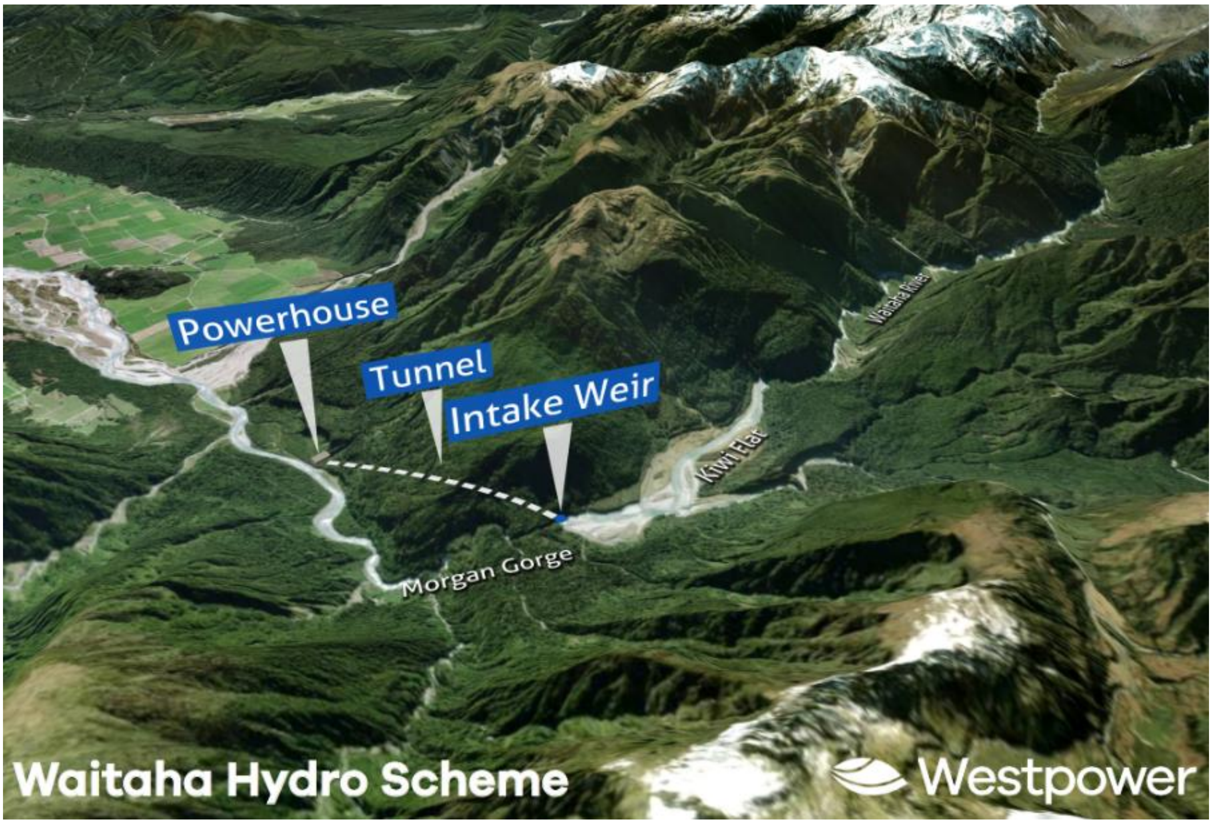

WAITAHA HYDRO SCHEME

PROJECT OVERVIEW

July 2025

Report prepared for Westpower Ltd

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1. EXECUTIVE SUMMARY

1.1 The Proposed Waitaha Hydro Scheme (the **Scheme**) is a significant energy initiative by Westpower Ltd aimed at enhancing the security and reliability of electricity supply on the West Coast of New Zealand and delivering renewable electricity generation to support growth and economic development across the region. The Scheme involves the development of a run-of-the-river hydro-electric power plant on the Waitaha River, approximately 60 km south of Hokitika. The Scheme is expected to generate approximately 120-140 GWh of electricity per year, equivalent to the electricity needs of approximately 12,000 households.

Project Rationale and Objectives

1.2 The West Coast currently relies heavily on the national grid for its electricity supply, with only 65% of its electrical energy needs generated locally. The Scheme will address this by increasing the availability of renewable electricity generation within the region, thereby improving resilience and security of supply. Additionally, the Scheme contributes to the government's ambitious emissions reduction and decarbonisation goals by delivering renewable electricity generation to support growth and economic development across the region (and New Zealand).

Project Description

1.3 The Scheme includes the construction of a low weir and intake structure at the top of Morgan Gorge (Headworks), a pressurised water tunnel, and a Power Station below Morgan Gorge. The intake structure will divert water into a pressurised tunnel and desander, with the diverted water then conveyed to the Power Station and returned to the Waitaha River via a tailrace. The Scheme also involves the construction of access roads, a transmission line, and various ancillary components. During construction there will be construction yards, construction staging areas, spoil disposal sites and the development of a new substation to connect the Scheme to the Westpower network.[1]

Environmental Considerations

1.4 Westpower has undertaken extensive measures to ensure the Scheme is designed, and will be developed, in an environmentally sensitive manner, based on thorough baseline assessments by environmental experts carried out over the last 15 years. The design includes features such as a low-profile weir, underground headworks and access route, and a compact power station to minimise visual, landscape and natural character effects. The Scheme has also been designed in a manner and mitigation proposed to minimise effects on ecology, hydrology and recreation. For example, the Scheme includes provisions for fish and kayak passage via portage, erosion and sediment management, and site rehabilitation. While the Scheme has a long history, Westpower has ensured that the Scheme has taken advantage of improvements in technology since its original design.

1.5 Since the beginning of the project, Westpower has been engaged in an iterative process that facilitated discussions between the design team, Poutini Ngāi Tahu and technical experts for each environmental effect. Initially this included workshops on the selection of the most suitable river and then the specific site. In the more recent years there were workshops held to re-iterate the considerations for landscape, local fauna and flora, in the context of the hydrology and sediment of

[1] A more detailed commentary on the scheme design is included below, and a detailed description of scheme can be found in Appendix A: Summary Project Description.

the Waitaha River. The specific matters addressed between the design team, and environmental experts were, for example:

- Location of the access portal at the Headworks – This involved a site visit with the engineers, tunnellers and experts in 3D imaging in May 2022. The location of the access portal was then moved to be "tucked in" near the gully at the intake while still allowing easy access to the river and temporary access to Construction Staging Area 1.
- Managing the effects on the whenua, awa, ngahere and wildlife including taonga species and collaboration with Poutini Ngāi Tahu.
- Ensuring the weir and intake structures accommodate for the passage of kōaro, kayakers and ducklings, and for the constant release of the environmental flow, through facilitated conversations between the design team and specific experts / groups.
- Enabling for sediment to be collected, stored, and transported to the tailbay for release at the time when the river is naturally turbid, through the selection of a desander. This ensures that water remains clear during low flow and therefore alleviates concerns regarding fish, freshwater invertebrates, and sediment deposition. A decision was also made to use a fully submerged desander which means the intake portal will be under water and therefore will not impact on landscape.
- Managing construction to adopt ecology recommendations to mitigate adverse effects.
- Identifying appropriate sites for investigative drilling in consultation with the design team, drillers, geologists and an ecologist.
- Identifying an appropriate potential route for the access road to the Power Station, to minimise effects on avifauna and avoid large trees and wetlands.

Consultation and Stakeholder Engagement

1.6 Westpower has engaged in extensive consultation with a wide range of stakeholders, including the Department of Conservation, local authorities, landowners, and recreational users. This consultation has influenced the development and design of the Scheme through the introduction of design measures to avoid or minimise potential adverse effects.

1.7 Westpower has also thoroughly engaged with its project partner Te Rūnanga o Ngāti Waewae and Te Rūnanga o Makaawhio (Poutini Ngāi Tahu). Poutini Ngāi Tahu strongly support the Scheme and have entered into a partnership agreement with Westpower in relation to the Scheme. If the approvals necessary to enable the development of the Scheme are granted and the Scheme proceeds, Poutini Ngāi Tahu and Westpower remain project partners and Poutini Ngāi Tahu will have a financial interest in the project. Engagement and the long standing relationship with Poutini Ngāi Tahu are discussed in the Partnership Report.

Construction and Operation

1.8 The construction of the Scheme is expected to take approximately 37 months, with a peak workforce of around 150 workers. The Scheme will be managed in accordance with a Construction and Environmental Management Plan to minimise environmental impacts during construction. Once operational, the site will be remotely controlled and monitored, with minimal on-site staff required.

2. INTRODUCTION

2.1 I am the General Manager Generation and Technology for Westpower and have been directly involved in the design and operation of local hydro Renewable Energy Generation (**REG**) with this company for more than 40 years. I am a Fellow of Engineering New Zealand (FEngNZ), a life member of the Electricity Engineers Association and am a Chartered Professional engineer (CPEng).

2.2 Westpower's proposed Scheme is a run-of-the-river hydro-electric power scheme on the Waitaha River, approximately 60km south of Hokitika on the West Coast of the South Island, New Zealand.

2.3 I have been managing the development of the Scheme since 2004 when it was first identified as a potential source of additional REG on the West Coast that could be sensitively developed within its surrounding environment.

2.4 The purpose of this report is to:

(a) introduce the Scheme;

(b) provide a broad project description; and

(c) summarise consultation undertaken,

so as to set the scene for Westpower's application and the technical reports.

2.5 To that end, this report:

(a) describes the background to the Scheme including:

(i) the rationale for the Scheme;

(ii) a summary of the history of the Scheme; and

(iii) the development approach to the Scheme, including the options considered and design refinements made over time to reduce effects; and

(b) presents an overview and detailed description of the Scheme including:

(i) the key Scheme components (including the transmission line, access roads, Power Station, tunnels, weir and intake structures);

(ii) preliminary/prefeasibility works, including geotechnical investigations;

(iii) design details including:

(1) the Scheme's design response to seismicity and safety risks if needed;

(2) overall design features; and

(3) key environmental constraints;

(iv) construction details including:

(1) anticipated construction sequencing and indicative timetable;

(2) site works (including contractor's facility at Kiwi Flat, earthworks and instream river structures);

(3) workforce details and management;

(4) general environmental management methods (hazardous substance management, erosion and sediment controls, construction traffic, etc); and

(5) site rehabilitation;

(v) operational details including:

(1) permanent workforce and traffic;

(2) ongoing operation and maintenance works (including instream works);

(3) permanent site services such as raw and potable water consumption, wastewater and stormwater;

(4) hazardous waste management; and

(5) public safety management including river safety through and below the abstraction reach;

(c) summarises the consultation undertaken with stakeholders and any outcomes reached.

3. BACKGROUND TO THE SCHEME

Rationale

3.1 A key cultural, social, economic and environmental risk on the West Coast is resilience, security and reliability of electricity supply, with only two main transmission lines into the region, both of which are subject to outages during extreme weather events. Approximately 220 GWh of energy is consumed on the West Coast each year with about 150 GWh (65%) of this generated locally. In other words, the West Coast is a net importer of around 70 GWh (35%) of its energy from the grid and therefore reliant on the grid to "keep the lights on".

3.2 The customer impact from loss of grid connection was brought into sharp focus in June 2024 with the severely constrained electricity supply into Northland lasting three days following a transmission tower collapse. An effective mitigation to this risk is the installation of local generation plant that can maintain supply even when a grid connection is unavailable.

3.3 This is particularly important for remote communities such as those served on the West Coast. Westpower wants to increase the availability of renewable electricity generation within the region to improve resilience and security of supply, support its customers and bolster the local and regional economies. The Scheme will also decrease Westpower's community's exposure to the higher retail electricity price that results from sourcing electricity generated at a significant distance from where it is used as discussed in Mr Westergaard's Electricity Resilience Report.

3.4 Also discussed in Mr Westergaard's report, is that the Government has ambitious emissions reduction and decarbonisation goals and targets. REG is essential to meeting those goals and targets with the Government wanting to 'turbocharge' the development of REG. Westpower wants to assist New Zealand in moving toward a decarbonised economy to mitigate the impacts of climate change including the significant threat climate change poses to biodiversity.

3.5 A key driver for Westpower in the development of REG on the West Coast is to ensure that any development was designed, and will be constructed, in the most environmentally sensitive manner practicable. However, to make a meaningful contribution to New Zealand's REG stock, REG schemes must be of a meaningful and therefore larger scale, such that adverse effects cannot in all instances be avoided. Westpower's approach to designing the Scheme in an environmentally considered way is elaborated on below.

3.6 Westpower is confident that the Scheme is one of the best local hydro opportunities that currently exists for a number of reasons, including that there are no significant impacts on ecological values during construction and operation. Over the last few years, the design of the Scheme has been able to integrate improvements to further mitigate construction and operational effects. Operational effects on natural values are at most minor with the proposed mitigations employed. Westpower has continued to promote the Scheme as an essential contribution toward achieving the Government's REG targets while bringing significant regional and national benefits.

History of Hydro Generation on the West Coast

3.7 Looking back in history, the Reefton Electric Light and Power Company (a predecessor of Westpower) commissioned the first public electricity supply in the Southern Hemisphere in Reefton in 1888 powered by a small hydro station. Since that time Westpower and its predecessors developed several small hydro schemes on the West Coast including:

(a) Arnold (3 MW) 1932

(b) Kumara (10MW) 1977

(c) Wahapo (3 MW) 1991

(d) Amethyst (7.6 MW) 2013

(e) Numerous other small hydro schemes totalling a further 2.5 MW (Duffers, Kaniere Forks, McKays Creek, Fox and Turnbull Power Stations).

3.8 Most of the schemes were sold to Manawa (then TrustPower) in 1999 as part of the industry restructuring undertaken at the time under the Bradford reforms, but the Amethyst scheme[2] was subsequently designed and built by Westpower. Amethyst has many similarities with the proposed Waitaha Scheme including being in the same general area and having a river intake with a tunnel and downstream powerhouse. The experience gained in the construction of the Amethyst scheme, and the similar geology likely to be encountered for Waitaha, has given Westpower a high degree of confidence that it will be able to successfully construct and commission the Scheme in a manner that will successfully avoid significant effects and appropriately minimise other effects.

Environmental Suitability

3.9 The West Coast is ideally suited to hydro generation because of its high levels of annual rainfall and unique topography which involves relatively steep rivers flowing down to the coast. The area has had a long history of involvement with local hydro generation, some of which was originally built to supply gold dredges in the early 20th century.

3.10 A unique feature of hydro generation on the West Coast are the high levels of generation availability that can be achieved despite most of the schemes being run-of-river with no storage. In the case of the Amethyst scheme, the annual capacity factor (the actual generation in a year as a percentage of

[2] Resource Consents for the Amethyst Hydro Project were gained in 2008, followed by design and construction, and then final commissioning in June 2013.

the maximum theoretical generation achieved if the station ran at 100% all the time) approaches 75% with the output rarely falling below 40% of the installed capacity. While the Waitaha Scheme is not expected to reach these numbers, the expected capacity factor of 60% is very good and much higher than solar or wind (which ranges between 10% and 35% depending on scale and location). Importantly, hydro generation can also complement wind and solar by running at times when the wind is not blowing and the sun is not shining.

3.11 Because of Westpower's experience with hydro generation and the abundant hydro resource available on the West Coast, an ongoing strategy of the company is to further invest in developing this valuable resource for the benefit of the local community where this can be done in an economically and environmentally appropriate way. This is why the company began looking at developing additional local hydro generation in 2004.

3.12 The Waitaha River, with a significant catchment and providing reliable flows throughout the year, quickly emerged as one of the front-runner options ideally suited to hydro generation development. Flow recording over several years on the Waitaha River has confirmed that over 120 GWh of energy could be reliably produced each year, supplying roughly half of the existing electricity consumption of the West Coast.

Approach to the Scheme's Development

3.13 Westpower represents the electricity consumers on the West Coast and as such is itself a long-term member of the community and is answerable to that community for its decisions. Accordingly, it wants to appropriately care for the environment for generations to come, while sustainably supporting the economic well-being of the community.

3.14 Westpower has a well-deserved reputation for being responsible environmental custodians for the schemes it has been involved with to date and has developed a strong working relationship with the local Department of Conservation (**DoC**) in achieving this. For this reason, DoC was carefully consulted from the earliest stages of the feasibility studies and their input was invaluable in continuing to refine the design features and minimise the overall impact on the environment.

3.15 The initial approach to developing a new scheme was to identify run-of-river opportunities that would have a reduced environmental impact and provide long-term supply of REG as well as reliable electricity to the consumers of the West Coast. Westpower is aware of the adverse environmental impacts associated with large dams and made a deliberate decision to avoid this type of scheme in its assessments.

3.16 As explained below, the Scheme has evolved over a long period of time. From the start Westpower wanted the Scheme to 'tread lightly on the land' recognising its location within the conservation estate and the values of the Waitaha River and its catchment. Westpower has sought the input of a wide range and number of independent experts to help it develop and shape the Scheme. This has been an iterative and team approach over a long period of time and has evolved at each opportunity.

Economic Sustainability

3.17 Westpower's purpose is to provide sustainable electrical solutions which enhance communities. Construction of an economically successful hydro scheme on the West Coast contributes directly to that purpose in its broadest sense. The Scheme would provide income to the community that owns Westpower and also provide much needed resilience to the Coast's economy through a local source of electricity. The Economic Benefits report (Appendix 15 of the Application) has detailed the benefits to both the local and national economy.

3.18 From time to time, alternative schemes have been suggested to Westpower and each of these has been assessed on their merits to confirm that they were unlikely to represent a more economically viable option. For instance, the West Coast Regional Energy Strategy published in 2022 included a desktop study of 17 potential schemes on the West Coast, two of which were not on conservation land.

3.19 While the locations of the schemes were not disclosed in the report, the two non-conservation land projects comprised very low heads and high flows (>40 cumecs), meaning that they would have to be on a major river (such as the Grey River) and involve large and long canals leading to a high cost per MW and with a significant environmental footprint. Accordingly, these schemes were discounted at an early stage. This also confirmed Westpower's initial assessment that economically viable schemes on the West Coast will require access to conservation land.

3.20 To be sustainable, the Scheme must be financially viable. Internal analysis to ensure the commercial viability of the Scheme includes an ongoing review of the key financial performance drivers, namely:

(a) the capital and operating costs of the Scheme;

(b) the amount of electricity produced; and

(c) the price received for the sale of electricity.

3.21 Westpower has sought a wide range of professional advice to understand the likely range for each of these parameters to feed into its Discounted Cash Flow (DCF) model including a sensitivity analysis to show how project performance is impacted by changes in each of these elements. The economic model is updated as more accurate cost and revenue information is gathered.

3.22 Work to confirm the capital cost of the Scheme is ongoing and an example of this is the geotechnical investigation program, which includes significant drilling and geophysical surveys. This is currently underway to better understand the underlying geology that the works will need to be constructed in. The tunnel represents approximately half of the capital cost of the Scheme and the tunnel geology will directly drive the cost of the Scheme in terms of the tunnel roof support design and tunnel advance rates. Having a clear understanding of the geology that will be experienced throughout the tunnel construction will help to determine the likely cost range of the project.

3.23 Westpower's recent experience in successfully constructing and operating Amethyst Hydro in nearby Harihari is just the latest example demonstrating a long track-record of successful hydro-scheme development on the West Coast. The Amethyst scheme has very similar geology to that expected for the Waitaha construction and the current geotechnical program is being used to confirm that understanding to further refine the cost and risk assessments.

3.24 Before proceeding with the Scheme, and based on the parameters set by the Fast-track Approvals Act Panel, Westpower's Board will be seeking a number of external peer reviews to confirm the financial viability of the project, which must stand on their own merits. Early indications, based on the parameters proposed in the application and assuming an appropriate concession fee, are that the project will meet the expected financial hurdle rates and return a positive Net Present Value (NPV) to the business.

3.25 Once concessions, consents and other approvals for the Scheme are received, further work will be undertaken to finalise the feasibility assessment of the project. This will take into account updated capital costs along with the ongoing compliance and other operational costs before reaching the stage where a Financial Investment Decision (FID) can be made. As noted above, all indications are that the Scheme will meet the necessary criteria, but this decision will need to be carefully reviewed based on the information available at the time and then stress tested before making a final commitment.

3.26 Once the Scheme is operational, it will continue to operate as long as the revenue available from sale of electricity exceeds the Short Run Marginal Cost (SRMC). This cost is very low for a hydro scheme and there are many examples where very old plants continue to run for periods of 100 years or more if properly maintained. Accordingly, if Waitaha is commissioned with reasonable operational costs, the ongoing revenue will ensure its ongoing viability.

History of the Scheme – Other generation options considered

3.27 A number of fuel sources have been considered for local generation on the West Coast over many years and these are briefly discussed below.

3.28 Thermal coal-fired generation was briefly considered in the mid-1990s to make use of the plentiful supply of thermal coal on the West Coast. However, the relatively small size of plant that could be accommodated with our current transmission system made this uneconomic. Such a scheme is no longer environmentally acceptable given the need to reduce greenhouse gas emissions.

3.29 Tidal energy has often been looked at as a source of reliable energy. However, the reality is that the high energy waves present on the West Coast (as it is exposed directly to the Tasman Sea) represents an extreme risk to any tidal energy system that could be employed. None of the available technologies have shown sufficient resilience or have enough of a track record to be considered for deployment in the region.

3.30 Solar energy is becoming more affordable and will likely become an important part of the energy mix in future years, but the West Coast is not well-known for its solar irradiance and so is not well suited to this form of renewable energy development. Moreover, the land area requirement for solar generation of around 2 ha per MW would require something like 40 ha of reasonably flat land to provide a similar level of generation to the Waitaha scheme, the key components of which take up only a fraction of that area. Finally, solar generation does not provide any energy security after dark or during times of heavy overcast conditions. While battery storage is an improving technology, the scale required and limitations on solar generation on the West Coast would not provide the community with comparable resilience to a hydro-scheme.

3.31 Geothermal generation was also investigated and Westpower partially funded a GNS Science investigation into geothermal potential in the Whataroa area. This showed that the low-grade heat available in the area was too deep to economically develop as a source of electricity generation.

3.32 Wind energy is also a poor match for the topography and weather conditions of the West Coast. The quality of the wind resource in the area is relatively poor with long periods of very low wind speeds. The best way to improve the situation is to install wind turbines in highly elevated areas, but there are good reasons to avoid this given the abundance of outstanding natural landscapes and vegetation clearance issues (and significant natural areas). Even then, it would be difficult to build new transmission lines into alpine areas far away from the existing transmission grid. These transmission lines would be expensive, as they would involve long distances, and would be vulnerable to damage from an alpine fault rupture. Westpower's assessment found no suitable area for wind generation of the scale of Waitaha within its network area.

Hydro Option Development and Scheme Selection

3.33 Westpower began the process of identifying potential hydro schemes by reviewing earlier studies such as "Small Hydro Electric Potential of West Coast" prepared for the Ministry of Works and Development in 1985[3] (attached as **Appendix B)** and a subsequent report by the Ministry of Economic Development released in 2004.[4] These reports include a comprehensive list of potential hydro generation sites on the West Coast.

3.34 An initial list of over 30 potential hydroelectric schemes on the West Coast included in the above reports were reviewed. A desktop study looked at various technical and non-technical issues to rank the various schemes and distil this list down. The schemes were:

- Various schemes on the Buller River
- Lake Christabel
- Upper Grey 1
- Upper Grey 2
- Upper Grey 3
- Upper Grey 4
- Roaring Meg
- Arahura 1
- Arahura 2
- Taramakau
- Arahura 1
- Arahura 2
- Kaniere and Styx
- Kokotahi
- Mikonui
- Poerua
- Butler
- Alexander River
- Taipo
- Falls Creek
- Jumbo Creek
- Makawhio
- Moeraki
- Tartare
- Waikukupa
- Rough River
- Big River
- Toaroha
- Waitaha
- Kakapotahi
- Amethyst

3.35 A desktop study carried out in 2005[5] entitled "Westpower Generation Development Strategy - Hydro Generation Scoping Study" (attached as **Appendix C**) considered the various technical (geology, access, dam locations, bedload, requirement for a tunnel, transmission capacity and riverbed degradation) and non-technical issues (fishing, location in a National Park, creation or value, cultural issues, environmental impact, isolation or river conservation orders) to rank the various

[3] Ministry of Works and Development. (Sep 1985): Small Hydro Electric Potential of West Coast: Final Report.
[4] A copy of this report is currently not available.
[5] [redacted] (Jan 2005): Westpower Generation Development Strategy: Hydro Generation Scoping Study (unpublished).

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schemes and distil this list down to a long list of 13 sites considered worthy of further investigation and site visits.

3.36 The sites identified, all of which were on conservation land, are shown in Table 1.

Table 1:

Site	Output (MW)	Comment
Waikukupa	5.5	Issues with erosion and located too far away from the load centres and transmission network.
Tartare	5.9	Requires a tunnel and suffers from degradation at the intake. Difficult ground conditions for tunnelling and scheme located within a National Park.
Waitaha	40	Possible intake site identified. Very high installed flow for an underground settling basin, but viable scheme may be possible at lower flow (a flow of 23 cumecs and approximately 20 MW output was subsequently decided on). All Crown land.
Kakapotahi	17	Suitable intake site. A water race would be required through challenging terrain. This river is highly valued by recreational users and would involve diversion of flow from one river into another.
Toaroha	25	Suitable intake site and tunnel location was identified with a long access road through difficult spots required. Worthy of further consideration but challenging.
Arahura 1	18	Very large flow with relatively low head. Likely to be a hollow bedload river needing a large settling basin. Riverbed ownership may be an issue.
Arahura 2	13	Same issues as Arahura 1 above.
Taipo	18	There is a possible scheme here but it involves a very large flow and tunnel. Difficult valley with high bedload and challenges installing an intake and settling basin.
Taramakau	46	The scheme would involve the diversion of a large flow of water from the Taramakau River into Lake Brunner and would have a significant impact on water quality in the lake and on the fishery and wildlife in the area. The mean flow in the downstream Arnold River would increase threefold.
Ahaura	13	Very large flow and a relatively low head. This is likely to be a high bedload river requiring a large settling basin, made more difficult by the lack of fall. Isolated site.
Big River	3.5	A relatively small scheme with a modest head. This would require an open race approximately 6.2 km long. The scheme is too small to develop economically.
Rough River	11.1	An 8.4 km water race through native bush and a large penstock would be required to make the scheme viable. The race crosses some challenging ground and the river is a popular fishing spot.
Alexander River	3.4	A suitable intake was found, but this relatively small scheme is in an isolated area and well away from the electrical grid.

3.37 The majority of the schemes in Table 1 were eventually discounted based on one or more of the following the following considerations:

(a) they were environmentally challenging (Tartare);

(b) had a high conservation or cultural value (Arahura 1 & 2);

(c) had insufficient resource (Alexander River, Big River, Waikukupa);

(d) had high recreational use (Kakapotahi);

(e) were too costly to economically develop (Taipo River, Rough River);and

(f) were simply too far away from the transmission network to economically connect to the grid (Waikukupa and Tartare, Alexander).

(g) None of the schemes were located outside of conservation land.

(h) Based on the above criteria, a shortlist was eventually developed, including:

(i) Toaroha (small and large options);

(ii) Kakapotahi; and

(iii) Waitaha.

3.38 While the Toaroha Scheme had some redeeming features, such as relative proximity to the Hokitika load centre, the difficulty of road construction presented a significant challenge. A 5 km access road between the powerhouse and downstream access portal would be technically challenging due to very steep cross fall in places, and then a further 1.6 km of access road would be required to the intake site through steep country. This access would result in significant landscape effects. A 2.7 km tunnel and further 1.7 km of penstock would be required for the larger 29 MW scheme, but would be highly dependent on tunnel geology, adding significant development risk. Accordingly, for technical and environmental effects-based reasons this scheme was "parked".

3.39 The Kakapotahi River has high recreational value due to its easy road access and a variety of kayaking grades suitable for all skill levels, making it popular among kayakers. Moreover, a specific challenge associated with this scheme was potential cultural sensitivity around diverting flow from one river into another.

3.40 The Waitaha scheme involved a river gorge that was not used for recreational purposes at the time it was being considered due to the extremely steep and narrow features in the gorge. The likely environmental impacts from the development of this scheme were also considered to be low, including compared to the other options considered, due to the majority of its key components being able to be contained within an underground tunnel including the diverted flow.

3.41 Accordingly, the focus turned to the two preferred options, the Waitaha River, which had the highest economic performance, and the nearby Kakapotahi River. Both rivers were assessed with respect to their flow characteristics and topographical and geological features. Installed capacities were determined along with a likely capital cost to develop a project. Natural hazards were also included as key elements of this assessment.

3.42 Waitaha had a number of compelling advantages[6] such as:

(a) A lower environmental footprint compared to the other schemes as the vast majority of the waterways would be constructed underground by the use of tunnels, avoiding the need for large and obtrusive canals.

(b) An access tunnel would also avoid the need for an access road to the intake, avoiding the associated landscape effects that other schemes would likely create.

[6] Please refer to the "Westpower Generation Development Strategy Hydro Generation Scoping Study" in Appendix B for further information.

(c) The use of a low-level weir that would avoid the creation of a lake that would otherwise have a significant environmental impact. The geology and topography at the head of Morgan Gorge is ideal for a small weir with a minimal footprint, whereas other schemes would require more substantial stream bed intakes.

(d) The powerhouse location was relatively close and accessible from the end of an already highly modified farming valley, while many of the other schemes required extensive roading development. The ability to access the intake through an underground access tunnel also obviated the need for a separate access road to the intake.

(e) At the time, the Morgan Gorge had not been kayaked, and so was seen as having a lower recreational impact than the nearby Kakapotahi Scheme. (Although it has since been conquered, the run is still only attempted sporadically by the most elite kayakers and is not seen as being a regular kayaking site. Importantly, an agreement is now in place with Whitewater New Zealand (WWNZ) to allow for no-take days when the gorge can still be used for this purpose. As a result, WWNZ have stated that they are content that the adverse effects on paddle sports / whitewater recreation have been appropriately mitigated.

(f) The water resource in terms of flow and head (the difference in elevation between the intake and powerhouse) was determined to be superior to many of the other options.

(g) The project economics in terms of capital cost per MWh produced were favourable, making it more likely the project would be commercially viable.

(h) After careful consideration of these and other factors, the Waitaha River was chosen as the preferred option to take forward into pre-feasibility assessment.

Waitaha Option Development and Scheme Selection

3.43 Westpower took an extensive period of time to develop and design the Scheme, adopting a particularly careful, constructive and collaborative approach to respect and reflect the public conservation land status and Westpower's partnership with Poutini Ngāi Tahu.

3.44 A formal pre-feasibility study was launched in 2006 that included detailed site investigations along with a wide range of ecological baseline assessments. Based partly upon the promising outcomes from these studies, formal consultation with a wide range of stakeholders began in earnest in 2007.

3.45 During the pre-feasibility study, six potential scheme design options were identified for this river as shown in **Figure 1** below. Four options (A-D) involving an intake at the Waitaha Gorge upstream of Morgan Gorge were technically feasible and superior due to higher head and lower water flows for the same output. However, these options would have significant environmental impacts, including a large canal structure and headpond in Kiwi Flat and reduced water flows in the Waitaha River through an area considered to be good whio (blue duck) habitat.

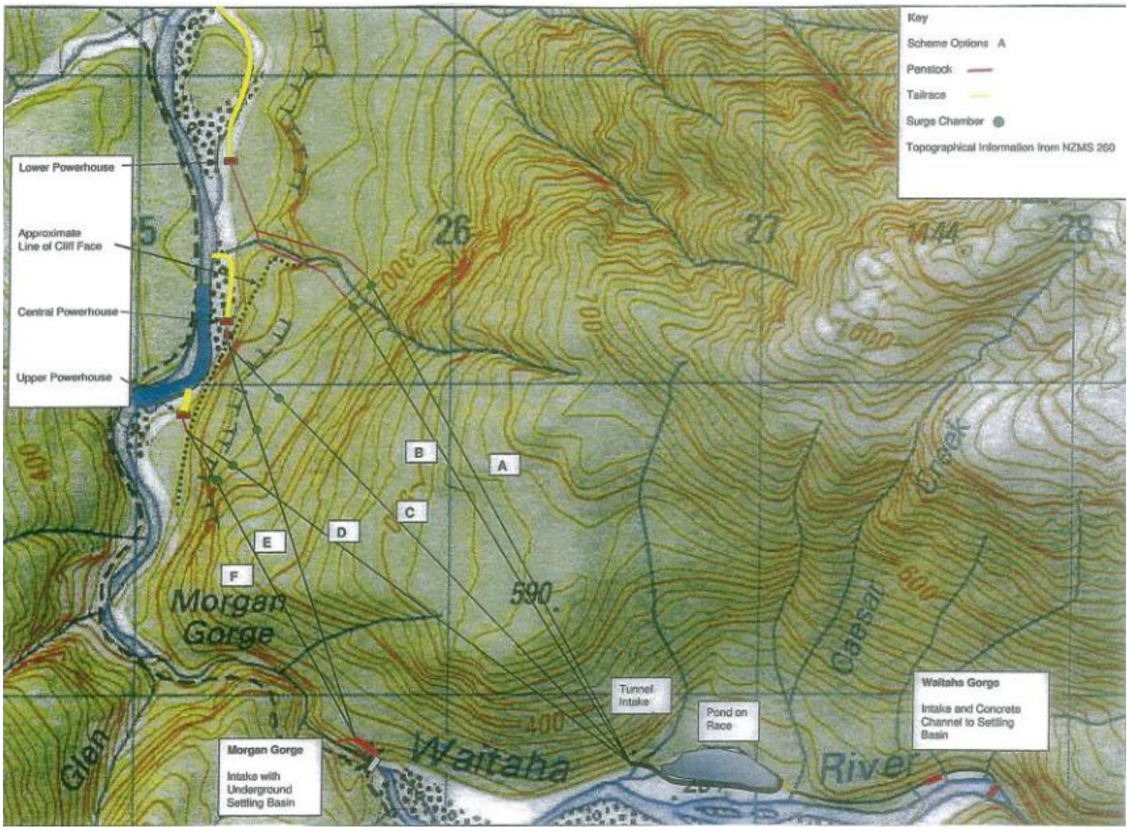


Figure 1: Waitaha Gorge Option

3.46 Morgan Gorge was finally selected as the optimum location for the intake to provide sufficient generation while avoiding the environmental impacts noted above. This left the flow in the Waitaha River through Kiwi Flat untouched and avoided building any significant structures within this natural landscape. By moving the intake downstream, some elevation (and hence generation potential) was lost but this was compensated for by the additional water flow coming in from Whirling Water, leading to an equivalent generation output albeit requiring a higher flow and slightly larger waterways (i.e. tunnels and penstocks).

3.47 Once this decision was made, considerable effort was put into refining the design to reduce the environmental footprint and other potential adverse effects as set out below.

3.48 To reduce potential adverse effects, the design:

(a) utilised a weir with a run of the river scheme as opposed to a dam;

(b) utilised a low-profile weir so that its landscape and visual effects were reduced with fish and kayak passage included;

(c) installed all key headworks (head gates, desander, flushing tunnels and penstock) underground within the tunnel to minimise visual impacts on the landscape;

(d) lowered the height of the Power Station building by not including a large internal gantry inbuilt crane to lift the turbines when required for maintenance etc (rather a portable crane will be used as required and the major items of equipment will be accessed via a removable roof); and

(e) the services of a landscape architect were engaged to ensure that both the Power Station and Headworks sat well within the surrounding landscape, and this was done by choice of colour, material and shape (e.g. the building has a jagged, saw-tooth pitched roof to minimise the overall landscape impacts).

3.49 The environmental and hydrological studies were subsequently extended and refined over several years until 2012 by which time sufficient comfort was gained for Westpower to make a formal decision to move forward with detailed investigations for the Waitaha Scheme as the preferred development option prior to submitting concession and subsequent resource consent applications.

3.50 Following further pre-application engagement with DoC and engagement with their landscape architect, the upper access portal was shifted to bring it down closer to the water level to minimise any impact on the hillside from construction of the access road needed to connect the portal to the riverbank.

Concession Application

3.51 In July 2014, Westpower's Concession Application for the Scheme was lodged with DoC to secure the necessary concessions to enable Westpower to proceed with the detailed design and development of the Scheme. The following two years were spent assisting DoC to complete a review of the assessment of the environmental effects during which time a number of beneficial changes to the Scheme were made. The "Notified Concession Officer's Report of the Decision Maker" referred to as the "intention to grant" report was released in August 2016. This report recommended that Westpower's concession application be approved in principle. The intention to grant the concessions for the Scheme were then publicly notified and submitters were heard at a public hearing, held by DoC in Hokitika in December 2016.

3.52 Further design changes were made around the time of the concession application in 2014. These changes further reduced the impact of the Scheme on the environment, including in regards to:

(a) landscape, natural character and visual amenity effects; and

(b) sedimentation.

3.53 Post-hearing, Westpower proposed:

(a) increasing the number of no take days from 2 to 4 to further reduce the impacts of the Scheme on kayakers; and

(b) further redesign of the intake structures to reduce their size and visual impact.

3.54 A final decision was made by Minister David Parker (the Minister for the Environment at the time) to decline Westpower's concession application in August 2019, on the basis of perceived impact on natural character and landscape values – both for intrinsic and recreational purposes.

3.55 Westpower disagreed with Minister Parker's decision on a number of grounds and in 2022 lodged a reconsideration application under section 17ZJ of the Conservation Act 1987. The Minister has not yet decided whether to undertake a reconsideration of the decision at this point. This reconsideration request has been suspended at the suggestion of Minister Potaka (the Minister of Conservation) so that Westpower can instead pursue an application for the concession under the Fast-track Approvals Act 2024 (**FTAA**). On that basis, there is no current concession application under the Conservation Act 1987, but there is a request for a reconsideration of the previous decline decision (but the Minister has not decided whether to proceed with that process).

Reconsideration design changes (2022)

3.56 In preparing for the reconsideration application Westpower undertook a further comprehensive design reassessment to determine whether any additional measures could be adopted to reduce the adverse effects of the Scheme.

Landscape and natural character

3.57 Westpower worked with its expert landscape consultants to reduce the impacts of the Scheme on the landscape's natural character by amending the Scheme as follows:

(a) the main upstream access portal being reduced in size (originally 5m by 7.5m - now 5m x 5m);

(b) aligning the portal entrances with the striations of the surrounding rock. Weathering of the intake and access portals was also detailed, illustrating how the use of rough-hewn concrete will enable plants and mosses to take hold and successfully grow. Careful placement following implementation of the Scheme of rocks and boulders also assists to integrate the portals into the natural landscape. Ancillary structures, such as a canopy portal cover to prevent rock fall, were not required, due to a better understanding of the surrounding geology;

(c) leaving the entrance to the portals as uncovered rock and designed to blend in with the natural lines of the surrounding schist, rather than strengthening the outer facing edges of the entrance with concrete and geometrically shaping the entrance. This gave the portals a more naturalistic cave-like appearance and further reduced the level of effect on natural character. (It has since been determined that concrete wingwalls will need to be added to each side of the portal for safety reasons, but the natural look will be preserved as far as reasonably practical);

(d) redesigning the intake portal so it will sit below water level and will not therefore be visible. Only the access portal will be visible and this has been brought down closer to the water level to reduce its visual impact avoiding the need for an access road with significant cuts and battered slopes and their proximity to riverbank features. This change also minimises the length and landscape impact of the access ramp down to the riverbed for ongoing maintenance; and

(e) a more compact design was prepared for the Power Station Site, reducing its overall footprint to one smaller than previously proposed.

Sedimentation

3.58 Changes were made to the design such that the sediment discharges required for flushing the Scheme will no longer occur in the lower reaches of the Morgan Gorge as originally proposed. This avoids the need to have a separate and highly visible flushing tunnel with a portal emerging high above the river level in Morgan Gorge.

3.59 Rather, flushed sediment will now be sluiced via a pipe from the desander down through the tunnel, to be mixed with the powerhouse water in the tailrace before re-entering the river, which by then will have recovered its full, natural flow. These “flushes” will be done during natural high-flow runoff events in the river, mimicking the natural behaviour of the river during freshes and floods.

Recreation

3.60 After consultation with recreational users, an offer was made to relocate the lower end of a nearby walking track so that the Power Station could not be seen by users of the track when accessing Kiwi Flat from the lower end of the valley. This continues to be included in the design and vegetation screening will be provided where practicable to minimise the view of man-made structures when walking the track.

3.61 Westpower has continued to work with Whitewater New Zealand (**WWNZ**) to develop outcomes that will minimise impact on their kayaking activities on the river. Westpower has offered four no take days per annum.

Fast-track Approvals Act design (2024)

3.62 In preparing its application for all necessary approvals under the FTAA, Westpower has continued refining and developing the Scheme’s design, construction methodology and operation practices following the latest expert reports and engineering designs. Key changes include:

(a) use of a fully-pressurised underground desander to manage the extreme flood rise in Morgan Gorge while still avoiding the need for a separate flushing channel into Morgan Gorge;

(b) the Power Station has been relocated upstream, closer to the lower tunnel portal, and lowered in height above ground, having the effect of reducing the Station’s overall bulk and footprint;

(c) more detailed assessment of the access road and transmission line route between Macgregor Creek to the Power Station Site to avoid wetlands and large podocarps as well as keeping well away from a stable tributary which has high ecological value;

(d) a realigned transmission route following the local roads and State Highway 6 to a connection point with Westpower’s 66 kV line (at Westpower’s existing Waitaha Substation site in Bold Head Road) so that the alternatives of crossing private land or traversing to the true left of the Waitaha River (requiring more vegetation clearance) are no longer needed;

(e) most recently in November 2024, following further detailed hydrological assessment in relation to river ramp rates, adding in a bypass valve to ensure that changes in flow through Morgan Gorge and downstream of the Power Station are kept to a minimum in the event of an emergency trip where the turbines have to shut off; and

(f) Westpower has worked with WWNZ experts for over a year to understand and provide for their use. This included the design of a solution that will provide a safe entry to the Gorge for kayakers. Westpower originally proposed a kayaking chute over the weir. However, as a result of these discussions, Westpower will make provision for kayakers to safely exit the river upstream of the intake and then portage over the intake structure to a safe launching area immediately downstream of the intake. Westpower will also make weather and flow information available on its website to kayakers in planning their runs.

4. PRELIMINARY DESIGN

Overview

4.1 The Waitaha River extends from the main divide of the Southern Alps to the Tasman Sea on the West Coast and is over 40 km in length with a total catchment area of 223 km^2.

4.2 The Scheme is located within, and on the true right bank of, the Waitaha River between the lower end of Kiwi Flat and Macgregor Creek within the Waitaha Valley. The Scheme is predominantly located on stewardship land managed by DoC. Some sections of the proposed access road are located on private land and/or land managed by Land Information New Zealand and the proposed transmission route is located on road reserve administered by Westland District Council (for local roads) or the Crown (for state highway), with some small sections on land controlled by DoC or LINZ.

4.3 In summary, the Scheme would be run-of-river with no instream storage. The proposed headworks include a low weir and intake structure situated at the top of Morgan Gorge that will divert water into a tunnel and pressurised desander. While a small pond may initially be created by the completion of the weir in the river channel, the bed of the river will quickly regrade to the top of the weir reducing landscape effects (minimal ponding) and allowing sediment/rocks to pass over the top of the weir into Morgan Gorge (natural processes to continue).

4.4 A pressurised water tunnel will convey the diverted water down to a Power Station below Morgan Gorge. After passing through the turbines the diverted water will be returned via a tailrace discharging to the Waitaha mainstem in the vicinity of the confluence of Alpha Creek. The Scheme is to divert up to a proposed maximum of 23 m^3/s, whilst maintaining a minimum residual flow of 3.5 m^3/s immediately downstream of the intake. The abstraction reach would include approximately 2.5 km of the Waitaha River, including Morgan Gorge.

4.5 Construction access to the headworks above Morgan Gorge will be via an access tunnel, while an access road will be required from the end of Waitaha Road to the Power Station and lower access tunnel portal.

4.6 There will be an upper and lower portal for each of the tunnels. The Kiwi Flat water intake portal will be below the water level on the upstream side of the weir at the top of Morgan Gorge.

4.7 The Scheme will produce approximately 120-140 GWh of electricity per year with a peak output of about 23 MW. This is equivalent to providing electricity to approximately 12,000 households. This additional local generation will reduce the need to import electricity, on which the West Coast relies.

Key design components

4.8 This section provides a general overview of, and narrative to, the Project Description. The description below starts at the upstream end of the Scheme and progresses downstream. Further detail on the preliminary design is set out in the Project Description attached as **Appendix A**.

Headworks (including intake structures and the weir)

4.9 The structures consist of a weir to maintain water levels, provision for portage of kayaks to enter into Morgan Gorge, a wetted surface on the downstream side of the weir to support migration for kōaro and blue ducklings, a radial arm sluice gate and channel to pass sediment and bedload, an environmental flow gate to ensure that the residual flow of 3.5 m/s is maintained along with intake screens, gates and an underground desander (a large cavern to allow sediment to settle out of the water before passing through the turbines).

4.10 The weir will be a gravity concrete structure tied into the natural bedrock in the channel. It will generally be less than 4 m high but will be up to 7 m above the invert of the sluicing channel formed by blasting of rock at the intake site. The majority of the intake structure will be below water level with the intake portal itself fully submerged.

4.11 Kayak access is being designed in conjunction WWNZ experts to ensure a safe exit in Kiwi Flat, a portage route over and across the intake structure and a practical launch re-entry point into Morgan Gorge for kayakers.

4.12 A wetted area on the true left of the weir is being provided downstream of the weir to promote migration of kōaro and passage for blue ducklings while continuing to provide a barrier to other species such as trout or salmon that are not currently present at Kiwi Flat and that need to be kept out of this area to maintain the ecological balance.

4.13 Sluicing of the channel immediately upstream of the weir will be carried out by opening a 3 m (W) x 2.5 m (H) radial arm sluice gate located at the very base of the weir on the downstream side to ensure the channel can be kept clear of sediment and this will generally only be operated during times of high flow or to clear the channel after a major event that has deposited a large amount of sand and gravel.

4.14 The environmental flow gate is a slide gate in the weir wall that is used to constantly pass at least 3.5 m^3/s residual flow.

4.15 The water intake itself will be through an underwater portal, approximately 10m wide by 3m high, and consists of coarse screens followed by a headgate to cut off flow for maintenance of the underground waterways.

4.16 The water will then flow into a large underground cavern approximately 11 m wide and 110 m long that will act as a desander to settle out sediment with particle sizes of greater than 0.3 mm. A further headgate on the downstream end of the desander will be used to isolate the pressure tunnel as required.

4.17 Excess sediment will be sluiced out of the desander on occasion by means of an approximate 550 mm diameter HDPE pipe that will run down the tunnel and into the tailrace.

Tunnel

4.18 The tunnelling will consist of two approximately 5 m x 5 m tunnels formed by drill and blast techniques from the bottom up, that is from the Power Station side to the Headworks. There will be cross drives approximately every 200 m to facilitate ventilation, improved egress and to increase advance rates for the tunnelling program by providing mucking bays for temporary storage of tunnel spoil.

4.19 The first tunnel will be a concrete lined pressure water tunnel to convey the water from the intake to the Power Station, with the bottom 100 m or so encased in an underground GRP penstock to take the water into the Power Station turbines. The upper portal of this tunnel will be underwater when construction is complete and thus invisible. The lower portal will also be sealed and the surrounding ground rehabilitated post construction.

4.20 The second tunnel will be used as an access tunnel to take construction equipment to the intake during its construction and then to provide staff access to the intake site during operation. At the Power Station end, the lower portal will include rock-fall protection in the form of a rock fence on the slope above the portal and a concrete structure immediately above the roof of the portal. Both portals will have wing walls to the side of the tunnel entrances to maintain stability. The access tunnel portal at the Headworks will be 5m by 5m and rock-fall protection measures are not required, except for wing walls on either side.

4.21 At the Headworks a short access route will provide vehicular access from the access portal down to the riverbed (A) and, during construction, alongside the river terrace (B) up to Construction Staging Area 1 (C) area above the river as shown in **Figure 2** below.

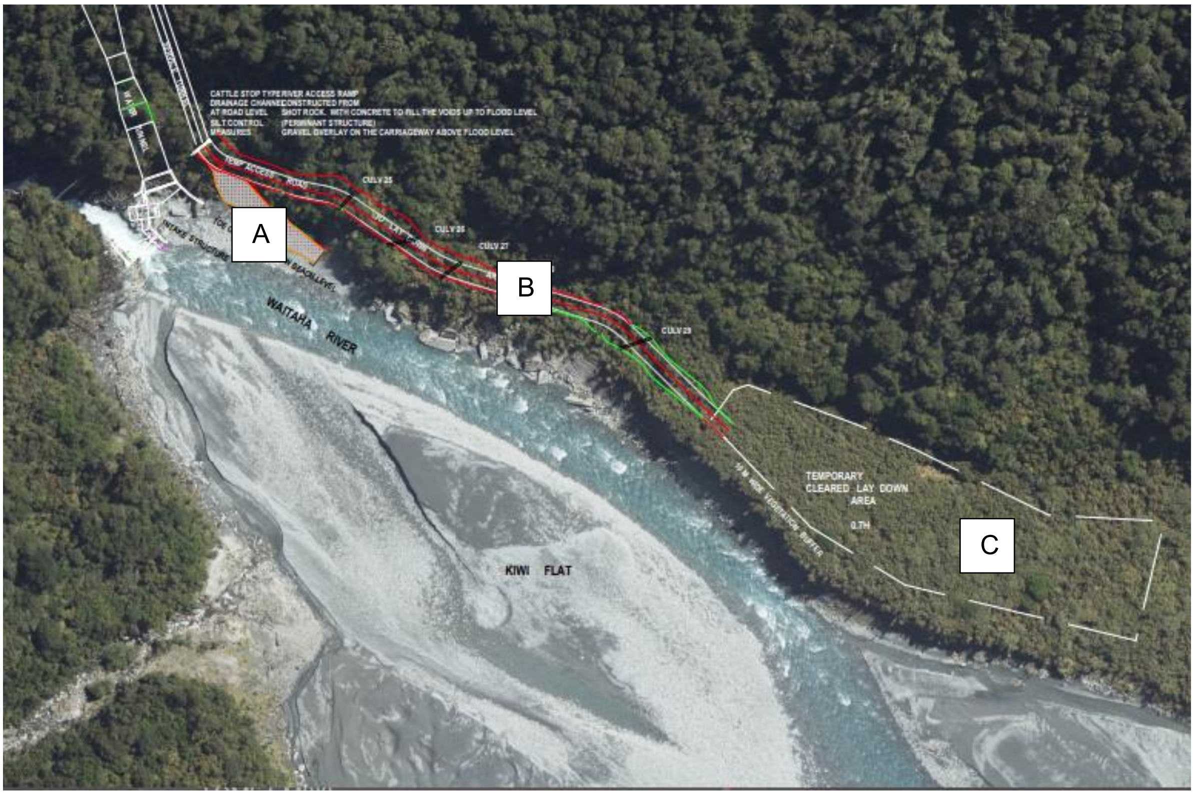


Figure 2 - Access Road and Construction Staging Area 1 at Intake

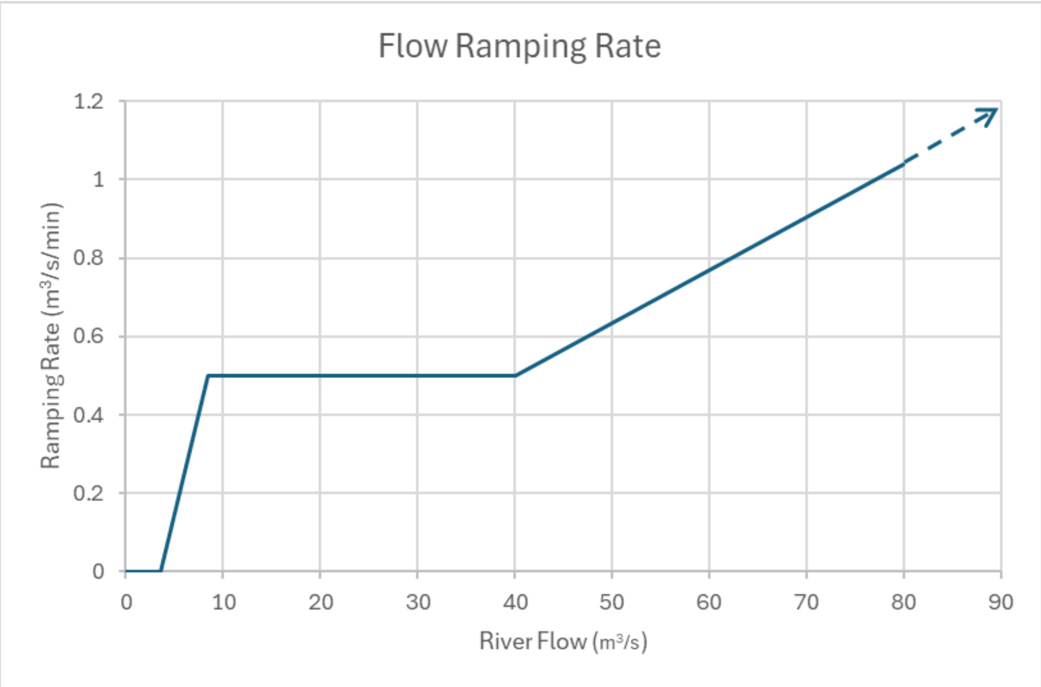
Power Station Site

4.22 Much of the 15 m x 35 m Power Station will be below ground level with only the top 6 m extending above ground. The building cladding will be in colour steel of a suitable colour with a double mono pitched roof to ensure that the building sits comfortably within the surrounding landscape. It will be situated close to the lower tunnel portal and screened from the nearby walking track.

4.23 The water from the Power Station will exit into a tail bay with steep concrete sides protected by appropriate climb proof fencing. From there it will flow into the tailrace proper that will comprise battered rock sides and back into the river.

4.24 In an emergency situation, such as loss of connection to the grid following a network fault or an internal plant failure, a bypass valve will allow water to exit the Station from the tail bay area when the turbines are not running by spraying water into the air to dissipate the remaining energy before settling back into the riverbed. This is necessary to maintain consistent flow rates in the river downstream of the Power Station and to mitigate potential risks to users of Morgan Gorge during emergency events.

4.25 As part of the assessment of effects from the operation of the scheme, a careful investigation was made to determine optimal flow ramping rates to minimise public safety hazards for river users and freshwater ecology impacts for fish downstream of the power station, while maintaining operational capability. The final rates selected involved symmetrical ramp-up and ramp-down rates and are partially dependent on the flow in the river as both the absolute and relative change in flow were considered important factors. These ramping rates are similar to those experienced during natural flood conditions and information on the assessed impact of the proposed rates are contained in the Public River Safety and Freshwater Ecology Reports. The ramping rate starts at zero when there is a residual flow of 3.5 m^3/s in the river, and increases to 0.5 $m^3/s/min$ at a river flow of 8.5 m^3/s. From that point, until a river flow of 40 m^3/s, a ramping rate of 0.5 $m^3/s/min$ is proposed. Once the river flow is above 40 m^3/s, the ramping rate becomes 1.3% of river flow per minute.[7] The following graphic depicts this.



4.26 The switchyard outside of the Power Station will be approximately 20 m long by 20 m wide and consist of a two-pole structure to terminate the incoming 66 kV line, a 15 m high lighting tower, a bunded transformer with concrete pad and associated ground mounted switchgear. It will be fenced with a standard climb-proof fencing and have signage that complies with relevant electrical safety regulations.

[7] Public Safety Report Table 2.

Ancillary Components

Road from intake access portal to Construction Staging Area 1

4.27 The temporary road from the intake access portal to Construction Staging Area 1 on the flat above the true right of the river in Kiwi Flat will have a similar construction to the road from Macgregor Creek to the Power Station, namely a 6 m wide carriageway. It will be used to provide access for contractors during construction. This road will be approximately 140 m long and include water tabling with some rock armouring to minimise damage during flood events. Culverts will be installed to maintain the flow of any minor streams identified during construction.

Accessway from intake access portal to the river

4.28 The road from the intake access portal to the river will have a similar construction to the road from Macgregor Creek to the Power Station, namely a 6 m wide carriageway.

4.29 It will begin at the access portal and provide access down to the riverbed for plant to access the Headworks for construction and maintenance. It will be developed in such a way as to minimise visibility from riverbed level, screened where possible by large rocks at the river margin. The maximum incline will be no steeper than 1 in 6. This access will be permanent.

