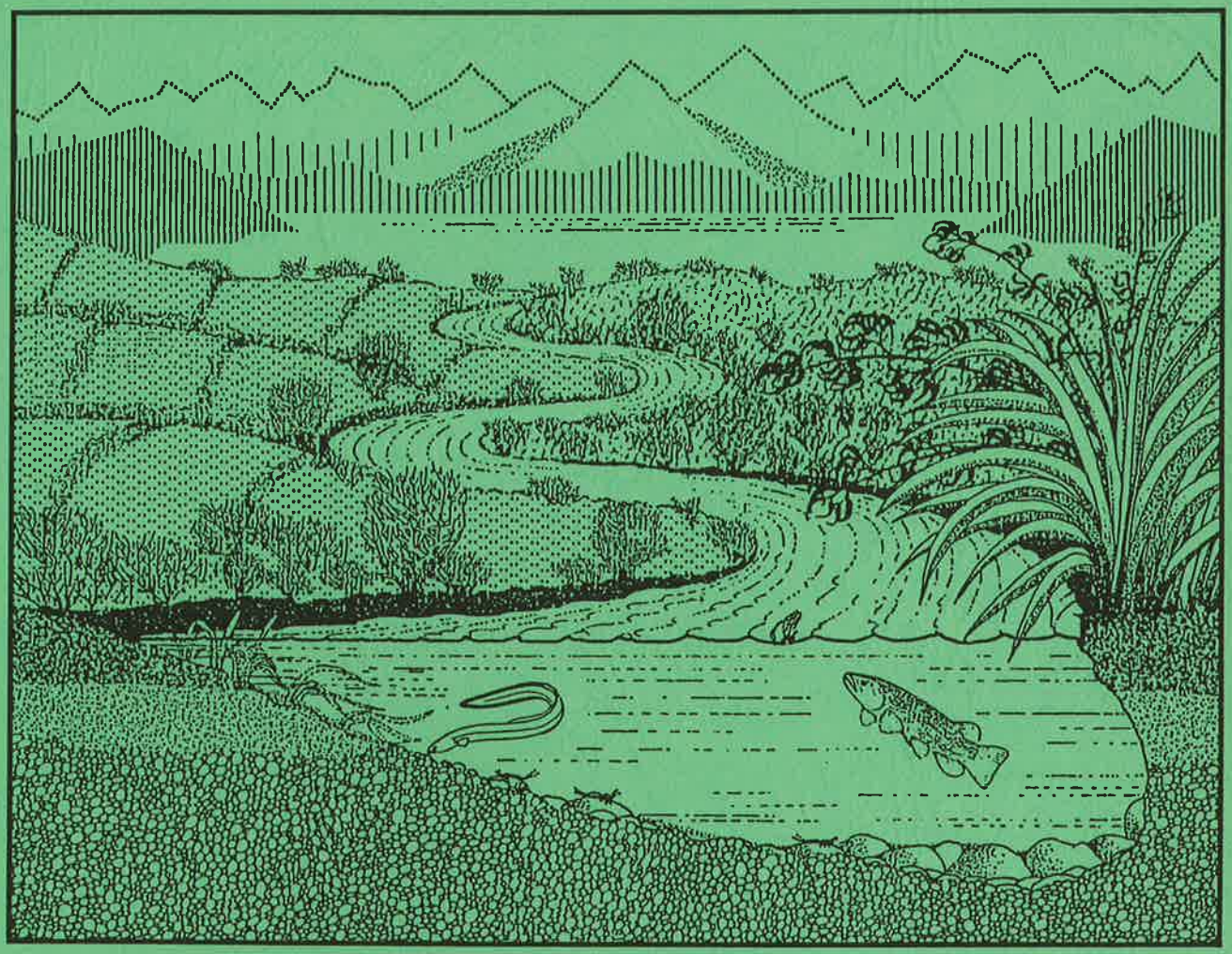

MAF Fish

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Possible impact of hydro development on fish and fisheries of the lower Clutha River

