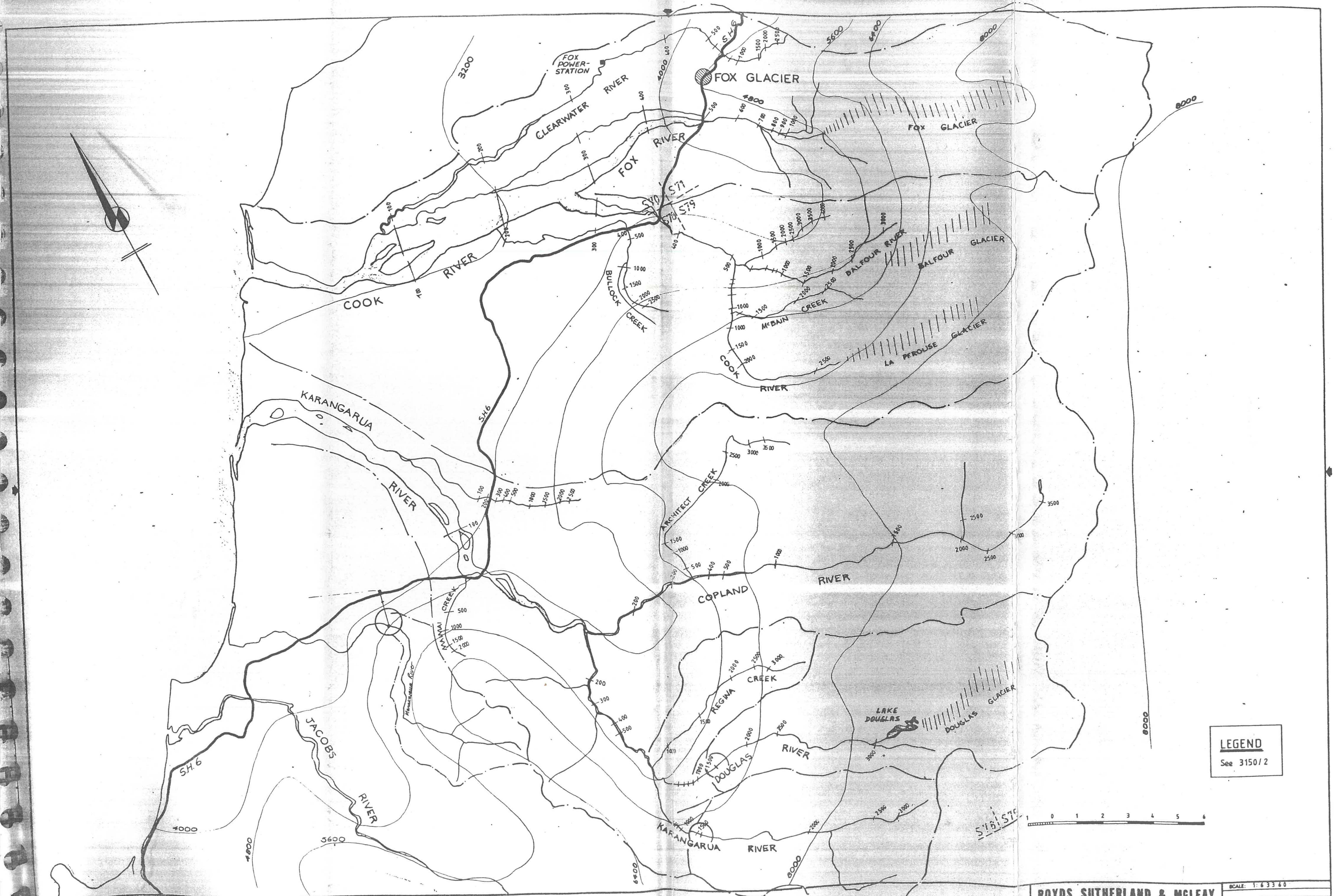


No	DATE	AMENDMENT	INITIAL
A	2/85		STH

	INITIALS	DATE
SURV.		
DGN.		
DR.		
TR.	K.F.M.	March 80
CH.		