Transmission line and access road from the Power Station Site to Macgregor Creek

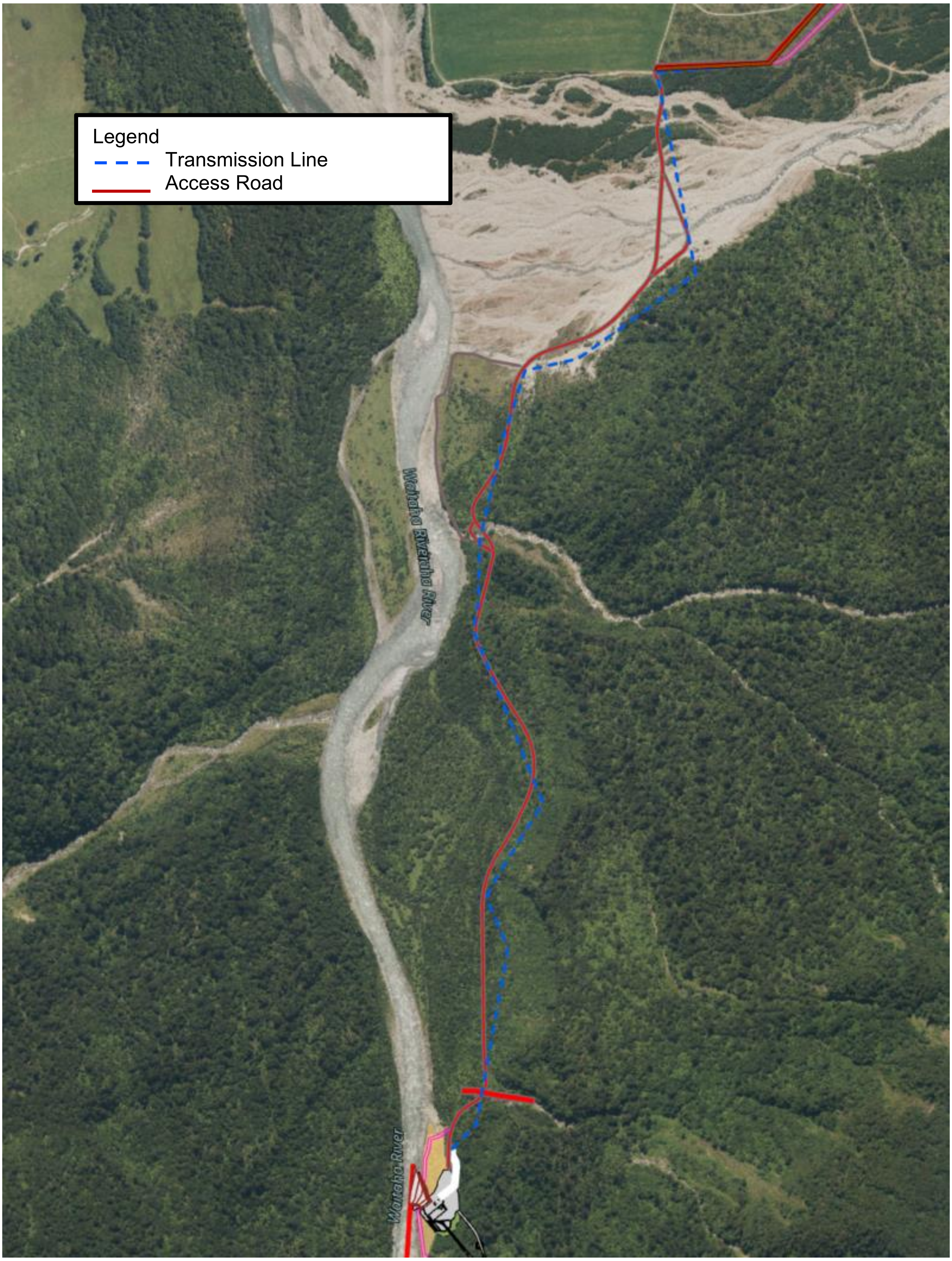


Figure 3 - Access and Transmission Route from Power Station to Macgregor Creek

4.30 The transmission line will consist of single poles, of generally no more than 16 m in height above ground. The only exceptions to this are as follows:

- a short section within a kilometre of the Power Station where an additional 3 m earth rod and earth wire may be required to be strung above the same poles, and
- the river crossing poles on the true left of Macgregor Creek where poles up to 20 m in height above ground may be required.

4.31 Pole spacings will be up to approximately 180 m (except for the span across Macgregor Creek which will be approximately 250 m) depending on the location of any change of angles and comprise aluminium conductors strung on porcelain or polymer insulators. It will mostly follow the access road and be part of the same corridor with a final width of 15 m for both the road and transmission line, except for occasional stay wires that may need to extend further into the surrounding land by up to 14 metres where a change in angle is required.

4.32 A 6 m wide carriageway will be formed for the access road from Macgregor Creek to the Power Station and will be set within a 15 m wide corridor in which the 66 kV transmission line will also run. It will be of standard road metal construction and will require minimal maintenance apart from occasional grading and compacting to keep the surface in good condition. There will be swale drains on either side of the carriageway.

4.33 As part of the design process, and acknowledging the environmental values inherent to this area, a design decision was made to avoid the stable tributary and all wetlands. In addition, mature podocarps were avoided as far as practicable through careful planning of the access route in conjunction with an indigenous tree expert.

4.34 Multiple culverts will be installed under the road to ensure all existing watercourses continue to run freely and that there is plenty of spare capacity for additional run-off during heavy rain events.

4.35 Access across Macgregor Creek will be formed using in-situ river gravels and the use of Hynds Driftdeck, or similar, for approximately 100m across the flowing section of the creek. Small concrete pads (approx. 6m x 1m) will be poured in situ in the creek to support the Driftdeck. The river will be trained to flow under the Driftdeck section to maximise accessibility during periods of low to moderate flow. It is expected that the flood events will still require the crossing to be maintained from time to time using machinery to repair the road after it is washed out. Access across the other main streams (except for Granite Creek which will be bridged) will be in the form of fords. Flows in lower order and ephemeral streams will be maintained by means of culverts.

4.36 A bridge with an approximately 20 m span and 5 m wide carriageway will be installed to cross the deeply incised Granite Creek with concrete abutments at either end. Some localised piling or other foundations may be required to stabilise the abutments, but no piles or piers will be located in the riverbed.

Transmission Line and access road from Macgregor Creek to Westpower 66 kV Network

4.37 From the Power Station to McLean Farm boundary at Macgregor Creek, there will be approximately 2.2 km of single circuit, 66 kV overhead oxygen AAAC (approximately 23 mm diameter conductor) transmission line using 18.5 m concrete poles with approximately 16 m out of the ground. The pole spacings will be up to approximately 150 m (apart from a single 250 m span across Macgregor Creek) and the conductor spacing will be between 1.7 and 2.5 m.

4.38 From McLean Farm boundary at Macgregor Creek to the end of Waitaha Road, there will be 3.6 km of similar overhead line construction within an easement through a farm property which will go through existing farm paddocks. For the last 1 km of the line route, the construction will change to a conjoint 66 kV over 11 kV design to allow the existing 11 kV distribution line to the milking shed and farm manager's house to be shifted on to the new poles, after which the redundant 11 kV poles will be removed.

4.39 The 66 kV line will continue along of Waitaha Road to State Highway 6, generally on the opposite side of the road to the existing 11 kV line feeding the local area. This allows the new line to be built in isolation from the existing network (to minimise power outages during construction), and with optimal spans of up to approximately 180 m. However, a conjoint 66 kV over 11 kV design will still be employed under the following circumstances:

(a) where there are protected heritage trees that will need to be avoided;

(b) where clearances from existing structures such as dwellings cannot otherwise be achieved under the current safety regulations (Electrical Code of Practice 34);

(c) where there is an existing corridor through vegetation, thus avoiding the need for additional clearance of vegetation; and

(d) for other practical line design reasons such as placement of poles or guy wires with respect to entranceways.

4.40 From State Highway 6 through to Westpower's connection point at its Waitaha substation, the line construction will be a conjoint 66 kV over 11 kV design that will utilise the existing line corridor, minimising additional vegetation clearance.

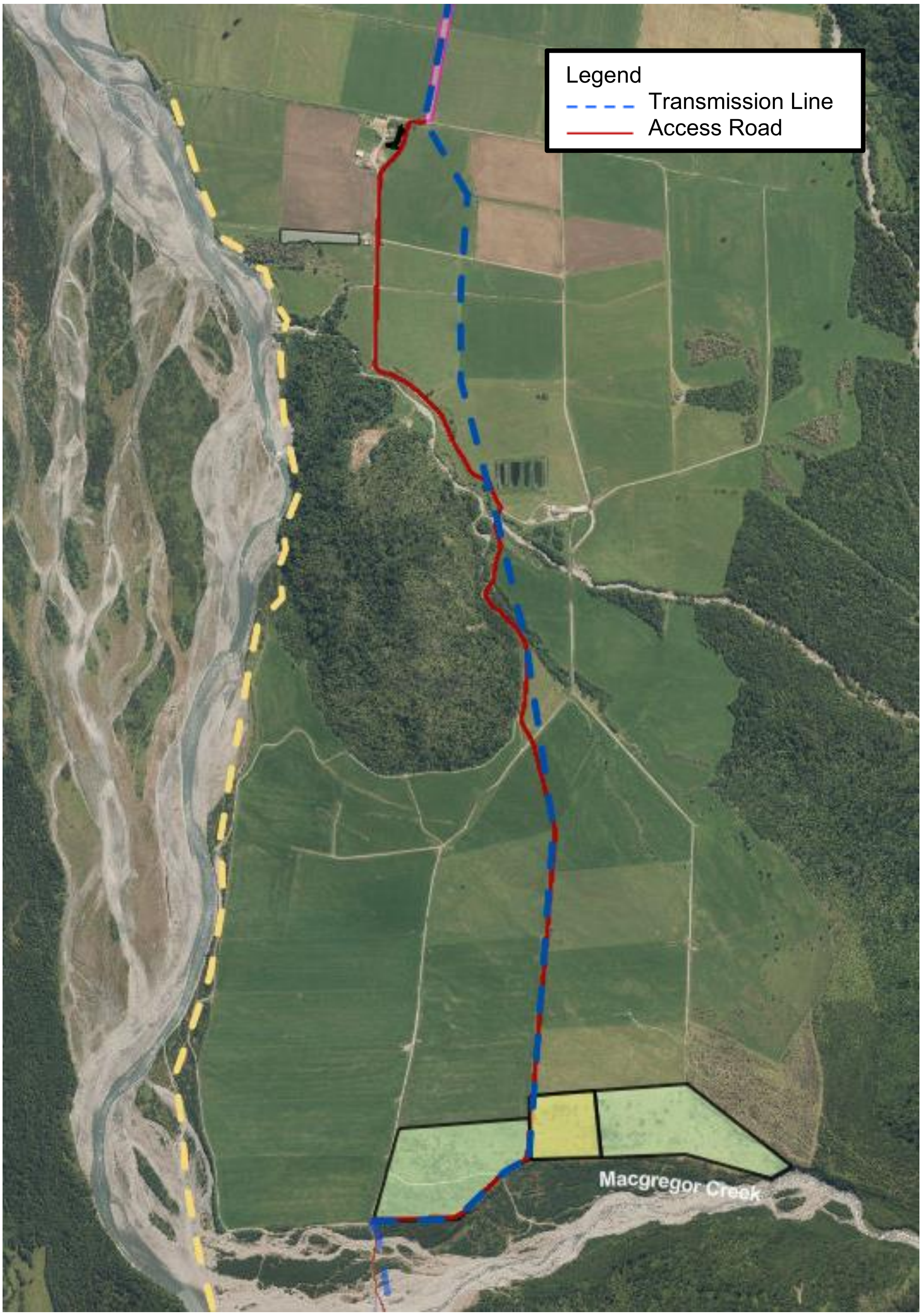


Figure 4 – Access Road and Transmission Line from Macgregor Creek to Waitaha Road

4.41 The access road through the farm will have a 6 m wide carriageway and generally follow the transmission line, except for the last 1 km approaching Anderson Road. In this latter section, the route will follow an existing farm track and carriageway will be widened to 7m to accommodate shared use with the farm.

4.42 There may be some short sections of the line that are built conjoint with the existing 11 kV line (namely the two lines will share the same, but taller, 18.5 m poles, where there is insufficient road corridor space to get around existing established trees that are considered to have significant value).

4.43 Near the start of Waitaha Road, a 66/11 kV conjoint transmission line will be constructed through a short (approximately 250 m), vegetated section near the intersection of Waitaha Road and State Highway 6 and then back along the eastern side of the State Highway for approximately 1.4 km to the Waitaha Bridge, then crossing the State Highway and proceeding another 600m as far as Westpower's existing Waitaha Substation on Bold Head Road. This will be carried out by upgrading the existing 11 kV line that is already in place and will involve changing the existing pole structures from 10.6 m to 18.5 m poles with limited additional vegetation clearance. (The vegetation growth limit zone (from the conductors to the nearest tree) for the upgraded 66/11 kV line will be 4 m, compared with a 1.6 m zone for the existing 11 kV line and will not require any mature podocarps to be felled).

4.44 The line will connect to a switching station comprising high voltage switching equipment (circuit breakers and disconnectors along with foundations, buswork and support posts along with a 3m x 3m control room) within Westpower's existing Waitaha substation. An indicative example showing these equipment types is below.

Figure 5 – Indicative Example of Switching Station

Spoil disposal sites and Construction Staging Area 3

4.45 The spoil sites will be generally as described in the Project Description in **Appendix A** and comprises two sites that currently serve as low-grade stock wintering areas with a total area of approximately 17 ha. Tunnel spoil from the excavation will be spread and eventually rehabilitated as pasture for the dairy farm on which it is situated. Any usable topsoil will be scraped off and stockpiled for later spreading back over the tunnel spoil material. This approach was successfully employed with the Amethyst scheme and has left a local farm with good quality pasture.

4.46 The maximum height of the material spread in this area will be no more than 1 m, with the actual level based on the final tunnel design and the amount of any spoil material required for building the powerhouse pad. A low rock bund will be installed on the river and hill side to protect this area from any potential inundation during extreme events.

5. NATURAL HAZARDS

5.1 The Geology and Geotechnical Report (Appendix 17 of the Application) and subsequent advice from the project geologist considered the risk that natural hazards present to the construction and operation of the Scheme. Key risks to the Scheme include earthquakes, aggradation, landslides and rockfall, flooding and fire.

5.2 Scheme design has considered mitigation of these risks, resulting in rock stabilisation, rockfall protection, and in-river maintenance procedures. While some hazards such as earthquakes are inherently difficult to mitigate, the Scheme does not involve large water storage structures which would pose a threat to the public during a seismic event. The sections below provide more detail on seismicity and flooding.

Seismicity

5.3 The Scheme will be constructed within a kilometre of the main Alpine Fault and special attention has been paid to this in the design of the Scheme. This is not dissimilar to the Amethyst scheme which is located 0.5 km from the fault.

5.4 Firstly, all key civil components of the Scheme, including the Headworks, tunnels and Power Station are located on the eastern side of the main fault, reducing the likelihood of a major shear resulting in uncontrolled release of water from the tunnel. The only structures traversing the fault line will be the access road and transmission line and it is these components that are expected to be most impacted by an Alpine Fault event. In such a case, it is relatively straightforward to push through a new temporary access track and stand up any poles that may have been toppled by the earthquake, quickly returning access and transmission services in the immediate vicinity.

5.5 All civil structures will be designed to operate after a major seismic event with a performance standard of Importance Level 4 (**IL4**) meaning that the Ultimate Limit State (**ULS**) will not be exceeded a 1 in 2500-year event.

5.6 To further reduce the risk of damage from a waterway rupture, the following features have been included in the design:

(a) Seismic sensors will detect ground acceleration due to seismic events and immediately shut the head gates.

(b) Excess velocity devices using ultrasonic flow sensors will detect an abnormal increase in the tunnel flow and will also shut the head gates, isolating supply.

5.7 Of key operational interest to Westpower, additional to the risk from an earthquake, will be landslides in the upper reaches of the Waitaha River and its tributaries that could greatly increase turbidity in the water. To address such an event more frequent flushing of the sediment chamber would be required or a higher rate of wear on machinery would need to be accepted until river conditions improve.

Flooding

5.8 The Waitaha River is subject to extreme flood rise in the Kiwi Flat area above Morgan Gorge which effectively acts as a choke in the river preventing any floodwaters from escaping quickly. This means that all of the infrastructure at the Headworks needs to be designed to continue functioning even when submerged under up to 20 m or more of floodwater. Nevertheless, with very high flood levels turbidity in the river can reach a point when the desander is not able to effectively settle out the suspended sediment. In this situation, it is likely that the Scheme will be shut down (with a controlled ramp-down) until the river level recedes sufficiently to allow operation to restart. This is only expected to take place a handful of times a year and only for a few hours at a time. In general, emergency shutdowns most often occur during storm events when the river would have a higher flow.

5.9 The Headworks are robust reinforced-concrete structures able to endure loadings from flood flows/levels, flood-borne debris and the possibility of rockfall. These different loading conditions will be included in the detailed design.

5.10 All mechanical and electrical equipment at the Headworks will be designed so that it can continue to operate in spite of full submergence. For the electrical equipment, this may include installing plant inside "diving bell" structures that maintain air pressure and keep the equipment dry in all flood events.

5.11 This was a critical design input for the desander, which is designed to operate fully submerged. This is an innovative, although not unique, design feature that means the desander can continue to operate over a wide range of river levels and international experts have been employed to ensure that a reliable solution has been developed and will be applied.

5.12 Of particular concern is the potential for floodwaters upstream of the intake to enter the tunnel network and then flow down through the access tunnel (as opposed to the pressurised water tunnel) damaging infrastructure. In response to this, the access tunnel has been designed with a high point that is well above the 1/1,000 year Annual Exceedance Probability (AEP) flood rise to provide intrinsic protection against this type of event.

5.13 Interestingly, the choking effect of the Morgan Gorge provides some natural protection to the infrastructure located at the Power Station Site by limiting the flood flows, and hence the flood rise, in the areas downstream of the gorge. This means that the flood rise around the Power Station is limited, resulting in little additional flood protection, apart from a slightly raised pad and a limited amount of rock armouring, being required. The design includes the Power Station platform providing an estimated 1/10,000 year AEP level of flood protection.

5.14 At Alpha Creek, bunding will be used upstream and downstream of the culvert to provide river training, initially to prevent inundation of Construction Staging Area 2 during the construction phase and then to protect the access road to the power station during operation.

5.15 Flooding is likely to have more impact on the access across Macgregor Creek. It is expected that machinery will be required to clear / maintain this access from time to time after major flood events as additional material migrates downstream and covers the access. This will be required to restore light vehicle access to the Power Station, and may only be required once or twice a year using a small excavator or similar equipment.

5.16 The access road between Macgregor Creek and the Power Station will be designed to handle normal flood events and will include overflow pathways to manage excess flow.

5.17 The access road from the access portal down to the riverbed margin may also require some remedial work from time to time after large flood events.

5.18 During construction, there is a heightened risk of harm to workers, and damage to the temporary construction works and plant at the intake and Power Station. In order to, mitigate this risk, remote rainfall and river level monitoring sites will be installed to provide an early warning of increasing river flows so that workers and equipment can be moved out of the hazard area and to higher ground before the river reaches dangerous levels. The monitoring sites will be at

- Moonbeam Hut
- Scamper Torrent
- Waitaha Gorge

To obtain accurate information about the Waitaha River flow during operations, there will also be a monitoring station placed just downstream of the weir.

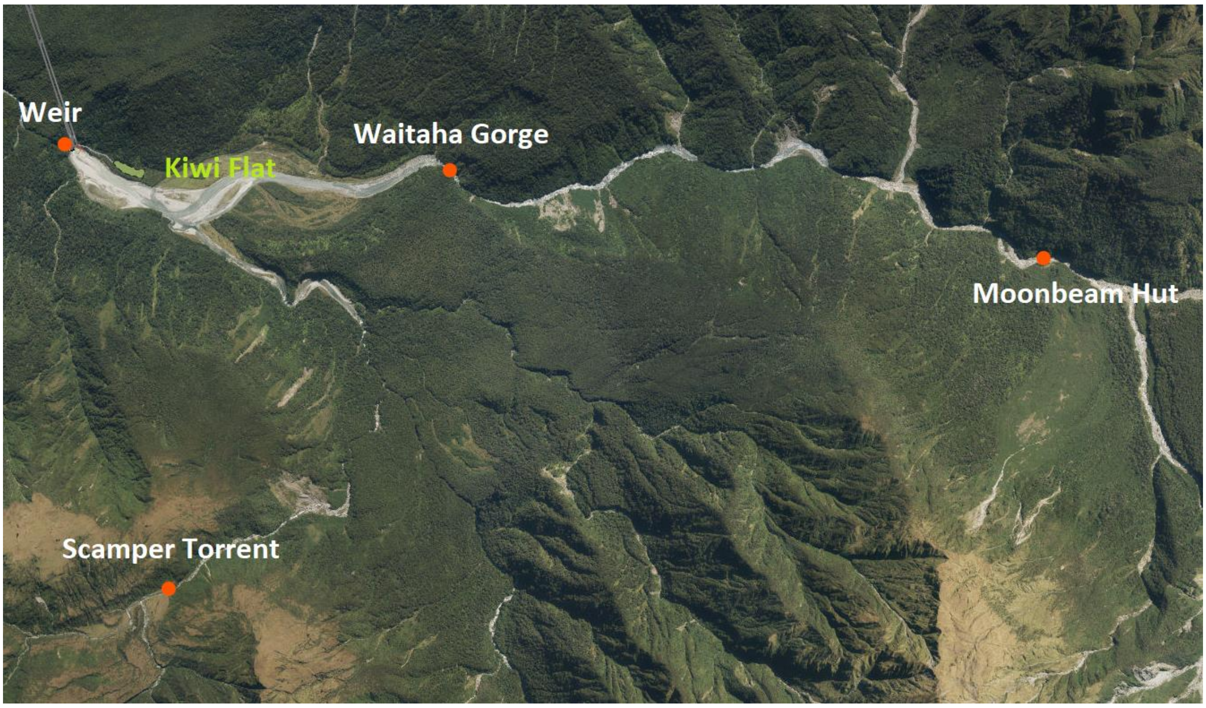


Figure 6 - Water Level Recorder Locations

5.19 The equipment will consist of a short pole approximately 4m high with a small control box, solar panel and outreach arm with water level detector and rainfall gauge similar to that shown below. At Waitaha Gorge, the water level recorder will consist of a galvanised pipe attached to the rock.

Figure 7 - Water Level/Rainfall Recorder

6. GEOTECHNICAL AND GEOPHYSICAL INVESTIGATIONS

6.1 In-situ rock property information is required to confirm detailed design and construction methods for key Scheme components as well as the final tunnel alignment and portal locations. This information will be acquired through geotechnical and geophysical investigations. Geotechnical investigations will include drilling several HQ size (85 mm diameter) boreholes using portable drilling rigs to inform the detailed design of the tunnel roof support systems.

6.2 To undertake this work, seven temporary drilling sites will be established: one at the lower tunnel portal (Power Station Site), one at the upper portal area (Headworks) and five located along the tunnel route. Each geotechnical drilling site will be approximately 10 m x 10 m (100 sq m) and will be managed using environmental controls consistent with DoC protocols and any conditions required by the Regional Council.

6.3 In addition, geophysical investigations will also be carried out at in the immediate vicinity of the intake and at the Power Station Site to define the underlying rock profile. The primary method for undertaking the geophysical investigation will be the use of ground penetrating radar (GPR) which involves towing a small trolley along the ground and recording the reflection of radar waves.

6.4 If necessary, GPR results will be supplemented by the use of shear wave or p-wave reflection/refraction methods. This involves stringing a number of small geophones (a type of microphone) on a linear route on the surface of the ground through the bush or along the river margin and then detecting reflected sound waves from a small charge to determine the underlying rock topography. The sound waves are produced using a hammer and plate, or a tube inserted into the ground with a blank charge. Depending on the method, there could be between 60 and 180 strikes. Again, this information will be used to confirm design and construction method details at key locations within the Scheme.

7. CONSTRUCTION

7.1 The Scheme's construction activities will be managed in accordance with a Construction and Environmental Management Plan (**CEMP**).

7.2 Anticipated sequencing and timetable:

(a) 1 – 6 months

(i) Construction will begin by clearing vegetation and forming the access road into the Power station and lower portal area, including a temporary access and bridge across Granite Creek until the main bridge can be constructed. The section of 66 kV transmission line from the Power Station to the end of Waitaha Road will be constructed at the same time and initially run at 11 kV to provide temporary power to the lower portal and Power Station site

(ii) In parallel with this, the main staging area (Construction Staging Area 3) will be set up on private land in the lower valley adjacent to Macgregor Creek, including offices, workshops, ablution blocks and a concrete batching plant

(iii) Build the permanent bridge across Granite Creek and disestablish the temporary bridge.

(b) 7 – 10 months

(i) Establish Construction Staging Area 2 at the lower tunnel portal

(ii) Develop the necessary site infrastructure including workshops, construction pads, sedimentation ponds etc. and develop both lower portals

(iii) Begin construction of the lower tunnel portal.

(c) 7 – 24 months

(i) Simultaneous excavation of both tunnels with the spoil being disposed of locally on the Power Station pad or trucked out to the spoil disposal area on private land adjacent to Macgregor Creek

(ii) Begin work on the Headworks using helicopter access only.

(d) 25 – 27 months

(i) Punch through of the upper access portal at the Headworks and creation of a continuous access tunnel from the Power Station site up to the Headworks. This will be used to transport machinery, equipment and concrete through to the Headworks to complete remaining construction of the civil works in that area

(ii) Complete tunnel construction (desander cavern)

(iii) Establish water intake portal at the Headworks.

(e) 28 - 33 months

(i) Construct Power Station and switchyard

(ii) Complete transmission line from Westpower network to the end of Waitaha Road. Enabling works on other parts of the Westpower network will be completed to handle the increased level of electricity that will be injected, but this will be carried out as part of of Westpower's normal network development programme and is outside the scope of this report.

(f) 33 - 37 months

(i) Final installation and testing of mechanical, electrical, control and communications equipment

(ii) Completion of all civil works including lining of the main pressure tunnel and sealing off the cross drives

(iii) Commissioning.

Construction workforce

7.3 Approximately 150 workers will be involved at different stages of the project including formation of the access road, bridging, tunnelling, concrete work, Power Station and Headworks construction, equipment installation etc. The peak workforce requirements will last throughout the tunnelling and commissioning stages, that is after the first 12 months of early works have been completed.

7.4 In addition, the Scheme will require local contractors including those supplying raw materials such as cement and aggregate, cartage contractors, surveyors, designers etc.

Construction traffic

7.5 Construction traffic will access the site offices and Construction Staging Area 3 from the end of Waitaha Road.

7.6 The impact of construction traffic will be minimised by establishing the site offices in Construction Staging Area 3 adjacent to Macgregor Creek and minimising the number of vehicle movements through the adjacent farm to that site.

Concrete Batching Plant

7.7 The concrete batching plant for the Scheme will be located on Construction Staging Area 3 and concrete trucks will be used to move the premixed concrete up to the Power Station Site and into the tunnel, without requiring use of the local roading network. The plant will require water for its operations and ancillary construction-related activities, including dust suppression. Water for concrete production will be stored in on-site storage tanks to limit the continuous offtake flow to less than 10 l/s.

7.8 The batching plant will have its own water runoff and truck washing water control systems in place. The area around the concrete batching plant will be carefully managed to minimise runoff and ensure that no contaminants beyond trace concentrations are discharged into nearby land. While the successful contract may have a different model, typical concrete batching plants have a total footprint of approximately 1200m^2 and cement silos can range in height from 10-20m.

7.9 Large items of plant and heavy equipment such as cranes will be transported via as far as Macgregor Creek and then use the access road through to the Power Station Site.

7.10 It is expected that there will be 30 light vehicle each way per day and sporadic heavy vehicle movements, with 1 very heavy vehicle movement per month (on average).

Site works (including access roads, fords, culverts, earthworks, instream river structures and works)

7.11 Construction Staging Area 1 is a contractor's laydown area (approximately 140 m long by 50 m wide or 0.7 ha) that will be established on the river terrace above Kiwi Flat. This will be used to store plant and equipment required to develop the Headworks. Laydown areas will also be established in the vicinity of the Power Station (Construction Staging Area 2) to support the main tunnelling contractor and adjacent to Macgregor Creek (Construction Staging Area 3 – 3 ha) where the main site offices and workshops along with the spoil disposal areas will be situated.

7.12 Portals for both the access tunnel and main water tunnel will be established using spiling and other ground support techniques along with concrete wing walls to ensure safety to personnel.

7.13 A tailrace channel will be formed from the Power Station Site out to the river and this will initially be used to create suitable areas for sedimentation ponds to ensure that any run-off from the tunnel construction does not result in excess sediment flowing into the Waitaha River.

7.14 The Power Station itself will require a deep excavation for the Power Station floor and then concrete walls to support the perimeter of the Power Station up to 6 m above ground level. Concrete walls and floors will also be installed in the tail bay area along with climb-proof fencing along the top of the walls for public safety.

7.15 As part of the access road construction, a temporary gravel ford will be created cross Macgregor Creek followed soon after installation of a Hynds Driftdeck crossing or similar which requires installation of foundations in the river. A concrete ford will be installed across Alpha Creek. A bridge will be installed across Granite Creek and this will not include any piers in the riverbed although some piles into the riverbanks to support the abutments. Any other waterways that are crossed will include suitably designed culverts to maintain existing environmental flows and be sized to pass normal flood flows.

7.16 At Construction Staging Area 3 (the main laydown area) a concrete batching plant will be established to provide the substantial amount of construction concrete used for the civil structures. The site offices will include an ablution block, project offices, cafeteria, drying rooms, workshops for the large machinery and geological laboratories for carrying out rock quality assessments. These buildings will generally consist of Portacom style buildings and repurposed shipping containers on temporary foundations that can be removed once construction is completed.

Spoil disposal sites and Construction Staging Area 3

7.17 The spoil disposal sites will be generally as described in the Project Description in **Appendix A** and comprises two sites that currently serve as low-grade stock wintering areas with a total area of approximately 17 ha. Tunnel spoil from the excavation will be spread, and progressively rehabilitated as pasture, for the dairy farm on which it is situated. Any usable topsoil will be scraped off and stockpiled for later spreading back over the tunnel spoil material. This approach was successfully employed with the Amethyst Scheme and has resulted in good quality pasture for the affected farmer.

7.18 The maximum height of the material spread in this area will be no more than 1 m, with the actual level based on the final tunnel design and the amount of any spoil material required for building the powerhouse pad. A low rock bund will be installed on the river and hill side to protect this area from any potential inundation during extreme events.

7.19 Vegetation clearance will be carefully managed to ensure that large podocarp trees are avoided as far as practicable and that only the minimum amount of vegetation is cleared for the task at hand.

Gravel extraction

7.20 Gravel will be required for construction of the access roads from the Power Station to the end of Waitaha Road. This gravel will be won from the Spoil Disposal Area and from the Waitaha River as follows:

(a) up to 100,000 m³ of river run material will be won from the spoil disposal areas during road construction by excavating gravel from the spoil disposal area and then backfilling this with the vegetation and organic material returned on the back load after the truck has delivered the gravel to the road construction terminal face. These pits will be progressively dug, filled and stabilised to minimise the amount of area exposed at any one time.

(b) up to 23,000 m³ of AP 40 and AP 65 gravel will be won from the Waitaha River and then screened on-site using a gravel screening plant to provide the necessary grades. This will be situated either at Construction Staging Area 3 or a site on the Macleans farm near to the point at which gravel is extracted from the river (at an unused airstrip).

7.21 Westpower has an agreement in place with a company that holds an existing resource consent to win rock from the Waitaha River. The agreement will allow us to secure consents for the necessary AP40 and AP65 screened gravels and will minimise the overall amount of material that will need to be extracted from the riverbed by allowing them to win rock (> 300 mm diameter) from the material that will not pass through the gravel screen.

7.22 Gravel is not required to form the temporary access road from the access portal to Construction Staging Area 1. This road will be formed by pushing the horizon 1 soils to the side to form a perimeter diversion bund and to expose the river gravels beneath.

Earthwork volumes

7.23 Indigenous vegetation will need to be cleared to allow the road to be constructed and structures to be placed. The areas involved are:

(a) Total Area of Disturbance – 6.8 ha

(b) Permanent loss of vegetation – 4.5 ha

7.24 The total earthworks volume estimate are as follows:

(a) Road Construction– 17,300 m^3

(b) Underground Works – 102,500 m^3

(c) Headworks/intake, laydown, Power Station and tailrace – 22,800 m^3

Erosion and sediment controls

7.25 A draft Erosion and Sediment Control Plan (**ESCP**) has been prepared by Southern Skies for all key areas of construction related disturbance activities including access routes, the Power Station Site, the Headworks, the spoil disposal site and all related construction staging areas. This ESCP adopts best practice erosion and sediment control guidelines.

7.26 In-river construction works will be required during the construction of proposed waterway crossing structures (including fords, river training structures, culverts and the Granite Stream Bridge), the

Headworks, weir and the Power Station tailrace. Details on the general methodologies used for these in-river works are provided in the DRAFT CEMP.

7.27 At both the Headworks and Power Station Sites, the slopes above the structures will be stabilised and then rehabilitated as far as possible to encourage regeneration of natural flora.

Site services

7.28 Potable water will be provided for all construction personnel through appropriate filtration of water available from the nearby watercourses.

7.29 Wastewater (sewage) will be stored in holding tanks (for Construction Staging Areas 2 and 3) that will be emptied whenever required and carted away in wastewater trucks to be disposed of in an approved manner. Any additional wastewater management required during construction or maintenance works will be provided by using temporary "Portaloo" facilities that will be regularly maintained by the supplier (for example, at Construction Staging Area 1).

7.30 Rubbish and site litter will be collected and stored locally in a secure location to avoid attracting pests and inquisitive birds such as kea, before being carted away off-site and disposed of in an approved landfill.

7.31 Site power will be provided from the local 11 kV distribution network along Waitaha Road, with the early construction of the 66 kV line from the end of Waitaha Road to the Power Station Site temporarily energised at 11 kV during the construction period to distribute power to the key locations.

Hazardous substance management

7.32 The ElectroNet group, of which Westpower is a part, have been accredited by Telarc as operating an environmental management system conforming to ISO 14001:2015 and this was most recently issued on 30 January 2024. Management of hazardous substances is a key element of this certification.

7.33 All hazardous substances for the Scheme will be managed under the group standard (*EWPP-HSE-GEN-023 - Hazardous Substance Management*) that deals with the full life-cycle of any hazardous substances including the following stages:

(a) Approval

(b) Purchasing

(c) Inventory control

(d) Safety Data Sheet (SDS) Management

(e) Storage and Transportation

(f) Usage

(g) Disposal

7.34 The process used to identify and manage hazardous substances for the Scheme is shown in **Figure 8** below:

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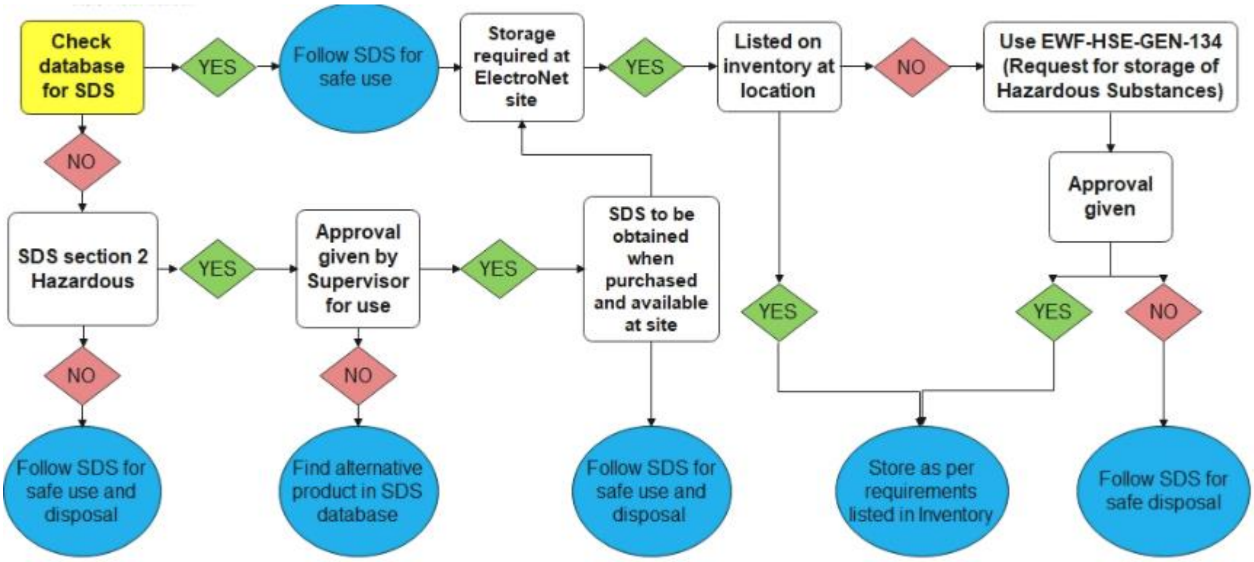

Hazardous Substances flow chart

Figure 18 - Hazardous Substance Management Flowchart

7.35 The hazardous substances involved with the operation of the Scheme include the storage of a significant amount of transformer insulating oil, which generally contains a mixture of paraffinic and napthenic mineral oil fractions. The transformer contains approximately 30,000 L of such oil and will be fully bunded to prevent environmental contamination. This will be provided by means of either underground storage tanks, which can contain the full amount of oil able to be released during a catastrophic failure of the containment vessel, or automatic oil detecting equipment that will only allow the release of water, and no contaminants, from the bunded area. The final option will be chosen during the detailed design stage, but the effects will be the same.

7.36 A table showing the other hazardous substances that are expected to be used during the operation of the Scheme, along with the quantities, is included below.

Substance Name	Substance UN Number	Maximum Quantity	Units
BP Diesel	3082	20	L
BP Petrol 91 Octane	1203	40	L
Chemetall ENVIRO CLEANER	3082	20	L
Chemz lano shield heavy duty natural lanolin protection	1950	1	L
CRC Bright Zinc 1L	1263	1	L
CRC bright zinc aerosol 2087	1950	2	L
CRC Zinc IT 2125	1950	1	L
REPCO BRAKE FLUID DOT5.1 500ML		0.5	L

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Rust Converter	1950	1	L
WATTYL KILLRUST GLOSS ENAMEL BLACK	1950	1	L
Wet & Forget moss mould lichen and algae remover		20	L

7.37 No refuelling will take place in the riverbed and all hazardous substances will be stored appropriately away from waterbodies and in accordance with Westpower's environmental standards.

7.38 Other hazardous substances expected to be required during the construction phase include significant amounts of cement and explosives (both packaged and in emulsion form). Specific management plans will be developed for each of these high-risk items in consultation with the successful contractor, but all substances brought on to site will be assessed using the method shown in the Hazardous Substances flow chart above (**Figure 5**).

7.39 The area around the concrete batching plant will be carefully managed to minimise run-off and ensure that no contaminants beyond trace concentrations are discharged into nearby land or waterways. Cement is a hazardous substance, both in its wet and dry forms, and appropriate measures will be put in place to manage the hazards involved.

7.40 The Erosion and Sediment Control Plan and the Construction Environmental Management Plan provides detail on how potential discharges to land and water, and management of dust related to the concrete batching plant will be treated.

7.41 During tunnel construction, particular attention will be given to ensuring sediment from the tunnel drainage is settled out in suitable settling ponds constructed in the area of the tail bay. The final discharge into the river will contain no contaminants or hazardous substances, beyond trace concentrations. Measures (such as dosing if required) will be taken to ensure that the pH of the receiving water is not changed by more than 0.5 pH units (where the pH is above eight or below 6.5) beyond a mixing zone of 200 m.

Rehabilitation

7.42 All sites of disturbance will be rehabilitated primarily through natural re-vegetation and supplementary planting where required at the end of construction. The spoil disposal and main site office areas will be contoured and grassed to turn them back into productive pasture for the local farmer. Any stockpiled soil will be spread out over the two designated spoil disposal areas on the farm and turned into productive pasture. This was successfully carried out during a recent similar project (the Amethyst Hydro Project completed in 2013) and resulted in high quality, well mineralised and easy draining pasture for the farmer.

7.43 The contractor staging area at the lower portal at the Power Station Site (Construction Staging Area 2) and at Kiwi Flat (Construction Staging Area 1) and temporary access to the access portal will be removed and all bare ground contoured and rehabilitated and/or revegetated.

Public safety

7.44 Public Safety is a key issue for Westpower as part of its normal day-to-day operations of running an electricity distribution business and it has a Public Safety Management system in place that is accredited by Telarc to AS/NZS7901.

7.45 Normal construction measures will be applied such as excluding the public during blasting by way of spotters with radios, ensuring security of powder magazines etc. Hazardous Substances will be used and stored in accordance with relevant health and safety regulations and further discussion is provided below.

8. OPERATION

Permanent workforce and traffic

8.1 There will be no permanent staff based on-site and during normal operation. Instead, the site will be remotely controlled and monitored from Westpower's Control Room in Greymouth to minimise the need for staff to travel to site. This is the same way that the Amethyst scheme is managed.

8.2 It is expected that visits to the Power Station Site will be made only weekly involving one vehicle trip (two vehicle movements). This will increase during annual maintenance periods, generally lasting 3 to 4 days, where up to 10 vehicle trips (20 vehicle movements) per day can be expected for contractor's vehicles coming to site.

8.3 The ElectroNet Group, of which Westpower is a part, will carry out the bulk of the maintenance on the Scheme and is certified as having a health and safety management system conforming to ISO 45001:2015.

8.4 Traffic safety is always a key focus, and experience with the Amethyst scheme will be used to inform the setting and enforcement of appropriate speed limits for any access roads past the end of the public Waitaha Road, including any limits required to mitigate the effects of the Scheme on wildlife as recommended by experts.

Operational and maintenance works

8.5 While general weekly visits to the intake will involve personnel only, it is likely that additional remedial work involving excavators will be required following large floods if gravel has filled the intake area, restricting flow into the tunnel. This will involve a hydraulic digger within the range of 12 to 20 tons working in the riverbed to recreate the channel and to help to flush the sediment through the sluice channel. It may also involve some river training work by digging out, no more than 100 m above the weir, riverbed gravels along the channel and move this material to the sides to form a bund to encourage the river to flow toward the true right of the gorge where the intake is situated.

8.6 In addition, ongoing maintenance will be required to the access track and in stream structures such as the fords and Driftdeck across Macgregor Creek following major flood events. This will involve use of a hydraulic excavator to clear excess gravel and realign any river training works that have been damaged.

8.7 Helicopter trips up to Kiwi Flat may be required on rare occasions if access through the main access tunnel is not available for any reason or if something needs to be attended to extremely urgently. This would be very much an exception.

8.8 Westpower has a proven reputation of maintaining high voltage distribution and generation assets and applies an ISO 55000 approach toward asset management including the development of formal asset management systems to ensure the assets continue to perform to expected standards with minimal risk to the environment.

Permanent site services

8.9 Raw water will be sourced from the penstock within the Power Station to provide bearing cooling water for the generators. Furthermore, this water will be used for supplying potable water (after being filtered), and for the site toilet, and will be stored in a small header tank or similar. If required, this water could also be used for firefighting purposes. Stormwater will be directed out into the tailrace and into the river.

8.10 Waste water and grey water from the Power Station will be directed into a holding tank that will emptied from time to time and the contents taken away in an approved manner by a waste disposal truck.

8.11 Site services will be remotely monitored including by the use of on-site video cameras and fire detection systems.

8.12 Solid waste management will be by means of small secure (to manage pests and birds) refuse bins that are regularly taken away for disposal in an approved manner, such as following a maintenance shutdown when staff are on-site for an extended period. Larger refuse bins will be used during the construction period but will be managed in a similar fashion by the contractors involved.

8.13 A standby diesel generator of up to 100 kVA will be installed on-site to provide essential supplies during power outages or if the Power Station needs to be black started (started where there is no power supply from the local grid). This will incorporate a double skinned diesel fuel tank to ensure that the generator is self-bunded.

Hazardous substance management

8.14 Operation of the site will involve the use of hydraulic oils, transformer oil, diesel fuel and detergents as detailed in section 7.36 above.

8.15 All sites used for the storage of hazardous materials will be adequately roofed and sealed with impervious materials.

8.16 In the case of the large power transformer adjacent to the Power Station which contains transformer oil, this will be fully bunded to contain the full amount of oil likely to be lost in the event of a tank rupture and an automatic oil/water detection system will ensure that no transformer oil is discharged into nearby waterways. This system will be fully monitored and alarmed.

8.17 Similarly, any hydraulic pressure oil systems and the powerhouse and at the intake will have fully bunded storage tanks and will be remotely monitored.

8.18 No refuelling will take place in the riverbed and all hazardous substances will be stored appropriately and according to existing Westpower environmental standards and HSNO and Health and Safety and Work regulations.

8.19 As for the construction stage, all hazardous substances will be managed according to the group standard (*EWPP-HSE-GEN-023 - Hazardous Substance Management*) that deals with the full life-cycle of any hazardous substances.

Stormwater management

8.20 Stormwater alongside the access road will be dealt with by means of swale drains with no direct run-off into the river. Multiple culverts along the access road will be generously sized and closely spaced to reduce the likelihood of damage from high rainfall events.

8.21 Stormwater from the Power Station Site will be discharged into the tailrace and managed in accordance with the Stormwater Management Plan, the development of which is one of the application's draft conditions. The single largest source of oil is the transformer which is surrounded by a large bund to mitigate against a potential oil spill. Stormwater from the bund is drained via an oil plate separator to a stormwater discharge point. The performance of the oil plate separator is 15PPM.

Public safety

8.22 Westpower has a very mature public safety management system and the has been accredited by Telarc as complying with NZS 7901:2014. This ensures that public safety hazards are identified, mitigation is proposed and risks assessed. Moreover, any public safety incidents are recorded and fully investigated following which corrective actions are employed and all steps are fully auditable.

8.23 To address the potential of a construction safety risk in the event of a flood, the access tunnel height has been designed to a conservative 1 in 1,000 year flood level. Both the access tunnel and the construction staging area are suitable retreat paths. Should an excessively severe weather event occur, two additional measures are planned. First, robust weather forecasting is monitored to inform construction teams of predicted events, and second, upstream in-river flow monitoring will be used to notify people of real time changes in flow level. The in-stream monitors will alert construction teams to move materials, equipment and people away from the area in advance of the flood risk.

8.24 Another specific public safety risk for this site involves the operation of a bypass valve that will be installed at the Power Station. When activated, 10 cumecs of water is sprayed in a plume and could create a public safety hazard for anyone in the riverbed in the immediate vicinity of the tailrace. The valve is anticipated to operate very rarely when equipment malfunctions or connection to the grid is lost. Planned mitigations for this hazard are to install signage and a siren that will sound and give a clear warning for around 30 seconds prior to the opening of the valve, and then the valve will very slowly open over approximately two minutes giving plenty of time for anyone to get clear of the riverbank on the true right side of the Waitaha River. The spray is only expected to extend into the centreline of the river so anyone on the true left bank will not be exposed to this hazard. Fencing will be provided to keep members of the public away from the disturbance area created by the plume resulting from the operation of the bypass valve.

8.25 The bypass valve will also provide a meaningful public safety benefit by regulating the flow through the tunnel in the event of an emergency so that consequential step changes in flow through Morgan Gorge and downstream of the Power Station are smoothed out. Again, a siren will also be located at the Headworks (along with signage there and at the hot pools (and downstream). This also helps to mitigate the risk of kayakers or anyone in very upper reaches of the Morgan Gorge being caught unaware by an unexpected increase in flow in the gorge.

8.26 A specific assessment of the safety risk to recreational users of the hot pools in the Morgan Gorge has been carried out by AusHydro[8] and has demonstrated the risk to be minor.

8.27 A general assessment of risk to other users of the river from the weir right down to the State Highway has been carried out by Martin Doyle. His Public Safety report[9] found that while some sections of the river could create a moderate hazard during trip events, the probability of these events occurring while someone was exposed to the hazard is exceedingly low. As noted above, the bypass valve will help to further reduce, but not completely eliminate, this residual risk. There are a number of mitigations, including sirens in the vicinity of the weir and Power Station as well as clear signage at all points of general public access to the river, proposed as part of the overall mitigation package to ensure the residual risk is as low as reasonably practicable.

8.28 A safety barrier will be constructed above the intake on the true right of the Waitaha River for safety, in case the walkers stray from the track at that point. There will be an information panel placed at the track near the swing bridge across Morgan Gorge to provide information about the scheme and clear warnings to discourage the public from getting too close to the structures.

8.29 At the tail bay, climb-proof fencing will be installed to mitigate the risk of a fall from height into the highly aerated fast flowing waterway. As this waterway transitions into a tail race, battered rock-wall slopes will be used with further fencing along the top of the slope.

8.30 Signage will be deployed throughout the site to warn members of the public of specific hazards including falls from heights and falling into water.

8.31 This is a similar approach to the Amethyst scheme and no public safety issues have arisen during its operation.

9. CONSULTATION

Department of Conservation

9.1 Throughout the development of the Scheme, Westpower has engaged with DoC, starting with the initial investigations in 2012. This includes DoC reviewing the initial studies and providing feedback, which was then incorporated into the Scheme's design.

9.2 This feedback and on-going input has influenced the development and design of the Scheme, hoping to ensure that it has the minimal possible environmental impact.

9.3 This is reflected in DoC's 'intention to grant' report, which assessed the Scheme as being largely consistent with the relevant conservation planning documents.

9.4 During the concession hearing process in December 2016, Westpower worked collaboratively with DoC including:

(a) responding to further information requests;

(b) providing feedback on the hearing report and department report;

[8] AusHydro, *Waitaha Hydro Project – Downstream Flow Modelling*, April 2025
[9] Doyle, Martin. *Westpower Ltd Proposed Waitaha Hydro Scheme – River Safety Following Commissioning*. July 2025.

(c) developing additional proposed measures and conditions in response to submissions;

(d) engaging in the further comments process from submitters and responding to those comments as required;[10]

(e) providing feedback on other reports and briefings in accordance with the concession process under the Conservation Act 1987.

9.5 Since the concession application was declined by Minister Parker in 2019, Westpower worked constructively with DoC to undertake a reconsideration process, which required a bespoke process to be developed for reconsidering the Scheme's application (and is now on hold).

9.6 Since the reconsideration application was placed on pause, and excluding more recent FTAA consultation, Westpower have undertaken the following consultation with DoC:

(a) provided a full briefing to Western South Island Operations Director in June 2024;

(b) worked closely with DoC staff to arrange the necessary research permits needed for the eDNA sampling and other environmental assessments to be updated and completed; and

(c) offered to meet further in December 2024 to provide an update on progress and discuss how Westpower could identify any residual concerns that DoC may have.

9.7 In January 2025 DOC established a consultation portal for FTA projects. Through that, Westpower has established regular meetings with DOC to discuss pre-application matters to ensure that the Department's feedback is considered when developing our submission.

9.8 Since that initial engagement, Westpower has had fortnightly meetings with DOC representatives from their Fast-track, permissions and Hokitika Operation teams on 17 April 2025, 1 May, 15 May, 29 May and 12 June. Westpower also briefed the **West Coast *Tai Poutini* Conservation Board** on 28 April 2025 (with a follow up email on 1 May, including a copy of the presentation and additional information as requested).

9.9 Key topics discussed with DOC and the Conservation Board have included:

(a) fish and whio duckling passage into Kiwi Flat and the importance of excluding other fish species (we have had separate meetings with DOC's Senior Science Advisor Marine Richarson on freshwater values, the AEE and mitigation actions);

(b) predator control and ecosystem protection more generally;

(c) sharing of experts' reports and associated management plans;

(d) investigative drilling and geophysical surveying;

(e) concession terms and conditions;

(f) recreation values and our negotiations with White Water New Zealand;

(g) community meetings that were held in May 2025;

(h) management of sediment, flooding risk and risks posed by a rupture of the Alpine Fault;

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[10] Letter from [redacted] to [redacted] dated 11 June 2018 and Letter from [redacted] to [redacted] dated 18 July 2018.

(i) cost recovery.

9.10 Westpower is committed to undertaking meaningful conservation work to mitigate any residual effects of the Scheme. The concept of “ecosystem programme” was introduced to Westpower by the local (Hokitika) DoC officers to enable Westpower to consider a wider range of conservation activities than predator control in order to make the most effective use of scarce resources. For example, a limited predator control scheme may take resources from weed management which could have a more effective conservation outcome in the Waitaha Valley, or alternatively contribution to existing conservation activities in another part of South Westland.

Local Authorities

9.11 A meeting was held with the West Coast Regional Council (**WCRC**) Chief Executive and planning team on 12 December 2024 to:

(a) provide a briefing on the current overall Scheme design,

(b) look at the operative policies, rules and objectives from the Regional Plan and proposed Te Tai Poutini Plan and show how the scheme aligns with these

(c) discuss how Westpower can effectively work with WCRC representatives to ensure they are fully informed and have everything they need to assess compliance with existing plans.

9.12 A similar meeting was held with the Westland District Council Chief Executive and planning team on 18 December 2024 to discuss the operative policies, rules and objectives from the Westland District Plan and the proposed Te Tai Poutini Plan.

9.13 On 11 March 2025 both Councils were represented at a site visit to Kiwi Flat where we discussed the intake design, construction and the drilling investigation.

9.14 We have since had ongoing discussions with Council officers on all aspects of the project, including but not limited to roading upgrades and maintenance, gravel takes, erosion and sediment risk and effects on the local community. We have shared reports as they became available, and have shared our draft concession conditions.

Landowners and local community

9.15 Engagement with the local community has occurred over a long period given the time this project has been underway.

9.16 Westpower has regularly maintained a Waitaha stand at its pavilion at the local AgFest event; a biennial agricultural event that attracts many landowners from the farming community in the Waitaha Valley and this has resulted in multiple one-on-one conversations with interested landowners where their questions were answered by Westpower representatives.

9.17 An access agreement has been arranged through the privately owned farm at the end of Waitaha Road (accessible via a short section of Anderson Road). The landowners have been very supportive of the Scheme and are also providing suitable areas for spoil disposal and Construction Staging Area 3 where the offices, workshops and concrete batching plant will be located.

9.18 All landowners in the Waitaha Valley have received an information update on the current state of the Scheme design along and been provided with contact numbers and email addresses to express any concerns will gain further information.

9.19 Public meetings were held in Waitaha Valley, Harihari and Hokitika on the evenings of 19 to 21 May 2025 respectively and these were widely advertised in advance through local print media and online social media. A good turnout of local stakeholders was experienced and a number of Westpower representatives were able to present detailed information about the scheme to those who came along and understand their concerns. Key issues were traffic safety and likely line routes and we will continue to engage with the community to assuage their valid concerns and make any necessary changes to our design that could achieve better outcomes.

9.20 A portal was developed on Westpower's website where full information on the Scheme can be found. As further information becomes available, this website is being kept up-to-date along with Frequently Asked Questions (FAQs).

9.21 An online information request form allows interested parties to contact Westpower for further information on the Scheme.

Other parties

9.22 Ongoing meetings have been held with representatives from WWNZ to discuss how we can work together to:

(a) ensure access to the Waitaha Gorge is able to continue with four no-take days being offered per year;

(b) develop a formal agreement between the two parties that will detail how this access will be managed; and

(c) mutually design safe access for kayakers' safe access to Morgan Gorge during no take days or at other times during normal operation of the scheme when flow conditions allow kayaking of the gorge.

9.23 To further enhance the kayaking experience during the proposed four no take days, Westpower is working with WWNZ to investigate the feasibility of a flow management regime through the gorge (by use of the proposed bypass valve to divert any excess flow above the preferred kayaking range) that would allow the Morgan Gorge to be kayaked for a greater range of natural flows. The initial response from WWNZ is that this would likely be beneficial from a whitewater recreation perspective.

9.24 An agreement has been reached with Whitewater New Zealand to ensure that they will continue to have regular access to Morgan Gorge for kayaking from time to time (we are proposing four no-take days per year) and that recreational and REG activities can successfully coexist as happens in other areas

9.25 A video meeting was held with Federated Mountain Clubs on 13 May 2025 to provide them with further information and determine how Westpower could work with them to ensure access into and within the valley could be shared and enhanced and any risks minimised.

9.26 In addition, further consultation with the following groups was undertaken in the weeks leading up to the FTAA submission

- West Coast *Tai Poutini* Conservation Board
- Fish and Game NZ
- New Zealand Game Animal Council

- Herenga ā Nuku Aotearoa, the Outdoor Access Commission
- NZ Transport Agency Waka Kotahi.

APPENDIX A: SUMMARY PROJECT DESCRIPTION

Summary of Project Description June 2025

Operation - General

- The Scheme;
  - Is a run-of-river design and has been chosen to avoid the need to develop large scale dam structures, impoundment and water storage lakes.
  - Diverts up to a maximum of 23 m^3/s (cumecs).
  - Retains a residual (minimum) river flow of 3.5 m^3/s.
  - Has an abstraction reach (intake weir to tailrace) approximately 2.5 km long.
  - Layout will develop about 105 m of head.
  - Generates an annual output of ~120-140 GWh with a peak output of 23 MW of power.
  - Has a 10-cumec bypass valve to maintain water flow following emergency station outages.
  - No works occur within existing reserves.

The operating conditions of the Headworks, i.e. weir and intake, can be summarised as:

Scenario description	River flow	Down-stream release	Intake flow (diverted)	Range of headwater level
Normal operation scenario *Operation up to average flow*	< 35 m^3/s	3.5 – 32 m^3/s (In practice this is likely to be 3.5 – 12 m^3/s)	0 – 23 m^3/s	EL 238.00 m
Kayak usage scenario *Flow range for kayakers*	15 – 25 m^3/s	15– 25 m^3/s	n/a	EL 238.40 m - EL 238.60 m
High flow scenario *Average to cutoff flow*	35 – 250 m^3/s	12 – 227 m^3/s	23 m^3/s	EL 238.00 m - EL 238.70 m
Extreme flood event scenario *No operation*	> 250 m^3/s	> 250 m^3/s	0 m^3/s	> EL 238.70 m

Note: for emergency station outage scenarios refer below to the Bypass Valve details.

- Scheme controlled remotely from Westpower Offices in Greymouth using communication links including real time information and camera footage. This includes continuous monitoring of equipment and river flows, managing the intake flows and flushing of sediment. Water level monitoring will include three sites upstream of Morgan Gorge.
- The operational footprint is less than 12 ha, which encompasses project areas between the Waitaha substation and the Headworks:

- In the area between the farm boundary at Anderson Road and the Headworks, more than 90% is made up of the road and transmission lines. Remaining footprint is spread over two distinct and discrete areas, the Headworks and the Power Station Sites.
- Designed to minimise the footprint and potential effect on the environment within which it is located.
- From the farm boundary at Anderson Road there is approximately 12.6 km of existing transmission line which continues via the Waitaha Road to SH6, along SH6, and then follows Beach Road and Bold Head Road to the connection with Westpower network. It is noted that the line will be upgraded at the beginning of Waitaha Road, along SH6 and along Beach Road and Bold Head Road, and a new 66 kV line will be built along the Waitaha Road (except the beginning) all the way to the Power Station.

- The only artificial (non-UV) lighting will be at the Power Station/substation and at the intake. These will normally be turned off and only switched on in the unlikely event that someone needs to attend the site for maintenance purposes after dark to check out a problem. The lighting will be designed to maximise the downward light output ratio and avoid any upward light/light scatter. The lighting will likely be turned on for a brief period (an hour or so) maybe two or three times per year, but it's also possible they might not be used at all in some years depending upon any faults we might experience. Where practicable lighting will be colour rated to 2700k or lower to avoid the emission of blue light.
- Remote controlled infrared cameras will be used to see what is happening at the Power Station/substation and at the intake after dark without need of additional lighting.
- Planned maintenance at the intake will be done in the summer (January - March) in low flow periods and outside of the whio breeding season (September-December).

  Urgent and unplanned maintenance may be required during the whio breeding season. To minimise this risk, pre-emptive maintenance work would be increased prior to the breeding season.