by

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MAFFish

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SUMMARY

MAFFish (formerly the Fisheries Research Division of the Ministry of Agriculture and Fisheries) has investigated the fisheries value of the lower Clutha River, from Roxburgh to Tuapeka Mouth, as one of a comprehensive series of studies on the impact of hydro development in this area. Earlier studies have looked at fish stocks and the recreational and commercial fisheries, and the present report considers the effect of hydro development on these features. Four scheme options have been proposed. The number of reservoirs in each varies from 2 to 4, although all have a dam at Dumbarton Rock, with an associated power canal and residual river.

Because the Roxburgh dam, lying at the upstream end of the proposed development, is impassable to all fish but a few eels, fish passes for salmon and trout are not recommended for any of the new dams, although passes for eels are. Intake screens are not recommended.

The availability of suitable spawning areas in the tributaries was estimated from surveys. The number of spawning fish per reservoir was then predicted and compared with the estimate of suitable spawning sites. The results indicated that there will be enough spawning areas in each reservoir, so that hatchery stocking will not be necessary. The potential yield of trout for each reservoir was estimated, using simple models.

The most important part of this study was an assessment of the "fishery value" of each reservoir and scheme. Points were allotted subjectively for the area of the shallow littoral zone, the magnitude of lake level fluctuations, the availability of spawning areas, and the residence time of water. The results showed that Scheme B (Tuapeka high dam) would provide the most productive fishery.

Diversion of water into the Dumbarton Rock power canal will affect a 5-km reach of the river channel. At a normal flow, most of this reach will become a backwater, leaving only about 1 km as a riverine environment; at higher flows, even this will be submerged and will become a backwater. Accordingly, the 5-km residual river will have little fishery value, except as a means of access to an eel pass. A

residual flow of 5-10 m^3/s would be sufficient for this. The flow from the Dumbarton Rock reservoir into the Benger Burn could be augmented by 0.3 m^3/s during summer, to enhance the rearing of juvenile trout in this stream, but this could only be justified if an irrigation scheme were to go ahead. Because the present fluctuation in flow from the Roxburgh dam probably limits the fishery value of downstream areas, we recommend total re-regulation of downstream discharge from the lower reservoir. We also recommend that enhancement of the recreational quinnat salmon fishery be continued, that the commercial potential of the lowest dam as a recapture site for ocean-ranched salmon be recognised, and that guidelines be provided to minimise the impact of construction.

1. INTRODUCTION

The lower Clutha River is being evaluated in response to a policy that the extent of the New Zealand hydro-electric resource should be established (Ministry of Works and Development 1984a). The potential of this area has long been recognised, and specific investigations were authorised by the Government in 1980. The Ministry of Works and Development (MWD) commissioned MAFFish to investigate the fish and fishery resources of the lower Clutha river during 1983-84. Results of these investigations are contained in Harvey and Jellyman (1986), Whiting (1986), and Pack and Jellyman (in press).

This report assesses the present fishery values of the lower Clutha study areas (Roxburgh to Tuapeka Mouth), and comments on the likely effects of the various hydro development options. Because Whiting (1986) surveyed all aspects of aquatic recreation, comments on recreation here are confined to angling.

2. PRESENT STATUS

2.1 Impact of Roxburgh Dam on Fish Stocks

Since it was commissioned in 1956, the Roxburgh dam has had a great impact on both upstream and downstream fish stocks (Jellyman 1984, Harvey and Jellyman 1986). The installation of the dam curtailed the migration of anadromous quinnat salmon *(Oncorhynchus tshawytscha)* to

Lakes Wanaka and Hawea, restricted the distribution of some native fish species to downstream areas, and changed reaches above the dam from a riverine to a partially lacustrine environment. Operation of the power scheme caused downstream flows to fluctuate, resulting in periodic dewatering of littoral areas. Scott (1978) has described the change from a river fishery to a "lake of limited value as a fishery" as "moderately adverse". Although specific effects of the fluctuating flow regime have not been studied, numerous overseas studies indicate that wide fluctuations in flow will reduce biotic productivity (e.g., Cushman 1985).