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY

COOK AND KARANGARUA RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY

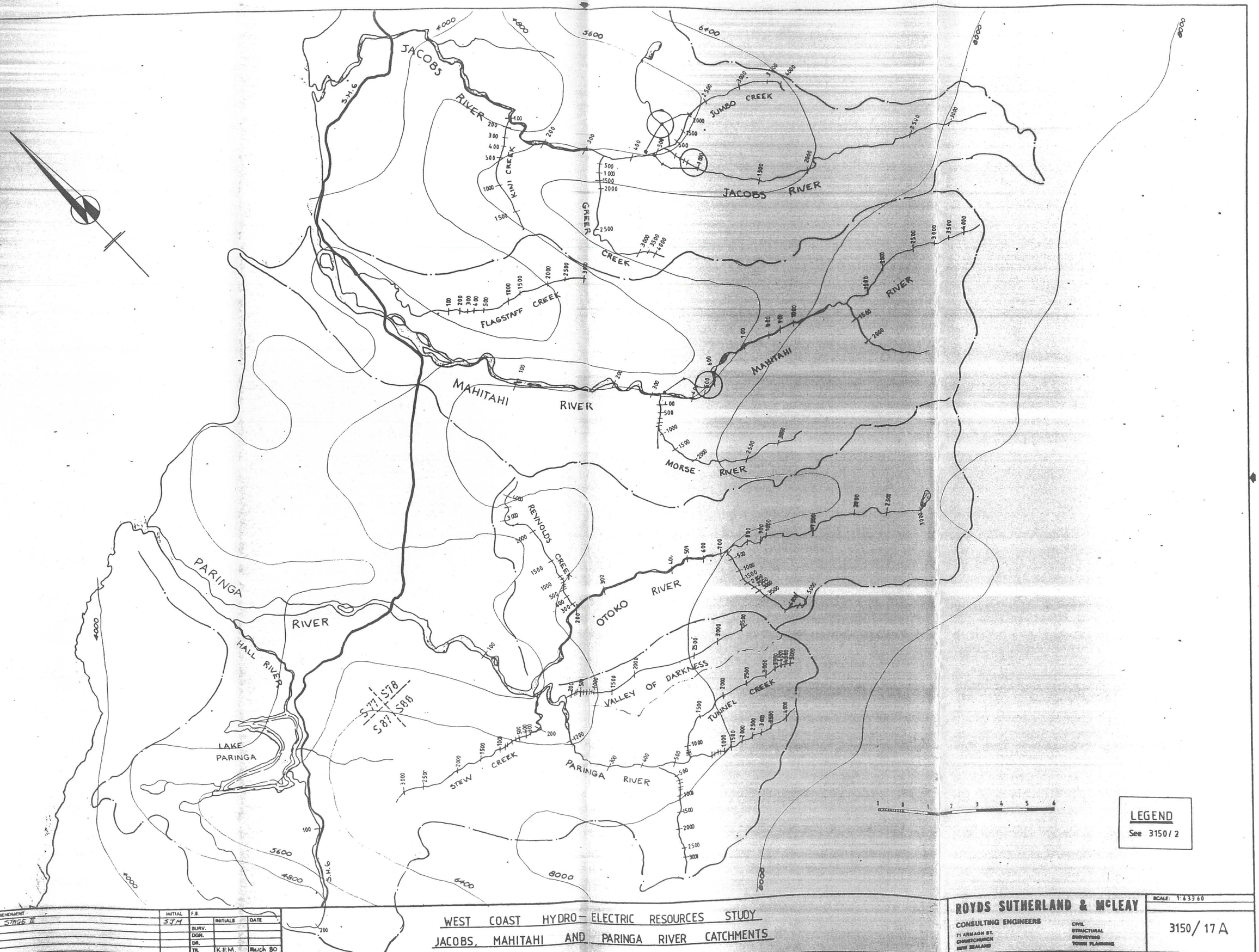
CONSULTING ENGINEERS

71 ARMAGH ST.
CHRISTCHURCH
NEW ZEALAND

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/16A



No.	DATE	AMENDMENT	INITIAL
A	4/85	STAGE II	SJM

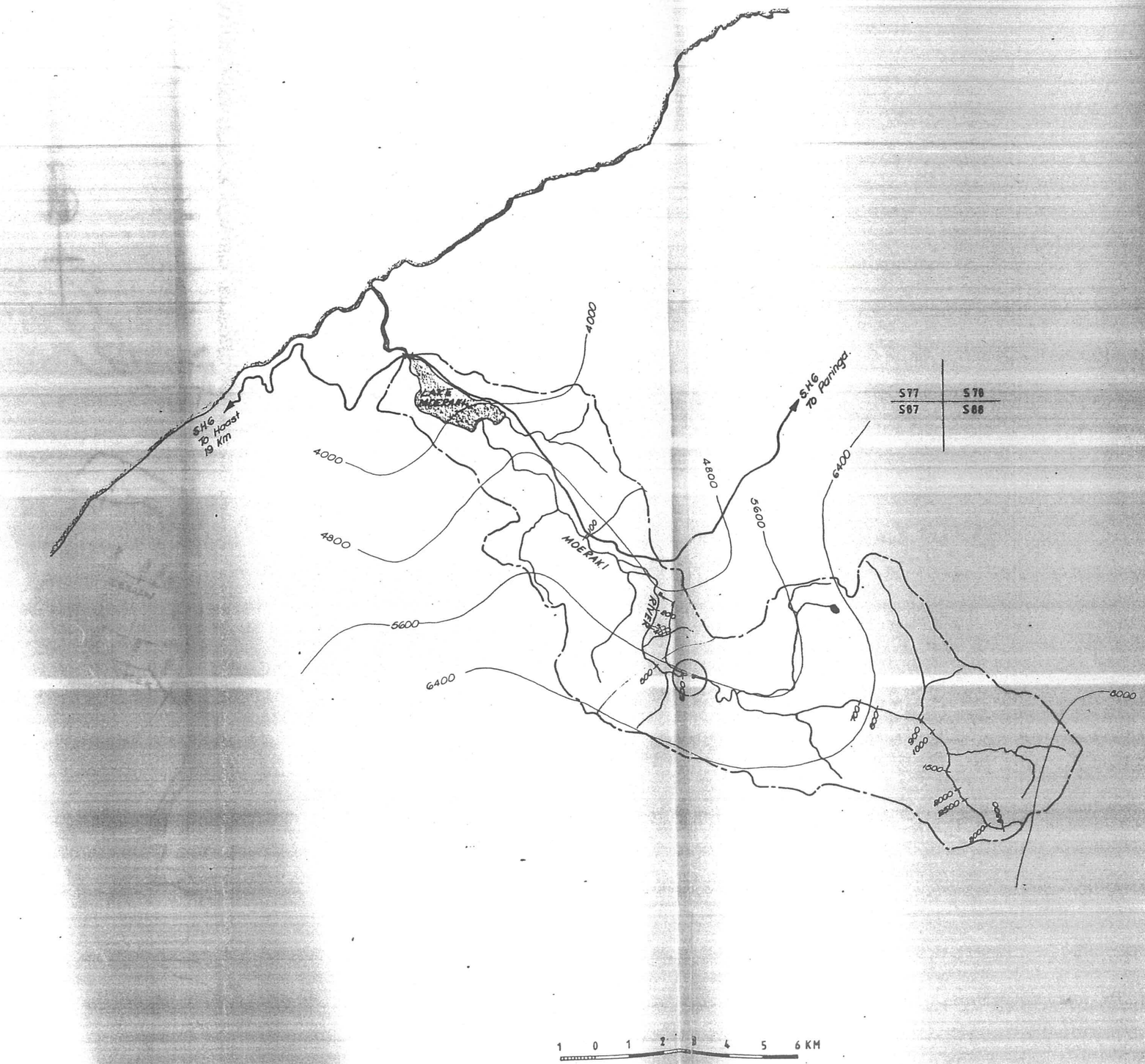
F.B		INITIALS	DATE
SURV.			
DGN.			
DR.			
TR.	K.F.M.		March 80
CH.			

WEST COAST HYDRO-ELECTRIC RESOURCES STUDY
JACOBS, MAHITAHI AND PARINGA RIVER CATCHMENTS

ROYDS SUTHERLAND & McLEAY
CONSULTING ENGINEERS
71 ARMAGH ST. CHRISTCHURCH NEW ZEALAND
CIVIL STRUCTURAL SURVEYING TOWN PLANNING

SCALE: 1:63360

3150/17A



S77	S70
S87	S88

LEGEND
See 3150/2

No	DATE	AMENDMENT	INITIALS	DATE
A	4/75	STAGE II		

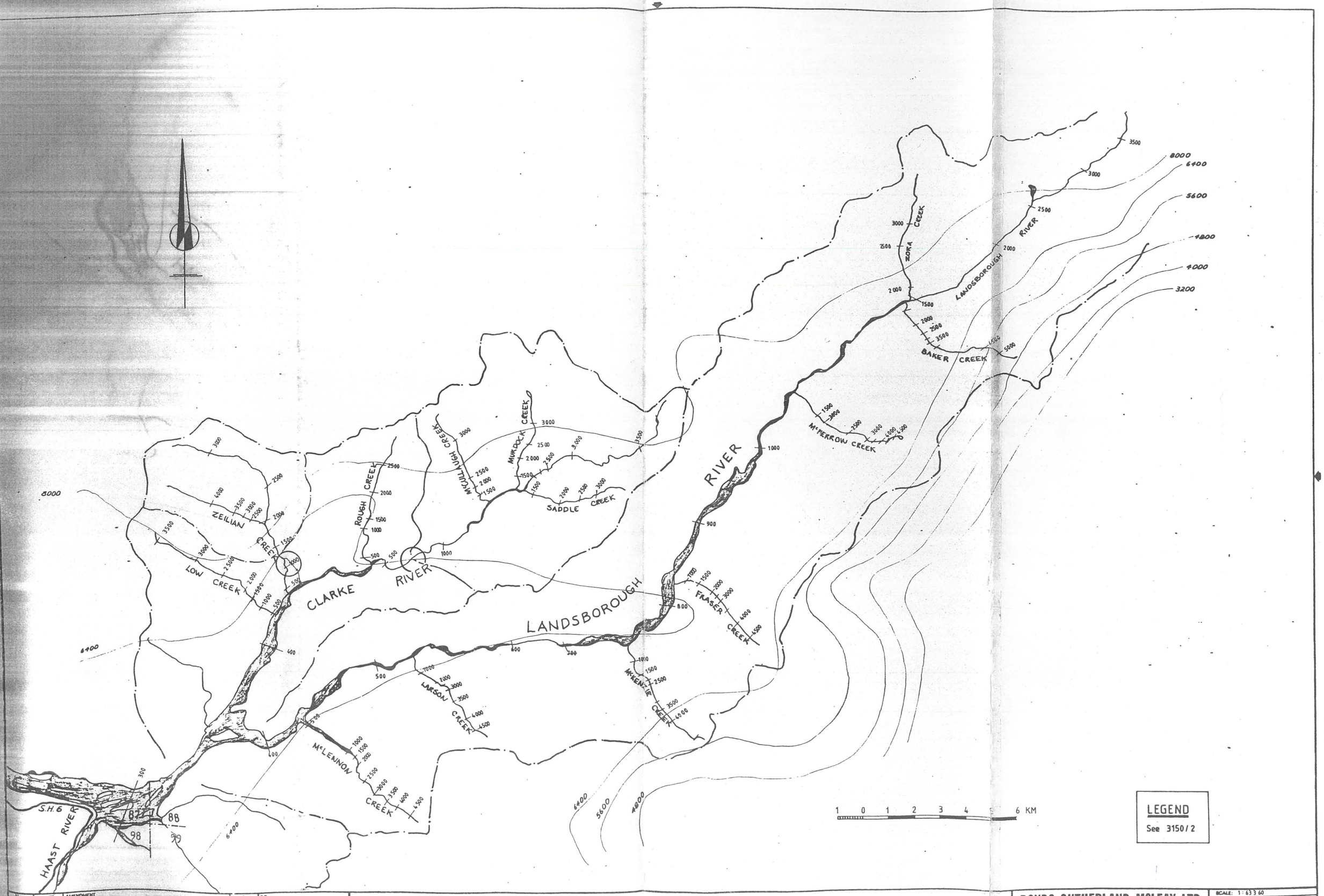
WEST COAST HYDRO - ELECTRIC RESOURCES ASSESSMENT

MOERAKI RIVER CATCHMENT

ROYDS SUTHERLAND McLEAY LTD.
CONSULTING ENGINEERS
CHRISTCHURCH
GREYMOUTH
PALMERSTON NORTH
CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE:

3150/18A



No	DATE	AMENDMENT	INITIAL
A	4/85	SAFE R.	SJM

	INITIALS	DATE
SURV.		
DGN.		
DR.		
TR.	K.F.M	MAY 80
CH.		
APP.		

WEST COAST HYDRO - ELECTRIC RESOURCES ASSESSMENT

LANDSBOROUGH AND CLARKE RIVER CATCHMENTS

ROYDS SUTHERLAND McLEAY LTD.