  Maintenance work in the river will involve an excavator (~12-20t), clearing gravel/boulders to ensure that the river flows toward the intake and sluice gate. It is not envisaged that the full intake channel profile would be recreated, but rather the channel 'trained', and larger boulders/debris moved so that it can flow in the desired direction and sluicing flows can do the bulk of the work of moving gravels.

  Planned maintenance will be undertaken if/when needed and river conditions are suitably low/stable, probably for a few hours (say a working day) rather than minutes or multiple days.

  The excavator will have to be in the riverbed, probably with the sluice gate operating to draw river levels down as necessary to minimise any depth of water that has to be forded. It will likely be excavating material from within the water column.

  Materials will remain in the riverbed, either moved over to the true left, where they may remain or be re-entrained by large flows and passed over the weir. The dark grey area indicates where materials may be placed, but this area is also expected to quickly fill up to weir level and be a gravel bar during drawn-down low flow conditions as opposed to flowing river.

  There will be a procedure in place to ensure that kōaro passage remains unimpeded.

  Safety precautions including forecasting, continual weather monitoring and excavation plans/procedures will be in place for any works in/near the river.

- During the first year of operation there may be one or two weekly site visits to check on structures and for regular maintenance, after which these are expected to drop back to one visit per week. The majority of vehicles will be light utility vehicles or small trucks, with occasional heavy vehicle access and sporadic oversize loads (for example bringing in replacement components or large machinery). This access will be from SH6, via the Waitaha Road and part of Anderson Road, continuing onto the access road on private land and subsequently to the Power Station Site.
- Access to the Headworks may be either through the tunnel and/or by foot or helicopter depending on requirements and work needed.
- Occasional periods of helicopter use for maintenance and monitoring purposes. No helipad is required during operation of the Scheme.
- A siren will sound during bypass valve operation at the Power Station Site and intake, as a warning that a plume of water is being released at the tailrace and a change in water flow of up to 13 cumecs may occur downstream of the intake.
- Localised active weed control management programme implemented within the Project Site and operational footprints.
- No dogs being brought into the area by personnel associated with the construction and operation/maintenance of the Scheme. Except specialist dogs may be required for monitoring purposes e.g. for whio.
- Additional weed/pest signage for the general public will be agreed in conjunction with DOC.
- Alternative foot access track east of the Power Station will be maintained as a permanent track. This will be in accordance with the DOC Track Construction and Maintenance Guidelines where practicable.

Construction – General

- Scheme design for consenting is subject to detailed design and effects management measures to minimise potential effects.
- No works occur within existing reserves.

Pre-construction activities include:

Investigative geotechnical drilling for tunnel construction (which may occur under a separate concession if the work needs to start before Westpower's fast-track application is decided). This will involve drilling rigs and possibly camp sites as follows:

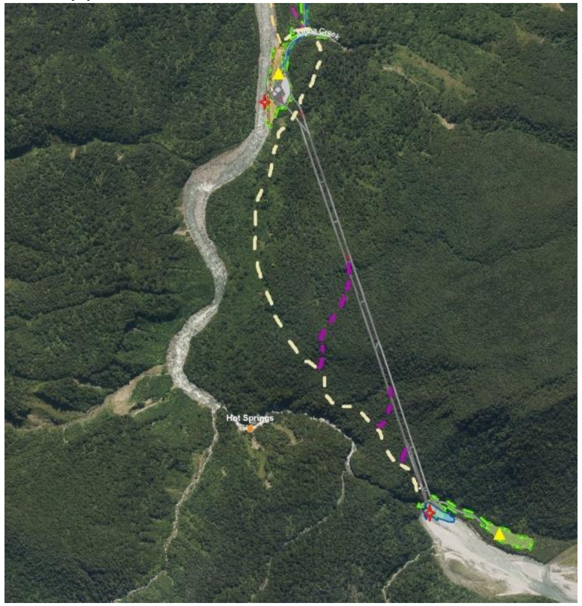
- six vertical locations and one horizontal drilling location from the surface, with multiple boreholes drilled from each entry point:
  - horizontal between the intake and access portal at the Headworks,
  - vertical at the start of the desander,
  - vertical at the headgate shaft,
  - vertical x2 in the middle section of the tunnel,
  - vertical at Power Station;
  - vertical on the plateau above the tunnel near Power Station Site.

  Boreholes will be up to around 200 m long, except for a short borehole at the Power Station.

Centrifuge will be used for excavated material to ensure it is contained and disposed of appropriately.

Approximate size of disturbance areas:

- drill site 10 x 10 m (note: helicopter landing is not required at the drill site),
- two helipads 10 x 12 m (near each campsite described below),
- emergency hut (if no camp) 3 x 4 m,
- two campsites – at locations that will later become Construction Staging Area 1 and Construction Staging Area 2: camp 10 x 10 m; generator 3 x 4 m; drying room 3 x 4 m, portable toilet 3 x 3 m; shower 3 x 3 m; there will be holding tanks used for shower and toilet water collection
- , pump site at closest water supply 3 x 3 m, taking up to 50 litres per minute and delivering water to drilling rig via a 32 mm pipe.
- Approximate water take locations, track routes and campsite locations are indicated on the following map:



- in situ and laboratory geotechnical testing,
- drilling equipment helicoptered to site (approximately one day's flying for set up and dismantling at each drilling location),
- use of generators for power supply at drill site,
- fuel tank of about 1,500 litres total at three locations,
- basic tracks between main access areas (such as from the supply pump to the drill).

Geophysical surveying will involve a ground penetrating radar (GPR) survey, and will be supplemented where needed by a seismic survey (shear wave or P-wave). For GPR, there will be a lawnmower size machine pulled along the lines. For the seismic survey there will be vibration generated at 128 points along each line (either by a 12 lb sledge hammer hitting a metal plate or by a "buffalo" gun firing blanks in a small 30 cm hole in the ground), and multiple receivers along the line will measure the reflected waves. Although these surveys are planned to happen along a line, they will go around any trees/shrubs bigger than a thumb size.

Road surveying for final road/access alignments. This includes final consideration of works in the vicinity of the Stable Tributary.

Surveying of vegetation to avoid, where practicable, any trees of significant size and or bat roosting potential;

Weir and intake design considerations including providing access for kōaro, kayakers, whio ducklings (while providing a barrier to trout).

Stormwater/Wastewater

- Stormwater management will consist of contouring/shaping/bunding any earthworks and cleared areas to reduce the potential for erosion and runoff directly into waterways. Where possible, use will be made of the permeability of the alluvial material such that water can temporarily pond and percolate into the ground.
- Wastewater management includes a wastewater holding tank at Construction Staging Area 3 (true right of Macgregor Creek), a similar smaller system for Construction Staging Area 2, and a small self-contained system (e.g. portable toilet and showers) at Construction Staging Area 1.

Timeline

- An intense period of activity over a period of about 3 - 4 years as the Scheme is established, followed by a low level of activity during routine operation and maintenance.
- Construction of the Scheme can be considered in four key stages.

Stage	Description	Estimated Period from Start
1.	Access road and transmission line from Waitaha Rd to the power station site. Staging Areas 2 and 3. Bridge across Granite Creek.	1-10 months
2.	Tunnels and subsurface structures. Early works at the intake. Construction Staging Area 1 and the access track from the access portal to Construction Staging area 1. Short access track from access portal at the intake to the river.	7-27 months
3.	Remaining water tunnel and desander excavations completed. Construction of the intake channel and weir. Construction of power station, switchyard and tailrace. Construction of the remaining section of the transmission line from Westpower's Waitaha Substation near SH6 to Macgregor Creek. Rebuild of Waitaha substation.	28-33 months
4.	Equipment installation and commissioning in power station, switchyard and intake.	32-37 months

Areas of Potential Disturbance

- Approximate areas potentially affected by scheme (overall footprint)

	Construction (ha)	Operation (ha)
Headworks/Intake Area		
Weir	< 0.1	< 0.1
Intake Channel (including Sluice Channel)	0.2	0.2
Intake Structure and Intake Portal	< 0.1	< 0.1
Tunnel Portal, Intake Accessway and River Protection	< 0.1	< 0.1
Road to Construction Staging Area 1	< 0.1	0
Construction Staging Area 1	0.7	0
Test Drilling Site (x 4)	< 0.1	0
Intake Totals Rounded	**1.2**	**0.3**
Power Station Area		
Power Station, Control Room, Switchyard	< 0.1	< 0.1
Hard fill area between power station, access road and tunnel portal	0.3	0.3
Tailrace & tailbay	0.2	0.2
Retaining wall, river protection, access ramp	0.1	0.1
Slope protection works	< 0.1	< 0.1
Construction Staging Area 2 (including temporary staging road and riverside flood protection)	0.8	0
Test Drilling Site (x 3)	< 0.1	0
Power Station Totals Rounded	**1.6**	**0.7**
Road / Transmission Line between farm boundary at Macgregor Creek and the power station site		
Transmission Line (where separate from the road)	0.6	0.6
Access Road (where separate from transmission line)	0.6	0.6
Access Road and Transmission Line (running in parallel)	3.2	2.7
Waterway Training and Flood Protection at Alpha Creek	0.2	0.1
Road / Transmission Line Totals Rounded	**4.6**	**4.0**

Farm		
Construction Staging Area 3 and Spoil Disposal Areas	20.3	0
Farm boundary at Macgregor Creek to farm boundary at Anderson Road – access road	2.15	2.15
Farm boundary at Macgregor Creek to farm boundary at Anderson Road – transmission line	2.15	2.15
Farm boundary at Macgregor Creek to farm boundary at Anderson Road – transmission line and access road adjacent	2.6	2.2
Gravel Screening area	0.8	
Farm Totals Rounded	**28**	**6.5**
Road / Transmission Line **Between farm boundary at Anderson Road and Waitaha Substation**		
Waitaha Road from Anderson Road to SH6 – transmission line and passing places *	11.1	<0.1
Along SH6, Beach Road and Bold Head Road and to Waitaha substation – transmission line *	2.3	0
Road / Transmission Line Totals Rounded	**13.4**	**<0.1**

** 11.1 ha and 2.3 ha accounts for the entire transmission corridor. During construction, actual disturbance will be limited to approximately 1-2 ha which is the area around the transmission poles.*

- In summary, there will be areas of disturbance on conservation land during construction of the Scheme, including in places a localised loss of forest/vegetation cover.
- The area of indigenous vegetation potentially affected between the Waitaha Substation and the power station site, and at the headworks, during construction will be approximately 6.8 ha (incl. 0.7 ha riparian), which will reduce through rehabilitation and regeneration to approximately 4.5 ha during the operational phase. (Refer to Appendix 2 for details.)
- All areas not required for the ongoing maintenance or operation of the Scheme will be rehabilitated.

Gravel Extraction

- Gravel for the access road will be sourced locally, at the following locations:
  - Beach areas in the Waitaha River (approximately 23,000 m^3) – by horizontal scraping of the dry gravel above the water level and away from the edge of wet areas; taken from the area of an existing resource consent in the vicinity of the farm;
  - Spoil disposal areas on McLeans farm (up to 100,000 m^3).

Gravel will be relocated either to Construction Staging Area 3 or to the Gravel Screening area on the farm before being screened for size. Unsuitable gravel will be used to back-fill excavation areas. Extracted Gravel will not require washing.

Excavated material

- The approximate volumes of excavated material (excluding cut to fill and vegetation/organic material, and not bulked) are shown in the table below.

	m^3
Underground works	102,500
Headworks, including Construction Staging Area 1, access road/track to river at the headworks	10,600
Power Station Site and adjacent excavations, including Construction Staging Area 2	15,800
Construction Staging Area 3	3,200
Road construction between farm boundary at Anderson Road and farm boundary at Macgregor Creek	12,200
Road construction between farm boundary at Macgregor Creek and the power station site (including Alpha Creek works)	1,500
Total	**145,800**

- Waste material from the construction of the access road will be deposited at the Spoil Disposal Areas.
- Vegetation from the formation of the access road to be disposed of.
- Spoil from the tunnels will be utilised as fill within the development earthworks areas where possible, such as to create a raised pad at the Power Station Site, or will be temporarily stockpiled before being transferred off conservation land. Spoil may be transported directly to Spoil Disposal Areas at day or night during 24/7 tunnelling operations.
- Spoil will be used for the rehabilitation of the Spoil Disposal Area and Construction Staging Area 3 into pasture for farming purposes. Deposition and recontouring of spoil material will be located outside riparian margins and managed in accordance with an erosion and sediment control plan, until vegetation cover is established. Total un-rehabilitated area of spoil will not be greater than 1 ha at any one time and will not exceed 1m in height.
- It is anticipated that all spoil material will be to cleanfill standards and not result in leachate or changes in pH levels in the surrounding environment; this will be confirmed by laboratory testing prior to deposition.
- There will be a requirement for temporary stockpiling locations in both Kiwi Flat and at the Power Station Site. This will be kept to a minimum (and no more than 100 m^3).

Construction Areas

- The access road corridor will provide for parking and storage areas as the road is progressively formed rather than the creation of further separate areas.

Noise

- Noise generation from helicopter movements and construction activities, such as blasting and possibly piling will occur intermittently during the construction period.
- Tunnel excavation will create noise in the early stages. During the initial stages of tunnelling it is common practice to confine work to a single extended day shift to limit the blasting to daylight hours and that is what is proposed in this case, after which it becomes a 24-hour operation.
- Underground blasting could occur at any time over the 24-hour working period, depending on when the tunnelling cycle is ready for blasting.
- At the Headworks, noise will be intermittent over the period of construction. When blasting channels in the rock at the Headworks, the explosions will be a sharp crack but of short duration, over a couple of weeks. This is dependent on low flow, so will need to be done in low flow season (likely winter), and may not be consecutive. A section of the walking track would be closed for several minutes when blasting, with personnel on each side to ensure no one walks the track at that time.
- Helicopters involved in the construction and maintenance of the Scheme will generally be limited to the lower part of Kiwi Flat and downriver.
- Helicopters will be used in the construction of the Headworks to transport personnel, equipment and materials from the Construction Staging Area 2 and Construction Staging Area 3 to the Headworks and Construction Staging Area 1 over a period of up to 24 months. On most days when conditions are suitable for flying there could typically be eight movements (i.e. two return trips at the start and end of the day). This could be higher when setting the Construction Staging Area 1, potentially up to 20 – 30 movements.
- Helicopters will also be used to pull conductors when stringing the transmission line. This will be completed within several days, however the work will not be continuous and may be spread out over the project Stages 1 and 3. Helicopters will be hovering for approximately two hours per day. Either all the poles or at least a large number of poles will need to be in place for conductors to go up.
- Once the Scheme is operational, noise generation will generally be very low. The main exception being infrequent helicopter movements for staff visit/maintenance and operation of the siren during very infrequent emergency station outages (refer below). Diverting some of the flow from the Waitaha River will generally slightly reduce ambient noise levels in the vicinity of the Waitaha River within the abstraction reach.

Traffic

Waitaha Road and Anderson Road

- From the end of Waitaha Road, the light and heavy traffic will follow a small section of Anderson Road to the farm entrance.
- During the busiest period (when the tunnelling, Power Station, Headworks and transmission line works are overlapping), on the Waitaha Road and the small section of Anderson Road there will be approximately 32 light vehicle movements one way (64 both ways) per day. The numbers exclude short trips along Waitaha Road when the transmission line will be built along the road corridor, and when there will be a constant presence of workers due to frequently moving between poles.
- After the initial few months, on the Waitaha Road and Anderson Road there will be a steady movement of trucks bringing in gravel and cement for concrete (for tunnel lining, Headworks, Power Station) for approximately two years, with an average number of trucks being four per day one way (eight both ways) with a short 5 month period (months 28 to 33) where there will be up to 6 trucks per day one way (12 both ways). It is assumed that gravel for the access

road across the farm, and between Macgregor Creek and the Power Station, would be sourced from Waitaha River and the Spoil Disposal Areas on the farm (therefore near the road construction site), and these numbers have been excluded from the calculations for Waitaha Road. The calculations also exclude transporting spoil from the tunnel, Power Station Site and road excavations to the designated area on the farm.

- Oversize vehicle (over 40 tonnes) movements on the Waitaha Road and Anderson Road will occur sporadically. Initially, to bring in parts for the temporary and permanent structures for crossing Granite Creek and Macgregor Creek, and then when the road to the Power Station becomes useable to bring in tunnel excavation machines. Later in the build, the turbine and switchyard equipment (generator, transformer) will be brought in.
- Large vehicle movements on public roads will be restricted to daytime hours, except for a small number of oversize deliveries which may require road closures (as discussed above). Deliveries of aggregate, for example, would occur during daylight hours.

<u>Access Road on the Farm</u>

- From Anderson Road, a new road will be built on private land, going through the farm to Construction Staging Area 3 and farm boundary at Macgregor Creek.

<u>Macgregor Creek to Power Station Site</u>

- On the access road between Construction Staging Area 3 (on private land) and Construction Staging Area 2 (Power Station Site) light vehicles will move particularly during shift changes during tunnelling. Trucks will use this part of the access road mainly to transport spoil from tunnel and Power Station excavations to the spoil disposal areas on private land. On average there will be 38 truck movements per day (19 each way; assuming a 20-tonne truck) over the period of two and half years (encompassing the road and tunnel construction, and excavation at the Power Station Site). Oversize vehicle movements here will occur sporadically.
- The large majority of vehicle movements will occur during daytime hours. A small number of vehicle movements will occur at night during the tunnelling stage of construction as this is a 24 hour activity. Night-time vehicle movements will be limited where practicable.
- We will aim to use shared transport where practicable to limit vehicle movements.

Helicopter Movements

- Used for transporting personnel, equipment and materials between Construction Staging Areas.
- Used for establishing the surface components of the investigative drilling.
- Anticipated an average eight movements per day (when conditions are suitable for flying and for work to be carried out) between these sites over a period of up to 24 months.
- Helicopter movements will occur only during daytime hours and do not occur during dawn or dusk for safety reasons.
- Flights taking concrete into the Project Site will be undertaken in such a manner that there could not be an accidental release into the active river channel.

Refuelling

- Refuelling will only be conducted at specified sites:
    - Helicopters will be refuelled at Construction Staging Areas 1 and 3.
    - Equipment, plant and other vehicles will be refuelled at controlled areas including all three Staging Areas and along the access road corridor during access formation, and at the intake and power station sites.

- No storage and refuelling within the beds, or on the bank of, any waterway. This includes within 10 m of waterways and 20 m from the stable tributary.
- Fuel will be stored in double skinned containers within bunded areas, with accidental spill procedures established.

Lighting

- Lighting will be required at the intake and Power Station portals during the tunnelling phase of construction as this will be a 24/7 operation. Lighting will be colour rated to 2700k and designed to limit upward light/light scatter where practicable.

Water level monitoring

- This will include monitoring of river flows at three sites upstream of Morgan Gorge.

Hazards

- Flood Hazard

The Scheme design includes the Power Station platform providing an estimated 1/10,000 AEP level of flood protection. Headworks (including the access portal) are expected to be inundated in medium-large floods and such loads need to be considered in detailed design.
There will be permanent river training bunds on the Alpha Creek side and temporary bunds along the Waitaha River to reduce risk of washout of the access road at this crossing and to protect Construction Staging Area 2.
The vertical alignment of the access tunnel provides passive protection against Kiwi Flat (intake) floods, with the tunnel rising to a high point above the 1/1000 AEP flood level at the intake.

- Landslide Hazard (small scale)

Concrete headwall/wingwall structures at the tunnel portals protect access from rockfall risk.
Access roads are generally aligned away from the toe of slopes, minimising landslide risk.

- Landslide Hazard (medium scale)

If medium-sized landslide within the catchment, headworks are able to pass sediment over weir and though sluice gate. Maintenance access to the river to allow mechanical movement of deposited sediment.

- <u>Landslide Hazard (large scale)</u>

Large scale landslide with millions of m³ of sediment introduced to the river not readily designed for, but as above, sediment will bypass the Headworks at weir level, and access from the elevated access tunnel portal should remain available for mechanical excavators.

- <u>Large Earthquakes – Alpine Fault, Glamour Glen Fault</u>

Detailed design will consider appropriate seismic loads. Alpine Fault Earthquake remains an important risk to the Scheme.
In the preliminary scope of geotechnical investigations, surface geological mapping will allow an initial assessment of evidence for ground surface deformation related to earthquake activity along Glamour Glen Fault and (when identified) assess the requirements for any further fault/earthquake investigations.

Pests and Weeds

- All machinery used on site as part of this development will be required to be weed free upon arriving.
- All gravel, fill or other material brought onto the site comes from a weed free source.
- Compliance with the Didymo prevention and cleaning protocols.
- Localised weed control management programme implemented within the project footprints.
- No dogs will be brought into the area by personnel associated with the construction of the Scheme. Except dogs may be required for monitoring purposes e.g. for whio.

Access

- In recognition of the potential construction effects, and to provide enhanced foot access, it is proposed that an alternative entry route to the existing foot access track at Alpha Creek and improvements at other locations where practicable be provided for recreational users to access Kiwi Flat.

  The final route and design of any track improvements will be subject to agreement and approval of DOC and take into consideration feedback from recreational users.

Tunnel Development summary

Component	Operation	Construction
Tunnels	▪ Diverted tunnel ground water discharged to river. Water is anticipated to be clean water but will be treated where required. ▪ In the access tunnel: · Concrete floor cast in-situ, · Drainage channel, · 550 mm HDPE for sediment sluicing.	▪ Two tunnels 1.5 km long and approximately 32 m apart, with an average grade of 1 in 15 will be excavated between the Power Station Site and the Headworks. This will comprise an access tunnel and a pressurised water tunnel. ▪ Groundwater from tunnels diverted to Construction Staging Area 2 for treatment and discharged to river.

Component	Operation	Construction
	· Ongoing electrical and communication service cables. ▪ Access tunnel provides access to Headworks for inspection and maintenance during non-flood periods.	▪ Ventilation ducting during construction. ▪ Tunnel spoil utilised, where suitable, as cleanfill for Power Station Site development or taken to spoil disposal areas. ▪ Final alignment is dependent on investigative drilling. ▪ Tunnels design to allow for: · driving the tunnels using drill and blast techniques, · transporting supplies and materials to the headworks construction site (access tunnel), · ongoing access for operation and maintenance (access tunnel). ▪ Indicative construction sequence (note: some works concurrent with work at the Headworks): · Form two tunnels starting from the bottom and alternating between them for drilling and spoil removal with cross drives less than 200 m apart, · Concurrently begin pre-construction works at the Headworks via helicopter access, · Continue with access tunnel and access portal, and breakout access tunnel to Headworks to give access to complete Headworks, · Construct access track between Construction Staging Area 1 and Headworks, · Excavate pressurised desander, · Desander concrete work, · Complete intake structure to safeguard portal from flooding, · Breakout hydraulic tunnel to portal and complete intake structure, · Complete Headworks, · Lay penstock to the Power Station Site.
Excavation & Construction		▪ Primarily constructed using drill and blast techniques. ▪ Areas of weak rock may be excavated using a milling head on an excavator. ▪ A water supply of up to 600 l/min will be required for tunnelling operations, which will be sourced either from the river or from tunnel seepage. ▪ Blasting could occur at any time over the 24-hour working period.

Component	Operation	Construction
		▪ At least 50% of the tunnels will likely require rock bolting and shotcrete during excavation. Shotcrete will include additives such as steel or polypropylene fibres. ▪ A significant proportion of the excavation will be concrete lined (both walls and floor). ▪ The break out from the intake portal is expected to result in some rock falling outside of the portal into Morgan Gorge. ▪ Before breaking out on the Headworks side, there will be work done from the outside first, for about 10 metres into the hillside. A small borehole will be slowly increased to the desired width using small charges (much less impactful than the charges that will be used underground).
Ventilation	Natural ventilation post construction.	▪ A high speed ventilation fan will be required at the exit portal to vent the tunnel during construction. ▪ Blasting gases would be removed by ducting and discharged outside the portal. ▪ Small quantities of dust may result from the blasting if the rock is dry but this will also dissipate quickly at the portal.
Tunnel discharge	▪ Sediment ponds will eventually be rehabilitated (where not part of structures). ▪ Following construction, tunnel discharge is anticipated to be running clean but will be treated where required. It is proposed (depending on volumes) this be directed either into the tailrace or directly into the river.	▪ Subterranean water encountered during the tunnelling will be kept separate from construction water where practicable. ▪ Construction water (such as cooling of drilling operations, water scaling of excavated surfaces, dust suppression) will be diverted to a temporary sediment retention pond and treated before being discharged to the river. ▪ Any geothermally heated water that might be encountered will be treated in the same manner to avoid discharge of heated water to the river. ▪ Water associated with concrete operations (including groundwater that cannot be kept separate from operations) will be considered concrete wastewater. It will be treated for clarity and pH levels, and following water treatment be diverted to the sediment retention pond. ▪ If pH levels within any settlement tank are outside of the +/-1 of baseline and outside of the range of 6.5pH and 9 pH levels then the

Component	Operation	Construction
		water will be pumped to the second treatment tank and treated with CO_2 or citric acid as required. The clean water is then discharged to ground. ▪ It is anticipated that the pond base will be unlined and treated water will filter into the underlying alluvium. The ponds would also include a discharge outlet to release decanted excess clean water either into the river or to a secondary retention pond within the Power Station Site/Construction Staging Area 2. ▪ Practical control measures will be taken around the tunnel portal to ensure the reduction of any significant sediment (or hydrocarbon) spills reaching adjacent watercourses and to manage the pH of any discharge.

Main Project Components (ordered upstream to downstream)

Component	Operation	Construction
Headworks - General	▪ Continuously pass residual flow downstream. ▪ Provides for kayak passage during dedicated kayak windows ("no-take" days). ▪ Provides for kōaro and whio passage and prevents trout migration upstream. ▪ Designed with minimal visual impact. ▪ Passes large quantities of bedload, comprising boulders and coarse gravels. ▪ Must allow for substantial flood rise. ▪ Permanent visible headwork structures consist of the weir, intake diversion, channel and access portal. ▪ No water storage in this type of run-of-river scheme so the generation output will follow the flow of the river. ▪ A maximum of 23 cumecs take through the Headworks.	▪ Includes all those works associated with the intake and weir at the top of the Morgan Gorge, including the access tunnel portal entrance. ▪ Intake works include construction of: · a low weir across the river, · an intake channel on the true-right bank which takes the river flow to the intake gate and incorporates a channel and gate to sluice sediment past the intake, · an intake gate housed at the start of a roofed culvert to convey the flow into the intake tunnel portal. ▪ Likely sequence of events following establishment of the access tunnel portal and access track to Construction Staging Area 1 and intake area is: · construction of water intake channel, · construction of intake portal structures,

Component	Operation	Construction
	▪ Scheme will constantly release at least 3.5 m^3/s (environmental flow) downstream. ▪ Initial backwater formed by the weir extends some 250 – 300 m upstream. This would likely fill quickly with sediment, possibly during the first flood, due to the relatively small storage volume with the riverbed regrading down to the weir. The weir and intake design do not create a lake upriver from the intake with the river reaching equilibrium and returning to natural base flow patterns in a short period following construction. ▪ Planned starting and stopping of the Scheme managed using ramping procedures to prevent a sudden increase in flow in the main stem of the river or in the case of starting, increased discharge from the tailrace. ▪ Procedures put in place to manage situations which may result in the Scheme shutting down without notice, e.g. automatic emergency shutdowns, including to maintain public safety. ▪ A 550 mm pipe will take sediment down to the Power Station through the access tunnel, where sediment will be discharged into the tailrace. ▪ Power and mobile phone services are required to supply lighting, power and communications to the tunnel and/or Headworks.	· construction of weir, · break-through to intake tunnel. ▪ Use of helicopters for access in addition to later tunnel access provides flexibility for construction and a longer window for the "in river" work. Also assists with lowering construction period. ▪ Helicopter landing located within the Construction Staging Area, although some equipment or materials, e.g. concrete, may be delivered directly to where it will be used. ▪ Cleaning of concreting tools or formwork is done in a contained area away from the river. ▪ River needs to be diverted during construction, to provide a dewatered construction area to ensure safety for construction crews. ▪ Construction within riverbed timed to take advantage of low river flows. Timing of the work to ensure that temporary site works such as boxing and bracing are not vulnerable to being washed away by the river. ▪ Activities will include blasting of rock, trimming of vegetation and concrete work. ▪ A number of small blasts to excavate and profile the diversion channel. ▪ Sediment from works returned to the river given topography of the area and flows in the river.
Coffer dam	▪ Coffer dam removed following construction.	▪ Temporarily redirect the Waitaha River above Morgan Gorge to one side or the other to allow dewatering of works for construction. ▪
Weir	▪ Maintains water levels for diverting water and managing sediment. ▪ Provides a stable water level upstream of the intake and passes flood flows and sediment downstream.	▪ Approximately 30 m long, 1 m crest width. ▪ Crest elevation of EL 238.00 m is proposed. ▪ Less than 4 m high, but up to 7 m in the sluice/diversion channel. ▪ A typical gravity concrete structure, on natural bedrock in channel. ▪ Top covered with steel alloy, bolted on. ▪ Includes a training wall – a concrete wall with a 0.5 m wide crest.

Component	Operation	Construction
		▪ Indicative construction sequence; · Construct temporary coffer dam to enable right abutment works. · Construct right abutment works (i.e. weir, intake, portal, etc.). · Re-construct temporary coffer dam to enable left abutment works. · Construct left abutment works (i.e. weir, kayaker gates, etc.).
Kayak access to river	▪ Allows periodic kayak passage (four "no-take" days per annum). ▪ Safe access to the river enabling seal launch below the weir to be maintained. ▪ Warning markers/signs above the weir (several markers/signs starting about 300 m above), also recommending portage. ▪ Information board at kayakers' take-out.	▪ Construction of permanent portage access for kayakers from above the intake structures to the river below intake structures, enabling a safe seal launch a small distance below the weir. ▪ Access to Morgan Gorge will be restricted during periods of construction of the intake for health and safety reasons.
Structure(s) enabling kōaro and duckling passage	▪ Structure(s) providing for kōaro and whio duckling passage. ▪ Constant wetted surface on downstream side of weir/abutment for kōaro. ▪ Structures prevent trout migration upstream.	▪ Structure(s) with wetted surface to provide for kōaro and whio passage ▪ Structures prevent trout migration upstream.
Sluice gate and channel	▪ Pass sediment and bed load. ▪ Promote spiral flow regime to reduce suspended sediment concentration (SSC). ▪ Regulate water levels for flows up to 80 m^3/s.	▪ Radial sluice gate 2.5 m high and 3.0 m wide. ▪ Located adjacent to the environmental flow gate. ▪ Roofed structure to protect gate from debris during overtopping. ▪ Sluice channel approximately 8 m wide. ▪ Divert water for main intake construction work.
Environmental flow gate	▪ Pass environmental flows at least 3.5 m^3/s downstream constantly.	▪ Vertical gate 1.0 m wide and 2.0 m high. ▪ Set gate opening of approximately 0.5 m to constantly pass at least 3.5 m^3/s.
Public safety at headworks	▪ Appropriate guard rails and signs installed around structures to mitigate public safety hazards. ▪ Siren to indicate sudden changes in flow caused by an emergency station outage.	▪ Appropriate signs installed to mitigate public safety hazards.
Intake	▪ Divert water with reduced suspended sediment concentration (SSC) for power production. ▪ Allow for isolation via vertical gate and stop logs.	▪ Blasting required to cut the intake channel into the rock by approximately 3 m. The upstream corner of the gorge will be trimmed with a 6 m high cut to provide a suitable alignment.

Component	Operation	Construction
	▪ Screen coarse bedload and floating objects. ▪ Allow for removal of fine sediment, sands and gravel and screen clear water for generation. ▪ Allow sealing of the intake during high flow periods, maintenance, and emergencies. ▪ Allow for spilling during load rejection and gate malfunction. ▪ Provide an audible warning (siren) to anyone located at the intake or Power Station for approximately 30 seconds when unplanned emergency station outage occurs (approximately four times per year). ▪ Allow for management of sediment and bedload. The rotation of flow (spiral flow) at the headworks is critical to ensuring favourable sediment transport. ▪ A vertical gate, located in an underground gate shaft will allow isolation and dewatering of the waterway and desander. Immediately in front of the portal and behind the intake screen, stop log slots will allow dewatering, and maintenance of the intake gates. Due to flood rise, the stop log slots will be required to have bolted covers to prevent water and sediment ingress. ▪ To avoid kōaro entrainment at the intake, the design relies on high sweeping velocities in front of the intake. ▪ Stop log slots for manual isolation. Sealed and bolted slots cover for operation.	▪ Floor of channel concreted near to the gate structures to provide better hydraulic conditions for sluicing sediment. Sides to retain natural rock as much as practicable. ▪ The channel is sized at 4 m width at the gate to keep flow velocities high enough to entrain bed material and move it past the intake. ▪ Intake channel to be completed prior to the weir construction. ▪ When weir is built, the temporary stopbank would be removed and the river diverted into the channel. On completion of the weir, the gate can be shut, and the intake becomes operable. ▪ Intake approximately 14.5 m wide, with two bays, of 3 m height (to allow for a 1 m high bed load deflecting sill below, and submergence of 1.5 m), 4.7 m wide. A 0.5 m pier between the bays. ▪ Coarse screen, 5 mm vertical stainless-steel bars 30-40 mm apart (measured between centres). Required screen area is assumed to be 38 m^2.
Intake gate	▪ Provides waterway isolation via vertical gate (and stop logs for maintenance). ▪ Access provided by sealed adits from access tunnel.	▪ Vertical intake gate located underground for waterway isolation and dewatering. ▪ Requires bonneted gates for pressurised condition.
Intake	▪ Concrete structure around the intake and rock will be minimised due to competent rock observed at the portal location ▪ There will be a semi-permanent accessway between the access portal and the riverbed. This will comprise a path benched into the rock slope approximately 60 m long down to the riverbank terrace, and a gravel track to the riverbed, rebuilt after major flood events. ▪ Additional construction areas rehabilitated.	▪ No high-level intake as proposed in earlier Scheme designs. ▪ The top of the intake (soffit) interfaces with the intake platform and weir, at EL 239 m at that location. The intake opening is about 14.5 m wide and 3 m high, but this will not be visible as it is submerged about 1.5 m below normal water level. ▪ The invert level will be approx. EL 227 m, and portal soffit at approx. EL 237 m.

Component	Operation	Construction
		▪ The water level during operation will be 1 m higher, at EL 238 m, so the intake portal will be entirely submerged. Thus, the new portal for the intake structure will not be visible in the completed works.
Intake tunnel	▪ To convey water from intake at reasonable velocity (low turbulence) to the transition.	▪ 6.5 m wide pressurised tunnel, invert level EL 231.00 m. ▪ Concrete lined.
Transition section	▪ To slow gradually the flow velocity to promote sediment setting in the desander.	▪ Transitions from headrace tunnel section to desander section. ▪ Slopes 1V:3H, dropping over 5.0 m. ▪ Transition section length is 15 m long.
Pressurised desander	▪ Slow water velocity to promote deposition of suspected particles, and to facilitate flushing of sediment periodically, with no operational curtailment.	▪ Design particle size 0.3 mm and greater in diameter. ▪ 107 m long, 11 m wide, minimum 9 m high. ▪ Downstream tunnel elevation at EL 231 m, sediment sluice at EL 223 m.
Head gate and stoplogs	▪ To provide isolation for the pressurised water tunnel during construction, maintenance and especially emergency.	▪ Two 3 x 3 m vertical gates and stoplogs. ▪ Actuated and maintained from an adit from the access tunnel.
Sediment flushing pipe	▪ 550 mm pipe to transport sediment from desander to the tailrace where it will be diluted by the water coming out of the power station.	▪ Constructed as part of access tunnel.
Pressure tunnel	▪ To transport pressurised water from the desander to the turbines in the Power Station.	▪ Conventional horseshoe-shaped tunnel driven from the Power Station area. ▪ 4 m diameter when finished with rock bolt and shotcrete lining, generally. ▪ Support works where ground conditions require.
Pressure tunnel portal at power station	▪ The appropriate bank protection and location still needs to be investigated. It will need to be informed by geotechnical investigation. ▪ Additional construction areas rehabilitated. The tunnel end and the penstock will be partially or entirely buried, with the tunnel end sealed. This will also reduce the risk of falling debris from the terrace edge. Concrete portal headwall to be covered by planted façade or similar.	▪ An underground penstock will transport water from the water tunnel into the power station. ▪ Forepoling will be used to stabilise the ground above the tunnel portal/roof in poor ground conditions. This involves driving horizontal piles (or spikes) into the ground. ▪ Located at the base of a 60 -70 m high near-vertical terrace edge. ▪ Approximate size 5 x 5 m. ▪ Pre-cast concrete portal used as a shield prior to commencing the tunnel and during excavations. ▪ Poor quality rock may be expected in the first 100 - 300 m from the end.

Component	Operation	Construction
Penstock	▪ Works maintained.	▪ The penstock will be partially or entirely buried and will transport water from the pressurised water tunnel portal to the Power Station. ▪ Diameter of the penstock approximately 2.8 m. ▪ At the Power Station end the penstock will bifurcate into two smaller sized penstocks located side by side to feed the two turbines inside the Power Station.

Power Station	▪ Power Station and associated infrastructure maintained.
	  ○ 66 kV switchyard and substation (fenced)
	  ○ Power Station (with toilet facilities via onsite holding tank)
	  ○ Tailrace
	▪ Parking area
	▪ Vehicular access will be to the mezzanine floor at ground level within the Power Station (forebay). Internal cranage will be used from the forebay to the machine floor.
	▪ A removable roof allows installation and maintenance activities involving heavy lifts with appropriately sized mobile cranes.
		▪ To be founded on quality bedrock, this is assumed to be elevation EL 128.50 m but depth may vary.
		▪ Requires around 5 to 6 m depth of excavation to reach bottom of draft tube (between the turbine and the tailrace). Smaller areas will need to be deeper, such as the drainage galleries and sumps. The assembly bay and generator floor are intended to be also founded on bedrock.
		▪ Comprises two horizontal shaft Francis turbines.
		▪ Power Station design comprises a double mono-pitch roof Estimated power station sloping roof elevation is EL 138.50 m to EL 140.00 m, which is approx. 4.5m to 6.0 m above the rock embankment elevation of EL 134.00 m.
		▪ Power Station size 15 m x 35 m.

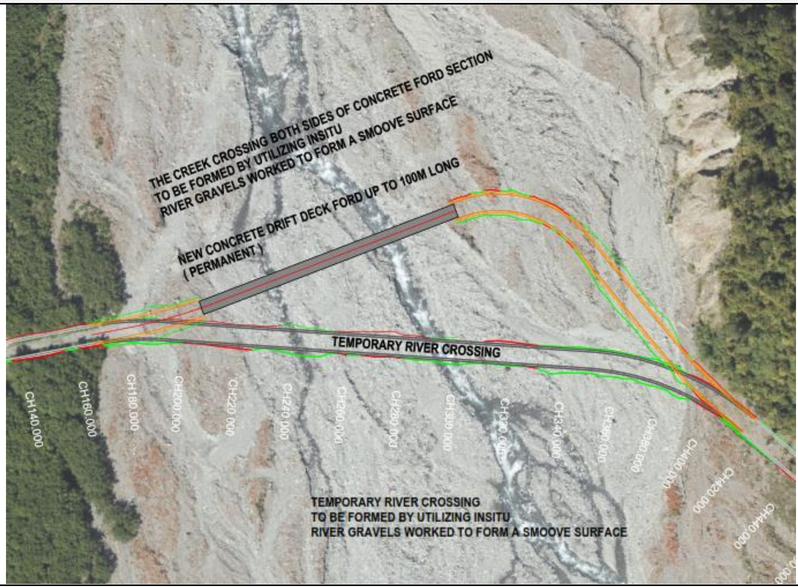
Tailbay and Tailrace Channel	▪ Works maintained. ▪ Fence/railing on the sides of the tailbay.	▪ Tailbay concrete construction 16 m long by 15 m wide to a depth of approximately 8 m. ▪ Tailrace widening towards the Waitaha River, to discourage fish from entering the tailrace channel. ▪ Natural boulder and rock could be placed here to provide additional protection and improve visual amenity.
Bypass Valve	▪ During an emergency station outage such as a circuit trip or an equipment malfunction when the turbine stops running a bypass valve will start releasing water to maintain water discharge (10 cumecs) from the power station. While the bypass valve is opening the generators will go into overspeed and continue to pass 40% of flow.	▪ A valve installed at the tailbay that will ensure at least 10 cumecs of water are being released from the Power Station when the turbines stop running due to an unplanned fault or trip. ▪ Will include a hood to reduce the extent of the plume.

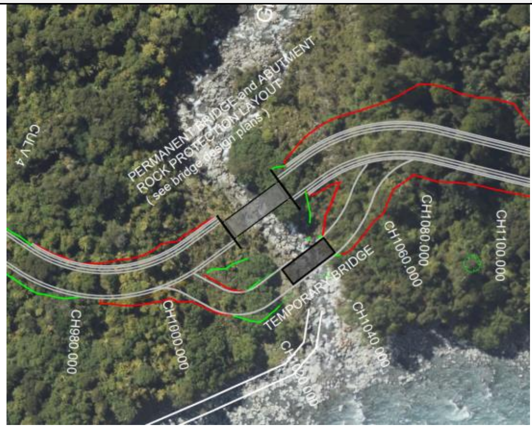
Component	Operation	Construction
	▪ This will likely occur about four times per year, for one hour on average (with the duration ranging between 15 minutes and 24 hours), typically during storm events causing a fault on the transmission network, or as a result of an internal plant/machinery malfunction. ▪ There will be a plume of water released directed downstream within the existing river channel, approximately 75 m long, 20 m high and 55 m wide. ▪ A warning siren will sound for approximately 30 seconds at the Power Station and intake portal prior to the bypass valve opening as an alert indicating a change in Waitaha River flow in Morgan Gorge (increase of up to 13 cumecs) and below the Power Station (decrease of up to 13 cumecs). ▪ Fencing/railing on the sides of the tailbay and adjacent to the tailrace, and warning signs will be installed.	▪ Illustrative images of a 10-cumec bypass valve in operation (Dillmans Power Station, Kumara):  

Site Access, Access Tunnels and Surface Works

Access Roads

Component	Operation	Construction
Waitaha Road from SH6 to Anderson Road, and short distance along Anderson Road	Allows long term access for the maintenance of the Scheme.	▪ Allows for construction traffic. ▪ Sealed passing bays/places spaced approximately 1.5 km apart. ▪ Warning signs. ▪ Additional safety measures for construction vehicles.
Access Road through farm	Allows long term access for the maintenance of the Scheme.	▪ On private land. ▪ Existing farm road widened and new sections constructed. ▪ Provides for both light and heavy vehicles. ▪ Culverts across waterways and stormwater flow paths. ▪ Approximately 3.6 km in length. ▪ The average width of the combined road and lines corridor during construction will be 17.5 m. ▪ The average width of the road will be 10 m (6-7 m carriageway; 0.5 m each side shoulder; 1 m water table on the higher side).
Access Road – Crossing of Macgregor Creek (farm boundary on Macgregor Creek true right, across Macgregor Creek and along the true left margin)	▪ Generally located in dry bed of creek. ▪ Gravel-based ford for crossing channels and use of Hynds Driftdeck or similar. Some works in creek margins where there is no existing access. ▪ Maintenance and remedial work of any damage. ▪ Metalled construction with a maximum width of 10 m for the road. The average width of the combined road and lines corridor will be 15 m.	▪ Generally located in dry bed of creek. ▪ River crossing to be formed by using insitu river gravels worked to form a smooth surface and use of Hynds Driftdeck or similar. Driftdeck requires concrete foundations. ▪ Temporary gravel based river crossing when the main crossing is being built. ▪ Some works in creek margins where there is no existing access. ▪ Approximately 0.7 km in length. ▪ Metalled construction with a maximum width of 10 m for the road. The average width of the combined road and lines corridor during construction will be 17.5 m. ▪ This will involve crown land managed by LINZ and will require an access agreement.

Component	Operation	Construction
		
Access Road – Macgregor Creek to PowerStation Site	▪ Metalled construction including water tables and sediment management measures. Limited seal either side of significant waterway crossings to limit traffic effects on road formation. ▪ The average width of the combined road and lines corridor will be 15 m. ▪ All infrastructure maintained; access road (incl. water tables and sediment controls), bridges, fords and protection works. ▪ Up to 50% of disturbed area at Alpha Creek may regenerate. Granite Creek crossing (incl. temporary and permanent bridge):	▪ Approximately 1.6 km. ▪ Route planning to avoid or minimise effects on vegetation and waterways. ▪ Bridge constructed across Granite Creek, which will include piles on at least one side of the riverbed. ▪ Temporary track on the side of the Waitaha River (true right) to walk a digger from Macgregor Creek to Granite Creek to construct a temporary bridge. ▪ Temporary bailey bridge (consisting of a metal support structure with wooden planks) to enable the construction of the permanent bridge. ▪ Small watercourses and stormwater flow paths crossed utilising concrete fords or culverts. There will be approximately 30 waterway crossings in total between Macgregor Creek and the Power -Station, and between the Headworks access portal and Construction Staging Area 1. ▪ Protection works undertaken at crossings as required.

Component	Operation	Construction
	 Alpha Creek crossing:  	▪ Aligned to avoid works within margins of, or discharge of sediment to, the "Stable Tributary". Minimum separation 20 m. ▪ Aligned to avoid wetlands. ▪ Box culvert across Alpha Creek, with side bunds topped with rip rap for channel control above and below the culvert. ▪ Construction of a box culvert and bunds at Alpha Creek. This will require vegetation clearance. ▪ The width of the combined road and lines corridor during construction will be approximately 17.5 m. A short section near Granite Creek is likely to be 25 m wide due to change in ground levels. ▪ Excess fill taken off site for disposal at sites on private land on true right of Waitaha River. ▪ Heavy earthworks machinery required for construction roading and installation of bridges and fords. ▪ General longitudinal grade of up to 6.5%, with a maximum of 12.5%.
Permanent maintenance accessway from the Headworks access portal to the river bed margin at the intake	▪ Permanent, unsealed, width 10 m, including maintenance watertabling and cut/fill. ▪ Will be maintained, post construction.	▪ Access developed from the Headworks access portal to the river bed margin at the intake. ▪ Average width for construction 12 m. Approximate length 60 m. ▪ Toe of the access is likely to require rock armouring to avoid damage from flood events. ▪ Grade no steeper than one in six.

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Component	Operation	Construction
		▪ Standard machinery for headworks construction and for subsequent intake structure maintenance.
Temporary construction access from the Headworks access portal to Construction Staging Area 1	▪ This access will be removed and the site rehabilitated following Headworks construction completion.	▪ Temporary access road from the Headworks access portal to Construction Staging Area 1. Unsealed. ▪ Average width for construction 9 m (comprising watertabling, cut/fill allowance and a carriageway). Approximate length 140 m. ▪ Grade no steeper than 1 in 6. ▪ Standard machinery for Headworks construction. ▪ Toe of the access is likely to require rock armouring to avoid damage from flood events.

Access Tunnel

Component	Operation	Construction
Access tunnel	▪ Access not available during flood flows in river. ▪ A 550 mm sediment pipe for transporting sediment from desander at the intake to the tailrace. ▪ Security gates installed for public safety.	▪ To maintain permanent access to the Headworks and to allow inspection and maintenance of the penstock and gates. ▪ Provides for the design construction vehicle (20 tonne excavator), to access headworks for construction, operation and maintenance purposes.
Headworks access Portal	▪ Portal maintained, including removal of potentially hazardous debris above the portal.	▪ The Headworks access tunnel portal will be approximately 5 m wide x 5 m high. ▪ Small wingwalls on both sides of the portal. ▪ The final portal location is subject to further geotechnical work, however it is estimated that it will be approximately 10 m distance (horizontally) from the water portal, with the floor approximately 6 m higher than the top of the water portal. ▪ With the Headworks access portal being higher than the intake, there needs to be access from the portal to the river bed at the intake (e.g. access ramp from dumped rock/aggregate). The access ramp would require frequent maintenance and would face washout by floods in the long term.

		▪ Because there needs to be a degree of flood safety at the portal (noting large floods will entirely submerge the portal), the level of the Headworks access portal needs to be higher than normal river levels. The invert level is at EL 245 m, or 7 m above normal operating water level.
Power Station access portal	▪ Portal maintained, including removal of potentially hazardous debris above the portal. ▪ To prevent stones/vegetation falling on people/vehicles, the ground surface will be treated with shotcrete and the reinforced concrete tunnel entrance will extend out from the portal face. In addition, the Power Station Site will require protection from falling rocks which may consist of a post and wire mesh or similar system and is likely to be up to 60 m or 70 m in length. ▪ Formed area at the portal large enough to allow vehicles to turn about 90 degrees from the road into the tunnel, about 8 - 10 m in diameter. ▪ Additional construction areas rehabilitated. ▪ The appropriate bank protection and location still needs to be investigated. It will need to be informed by geotechnical investigation.	▪ Size approximately 5 m x 5 m. ▪ Located approximately 32 m north-east from the water tunnel portal. ▪ Exact portal location still to be confirmed following geotechnical investigations. However, it is anticipated that a concrete wall (approximately 6 m high at the highest point), spanning between and around the portals will be built. In addition, the Power Station Site will require protection from falling rocks which may consist of a post and wire mesh or similar system and is likely to be up to 60 m or 70 m in length. ▪ Forepoling will be used to stabilise the ground above the tunnel portal/roof in poor ground conditions. This involves driving horizontal piles (or spikes) into the ground. ▪ Located at the base of a 60 -70 m high near-vertical terrace edge.

Construction Staging areas and Spoil Disposal Areas

Please note: Construction staging areas are also referred to as laydown areas.

Component	Operation	Construction
Construction Staging Area 1 (above Morgan Gorge)	▪ Not required following the completion of construction. ▪ Land rehabilitated to indigenous vegetation cover following construction.	▪ Located on a low terrace, on the true right of the river above Morgan Gorge. ▪ Approximate area 0.7 ha. ▪ Works required to the margins of the river to provide access up on to the terrace. ▪ Area levelled and cleared to provide for location of infrastructure, buildings including an emergency hut, machinery and explosives out of the flood plain. Includes a temporary helipad for construction works,

Component	Operation	Construction
		and equipment/vehicle wash-down area. Self-contained ablution facilities provided Vegetation buffer retained to minimise views of the facility from the surrounding area. ▪ Area will also include sediment control devices and equipment to treat any high pH and/or concrete contaminated water generated from top portion of access tunnel construction works since this section slopes down towards the Headworks area.
Construction Staging Area 2, including Potential Construction Disturbance Area (at the Power Station)	▪ Following completion of construction, the area outside the tunnels, Power Station and associated built infrastructure footprint will be rehabilitated to establish a vegetative cover. This may include the wingwalls to assist with integrating them into the environment. ▪ Water from the tunnel is diverted and discharged to the Waitaha River on a continuous basis when the Scheme is operational. ▪ Power Station and associated infrastructure maintained. ▪ Staging area from Alpha Creek to the Power Station infrastructure, and not required for Power Station operation, will be rehabilitated.	▪ The land between Alpha Creek and the upstream end of the flat is cleared and levelled for use as the staging area for construction of the tunnels, Power Station, substation, lines for conveying electricity (construction and operation), and the access road. However, we will try to maintain as much vegetation as possible to provide screening of the Power Station from the access track used for recreation. ▪ Area approximately 0.8 ha in size. ▪ Used for storage of materials and equipment, refuelling, explosives magazines. ▪ Machinery associated with these activities, including heavy vehicles, will be located and used at this site. ▪ The area will be used for small scale stockpiling of earth and rock spoil, approx. 100 m^3, with excess material being carted to the Spoil Disposal Areas established adjacent to Staging Area 3. ▪ Suitable spoil, including excavated tunnel material, may be re-purposed as construction material and aggregate for site development purposes. ▪ Water treatment systems (including sediment protection ponds) will be located in this area to manage discharge of water from all works, including the tunnel and associated groundwater. ▪ Clean and treated water will be discharged to the river. ▪ Temporary site buildings including an emergency hut and temporary self-contained toilet facilities. ▪ All rubbish will be contained and removed on a regular basis from the site. ▪ Activities as far away from the active bed of the Waitaha River as is possible.

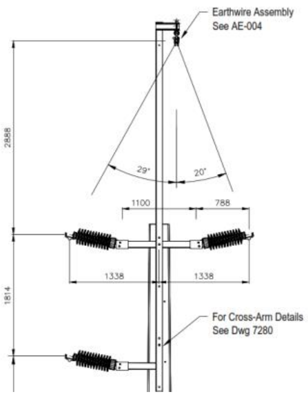
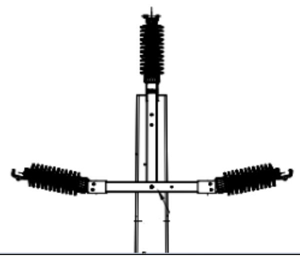
Component	Operation	Construction
		▪ The appropriate bank protection and portal location still needs to be investigated. It will need to be informed by geotechnical and geophysical investigations. ▪ Geotechnical treatment will be required to stabilise the slope and protect from debris and rockfall. This treatment may involve rock anchors, soil nails, gabions, shotcrete and mesh, etc. Concrete wingwalls will be built around and connecting the portals, with steel mesh (fence) to stop falling rock. ▪ Power and mobile phone services are required at the staging area, to supply lighting, power and fibre optic communications to the tunnel and/or Headworks. ▪ Area will also include sediment control devices and equipment to treat any high pH and/or concrete contaminated water from tunnelling works.
Construction Staging Area 3 (True Right of Macgregor Creek)	▪ Following construction, the land will be rehabilitated to pasture, in accordance with the requirements of and as part of, the farming operation.	▪ Developed on private land on the true right of Macgregor Creek, outside the margin of the creek. ▪ Approximate area 3.2 ha. ▪ Site will be cleared, levelled and stabilised for use. ▪ Activities on the site will include: · Main site administration, project management and staff facilities and buildings, · Tea room, · Storage areas for vehicles, machinery, infrastructure, · Machinery repair and workshop, · Concrete batching plant, · Gravel screening; · Geotech assessment base; · Parking; · Helipad ▪ Self-contained ablution facilities.
Spoil Disposal Areas – True Right of Macgregor Creek	▪ Following construction, the land will be rehabilitated to pasture, in accordance with the requirements of and as part of the farming operation.	▪ Two spoil disposal areas established on private land on the true right of Macgregor Creek, outside the margin of the creek. ▪ Excess spoil from works across the scheme construction carted to and spread across these areas.

Component	Operation	Construction
		▪ Spoil will include vegetation from the construction of the access road, line corridors and scheme components. ▪ Size approximately 9 ha and 8.1 ha (17.1 ha in total), up to 1 m high. ▪ Works will be undertaken using heavy earthworks machinery to spread and contour the spoil. ▪ Spoil may also be used as a source of gravel for the access road.
Gravel Screening	▪ Following construction, the land will be rehabilitated to pasture, in accordance with the requirements of and as part of the farming operation.	▪ Area approximately 30 m wide and 220 m long adjacent to the unused airstrip on the farm. ▪ Will be used for gravel screening for gravel sourced from Waitaha River near this location. 

Transmission

Component	Operation	Construction
66/11kV at the connection point with Westpower network	Works maintained.	▪ Existing Waitaha substation upgraded to include circuit breakers, disconnectors and other connection equipment. ▪

Component	Operation	Construction
66 kV Transmission Line: Waitaha Road Reserve to SH6	▪ Works maintained. ▪ Requirement for future clearance and trimming of vegetation to maintain the integrity of the line, in accordance with *Electricity (Hazards from Trees) Regulations 2003*.	▪ The 66 kV transmission line will follow the Waitaha Valley on the true right of Waitaha River to SH6, then follow SH6, Beach Road and Bold Head Road to connect with Westpower's network at the existing Waitaha substation. ▪ The existing 11 kV line along Bold Head Road, Beach Road, SH6 and at the start of Waitaha Road will be upgraded to host both 66 kV and 11 kV circuits. ▪ Power poles will be installed using a tracked excavator with the conductors strung using helicopters. ▪ Poles will be concrete poles. ▪ Height of the poles generally around 15.5 m high (above ground) with approximately 3 m below ground. Pole spacing along the corridor will range from 150 - 180m.
66kV Transmission Line: Power Station Site to Waitaha Road	▪ Works maintained. ▪ Requirement for future clearance and trimming of vegetation to maintain the integrity of the line. ▪ Lines that were established at 11 kV for construction purposes will be upgraded to 66 kV to provide for transmission of electricity from the Power Station to the distribution network at the State Highway. ▪ The average width of the combined road and lines corridor between Macgregor Creek and the Power Station Site will be 15 m. Where not adjoining, the road corridor and the lines corridor will each be up to 10 m. ▪ The average width of the corridor excludes guy wires required for poles with additional load (such as on corners). Guy wires can be up to 14 metres distance from transmission line poles, and while there would generally be one guy wire used, there can be up to three guy wires supporting one pole.	▪ The first section of the transmission line will initially be built from the existing 11 kV distribution network on the farm to the Construction Staging Area 3, and to the farm boundary on the true left of Macgregor Creek. From there the line will span across Macgregor Creek, and follow the access road to the Power Station/tunnel entrance site. ▪ The line will be operated at 11 kV to provide electricity for the site's construction activities, however it will be built to the 66 kV standard. ▪ The line will cross the margins of Macgregor Creek, and while there might be poles in the margins, there will be no poles within the bed of the creek. ▪ It is anticipated that there will be a pi-pole used on the raised area on the true left of Macgregor Creek (to avoid putting poles in the creek bed), within 60 metres of the access road. ▪ During construction, the average width of the combined road and lines corridor between Macgregor Creek and the Power Station Site will be 17.5 m. Where not adjoining, the road corridor and the lines corridor will each be 10 m. Communications lines will be included. ▪ Power poles to be installed using a tracked excavator and the conductors

Component	Operation	Construction
	▪ Configuration of conductors: (1) for 1 km from the Power Station the set up will include an additional 10 mm earth wire suspended on a steel post approximately 3 m above the pole to support an earth wire. The arrangement of wires on top of pole is shown on the following images:   (2) beyond 1 km from the Power Station the configuration of wires on top of pole will be as follows, and will continue along the Waitaha Road: 	will be strung using a helicopter. ▪ Poles will be generally concrete, except for any 21m poles that will be treated hardwood. ▪ Height of the poles is generally around 15.5 m high (above ground) while the height of the poles used at either side of Macgregor Creek will be at a maximum of 21 m (above the bed of the channel) with approximately 3 m below ground. There will be no poles in waterways. ▪ Pole spacing along the corridor will generally range from 150 - 180m, except where shorter spans are required to negotiate bends, or where a longer span has to be used to avoid undesirable placement of poles such as in the riverbed. ▪ Telephone services will be via mobile phone ▪ Local electricity reticulation will be cabled at or below ground level.