Although we have few data on the Clutha fisheries from the period before the dam was built, we do know that the annual run of salmon in the river beyond Roxburgh was sizeable. During the years immediately after the Roxburgh dam was built, large schools of salmon would accumulate below it. For instance, in 1959, 3 years after the dam was commissioned, salmon redd counts were 306 in the Benger Burn and 150 in the Teviot River, compared to 0 and 7 in 1971 (Wing and Dougherty 1971), and 3 (plus some multiple redds) and 0 in 1983 (Pack and Jellyman in press). Anadromous salmon have decreased greatly in average size since the dam was built (Pack and Jellyman in press), possibly because they spend longer in fresh water, less time at sea, or both. Salmon found in Lake Roxburgh during spring and summer are thought to have derived from Lakes Wakatipu, Hawea, and Wanaka, and to be on their way to the sea. They sustain the anadromous salmon stocks, together with those which are spanwed downstream from Roxburgh. From 1977 until 1986, the natural stocks have been supplemented by the release of juveniles from the salmon hatchery at Kaitangata. It is understood that the present owners, Southland Salmon Ltd., follow a policy of rearing juveniles for transfer to sea cages, with any surplus being released into the river.

It is difficult to interpret apparent changes in the trout fishery. Graynoth (1974) noted a decline in the average size of brown trout from 48.0 cm to 37.5 cm during pre-Roxburgh dam surveys (1947-52), and attributed an increase to 43.0 cm in 1967 (post-Roxburgh dam) to a change in angling patterns rather than to a change in the fish stocks themselves. Scott and Watson (1980) recorded average lengths of 38.0-41.0 cm between 1973 and 1980.

The increase in estimated total annual catch between 1947 and 1967 (Graynoth 1974) corresponded to that in licence sales over the same period. The pre-Roxburgh dam catch rate of 0.64 fish per hour (Allen and Cunningham 1957) was significantly greater than the post-dam rate of 0.12-0.36 fish per hour (Scott and Watson 1980). However, comparison of these results is confounded by the difference in survey techniques. Allen and Cunningham (1957) used volunteer diarists, who tended to 'inflate' the catch data, because the keenest anglers, who were presumably the most skilled, would have co-operated in greater numbers than those less skilled; in contrast, Scott and Watson (1980) used random angler interviews.

The Roxburgh dam has also virtually prevented the recruitment of eels *(Anguilla* spp.) into upstream areas (Boud and Cunningham n.d.a, Pack and Jellyman in press), and has barred the upstream movement of such species as sea-run brown trout *(Salmo trutta),* lampreys *(Geotria australis),* koaro *(Galaxias brevipinnis)* and common bullies *(Gobiomorphus cotidianus).*

Netting surveys in the part of the Clutha River below the Roxburgh dam (hereafter referred to as the Clutha River) indicated that a good number of trout could be caught only in areas where the flow was reduced, such as backwaters and willow-lined silty banks. Such habitats are limited to only 1% and 8% of the total river area (figures extrapolated from data in Shand and Biggs 1985). Despite partial or complete daily dewatering under normal generation, they do retain sizeable populations of invertebrates (Biggs and Shand 1985). However, the periodic dewatering means that these habitats cannot be used by fish for roughly a third of each day, so that the fish must move out daily to avoid being stranded. The considerable daily variation in discharge also diminishes both the quality and the quantity of fish habitat. It is the local opinion that such fluctuations have led to a marked decline in the trout fishery since the Roxburgh dam was built (Turner 1983).