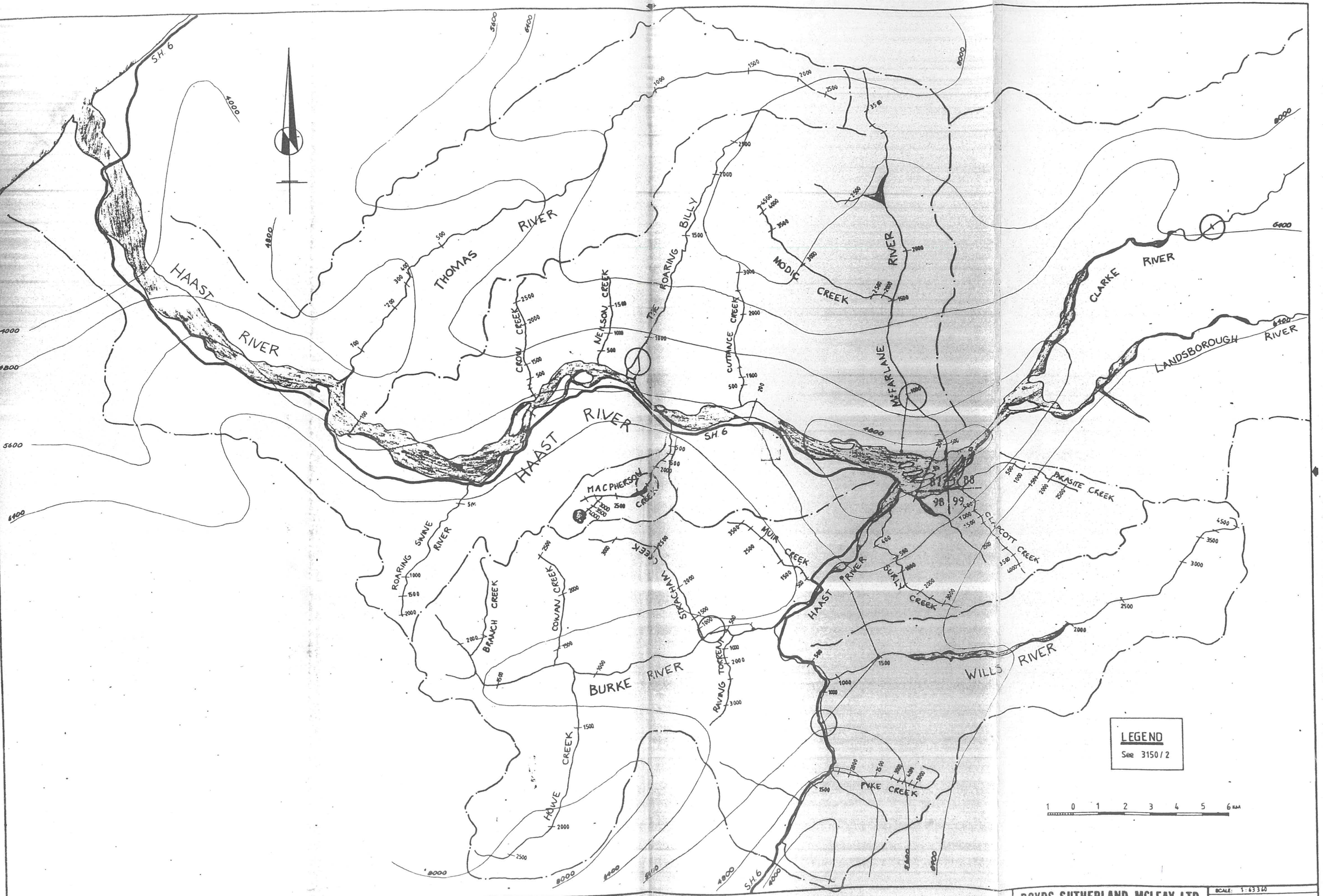
CONSULTING ENGINEERS

CHRISTCHURCH
GREYMOUTH
PALMERSTON NORTH

CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/19 A



No	DATE	AMENDMENT	INITIAL
A	4185	STAGE II	S.J.M.

F.B.	INITIALS	DATE
SURV.		
DGN.		
DR.		
TR.	K.F.M	MAY 1980
CH.		

WEST COAST HYDRO ELECTRIC RESOURCES ASSESSMENT

HAAST RIVER CATCHMENT

ROYDS SUTHERLAND McLEAY LTD.

CONSULTING ENGINEERS

CHRISTCHURCH, GREYMOUTH, PALMERSTON NORTH

CIVIL, STRUCTURAL, SURVEYING, TOWN PLANNING

SCALE: 1:63360

3150/20 A

JACKSON RIVER
CAULDRON CREEK
LAKE EVELYN
JOSEPH BROOK
TURNLEY CREEK
CURL CREEK
THOMSON CREEK
ARAWATA RIVER
TURNING FORK CREEK
HINDLEY CREEK
WAIATOTO RIVER
DONALD RIVER
DONAR RIVER
DRAKE RIVER
TE NAIHI RIVER
WAIPARA RIVER
CASEY CREEK
MUELLER RIVER
TURNBULL RIVER
OSSIFY CREEK
HAPUKA RIVER
VENTURE CONE
TURNBULL POWER STATION
NORTH NERGER CREEK
SOUTH NERGER CREEK
OKURU RIVER
LAKE DOUGLAS
FRANKLIN CREEK
LINDSAY CREEK
EMILY CREEK
NGATAU RIVER
PRINCESS CREEK

1 0 1 2 3 4 5 6 KM

LEGEND
See 3150/2

No.	DATE	AMENDMENT	INITIALS	DATE
A	4/86	STAGE II		

WEST COAST HYDRO - ELECTRIC RESOURCES ASSESSMENT

OKURU, TURNBULL, WAIATOTO AND LOWER ARAWATA RIVER CATCHMENTS

ROYDS SUTHERLAND McLEAY LTD.
CONSULTING ENGINEERS
CHRISTCHURCH
GREYMOUTH
PALMERSTON NORTH
CIVIL
STRUCTURAL
SURVEYING
TOWN PLANNING

SCALE: 1:63360

3150/21A

No.	DATE	AMENDMENT
A	4/85	STAGE II

WEST COAST HYDRO - ELECTRIC RESOURCES ASSESSMENT

UPPER ARAWATA AND CASCADE RIVER CATCHMENTS

ROYDS SUTHERLAND McLEAY LTD.

CONSULTING ENGINEERS

CHRISTCHURCH GREYMOUTH PALMERSTON NORTH

CIVIL STRUCTURAL SURVEYING TOWN PLANNING

SCALE: 1:63 360

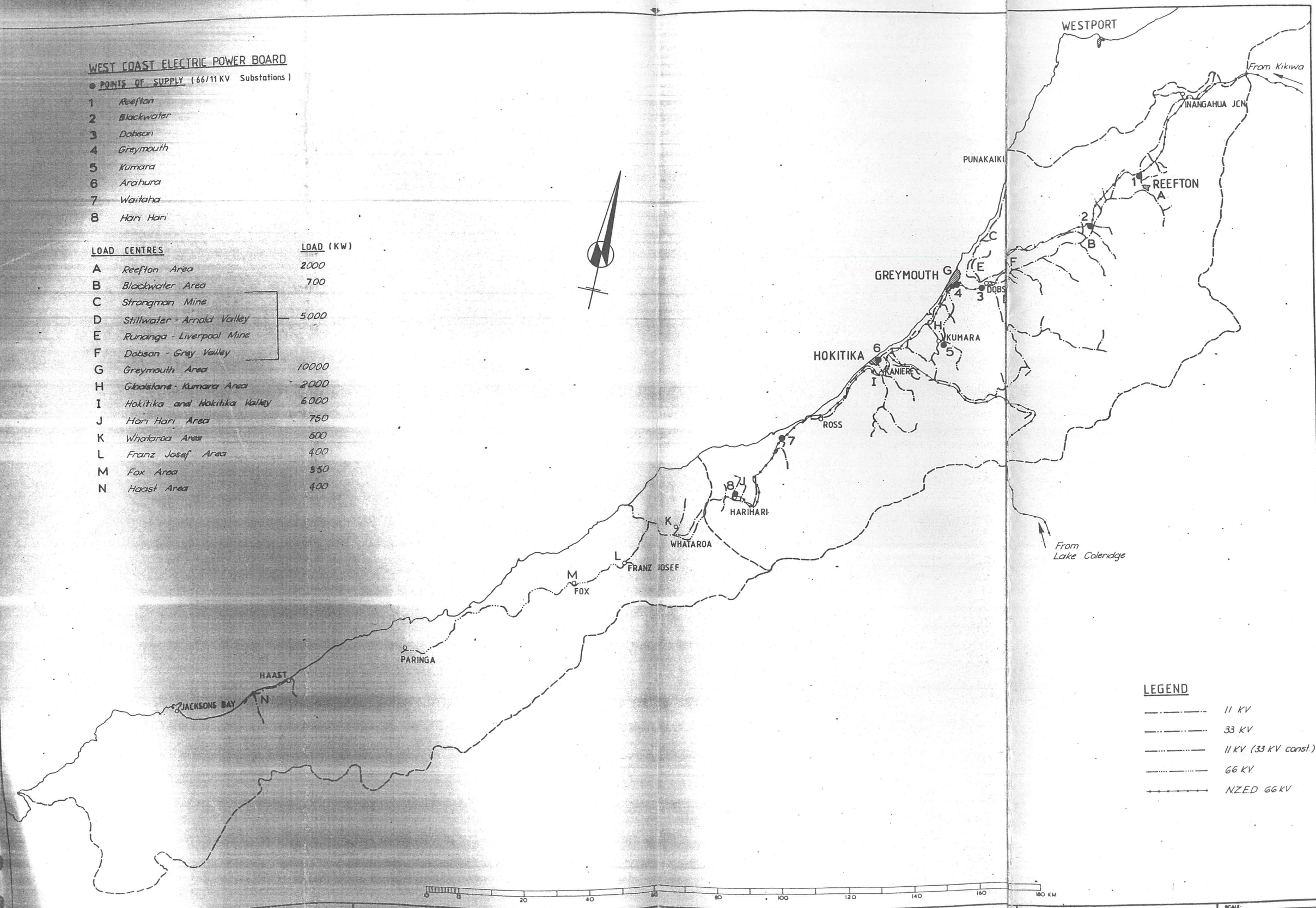
3150 / 22 A

WEST COAST ELECTRIC POWER BOARD

● POINTS OF SUPPLY (66/11 KV Substations)