Component	Operation	Construction
	 (3) there will be a small number of pi-poles (at least one) used as part of the 66 kV line where a longer span is required. While the exact size and number of pi-poles will be determined by the detailed design, the pi-pole on the true left of Macgregor Creek will likely have metal crossarms, 8 m span, and wooden poles (an illustrative photo, although showing a wooden crossarm, is below). ▪ 	
Switchyard	▪ Works maintained.	▪ Located on the downstream side of the Power Station. ▪ Area no greater than 25 m by 15 m. ▪ Yard will be fenced and include switching gear, 1 transformer (of up to 66 kV), and transmission line infrastructure for connection to local distribution at the State Highway.

Component	Operation	Construction
		▪ Maximum height of the structures in the switchyard will be no more than 15 m. ▪ Transformer will be located within bund to manage potential oil spills.

Appendix 1: Waterway Crossings

Culvert number starting from Anderson Road	Length (m)	Diameter (cm)	Class
Farm			
1	10	450	RRJ CLASS 4
2	10	450	RRJ CLASS 4
3	10	450	RRJ CLASS 4
4	10.5	4m wide x 2 m wide	BOX CULVERT
5	10.5	4m wide x 2 m wide	BOX CULVERT
6	12.5	750	RRJ CLASS 4
7	12.5	750	RRJ CLASS 4
8	12.5	Twin 900	RRJ CLASS 4
9	26.4	1050	RRJ CLASS 4
Macgregor Creek Crossing	100		HYNDS DRIFTDECK
From Macgregor Creek to Power Station Site			
10	16.8	1050	RRJ CLASS 6
11	14.4	450	RRJ CLASS 6
12	12	600	RRJ CLASS 6
13	14.4	600	RRJ CLASS 6
Granite Creek Crossing	18 plus abutments		BRIDGE
14	12	600	RRJ CLASS 6
15	14.4	600	RRJ CLASS 6
16	14.4	600	RRJ CLASS 6
17	12	600	RRJ CLASS 6
18	12	600	RRJ CLASS 6
19	12	450	RRJ CLASS 6
20	14.4	600	RRJ CLASS 6
21	12	750	RRJ CLASS 6
22	14.4	600	RRJ CLASS 6
23	12	600	RRJ CLASS 6
24	21.6	600	RRJ CLASS 6

25	12	450	RRJ CLASS 6
26	12	450	RRJ CLASS 6
27	12	600	RRJ CLASS 6
28	12	450	RRJ CLASS 6
29	12	450	RRJ CLASS 6
30	12	750	RRJ CLASS 6
31	12	750	RRJ CLASS 6
32	21.6	600	RRJ CLASS 6
Alpha Creek	4 m wide 2 m high 12 m long		BOX CULVERT
33	19.2	750	RRJ CLASS 6
Headworks			
34	7.2	750	RRJ CLASS 6
35	12	750	RRJ CLASS 6
36	12	750	RRJ CLASS 6
37	9.6	750	RRJ CLASS 6
38	12	750	RRJ CLASS 6

Appendix 2: Indication of Indigenous Vegetation Cover Status by Broad Category (Indicative Areas)

Waitaha Hydro Scheme - Indication Of Indigenous Vegetation Cover Status By Broad Category

Note: All figures given are hectares for construction effect

Scheme Area	Land Status	Mature/High Forest & Regenerating Forest	Shrub/Seral Cover	Open, Generally Non-Woody Species Occupancy	Area Totals
Area 1	D.o.C	0.04495	0.89285	0.0685	1.0063
Area 2	D.o.C & LINZ	3.5294	0.9065	1.1425	5.5784
Sub-total Non-freehold		*3.57435*	*1.79935*	*1.211*	*6.5847*
Area 3	Private Freehold	Non-indigenous	Non-indigenous	Non-indigenous	0.000
Area 4	Private Freehold	0.0	0.2050	0.0	0.2050
Scheme Footprint Total		***3.5744***	***2.0044***	***1.2110***	6.7897

Notes:

1/ Regenerating Forest is grouped with Mature/High Forest because Regenerating Forest contains a high incidence of stems 15+ cm dbh (given this is a very low dbh limit)

2./ Shrub/Seral cover category will contain some varying frequency (generally low) of stems 15+ cm dbh, however predominant cover is by stems <15 cm dbh

3./ Open, Generally Non-Woody Species Occupancy refers to areas of herbaceous/monocot cover with some incidence (extremely low, if any, of stems 15+ cm dbh) of woody shrub species

APPENDIX B: SMALL HYDRO ELECTRIC POTENTIAL OF WEST COAST

MINISTRY OF WORKS AND DEVELOPMENT

SMALL HYDRO ELECTRIC POTENTIAL OF WEST COAST

Final Report

September 1985

ROYDS SUTHERLAND McLEAY LTD
CONSULTING ENGINEERS AND PLANNERS
Christchurch • Greymouth • Palmerston North

ROYDS
SUTHERLAND
McLEAY LTD

Consulting Engineers
and Planners

Tasmania House, 71 Armagh Street, Christchurch, New Zealand P.O. Box 870, Phone 67449

3150
19 September 1985

The District Commissioner of Works,
Ministry of Works and Development,
P.O. Box 1479,
CHRISTCHURCH

Dear Sir,

RE: Small Hydro - Resource Assessment of the West Coast - Final Report

We have pleasure in presenting our final report on the Small Hydro Electric Potential of the West Coast. This final report incorporates our Stage I report presented to you in August 1981.

While this final report includes a detailed study of the southern region of the West Coast, possible schemes may still have been overlooked. The difficulties of access and recognition of schemes in the generally bush covered country has obviously precluded the identification of all schemes. However, we are confident that the larger and most economic schemes have been recognised and consider that to attempt to identify all the smaller or less economic schemes in remote areas is unnecessary and would be a waste of resources.

The high rainfall and steep river gradients on the West Coast result in considerable hydro-electric potential. However, high bed loads in most rivers, poor access, and the distance from load centres, discourage development. The schemes proposed appear viable even when these constraints are considered.

Fifty-six schemes with a total capacity of 818 MW have been identified. A number of these appear very economical with 16 having a cost/KW less than $2000.00.

Two further schemes, Kaniere and Duffers II which have both been reported on in detail have costs in the order of $2000.00 per KW.

We thank you for the opportunity to undertake this study.

Yours faithfully,
ROYDS SUTHERLAND McLEAY LIMITED

[redacted]

[redacted]

ACKNOWLEDGEMENTS

Considerable assistance by way of technical information and suggestions has been received from many organisations including:

Ministry of Works and Development,
Wellington, Christchurch and Greymouth

West Coast Electric Power Board

Westland Catchment Board

New Zealand Meteorological Service

Many helpful comments and suggestions were received for the Stage I study from the Steering Committee - Local Hydro Development, West Coast Comprising representatives of:

Ministry of Works and Development,
Christchurch

Ministry of Works and Development,
Greymouth

West Coast Electric Power Board

Buller Electric Power Board

Westland Catchment Board

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GLOSSARY

Map Reference: Given to the grid on the N.Z.M.S. 1 topographical maps. However this grid is not shown on the plans included in this report.

m^3/s: A flow of 1 cubic metre per second or cumec. 1 m^3/s equals 35.315 cubic feet per second or cusecs.

Plant Factor: The ratio of mean annual output of a power station to maximum annual output if operating at full capacity for the whole year. May also be considered to be the ratio of mean annual flow to maximum flow through the turbine.

NOTE

Metric units have been used throughout this report except that references have been made to the contour lines on NZMS 1 topographical maps. These contours are to 100 foot intervals and are identified on the maps in multiples of 100 feet. Some levels relating to these contours are also given in feet.

INDEX

SECTION ONE

INTRODUCTION

SECTION ONE : INTRODUCTION

1.1 AREA AND TERMS OF REFERENCE

In March 1979 Royds Sutherland McLeay Ltd were commissioned by the Ministry of Works and Development to assess the small hydro-electric potential of the West Coast Electric Power Board area of the Westland Catchment Board's district. The area north of the boundary between the Whataroa and the Poerua catchments, was considered the most important, and was to be studied in greater detail. The South Westland area was to be assessed to a lower standard. This study was completed with the Stage 1 report published in 1981. It recommended that a further study be made of the southern area.

In November 1984 Royds Sutherland McLeay Ltd were commissioned to complete Stage II, the detailed study of the Southern area.

This report covers both Stage I and Stage II assessments.

The terms of reference required that potential schemes which could have capacities between 0.5 MW and 50 MW be considered, except where such schemes would conflict with sites of possible hydro-electric development by the State.

The cost of transmission to the nearest suitable point on the existing transmission network has also been included in the scheme costs. For the larger schemes north of Haast this involves at minimum a 66kv transmission line to Hari Hari to link into the national grid. For schemes south of Haast it involves a transmission line to Luggate.

The costs of the schemes identified by this study have been estimated and those considered economic or marginally economic have been ranked in terms of capital cost per kilowatt and cost per kilowatt hour. Costs prepared for the Stage I report have been updated to present day costs using the MWD CCI Index.

During the Stage I study the Steering Committee considered the desirability of a detailed study of one catchment. It was considered that there are particular difficulties in developing West Coast rivers and a more detailed study could identify these difficulties, possible solutions, and likely costs of development. This would provide more information to assess the energy potential of the region and enable these resources to be compared with conservation values. However, such a detailed study of one catchment was not included as part of the Stage II brief because of the wide differences between west coast rivers and the difficulty of selecting a typical river, the study of which would be relevant to other rivers.

1.2 METHOD OF STUDY

The method of study used for this report generally followed the Decision Tree (Appendix B) and included -

1. Hydrological desk studies to determine flow duration curves for the rivers within the study area (Appendix C).

2. Desk studies of available topographical information, in particular N.Z. Topographical Map Series NZMS 1, to identify possible sites for hydro-electric schemes, their required structural components and any other pertinent factors.

3. Determination, from the above, of installed flows, generating capacities, scheme outputs and sizes of diversion structures, dams, spillways, tunnels, races, etc.

4. On-the-ground site inspection of some of the identified sites, where access permitted and aerial observation from fixed wing aircraft for the majority of sites.

5. Reappraisal and in some cases deletion of proposals as a result of the above inspections.

6. Determination of scheme costs in accordance with Appendix D- Costing Information, and of the unit costs of the energy generated.

7. Ranking of the schemes by the criteria of cost/kW and cost/kWH (Refer Appendix E).

8. Preliminary desk studies to determine possible environmental effects and obvious conflicting uses of the water resources.

The above procedures are expanded upon in the report and the Appendices.

SECTION TWO

SUMMARY

SECTION TWO : SUMMARY

The West Coast area has a very high rainfall, mountainous terrain, and rivers and streams with a relatively high bedslope. Consequently, there is considerable potential for small hydro-electric development.

The number of small hydro-electric schemes at present operated by the West Coast Electric Power Board are evidence of this potential. While the need to develop small hydro schemes has arisen from, originally, the lack of transmission lines to smaller centres, it is apparent that near most load centres it has been possible to develop economic schemes.

The large area of the West Coast, the difficulties of access, and the large number of possible schemes has meant that recognition of all schemes has not been possible. However, identification of all schemes, particularly those in remote areas and near the lower end of the capacity range, is unnecessary and would be a waste of resources. For smaller remote schemes the estimated cost of the transmission system to the nearest point of supply represents a high proportion of the total cost and such schemes are unlikely to be economic under the criteria given in the brief.

In the northern area 28 schemes have been identified ranging from 1 MW to 60 MW with the mutually exclusive schemes giving a total of 395 MW. The majority of these schemes are remarkably low in cost with ten of the schemes having an estimated cost/kW of $2000 (September 1984 costs) or under. Even at much higher plant factors most of the schemes would still be economically viable. Kaniere, 37.2 MW and Duffers II, 1.0 MW (Ref. 12, 13) also have costs of the order of $2000/kW.

In the southern area 28 schemes have been identified ranging from 2MW to 62MW with the mutually exclusive schemes giving a total of 423MW. Six of these schemes have an estimated cost of less than $2000 per kW.

It is evident that because of the difficulty of identification and budget limitations, there must be smaller schemes in the range of 0.5 MW to several megawatts which have been omitted. It is also possible that some larger less economic schemes have not been recognised.

Over the whole study area, but particularly in the south, it would be unrealistic to try and identify all possible schemes. Some would be a long distance from load centres or existing reticulation and in some areas and on some rivers there would be possible environmental restraints to development. It must be appreciated that all the hydro-electric potential of the West Coast has not been identified by this study and in this respect this report differs from similar reports for other regions.

A summary of the economic schemes identified in this study is given in Table 2.1 on Page 4 and 5.

TABLE 2.1 (a)

Economic Schemes Identified in the Study - Northern Area

SITE NAME		INSTALLED CAPACITY (MW)	ANNUAL OUTPUT (GWh/a)
Stony River	(a)	5.5	24.1
	(b)	6.7	29.3
	(c)	8.8	39
Larry (Awarau)		4.0	17.5
Giles	(a)	1.0	4.4
	(b)	3.0	13.1
Rough River		11.1	49
Big River		3.5	15.3
Roaring Meg		1.1	4.8
Lake Christobel		6.4	28
Upper Grey	(a)	7.1	31
	(b)	10.0	44
	(c)	35	153
	(d)	18	79
Alexander		3.4	15
Ahaura	(a)	13	57
	(b)	42	182
Taipo	(a)	33	180
	(b)	23	101
Arahura	(a)	18	79
	(b)	13	57
Toaroha		25	110
Mikonui		24	105
Kakapotahi	(i)	17	75
	(ii)	29	127
Waitaha	(i)	40	175
	(ii)	60	263
Amethyst		8	35
Poerua		9.4	41

TABLE 2.1 (b)

Economic Schemes Identified in the Study - Southern Area

SITE NAME	INSTALLED CAPACITY (MW)	ANNUAL OUTPUT (GWh/a)
Butler	22.5	118
Wahapo	2.0	12
Tartare	5.9	31
Waikukupa	5.5	29
Manakaiau	2.9	15
Douglas	34.0	223
Karangarua	18.0	103
Rototekoiti (a)	7.2	35
(b)	12.6	60
Jacob	13.1	69
Mahitahi	9.0	47
Moeraki	8.8	46
Clarke	15.0	79
Zeilian Creek	8.8	50
McFarlane	22.0	116
Roaring Billy	10.4	55
Gates Haast	32.5	171
Burke	10.5	60
Lake Douglas	44.0	193
McPherson Creek	12.0	52
Turnbull	15.2	80
Casey Creek	3.0	15
Te Naihi	9.5	50
Drake	18.4	97
Waiatoto	24.2	127
Arawata	62.0	326
Cascade	17.7	93

SECTION THREE

DESCRIPTION OF STUDY AREA

SECTION THREE : DESCRIPTION OF STUDY AREA

3.1 INTRODUCTION

The area covered by this study is the West Coast Electric Power Board's district. This extends from the coast to the main divide, a distance of up to 80 km, over a length of some 430 km between Inangahua and the southern boundary of the Fox River catchment in the north, to Big Bay and the southern boundary of the Arawata catchment in the south. The area of the study area is approximately 18,000 km² and the boundaries are shown on Drawing 3150/1.

3.2 TOPOGRAPHY

The study area is bisected by the alpine fault which runs the length of the area and lies some 70 kilometres inland at Springs Junction in the north and 6 kilometres inland at Jacksons Bay.

The terrain is generally highly ice modified and rises steeply to the main divide east of the fault, with peaks of up to 1600 metres in the north and 2400 metres to 3400 metres in the southern and central regions.

West of the fault and south of the Taramakau River the topography is dominated by rugged bush covered moraine formations, with some coastal plains, while to the north it is dominated by the Grey River basin and the coastal Paparoa Ranges in the north-west. Permanent ice is now generally only above 2000 metres.

3.3 GEOLOGY

The rock types of the region are divided by the Alpine fault, with very old Precambrian greywackes to the west, overlain in large areas by moraines and outwash gravels, but including a number of large granite outcrops and occasional marine deposits. East of the fault, to near the main divide, lies a band of schist abutting Mesozoic greywackes and argillites, which intrude in places up to 5 kilometres west across the divide.

Most of the 500 kilometres lateral fault movement occurred during the Mesozoic era and since that time movement has been predominantly vertical although recent activity has been infrequent.

3.4 CLIMATE

The climate is temperate, with rainfall spread evenly throughout the year. Annual rainfall varies from 2000 mm in the Grey River basin to over 8000 mm towards the main divide and is delivered predominantly by the prevailing north-west wind. Intense rainfall occurs frequently.

3.5 DRAINAGE

In the south the area is generally drained by numerous swift flowing rivers rising in the Southern Alps and flowing directly to the nearby coast. These rivers are characterised by steep beds and with the very high rainfall have high bedloads except where a high proportion of the catchment is stable rock or is stabilised by vegetation. The north of the study area is generally drained by larger rivers including the Grey and its tributaries, the Taramakau and the Hokitika.

3.6 VEGETATION

With the exception of pastoral farming land on the floors of the larger river valleys and on some narrow coastal plains, the area is extensively forest clad up to an altitude of 1000 metres. Above this the forest gives way to scrub and tussock with barren screes and snowfields above 1500 metres.

3.7 POPULATION

The main centres of population in the area are Greymouth and Hokitika with a number of smaller centres servicing local coal mining and timber industries or the farming sector.

The total population of the study area at the time of the 1981 census was approximately 25,800, a fall of some 500 from 1976.

3.8 ROADING

State Highway 6 links South Westland and Otago and runs north parallel to the coast through Greymouth, to Westport and then inland to Nelson. From Greymouth S.H. 73 links Westland and Canterbury through the Taramakau Valley and Arthurs Pass. State Highway 7 runs north-east from Greymouth through the Grey Valley to Reefton and over Lewis Pass to North Canterbury. Generally access to the river valleys is poor and apart from the State Highways only a few valleys are serviced with subsidiary roads or forestry roads, predominantly in their lower reaches.

3.9 WATER AND SOIL ADMINISTRATION

River and catchment control of the region is the responsibility of the Westland Catchment Board. The Christchurch office of the Water and Soils Division of the Ministry of Works and Development has jurisdiction over the area.

Both these authorities collect flow gauge information from a number of the rivers in the area. Little research into or measurements of bedloads in the rivers has been undertaken, although suspended sediment assessments have been made at the various gauging stations.

3.10 EXISTING ELECTRIC POWER SUPPLY

Electric power reticulation and supply within the region is the responsibility of the West Coast Electric Power Board (W.C.E.P.B.) whose area covers 18,000 square kilometres. This is the area covered by this assessment with the exception of minor sections on the north boundary which have been included in the assessment of hydro potential in the Buller region, to avoid dividing catchments.

The New Zealand Electricity (N.Z.E.) distribution system and points of supply in the study area are shown on Drawing 3150/23.

The W.C.E.P.B. itself generates a significant part of its load from its nine existing hydro-stations, whose total capacity is 14.4 MW. Information relating to these stations and the distribution network of the Power Board is given in Appendix A and on Drawing 3150/23. Further information on the history of the existing stations is given in Section Four. The peak load in the Power Board area during the winter of 1984 was 27.3 MW while the total energy consumed in the year 1984-85 was 126.8GWh at a load factor of 53.0%. The Power Board's stations generated 35% of the above 1984-85 peak and 47% of the total energy.

3.11 PROJECTED DEMAND

The slight fall in population in the study area is countered by an extension of the reticulated area and an increased usage of electricity to give an increasing demand. However, any projection of future demand is dominated by possible large energy consuming industries such as the wood chip or mining industries. There is also a steadily increasing demand by the Tourist industry. The W.C.E.P.B. predictions are for a 7.5% annual increase in energy consumption in the next five years to 1990.

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SECTION FOUR

PREVIOUS INVESTIGATIONS AND

DEVELOPMENT IN STUDY AREA

SECTION FOUR : PREVIOUS INVESTIGATIONS AND DEVELOPMENT IN STUDY AREA

The first public electricity supply installed in the Southern Hemisphere was in the study area at Reefton. The plant, a 20 kW, 100 volt D.C. dynamo driven by a water turbine fed from the Inangahua River, was commissioned in 1887.

In 1904, P.S. Hay (ref. 10) considered and reported on a number of possible hydro schemes in the area. He noted that a very large amount of power was available from the Westland rivers but that rock debris was likely to be a problem.

Ross Goldfields Ltd commissioned the Kaniere Forks Power Station (500 kW) in 1909 to provide a power supply for gold mine dewatering. This station and much of the original equipment are still in operation as part of the West Coast Electric Power Board's generation system. A number of small schemes were investigated by gold mining interests at this time.

In 1927 a company called Westland Power Limited described in its prospectus, four possible power stations using the water race systems installed previously for gold mining purposes, generally in the Kumara area. Only two of these stations were constructed. The first at Duffers Creek (160 kW) started generating in 1928 but was obsolete by 1934. The second, the Dillmans Power Station (620 kW) was also commissioned in 1928 and remained in operation until 1978 when the new Dillmans hydro-electric scheme was commissioned.

Following investigations on the Kaniere River during the latter part of the 1920's the Mackays Creek Power Station (1200 kW) commenced operation in 1931. This station is still generating today and is much the same as it was when commissioned.

Subsequent to the setting up of the Grey Electric Power Board in the early 1920's, feasibility investigations were undertaken to study schemes on the Arnold River, the Crooked River and the Kumara Water Race system. The Arnold scheme was adopted but was then postponed in favour of a steam plant at Dobson, burning local slack coal. It was not until 1932, following overloading of the coal fired station, that the Arnold hydro-electric scheme (2500 kW) started generating. This station was purchased by the State Hydro-Electric Department in 1938.

Some small hydro-electric stations were used to supply private houses in the Fox Glacier area in the 1920's. The first commercial undertaking was on the Clearwater River in 1926 to supply the hotel. The Fox Glacier Power Station (250 kW) was constructed by the Gillespies Beach Dredge Company in 1933. This station is still used by the West Coast Electric Power Board as part of their system. The Tartare Power Station (150 kW) at Franz Josef was constructed in 1937 to supply the hotel. This station was shut down in 1984. In 1939 the State Hydro-Electric Department commissioned the Lake Coleridge to West Coast 66 kV transmission line. However, with the limited transmission system on the West Coast, development in small hydro-electric schemes continued with the Amethyst Power Station (240 kW) in 1960, Wahapo Power Station (280 kW) in

1960, and the Turnbull Power Station, Haast (510 kW) in 1974.

In 1974 Royds Sutherland and McLeay, and Mandeno, Chitty and Bell reported on possible hydro-electric developments for the Greymouth and Hokitika Region (Ref. 11). They identified schemes in the Kumara-Dillmans area; in the Lake Kaniere area involving the Arahura, Styx and Kokatahi Rivers as well as the lake catchment; and a scheme associated with the old Humphreys Gully Water Race on the south side of the Arahura River. This latter scheme was considered uneconomic because of the estimated cost of reinstating the race, although it was considered that partial reinstatement, to serve a small scheme (200 kW) for the settlement of Hans Bay on Lake Kaniere, may have been viable. This proposal is now redundant because of the projected expansion at Hans Bay and the installation of underground reticulation to the area by the Power Board from its main distribution system.

The scheme in the Kumara-Dillmans area was considered the most favourable. This scheme was thus given priority in the report and considered in some detail. Subsequently the West Coast Electric Power board proceeded with the construction of this scheme, the new Dillmans Hydro-Electric Power Scheme, with the Dillmans and Kumara Stations (9.8 MW) being commissioned in 1978 and the Duffers No. 1 Station (500 kW) in 1980.

A draft feasibility study for Duffers II power station (Ref. 13) was presented to the Power Board in October 1979. This station (1.0 MW) would be part of the Dillmans Scheme, using surplus fall available within the scheme. The report showed that the station would be economically viable both from a national viewpoint and also to the Power Board. A summary is given in Appendix A.

In April 1979 Royds Sutherland and McLeay et al, presented to the West Coast Electric Power Board a pre-feasibility study and environmental study of hydro-electric schemes based on Lake Kaniere (Ref. 12) as identified in the above 1974 report. Various alternatives were promoted and it was demonstrated that these were economically viable to the Power Board and also met the Government criteria for Local Authority hydro-electric schemes. Some further evaluation of the alternatives and environmental investigation is proceeding. A summary is given in Appendix A.

In November 1979 the New Zealand Forest Service, as a result of its involvement with the State Coal Mines operation of the Island Block Opencast Mine (Garvey Creek) near Reefton, commenced investigation into the construction of a hydro-electric scheme on the Waitahu River. It was considered that the overburden from the mine could have been disposed of in an environmentally acceptable and economic manner in the construction of a rock filled dam. Although the availability of "free" material for the dam appeared attractive, investigations indicated that this scheme may not be viable. The possible problems with the grading of the overburden material, the costs of foundation preparation and placing fill, the costs of the diversion and the spillway, and the long period over which the fill material was available combined to make the scheme uneconomic, at least in the foreseeable future (Ref. 16).

SECTION FIVE

DESCRIPTION OF THE CATCHMENT AREAS AND POSSIBLE HYDRO SCHEMES

SECTION FIVE : DESCRIPTION OF THE CATCHMENT AREAS AND POSSIBLE HYDRO SCHEMES

5.1 INTRODUCTION

This Section sets out the results of the investigations of the study area. Each individual catchment within the area was studied and these catchment areas are shown on Drawings 3150/2 to 22 appended to this report. A description of each catchment, and possible small hydro schemes within the catchment, including details of the type of development, are given.

The high specific discharge of the rivers of the West Coast, together with the usually steep river beds, means that there is a very high potential for hydro-electric development in this area. Normally small hydro schemes require an adequate flow coupled with a favourable combination of topographical features and can generally, with experience, be readily identified. However, because of the relatively large flows in West Coast rivers, sites with less obviously favourable topographic features may be developed economically but the poor access to most of the rivers coupled with the thick bush vegetation, makes identification of these sites difficult. Many schemes were considered and finally fifty six apparently viable schemes were identified in both the northern and southern areas. However, all these sites are not mutually exclusive. It is significant that most of the sites identified and examined have a relatively low cost and it is probable that there are other sites less favourable, but still falling within the economic guidelines for small hydro schemes, which have not been identified. However, it would be very costly to identify all these sites, the majority of which would be of relatively low capacity.

The scheme details given in this section are subject to a lack of reliability in three main areas.

(a) Hydrological

Rainfall and river flow information are based on only a relatively small number of gauging stations. As stated in Appendix C confidence in the published rainfall information and derived flows is not high although additional rainfall information provided by the New Zealand Meteorological service for Stage II was useful.

(b) Costs

Costs have been derived from recently constructed schemes in New Zealand and for schemes under study where costs have been estimated in some detail. However, they can be considerably affected by site factors and by anomolies in inflation indices (ref. Appendix D). The assessment budget, and the weather, precluded site visits and even aerial inspections of some of the possible sites identified on the topographical maps.

(c) River Intakes

The majority of the schemes identified in this assessment are "run-of-river" and require an intake to divert water from the river into a headrace or tunnel. In general a suitable intake site is a prerequisite for a successful small hydro scheme.

The intake can either be a "stream bed" type intake or a "side intake" or a combination of both. To function correctly the intake has to divert water without diverting debris or gravel. Finer sediment can be removed by installing a flushable stilling basin downstream of the intake.

For this assessment it has not been possible due to finance and access problems to carefully examine the intake sites for all the schemes identified. However it is considered that a suitable intake site is available for most of the schemes within a reasonable distance of the location given in the text. It is considered that intake designs are available to deal with the high sediment load and the destructive potential of the West Coast rivers when they are in flood and carrying large volumes and large sized sediment.

In the remainder of this section the major catchments in the area are considered in detail.

5.2 THE INANGAHUA CATCHMENT

5.2.1 General Features

The Inangahua River is one of the larger tributaries of the Buller River and also the northern-most river in the study area. Its catchment is bounded by the Paparoa Range to the west, the Victoria and Brunner Ranges to the east and the Grey River catchment to the south. The total catchment area above Inangahua Landing is 1000 km² and the distance from its source to its confluence with the Buller River is 70 km.

5.2.2 Catchment Relief

The lower reaches of the Inangahua River are relatively flat and lie in a continuation of the Grey Valley depression. Downstream of Reefton the valley floor is up to 5 km wide. The bulk of the river's flow originates from tributaries to the east which are also relatively flat from the foot of the Victoria and Brunner Ranges but lie in deeply entrenched valleys. Above here they fall steeply through rugged country from the range tops at 1600 m.

The few tributaries to the west fall rapidly from the Paparoas from about the 1250 m level.

5.2.3 Geology

West of Reefton through to the granite of the Victoria and Brunner Ranges the ground is of severely faulted Waiuta greywackes with sandstone outcrops and coal measures. The Paparoa Range to the west is predominantly granite with a limestone belt along the eastern toe.

The valley floors are of Old Man and recent alluvial gravels with occasional glacial outwash deposits.

5.2.4 Climate

As with the remainder of the Coast, precipitation is evenly distributed throughout the year and is delivered predominantly by a northwest air stream. Precipitation also increases with altitude and decreases with distance from the sea leading to 6400mm annually along the top of the Paparoas, 2000mm on the Inangahua Valley floor, increasing again to 4800mm along the Victoria and Brunner Ranges.

5.2.5 Vegetation

The overall vegetation cover of the catchment is approximately as follows:

Native Bush	85%
River flats and farmland	10%
Bare tops	5%

5.2.6 Bedload

As for the remainder of the Coast little or no information on bedload is available. However, from inspection of the Inangahua and tributaries, bedload appears low and this is consistent with the catchments high vegetation cover.

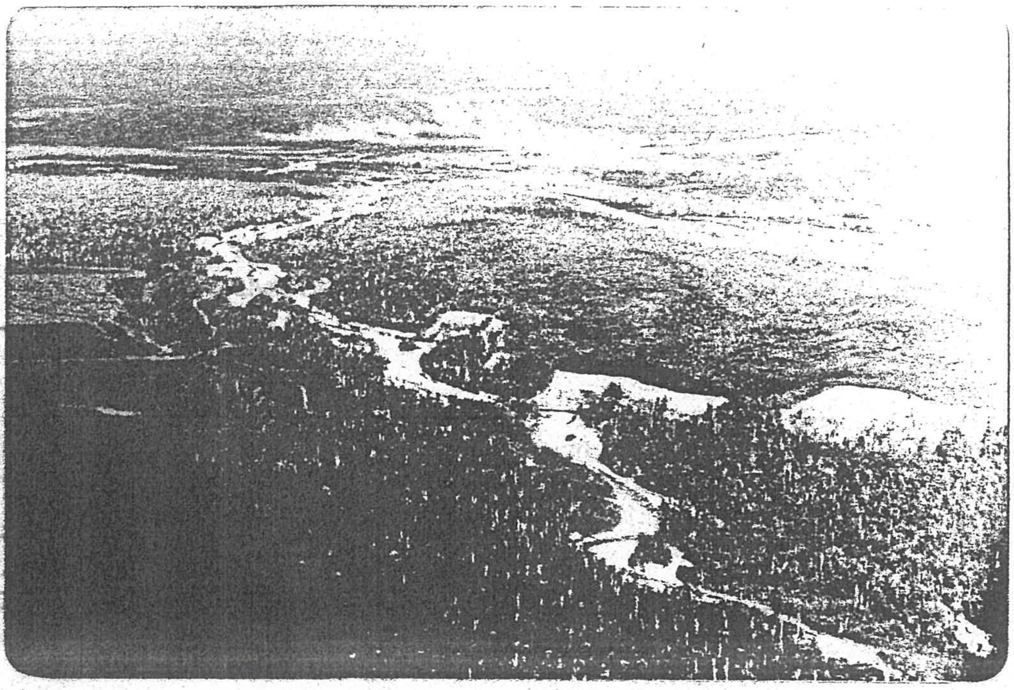
5.2.7 Possible Small Hydro Electric Schemes

On the Inangahua River itself there is little potential for hydro development but there are a number of possible schemes on its steeper tributaries as detailed in the following sections.

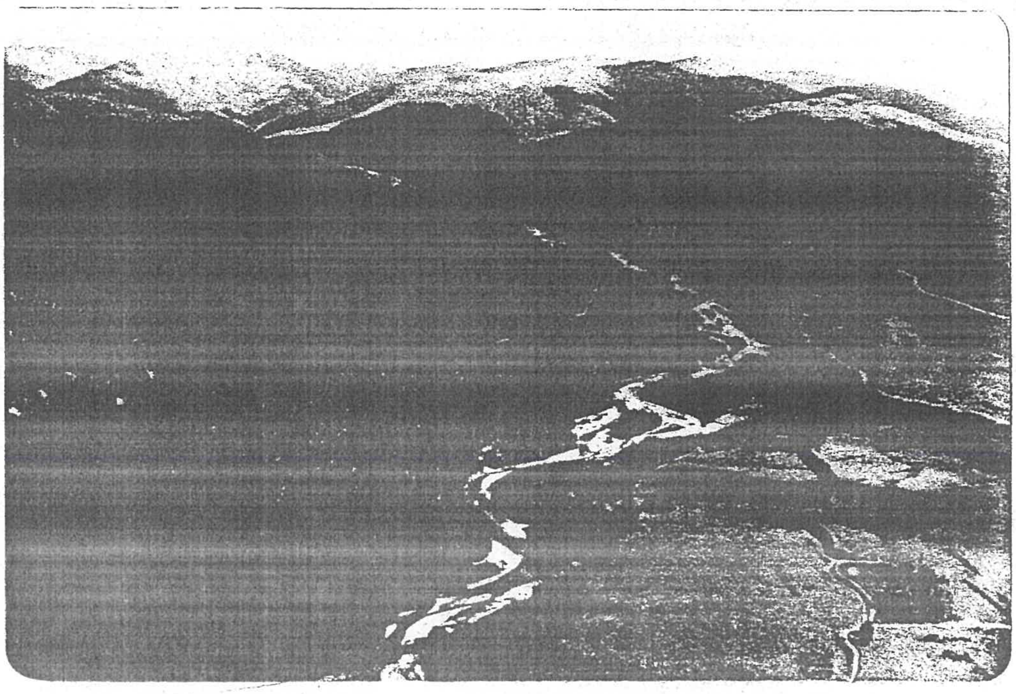
5.2.7.1 Stony River (Te Wharau)

The Stony River rises in the ice modified granite country of the Paparoas and joins the Inangahua 17km from the Buller. Over its 22km length the river falls 1300m through its 90% bush covered catchment.

Three alternative run-of-river schemes appear possible.



STONY RIVER:
LOWER SCHEME PENSTOCK INTAKE SITE AT MID-HEIGHT R.H. SIDE OF PHOTO. INANGAHUA RIVER FLOWS RIGHT TO LEFT IN MIDDLE DISTANCE AND ALSO JOINED BY THE AWARAU OPPOSITE THE STONY.



AWARAU LOOKING UPSTREAM.
RACE FROM INTAKE IN MIDDLE DISTANCE WOULD RUN ALONG TERRACES ON THE TRUE LEFT (RIGHT OF PHOTOGRAPH).

The first has not been described in detail because the more favourable second alternative would preclude its construction.

The second option would have a river intake just above the bridge site at the 800ft contour (map reference S31/271412) and a second small intake would pick up McMahon Creek.

The intakes would be founded on a band of sandy limestone. From these a race would follow around the hillside in old moraine gravels on the true right of the river to a saddle 110m above the Inanagahua and drop from there to a powerhouse at S31/321411.

The mean flow at the intake is some 6.6m³/s from the 55km² catchment. With an installed flow of 7.3m³/s at a 50% plant factor the installed capacity would be 6.7MW from the 110m head.

There is access to the intake site but a new road would be required to the powerhouse site.

The penstock slope is visible from S.H.69 but would not be visually obtrusive.

The third scheme on the Stony would have a streambed intake at the 1300ft contour at S38/237397 and from here water would be diverted south-east through a 1775m tunnel to a point 200m above Giles Creek where the powerhouse would be located at S38/265386.

The estimated mean flow at the intake is 5.3m³/s from the 33km² catchment. With an installed flow of 5.3m³/s at a 50% plant factor the installed capacity would be 8.8MW from the 200m head.

Access to the power station site is straight forward but access to the intake would require 4km of road along a steep hillside. This would be in reasonably stable granite and, although expensive, should not be too difficult.

5.2.7.2 Giles Creek

Giles Creek lies to the south of the Stony and flows into the Inangahua 8km further upstream. Over its 14km it falls 1250m through terrain generally similar to that of the Stony with granite in the headwaters then crossing a narrow band of limestone and mudstone before continuing over moraines and outwash gravels to the Inangahua River.

A scheme here would have a streambed intake at the 600ft level at S38/266386 and a race to a sizeable headpond 45m above and 1350m from a powerhouse beside the Inangahua River at S38/298378.

The estimated mean flow at the intake is 2.7m^3/s from the 27km^2 catchment. With an installed flow of 2.7m^3/s at a 50% plant factor the installed capacity would be 1.0MW from the 45m head.

An alternative possibility is to construct a scheme in conjunction with the upstream proposal on the Stony. This increases the installed flow to 8.0m^3/s and installed capacity to 3.0MW in addition to the 8.8MW from the Stony power station.

Construction problems and visual impact should not be significant.

5.2.7.3 Larry River (Awarau)

The Larry flows from the east to the Inangahua River opposite Stony River. Over its 25km length it falls 1500m through a 95% bush covered catchment of predominantly granite to the north, Waiuta greywacke to the south and with glacial outwash gravels on the lower valley floor.

A possible hydro scheme would include a streambed intake at the 520 foot level at S38/391392 with a race running along a terrace on the true left bank to a point 42m above a powerhouse site on the Inangahua River flats at S31/351422.

The estimated mean flow at the intake site is 9.6m^3/s from the 137km^2 catchment. With an installed flow of 11.5m^3/s at a 50% plant factor the installed capacity would be 4.0MW from the 42m head.

The majority of the race would be in scrub with the intake on the fringe of a bush covered face and the powerhouse on river flat farmland.

5.3 THE GREY CATCHMENT

5.3.1 General Features

The Grey is the largest river in the study area with a total catchment area of 3830km^2 above Dobson and a distance of 120km from its source to the Tasman Sea. It is bounded by the Paparoas to the north-west, the Inangahua catchment to the north, the main divide to the east, and the Taramakau catchment to the south.

5.3.2 Catchment Relief

Much of the catchment lies in the north-east trending Grey Valley synclinal depression that dominates the area. The bulk of the Grey flow is yielded by major tributaries to the south-east that rise at the main divide. These generally flow at mild gradients from the foot of the main ranges through much terraced and indented glacial and alluvial deposits to the Grey River up to 30km to the north-west. These tributaries include the Upper Grey, the Ahaura and the Arnold. A number of lakes occur in these deposits but, except for Lake Brunner, have very small catchments. Tributaries arising from the Paparoa ranges to the north-west are generally of short length and steep gradient, the largest tributary being Rough River which is 30km long.

5.3.3 Geology

The Grey Valley synclinal depression is floored with late Pleistocene glacial and alluvial deposits and occasional protruding mudstones. The Paparoas to the north-west are mainly of granite with Greenland greywacke to the south and sedimentary deposits on the southern extremity.

Large granite masses lie to the east through to the Alpine fault with schists and greywackes beyond. North of the Snowy River through into the Inangahua catchment is an area of Waiuta greywacke.

5.3.4 Climate

This is typical of the region but with a decreased rainfall in the middle reaches caused by the sheltering effect of the Paparoa Range. Rainfall varies from 6400mm in the Paparoas to 2000mm around Ikamatua then rising again to between 4000mm and 6500mm in the main ranges to the east.

5.3.5 Vegetation

The overall cover of the catchment is:

Native Bush	85%
River flats and farmland	10%
Bare land including lakes	5%

5.3.6 Bedload

Bedloads are generally low although of significance in the Ahaura River due to a sizeable headwater area in schist and greywacke.

5.3.7 Possible Small Hydro Electric Scheme

There are twelve possible schemes in the Grey River catchment involving the steeper upper reaches of the Grey above Ikamatua and some of its steeper or gorged tributaries. The Grey itself below Ikamatua is too broad and flat except at the Brunner Gorge to be seriously considered and the area of farmland and communication routes flooded here rule out this site.

5.3.7.1 Lake Christabel

Lake Christabel lies near the head of the Grey River at a level of 650m and with a 27km² catchment in schist and greywacke surrounded by peaks up to 1700m. The lake itself lies in behind a terminal moraine wall and has an area of 2.5km². At present the lake outlet is underground and should a scheme proceed this would have to be blocked off. A possible scheme includes tunnelling through this moraine wall and running a penstock 1650m to gain 125m of head.

The installed capacity available at 50% plant factor, 6.1m³/s installed flow and 125m head, is 6.4MW.

This scheme would lie entirely within a Forest Service Ecological Reserve. Judgements on environmental grounds are considered to be outside the scope of this report and therefore this scheme has been included. However, it is considered that a scheme at Lake Christabel would be environmentally unacceptable.

5.3.7.2 The Upper Grey

The schemes on the Upper Grey include three river intake and race sites and a major dam site.

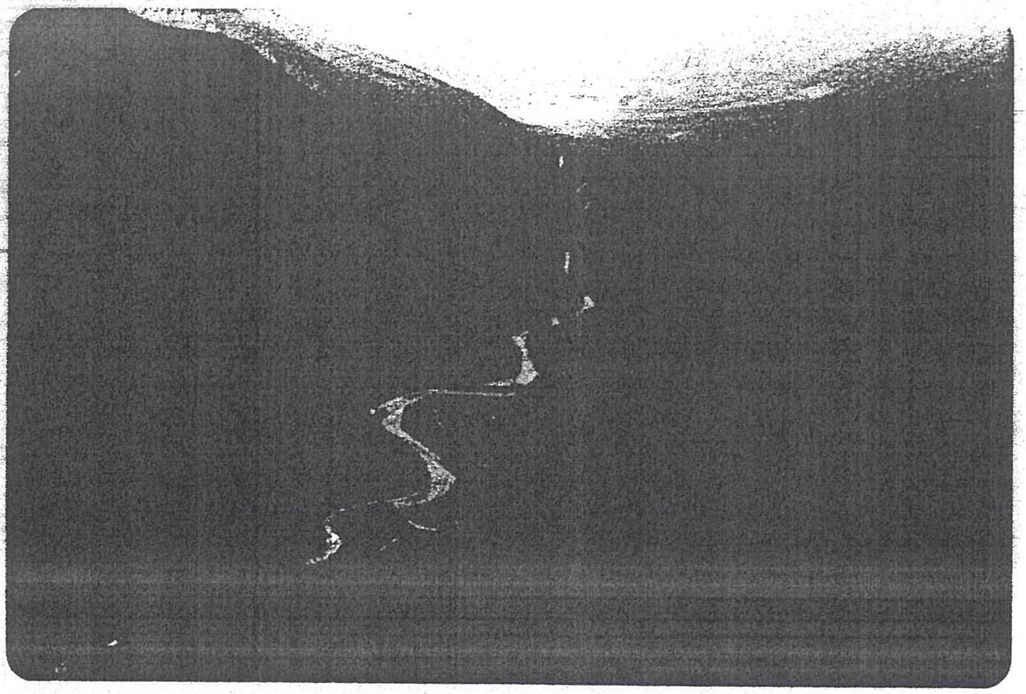
The first intake site lies 2km below the confluence of the Blue Grey and the Upper Grey at the 1300 foot level. At this point the river is running along the Alpine Fault with the catchment to the south-east in schist and greywacke and the catchment to the north-west in granite. Peaks on both sides rise to over 1500m.

From the intake site a 6.3km race would follow the contour on the true left bank to a point 50m above the Grey where it swings to the north-west. Access would be from the County road adjacent to the proposed race. The crossfall, bush cover and terrain irregularities along the race line may lead to some construction difficulties and additional costs.

The estimated mean flow at the intake is 12.9m³/s from the 192km² catchment. With an installed flow of 17m³/s at a 50% plant factor the installed capacity would be 7.1MW.

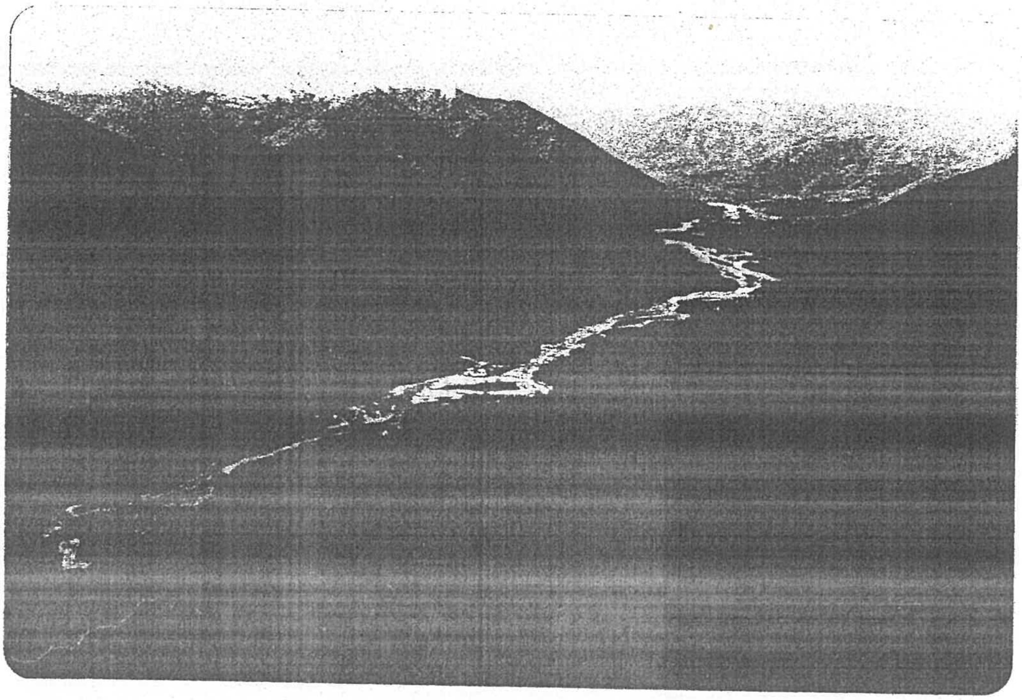
The second intake site is at the 900 foot contour on the section of the Grey between the Tass River and the Gentle Annie Gorge.

This scheme is similar to the first scheme with a race running 5.7km along the toe of the hill on the true right to a point just short of Snow Creek where 30m head is



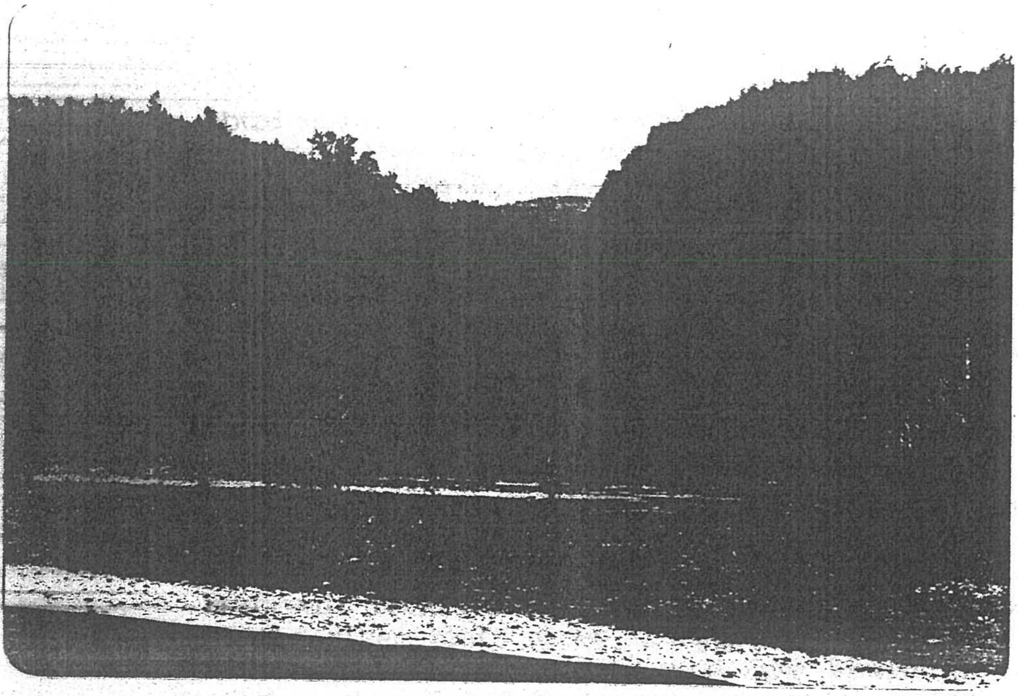
UPPER GREY:
LOOKING N.E. (UPSTREAM) TOWARDS THE BLUE GREY
FROM ABOVE THE ROBINSON.

THE SCHEME (a) INTAKE SITE LIES TOWARDS THE SADDLE
WITH A RACE ALONG THE TRUE LEFT.

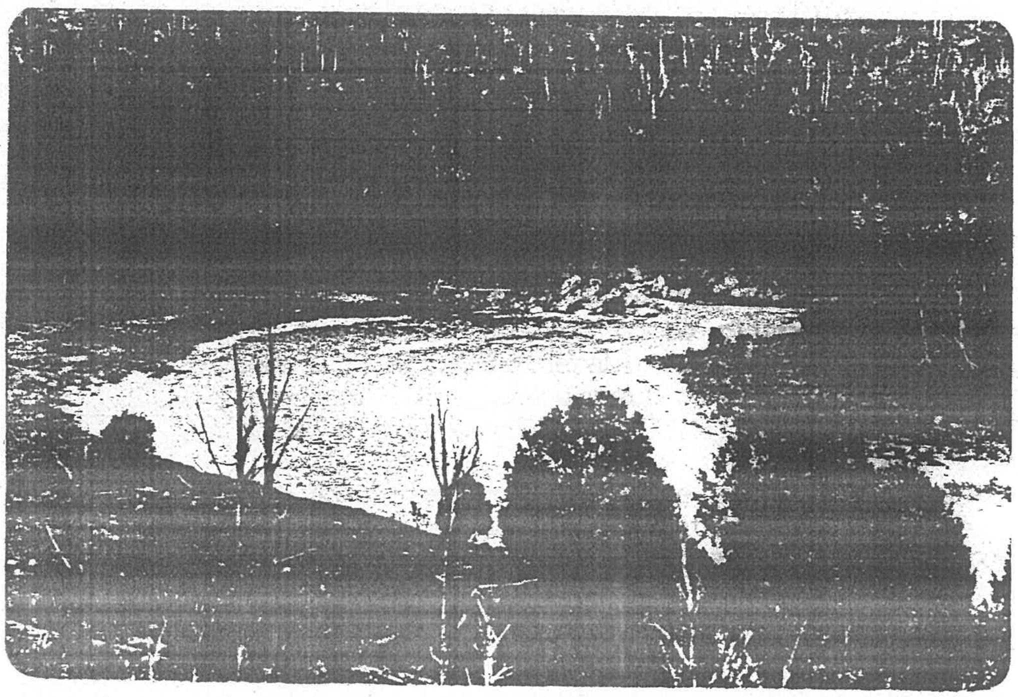


UPPER GREY:
LOOKING N.W. (DOWNSTREAM) FROM THE ROBINSON
TO THE GENTLE ANNIE GORGE.

THE SCHEME (b) INTAKE SITE LIES IN THE MIDDLE
DISTANCE WITH A RACE ALONG THE TRUE RIGHT.



GREY RIVER:
LOWER END OF WAIPUNA GORGE & POSSIBLE DAM SITE



GREY RIVER:
GRANITE OUTGROP AT HEAD OF MACKLEYS PLAIN.
POSSIBLE RIVER INTAKE SITE.

obtainable. Again the ground crossfall and bush cover on the race line may lead to construction difficulties and additional costs. Granite bedrock might also be encountered over some lengths. A County road runs to the powerhouse site but a new road would be required along the race alignment to the intake.

The estimated mean flow at the intake site is 28.9m³/s from the 402km² catchment. With an installed flow of 40m³/s at a 50% plant factor the installed capacity would be 10.0MW.

The third site on the Grey lies at the lower end of the Waipuna Gorge where the high granite walls would enable a dam of around 75m height to be constructed creating a reservoir back through the gorge and over the lower end of the river flats above to approximately the 820 feet level. A secondary County road runs almost to the dam site at present but would require some upgrading.

The estimated mean flow at the dam site is 38.3m³/s from the 540km² catchment yielding 35MW at an installed flow of 65m³/s, a 65m nett head, and 50% plant factor.

Bedload in the river at this point does not appear to be high but would have to be determined accurately before construction of a dam could go ahead. A higher dam and increased storage may also be possible.

The fourth and lower of the schemes on the Upper Grey is a further river intake site in a small granite outcrop through which the river passes 5.8km downstream of the Waipuna Gorge and immediately above the M.W.D. gauging station. (Map reference S45/260994). From here a race would follow the 500 foot contour 9.0km along the terraces and terrace faces on the true left to gain 30m head at the confluence of the Grey and Waipuna Rivers. The two terrace scarps to be climbed are in the order of 30m high and considerable excavation in gravels would be involved. The race invert on the first terrace is likely to be in mudstone.

The mean flow at the intake site is estimated to be 48.6m³/s from the 642km² catchment. With an installed flow of 73m³/s at a 50% plant factor the installed capacity would be 18MW.

5.3.7.3 Alexander River

The Alexander River joins the Grey in the Waipuna Gorge and rises 14km away at 1600m elevated in the southern extremity of the Victoria Range that also feeds the Inangahua catchment. A streambed intake could be constructed at the 1020 foot level near the site of the old Alexander River gold battery 1km upstream from the present County road. A race would sidle 1.6km along the bush covered hillside then 1.7km across a terrace to 100m above the Grey River 1km upstream of the Grey-Alexander confluence.

The estimated mean flow at the intake site is 3.7m³/s from the 38.7km² catchment. With an installed flow of 4.1 cumecs at a 50% plant factor the power obtainable from the 100m head is 3.4MW.

As the entire catchment is in granite and is bush covered except along the tops, bedload will be low. The intake is also likely to be founded on granite and the race in moraines and outwash gravels. Some 3.5km of new roading would also be required.

5.3.7.4 Rough River (Otututu)

The 30km long Rough River lies on the eastern side of the Paparoa Ranges joining the Grey River 3.5km below Ikamatua. Its long narrow valley was shaped by glacial action but is now clad in bush up to 1000m. Numerous peaks exist between 1250m and 1500m.

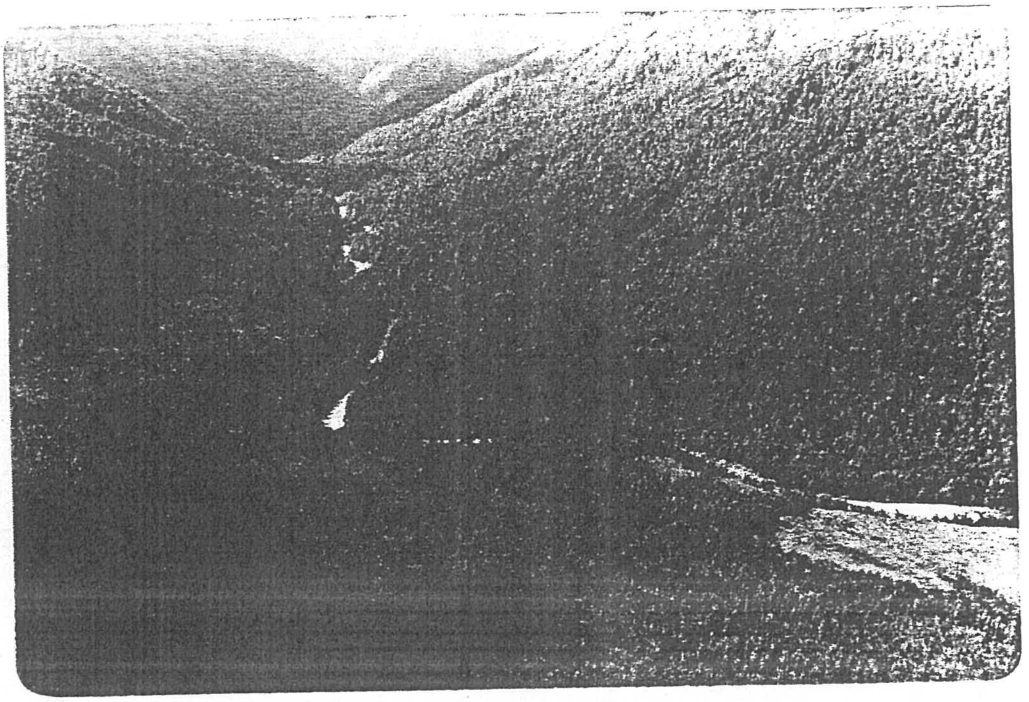
A small hydro scheme could be constructed with an intake at 625 feet immediately below Mirfin Creek and 10km above the Atarau Road bridge. The bed at this point is covered with rocks but parent material is probably not far below. A race would run 8.4km from here through outwash gravels on the true right to gain 65m head above a powerhouse site on the river flats 2km above the bridge. The first section of race is an easy sidle on to a wide terrace where some short term storage could be provided.

This is followed by a 3km sidle to the penstock intake along a second terrace face with a slope up to 25°. Construction along this face should present few problems.