2.2 Present Fishery Values

2.2.1. Recreational Fisheries

The lower Clutha River supports a regionally important recreational fishery (Richardson *et al.* 1984). After the Taieri River, the lower

Clutha is the most heavily fished river in the Otago Acclimatisation Society district, receiving an estimated 30 000-35 000 visits per year (Richardson *et al.* 1984, Whiting 1986). About 80% of these are made by trout anglers, and the other 20% by salmon anglers (Richardson *et al.* 1984).

The main species caught is brown trout, at an estimated annual catch of 21 000 (Whiting 1986) to 25 000 (Graynoth 1974). The salmon catch is much smaller, being estimated at about 2000 fish for the 1982/83 angling season (Whiting 1986). Large sea-run (anadromous) brown trout enter the river from December to March, and are caught mostly in the Pomahaka River and below Balclutha, although some are caught as far up the river as Roxburgh. A few rainbow trout *(Salmo gairdnerii)* and perch *(Perca fluviatilis)* are also caught.

Results from the postal questionnaire of the 1982/83 angling season (Whiting 1986) indicated that the reach below Balcutha was the most popular with both adults and juniors. This was followed by the reach from Roxburgh to Beaumont Bridge for adults, and Lake Roxburgh and the Tuapeka Mouth-Balclutha reach for juniors. The least popular reach was that from Beamont Bridge to Tuapeka Mouth. The fishery below Balclutha is so popular that, since 1973, it has been open to anglers throughout the year (Otago Acclimatisation Society 1975), whereas, further upstream, the river can be fished only from 1 October to 30 April. Lake Roxburgh is also open for fishing all year.

Although angler surveys have not been carried out each year, the available information shows that there have been some 'good' salmon fishing seasons since the Roxburgh dam was installed. For instance, during the 1972/73 season, 695 salmon were caught, and the number caught in the following season "far exceeded the 1973 figure" (Otago Acclimatisation Society 1973, 1974). However, these years were exceptional, and the average catch per season would appear to have been about 100 salmon. Since 1983, the salmon fishery has been enhanced by releases of fry and smolts from the ICI/Watties salmon farm at Kaitangata. The annual catches for 1979-82 were estimated to be 50-200 fish, but more recent estimates are higher: 800 (1982/83), 1400 (1983/84), and 1200 (1984/85) (Gillard 1984 and pers. comm.). These estimates may well be conservative, because the 1982/83 figure is only

40% of the estimate obtained from the postal questionnaire of Whiting (1986). Figures 1 and 2 show salmon fishermen, and a salmon caught at the Roxburgh dam.

The proportion of ex-hatchery salmon in the catch varies with location in the river and with season. During 1983/84, all of the fish caught below Balclutha (n = 257) were considered to be ex-hatchery fish, compared with 42% of those caught at Roxburgh (n = 386). This was so probably because ex-hatchery fish tended to remain near their place of origin, although few actually returned to the hatchery, while wild fish continued further upstream. For the 1982/83 and 1984/85 seasons, the proportion of ex-hatchery fish in the total catch has been estimated at 31% (1982/83), 78% (1983/84), and 64% (1984/85). Table 1 gives the age distribution of ex-hatchery salmon caught in the Clutha River. The large average size of salmon caught during 1984/85 was due to a high percentage of 3-year-olds in the run, whereas 2-year-olds dominated in the 2 previous seasons.

Associated with the increasing number of salmon caught in the Clutha River over recent years has been the development and promotion of the fishery. An Otago branch of the New Zealand Salmon Anglers Association was formed on 7 April 1984, and currently has more than 350 members (Ellis 1986). In submissions to the Lower Clutha Hydro-electric Investigations Interim Report (Ministry of Works and Development 1984a), the Clutha Central Otago United Council, the Otago branch of the New Zealand Salmon Anglers Association, the Otago Regional Development Council, the Roxburgh Borough Council, and the Lower Clutha Residents and Ratepayers Association all stressed the importance of safeguarding the existing fishery below Roxburgh. In their submissions, they suggested that the passage of salmon to Roxburgh be maintained by installing fish passes on any dams that are constructed.