1 Reefton
2 Blackwater
3 Dobson
4 Greymouth
5 Kumara
6 Arahura
7 Waitaha
8 Hari Hari

LOAD CENTRES		LOAD (KW)
A	Reefton Area	2000
B	Blackwater Area	700
C	Strongman Mine	5000
D	Stillwater - Arnold Valley	
E	Runanga - Liverpool Mine	
F	Dobson - Grey Valley	
G	Greymouth Area	10000
H	Globestone - Kumara Area	2000
I	Hokitika and Hokitika Valley	6000
J	Hari Hari Area	750
K	Whataroa Area	500
L	Franz Josef Area	400
M	Fox Area	350
N	Haast Area	400



LEGEND

- 11 KV
- 33 KV
- 11 KV (33 KV const.)
- 66 KV
- N.Z.E.D 66 KV

NO	DATE	AMENDMENT	INITIAL	F.S.	INITIALS	DATE
1	11/85	Loads Altered				

WEST COAST HYDRO - ELECTRIC RESOURCES ASSESSMENT

POWER TRANSMISSION NETWORK

ROYDS SUTHERLAND McLEAY LTD.
CONSULTING ENGINEERS
CHRISTCHURCH, GREYMOUTH, PALMERSTON NORTH
CIVIL, STRUCTURAL, SURVEYING, TOWN PLANNING

SCALE:

3150 / 23 A

APPENDIX C: WESTPOWER GENERATION DEVELOPMENT STRATEGY – HYDRO GENERATION SCOPING STUDY

WestPower Generation Development Strategy

Hydro Generation Scoping Study

PREPARED BY: [redacted]

PREPARED FOR: Westpower

DATE: 12 January 2005

Summary

The brief for this study was to review previous studies of Hydro Electric potential on the West Coast and provide a shortlist of schemes for more detailed investigation at a pre feasibility level.

A total of thirtyone (31) potential hydroelectric schemes had previously been identified in the reports that were reviewed. This was reduced to a short list of six (6) schemes for a site inspection and from this three schemes are recommended as the most appropriate for further work to a pre feasibility stage. Details of these schemes are shown in the table below along with details of the Amethyst scheme which has already been progressed to the pre feasibility stage. The Amethyst scheme would have been included on this short list.

Scheme Name	Installed Flow (m^3/sec)	Head (m)	Installed capacity. (MW)	Output (Gwh)	Estimated Civil Cost ($M)	Cost /kw	Discounted Cost/kwh (Cents)
Waitaha	20	115	22.5	138	42	1865	2.59
Kakapotahi	10	130	12.7	77	27	2100	3.06
Toaroha	10	210-300	20.5	122	41	2000	2.86
Amethyst	1.5	420	5.2	38	11.2	2150	2.57

Notes:

1. Installed capacity & costs based on lower head where a range is given
2. Output based on a Plant Factor of 70% except Amethyst 85%
3. Costs exclude mechanical/electrical and transmission costs.
4. Cost/kwh based on 20years and 6%

Table 1 Details of Schemes proposed for further study

It is recommended that pre feasibility work on the Waitaha and Kakapotahi schemes proceed in parallel with further work on the Amethyst scheme. These three schemes are in the same geographical area and there should be cost savings in undertaking further work on all three at the same timeframe.

Further work on the Toaroha scheme could be done at a later stage. Most of the costing information required for the Toaroha scheme would be obtained in the prefeasibility work on the other two schemes as the flow and head are similar.

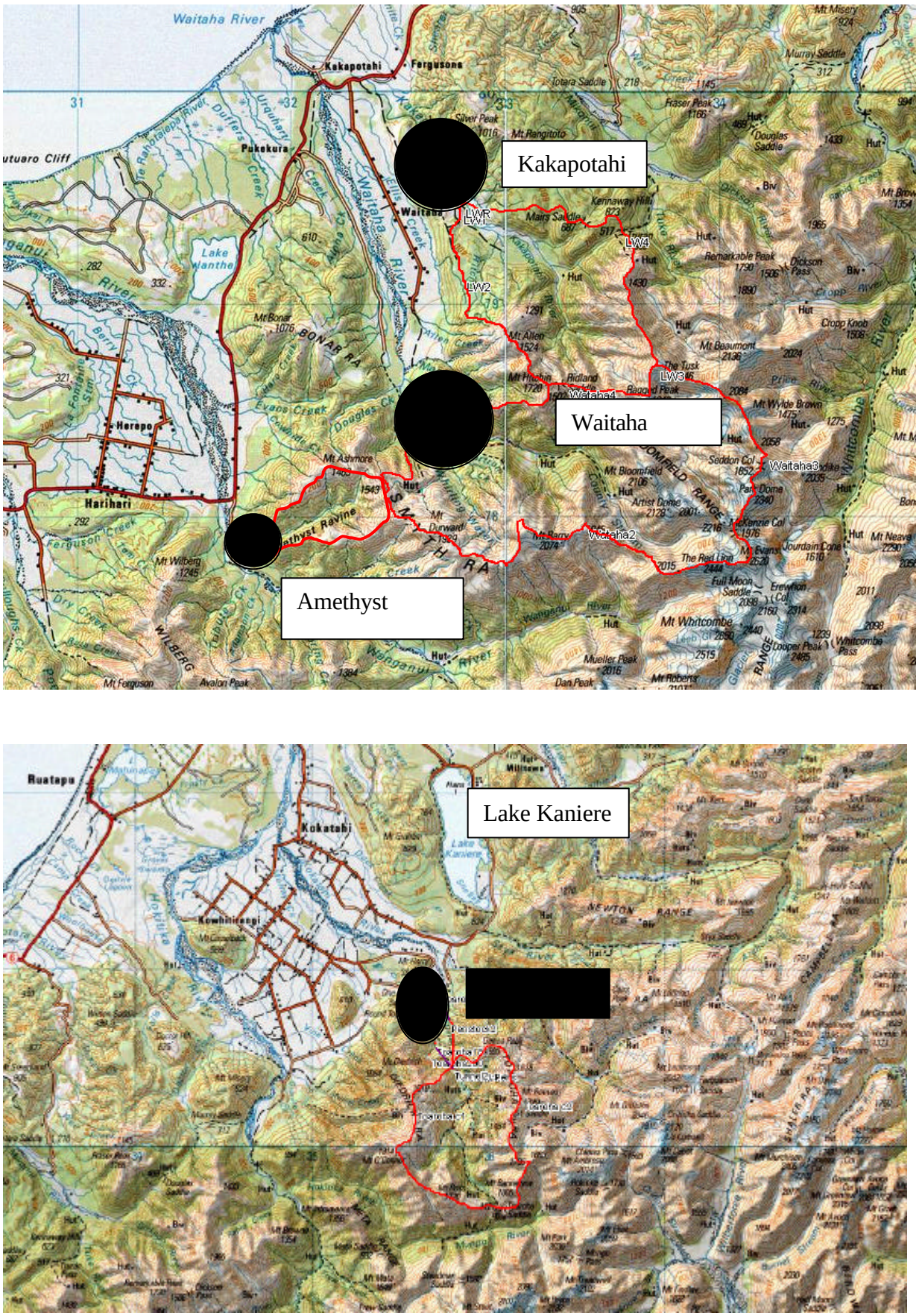


Fig 1 Location and Catchment Boundaries for Short Listed Schemes

1.0 Brief

To review previous studies of Hydro Electric potential on the West Coast and provide a shortlist of schemes (about 3) for more detailed investigation at a pre feasibility level.

The study was to identify land ownership and any potential issues that would require resolution for a scheme to proceed.

Initially no size limit was set by for the short listed schemes but as the study progressed there was a clear preference shown for the larger schemes.

2.0 Methodology

The methodology used was as follows:

1. Review the following:

   MWD report on Small Hydro Potential of the West Coast (1984) [1]
   MED Report on NZ Hydro Potential (2002) [2]
   Newspaper article by Dr Murry Cave in Greymouth Evening Standard

2. A brief scan of schemes in MWD report to get familiar with methodology used. This included all schemes from the Buller River to the Moeraki River.

3. An initial cut of schemes that were considered too remote, included a dam, or were excluded by river conservation orders.