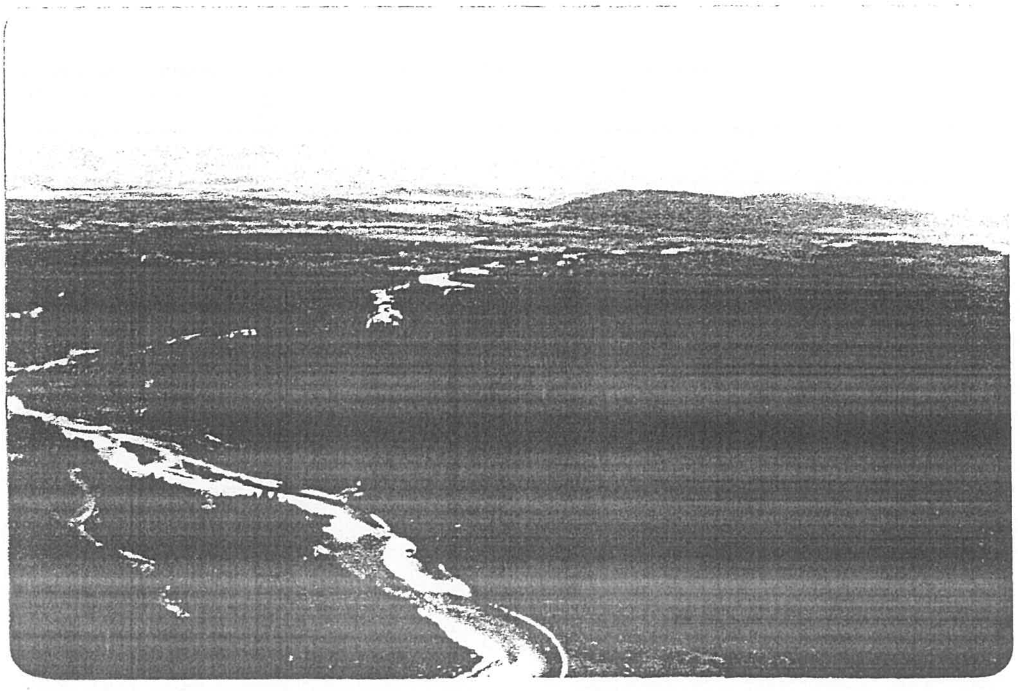
The mean flow from the 124km² catchment is estimated to be 15.8m³/s. With an installed capacity of 20.5m³/s at a 50% plant factor the power obtainable is 11.1MW.

Bedload from the bush clad granite catchment will be low.

A county road passes close to the powerhouse site and there are forestry roads in the vicinity of the intake but a new road would be required along the race line. As much of the area downstream of Mirfin Creek has been milled, a race through the area would not significantly damage the environment although the lower 3km will be visible from State Highway 7.



ROUGH RIVER - MIRFIN CREEK AT LEFT:
POSSIBLE INTAKE SITE IMMEDIATELY BELOW THE CONFLUENCE



ROUGH RIVER LOOKING DOWNSTREAM -
RACE WOULD LEAVE RIVER FLAT AT LOWER EDGE OF PHOTOGRAPH THEN CLIMB ONTO AND CROSS THE FIRST TERRACE AND HEAD TOWARDS THE TERRACE IN THE MIDDLE DISTANCE.

5.3.7.5 Big River

Big River lies to the south-west of Rough River rising at 1300m in the Paparoas to join the Grey River 22km downstream opposite the Ahaura River.

A streambed intake could be constructed at 400 feet with a smaller secondary source from an intake on Slaty Creek which joins Big River 1km downstream. A race would then run 6.2km along the terrace top on the true left to a point 60m above a powerhouse site on the Grey River flats 2km above the Grey- Big River confluence. The race and intakes would be in outwash gravels and construction should be straight forward. Some sandstone may also be encountered at the intakes. Short term storage could also be provided on the race alignment. Access at present exists to near both the powerhouse and intake sites.

The estimated mean combined flow for the intakes is $5.9m^3/s$ from the $67km^2$ catchment. With an installed flow of $7.1m^3/s$ at a 50% plant factor 3.5MW is obtainable.

5.3.7.6 Roaring Meg

Roaring Meg is a small river of 11km length that falls steeply from the Paproas 4km north-east of Blackball. It has been suggested for hydro development previously because of the steep fall but access and extraction of water would be extremely difficult due to the entrenched nature of the valley.

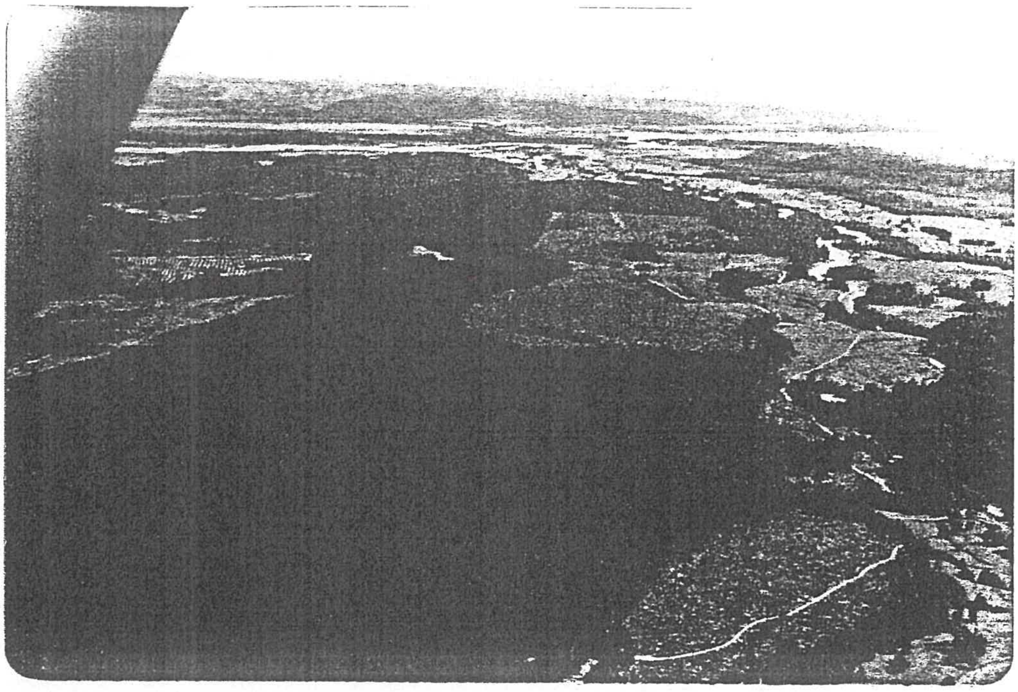
Should a scheme be feasible it would probably include an intake at the 1000 foot level in Greenland Greywacke with 1600m of piped flow along a bench cut on the true right bank. This would give 150m of head above a powerhouse site at the end of the existing access off the Atarau Road.

The estimated mean flow from the $11.3km^2$ catchment is $1.3m^3/s$ but, because of rapid runoff, installed flow at a 50% plant factor would only be $0.9m^3/s$ to give an installed capacity of 1.1MW.

This entire scheme would be within an ecological reserve gazetted in 1979.

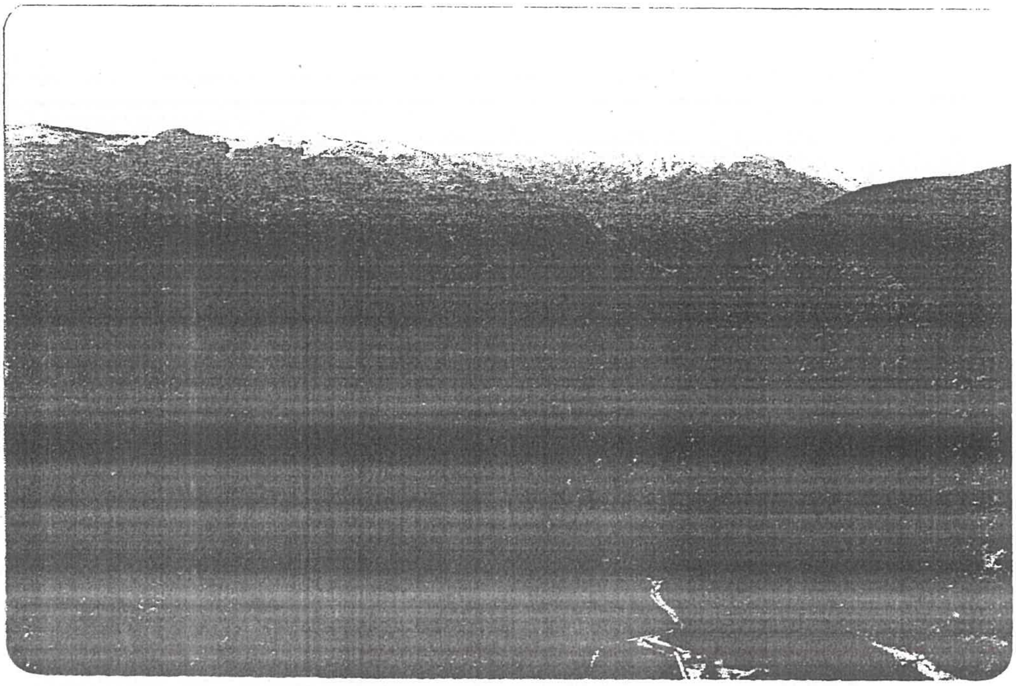
5.3.7.7 Ahaura River

The Ahaura is the largest of the Grey River tributaries at approximately 80km length. It is bounded by the Taramakau to the south, the main divide to the east, and the Upper Grey to the north. Peaks along the divide are



BIG RIVER:

RACE LINE UP CENTRE OF PHOTO
GREY RIVER IN BACKGROUND.



ROARING MEG

up to 1800m in height.

Because much of the catchment is east of the Alpine Fault and in schist and greywacke there is a high bedload. In the middle reach between the Trent River and the Ahaura Gorge is 35km of alluvial flats up to 5km wide and below this is a gorge where the river has cut itself well down into the moraines and outwash gravels and a localised granite outcrop.

Two schemes on the Ahaura River appear feasible. The first includes a river intake at the 800 foot level 2km below the Waiheke junction with a 4.1km race along the toe of the hill on the true left to obtain 30m head above Bellews Creek.

The mean flow in the river here is 34.4m³/s from the 286km² catchment. The installed flow at a 50% plant factor would be 52m³/s to give an installed capacity of 13MW.

Additional costs may be incurred on sections of race with significant crossfall.

Access would be by way of an existing county road.

The second Ahaura scheme lies at the head of the gorge about 0.5km below Hamers Flat (map reference S45/213892). It includes a 35m high earth dam ponding water to the 460 foot level and a short head race to above Jims Flat where 35m of head is available.

The mean flow from the 845km² catchment above the dam site is 85.6m³/ s to give an installed flow of 145m³/s at a 50% plant factor. From this 42MW could be obtained.

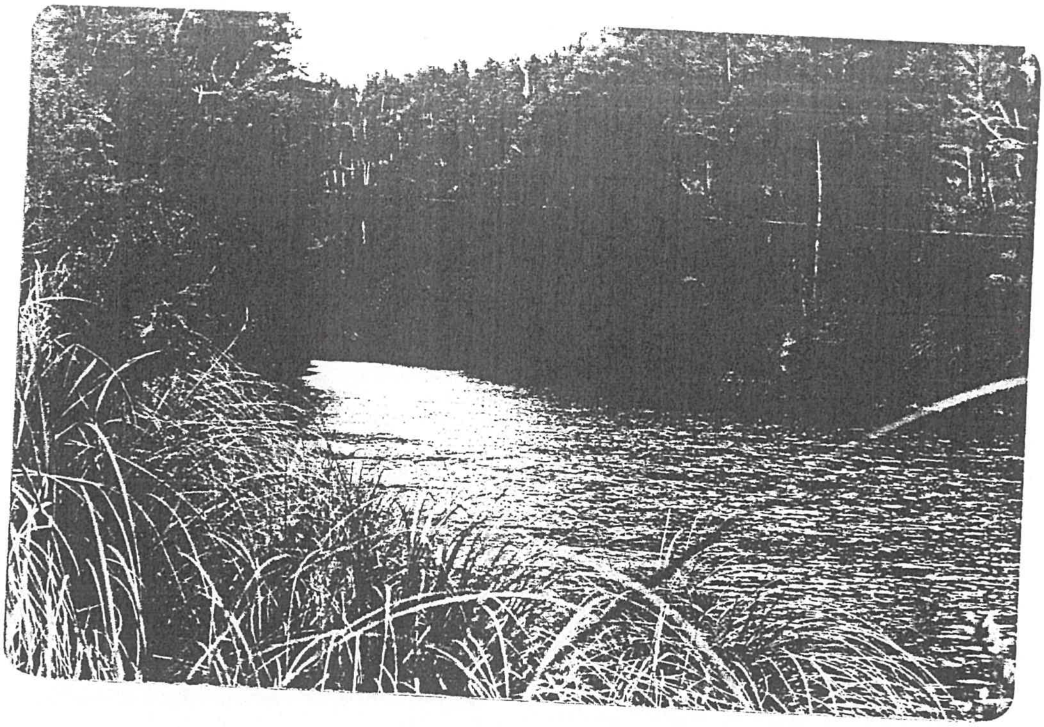
The entire scheme would be in cemented glacial outwash gravels which along the river stand vertically. Some 2km downstream the river passes through a granite outcrop but at this locality a much larger dam would be required to obtain the same storage. A spillway at the dam site would be built into the spur at the end of the left abutment.

A county road passes within 2.5km of the site, with a rough track, that would required upgrading, to the site.

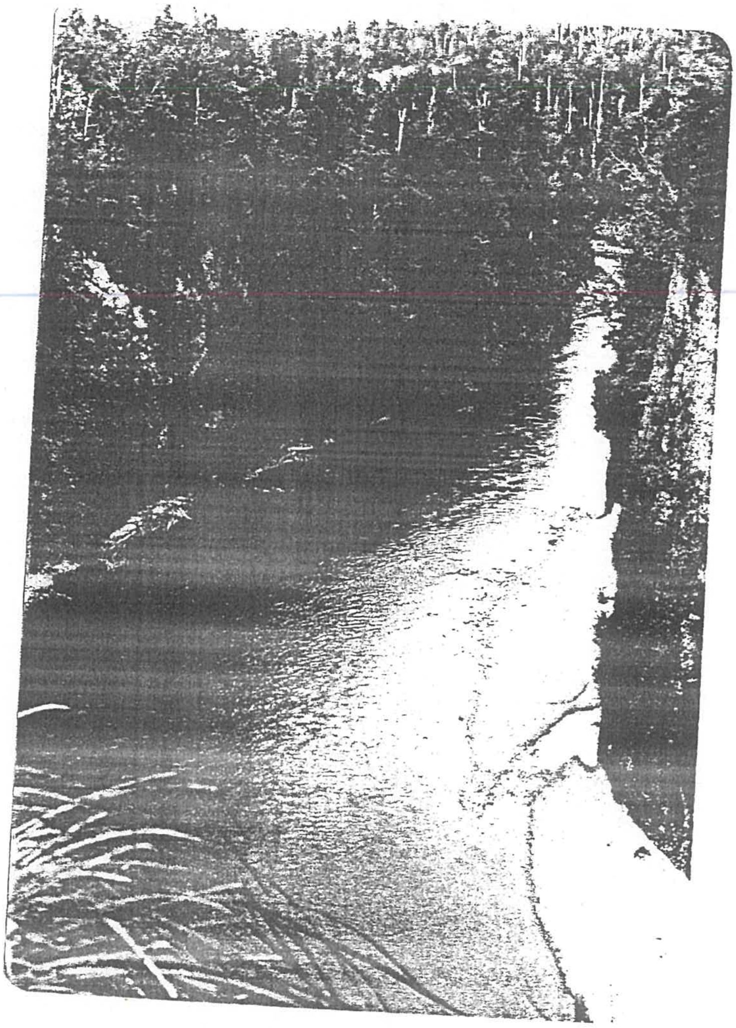
The dam site also lies within the upper end of the Ahaura Gorge amenity zone.

5.3.7.8 Nelson Creek

Nelson Creek rises at 350m on the glacial outwash



AHAURA:
LOOKING UPSTREAM AT M.W.D. GAUGING STATION



AHAURA:
POSSIBLE DAM SITE AT HEAD OF GORGE

terraces to the south of the Ahaura Gorge. It has two tributaries known as the Left and Right Branches, the Right (southern) branch 18km long and the Left (northern) branch 11km long and draining the 4.7km² Lake Hochstetter. They join 12km above the confluence of Nelson Creek and the Grey River.

Lake Hochstetter is approximately 150 metres above the Ahaura River but has insufficient catchment for any scheme to be viable. It is noted, in passing, that a small tunnel of gold mining origin runs from the north-west of the lake through to above the Ahaura Gorge.

Two low output run-of-river schemes, one on each branch, were identified and studied during the map study stage but rejected as impractical following an aerial inspection.

5.4 TARAMAKAU CATCHMENT

5.4.1 General

The Taramakau catchment is bounded by the Grey catchment to the north, the Arahura to the south and 60km of main divide to the east.

The Taramakau River drains 960km² and flows 77km from its source, at Harper Pass, to the sea. Half of this length is in mountainous country to the east of the Alpine Fault including much of the Arthurs Pass National Park and peaks up to 2250m high. The bed is typically 1km wide in the lower 50km below the Otira confluence, except for two terminal moraine restrictions above Kumara, and over this length has an average grade of only 1 in 220.

Major tributaries include the Taipo, Otira and Otehake Rivers.

Above the Otira River confluence and in the headwaters of the Taipo the base rock is greywacke, much of which is above the vegetation level of 1000m and, under the action of high rainfall, results in a high river bedload. From the Otira to the Alpine Fault, including most of the Taipo, is a band of schist and immediately downstream the granite outcrops of Mt. Turiwhate and the Hohonu Range. The remaining length to the coast is through moraines and outwash gravels.

Rainfall varies considerably over the catchment from 2800mm on the coast to 6400mm along the main divide but peaking at over 8000mm along the Campbell Range on the eastern side of the Taipo River.

Bedload in the Taramakau is reasonably high being mainly supplied by the Upper Taramakau, Otehake and Otira but with a significant contribution from the Taipo also.

5.4.2 Possible Small Hydro Electric Schemes

5.4.2.1 Taramakau River

Except for the Taipo, the Taramakau and its other tributaries are either too flat or have too high a bedload for any scheme to be feasible.

This conclusion was reached after consideration and inspection of several sites.

It is understood that the diversion of the Taramakau into Lake Brummer has been considered but this would be a large scheme and outside the scope of this study.

5.4.2.2 Taipo River

The Taipo River is one of the major tributaries of the Taramakau which it joins 33km from the sea. This northward trending river is 30km long from its source to the Taramakau and has a catchment of around 185km² bounded by the Otira River and Main Divide to the east, the Waimakariri and Wilberforce headwaters to the south and the Arahura to the west.

Peaks along the divides are generally over 1500m and up to 2100m. The entire catchment is in schist or greywacke with only 50% bush cover and hence bedload is moderate.

Two alternative sites on the river appear practicable for hydro development. The first includes a river intake 8.2km above the State Highway Bridge and just downstream of Seven Mile Creek. From here a race would run 2.1km along the flats to a 2.3km tunnel through Bald Range to gain 75m head above the Taramakau.

The mean flow for the 147km² catchment above the intake site is 32m³/s. For a 50% plant factor the installed flow would be 54m³/s and the power obtainable 33MW.

Storage would be insignificant unless off-stream storage was constructed on the flats upstream of the tunnel. The Taipo River is unusual however in that neither extreme highs or extreme lows appear to occur due to the self regulating nature of the catchment and it therefore has an installed flow to mean flow ratio similar to that for some storage schemes.

Access to the intake would require considerable upgrading of the existing four wheel drive track originally constructed for logging in the valley. River protection works would also be required. The tunnel exit and powerhouse are adjacent to S.H. 73 and only minor works here would be necessary. It is anticipated that the tunnel would be entirely in schist with much loose material at the portals.

An alternative scheme for the Taipo would be to draw off water at the confluence with Rocky Creek 2.2km above the State Highway Bridge and run it 900m north-west through a tunnel to a point 40m above the Taramakau. To utilize this head an 800m long tailrace up to 10m deep would be necessary.

The mean flow from the 178km² catchment above the intake site is 38m³/s. For a plant factor of 50% the installed flow would be 68m³/s and the power obtainable 23MW.

Access would again be over part of the present four wheel drive track but without the river control problems.

The tunnel portals are likely to be in moraines and outwash gravels with the middle section of the tunnel in schist.

A third alternative would be to construct a dam a further 0.5km downstream within the lower gorge and again tunnel north-west to feed water to the same powerhouse site as previously.

Installed capacity would increase to 72m³/s and the head to around 50m to yield 30MW.

This dam would be founded on moraines and gravels which may complicate construction. Construction of a diversion is also likely to be extremely difficult and expensive. Storage would not be considerable so bed load accumulation could be a critical factor. Because of the apparent difficulties this scheme has not been included in the tables although it is mentioned here because, if more detailed investigations proceeded, it could be considered as an option.

5.4.2.3 Duffers II Scheme

This scheme would form part of the Dillmans scheme using available head between the existing Duffers I powerhouse and Loopline Reservoir, a storage reservoir for the Dillmans scheme. It has been included in the Taramakau catchment because the Dillmans scheme takes water from three catchments including the Taramakau and discharges into the Taramakau. Brief details are given in Appendix A and a full feasibility study (Ref. 13) has been prepared.

5.5 ARAHURA CATCHMENT

5.5.1 General

The Arahura River has its source at Lake Browning on the main divide at 1350m and flows from there 55km to the sea. It is bounded to the north by the Taramakau catchment and to the south by the Hokitika catchment.

Peaks up to 2000m occur in the upper catchment and decrease in height westwards to the 250m high moraine hills near the coast.

The significant tributaries are Wainihinihi and Kawhaka Creeks, the headwaters of which are diverted into the Taramakau via the Dillmans Hydro Electric Scheme, and Olderog Creek. Bedload is reasonably high as much of the catchment is in schist with a little granite being contributed by Kawhaka and Wainihinihi Creeks which join the Arahura near the Alpine Fault.

Rainfall in the catchment varies from over 8000mm in the headwaters to 2800mm on the coast.

Bush cover in the catchment is of the order of 60%.

The Arahura River is also unique with its entire bed under private title having been retained by the Maori people (in the name of the Mawhera Incorporation) as New Zealand's traditional Greenstone source. The Incorporation's approval would be necessary before any scheme could proceed and some form of compensation could be involved.

5.5.2 Possible Small Hydro Schemes

Two independent schemes appear possible. The first includes an intake to draw water from the river near the head of the Second Gorge and below Prices Creek and carry it, in a 825m tunnel through a spur on the north side, to a point where 60m head is available.

The catchment area is 113km^2 at this point and the mean flow 26m^3/s. At a 50% plant factor the installed flow would be 36m^3/s from which 18MW is obtainable.

Rough access exists to both the powerhouse and intake sites at present but extensive upgrading would probably be required. The tunnelling would be in biotite schist.

The second scheme includes a river intake on the lower Arahura at the 200 foot level 15km above the mouth with a 7.6km race following the 200 foot contour to a point approximately 1km above the Kawhaka confluence where 30m head is available.

The catchment area at the intake is 194km^2 and the mean flow 38m^3/s. At a 50% plant factor the installed flow would be 53m^3/s from which 13MW is obtainable.

This scheme would be entirely in gravels and involves considerable earthworks. No problems are anticipated. However, a short length of new roading is also required and possibly an additional bridge over the Kawhaka Creek.

5.6 HOKITIKA CATCHMENT

5.6.1 General

The Hokitika is one of the larger rivers in the study area draining around 1100km² and a 50km length of the main divide. It has a number of major tributaries including the Whitcombe, Mungo, Toaroha, Kokatahi, Styx and the Kaniere which drains the 14.5km² Lake Kaniere.

The Hokitika catchment is divided by the Alpine Fault into two distinct regions with the area west of the fault containing the broad Hokitika Valley outwash plain, occasional moraine hills and a line of granite outcrops.

The region east of the fault is of very broken schist and greywacke much of which is exposed above the 1000m vegetation level and therefore subject to severe attrition. Peaks along the main divide are generally around 2000m with heights decreasing to around 1000m adjacent to the Fault.

Rainfall in the catchment varies considerably with 2800mm annually on the coast and generally over 8000mm along the divide. In the Upper Hokitika catchment however mean annual rainfall is over 10,000mm with a recorded peak of over 15,000mm a short distance from the divide.

Permanent ice occurs in pockets along the divide above 1500m.

5.6.2 Possible Small Hydro Schemes

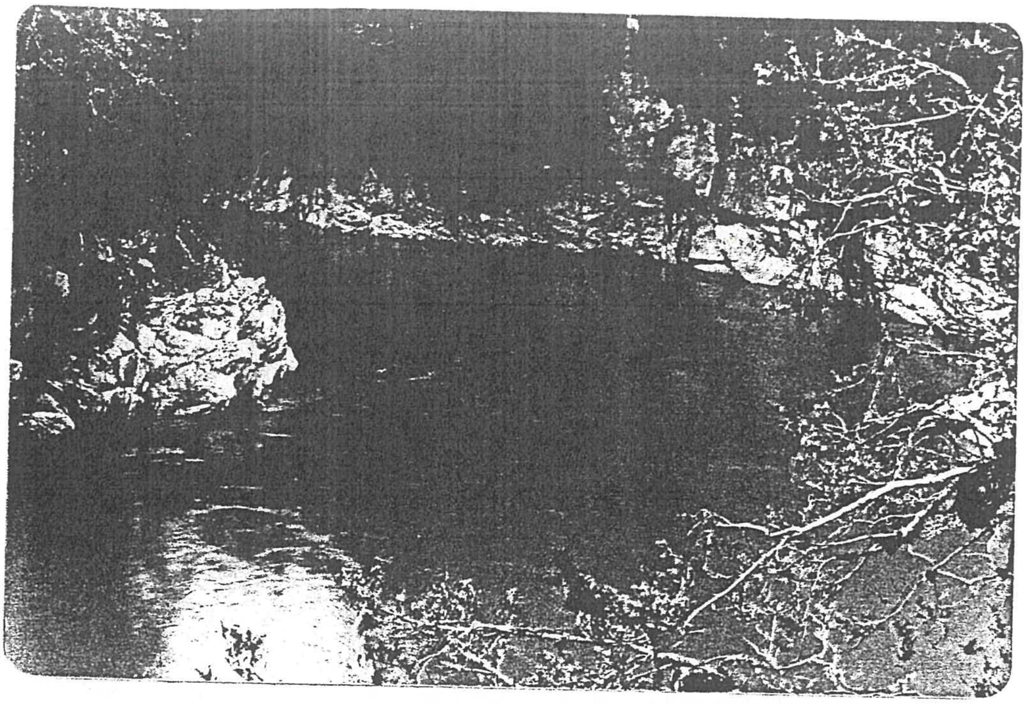
5.6.2.1 Kaniere/Styx/Kokatahi River

Significant potential exists with the diversion of the Kokatahi and Styx through Lake Kaniere. This however has been covered by a previous study and is not discussed here (Royds Sutherland McLeay 1979 Ref. 12). Brief details are given in Appendix A.

5.6.2.2 Toaroha River

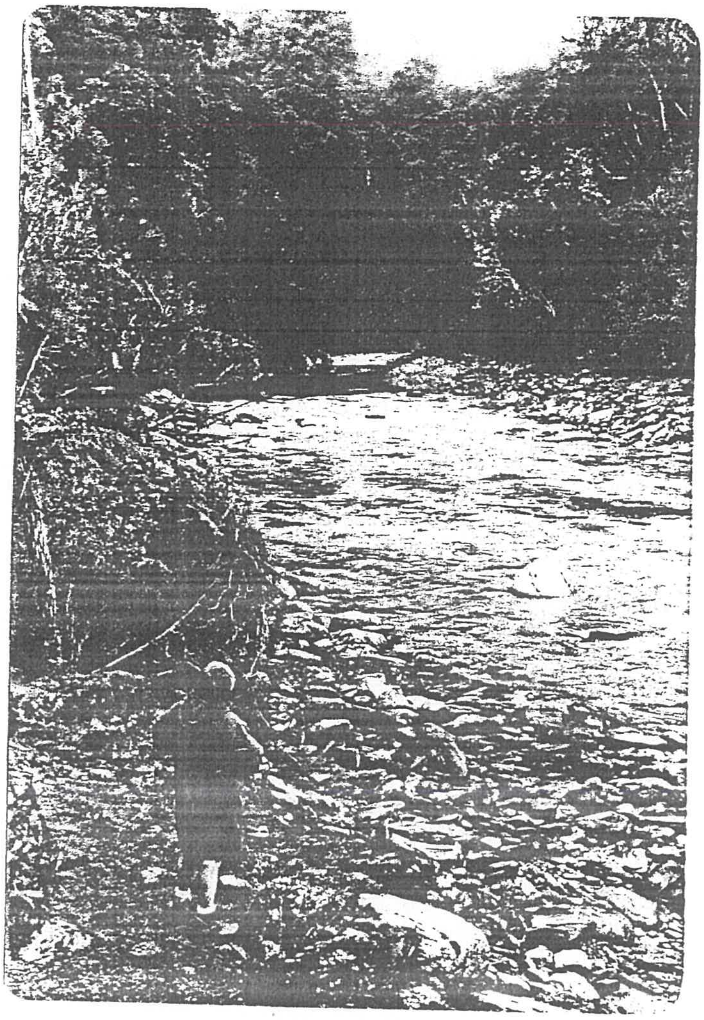
The Toaroha lies between the Upper Hokitika and the Kokatahi which it joins on the Alpine Fault and which itself is a tributary of the Hokitika. Over its 20km length it falls 1700m in a generally northerly direction and is enclosed by 1500 to 1800m peaks.

The entire catchment is of schist with alluvial deposits



HOKITIKA RIVER:

LOOKING DOWNSTREAM FROM THE SWINGBRIDGE IN THE HOKITIKA GORGE.



TOAROHA:

LOWER END OF THE CANYON.

prohibitively expensive.

If the access problem could be overcome an intake and tunnel scheme on the Whitcombe could yield 60MW and a similar scheme on the Hokitika, 36MW. If the bedload problem could be solved a 100m high dam on the Hokitika could yield 120MW.

5.7 MIKONUI CATCHMENT

5.7.1 General

The Mikonui is a 28km long river draining 155km² between the Hokitika to the north and east and the Waitaha to the south. From its source at around 2000m it falls to the Alpine Fault at the head of Gribben Flat 12km away and at 140m. The flats extend 5km from here beyond which is a 6km meandering gorge section and a further 5km of flats to the sea.

The geology is rather mixed with schist in the headwaters above the Alpine Fault, alluvial gravels over Gribben Flat bounded by moraine hills to the north and a granite range to the south, then Greenland greywacke through the gorge with further alluvial flats and moraine hills towards the coast.

Vegetation cover in the catchment is approximately 80%.

5.7.2 Possible Small Hydro Schemes

Provided a stable road can be formed, it should be possible to construct a 75m high rockfill dam in the Mikonui gorge by utilising the spur immediately upstream of Bullock Creek. This would create a reservoir 7km long back to the 350 foot level. The reservoir would eventually fill with sediment and provision would need to be made for sluicing or bypassing sediment once this occurred.

The mean flow from the 118km² catchment above the dam site is 25m³/s. For a plant factor of 50% the installed flow would be 42m³/s yielding 24MW from the 70m mean head.

Diversion of the river during construction would be by single or twin 300m tunnels through the spur on the dam's northern shoulder.

5.8 WAITAHA CATCHMENT

5.8.1 General

With the aid of the Mikonui to the north the Waitaha River drains an area enclosed by the Hokitika and Wanganui catchments and therefore does not reach the main divide. There are still numerous high peaks in the upper catchment however and some glaciation persists. A major tributary, the Kakapotahi (or Little Waitaha), joins 3.5km from the mouth immediately downstream of the state highway bridge and together these two drain 325km².

5.8.2 Mid and Upper Waitaha

5.8.2.1 Catchment Description

The Waitaha proper falls 2640m over its 40km length and drains 223km² to the gauging site at the state highway bridge. The catchment above the Alpine Fault 18.5km from the coast is in much gorged and steep sided schist. Below the fault the river cuts through a broad band of granite with pockets of Greenland grewacke to form hills up to 1000m high and a flat valley floor up to 3km wide. From these hills to the coast are large moraine deposits and the glacial outwash gravels. 400m west of the Alpine Fault is the secondary Fraser fault which extends to at least the Arahura in the north and the Wanganui in the South. Between the two faults lies a zone of severe crushing.

Rainfall in the catchment varies from 3200mm on the coast to over 8000mm in the back ranges with significant snow accumulation during winter.

Bush and scrub cover is around 40% and generally below 1200m leaving much terrain open to the effects of erosion. Bedload is therefore very high.

5.8.2.2 Possible Small Hydro Schemes

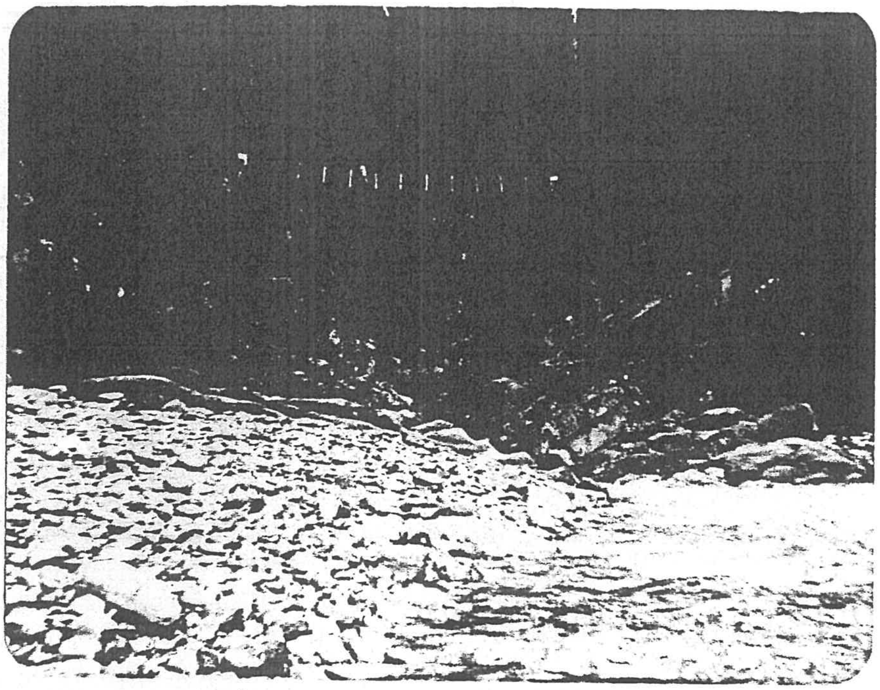
A power scheme utilising the 100m fall through the Morgan Gorge appears feasible by means of a river intake at the lower end of Kiwi Flat and a 1400m tunnel to a point above the top end of the flats 2.4km above Robinson Slip.

The mean flow from the 131km² catchment at the intake site is 37m³/s. For a plant factor of 50% the installed flow would be 48m³/s and the power obtainable 40MW.

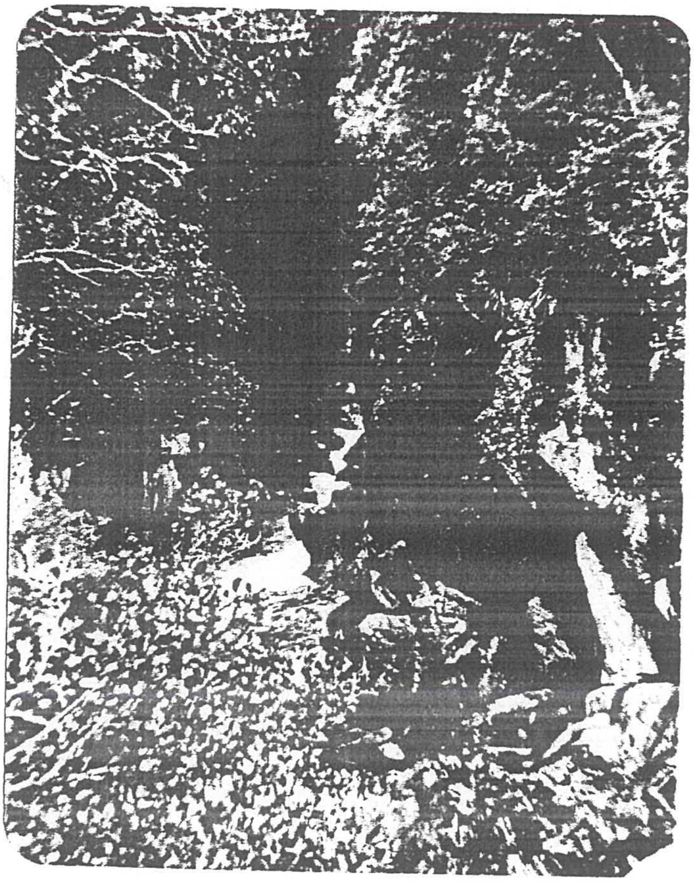
A 4.5km length of new access road would be required from the end of the Waitaha Valley road including a difficult section from the powerhouse site to Kiwi Flat over a spur on the north side of the gorge.

Bedload would also be a problem during periods of high flow particularly with intake abrasion and sediment removal. The intake site would be in the vicinity of an existing Forest Service foot bridge over a chasm in schist 20 to 30m deep and some 15m wide. Because of this any settling basin would have to be underground and could be very expensive.

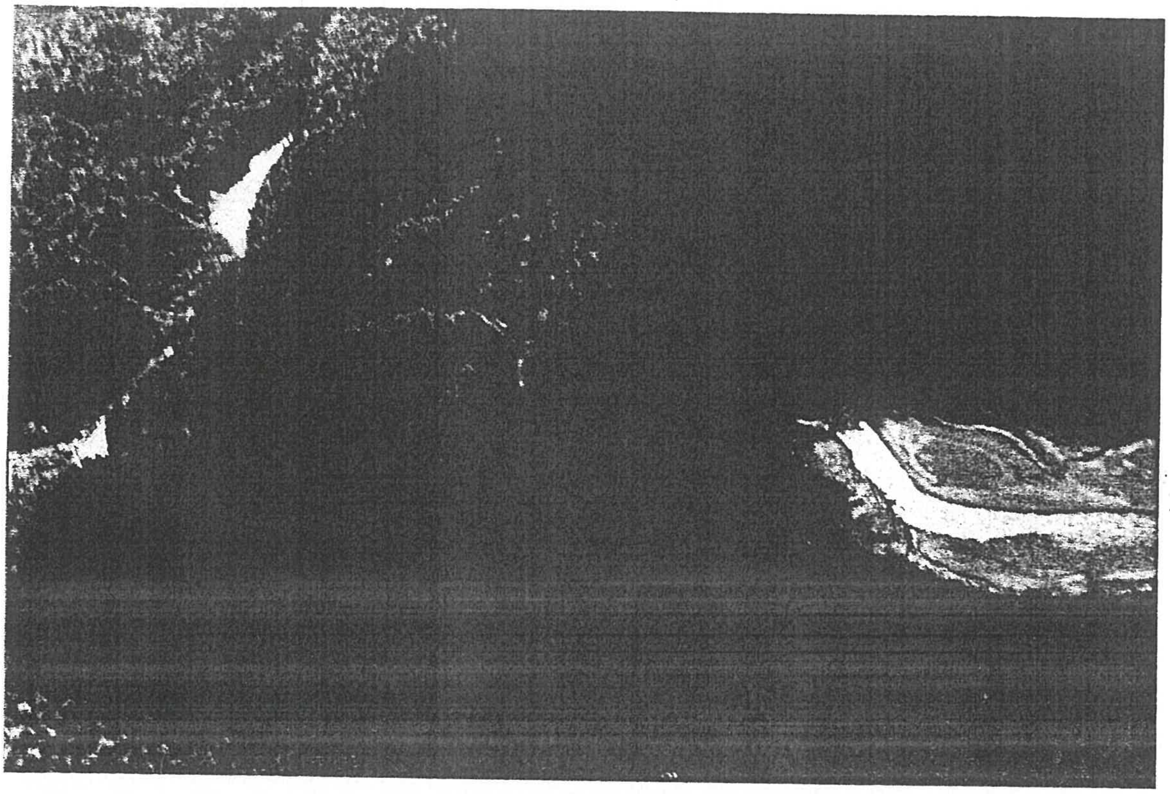
It could also be possible to construct a 20m high intake structure to gain additional head and increase power output to 60MW. However, any storage so gained would



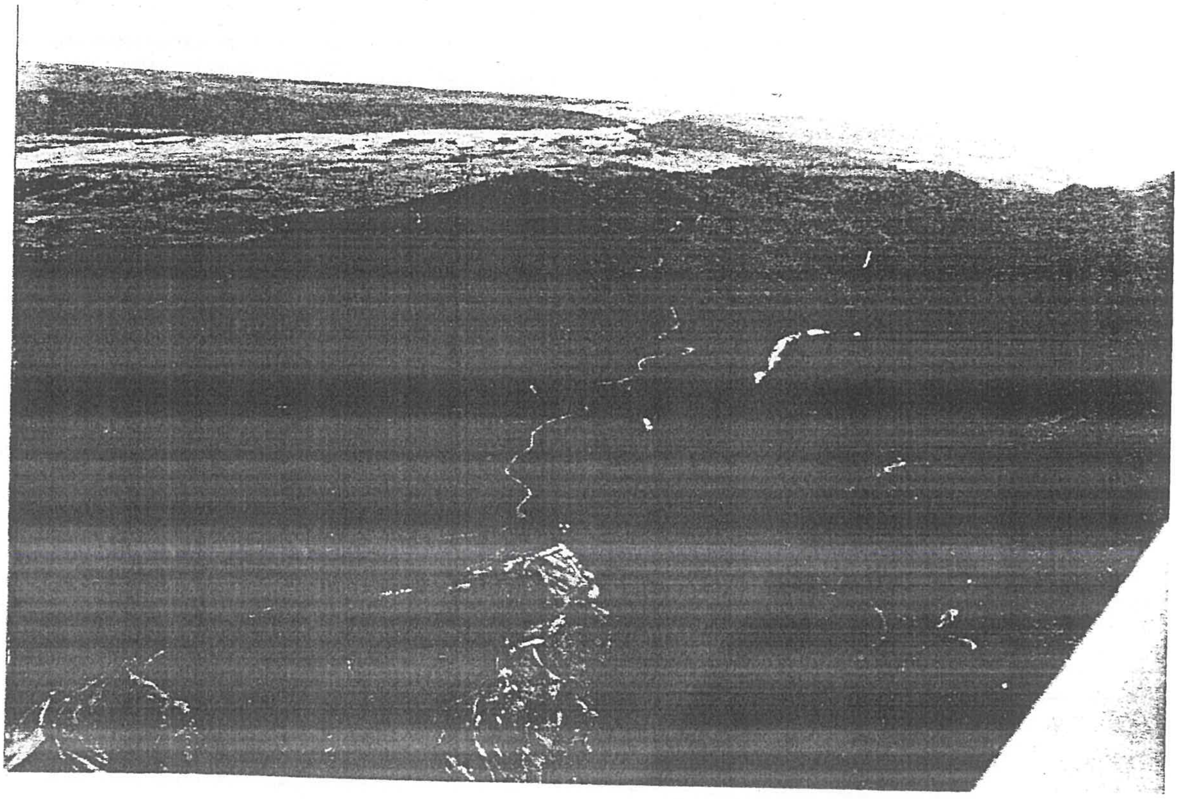
WAITAHA:
HEAD OF MORGAN GORGE AT POSSIBLE INTAKE SITE.



WAITAHA:
LOOKING DOWNSTREAM FROM THE SWING BRIDGE



Waitaha River at Morgan Gorge. Intake at top of gorge with tunnel through spur on right.



Kakapotahi River showing Happy Valley Flats leading into the gorge. A possible scheme would use the head between the Kakapotahi and Waitaha on the flats below (top left of photograph).

probably be lost within a year or so. The large quantities of material to be flushed and the abrasive nature of this material could preclude flushing.

5.8.3 Kakapotahi Catchment (Little Waitaha)

5.8.3.1 Catchment Description

The 24km long Kakapotahi River drains the northern side of the Waitaha catchment and joins the Waitaha 3.5km from the coast. It rises in the Hitchin Range at 2000m then falls rapidly over 8km to the head of the Happy Valley flats at 250m. The Alpine fault also crosses at this point. The flats run another 5km at up to 600m width having been formed through the infilling of an old glacial lake. From the end of the flats the river falls 11km through a canyon in granite and then old moraine formations before joining the Waitaha.

Rainfall varies from 3200mm in the lower reaches to above 6500mm along the tops. Vegetation cover in the catchment is around 80% and accordingly bedload is only moderate.

5.8.3.2 Possible Small Hydro Schemes

By installing a river intake in the granite chasm at the lower end of Happy Valley and the excavation of 4.1km of contour race, the 115m head difference between Happy Valley and the Waitaha flats could be developed.

At the intake site the catchment area is 65km² and the mean flow 14.5m³/s. For a plant factor of 50% the installed flow would be 17.4m³/s and the power obtainable 17MW.

Alternatively a higher intake structure could be built to create a flushable reservoir and, by increasing installed flow, increase power obtainable to around 29MW.

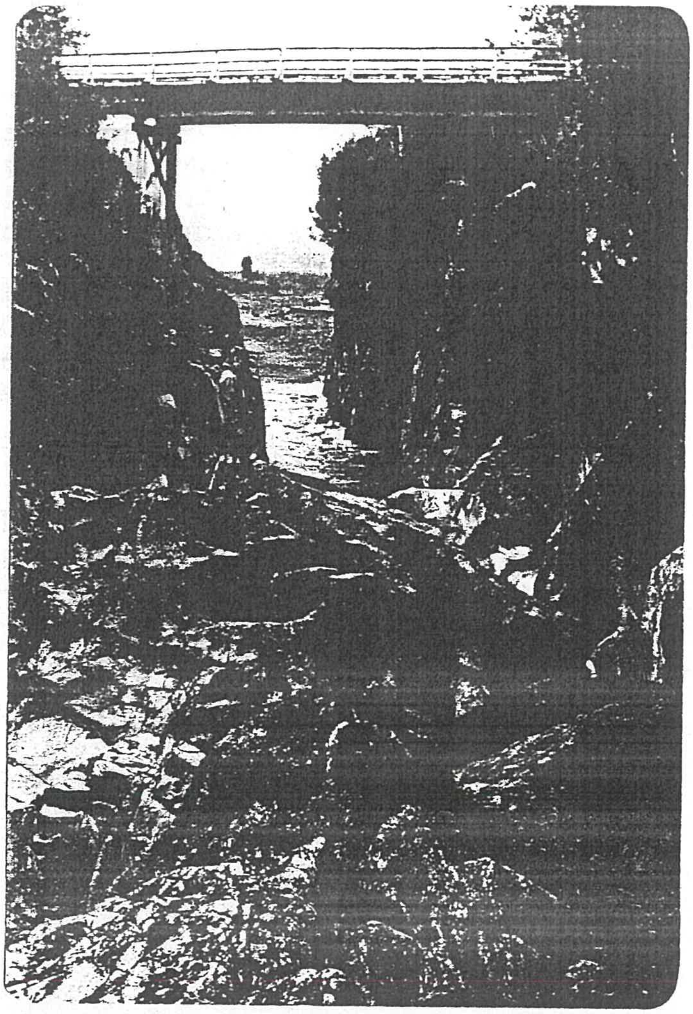
Access exists to the intake site along a route parallel to the race alignment through ground clear-felled of bush. The race itself would run along a terrace of predominantly moraine gravels but a little siltstone and granite bedrock could also be encountered over some lengths.

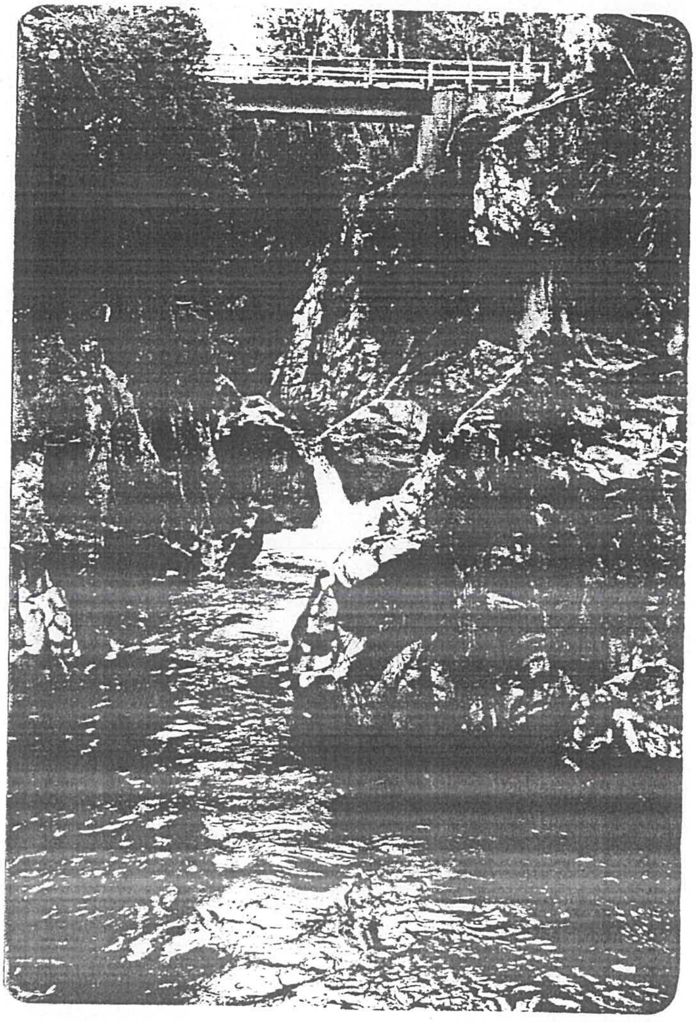
1.4km of tailrace is also included which would be in alluvial gravels.

5.9 WANGANUI CATCHMENT

5.9.1 General

The Wanganui is another of the major Westland rivers and lies to the





KAKAPOTAHI:
AT THE LOWER END OF
HAPPY VALLEY.

POSSIBLE INTAKE SITE
IN CHASM BELOW BRIDGE.

south of the Waitaha catchment. Its 50km length drains 510km² including 24km of the main divide, much of which is over 2400m. Glaciation in the upper catchment is extensive and during heavy rainfall combined runoff and snow melt leads to severe flooding.

Much of the Wanganui itself is of gentle grade particularly the 23km downstream of the state highway bridge where the river flats are up to 6km wide. Upstream of the bridge the bed is narrow and steep sided but falls only 150m over 11km.

5.9.2 Possible Small Hydro Schemes

The frequent flooding and unstable bed of the Wanganui combined with its generally flat or inaccessible nature preclude any hydro development on the main channel. A scheme has existed for some time however on the Amethyst Ravine and it may be possible to upgrade this to a higher head.

5.9.2.1 Amethyst

The Amethyst is a short, 8.5km river, joining the Wanganui from the north 1km above the state highway bridge. Some 400 of the total 1450m fall in the catchment occurs over the last 2km and this head could be utilised by a river intake and 730m tunnel to a level 400m above the Wanganui 4km upstream of the state highway.

At the intake site at the 1710 foot level the likely installed flow for a 50% plant factor is 2.5m³/s to yield a power output of 8MW.

Road access may be difficult around Canopy Bluff and it would probably be impossible to run a road further than half way up the penstock slope. From here a cableway may be constructed to the tunnel portal and possibly continue to the intake.

Access to the intake for inspection purposes during opration could be a major problem.

5.10 POERUA CATCHMENT

5.10.1 General

The Poerua is a 225km² catchment adjacent to the Wanganui and on the southern boundary of the main study area. It rises in the Adams Range at 2400m and falls to 100m above sea level at the Alpine Fault 15km away. From here is flows 20km to the coast through forested moraines and outwash gravels and a little farmland. The state highway is crossed 5.5km below the fault.

5.10.2 Possible Small Hydro Schemes

The lower reaches of the Poerua are generally too flat and the upper reaches too inaccessible for any hydro development but at the lower end of the gorge at the 500 foot contour a scheme may be feasible. At this point, if access is possible, a river intake would feed a 1000m tunnel on the true right to gain 50m of head above the upper end of the Poerua flats.

At the intake site the mean flow is $16m^3/s$ from the $60km^2$ catchment. For a 50% plant factor the installed flow would be $22.4m^3/s$ and the power obtainable 9.4MW.

The intake and tunnel will be in biotite schist. No storage is available.

5.11 WHATAROA CATCHMENT

5.11.1 General

The 51 km long Whataroa River drains $585km^2$ including a 30 km length of the main divide. The catchment includes a number of mountain peaks over 2400 m. The major tributories are the Perth and Butler rivers. There is extensive glaciation and a large proportion of the catchment is above the bush line. Consequently the river has a very high bed load with severe floods. The lower 35 km of the river is of gentle grade, particularly the 25 km downstream of the state highway bridge.

The majority of the catchment is east of the alpine fault and consists of various schists of the Haast Schist Group with some greywacke along the alpine divide and river gravels in the valley floors.

5.11.2 Possible Small Hydro Schemes

5.11.2.1 General

The frequent flooding and high bedload of the Whataroa generally preclude hydro electric development.

5.11.2.2 Perth River

A scheme on the Perth River was referred to in the Stage 1 report, however, closer inspection indicates that this would not be economic due to the rugged nature of the terrain.

5.11.2.3 Butler River

The Butler is a tributary of the Whataroa with the majority of its 43 km^2 catchment adjacent to the alpine divide. A scheme could comprise of an intake at the head of the Butler Gorge (S71/060697) with a 2.1 km tunnel to a penstock and powerhouse in the Whataroa river valley (S71/040717). With an installed flow of 9.6

m^3/sec and 275 m nett head, the installed capacity would be 22.5 MW.

A major difficulty would be access roading to the powerhouse and intake sites. The sediment load in this river is also likely to be very high as the river is glacier fed. The tunnel would be in quatzo feldspathic schist.

5.12 WAITANGITAONA CATCHMENT

5.12.1 General

The Waitangitaona lies between the Whataroa River and the coast and drains the western slopes of the Price range. In excess of 50% of the catchment is above the bush line and erosion is severe. Recent studies (Griffiths and McSaveney) have suggested that the catchment has a total sediment yield of 13,300 tonnes per square kilometer per year.

The Waitangitaona downstream of the State Highway bridge has frequently changed course either flowing north and parallel to the Whataroa or west through Lake Wahapo. The Westland Catchment Board has proposed constructing stopbanks to keep the river flowing through Lake Wahapo and then into the Okarito River.

5.12.2 Possible Small Hydro Schemes

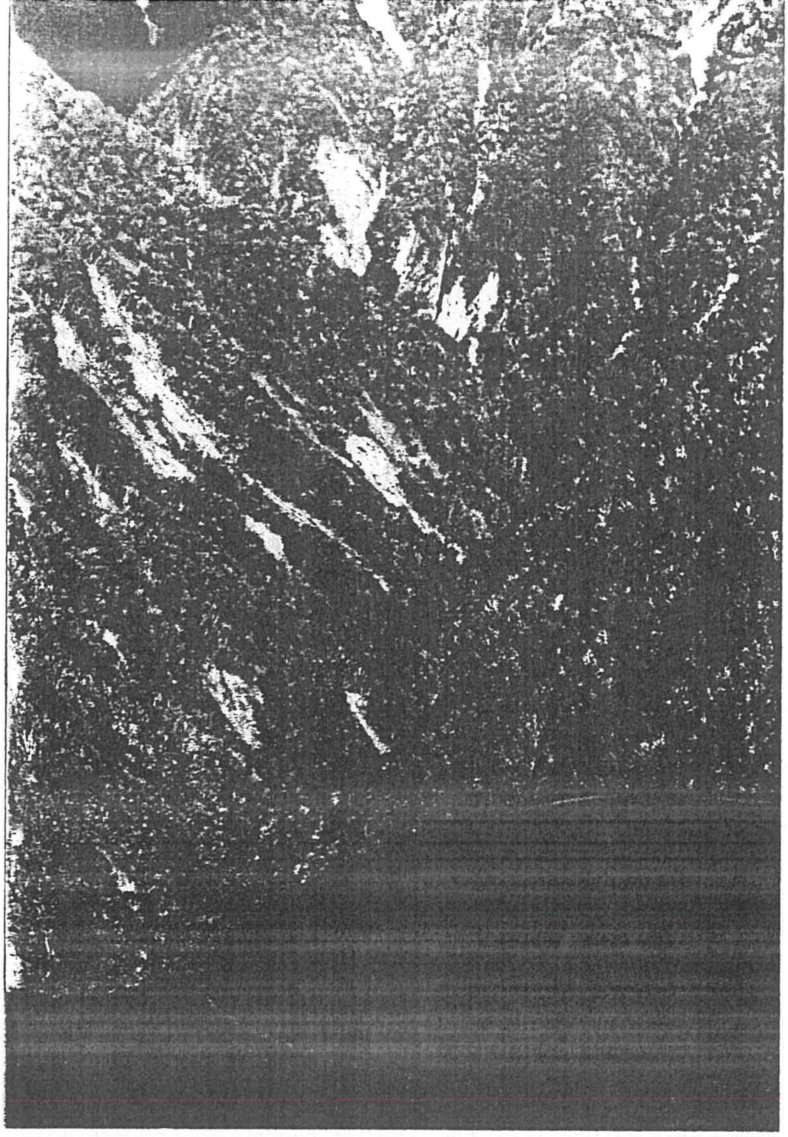
5.12.2.1 General

There are no economical schemes on the Waitangitaona itself.

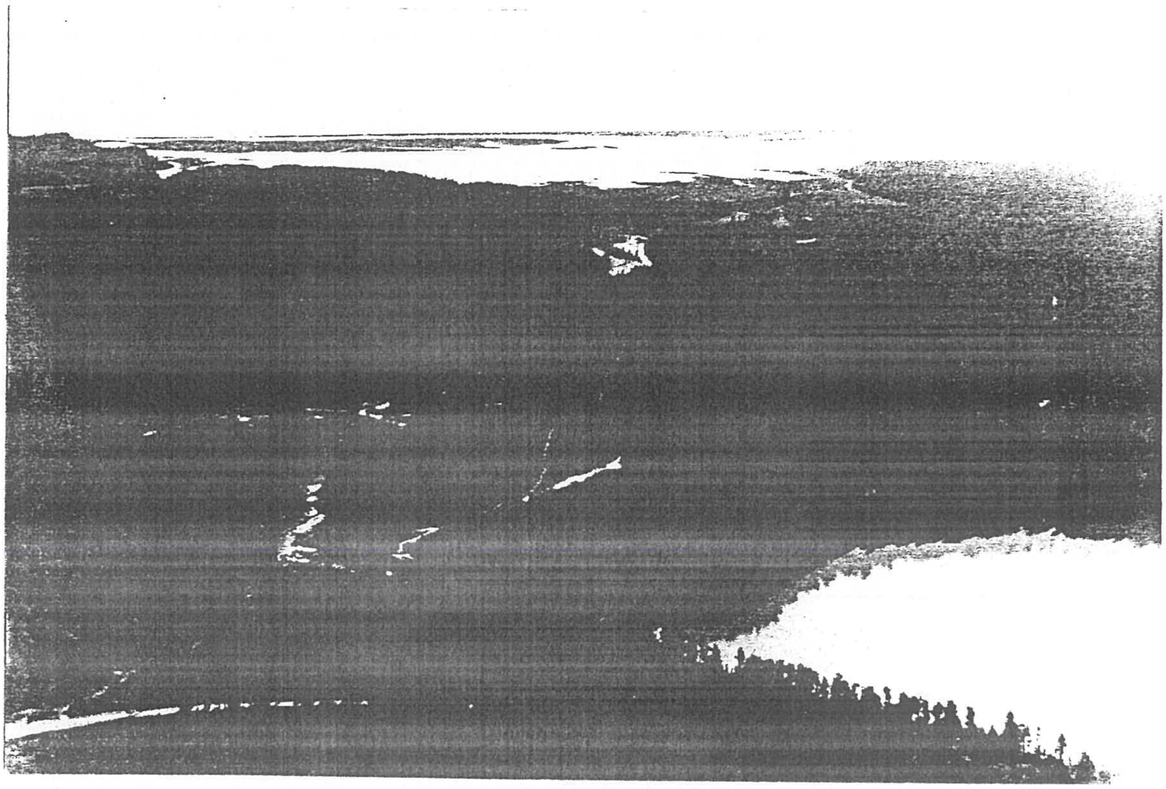
5.12.2.2 Lake Wahapo

The West Coast Electric Power Board have a small (250 kW) scheme utilizing 30 m head between Lake Wahapo and the Okarito river. This scheme operates with an installed flow of 1.0 m^3/sec, whereas the mean flow from the lake with the flow from the Waitangitaona is 10m^3/sec.