Results from the National Angling survey (Teirney *et al.* 1982), conducted over the 1978/79 angling season, indicated that many Otago and Southland anglers were prepared to travel to the Waitaki River for salmon fishing. The improvement in the Clutha salmon fishery over recent years has provided an alternative closer to home for these anglers. For instance, interviews of 243 anglers fishing between Roxburgh dam and the township showed that only 6 were not from Otago or

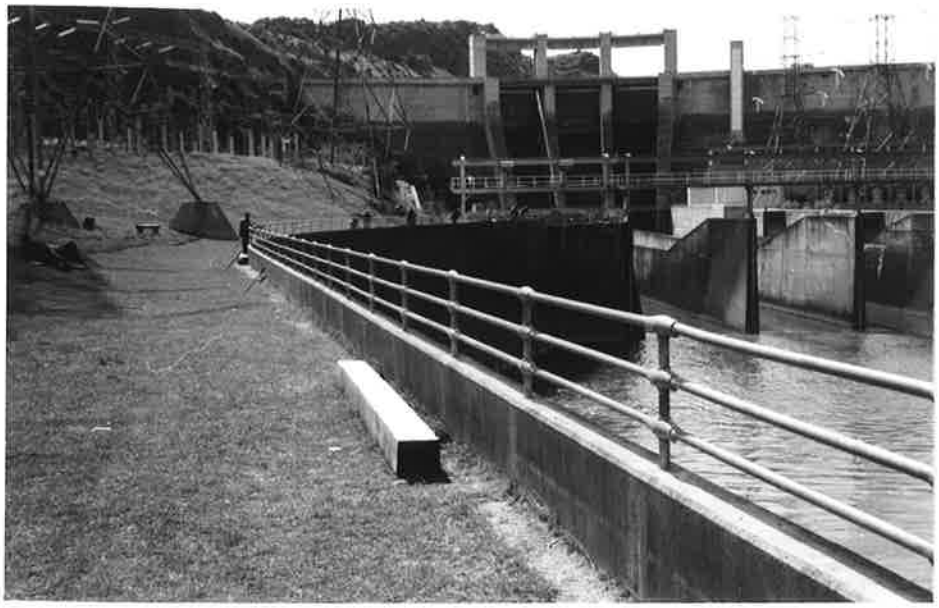


FIGURE 1. Salmon anglers, Roxburgh Dam, March 1984.

FIGURE 2. A 7-kg quinnat salmon caught by an angler at Roxburgh Dam.

Southland (Whiting 1986). Therefore it is likely that anglers from these areas would strongly advocate that salmon fishing continue to be available in the Clutha River.

TABLE 1. Age distribution of ICI/Watties salmon caught in the Clutha River, 1983-85. (Returns of hatchery fish were insignificant before 1982/83. Average weight data are from Gillard 1983, 1984, 1985.)

Fishing Season	Percentage per age class 2	3	4	Total (n)	Mean weight (kg)
1982/83	100	0	0	241	2.6 ± 1.6
1983/84	60	40	0	725	2.9 ± 1.9
1984/85	3	93	3	646	6.5 ± 1.6

2.2.2 Commercial Fisheries

A small eel fishery exists in Lake Roxburgh and the Clutha River. Results of a survey of 19 registered eel fishermen from Otago and Southland showed that 6 of 13 respondents had fished the river or the lake; their combined annual catch from both areas was estimated at 20 tonnes, which is considerably more than the 4-5 tonnes reported earlier (Jellyman 1984). Fishing is seasonal, from October to March or April. One fisherman commented that the river below Roxburgh "has a large stock of eels in it but is hard to fish as the water level can vary too much from the hydro."

The catch from Lakes Wakatipu, Hawea, and Wanaka was estimated to be 40 tonnes per year (Department of Internal Affairs 1981), and 1 fisherman estimated that he had taken 300 tonnes from these lakes over the past 12 years. He noted a marked decline in a 'good' day's catch from 450 kg to 90 kg during the past 8 years. This has probably been caused by fishing pressure and the minimal recruitment of elvers past the Roxburgh dam.