4. A detailed Map study of remaining schemes using NZMS 260 series (MWD work done using older NZMS 1 Series maps)

   The aim of the map study was to check head availability and the proposed scheme layout and to briefly look at possible alternatives. Maps showing possible scheme layouts were prepared for future site inspections and reporting. The catchment area was measured and checked with the MWD report. The hydrology calculations were not checked at this stage.

   Details of the map study are provided in Appendix A.

5. A review of the Amethyst Scheme Pre Feasibility report by Geotech Consultants to assist with comparing this scheme with others.

6. An update of the costing information from MWD report and comparison with Amethyst

7. A short list of six schemes was prepared for site inspection. The site inspection consisted of a thorough aerial inspection by helicopter. Some of the schemes that had been deleted in the map study were also briefly inspected.

8. Review short listed schemes and costs in light of site inspection

9. Prepare final short list and report.

1. Small Hydro Electric Potential of the West Coast
Final Report September 1985
Prepared by Royds Sutherland and Mcleay Consulting Engineers
2. Ministry of Economic Development
Hydro Potential of New Zealand (2002)

3. Description of Short Listed Schemes

A description of each of the short listed schemes is provided in the sections below. Some of this information has been taken directly from the MWD report. This is shown in italics and is included for completeness. A plan showing the scheme layout and possible option is included.

3.1. Waitaha

3.1.1 Catchment Description

The Waitaha proper falls 2640m over its 40km length and drains 223km^2 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 greywacke 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. Some 400m west of the alpine fault is the secondary Fraser fault 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 8000m 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.

3.1.2 Scheme description

A power scheme utilizing 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 Robinsons Slip.

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 northern 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 bridge over a chasm in schist20 to 30m deep and some 15m wide. Because of this any settling basin would have to be underground and could be very expensive.

The 1984 scheme would have developed a head of 100m. The assumed installed flow was 48m3/sec and the output 40MW.

The site inspection highlighted the problems associated with both the road access to Kiwi Flat and the proposed intake site. The river is very confined at the intake to the Morgan Gorge and it would be a very difficult site to construct an intake.

There would appear to be an alternative intake site some 2 km upstream at the bottom end of the Waitaha Gorge. An intake here could feed water to a settling basin on the true right

with an open race leading to a tunnel intake either 1300m downstream of the intake or further downstream just before the start of the Morgan Gorge. A 1300m tunnel would then lead to a penstock and powerhouse either at the site proposed in the initial study or some 200m further downstream.

The most appropriate powerhouse and tunnel location would be assessed as a part of the prefeasibility study. It should not be difficult to provide road access to either of the powerhouse sites and the downstream tunnel portal. Access to Kiwi flat is very difficult and may have to be through the tunnel. The cost estimates have allowed for an access road.

The higher level intake site will provide perhaps 10m additional head but will miss the flow from the Whirling River catchment. The mean flow at the higher intake is estimated at $29m^3$/sec compared to $37m^3$/sec at the entrance to Morgan Gorge. However the loss of flow may be compensated by a much lower residual flow being required than if the intake was at Morgan Gorge as a good residual flow will be provided by the Whirling River.

For a plant factor of 70% the installed flow would be $20m^3$/sec and this with 115m head would provide an output of 22.5MW. A plant factor of 70% is considered more appropriate for a run of river scheme without any storage. The 50% plant factor used in the MWD report for all schemes was a requirement of the brief for that project.

The lower powerhouse site would provide an additional 10m of head but may require a longer tunnel.

The scheme lies entirely in crown land that is administered by the Department of Conservation. No particular environmental values are highlighted on their website.

3.1.3 Preliminary Cost Estimate

Waitaha Upper Powerhouse

Item		Length (m)	Rate	Total ($000)
Intake Weir				3500
Settling basin				2200
Open Race		2100	800	1680
Race Spillway/protection				1000
Tunnel		1300	8000	10400
Penstock Intake				1000
Penstock		400	9000	3600
Powerhouse				4000
Tailrace		50	800	40
Roading		3600	650	2340
Bridging		50	6000	300
Total				30060
Contingencies	25%			7515
Design & Inv.	15%			4509
				42084

3.1.4. Issues to consider

Issues that will need to be considered as part of the Pre Feasibility work are;.

1. Confirm suitability of upper intake site
2. Assess if a road can be constructed up to Kiwi flat
3. Confirm most appropriate tunnel route and powerhouse site
4. Review hydrology. (Gauging site at SH bridge no longer exists so will need to correlate with other sites.)
5. Further check that there are no major environmental issues

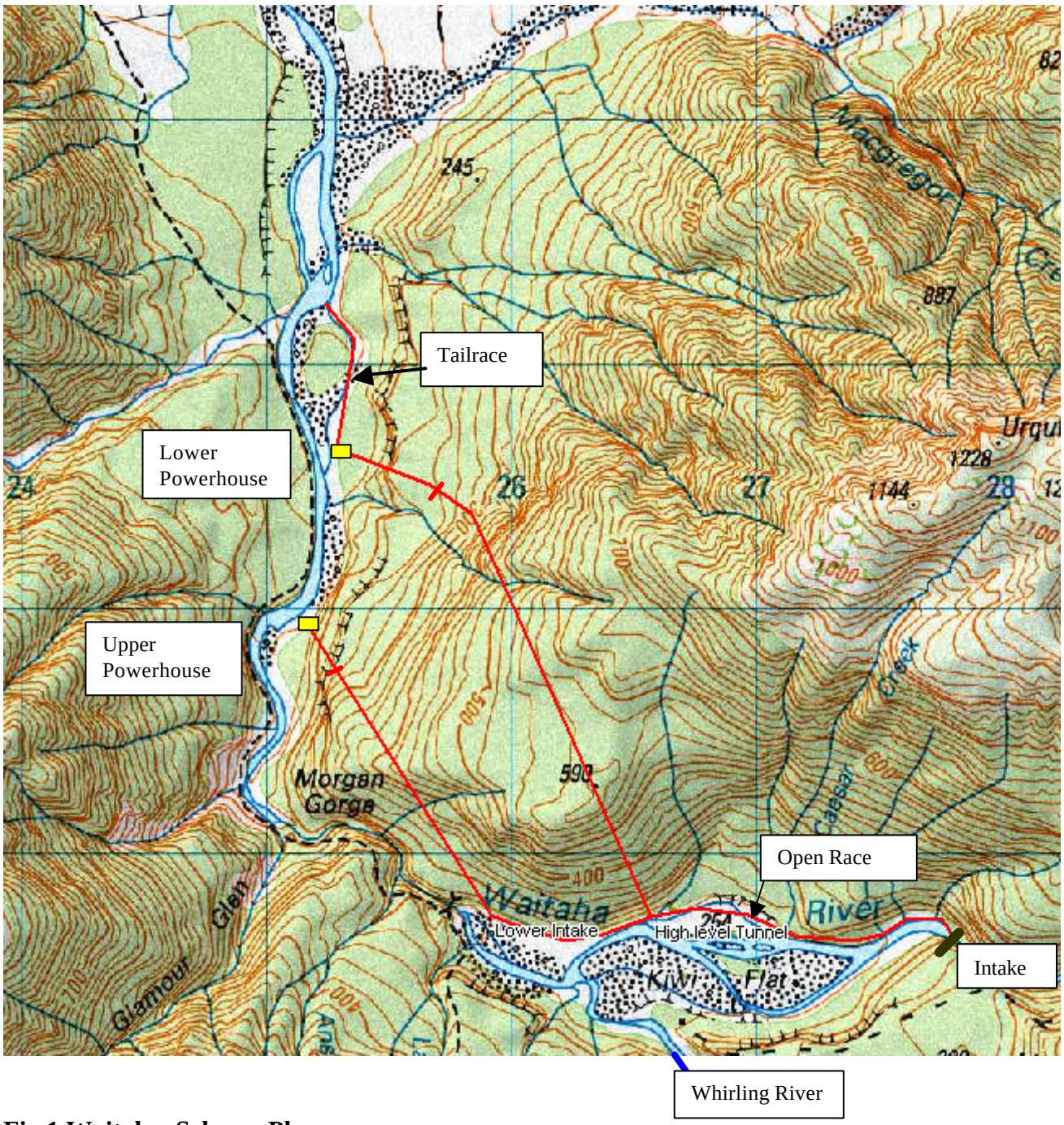


Fig 1 Waitaha Scheme Plan

Shows two possible tunnel and penstock alignments and powerhouse sites with a river intake at the outlet from the Waitaha Gorge.

3.2. Kakapotahi (Little Waitaha)

3.2.1 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 Hitchen 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 before joining the Waitaha.

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

3.2.2 Scheme Description

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 of head between Happy Valley and the Waitaha flats could be developed.

At the intake site the catchment area is 65km^2 and the mean flow is 14.5m^3/sec

The site inspection confirmed the suitability of the intake site.

The intake would consist of a diversion channel on the true right hand side and a 15m high structure to lift the water to the level of the adjacent terrace. This would be just below the road level. A settling basin would still be required as it is anticipated that any storage behind the intake structure would fill with gravel.