The existing scheme could be replaced by a larger scheme comprising of a new intake on Lake Wahapo feeding a 400 m tunnel through the Okarito moraine to the present penstock intake site. A new penstock and powerhouse would be located close to the existing penstock and powerhouse. With an installed flow of 8 m^3/sec the installed capacity would be 2.0 MW. Alternative schemes involving the upgrading of the existing scheme intake and race system could be adopted and may well be more economic than the scheme proposed.



Tartare River Gorge



Lake Whahapo with headpond for the existing scheme in the centre of the photograph. Okarito Lagoon in background.

5.13 WAIHO CATCHMENT

5.13.1 General

The Waiho river is south of the Whataroa and drains 285km² including the Franz Josef glacier. Major tributaries are the Callery River and the Tartare Stream, which are both glacier fed.

The bedload in the Waiho and Callery is very high and the Waiho river is constantly aggrading or degrading depending on movement of the Franz Josef Glacier. Downstream of the State Highway bridge the river flattens and is contained within stopbanks to prevent flooding of adjacent farmland.

The majority of the catchment is within the Westland National Park.

5.13.2 Possible Small Hydro Schemes

5.13.2.1 General

There are no economic hydro electric schemes on the Waiho or Callery rivers due to the high bed load and unsuitable topography.

5.13.2.2 Tartare River

The West Coast Electric Power Board have had a small (150 kW) hydro scheme on the Tartare River. This has recently been closed down because the stream bed has degraded below the intake.

As a replacement for the previous scheme near the lower end of the gorge it appears feasible to make use of a much greater fall from the gorge to the Tartare River flats. This scheme would consist of a river intake (map reference S71/857725) and a 1350m tunnel feeding directly into a penstock. An installed flow of 4.0m³/sec. would produce 5.9MW from a 180m head. Main access to the intake would of necessity, be through the tunnel with a road up to the tunnel exit.

The scheme would be in the Westland National Park, close to the Franz Josef township and thus may be environmentally unacceptable.

5.14 OMOEROA AND WAIKUKUPA CATCHMENTS

5.14.1 General

These two rivers are south of the Waiho and drain the Fritz and Victoria ranges. The Waikukupa River is fed by the Fritz Glazier.

The State highway which runs parallel and close to the alpine fault splits the catchments in two. West of the highway the catchments are 100% bush clad with numerous 'perched' swamps. East of the State highway the rivers rise rapidly. Barely 50% of the catchment is bush clad and there is considerable erosion particularly on the Waikukupa in the vicinity of the Alpine Fault.

Both catchments are in the Westland National Park.

5.14.2 Possible Small Hydro Schemes

5.14.2.1 Waikukupa

Water could be diverted from the Waikukupa River at the 1400ft level (S71/735646) through a 2.2 km tunnel to a powerhouse on the Clearwater River (S71/701653). An installed flow of 5.0m³/sec with 130m nett head would provide an installed capacity of 5.5MW.

Access to the penstock and powerhouse would be straight forward but access to the intake could be difficult. The stilling basin may have to be underground and the tunnel would pass through the alpine fault.

The Waikukapa catchment is severely eroding, especially in the vicinity of the alpine fault, and has a high sediment load. It is possible that this sediment load could be sufficiently high to make this scheme uneconomic.

5.15 KARANGARUA CATCHMENT

5.15.1 Catchment Description

The Karangarua has a 420 km² catchment including an 18km length of the main divide. Major tributaries are the Copland and Douglas Rivers. Both of these tributaries are fed by minor glaciers and 80% of their catchments are above the bush line. The Catchment includes a number of peaks above 2400 m.

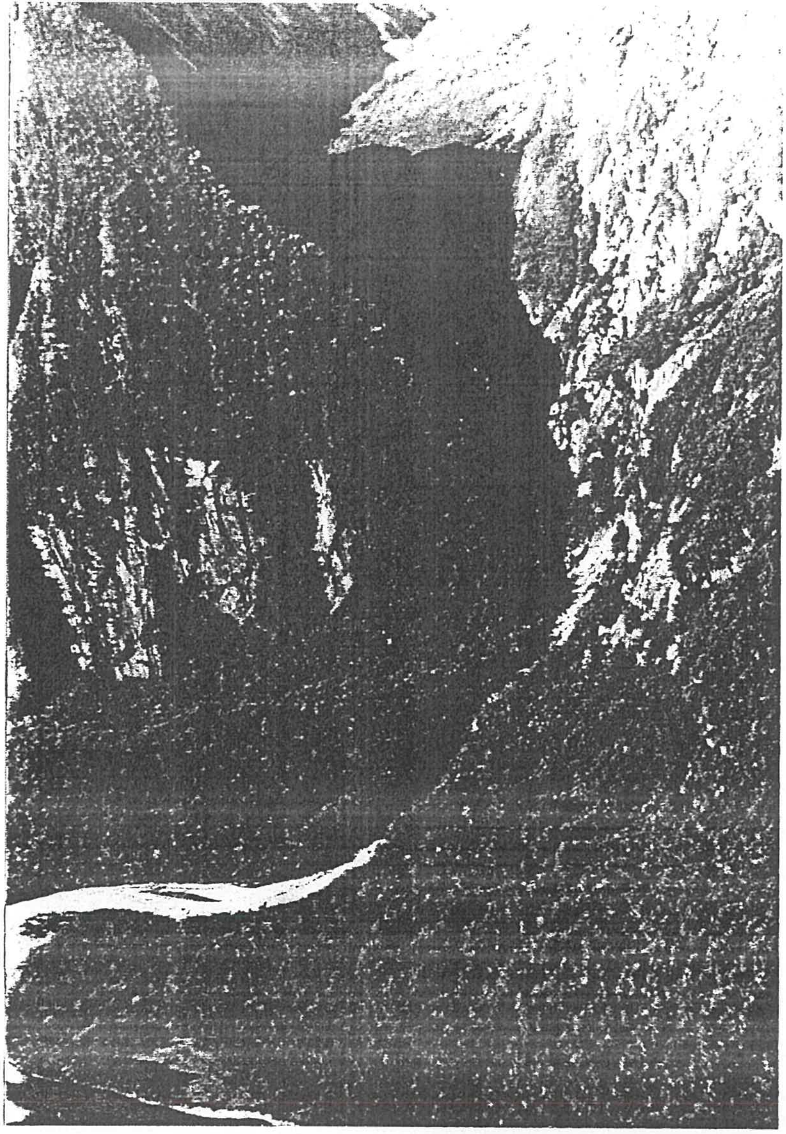
The majority of the catchment is east of the alpine fault and consists of various schists from the Haast Schist group with some greywacke on the main divide, and glacial fill and gravels in the river valleys.

5.15.2 Possible Small Hydro Schemes

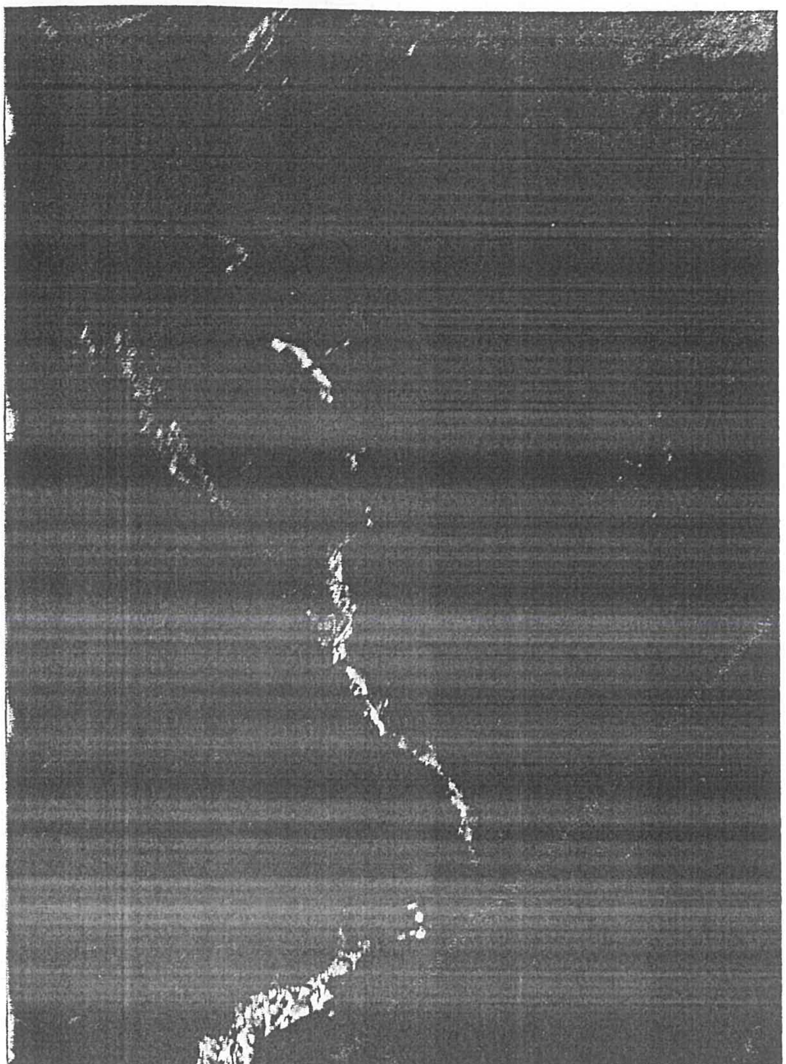
5.15.2.1 Douglas River

The Douglas River rises from the Douglas and Horace Walker glaciers and falls 340m in 1.4km immediately upstream of its confluence with the Karangarua.

An intake at the 1700ft contour (S78/552380) with a 1.20km tunnel leading to a penstock and powerhouse



Douglas River immediately upstream of the Karangorua confluence.



Karangarua River Gorge.

downstream of the gorge would provide 330m head. With an installed flow of 12.5m³/sec the installed capacity would be 34MW. The penstock and turbines would need to be designed to pass the very fine glacial silt as it is unlikely all the silt could be removed in a settling basin.

The scheme is within the Westland National Park. Access to the powerhouse site would be reasonable but access to the intake would be extremely difficult and would have to be by aerial ropeway or tunnel.

5.15.2.2 Karangarua River

The Karangarua falls 300m in 1.3km just upstream of the Douglas River confluence.

The scheme would comprise of an intake at the head of the gorge (S78/532359) with a 1.2 km tunnel leading to a penstock and powerhouse at map reference (S78/525375). With 275m head and an installed flow of 8m³/sec the installed capacity would be 18MW. Access to the intake site would be difficult and would probably have to be by aerial ropeway or tunnel.

The scheme would be within the Westland National Park. Joint development with the scheme on the Douglas River would minimise access and transmission costs.

5.16 MANAKAIAUA CATCHMENT

5.16.1 Catchment Description

This is a small (19km²) catchment to the south of the Karangarua River. Approximately 70% is bush clad with 1600 m peaks surrounding the head of the catchment.

The river falls 200m in 2km just upstream of the state highway bridge.

5.16.2 Possible Small Hydro Scheme

The scheme would consists of an intake at the 500ft contour (S78/458499) with a 700m tunnel leading to a penstock and powerhouse beside the state highway (S78/460513). Water would be discharged from the powerhouse into a swamp at the head of Hunt Creek.

An alternative would be a tunnel to a powerhouse further down the gorge at map reference (S78/440499).

There would be 115m of head which with an installed flow of 3.1m³/sec would provide an installed capacity of 2.9MW.

5.17 MAKAWHIO (JACOBS) CATCHMENT

5.17.1 Catchment Description

The Makawhio River lies to the south and west of the Karangarua river. It drains the Bare Rocky and Bannock Brae Ranges but does not extend inland to the alpine divide. The total catchment area is 153 km² with approximately 50% bush clad. The catchment includes some spectacular scenery with very steep cliffs rising dramatically from the valley floor. The catchment consists of various schists of the Haast Schist Group.

The river appears to carry a moderate bed load in relation to other larger rivers in the area.

5.17.2 Possible Small Hydro Schemes

5.17.2.1 Jumbo Creek and Lake Rototekoiti

Lake Rototekoiti is a small alpine lake approximately 4150ft above sea level.

The scheme would consist of an intake on the creek draining Lake Rototekoiti at about the 2000ft contour. (S78/450395). A 700m tunnel and 1200m penstock (partially in the tunnel) would carry water to a powerhouse at map reference S78/436391) beside the Jacob river.

With an installed flow of 2m³/sec and head of 440m the installed capacity would be 7.2MW.

Access to the powerhouse site up the Makawhio River would be reasonable. Access to the intake would have to be via the tunnel or an aerial cableway.

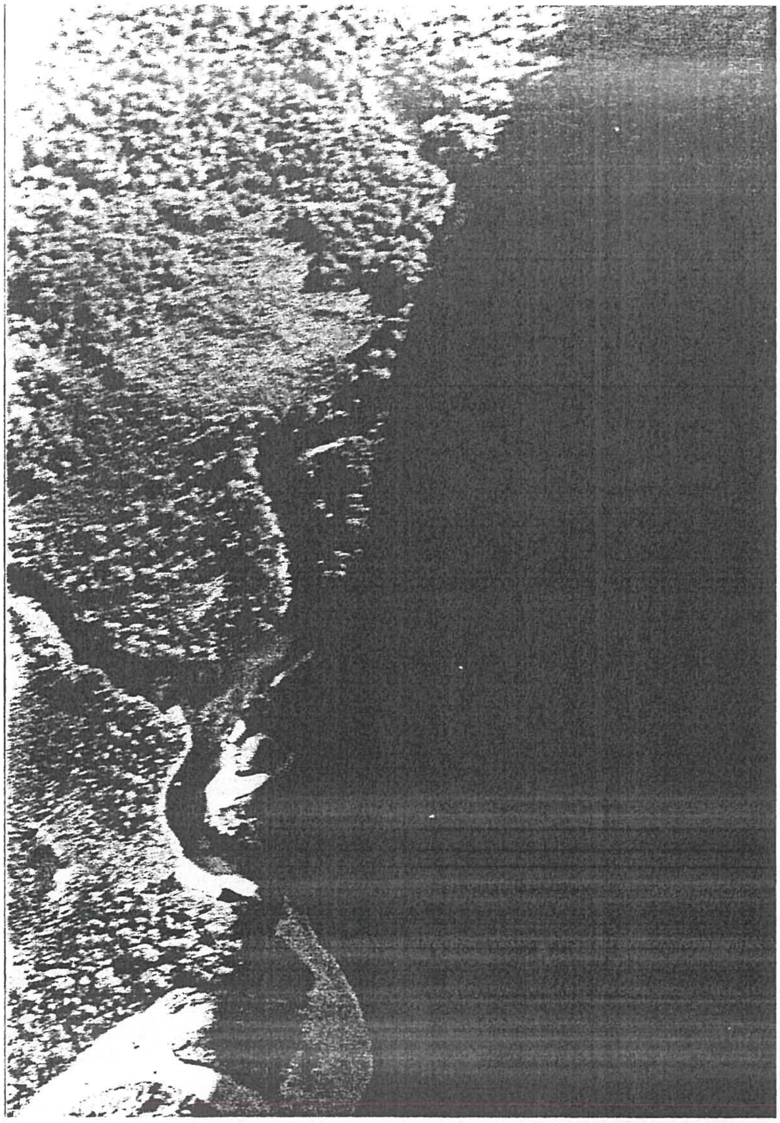
Additional water could be provided with an intake on Jumbo Creek. An 1150m tunnel would carry the water to the intake on the Lake Rototekoiti Creek. This would allow an increase in the installed flow to 3.8m³/sec and increase the installed capacity to 12.6MW.

Some control on the outlet of Lake Rototekoiti would be advantageous and improve the scheme plant factor.

5.17.2.2 Makawhio River

The Makawhio River falls 180m in 2km just upstream of the Jumbo Creek confluence.

A scheme could comprise of an intake at the 1000ft contour, map reference (S78/448372) with a 13km tunnel and 600m of penstock leading to a powerhouse below the Jumbo Creek confluence at map reference (S78/439389).



Moeraki River meanders across the valley floor to the start of the gorge (top of photograph)

Mahitahi River Scheme would use the 90 m fall in the river bend in the middle to lower part of the photograph.

the valley floor for 4km. Some 8km downstream of the gorge the river enters Lake Moeraki which has a surface area of 2.3km² and is approximately 5m above mean sea level.

5.19.2 Possible Small Hydro Schemes

A possible scheme to utilize the head through the gorge would consist of an intake at about the 600ft contour at the change in river gradient. (map reference S87/109218) with a race following the contour on the right hand side of the river to a penstock intake at map reference (S87/115238) and powerhouse at map reference (S87/110240). Much of the race would be on a terrace but there is likely to be a steep crossfall in some sections and this may lead to construction difficulties and higher costs.

With a head of 90m and an installed flow of 12m³/sec the installed capacity would be 8.8MW.

Access to intakes and the powerhouse would be reasonably straightforward as the scheme is within 3km of the state highway and cuts across the old Haast Paringa track.

5.20 HAAST CATCHMENT

5.20.1 Catchment Description

The Haast is one of the larger catchments in the study area. It is 70 km from the Tasman Sea to the headwaters in the Wills River and the total catchment area is 1500km².

The major tributary of the Haast is the Landsborough River which runs adjacent and parallel to the main divide for 45km.

A large proportion of the Haast catchment is behind the coastal ranges and in a rain shadow area in comparison to other catchments in the study area.

The alpine fault crosses the river 8km from the coast and most of the catchment is in various schists of the Haast Schist group with greywacke along the alpine divide.

5.20.2 Possible Small Hydro Schemes

5.20.2.1 Clarke River

A scheme on the Clarke River was proposed in the Stage I report. The scheme comprises of an intake at the head of the lower gorge (map reference S88/313112) feeding a tunnel and penstock to a powerhouse at the lower end of the gorge.

The output available from a 12m³/sec installed flow and 150m head would be 15MW.

Access, to the site would be from State Highway 6 at Pleasant Flat on the right hand side of the Haast with a bridge across the Landsborough near Strutt Bluff. Access bridging and transmission difficulties are typical of all the high country schemes and represent a considerable proportion of the total cost.

5.20.2.2 Zeilian Creek

Zeilian Creek is a small tributary of the Clark River. It has a 24km² catchment with a catchment mean altitude of 4000ft.

A possible scheme could consist of an intake at the 1400ft contour (map reference S88/259113) with a 700m tunnel and 600m penstock leading to a powerhouse beside the Clarke River.

With a nett head of 270m and installed flow of 4m³/sec the output would be 8.8MW.

Access to the intake site would be either via a tunnel or aerial ropeway.

This scheme would only be viable if combined with the scheme on the Clarke River described in 5.20.2.1.

5.20.2.3 McFarlane River

The McFarlane is a minor tributary on the northern side of the Haast River and joins the Haast just downstream of the Haast/Landsborough confluence. About 50% of the catchment is bush clad and the sediment load is probably fairly high. The McFarlane falls some 200m in the 3km upstream of its confluence with the Haast.

It would be possible to utilize this head with an intake at the 950ft contour (map reference S87/183041). A 1400m long tunnel and 500m long penstock would carry water to a powerhouse on the northern bank of the Haast River at map reference S87/180017.

An installed flow of 13.8m³/sec with 195m head would provide an output of 22MW.

Access to the site would require a bridge across the Haast, probably just upstream of the MWD guaging site at map reference S87/066043 and a road up the northern side of the Haast River. Access to the intake would either be by tunnel or aerial ropeway.

Transmission would either be to Luggate or Hari Hari but for the scheme to be economical transmission costs would have to be shared with other schemes in the Haast area.

5.20.2.4 Roaring Billy

The Roaring Billy is a minor river on the northern side of the Haast River. It is immediately to the west of the McFarlane River. The catchment is a hanging valley with a very steep fall of 180m in the 0.4km before it joins the Haast.

At times of high flow the river forms a spectacular waterfall which is visible from the end of a short nature walk beside State Highway 6.

A scheme could comprise of an intake at the 900ft contour (map reference S87/067058) feeding into a 900m long tunnel and 400m penstock leading to a powerhouse at map reference S87/065048.

With an installed flow of 6.2m³/sec and nett head of 205m the output would be 10.4MW.

Access would be across the Haast River as for the McFarlane River scheme, with a short extension of the road to the powerhouse. Access to the intake site would either be by tunnel or aerial ropeway.

This scheme would only be economic if it was combined with the scheme on the McFarlane river.

5.20.2.5 Haast River

The Haast River falls 300m through the ``Gates of Haast'' gorge in 4km. The Wills river joins the Haast midway through this gorge and has a similar gradient.

A possible scheme to utilize the fall through the gorge would consist of an intake on the Haast river at about the 1400ft contour at map reference S98/145901 at the head of the gorge. A 3.3km tunnel would lead to a further intake on the Wills river at map reference S98/168928. A 2.8km tunnel would then take water from both intakes under the Bealy Range to a penstock and powerhouse on the Haast river flats at map reference S98/159962. With an installed flow of 13.5m³/sec and 290m nett head the installed capacity would be 32.5MW.

An alternative smaller scheme would consist of an intake on the Haast river at the 1400ft contour with a 2.1km tunnel leading to a penstock and powerhouse upstream of Thunder Creek falls on the left hand side of the Haast River at map reference S98/132928. With an installed flow of 5.0m³/sec and a nett head of 260m the installed capacity would be 10.7MW.

5.20.2.6 Burke River

The Burke River falls approximately 90 m through 'Churn Rapids' some 2 km upstream of its confluence with the Haast River.

A scheme to utilize this fall could consist of an intake at Map reference S98/096939 diverting water via a stilling basin, 1700 m tunnel and penstock to a powerhouse at map reference S98/115941 downstream of Bonney Stream. Access to the powerhouse and intake sites would be difficult.

The installed capacity would be 10.5 MW from 85 m nett head and an installed flow of 15m³/sec.

5.20.2.7 MacPherson Creek

MacPherson Creek lies near the northern extremity of Aspiring National Park and falls steeply from a 75ha tarn at its source to the Haast River 1200m below. A low concrete dam could impound water at the end of a river flat at 700m and supply a powerhouse on the Haast river floor with a 650m head. An installed flow of 2.25m³/s would yield a 12MW output.

Power generated would have to be transmitted to either Hari Hari or Luggate. Access to the intake and along the penstock would have to be by aerial ropeway or cableway.

5.21 OKURU CATCHMENT

5.21.1 General

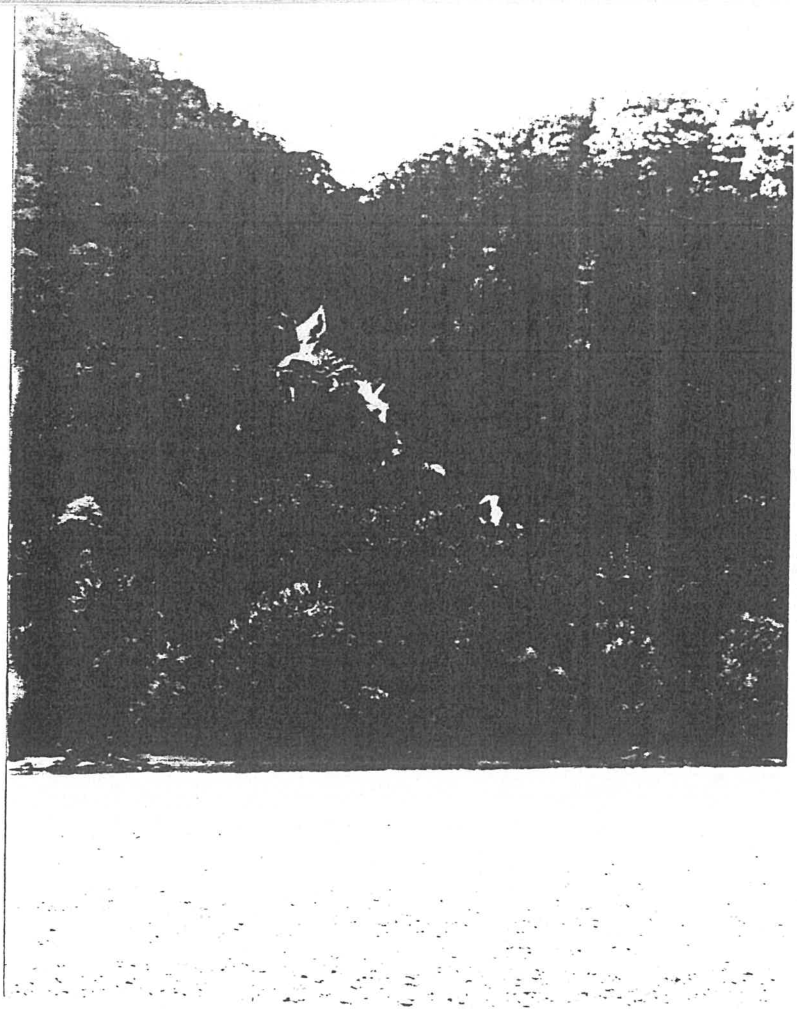
The Okuru River is south of the Haast River and drains a 255 km² catchment including the Mark and Browning Ranges and an 18km length of the main divide. The catchment includes two small alpine lakes, Lake Douglas and Lake Eggling. The main river channel is relatively flat with the 200ft contour some 25km from the sea and only 3.5km from the main divide.

Approximately 50% of the catchment is bush clad and there are small areas of permanent ice and snow. The catchment generally consists of quatzo feldspathic schist.

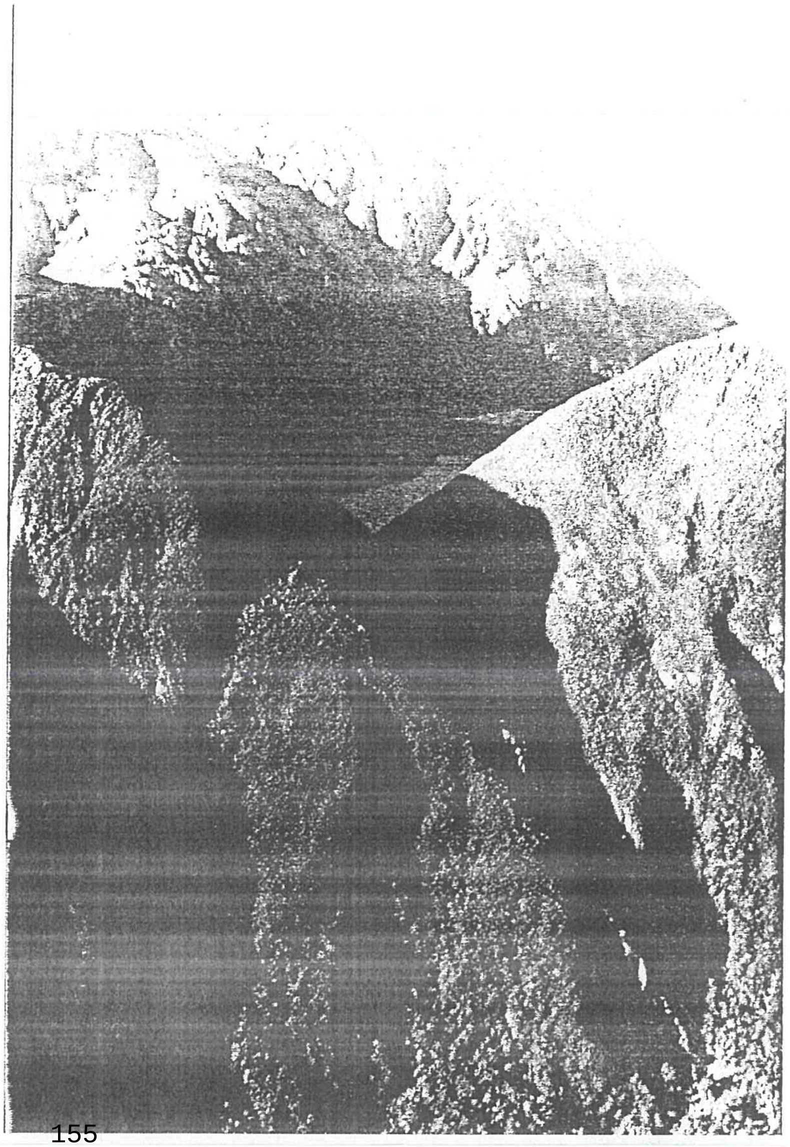
5.21.2 Possible Small Hydro Electric Schemes

5.21.2.1 Okuru

There are no economic hydro-electric schemes on the main channel of the Okuru River.



Roaring Billy River with
Haast River in foreground.



Lake Douglas with
outlet to the Okuru River
in centre right of photograph.

5.21.2.2 Lake Douglas

Lake Douglas lies near the northern boundary of Aspiring National Park in the Mark Range at an altitude of approximately 2050ft. This makes available a head of almost 600m to the Okuru valley floor. A control weir could be constructed at the Lake outlet (map reference S88/875007) to control the lake water level and to divert flow into a tunnel leading to the head of the penstock slope, or alternatively a pressure tunnel feeding the powerhouse directly.

An installed flow of 9.5m^3/s and head of 570m could produce 44MW.

Access to the powerhouse site would require 14km of easy roading but access to the intake site would probably require an aerial ropeway.

5.22 TURNBULL CATCHMENT

5.22.1 General

The Turnbull River drains a 187 km^2 catchment including the Browning and Selbourne Ranges. The Mueller River is the only major tributory.

The catchment is 50% bush clad with small areas of permanent ice and snow in the upper catchment. The sediment load in the river is high and similar to other West Coast rivers.

5.22.2 Possible Small Hydro Schemes

The Turnbull falls 150m through the Venture Gorge in 3.5km.

Water could be drawn from the river at the head of Venture Gorge (map reference S98/773970) to be fed through a tunnel and penstock to a powerhouse on the lower flats. Part of the outflow from this station could be fed into the headworks of the existing 1.0MW station downstream.

An installed capacity of 15.2 MW would be possible from an installed flow of 31 m^3/s and 60m head.

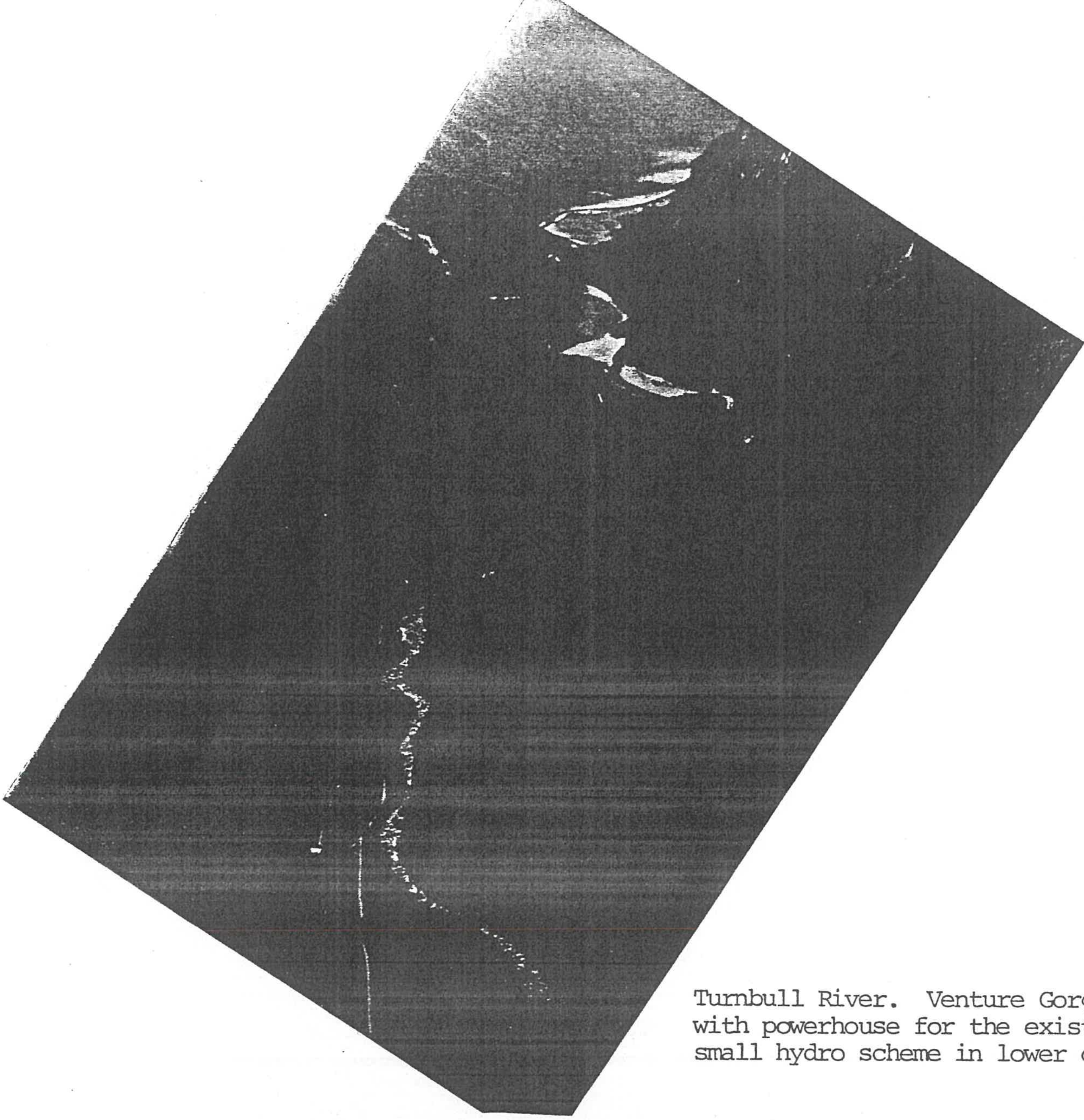
Access to the site would be by an extension of the existing road to the gorge. This should not present any difficulty.

Power transmission would be to Haast and then to either Hari Hari or Luggate.

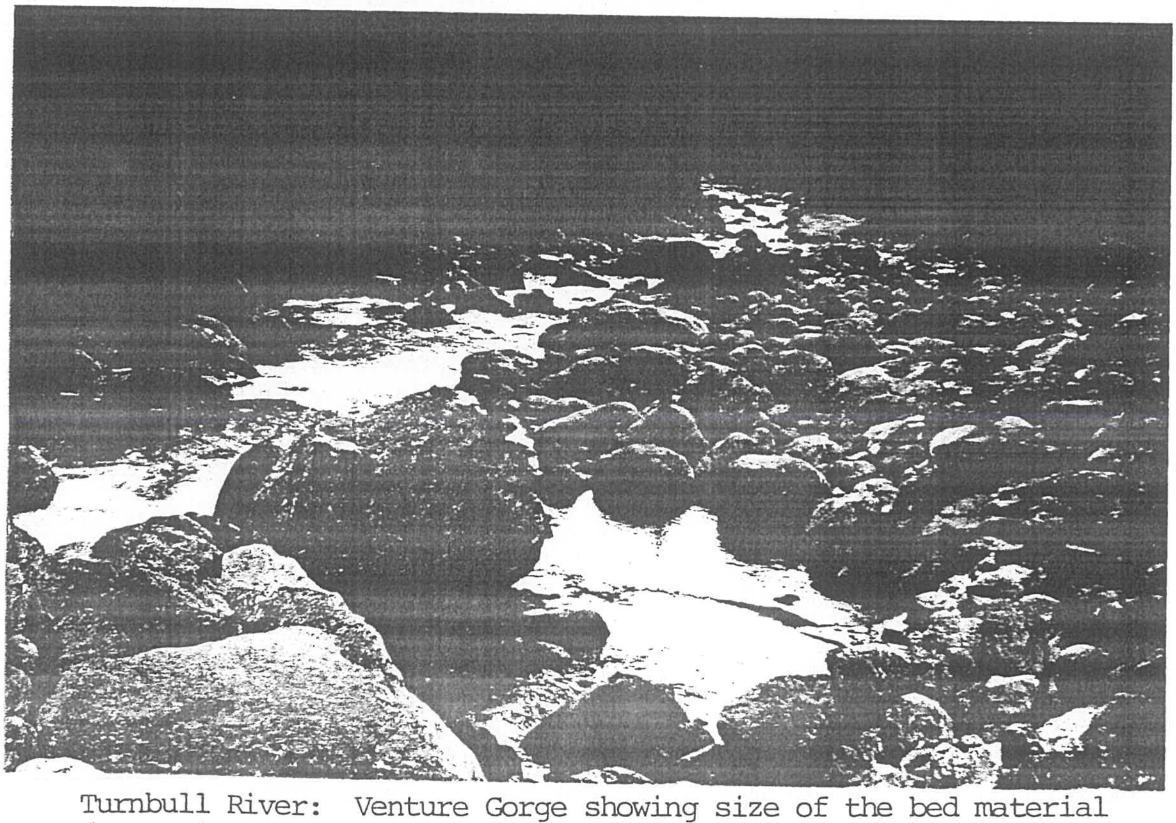
5.23 WAIATOTO CATCHMENT

5.23.1 General

The Waiatoto River has its source in the Volta Glacier at the base



Turnbull River. Venture Gorge with powerhouse for the existing small hydro scheme in lower centre.



Turnbull River: Venture Gorge showing size of the bed material (Note figure in centre of picture).

of Mount Aspiring and flows due north for 45km to the Tasman Sea at Jacksons Bay.

The total catchment area is 460 km^2 and includes a 35km length of the main divide to the east and the Haast Range to the west.

The lower slopes of the catchment are heavily bush clad and there are large areas of permanent ice and snow in the upper catchment. There is no roading in the catchment except for the Haast Jacksons Bay road which crosses the Waiatoto 1km from the sea. The Waiatoto river is described by Eggar[5] as being one of the most beautiful rivers in South Westland with very high scenic and recreational values.

Major tributories are the Te Naihi and Drake Rivers.

The catchment generally consists of schist of the Garnet and Oligoclase Zones of the Haast Schist Group.

5.23.2 Possible Small Hydro Electric Schemes

5.23.2.1 Casey Creek

This is a small catchment fed from a high altitude lake. The creek drops 180m at the Hindley Falls. A possible scheme would consist of an intake at the head of the falls diverting water into a 170m long tunnel and penstock with a powerhouse near the base of the falls at map reference S97/692863. With an installed flow of 2.1m^3/sec and a nett head of 175m the installed capacity would be 3.0MW.

Access to the powerhouse site would be up the Waiatoto River Valley and would be reasonable. Access to the intake site would be by aerial cableway. The site is just outside the Mount Aspiring National Park. It is unlikely that such a small scheme could be justified in such a remote area.

5.23.2.2 Te Naihi River

The Te Naihi joins the Waiatoto some 25km from the sea. Its source is a small lake at the foot of the Axius Glacier on the main divide.

The river falls 105 m in 2.5km just upstream of its confluence with the Waiatoto. A scheme to utilize this fall would consist of an intake at map reference S97/682819 with a 1.2km tunnel leading to a penstock and powerhouse at map reference S97/668819.

With an installed flow of 12.3m^3/sec and the nett head of 95m the installed capacity would be 9.5MW.

Access to the intake site would be difficult and the site is remote from any load centre.

5.23.2.3 Drake River

The Drake River falls 250m in 3km through the Guardian Gorge just upstream of the confluence with the Waiatoto River.

A possible scheme to utilize the fall would consist of an intake at the 1000ft contour supplying water via a 2.4km tunnel and penstock to a powerhouse in the Waiatoto River Valley at map reference S97/623729.

With an installed flow of 9.8m^3/sec and a nett head of 230m the installed capacity would be 18.4MW.

The site is very remote and access and transmission costs are a large proportion of the total cost. The site is in the Mount Aspiring National Park.

Another possible scheme, some 4km upstream of the one described above was investigated but found to be uneconomic.

5.23.2.4 Upper Waiatoto River

There is a moderately steep fall in the river from 2000ft to 1500ft in approximately 1km and a further fall to the 900ft contour in another 1km.

A possible scheme to utilize this head would consist of an intake at map reference S106/611569 with a 2.4km long tunnel and a penstock leading to a powerhouse at map reference S106/630591.

With an installed flow of 9m^3/sec and 325m nett head the installed capacity would be 24MW.

Access to both the powerhouse and intake sites would be very difficult and the site is in the Mount Aspiring National Park. The sediment load is also expected to be high.

While apparently economic this scheme cannot be considered as realistic given the access problems, its location relative to the load centres and the fact that it is at the heart of the Mount Aspiring National Park.

There would be significant cost savings if all the schemes on the Waiatoto shared access roading and transmission facilities.

5.24 ARAWATA CATCHMENT

5.24.1 General

The Arawata is south west of the Waiatoto and runs parallel to it. It has a 910 km² catchment and drains the main divide to the south, the Haast Range to the east and the Olivine Range to the west. The river is wide and braided and has a relatively gentle grade until well into the headwaters.

The catchment topography and ground cover is similar to the Waitoto. The upper catchment is in the Mount Aspiring National Park, and the river is considered by Egar[5] to have high scenic and recreational values.

5.24.2 Possible small hydro-electric schemes

The Arawata River falls 150m in 3km through "Ten Hour Gorge". A possible scheme to develop this head would consist of an intake and stilling basin at map reference S106/370500 with a 2.7km tunnel leading to a powerhouse at map reference S106/398518.

With an installed flow of 52m³/sec and nett head of 145mm the installed capacity would be 62MW.

The problems of access, the isolation, and the river sediment load are all considerable at this site. The scheme would also be within the Mount Aspiring National Park.

5.25 CASCADE CATCHMENT

5.25.1 General

The Cascade is the southernmost river in the study area. It has a catchment of 415 km² including the Red Hills and Olivine Ranges.

It is extremely isolated and there are no formed roads within the catchment.

5.25.2 Possible Hydro Electric Schemes

The Cascade River falls 130m through the Cascade Gorge.

A possible scheme would consist of an intake at map reference S105/280620 with a 2.8km tunnel loading to a powerhouse at map reference S105/300645. With an installed flow of 18.8m³/sec and a nett head of 115m the installed capacity would be 17.7MW.

While the scheme appears marginally economic the extreme isolation of the site would mean that in practical terms it would not be likely to be developed.

Two small schemes were also identified on the Cascade River but both were found to be uneconomic. One was 4km upstream of the scheme identified above. The other involved the diversion of the Martyr River into the Cascade River.

SECTION SIX

DETAILS OF SPECIFIC SCHEMES

SECTION SIX : DETAILS OF SPECIFIC SCHEMES

6.1 INTRODUCTION

Following desk studies and some field inspections fifty six of the identified schemes in the area were considered in greater detail. Twenty eight of these schemes are in the northern region and twenty eight in the southern region. The twenty-eight schemes in the northern region do not inlcude Kaniere and Duffers II which were reported on in earlier studies (Ref. 12, 13). Many schemes that were initially identified were deleted as uneconomic primarily because of the access difficulties and the transmission distances.

On Table 6.1. details of river parameters and scheme capacities for the intake sites considered are given. From these capacities and the topographical features of the sites the required components for each scheme were derived and details of these are shown on Table 6.2. Calculated costs for the components of all schemes are shown on Tables 6.3.(a) and 6.3.(b) with total costs, costs/kW, costs/kWh and scheme rankings given on Table 6.3.(b).

The basis for estimating installed capacities and costs and the significance of the ranking is discussed below.

6.2 ESTIMATING SCHEME COSTS

The costs of the schemes in this report have been based on the costing information provided in Appendix D. These costs are September 1984 costs equivalent to M.W.D. Construction Cost Index of 2180.

The costing information in Appendix D was based on actual costs and estimated costs of small hydro schemes constructed or about to be constructed in New Zealand.

6.3 ESTIMATING SCHEME OUTPUT

The installed capacities of all schemes in the northern area have been based on a plant factor of about 50%. This plant factor was given as a requirement by M.W.D. in the brief for regional assessments of hydro potential. Use of substantially the same plant factor for all schemes allows economic comparison of the schemes on a cost/kW basis.

The installed capacities of the schemes in the southern area have been based on a plant factor of about 60% as this was considered more appropriate for run-of-river schemes with no storage when the schemes are isolated from the mainload centres.

The head given in Table 6.1 is an estimate of the nett head available for power generation. The installed capacity has been calculated using the formula:

Installed Capacity = K x nett head x installed flow

where K varies from 8.2 to 8.5

The annual output has been calculated as:

$$\text{Annual Output} = \left(\frac{\text{Plant factor}}{100}\right) \times \text{installed capacity} \times 8760$$

Losses in transmission have not been considered as these are considered minor in relation to the asumptions made to determine scheme outputs.

6.4 RANKING OF SCHEMES

All the schemes have been ranked according to two criteria. The first is a comparison of the cost per kilowatt ($/kW) for each scheme. This provides a first order method of ranking schemes with a similar plant factor.

The second ranking is by comparison of the unit cost of the power produced (cents/kWh) for each scheme. The unit cost is determined using the standard discounting procedures used by N.Z.E. for comparing various types of generating systems. The method requires assumptions of the period of construction, cash flow during construction and likely maintenance costs.

Comments on the validity of these methods of ranking schemes are included in Appendix E, "Discussion on Ranking Criteria".

The brief required that schemes costing more that $4000/kW (September 1984) should be regarded as uneconomic and that the study should concentrate on schemes costing less that $3000/kW. Table 6.3.(b) shows that 37 of the schemes identified have a cost less than $3000/kW. Sixteen have estimated costs less than $2000/kW which is remarkably low. The estimated costs for Giles (a) show it to be uneconomic but it has been included in the table for comparison with Giles (b) to indicate the effect of adding Stony water to the scheme. The Kaniere and Duffers II schemes have also been included in the Tables so that the Tables form a complete record of the identified schemes on the West Coast.

Excluding Giles (a), the average estimated cost of the schemes identified and listed in Table 6.3.(b) excluding Kaniere and Duffers II is $24 75/kW.

It is possible that in the northern area some higher cost schemes above say 2MW in capacity which would still have a cost of less than $4000/kW have not been identified. It is certain that a number of smaller schemes between 0.5MW and 2MW have been overlooked because of the difficulties of access and the thick vegetation cover.

In the southern area twenty eight schemes have been identified but it is probable that there are a number of smaller potential schemes which have not been identified due to access difficulties and vegetation cover.

In considering the costs presented in the tables below, four points should be remembered:

(a) Not all the sites were inspected either on the ground or from the air.

(b) Land purchase costs have not been included. Very little of the land required to construct the schemes discussed in this report would be privately owned.

(c) In the northern area transmission line costs have been based on a transmission line to the nearest existing transmission line. Generally in the southern area the nearest transmission line is of inadequate capacity and transmission over a longer distance, northwards to the West Coast Electric Power Board system or eastwards to Luggate in Otago has been assumed and allowed for in the estimated costs. Combining a number of schemes in the southern area would substantially reduce these transmission costs.

(d) The majority of the schemes are run-of-river schemes and if a number were constructed they would significantly affect the West Coast Electric Power Board's generation pattern and demand from New Zealand Electricity. As required by the brief a plant factor of 50% has generally been assumed but, to improve availability of full output, it would be necessary to increase the plant factor of some run-of-river schemes by reducing installed capacities and this would increase the costs/kW.

The large number of potential small hydro schemes on the West Coast is apparent in the tables below. The constraint on development is not the availability of suitable sites but the lack of demand. Development is therefore dependent on either an increased demand for power by the establishing of new industries on the West Coast or by developing sufficient capacity to make transmission the power out of the region economic.

TABLE 6.1.

RIVER PARAMETERS AND SCHEME CAPACITIES

SITE NAME		CATCHMENT AREA (Km^2)	DIVERSION FLOW Q_{10} (cumecs)	SPILLWAY FLOW Q_{500} (cumecs)	MEAN FLOW ($\bar{Q}$) (cumecs)	$QI/\bar{Q}$	Installed Flow (QI) (cumecs)	Head (m)	Installed Capacity (MW)	Annual Output (GWh/a)
Stony River	(a)	61			6.8	1.2	8.2	80	5.5	24.1
	(b)	55			6.6	1.1	7.3	110	6.7	29.3
	(c)	33			5.3	1.0	5.3	200	8.8	39
Larry (Awarau)		137			9.6	1.2	11.5	42	4.0	17.5
Giles	(a)	27			2.7	1.0	2.7	45	1.0	4.4
Giles	(b)	60			8.0	1.0	8.0	45	3.0	13.1
Rough River		124			15.8	1.3	20.5	65	11.1	49
Big River		67			5.9	1.2	7.1	60	3.5	15.3
Roaring Meg		11.3			1.3	0.7	0.9	150	1.1	4.8
Lake Christobel		47.5			3.6	1.7	6.1	125	6.4	28
Upper Grey	(a)	192			12.9	1.3	17	50	7.1	31
	(b)	402			28.9	1.4	40	30	10.0	44
	(c)	540	950	1600	38.3	1.7	65	65	35	153
	(d)	642			48.6	1.5	73	30	18	79
Alexander		38.7			3.7	1.1	4.1	100	3.4	15
Ahaura	(a)	286			34.3	1.5	52	30	13	57
	(b)	845	1600	2600	85.6	1.7	145	35	42	182
Taipo	(a)	147			32	1.7	54	75	33	180
	(b)	178			38	1.8	68	40	23	101
Arahura	(a)	113			26	1.4	36	60	18	79
	(b)	194			38	1.4	53	30	13	57
Toaroha		46.4			12.1	1.2	14.5	210	25	110
Mikonui		118	1200	2000	25	1.7	42	70	24	105
Kakapotahi	(i)	65			14.5	1.2	17.4	115	17	75
	(ii)	65	600	1000	14.5	1.7	25	140	29	127
Waitaha	(i)	131			37	1.3	48	100	40	175
	(ii)	131	1800	3000	37	1.6	60	120	60	263
Amethyst		14.9			3.6	0.7	2.5	400	8	35
Poerua		60			16	1.4	22.4	50	9.4	41

Continued over/..

TABLE 6.1

RIVER PARAMETERS AND SCHEME CAPACITIES

SITE NAME	CATCHMENT AREA (km)	DIVERSION FLOW Q10 (cumecs)	SPILLWAY FLOW Q500 (cumecs)	MEAN FLOW (Q) (cumecs)	QI/Q	INSTALLED FLOW (QI) (cumecs)	HEAD (m)	INSTALLED CAPACITY (MW)	ANNUAL OUTPUT (GWh/a)
Butler	43			12.0	0.8	9.6	275	22.5	118
Wahapo				11.3		8.0	30	2.0	12
Tartare	22			5.9	0.7	4.0	180	5.9	31
Waikukupa	24			6.3	0.8	5.0	130	5.5	29
Manakaiau	19			3.9	0.8	3.1	115	2.9	15
Douglas	68			20.5	0.6	12.5	330	34.0	223
Karangarua	45			13.2	0.6	8.0	275	18.0	103
Rototekoiti (a)	8			2.0	1.0	2.0	440	7.2	35
(b)	16			4.0	0.95	3.8	440	12.6	60
Jacob	51			13.6	0.8	11.0	145	13.1	69
Mahitahi	79			19.8	0.8	15.8	70	9.0	47
Moeraki	56			15.0	0.8	12.0	90	8.8	46
Clarke	69			15.0	0.8	12.0	150	15.0	79
Zeilian Creek	25			7.0	0.6	4.0	270	8.8	50
McFarlane	72			17.3	0.8	13.8	195	22.0	116
Roaring Billy	32			7.8	0.8	6.2	205	10.4	55
Gates Haast	108			19.3	0.7	13.5	290	32.5	171
Burke	108			22.1	0.7	15.0	85	10.5	60
Lake Douglas	22			6.2	1.5	9.5	570	44.0	193
McPherson Creek	8			1.8	1.2	2.2	650	12.0	52
Turnbull	138			39.0	0.8	31.0	60	15.2	80
Casey Creek	9			2.4	0.9	2.1	175	3.0	15
Te Naihi	70			15.4	0.8	12.3	95	9.5	50
Drake	51			12.2	0.8	9.8	230	18.4	97
Waiatoto	48			11.3	0.8	9.0	325	24.2	127
Arawata	260			65.0	0.8	52.0	145	62.0	326
Cascade	81			23.5	0.8	18.8	115	17.7	93

WCTAB6.1

TABLE 6.2.

DETAILS OF SCHEME COMPONENTS

ITE AME		TYPE	TUNNEL LENGTH (m)	DIA. (m)	HEAD RACE LENGTH	PEN STOCK LENGTH (m)	TAILRACE LENGTH (m)	DAM HEIGHT (m)	VOL. m^3 $x10^3$	LENGTH ROADING (Km)	LENGTH BRIDGES (m)	TRANSMISSION Km/Kv All 66kV
tony River	(a)	A	-	-	1700	1500	350	-	-	3.2	-	1.3
	(b)	A	-	-	3800	1000	60	HP	60	4.8	-	3.8
	(c)	A	1775	2.1	-	975	-	-	-	6.0	10	6.0
arry		A	-	-	4000	575	300	HP	70	4.8	-	1.1
iles	(a)	A	-	-	1600	1350	250	HP	30	2.4	-	4.8
iles	(b)	A	-	-	1600	1350	250	HP	50	8.4	-	4.8
ough River		A	-	-	8400	700	400	HP	90	2.5	-	0.8
g River		A	-	-	6200	860	250	-	-	6.0	-	0.5
aring Meg		A	-	-	1600*	300	-	-	-	1.6	-	1.6
ke Christobel		D	700	2.3	-	1650	-	-	-	8.2	20	50 To Reefton
per Grey	(a)	A	-	-	6300	640	225	-	-	0.6	-	40)
	(b)	A	-	-	5700	250	-	-	-	5.4	20	24)
	(c)	B	Dam	-	-	180	-	75	2100	1.9	-	20) To
	(d)	A	-	-	9000	250	300	-	-	3.2	-	14) Blackwater
exander		A	-	-	3300	390	60	-	-	3.5	-	21)
aura	(a)	A	-	-	4100	380	950	-	-	5.1	10	45
	(b)	B	Dam	-	-	95	-	35	280	-	-	23
ipo	(a)	A	2300	5.4	2100	400	575	-	-	7.0	10	0.2
	(b)	A	900	6.0	250	475	800	-	-	2.5	-	0.2
ahura	(a)	A	825	4.6	250	350	-	-	-	6.0	40	13.3
	(b)	A	-	-	7600	380	380	-	-	1.6	20	0.5
aroha		A	1000	3.2	-	675	-	-	-	7.0	30	27) To) Kaniere
konui		B	Dam	-	-	160	-	75	1600	6.0	50	8.0
kapotahi	(i)	A	300	3.5	4100	700	1400	HP	80	0	20	4.8)
	(ii)	B	Dam	-	4100	750	1400	35	500	0.6	20	4.8)
itaha	(i)	A	1400	5.2	-	350	-	-	-	4.5	100	13.5) To
	(ii)	C	1250	5.7	-	440	-	30	210	4.5	100	13.5) S.H.6
ethyst		A	730	2.0	-	950	200	-	-	3.2	-	3.5)
erua		A	1000	3.8	-	675	700	-	-	3.8	20	6.0)

Continued over/..