The ICI/Watties salmon development project (now Southland Salmon Ltd.) at Kaitangata was designed to be a commercial ocean-ranching venture. Although returns to the angler have been greatly enhanced in

recent seasons, few fish have returned to the release site (Gillard 1985). Nevertheless, the project has been able to attain overall return rates (percentage of fish released to returning adults) to the river greater than the 1.5% normally regarded as the economic 'break-even' point. The returns to date have also been characterised by a low level of straying out of the catchment. Although the principal interest of Southland Salmon Ltd. is to rear salmon for transfer to sea cages, the company has indicated "that they will endeavour to continue experimental releases into the Clutha, but plan to review progress annually" (Watson 1987).

3. PROPOSED DEVELOPMENT

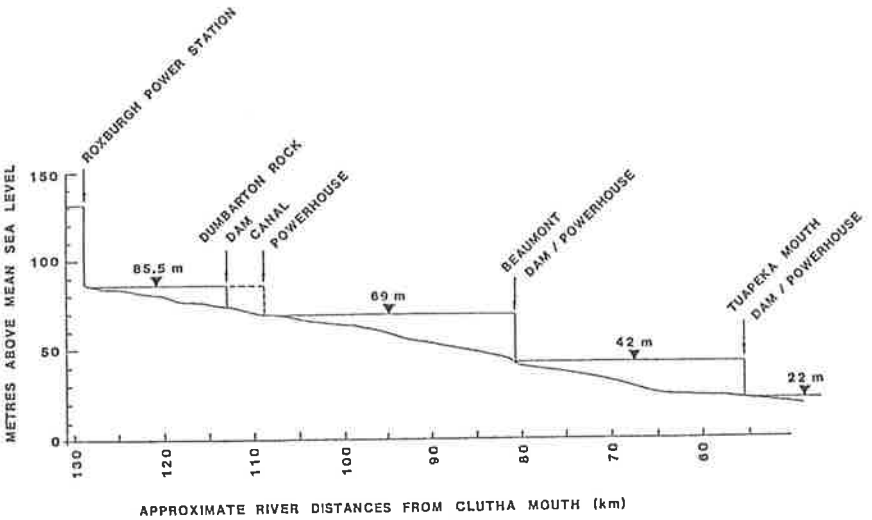
3.1 Scheme Descriptions

Four schemes have been suggested to utilise the 64 m of hydraulic head available between Roxburgh and Tuapeka Mouth. These are described in Ministry of Works and Development 1984a and Pickford 1985, and are summarised only briefly here (Table 2, Fig. 3).