The open race would follow the 170-175m contour for 4.1km to a penstock intake above the Waitaha flats. The open race is in some challenging terrain and there may be a need to have some deep cuts (up to 25m) or even a short section of tunnel. The positive is that there is also the opportunity to provide valuable storage on the race alignment.

An 800m long penstock would lead from the end of the race to a powerhouse adjacent to Ellis Creek. A 1400m tailrace would then take the flow back to the Waitaha River. The tailrace would be across farmland and in alluvial gravels.

For a plant factor of 70% the installed flow would be 10m^3/sec and the installed capacity 12.7MW.

The open race nad part of the penstock would be on land currently owned by Timberlands. The diversion for the intake on the true right bank is crown land administered by DOC. The powerhouse, part of the penstock and tailrace would be on privately owned land. Some 80ha of land on the Happy Valley flats above the intake would be flooded. Most of this is within the river boundary and crown land but some is privately owned.

3.2.3 Preliminary Scheme Costs

Kakapotahi

Item		Length (m)	Rate	Total ($000)
Intake Weir				5850
Settling basin				1200
Open Race		3650	800	2920
Open Race(Deep Cut)		800	2500	2000
Penstock Intake				500
Penstock		800	4300	3440
Powerhouse				2500
Tailrace		1400	400	560
Roading		0	0	0
Bridging(Tailrace)		30	6000	180
Total				19150
Contingencies	25%			4788
Design & Inv.	15%			2873
				26810

3.2.4 Issues to Consider.

Issues that will need to be considered as part of the Pre Feasibility work are;

1.Confirm available flow and installed flow.

The scheme involves diverting water from one catchment to another and a reasonable base flow will have to be left in the Kakapotahi. The gorge below the intake is also a popular kayaking site and the scheme assessment would need to recognize that flows higher than the base flow may have to be provided for kayaking from time to time.

2. A more accurate assessment of the dimensions of the intake structure.
2.Confirm the most appropriate race alignment and potential storage.
3.Check if Ellis Creek could act as the tailrace. This will depend on the installed flow.
4. Further check that there are no major environmental issues

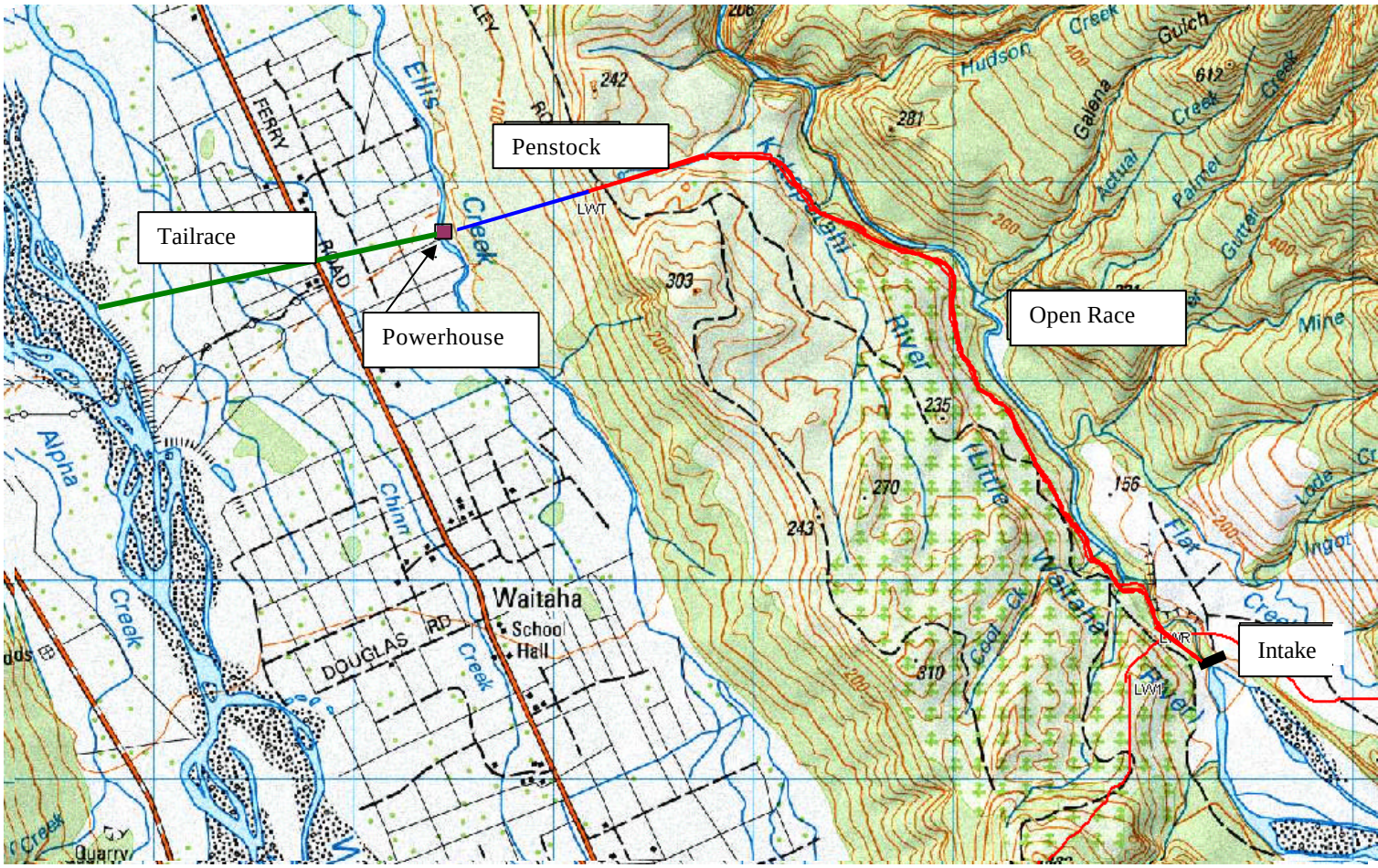


Fig 2 Kakapotahi Scheme

3.3. Toaroha

3.3.1 Catchment Description

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 northern direction and is enclosed by 1500 to 1800m peaks.

The entire catchment is of schist with alluvial deposits on the small river flats and river shoulders downstream of the gorge.

Eight kilometers above the Kokatahi junction lies a gorge known as the Toaroha canyon which falls steeply as it passes around the toe of a major westward protruding spur.

3.3.2 Scheme Description

The scheme would consist of a river intake at the 420m level, about 200m above the start of the canyon, with a 1000m tunnel leading to a 600m penstock and powerhouse on the side of the river below the canyon. This would provide some 210m of head for generation. Bedrock is visible on one side of the river at the intake site.

The catchment area above the intake site is 46.5km^2 and the mean flow is 12.1m^3/sec. With a plant factor of 70% the installed flow would be 10m^3/sec and the installed capacity 20.5MW.

Some 4.8km of new access road would be required to the powerhouse and downstream tunnel portal and this would be expensive due to the very steep cross fall in places. A further 1.6km of access road would be required to the intake site but access to the intake may need to be through the tunnel.

A much larger scheme requiring a 2.7km tunnel and 1700m of penstock leading to a powerhouse on the flats 3.6km upstream from the Kokatahi river junction would provide an additional 90m of head and an output of 29MW. Initial cost estimates indicate that the power from this larger scheme would be more expensive but still is at a low enough cost to be worth exploring at the feasibility stage. The viability is very dependant on tunneling costs. Roading costs would be significantly reduced if access to the intake via the tunnel was acceptable.

The scheme is all on crown land managed by the Department of Conservation. No significant environmental issues are noted on their website.

3.3.3 Preliminary Scheme Costs

Toaroha Upper Powerhouse

Item		Length (m)	Rate	Total ($000)
Intake Weir				4000
Settling basin				4000
Tunnel Portal/Penstock Intake				1000
Tunnel		1000	8000	8000
Penstock		600	5000	3000
Powerhouse				4000
Tailrace		50	800	40
Roading		6400	750	4800
Bridging		100	6000	600
Total				29440
Contingencies	25%			7360
Design & Inv.	15%			4416
				41216

3.3.4 Issues to Consider.

Key issues that will need to be considered as part of the Pre Feasibility work are;

1.Suitability of Intake site
2.Viability of higher head scheme.
3.Assess if an access road can be constructed to the intake site.