SITE NAME	TYPE	TUNNEL LENGTH (m)	DIA. (m)	HEAD RACE LENGTH (m)	PENSTOCK LENGTH (m)	DIA. (m)	TAILRACE LENGTH (m)	LENGTH ROADING (km)	LENGTH BRIDGES (m)	TRANSMISSION km/kv	
3utler	A	2100	2.4	–	550	1.9	–	15	400	41/66	
Jahapo	D	450	2.5		500	2.0	50	–	–	2/33	
:artare	A	1350	1.8	–	1000	1.2	50	3	–	2/33	
Jaikukupa	A	2200	1.8	–	900	1.7	50	4	–	2/33	
lanakaiaua	A	700	1.8		450	1.2	2000	–	–	1/33	
ouglas	A	1200	2.5		600	2.0		18	400	118/66	
:arangarua	A	1200	2.0		600	1.7					
otetekoiti	A	700	1.8		1200	0.85		10	150	10/33	
otetekoiti plus Jumbo	A	1150	1.8		1200	1.0		10	150	10/33	
acob	A	1300	2.4		570	1.9		10	150	10/33	
lahitahi	A			1400	950	2.3		10	180	10/33	
oeraki	A			2000	550	2.1		3	30	8/33	
larke	A	1300	2.5		450	2.0		25	580	80/66	
eilan Creek	A	600	1.8		700	1.5					
cFarlane	A	1400	2.4		500	1.9		15	360	90/66	
oaring Billy	A	900	1.8		400	1.2		2	–		
ates Haast	A	3200	2.5		380	2.1				60/66	To
urke	A	2400	2.5		300	2.1	100	3		60/66	Luggate
cPherson Ck	A				2700	0.9		1		90/66	
ake Douglas	C/D	800	2.7		1000	1.8		17	60	130/110	
urnbull	A	1000	4.0	1000	450	3.2		4		130/110	
asey Creek	A	170	2.0		370	1.0		16	60	16/11	
e Naihi	A	1200	3.0		260	2.1		25	120	48/33	To Haast
rake	A	2450	2.5		730	1.9		38	280	61/66	To Haast
aitoto	A	2000	3.0		1150	1.9		50	540	72/66	To Haast
rawata	A	2700	5.5		300	2x3.0		45	540	68/110	To Haast
ascade	A	2750	3.0		220	2.3		31	300	54/66	To Haast

OTE: An additional costs of $250 per Kw is included to cover transmission beyond Haast to Luggate or Hari Hari

TABLE 6.3(A)

SCHEME COSTS $x1000

SITE NAME	ELECTRO-MECHANICAL	POWER-HOUSE	PENSTOCK INTAKE	PENSTOCK	RIVER INTAKE	RACES	DAM	SPILLWAY	DIVERSION	SUPPLY TUNNEL	BRIDGING	TRANS LINES	ROADING	TOTAL	+ 25% CONTINGENCIES & ENGINEERING	MW	GWh/a	$/kW	c/kWh	RANK
Stony River (a)	1820	950	200	3400	1740	730	–	–	–	–	–	90	550	9480	11850	5.5	24	2155	6.14	3B
(b)	1930	1000	175	2600	1620	1375	200	–	–	–	–	240	550	9690	12110	6.7	29	1810	5.24	2A
(c)	2025	1000	130	3400	1380	–	–	–	–	11990	60	360	880	21225	26530	8.8	39	3015	8.40	5C
Larry	1715	900	270	1780	2040	1155	245	–	–	–	–	75	660	8840	11050	4.0	18	2760	7.73	4B
Giles (a) with Stony (c) flow	640	290	60	1200	960	445	110	–	–	–	–	300	330	4335	5420	1.0	4	5420	13.94	5D
Giles (b)	1377	725	185	3200	1500	510	175	–	–	–	–	300	330	8300	10380	3.0	13	3460	9.08	5C
Rough River	3145	1675	325	4000	2700	2885	310	–	–	–	–	60	275	15375	19220	11.1	49	1730	5.03	2A
Big River	1430	750	165	1780	1620	2220	–	–	–	–	–	30	660	8655	10820	3.5	15	3090	8.6	5C
Roaring Meg	505	235	20	175	570	335	–	–	–	–	–	90	175	2105	2630	1.1	48	2390	6.43	3B
Lake Christobel	1820	950	140	4400	–	–	–	–	–	4660	120	3000	1100	16190	20240	6.4	28	3160	8.78	5C
Upper Grey (a)	2460	1350	280	3000	2460	2220	–	–	–	–	–	2400	110	14280	17850	7.1	31	2515	7.09	4B
(b)	3550	2150	650	2800	3780	2775	–	–	–	–	120	1500	660	17985	22480	10	44	2250	6.4	3B
(c)	7035	4000	2285	3000	–	–	9324	14210	15095	–	–	1200	265	56414	70518	35	153	2015	5.78	2B
(d)	5560	3500	1235	5000	5220	6215	–	–	–	–	–	900	330	27960	34950	18	79	1940	5.58	2A
Alexander	1230	600	95	560	1200	1045	–	–	–	–	–	1260	385	6375	7970	3.4	15	2345	6.32	3B
Ahaura (a)	4265	2500	840	5400	4320	3000	–	–	–	–	60	2700	440	23465	29330	13	57	2255	6.41	3B
(b)	9340	5875	5125	3800	–	–	1245	12210	13100	–	–	1380	–	52075	65095	42	182	1550	4.56	1A
Taipo (a)	7235	4000	885	6200	4380	1420	–	–	–	25500	60	30	880	50590	63240	33	145	1915	5.52	2A
(b)	5915	3750	1120	8400	4920	665	–	–	–	9990	–	30	330	35120	43900	23	101	1910	5.5	2A
Arahura (a)	4455	2475	580	3400	3600	165	–	–	–	7770	240	90	880	23655	29570	18	79	1640	4.8	1A
(b)	4265	2750	860	5400	4380	4220	–	–	–	–	120	30	175	22200	27750	13	57	2135	6.09	3B
Toaroha	4145	2000	235	6400	2280	–	–	–	–	7770	180	1650	1100	25760	32200	25	110	1288	3.87	1A
Mikonui	5305	3000	1470	1800	–	–	7100	14875	9990	–	300	480	990	45310	56640	24	105	2360	6.68	3B
Kakapotahi (i)	3630	1875	280	4600	2520	2040	265	–	–	2440	120	285	0	18055	22570	17	75	1330	3.98	1A
(ii)	5090	2500	885	8200	–	2285	2220	5330	5550	–	120	285	90	32555	40695	29	127	1403	4.18	1A
Waitaha (i)	6925	3750	790	5200	4140	–	–	–	1110	15540	600	810	1760	40625	50780	40	175	1270	3.83	1A
(ii)	8790	4750	2100	10200	–	–	1110	7770	8435	13875	600	810	1760	60200	75250	60	263	1255	3.79	1A
Amethyst	1595	950	60	3400	960	65	–	–	–	3330	–	210	2640	13210	16510	8.0	35	2065	5.91	2B
Poerua	2985	1650	370	4200	2820	290	–	–	–	8880	120	360	440	22115	27645	9.4	41	2940	8.2	5B

TABLE 6.3(A)
SCHEME COSTS

TABLE 6.3(B)

CONSTRUCTION COST ($x1000)

SITE NAME	ELECTRO-MECHANICAL	POWER-HOUSE	PENSTOCK INTAKE	PENSTOCK	RIVER INTAKE & SETTLING BASIN	RACES	DAM	SPILLWAY	DIVERSION	SUPPLY TUNNEL	BRIDGING	TRANS LINES	ROADING	TOTAL	+ 30% CONTINGENCIES & ENGINEERING	MW	GWh/a	$/kW	c/kWh	RANK
Butler	3720	1575	400	4150	1860	–	–	–	–	13650	2400	2460	3000	234115	44350	22.5	118	1971	4.8	1A
Wahapo	1170	540	250	1165	–	150	200	–	–	750	–	–	–	4225	5495	2	12	2747	5.36	2B
Tartare	1600	825	150	2500	1200	–	–	–	–	8100	–	160	250	14785	19220	5.9	31	3258	7.6	4C
Waikukupa	1625	770	250	1920	1345	–	–	–	–	14300		80	480	20770	26995	5.5	29	4907	11.29	5D
Manakaiaua	1065	545	100	560	1050	200	–	–	–	4200	–	25	–	7745	10070	2.9	15	3472	8.07	5C
Karangarua	2970	1350	350	4130	2120	–	–	–	–	7800	2400	7080	5700	57950	75335	18	326	1449	3.65	1A
Douglas	4930	2550	350	6300	2120	–	–	–	–	7800	Note 2	–	–	–	–	34	–	–	–	–
Rototekoiti (a)	1440	1080	–	3150	850	–	200	–	–	4560	900	600	1500	14280	18565	7.2	35	2580	6.12	3B
(b)	2520	1620	–	3780	1655	–	200	–	–	11460	900	600	1500	24235	31505	12.6	60	2500	5.95	2B
Jacob	2890	1510	300	2400	1990	–	–	–	–	9100	900	600	1500	21190	27550	13.1	69	2103	5.08	2B
Mahitahi	2700	1440	300	3230	2385	700	–	–	–	–	1080	400	1500	13735	17855	9	47	1984	4.83	1A
Moeraki	2605	1305	330	1650	2130	1000	–	–	–	–	300	400	420	10140	13185	8.8	46	1498	3.76	1A
Clarke	3150	1500	300	2430	2120	–	–	–	–	8060	3480	6800	3000	30840	40095	15	79	2673	6.33	3B
Zeilian Creek	1870	1100	200	1975	1500	–	–	–	–	4200	600	–	2701[1,2]	14145	18388	8.8	50	2090	508	2B
McFarlane	3960	1630	500	2750	2400	–	–	–	–	10500	2160	9900	4950	51440	66872	22	171	2063	5.01	2B
Roaring Billy	2290	1350	200	1400	1600	–	–	–	–	5850	Note 2	–	–	–	–	10.4	–	–	–	–
Gates Haast	4620	1980	500	3300	3300	–	–	–	–	42450	–	8400	900	65950	85735	32.5	171	2638	6.29	3B
Burke	2940	1315	500	900	2320	100	–	–	–	12750	–	7000	1275	29100	37830	10.5	60	3603	8.35	5D
Lake Douglas	6885	3750	875	5400	750	–	1330	150	300	6000	420	15600	5000[1]	46460	60400	44	193	1375	3.49	1A
McPherson Creek	1890	1500	125	12000	1050	–	1330	150	300	–	–	10800	2600[1]	31745	41270	12	52	3439	8.01	5C
Turnbull	4000	2220	900	3400	3800	–	–	–	–	–	–	15600	600	30520	39675	15.2	80	2610	6.19	3B
Casey Creek	975	450	75	370	870	–	–	–	–	1105	360	640	2400	7245	9420	3	15	3140	7.34	4C
Te Naihi	2660	1400	350	885	2560	–	–	–	–	7540	720	3375	3750	23240	30210	9.5	50	3180	7.43	4C
Drake	5250	1655	300	2980	1880	–	–	–	–	15925	1680	10030	5700	45400	59020	18.4	97	3208	8.15	5C
Waiatoto	3630	1950	300	6900	1800	–	–	–	–	13000	3240	10040	7500	48360	62868	18.4	97	3416	8.68	5C
Arawata	9300	4650	1500	3850	5000	–	–	–	–	32520	6000	23000	6750	92570	120340	62	326	1941	4.73	1A
Cascade	3900	2120	500	1230	2600	–	–	–	–	26050	1800	7665	4650	50515	65670	17.7	93	3710	8.59	5C

NOTE:
1. Includes $2.5m for an aerial ropeway
2. Access and Transmission costs shared with scheme above

Ranking - Unit Cost

1. <5.0c/Kwh
2. 5.0 to 6.0c/Kwh
3. 6.0 to 7.0c/Kwh
4. 7.0 to 8.0c/Kwh
5. >8.0c/Kwh

Ranking - Capital Cost Per Kw

A <$2000/Kw
B $2000 to $3000/Kw
C $3000 to $4000/Kw
D >$4000/Kw

TABLE 6.3.(b) Continued/....

The following Schemes are covered in detail by References 11, 12 or 13.

SITE NAME	BRIDGING	LAND PURCHASE	TRANSMISSION LINES	ROADING	TOTAL	+ 25% CONTINGENCIES & ENGINEERING	MW	GWh/a	$/kW	¢/kWh	RANKING
Kaniere Scheme N3											
STAGE I					8,970		8.0	36.8	1120	2.9	
I & II					20,200		15.5	70.9	1300		
I, II & III					33,700		32.1	147	1050		
IV					4,000		5.1	21.6	784		
Total					37,700		37.2	169	1013	2.89	
Duffers II					1,346		1.0	4.0	1346	2.83	

Costs as at April 1979.

For the Kaniere and Duffers II schemes where details and costs of components have not been itemised in the relevant reports they have been omitted from these tables. This omission does not imply that such components are not included in the schemes.

APPENDIX A

EXISTING SUPPLY SYSTEM AND OTHER POWER SCHEMES STUDIED.

APPENDIX A : EXISTING SUPPLY SYSTEM AND OTHER POWER SCHEMES STUDIED

1.0 INTRODUCTION

In this appendix details of the West Coast Electric Power Board's existing supply system is given. Also included are brief details of two schemes which in recent years have been investigated in some detail.

2.0 EXISTING SYSTEM

The area of the West Coast Electric Power Board's district is 18,020km². In 1984-85 the Board had a peak load of 27,312kW, occuring at 1100 hours on the 14 June 1984. The energy supplied in 1984-85 was 126GWh at a load factor of 53.0%.

On Table A1 the Board's load centres are shown with peak loads. Table A2 shows the New Zealand Electricity points of supply with transformer bank capacities and Table A3 the Board's power stations.

3.0 OTHER POWER SCHEMES STUDIED

3.1 Introduction

This section includes only power schemes studied in recent years but not constructed. Two schemes are in this category, Duffers II and Lake Kaniere.

3.2 Duffers II

Duffers II has been studied to feasibility stage and a report prepared for C.L.A.H.D.

This scheme would form part of the Dillmans scheme using head available between the existing Duffers I tailrace and the Loopline Reservoir, a storage for the main powerstations in the Dillmans scheme. Duffers II would have a head of 18.0m and with an installed flow of 6.9m³/s an installed capacity of 1.0MW.

The Feasibility Study (ref.13) prepared by Royds Sutherland McLeay Limited, in 1979 for the West Coast Electric Power Board, showed the cost/kWh to be 2.83 cents.

3.3 Lake Kaniere

A Prefeasibility Report and Environmental Study of Hydro Electric Schemes based on Lake Kaniere (ref.12) was prepared for the West Coast Electric Power Board in April 1979. The principal adviser was Royds Sutherland McLeay Limited.

The proposed scheme includes the diversion of up to 20m³/s from the Kokatahi River through a 2.5km tunnel to the Styx River.

The 30m of available head at this point would permit an installed capacity of 5.1MW. This diverted flow, together with a maximum of 12m³/s from the Styx River, would then be diverted into Lake Kaniere through the Styx Saddle.

Downstream of Lake Kaniere three options were considered. These have different race alignments and different powerhouse sites. One option has two powerhouses in series. The installed flow downstream of the Lake would be 36m³/s and with a head up to 105m would give an installed capacity of up to 32.1MW. The total installed capacity of this scheme is up to 37.2MW with an output of 168.6GWh/a.

This output is much greater than the West Coast Electric Power Board's present requirements but an advantage of the scheme is that it can be build in four stages to provide power as required.

The total cost of the scheme was estimated in 1979 to be $37,700,000. The cost/kWh for the complete development, assuming a twelve year construction period, was 2.89 cents.

TABLE A1

LOAD CENTRES

			Approx. Peak Loads (kW)	%
Reefton Area			2000	7.1
Blackwater Area			700	2.5
Strongman Mine	1700	)		
Stillwater - Arnold Valley	1300	)		
Runanga - Liverpool Mine	700	)	5000	17.8
Dobson - Grey Valley	1300	)		
Greymouth Area			10000	35.6
Gladstone Kumara Area			2000	7.1
Hokitika Area	4000	)	6000	21.3
Hokitika Valley & Ruatapu	2000	)		
Hari Hari Area			750	2.7
Whataroa Area			500	1.8
Franz Josef Area			400	1.4
Fox Area			350	1.3
Haast Area			400	1.4
				100.0

A4

TABLE A2

NEW ZEALAND ELECTRICITY POINTS OF SUPPLY

(66/11 kV Substations)

Reefton - Capacity of Transformer Banks -	5 MVA
Blackwater	750 kVA
Dobson	12 MVA
*Greymouth	2 x 10 MVA
*Kumara	10 MVA
Arahura	2 x 5 MVA
Waitaha	500 kVA
Hari Hari	2.25 MVA + 1.0 MVA

* Transformers owned and operated by the West Coast Electric Power Board.

TABLE A3

WEST COAST ELECTRIC POWER BOARD POWER STATIONS

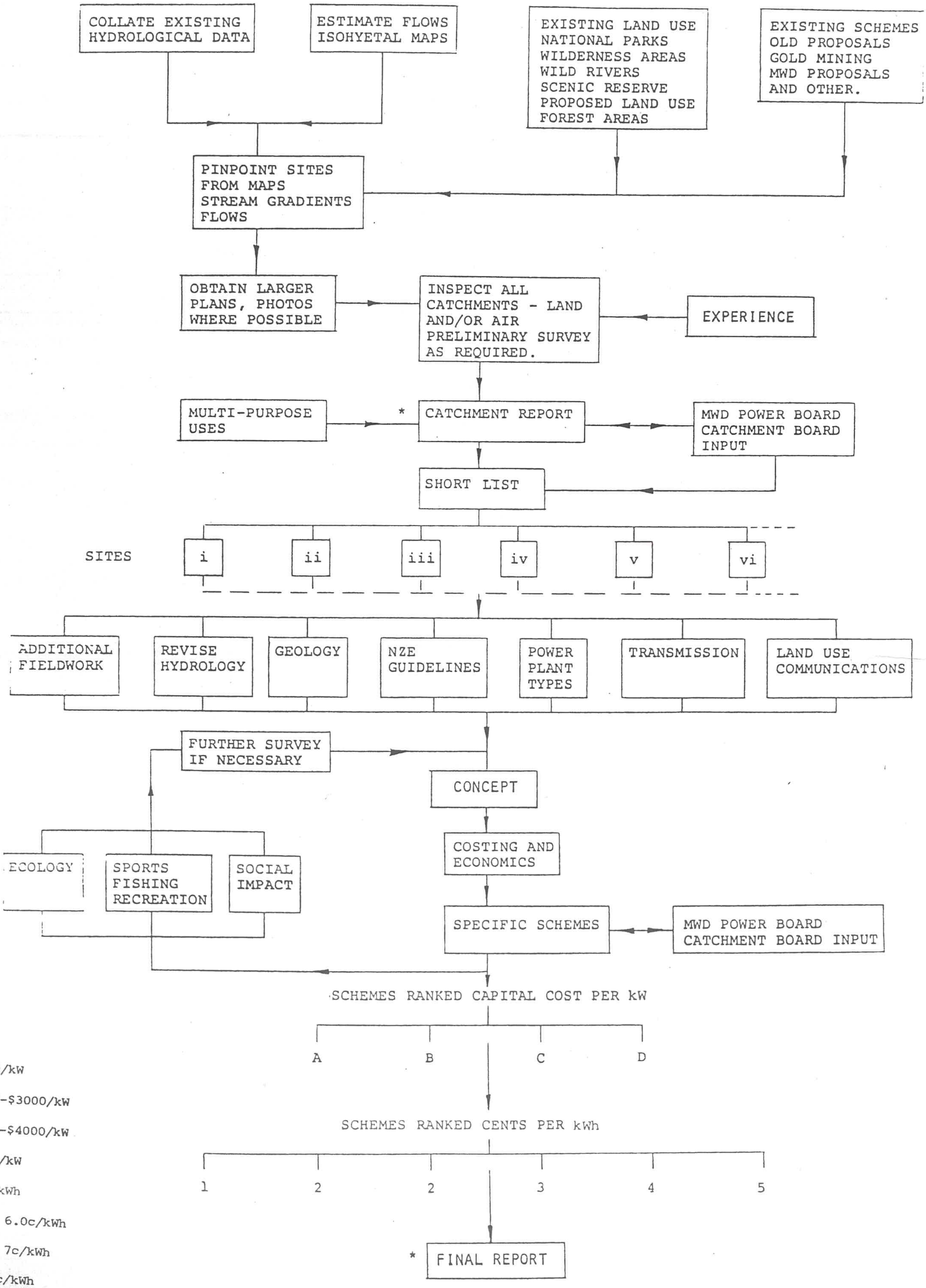
		Installed kW
Dillmans	) New Dillmans Scheme	4000
Kumara	)	6500
Duffers	)	500
Kaniere Forks		450
McKays Creek		1180
Amethyst		225
Wahapo		280
Fox Glacier		250
Turnbull		1000
TOTAL		14,385 kW

APPENDIX B

DECISION TREE METHOD OF STUDY

SMALL HYDRO-ELECTRIC RESOURCE ASSESSMENT

METHOD OF STUDY



A <$2000/kW

B $2000-$3000/kW

C $3000-$4000/kW

D >$4000/kW

1 <5.0c/kWh

2 5.0 to 6.0c/kWh

3 6.0 to 7c/kWh

4 7 to 8c/kWh

APPENDIX C

HYDROLOGY

C1

APPENDIX C : HYDROLOGY

1.0 INTRODUCTION

This appendix describes the hydrological studies carried out to evaluate the hydro-electric potential of the West Coast. Data that was available is summarised and the methods used to derive information for the small hydro-electric assessment are described.

Initially the investigations were directed towards determining rainfall - runoff characteristics for the area, followed by determination of mean and installed flows for the sites where preliminary desk studies indicated possible hydro-electric schemes.

2.0 DATA AVAILABLE

Continuous flow records were available from fourteen Ministry of Works and Development gauging stations set up throughout the region over the last 22 years and computer outputs obtained from T.I.D.E.D.A. in the following form:

i) Mean monthly flows
ii) Maximum discharge
iii) Flow duration curves

A list of permanent sites in the study area serviced by the Ministry of Works and Development is provided in Table C1.

Use was also made of the New Zealand Meteorological Service isohyet maps at 1:500,000 scale showing mean annual rainfall (1941-70) over the whole country. These had to be used with caution because, as stated on the maps, in mountainous areas where there are very few stations and often large rainfall gradients, as on the West Coast, the isohyets only indicate the general pattern of the rainfall distribution. Recent studies confirm this with annual rainfall peaks up to 15 metres where the maps show only 8 metres. In all gauged catchments south of the Taramakau, runoff is in excess of the rainfalls shown without allowing for any losses.

For the Stage II study an updated isohyet map at a scale of 1:1,000,000 was made available by Mr. A. Tomlinson of the N.Z. Meteorological Service, Christchurch.

3.0 STREAM FLOWS

3.1 Determination of Catchment Specific Discharges

To estimate runoffs and specific discharges of rivers and streams an attempt was made to find a relationship between the published isohyetal information and gauged flows.

For the Stage I study the following procedure was adopted:

i) North of the Taramakau catchment, adopting a loss rate of 50l/s/km², a reasonable correlation was obtained between rainfalls and runoff.

ii) For the Taramakau catchment and catchments south, the published rainfall information was scaled upwards by a factor of 1.83 and a loss rate of 146 l/s/km² adopted. For the gauged catchments this gave a correlation coefficient of 0.967 representing a maximum error of 20%. A further relationship giving specific discharge in terms of catchment mean altitude and catchment centroid distance from the sea was derived. This gave a very good correlation (correlation coefficient 0.987 and error 9%) without reference to rainfall information.

For the Stage II study, that is for catchments south of the Poerua Catchment, a relationship giving specific discharge in terms of catchment mean altitude and distance from a mean line through the 4000 ft contour was derived. This gave a good correlation without reference to rainfall information. The specific discharge from this formula was then checked against the updated rainfall information from the isohyetal map.

A mathematical method for calculating rainfall across the alpine divide is provided in a paper by Griffiths and McSaveney [20], Regions of New Zealand'. The method requires the assessment of the mean annual rainfall at sea level and at the ridge crest for every transect considered and then solution by complex mathematical formula for the variation of rainfall with altitude across the transect. This method was not considered appropriate for this 'broad scale' assessment of hydro electric potential.

Flows determined by the above relationships were checked against the specific discharges of neighbouring catchments where possible and after considering all the available information a specific discharge was assumed.

3.2 Flow Distribution and Installed Flows

To accurately determine the generating potential of a proposed hydro-electric scheme, a flow duration curve of daily mean discharges, or alternatively weekly or monthly mean discharges if adequate storage is available, is required for the proposed intake site. However, for this study, few of the potential sites were near gauging stations and so installed capacities were derived from mean flows following a study of the mean flow/installed capacity relationships for the gauged stations and consideration of catchment characteristics.

The available flow duration information has been plotted in a dimensionless form (Q/Q_{mean} v. % time Q exceeded) and this information is presented in Figures A1, A2 and A3.

Plant Factor curves for the unregulated flows are also shown.

The guidelines in the study indicated that the installed flow for this assessment should be taken as that flow which would give a plant factor of 50%. For the northern catchments covered in Stage I a flow corresponding to an unregulated plant factor of 50% has been adopted. Depending on the catchment size and locality, the installed flow varies from 0.7 to 1.8 times mean flow for run-of-river schemes.

For schemes with reservoirs of significant storage capacity, the installed flows have been adjusted to take into consideration the improved utilisation of the available water with the plant factor remaining at 50%. In these cases the installed flow ratio varies between 1.6 and 1.9 times the mean flow.

For the Southern catchments in the Stage II study the installed flow adopted for run-of-river schemes varies from 0.6 to 0.8 times the mean flow. This range was adopted because:

i) It was considered that a 60% plant factor was more appropriate for run-of-river schemes with no storage when the schemes are isolated from the main load centres.

ii) Additional water would be required to remove sediment from the water before it could be used for generation. This water would not be available for generation.

No allowance has been made for leaving a residual flow in the river downstream of the intake. This was considered an unnecessary complication given the assumptions already made to determine the mean flow and flow duration curves. The required residual flow could vary considerably depending on the lcoation and size of the river involved.

3.3 Flood Flows

An estimate of possible flood flows at each of the potential dam sites was required for spillway and diversion sizing and costing purposes.

Some information on flood flows was available from the Ministry of Works and Development for their gauging stations but, because of their relatively recent installation, Technical Memorandum 61 (ref. 18) in conjunction with

C4

Tomlinson (1980) (ref. 17) was used instead to give estimates of 500 year return period floods.

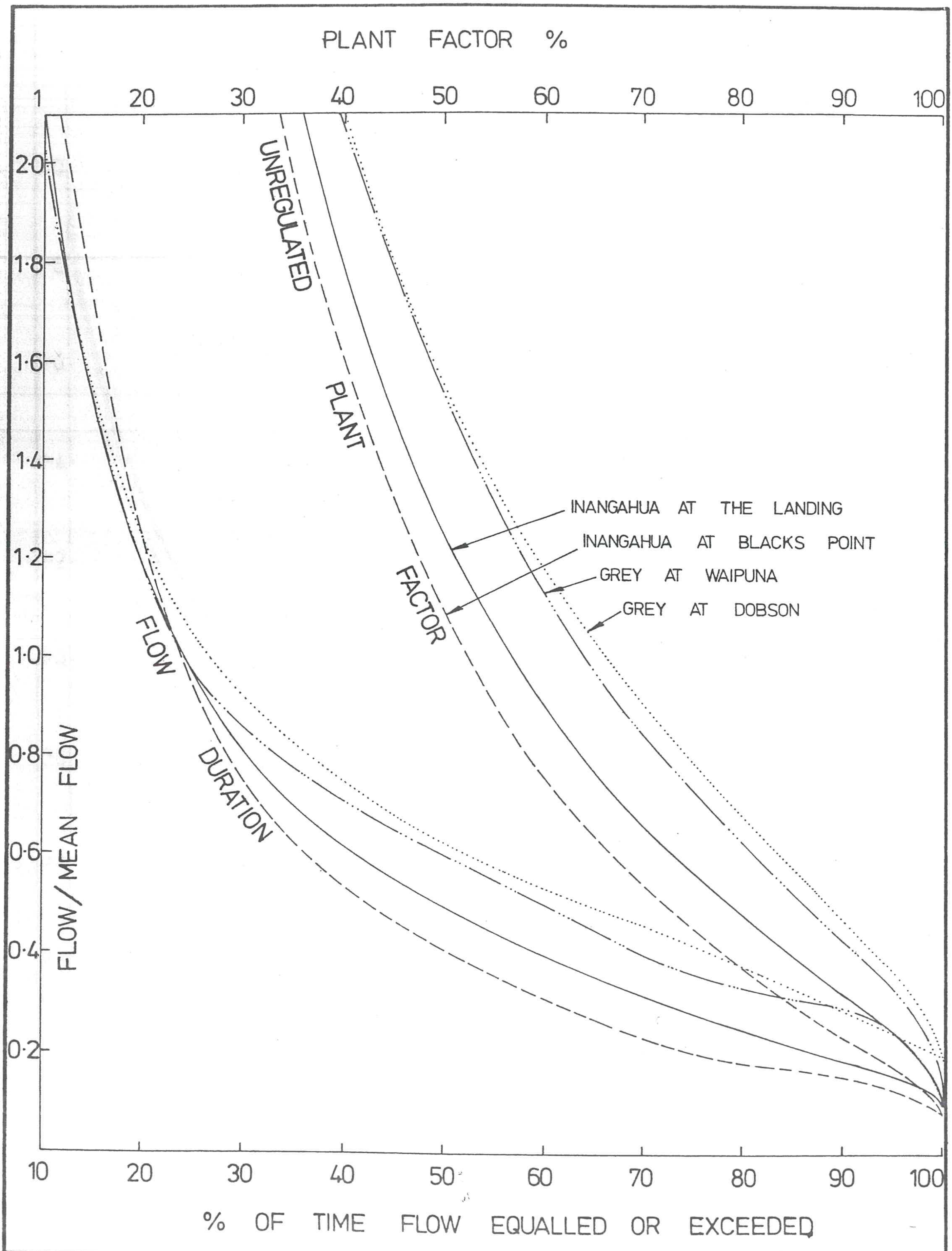
TABLE C.1.

RIVER FLOW RECORDING STATIONS

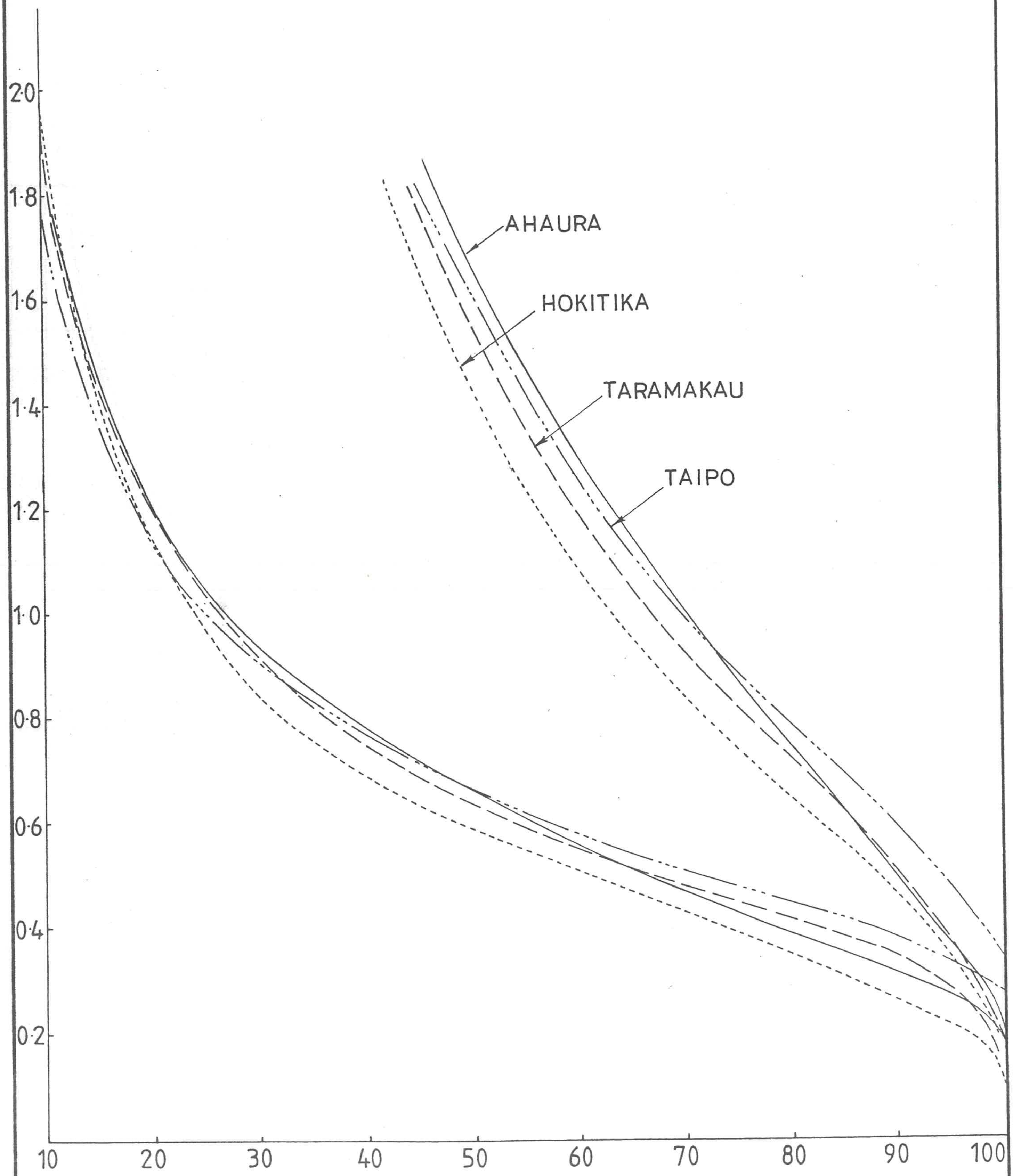
Site Number	River Name	Site Name	Map Reference	Recording Period	Recording Authority	Catchment Area (km^2)	Mean Flow (m^3/s)	Qs. ($\ell/s/km^2$)
93602	Waimangaroa	Smokestack	S24/305733	7/74 - 3/79	C.H.S.W.	19.6	3.48	180
93206	Inangahua	Landing	S31/356535	12/63 - 5/79	"	1000	71.7	72
93207	Inangahua	Blacks Pt.	S38/340281	6/65 - 2/79	"	234	14.7	63
91404	Grey	Waipuna	S45/258999	4/69 - 2/80	"	642	48.6	76
91401	Grey	Dobson	S44/818877	8/68 - 2/80	"	3830	356	93
91407	Ahaura	Gorge	S45/215898	6/68 - 4/79	"	790	85.6	108
91405	Arnold	L. Brunner	S45/973727	6/70 - 3/79	"	440	54.4	120
91101	Taramakau	Greenstone Br.	S51/729662	3/79 - 8/84	"	863	173	200
91103	Taipo	S.H.B.	S51/912511	6/78 - 8/84	"	181	45.0	249
90605	Butchers Cr.	Butchers Cr.	S58/630487	8/71 - 9/84	"	3.9	0.34	90
90604	Hokitika	Colliers Cr.	S58/551225	6/71 -10/84	"	352	105.8	300
90101	Waitaha	S.H.B.	S57/272233	1/78 - 1/84	"	223	61.1	274
87301	Moeraki	L. Moeraki	S77/046305	12/76 - 7/84	"	98.4	23.8	242
86802	Haast	Roaring Billy	S87/066042	7/69 - 7/84	"	1020	201	197
89103	Lk. Wahapo			12/67 - 5/80			11.3	

Note : Recordings are continuing at all Stations. (except 90101, 89103)

C.H.W.S. = Water & Soil Division, M.W.D. Christchurch

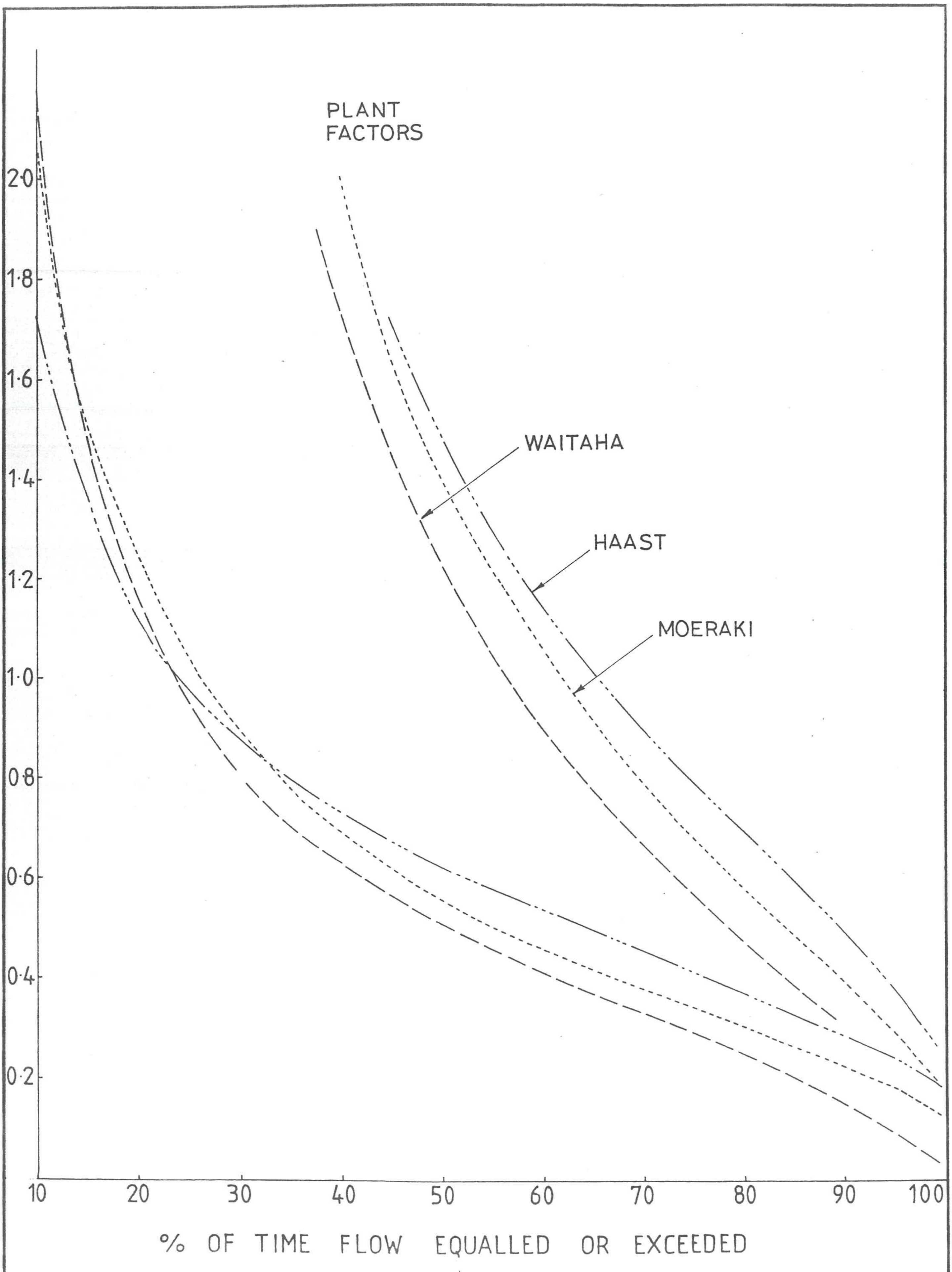


FLOW DURATION AND PLANT FACTOR CURVES	ROYDS, SUTHERLAND & McLEAY CONSULTING ENGINEERS — CIVIL 71 ARMAGH ST. — STRUCTURAL CHRISTCHURCH — SURVEYING NEW ZEALAND — TOWN PLANNING	Date: FIG. C1



% OF TIME FLOW EQUALLED OR EXCEEDED

FLOW DURATION PLANT FACTOR CURVES	ROYDS, SUTHERLAND, McLEAY LTD CONSULTING ENGINEERS & PLANNERS CHRISTCHURCH GREYMOUTH PALMERSTON NORTH	Date: FIG C2



FLOW DURATION
PLANT FACTOR CURVES

ROYDS, SUTHERLAND, McLEAY LTD
CONSULTING ENGINEERS & PLANNERS

CHRISTCHURCH
GREYMOUTH
PALMERSTON NORTH

Date:

FIG C3

APPENDIX D

COSTING INFORMATION

APPENDIX D : BASIS OF COSTING SCHEMES

INDEX

APPENDIX D

BASIS OF COSTING SCHEMES

1.0 INTRODUCTION

The report on the Small Hydro Electric Potential of Nelson contained a comprehensive costing appendix in a form suitable for use in other hydro resource assessments. The costing information in the Nelson report was based on September 1978 costs. (MWD CCI = 981)

The costing information in the Nelson report was subsequently used in preparing assessments on the small hydro-electric potential of West Coast Stage I (1980) North Canterbury (1980), Otago (1981), Marlborough (1981) and Waitaki (1982). The costs in all these reports were based on September 1978 prices and adjusted acording to the movement of the MWD construction cost index.

With the preparation of the West Coast Stage II report it was considered appropriate to update the Nelson costing information to current day costs by considering the costs of recently constructed small hydro-electric schemes and the movement in the construction cost indices. This revised costing information is provided in the following sections of this Appendix.

2.0 COSTS OF SCHEME COMPONENTS

2.1 Introduction

Cost parameters are provided for all the components of hydro-electric schemes (e.g. dam, spillway, conduits). These costs have been derived from investigations into the cost of hydro schemes that have recently been constructed in New Zealand and for schemes under study where costs have been estimated in some detail.

In the case of schemes involving relatively large dams, where data was not so readily available, reasonably detailed estimates of scheme components (e. g. diversion, spillway) were prepared for one particular scheme and the costs for the other schemes proportioned according to the appropriate parameters (e.g. diverted flow, dam height).

All the costs must be considered as preliminary and are only indicative of likely costs. They have been based on the costs of typical small hydro schemes but experience shows that costs can vary widely depending on a large number of factors. Perhaps the most important of these is the ground conditions at the site, and as no sub-surface investigations have been carried out, this could lead to significant inaccuracies in the estimates. However, the costs given are considered sufficiently accurate for this resource assessment.

Costs have been determined using September 1984 prices. (Ministry of Works and Development Construction Cost Index = 2180).

2.2 Powerhouse - Mechanical and Electrical Equipment

For the purposes of this report the costs of the Mechanical and Electrical plant have been derived from the family of curves shown in Figure B1. These curves have been derived from investigations into the costs of machines and powerhouse equipment for schemes in the 20 kW to 25 MW range that have been built or designed in New Zealand over the last few years.

These curves apply to a synchronous machine and follow the general law:-

$$\$/kW = \frac{8750}{P^{.3}\ H^{.25}}$$

P = power in kW
H = head in m

The prices are for synchronous machines up to 10 MW. If induction machines are used, the cost is reduced by about 20%. However, the cost of the ancillary equipment (estimated as 50% of the cost of the synchronous machines) should be estimated at 55% of the cost of the induction machines.

There are limitations to the use of these curves. They cannot be used for optimising an individual station or machine because, in effect, they assume the most favourable machine speed and the cheapest possible type of machine. When optimising, the speed (and hence dimensions, turbine setting and cost) is the most important single factor in the exercise. The next most important factor is the type of machine. For this no general guidelines can be given as every site must be treated on its merits.

Factors which must be considered are:

- the ratio of maximum and minimum outputs
- the shape of the flow/duration curve
- the amount of storage available
- the load for best efficiency
- water hammer
- discharge at runaway speed
- physical constraints of the site
- transport limitations
- whether turbine guide vanes are required

To summarise, the curves provide a quick and reasonably reliable method of estimating mechanical and electrical costs for the purposes of a pre- feasibility study; they should not be used for more detailed investigations.

The cost of concrete lining, syphons, flumes and bridges have been added to the cost obtained from the figure.

2.8 Dam Costs

The costs of earth/rockfill dams have been based on the estimated volume of earthworks involved. An additional 5 m has been added to the height of any dam to allow for excavation to a suitable foundation. The all-in cost of earthworks has been taken as \$3.50to \$5.00/m^3 depending on the volume involved.

The costs of concrete dams have been based on the estimated volume of concrete involved using concrete costs in the range \$250-\$500/m^3 depending on the volume involved.

2.9 Spillway

The costs of a gated spillway, including a lined channel and stilling basin have been estimated using the formula.

$$\text{Cost (\$)} = 4750\ hQ^{1/2}$$

where Q = Design flood flow (m^3/s)
h = Dam height (m)

2.10 Diversion

The cost of a standard diversion based on a culvert passing under the proposed dam including coffer dams, channels to and from the diversion and stilling basin have been estimated using the formula.

$$\text{Cost (\$)} = 6500\ hQ^{1/2}$$

where Q = Diversion flow
h = dam height

2.11 Tunnels

Tunnel costs have been assumed as follows:

Tunnel Diameter	Cost/metre (\$)
2.0 - 2.5 m	6,500
2.5 - 3.0 m	7,500
3.0 - 3.5 m	8,500
3.5 - 4.5 m	9,500
4.5 - 6.0 m	12,000

These figures are for a tunnel length of 1,000 - 2,000 m and should be adjusted for shorter or longer tunnels.

2.12 Roading

The cost of relocating existing roads and constructing access roads as follows. The range in costs is to allow for differences in topography.

State highway	$250,000 to $350,000 per km
Primary County Road	$150,000 to $250,000 per km
Secondary County Road	$ 80,000 to $120,000 per km
New Access Roads	$100,000 to $200,000 per km

2.13 Bridging

Bridging costs have been estimated at $6000 per metre

2.14 Land

Land costs vary throughout the study area. Where land costs have been included, costs in the range $750 to $1,250 per hectare have been used depending on land use.

2.15 Transmission

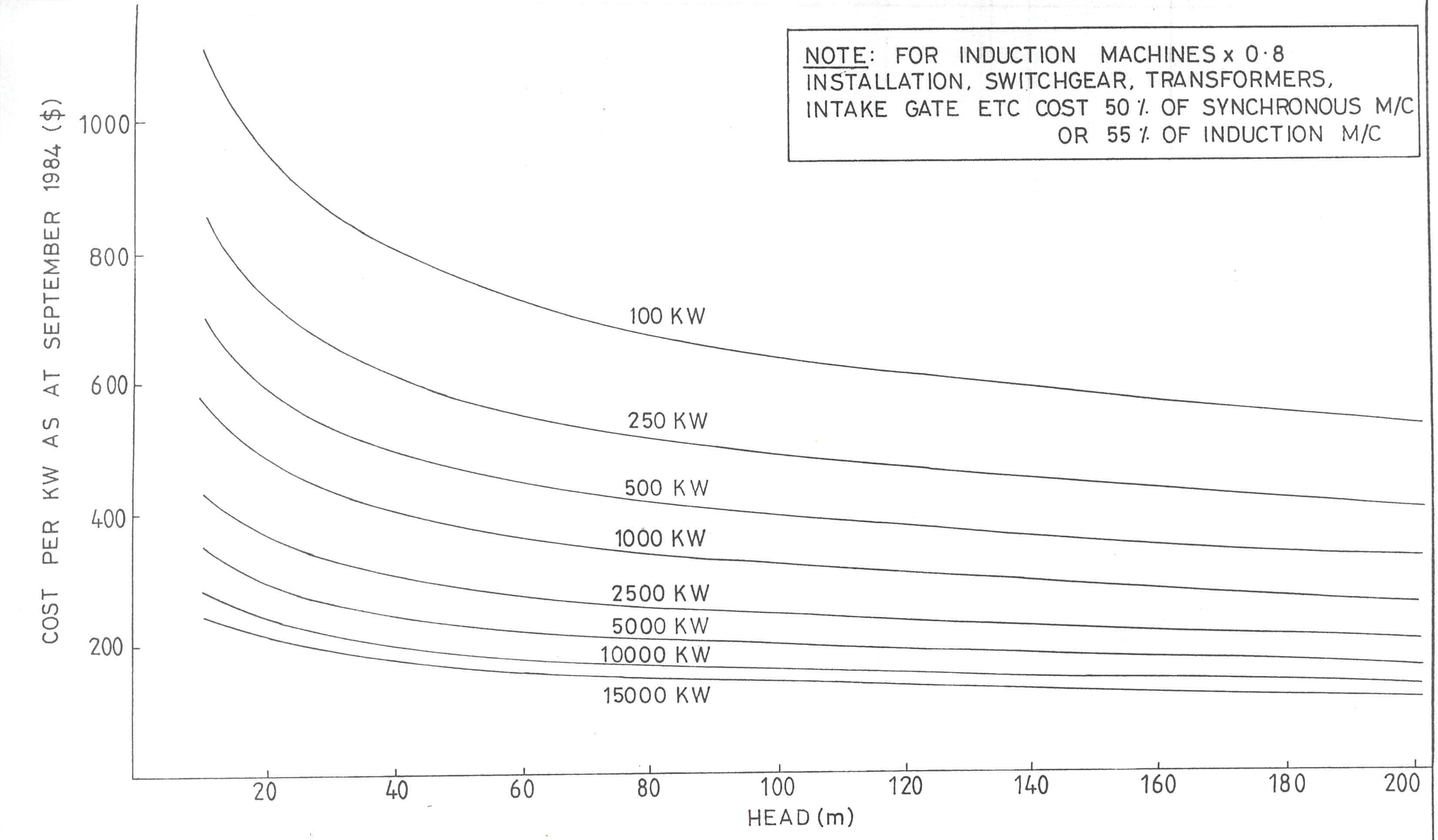
The costs for the standard transmission voltages have been assumed as follows:

11 kV	$25,000
33 kV	$40,000
66 kV	$60,000
110 kV	$120,000

The costs of access roads to tranmission lines must be added to the above costs.

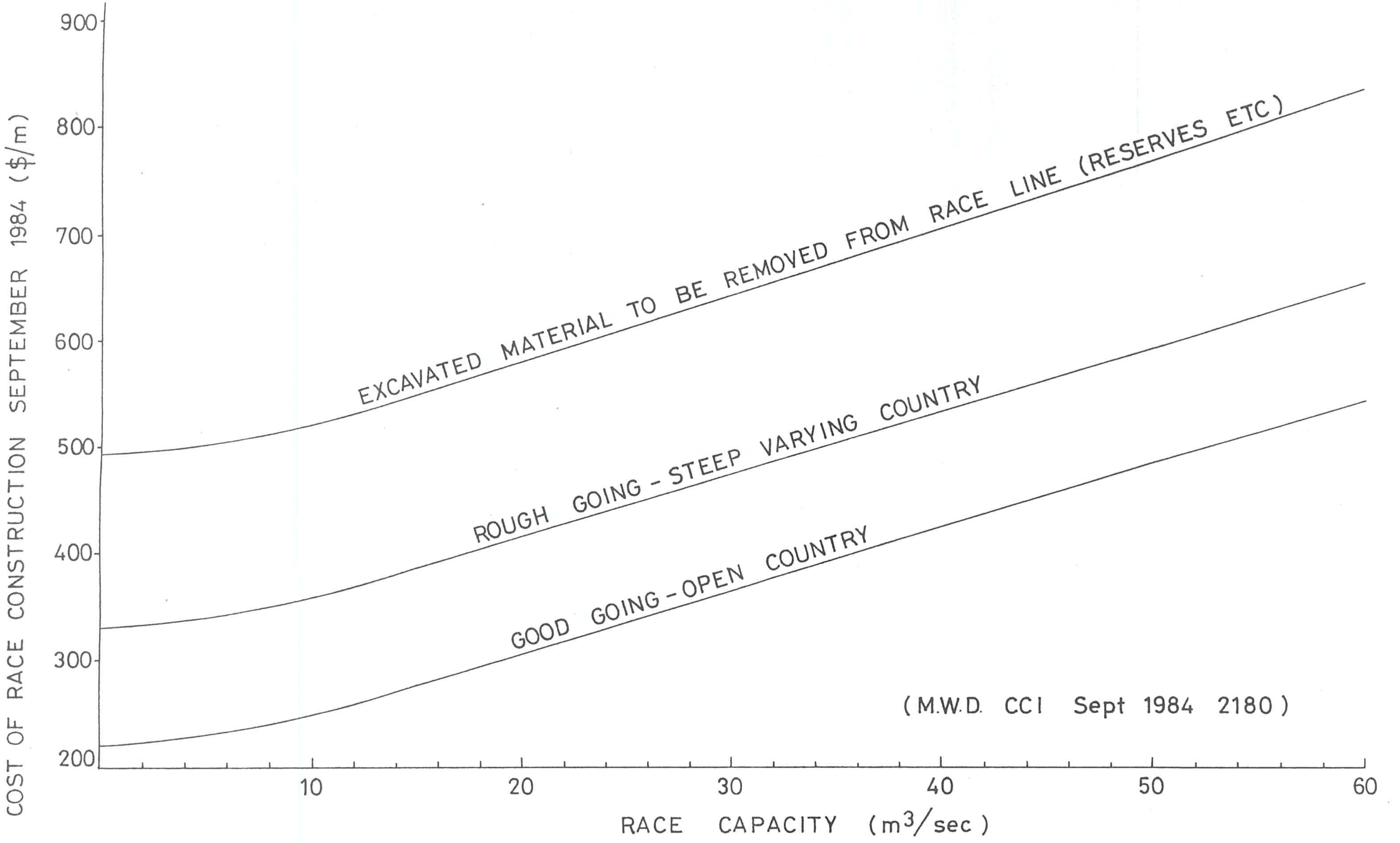
2.16 Allowances for On-Costs

An allowance of 15% for contingencies and 15% for engineering costs has been added to the total construction cost to give a total scheme cost.



COST OF TURBINE AND SYNCHRONOUS GENERATOR C.I.F

FIG D1



COST OF RACE CONSTRUCTION

FIG D3
REV. A

APPENDIX E

DISCUSSION ON RANKING CRITERIA

APPENDIX E : DISCUSSION ON RANKING CRITERIA

Two criteria have been used to rank the schemes considered in this report - cost/kW and cost/kWh. Both criteria must be used with considerable caution.

Cost per installed kW is frequently used as an indication of economic viability and a method of comparing schemes. However, as it depends on installed capacity rather than available flow, a low cost per kW may indicate an economical scheme, an inappropriate installed capacity, or a scheme designed with a very low plant factor to meet peaks only.

New Zealand Electricity requires that schemes should "reasonably follow the local authority's load curve." This is frequently misinterpreted as a requirement that a scheme match the authority's annual load factor. If this requirement does have a link with load factor it is with the winter daily load factor. While it is true that many schemes which satisfy this New Zealand Electricity criterion do match the authority's annual load factor, the same annual load factor could also be met by a run-of-river scheme on a river with low winter flows and high summer flows or a scheme which generates at approximately half load continuously, neither of which would satisfy New Zealand Electricity.

The Committee on Local Authority Hydro Development has set a discounted cost of 3 cents/kWh (June 1978) as the upper limit for economic viability of small hydro schemes and have indicated that schemes should be optimised until the marginal cost of additional units is 3 cents/kWh. (This 3 cents/ kWh is an estimate of the long run incremental cost of New Zealand Electricity generation.) It is a reasonable yardstick for small hydro schemes which are able to deliver their rated output during peaks and therefore substitute for thermal plant. Schemes that cannot do this should have their firm output compared with the 3 cents/kWh criterion and the remainder of their output compared to a lower figure of say 1.5 to 2 cents/ kWh.

The 3 cents/kWh is linked to the New Zealand Electricity system load factor. For small hydro schemes with a high plant factor the criterion should be lower than 3 cents - reflecting the lower cost of base load generation - and for schemes with reliable peaking capacity the figure could be higher because much of the peak power is generated by oil fired stations.

The conclusions to be drawn from the above is that in determining installed capacity and assessing scheme viability, considerable judgement is required to ensure that all components of a scheme are optimised so that neither water nor money are wasted. Plant factors of 30% for a low cost scheme with ample storage and 80% for a run-of-river scheme may then show the best return to the nation and be accepted as "reasonable" in relation to the authority's load curve.

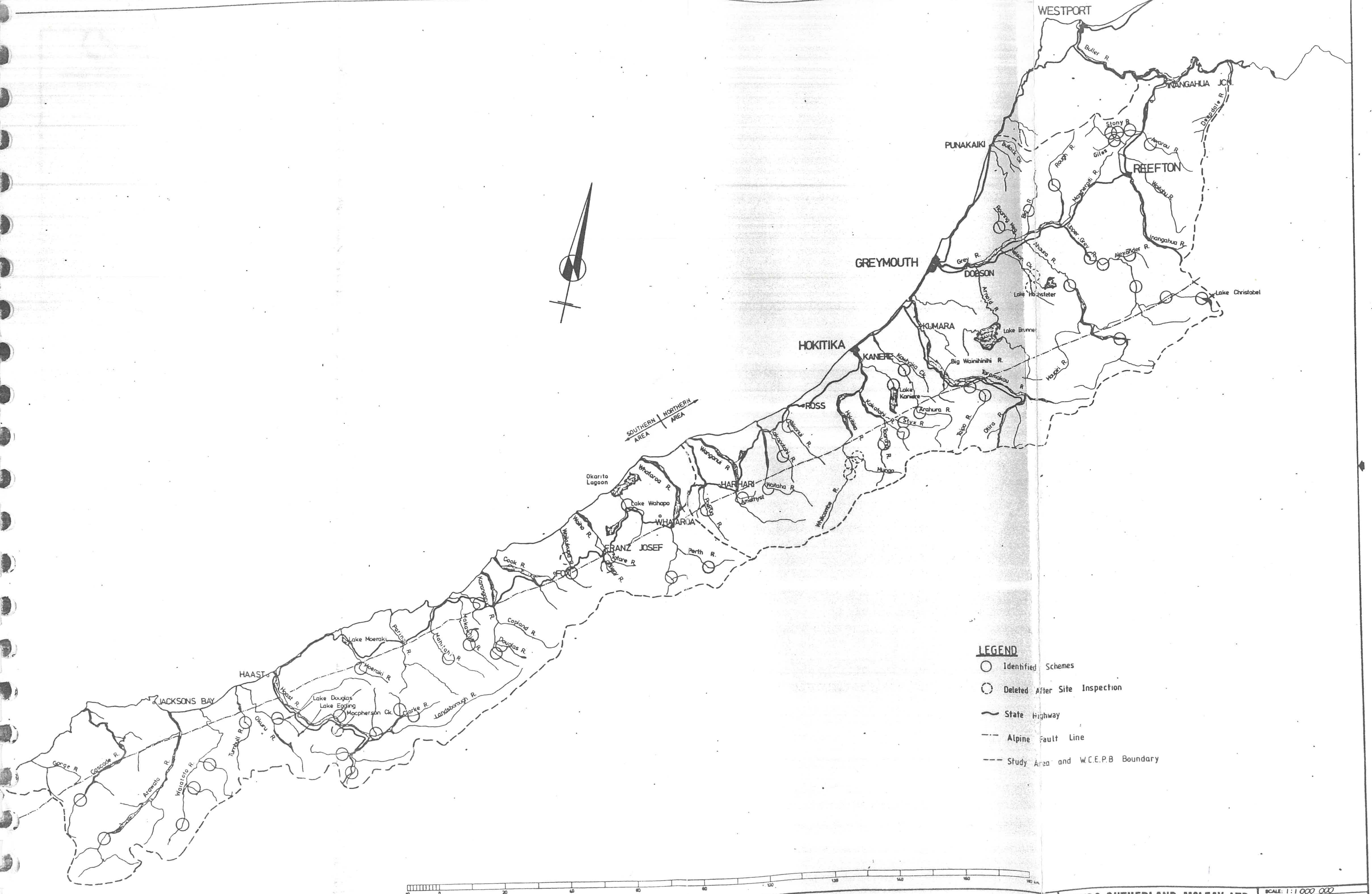
In this report, as required by the brief, a plant factor of 50% has been used for all schemes considered in the northern area and a plant factor of 60% for the majority of schemes in the southern area. This means that the costs/kWh are virtually proportional to the costs/kW. Both figures have been included however so that the schemes identified on the West Coast by this assessment may be compared to schemes identified in other areas by similar studies.

The economic criteria discussed above both relate to a national value of the scheme and do not necessarily reflect the value of the scheme to a local authority. The benefit to a local authority is the saving in the cost of power and energy purchased from the New Zealand Electricity.