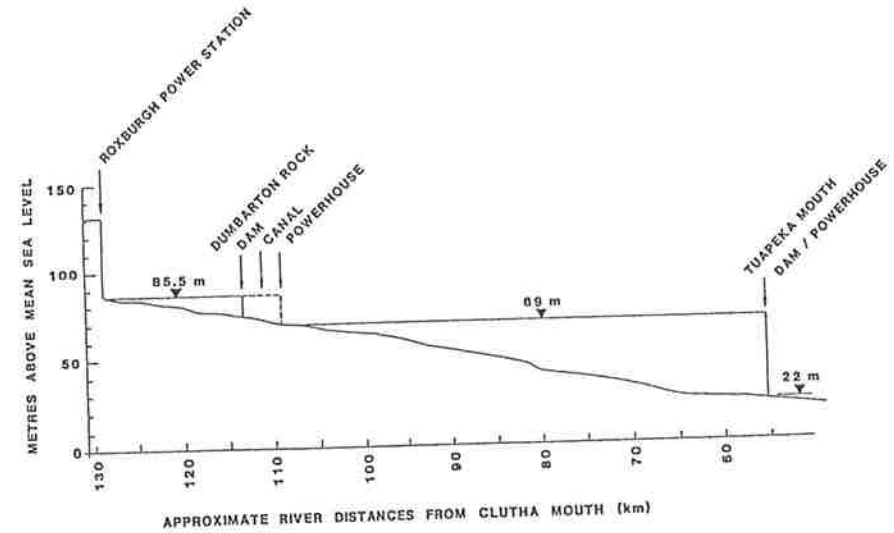
All 4 schemes involve an 11-m high dam at Dumbarton Rock, and a 4.5-km canal leading to a power station. Scheme A has dams also at Beaumont (27 m), and Tuapeka (20 m). In addition to Dumbarton Rock, Scheme B has a high dam at Tuapeka (47 m). In Scheme C, the high dam (39 m) is 14 km upstream at Birch Island. Scheme D has the Dumbarton Rock and Beaumont dams, plus low dams at Birch Island (12 m) and Tuapeka Mouth (8 m). The areas which would be flooded or occupied by canals have been calculated as 1543 ha for Scheme A, 2680 ha for Scheme B, 2003 ha for Scheme C, and 1078 ha for Scheme D (this would be 1298 ha if the Island Block bunds are not constructed). Scheme A would cause the least inundation, and thus the least displacement of persons and the smallest loss of agricultural land. Scheme B is probably the most attractive from the engineering and economic viewpoints, whereas Scheme C would preserve the botanically important Birch Island area, but would not utilise the full power potential available between Roxburgh and Tuapeka Mouth. Scheme D is a 'minimum impact' option which would flood the least land, but is probably the least attractive economically.

TABLE 2. Summary of power generation features of the proposed lower Clutha power stations. (Data from Jowett 1984a, Pickford 1985, Ministry of Works and Development 1986, Mulcock and Jowett 1986.)

	Mean flow (m^3/s)	Operating range (m)	Operating storage ($x10^6$ m^3)
Clyde	482	1.0	26.4
Roxburgh	500	1.9	10.9
Scheme A (2020 GWh)			
Dumbarton Rock	505	2.0	4.4
Beaumont	511	2.0	21.2
Tuapeka (low)	515	2.0	18.0
Scheme B (2120 GWh)			
Dumbarton Rock	505	2.0	4.4
Tuapeka (high)	515	2.0	64.0
Scheme C (1830 GWh)			
Dumbarton Rock	505	2.0	4.4
Birch Island	514	2.0	47.0
Scheme D (1930 GWh)			
Dumbarton Rock	505	2.0	4.4
Beaumont	511	2.0	21.2
Birch Island	514	2.0	6.4
Tuapeka (low)	515	2.0	6.0