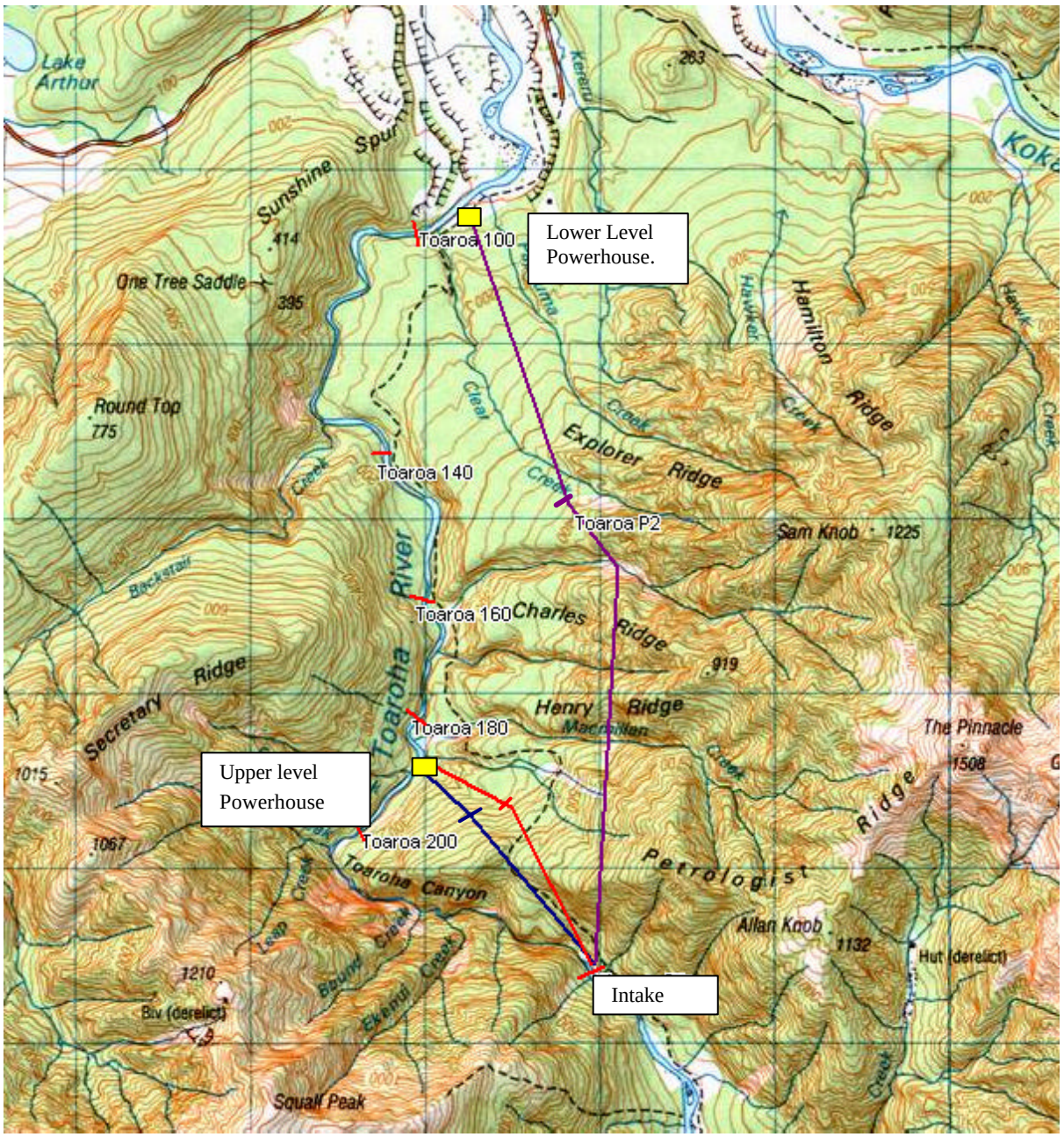


Figure 3 Toaroha Schemes.

Red and blue lines show two possible tunnel and penstock alignments to an Upper level powerhouse.

Purple line shows possible tunnel and penstock to a lower level powerhouse.

Access road assumed to follow walking track

3.5 .Amethyst Hydro Scheme

Geotech Consultants Ltd has prepared a prefeasibility report for the Amethyst scheme. The brief required that this scheme was reviewed and compared with the schemes selected in this study.

The review has shown that the Amethyst scheme should be included in any short list for future development. The reason for this is the combination of high head with a reliable flow and good access to the powerhouse. The Amethyst compares favorably on a cost basis and the added bonus is that water rights for the scheme appear to be readily obtainable. Technical and environmental issues are also well understood.

3.6 Taramakau River

A scheme on the Taramakau that involves diverting flow to Lake Brunner was suggested as the preferred scheme for the West Coast in a newspaper article written by Dr Murry Cave.

It was not considered in the MWD study as it was outside the scope. Map studies and a site inspection have confirmed that a scheme may be possible. A possible layout is shown on Fig 3.6.1.

The scheme would consist of an intake on the Taramakau near Inchbonnie feeding water to a large settling pond beside the river. An open race would then carry water to two powerhouses with a tailrace leading to Lake Brunner.

The mean flow at Inchbonnie is estimated to be 105m^3/sec and with a plant factor of 70% the installed flow would be 94m^3/sec.The difference in level between the Taramakau at Inchbonnie and Lake Brunner is 50m. Assuming a net head of 45m the installed capacity would be 41.5MW.

The estimated cost for this scheme is $130 million.

There are two major issues with this scheme. The first is the impact such a large diversion would have on Lake Brunner and the Arnold River. The diverted flow would increase the mean outflow from the Lake from 55 to 150m^3/sec. The sediment in the Taramakau water may well alter the look of Lake Brunner and have a negative impact on the ecosystem of the Lake.

The second issue is providing a suitable intake on the Taramakau that will operate under all river conditions and provide water that is acceptable to discharge into Lake Brunner.

The scheme is more expensive (on a cost/kw basis) than others considered in this study and the two issues mentioned above are likely to take a considerable time to research and resolve. For this reason the scheme has been dropped from further consideration.

Fig 4 Taramakau: Possible Scheme

4. Basis of Costing Schemes

The MWD report contains a comprehensive costing appendix in a form suitable for use in other hydroelectric assessments. Some pages were missing but these were available from the Nelson hydroelectric assessment study done in 1978.

The costing used in the earlier assessments have been updated using the movement in cost indices obtained from Rawlinsons New Zealand Construction Handbook. These were then checked against recent estimates for civil engineering work.

The movement in the Indices has been as follows

Date	MWD CCI Index	CGPI Index Other Construction	Factor to Sept 2004
Sept 1978	981		4.7
Sept 1984	2180		2.1
June 2002	4400	1113	
March 2004		1144	
Sept 2004		1165 Assessed	

In general the updated figures were considered sufficiently accurate to use for this initial study with two exceptions. These were tunneling and penstock costs where the Index updated costs were significantly higher than costs obtained by Geotech consulting for the Amethyst scheme

For the penstocks the indexed cost is $12500 per tonne of steel compared to a figure of $6700 per tonne installed in the Amethyst costing. The penstock diameter required for most of the schemes in this study is greater than the diameter for the Amethyst (1.8 to 3.0m compared to 900mm) This is likely to mean higher transport and installation costs and larger support and anchor block structures. Hence a figure of $8000 per tonne has been used.

For the tunnels the indexed cost for a 2.5m diameter tunnel is $13,600/m compared to a figure of $4000/m used in the Amethyst costing. Geotech have done considerable research into tunnel costs and there is no reason to doubt their figures

Most of the schemes in this study would require a tunnel size of 2.5 to 4.0m dia or possibly 5m dia. if the tunnel is to be used for road access. Hence tunnel costs ranging from $6000/m to $9000/m have been used depending on size and length of the tunnel.

Appendix A

Scheme Details and Comments for schemes that were considered in more detail.

Listed from South to North

Waikukupa
Tartare
Kakapotahi
Waitaha
Toaroha
Arahura 2
Arahura 1
Taipo
Taramakau
Ahaura
Big
Rough
Alexander

Scheme Name	**Waikukupa**	
NZMS 260 Map Reference	Sheet H35	
Brief Description	Intake at 440m m level 3 km tunnel and then 1km penstock to Powerhouse on Clearwater River.	
Some Dimensions	Tunnel Penstock	2.5 m 1.5m
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	130 m 5.0 m^3/sec 5.5 MW 29 Gwh 5D	230 m
Issues	The eroding nature of the catchment and potential degradation of the bed at the intake. River is very steep and the head would need careful checking. Difficult to pick contour level at intake site. Higher head with a lower flow may still produce a viable scheme. Well south of load centre and outside brief.	
Assessment	Delete from Study	

Scheme Name	**Tartare**	
NZMS 260 Map Reference	Sheet H35	
Brief Description	Intake at 340 m level 1250 km tunnel and then 400 m penstock to Powerhouse at about 165 m level.	
Some Dimensions	Tunnel Penstock	2.5 m 1.2 m
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	180 m 4.0 m^3/sec 5.9 MW 31 Gwh 4C	175
Issues	The eroding nature of the catchment and potential degradation of the bed at the intake. Previous scheme had problems with this Suitability of Intake site. Ground conditions for tunneling. Scheme is in National park with walkway into old power scheme. Well South of load	
Assessment	Delete from Study	

Scheme Name	**Waitaha**	
NZMS 260 Map Reference	Sheet I34	
Brief Description	Intake at Head of Morgan Gorge at 240m level Settling basin in Tunnel with flushing Adit 1400m Tunnel to Penstock and Powerhouse	
Dimensions	Tunnel Size Penstock Tunnel Length Penstock Roading Length	5.2m 4.0m 1400m 350m 4.5 km
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	100m 48 m^3/sec 40 MW 175 Gwh 1A	100-140 possible On High side
Issues	Suitability of Intake Site. Appears possible from photo in MWD report Very High Installed flow for an underground settling Basin especially with a high bedload. Scheme may well be more viable at lower installed flow. Check access to Powerhouse comment in MWD report A range of Tunnel lengths and powerhouse sites to consider in next stage. Eg Tunnel of 3km could gain an extra 40m head. Note similarity/proximity to Amethyst . Very close to the Alpine fault	
Land:	All crown land under DOC management	
Assessment	Leave in for Site Visit	

From Site Inspection (20 Dec 2004)

Intake as proposed could be difficult to construct as site is very constrained with little room for a diversion.
Alternative could see an intake at downstream end of the Waitaha Gorge with an open race leading to a settling basin on the right bank some 200m above the Morgan Gorge.
This would reduce flow by about 20% but has advantage of good site for a stilling basin beside the Waitaha river.
Upper and lower powerhouse sites both appear feasible.