At the present time, with authorities purchasing power on one of two bulk tariffs which place different values on power and energy, the benefits of a scheme to a local authority are different from, and have to be assessed separately from, the national value. However, changes in the bulk tariff are proposed and when this tariff relates more closely to the actual cost of generation, the national value of a scheme in cents/kWh will closely relate to its value to a local authority.

APPENDIX F

MAPS AND DRAWINGS



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A	6/85	STAGE 2	

F.B.	INITIALS	DATE
SURV.		
DGN.		
DR.		
TR.		
CH.		

WEST COAST HYDRO ELECTRIC RESOURCES ASSESSMENT.

KEY PLAN.

ROYDS SUTHERLAND McLEAY LTD.

CONSULTING ENGINEERS

CHRISTCHURCH
GREYMOUTH
PALMERSTON NORTH

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:1 000 000

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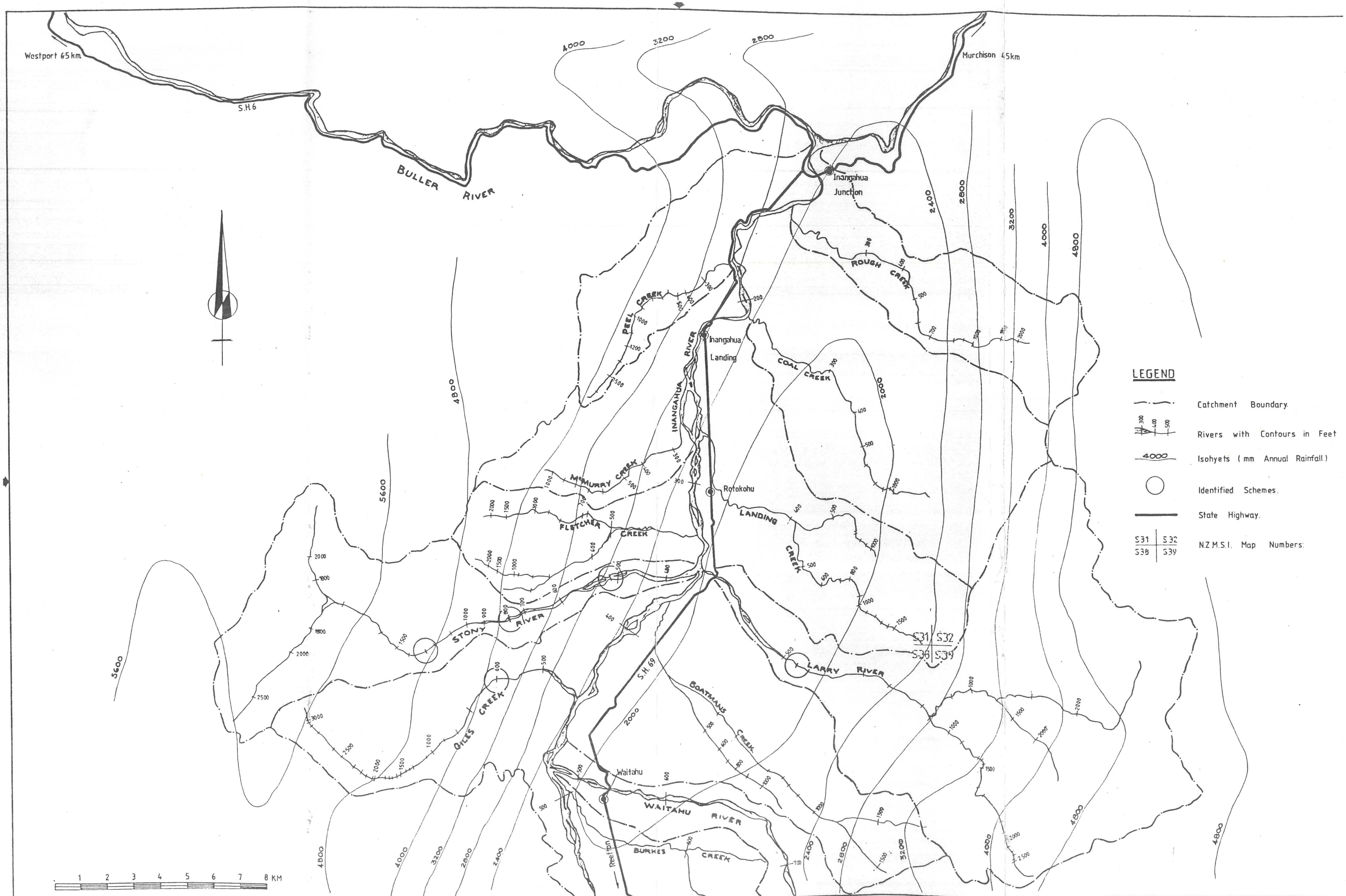

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				DSN.		
				DR.		

WEST COAST HYDRO—ELECTRIC RESOURCES ASSESSMENT.

LOWER INANGAHUA RIVER CATCHMENTS

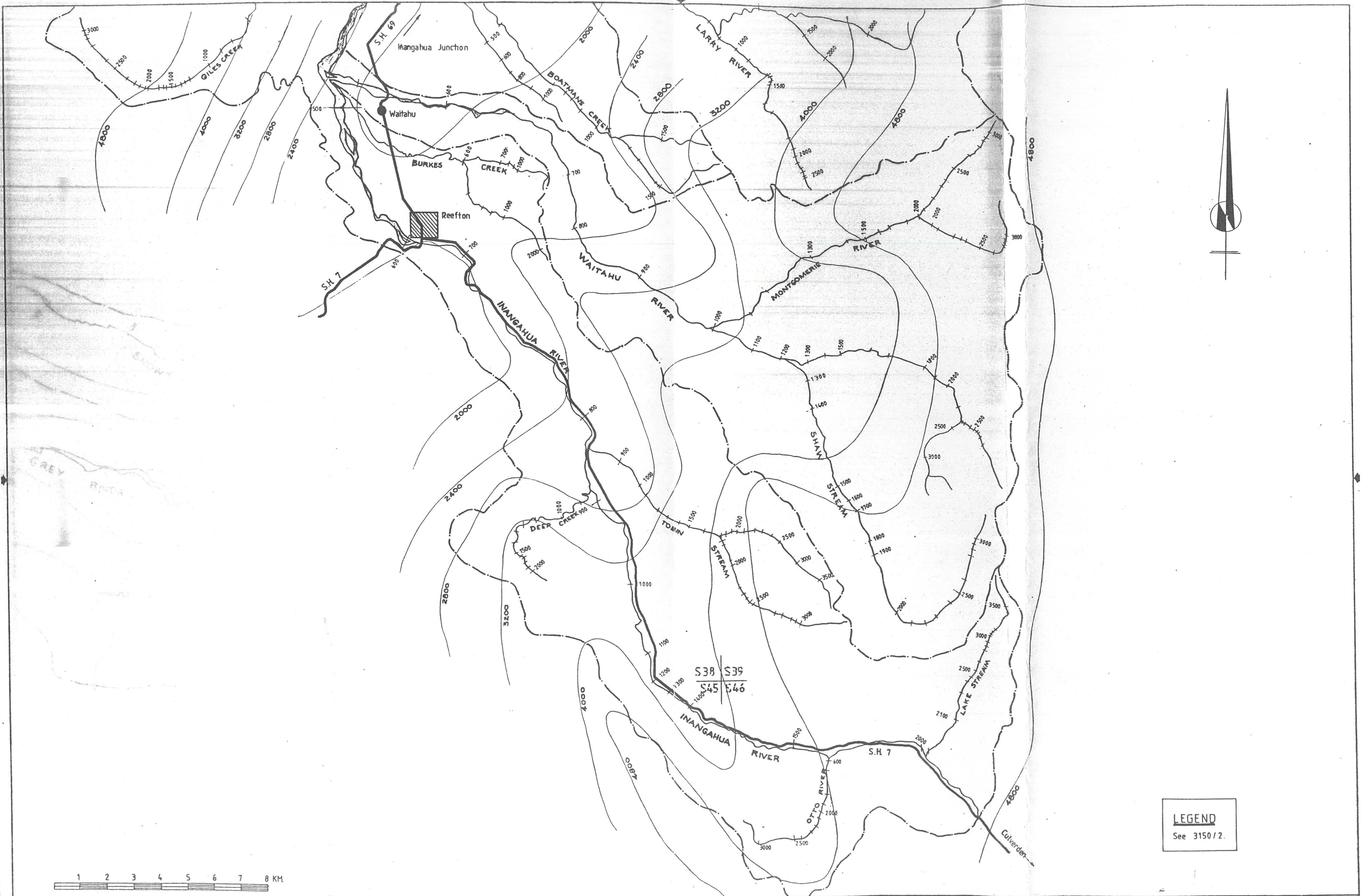
ROYDS SUTHERLAND & McLEAY

CONSULTING ENGINEERS — CIVIL, STRUCTURAL

71 ARMAGH ST.

SCALE 1:63360

3150 / 2



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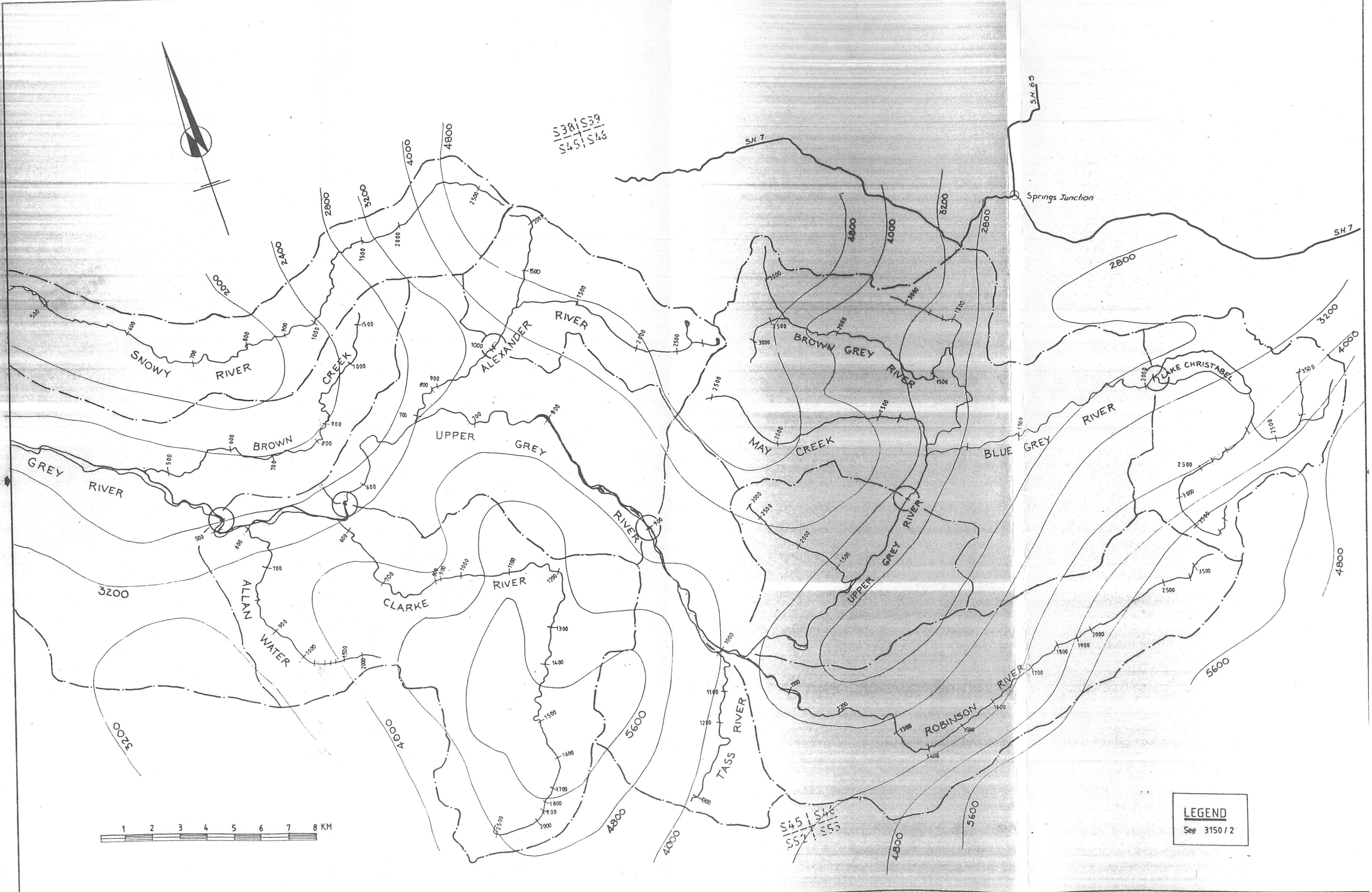
				DGN.		
				DR.		
				TR.	K.F.M.	9/8/79
				CH.		
				APP.		

WEST COAST HYDRO-ELECTRIC RESOURCES ASSESSMENT.
UPPER INANGAHUA AND WAITAHU RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY
CONSULTING ENGINEERS
71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND
CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE 1: 63360

3150/ 3



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					INITIALS	DATE
				SURV.		
				DGN.		
				DR.		
				TR.	K.F.M	8/79
				CH.		
				APP.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

UPPER GREY RIVER CATCHMENTS (A)

ROYDS SUTHERLAND & McLEAY

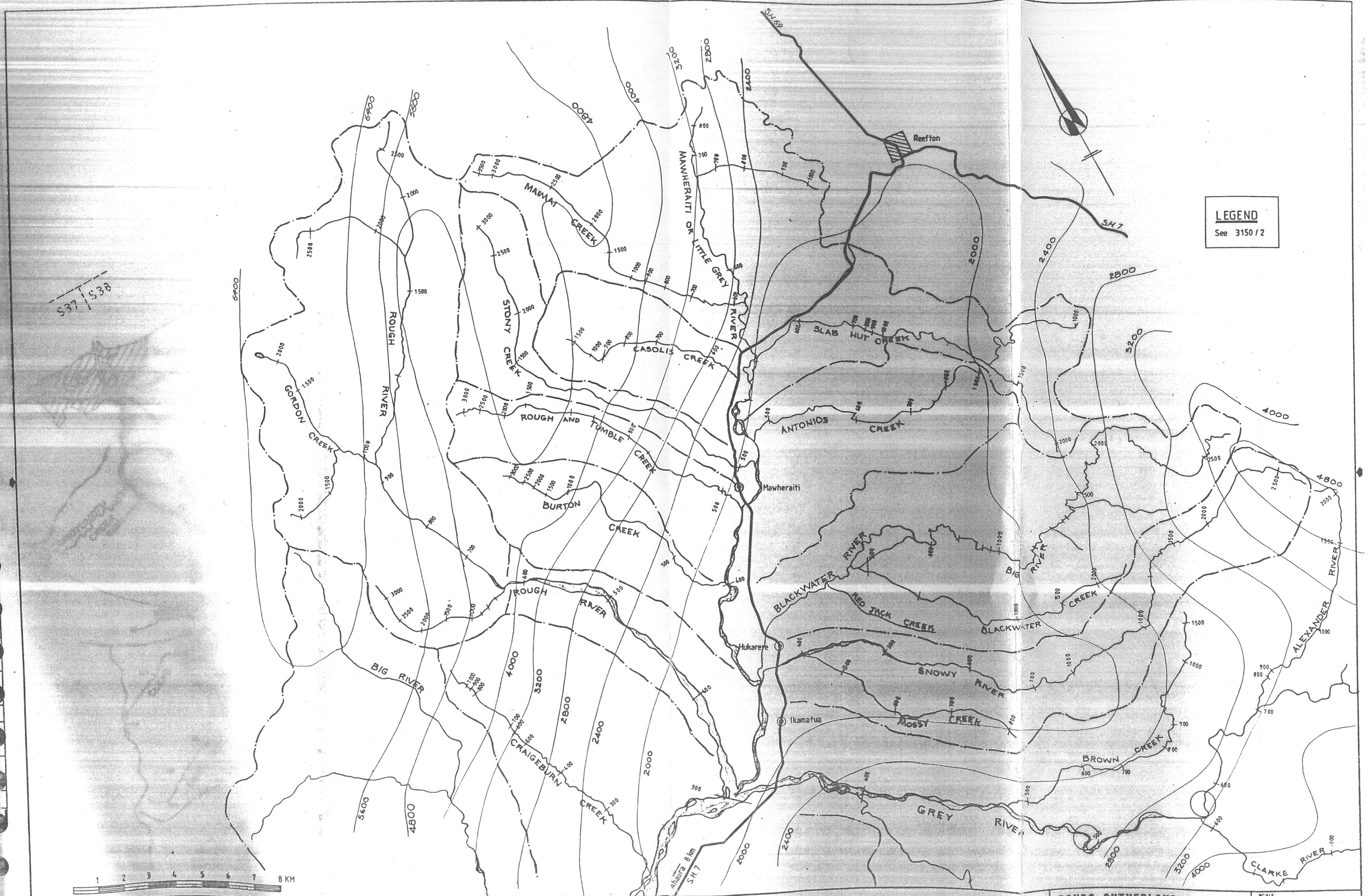
CONSULTING ENGINEERS

71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/4



No.	DATE	AMENDMENT	INITIAL

F.B.	INITIALS	DATE
SURV.		
DGN.		
DR.		
TR.	K.F.M.	6/76
CH.		
APP.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

UPPER GREY RIVER CATCHMENTS (B)

ROYDS SUTHERLAND & McLEAY

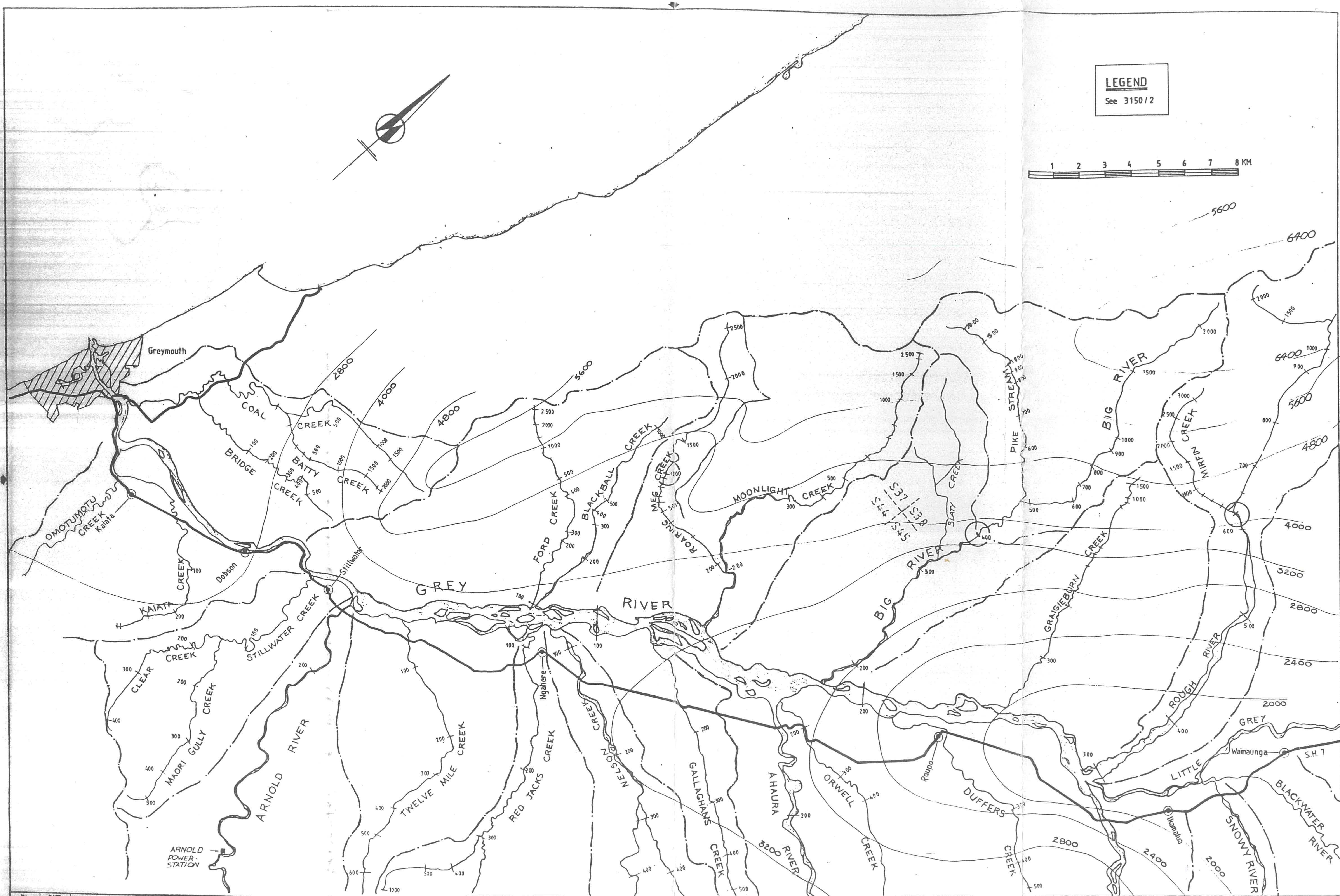
CONSULTING ENGINEERS

71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/5



No	DATE	AMENDMENT	INITIAL

	INITIALS	DATE
F.B.		
SURV.		
DGN.		
DR.		
TR.	KFM	9/79
CH.		
APP.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

GREY RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

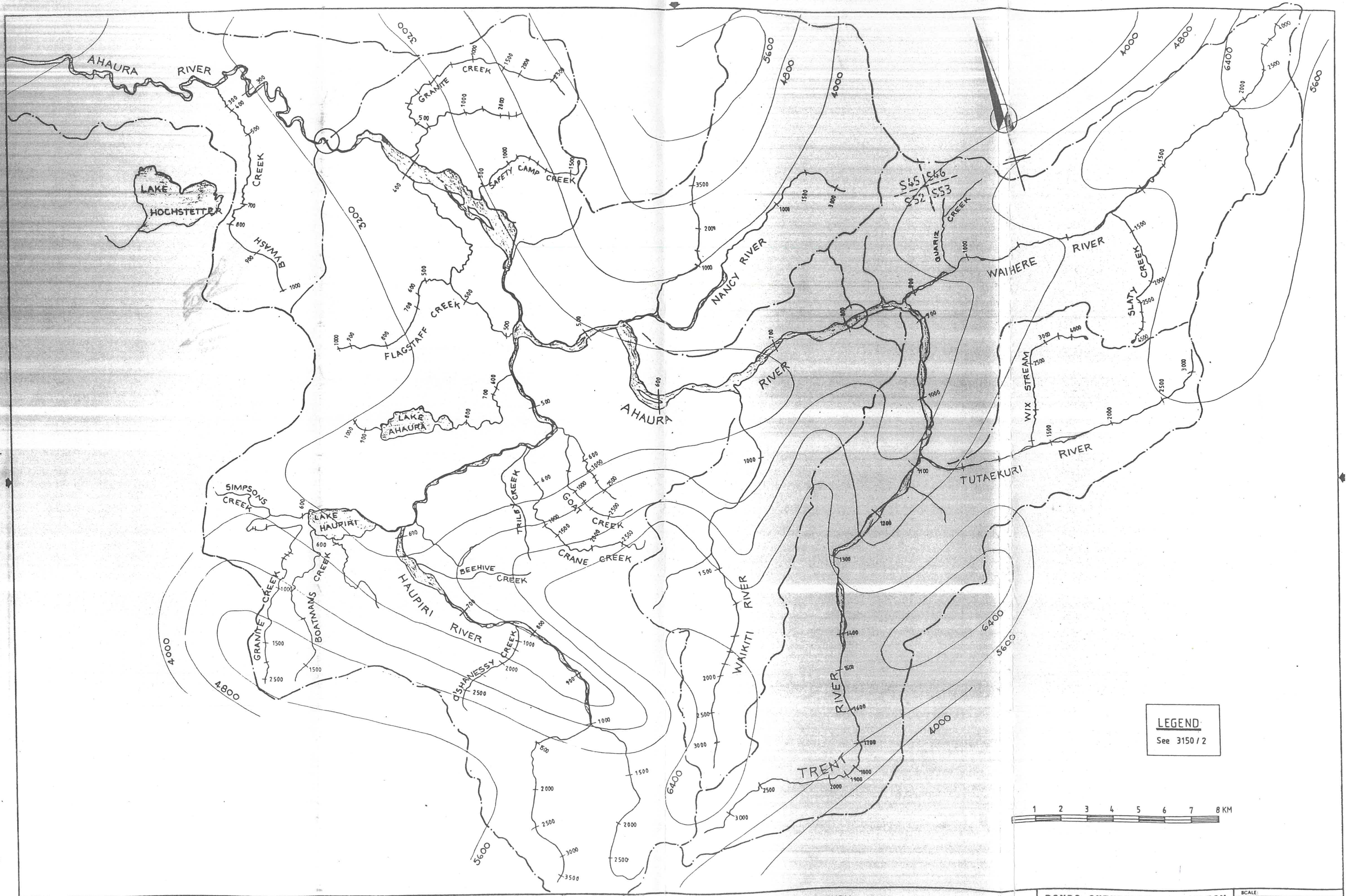
CONSULTING ENGINEERS

71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/6



No	DATE	AMENDMENT	INITIAL	F.B.	INITIALS	DATE
				SURV.		
				DGN.		
				DR.		
				TR.	K.F.M	10/79
				CH.		
				APP.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

AHAURA RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

CONSULTING ENGINEERS

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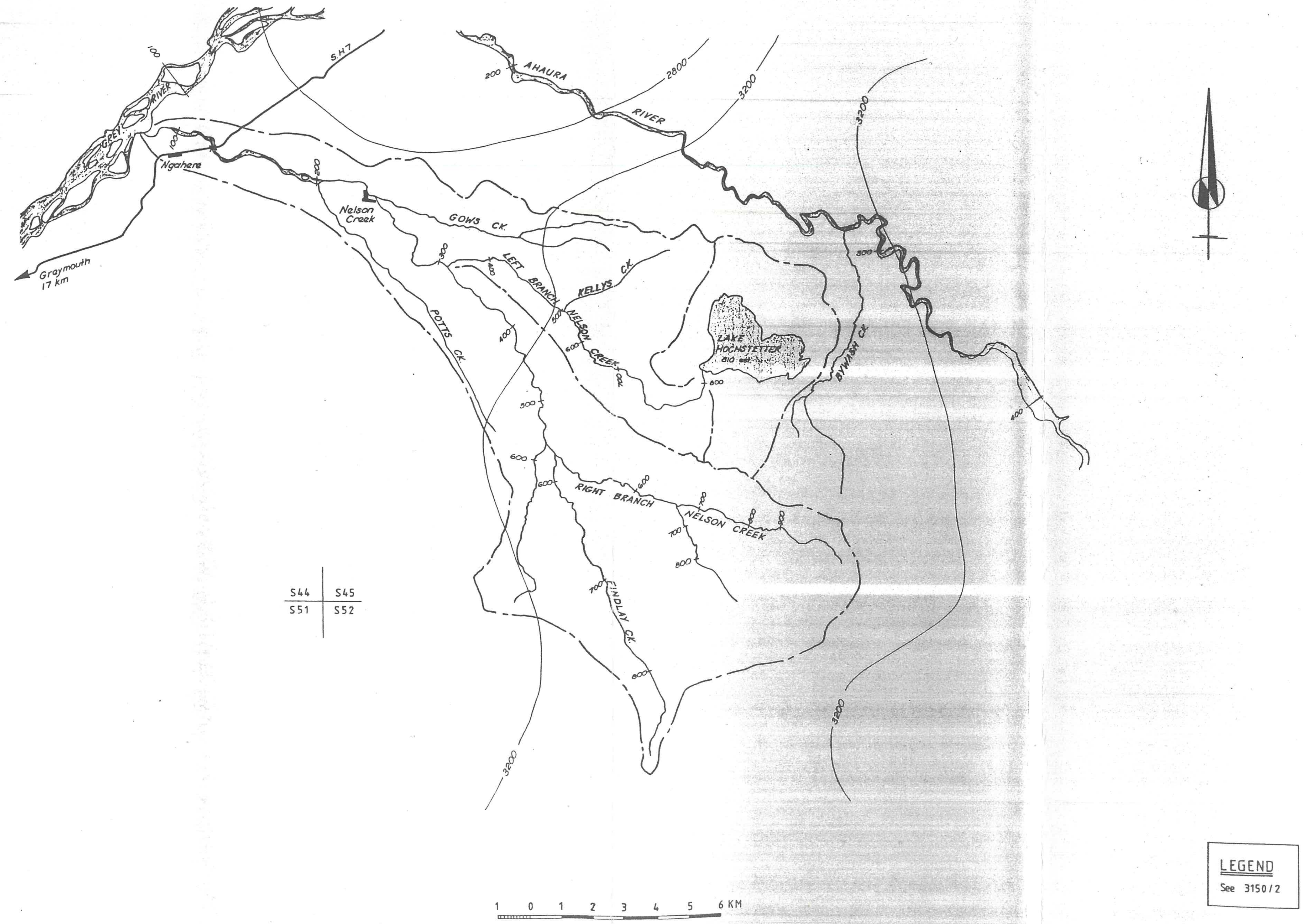
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/7



DATE	AMENDMENT	INITIAL	F.B.	INITIALS	DATE
			SURV.		
			DGN.		
			DR.		
			TR.	CYS	8 81
			CH.		
			APP.		

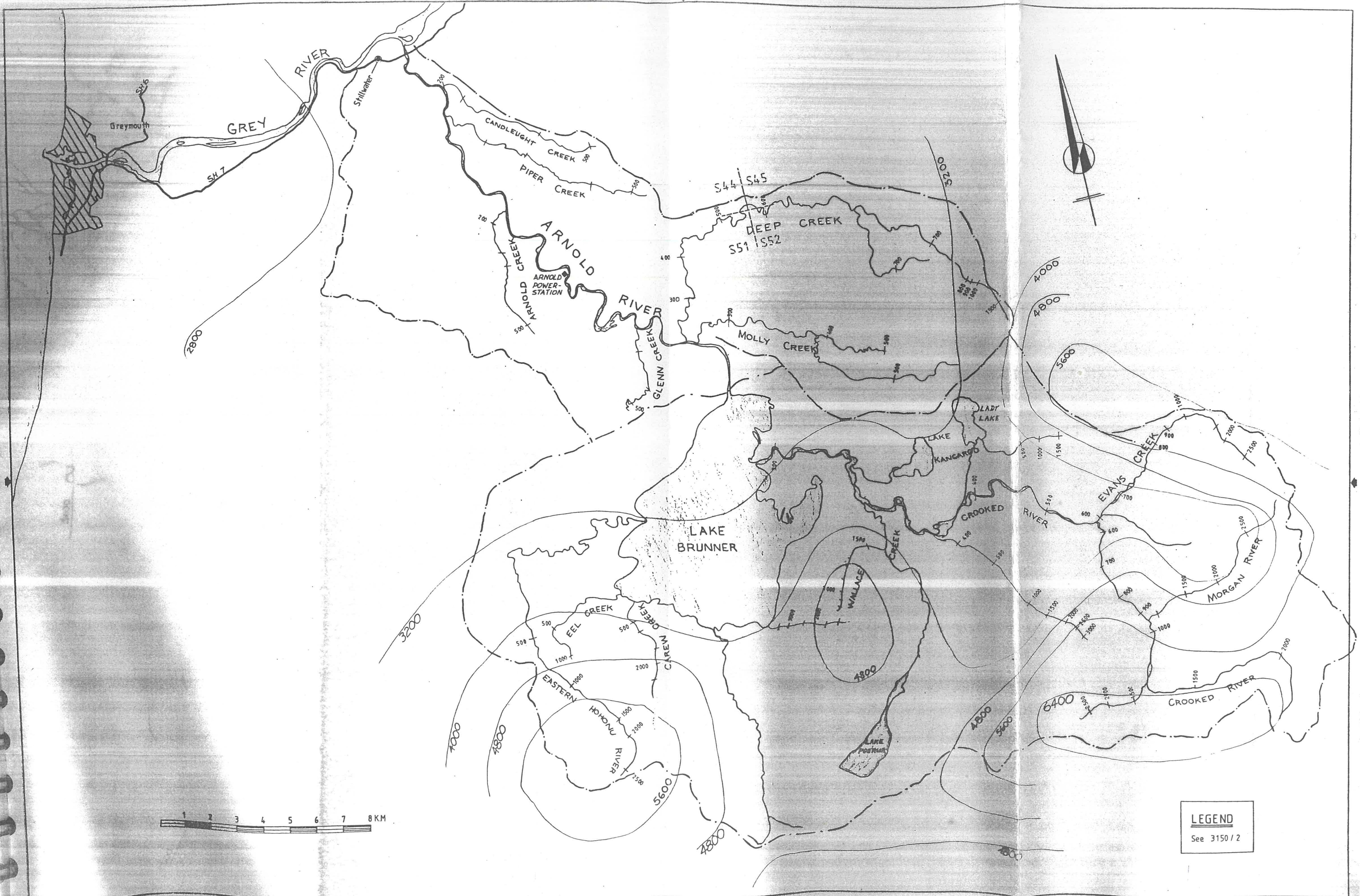
WEST COAST HYDRO - ELECTRIC RESOURCES ASSESSMENT

NELSON CREEK CATCHMENT

ROYDS SUTHERLAND McLEAY LTD.
CONSULTING ENGINEERS
CHRISTCHURCH
GREYMOUTH
PALMERSTON NORTH
CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE:

3150/8



No	DATE	AMENDMENT	INITIAL

	INITIALS	DATE
F.B.		
SURV.		
DGN.		
DR.		
TR.	K.F.M	10/9
CK.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

ARNOLD RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

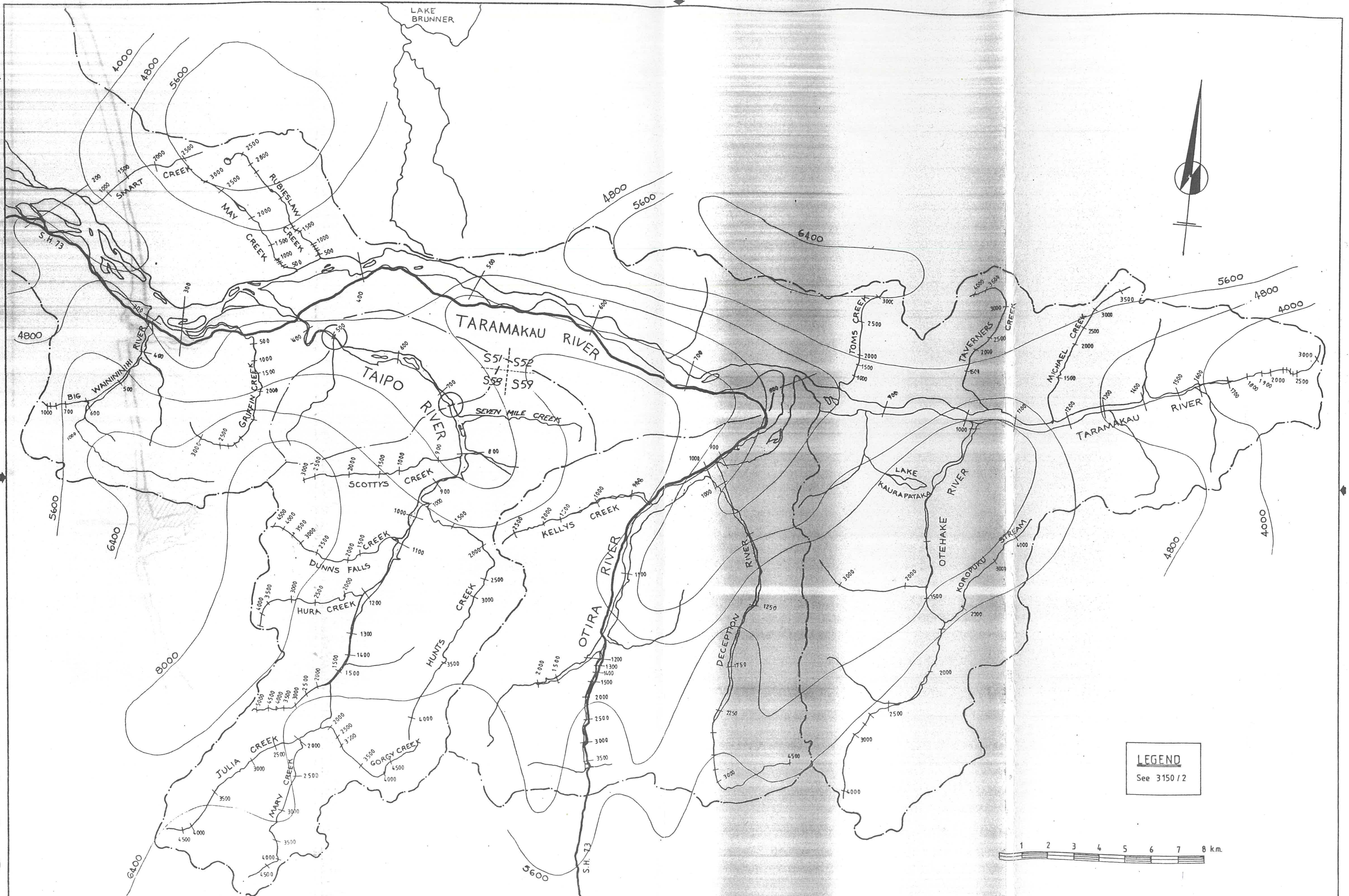
CONSULTING ENGINEERS

71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/9



No	DATE	AMENDMENT	INITIAL

F.B.	INITIALS	DATE
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DGN.		
DR.		
TR.		
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APP.		

WEST COAST HYDRO – ELECTRIC RESOURCES STUDY

TARAMAKAU, OTIRA AND TAIPO RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

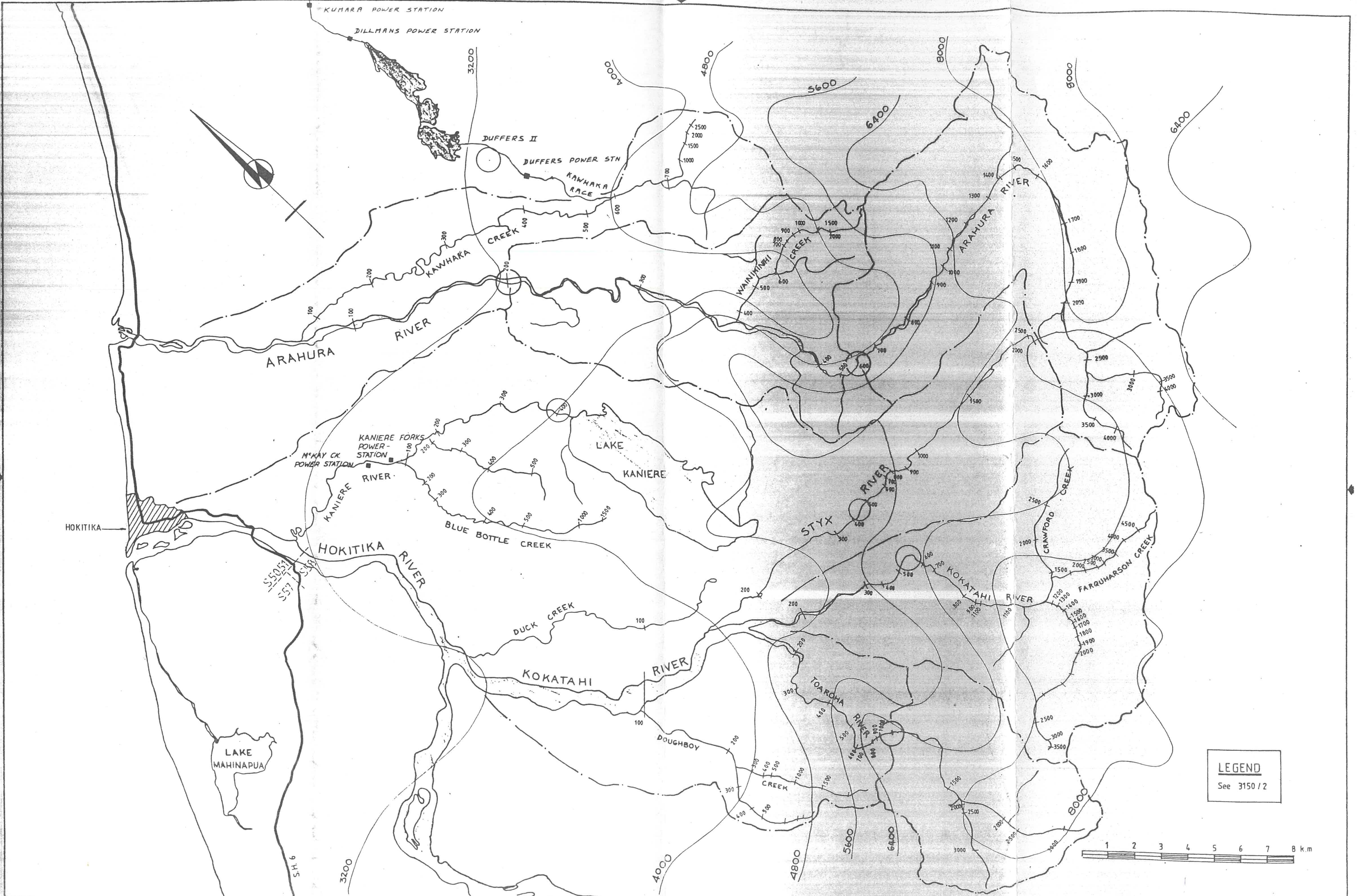
CONSULTING ENGINEERS

71 ARMAGH ST, CHRISTCHURCH NEW ZEALAND

CIVIL STRUCTURAL SURVEYING TOWN PLANNING

SCALE:

3150/10



No	DATE	AMENDMENT	INITIAL	F.B.	INITIALS	DATE
				SURV.		
				DGN.		
				DR.		
				TR.		
				CH.		
				APP.		

WEST COAST HYDRO – ELECTRIC RESOURCES STUDY

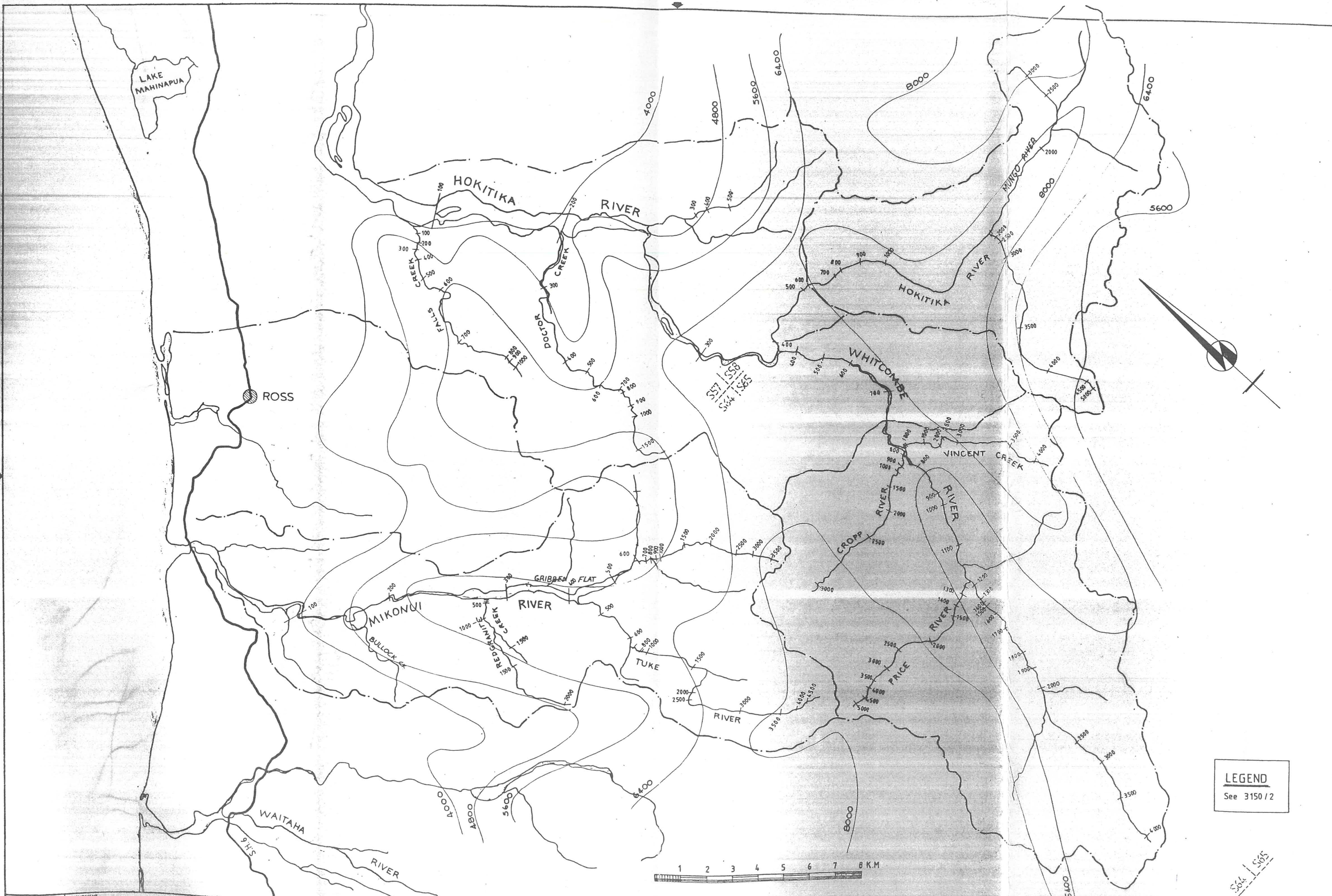
ARAHURA, STYX, KOKATAHI, TOAROHA AND LAKE KANIERE CATCHMENTS

ROYDS SUTHERLAND & McLEAY
CONSULTING ENGINEERS
71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/11



No	DATE	AMENDMENT	INITIAL

F.B.	INITIALS	DATE
SURV.		
DGN.		
DR.		
TR.		
CH.		
APP.		

WEST COAST HYDRO – ELECTRIC RESOURCES STUDY

HOKITIKA, WHITCOMBE, AND MIKONUI RIVER CATCHMENTS

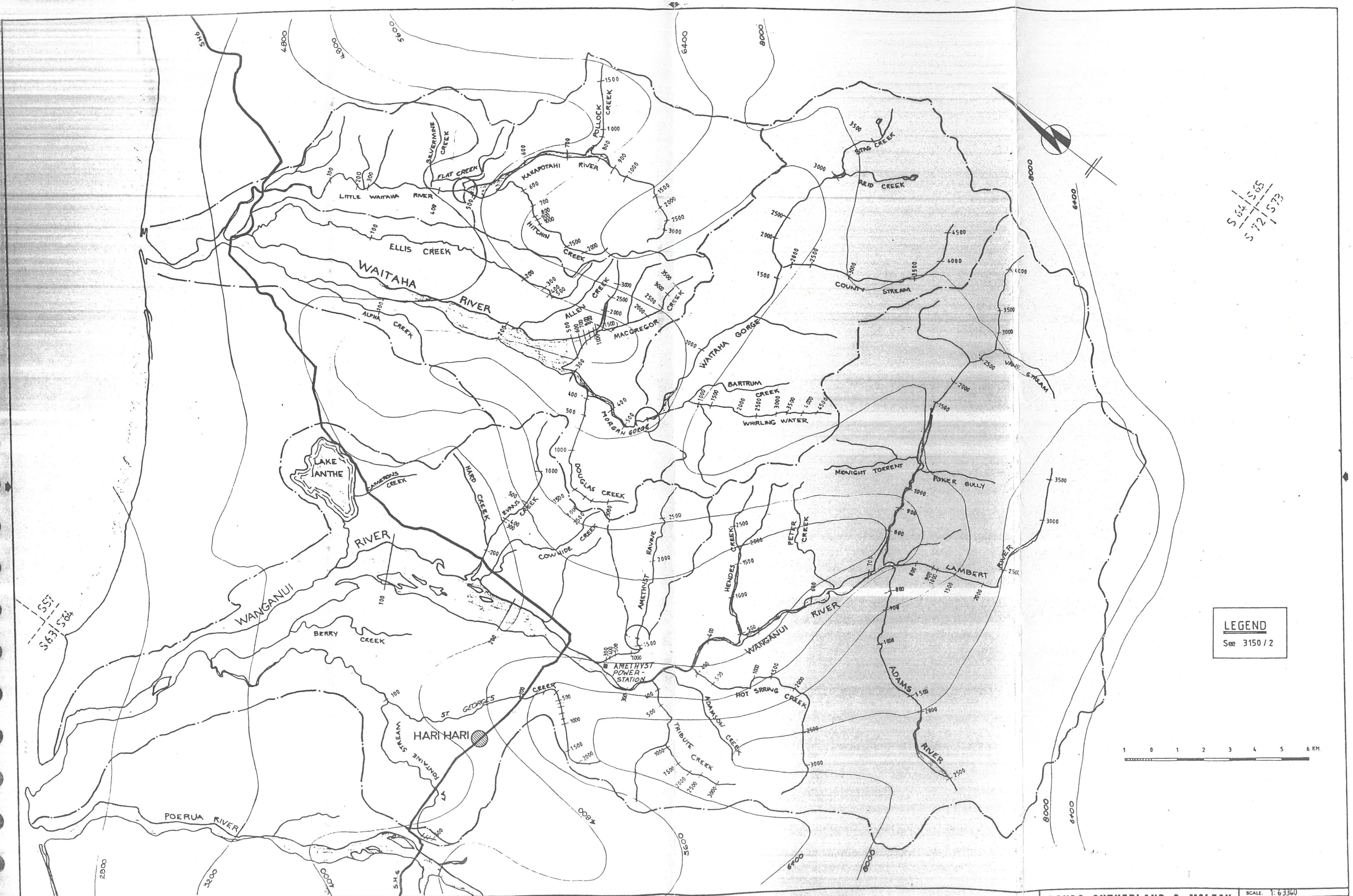
ROYDS SUTHERLAND & McLEAY

CONSULTING ENGINEERS
71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/12



No.	DATE	AMENDMENT	INITIAL	F.B.	INITIALS	DATE
				SURV.		
				DGN.		
				DR.		
				TR.	K.F.M	MARCH 80
				CH.		
				APP.		

WEST COAST HYDRO-ELECTRIC RESOURCE STUDY

WAITAHA AND WANGANUI RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

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NEW ZEALAND

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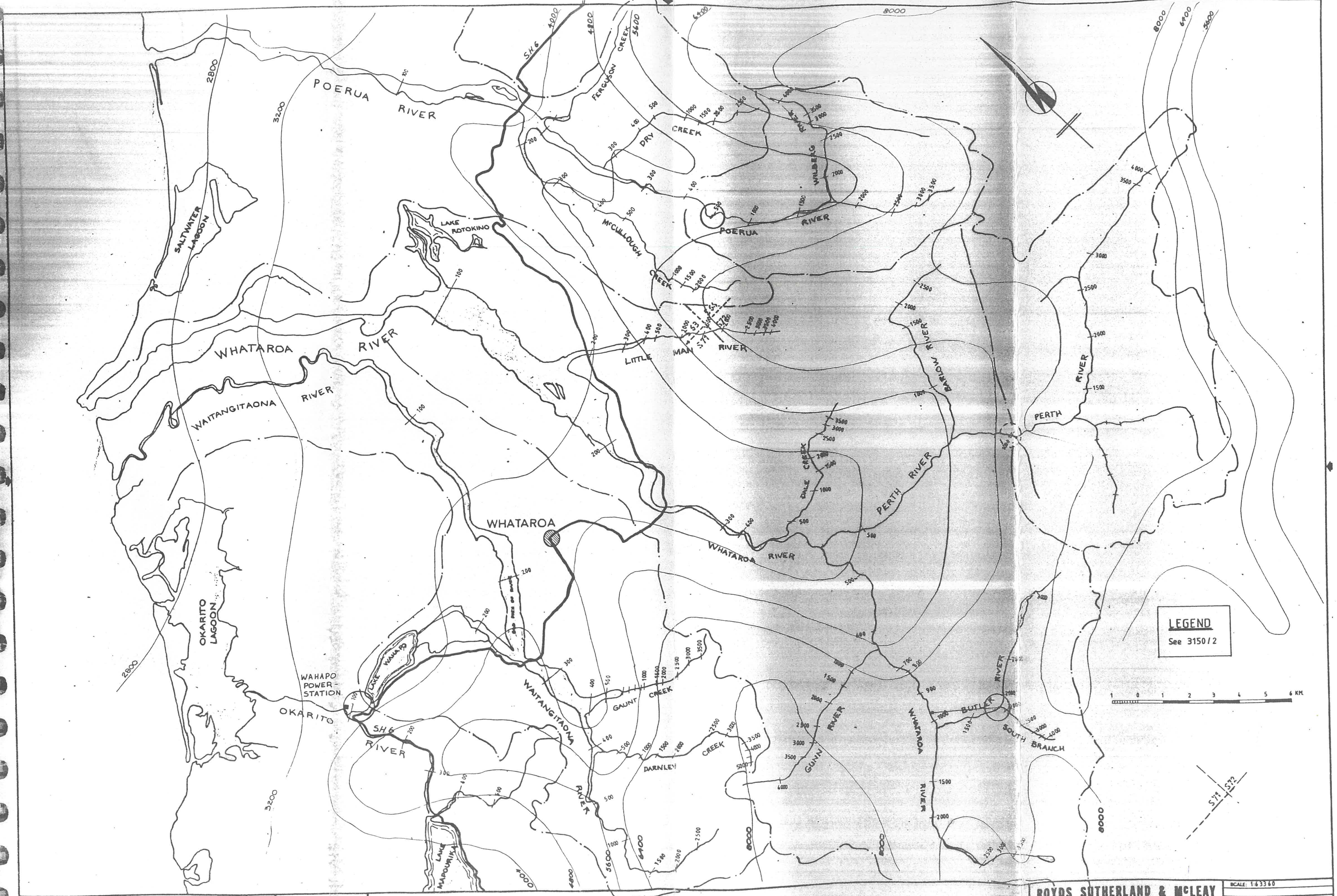
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/13



No	DATE	AMENDMENT	INITIAL
A	4/85	STAGE II	S.J.H.

F.B.	INITIALS	DATE
SURV.		
DGN.		
DR.		
TR.	K.F.M.	March 80
CH.		
APP.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

POERUA, WHATAROA AND WAITANGITONA RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

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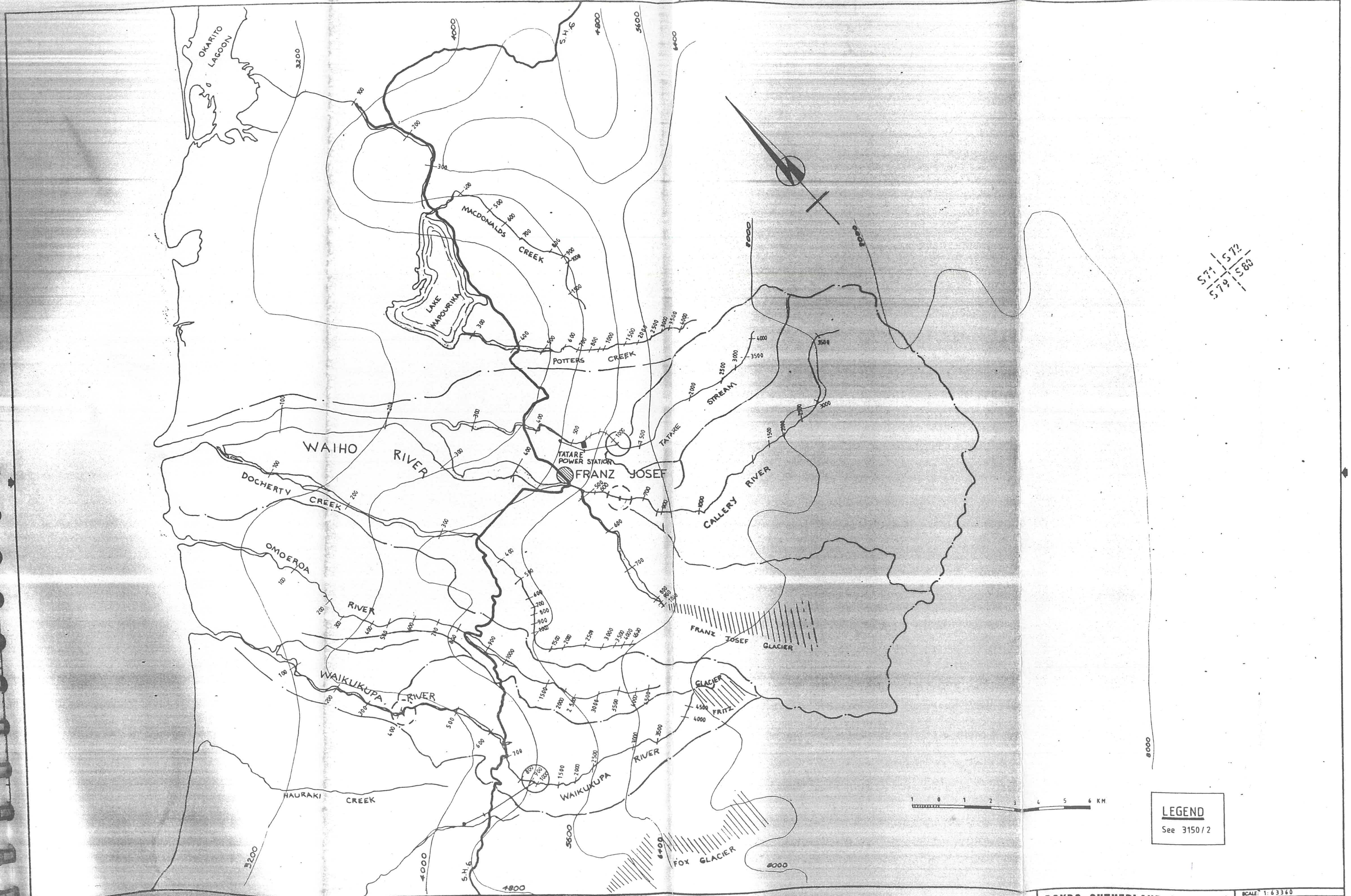
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/ 14 A



No	DATE	AMENDMENT	INITIAL
A	4/85	STAGE II	SJM

	INITIALS	DATE
F.B.		
SURV.		
DGN.		
DR.		
TR.	KFM	MARCH 90
CH.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

OKARITO, WAIHO, OMOEROA AND WAIKUKUPA RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

CONSULTING ENGINEERS
71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
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SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/15A