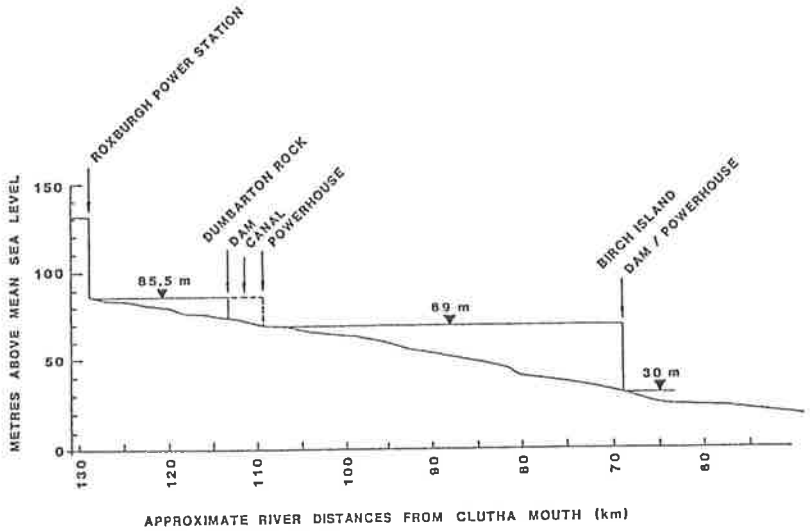


SCHEME A - LONGSECTION

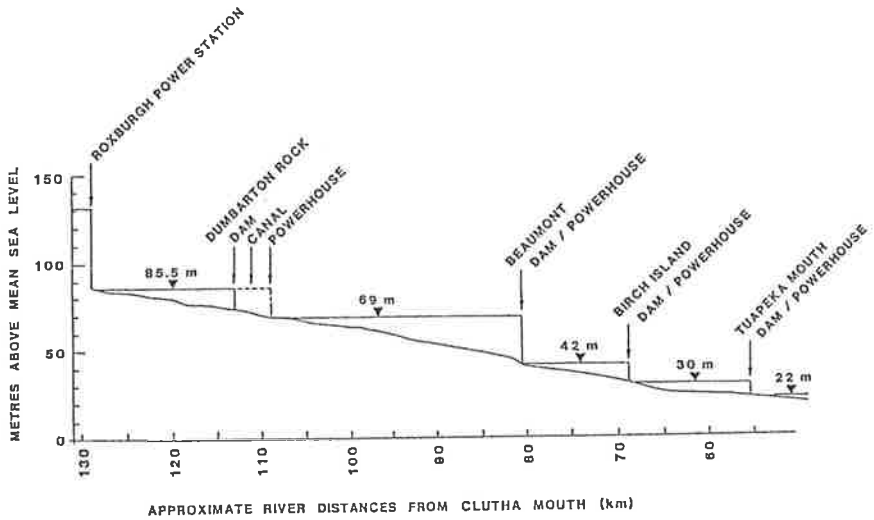


SCHEME B - LONGSECTION

FIGURE 3. Profiles of the proposed scheme options for hydro development of the lower Clutha River. (Source: Ministry of Works and Development 1986.)



SCHEME C - LONGSECTION



SCHEME D - LONGSECTION

3.2 Scheme Operations

The fluctuating flows from Roxburgh are considered to be a limiting factor on the potential of the downstream fisheries, although the impact decreases with distance downstream. Concern has been expressed that the present regime has also led to channel erosion, partial blockage of the river mouth, and impairment of gravity drainage (Otago Regional Water Board 1980). Such problems will continue unless flows from the proposed lower power station are substantially re-regulated. Accordingly, Jowett (1984a) proposed that flow re-regulation should be seen "as a worthwhile objective", and he investigated the effect this would have on lake levels and power production.

Although the prescribed operating range of Roxburgh is 1.85 m, the average daily level variation for 1975-83 was 0.76 m, with a corresponding variation in discharge of 329 m^3/s (Jowett 1984a). Re-regulation of the flow below Roxburgh in order to eliminate the variation in discharge would require that the full operating range of Lake Roxburgh be utilised. This would further limit the production of its fisheries, but if all of the Clutha power stations (upper and lower) were operated as an integrated chain, the lake level could be held more constant (e.g., 0.1 m daily fluctuation), because the reservoir furthest downstream could then re-regulate the downstream flow. Variation in the level of the downstream reservoir would in turn be determined by the storage available and the generation pattern adopted by Electricorp. For example, under the present generation pattern, the mean lake level of the Tuapeka low reservoir (Scheme A) would vary by 0.5 m, and that of the Tuapeka high reservoir (Scheme B) by 0.2 m; with total re-reguation, these fluctuations would double (Pickford 1985). Under Scheme D, level fluctuations in the Tuapeka (low) reservoir and the Birch Island reservoir would exceed 1 m, as the storage of both would be needed for re-regulation.

Re-regulation (see Section 5.6) involves the release of water during off-peak periods, with a consequent loss of potential revenue. Jowett (1984a) estimated that re-regulation using the Tuapeka high dam scheme would reduce the peak generating capacity by 15%, but that the loss in the other schemes would be less.