Scheme Name	**Kakapotahi (LittleWaitaha)**	
NZMS 260 Map Reference	Sheet I34	
Brief Description	Intake at end of Happy Valley Flat at 150m level? 4 km open race to tunnel and then penstock to powerhouse on Waitaha Flats. 1.4 km tailrace to Waitaha River	
Some Dimensions	Open Race Tunnel/Penstock Race Tunnel Tunnel Dia Penstock Length Tailrace	Similar Branch 2.5 m 4100m 700m 3.5m 700m 1400m
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	115 m 17.4m^3/sec 17 MW 75 Gwh 1A	110-115 appears high
Issues	Suitability of Intake Site. From photo it appears to be in a steep Chasm. Unsure of site for settling basin and link to open race . Open Race is in some challenging terrain. Positive is that here may be some valuable storage on the race alignment but there may also be some deep cuts or a need to tunnel short sections. Would need to look carefully at installed flow. Powerhouse site is on side stream. Could it act as tailrace? Route for tailrace?	
Environmental Issues	Diversion of flow into another river Recreational Use?	
Land	DOC on the true right (Diversion) Timberlands on the left for all race alignment Private land. powerhouse and tailrace sites and flats above intake.	

From Site Inspection (20 Dec 2004)

Intake site appears suitable with room to construct a diversion on the true right.
Dam structure to lift intake level to about RL175 would allow for stilling basin and an easier open race(over the first part). This higher level may also allow for race to avoid difficult spur at about 3km mark and may also allow for elimination of tunnel. (Or at least make a cut and cover section possible)

Stream at Powerhouse(Ellis Creek) may be OK to use as the tailrace with a lower installed flow.

Scheme Name	**Toaroha**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 400 m level at Head of Toaroha Gorge 1 km tunnel and then 675 m penstock to Powerhouse at about 190 m level.	
Some Dimensions	Tunnel Penstock Tunnel Length Penstock Length Road to PH	3.2 m 3.2 m 1000m 675m 7.0 km
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	210 m 14.5 m^3/sec 25 MW 110 Gwh 1A	210m
Issues	Note Page 27 missing from MWD report.(Obtained from a draft copy) Suitability of Intake site. Ground conditions for tunneling. Long access road in with some difficult spots. Is tunnel access the only way to the Intake Site? A more extensive scheme would place the powerhouse on the flats. Tunnel length increases to 2.7km and the penstock to 1.7km for an extra 90m of head.	
Land	DOC.	
Assessment	Leave in for Site Visit	

From Site Inspection (20 Dec 2004)

A possible intake site noted but will be a challenge.
Very difficult terrain for road construction to both the powerhouse and the intake sites.

The more extensive scheme appears possible but needs costing to confirm if can be justified.

Scheme has considerable potential and worth investigating further at some stage.

Scheme Name	**Arahura 2**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 60 m level 7.6 km open race on true right and then 675 m penstock to Powerhouse at about 30 m level.	
Some Dimensions	Race Penstock Race Length Penstock Length	15m at Invert .30 at top 2 *3.2 m 7600m 380m
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	30 m 53 m^3/sec 13 MW 57 Gwh 3B	
Issues	Very large flow & relatively low head. Could easily see head reduced substantially with settling basin and penstock losses Suitability of Intake site. Likely to be a high bed load which will need a large settling basin. Ideally need to be able to form a ponding area like the Branch scheme. Race follows scarp on right bank and will involve significant cuts. River Bed Ownership	
Assessment	Delete from study.	

Scheme Name	**Arahura 1**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at top of second gorge at 200 m level Then 825m tunnel to penstock intake and powerhouse	
Some Dimensions	Tunnel Penstock Penstock Length Road to PH	4.6m Dia 2 *2.8 m 350m 6 km
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	60 m 36 m^3/sec 18 MW 79 Gwh 1A	55 m at most
Issues	Very large flow for a scheme with a tunnel. Need to check if any storage is available below tunnel. Suitability of Intake site. Likely to be a high bed load which will need a large settling basin. Not at all clear if suitable space is available from Topo maps. River Bed Ownership	
Assessment	Delete from study	

Site Visit on 20 Dec confirmed constraints at intake end.

Scheme Name	**Taipo**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 200 m level 2.3 km tunnel and then 400 m penstocks to Powerhouse at about 130 m level. 500m Tailrace to Taramakau River	
Some Dimensions	Tunnel Penstock Tunnel Length Penstock Length	5.4 m 2 *3.2 m 2300 675
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	75 m 54 m^3/sec 33 MW 180 Gwh 2A	55 to 60
Issues	Suitability of Intake site. Ground conditions for tunneling. Long access road in with some difficult spots. Pre feasibility report done in 1990's. This is now the property of Trustpower. Scheme proposed in this report was on the true left not the true right as described above	
Environmental	Proximity to national park and a popular tramping area.	
Assessment	Delete from Study. Low Head high flow for a tunnel scheme. Also not a positive history with WCPB.	

From Site Inspection (20 Dec 2004)

The most suitable intake site is further downstream than indicated in the MWD report and would explain the true left option. The open race terrain on the left appeared very challenging.

Scheme Name	**Taramakau**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 140 m level near Inchbonnie Intake with a stilling basin adjacent to the Taramakau River. Large open race leading to **two powerhouses** in parallel with discharge into Lake Brunner. Open race would be on the true left of the valley between the river and Lake Brunner. Penstocks and powerhouses cut unto spurs.	
Some Dimensions	Open race Open Race length Penstock Penstock Length	8m Invert 4m depth water 8.5km 2*5m Dia 100m at each powerhouse
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	Not included in MWD report	50m (25 at each powerhouse) 95m3/sec 2*23 MW 180Gwh (70%PF)
Issues	Suitability of Intake site and whether a stilling basin can be constructed that can be flushed. Suitable Powerhouse sites would need to be confirmed. Very large fills and cuts will be required	
Environmental	Diversion of such a large flow into Lake Brunner. Impact on water quality in Lake Brunner and hence on fishery and wildlife. Impact on Arnold River. Mean flow would increase from 54 to 145 m3/sec	
Assessment	Delete from Study.	

From Site Inspection (20 Dec 2004)

Intake site remains a concern.

Scheme Name	**Ahaura**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 200m level Open race to penstock intake	
Some Dimensions	Open Race Penstock Penstock Length Tailrace Length Roading	Large 2 * 2.8 m 380 m 950 m 5.1 km
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	30 m 52 m^3/sec 13 MW 57 Gwh 3B	30
Issues	Very large flow & relatively low head. Could easily see head reduced substantially with settling basin and penstock losses Suitability of Intake site. Likely to be a high bed load which will need a large settling basin. Ideally need to be able to form a ponding area like the Branch scheme. Not at all comfortable that there is sufficient fall near intake to operate a stilling basin. Site is isolated although access is OK	
Assessment	Delete from study	

Scheme Name	**Big River**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 120 -140 m level upstream of Slaty Creek 6.2km open race following approx 130m contour to an intake on the terrace above the Grey river.	
Some Dimensions	Open Race Penstock Penstock Length	2m invert 1.8 m dia. 675m
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	60 m 7.1 m^3/sec 3.5 MW 15 Gwh 3B	60+(provided at 130 at intake)
Issues	Is a relatively small scheme. With modest head Suitability of Intake site. Important that intake site is above the 130m contour otherwise race costs likely to be prohibitive Need some storage on the race line (mentioned in previous report) for a scheme like this to succeed. It appears to be available in a number of places. Extra water from Slaty Ck? Small scheme	
Land	Majority of scheme is on land in private ownership	
Assessment	Leave in for site inspection	

From Site Inspection (20 Dec 2004)

Intake site appears Ok and at the right level. A sizeable cut required for initial section of race. The majority of the open race is cleared land and would be simple to survey and check alignment. Storage could be provided on the race.

Major issue is that scheme is relatively small for the effort involved in development.

Scheme Name	**Rough River**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 190 m level below Mirfin Ck 8.4 km open race on true right bank then 675 m penstock to Powerhouse at about 120 m level.	
Some Dimensions	Open Race Penstock Tailrace Penstock Length Roading	4 m invert 20m top 2.5 m dia. 400 m 700 m 3.0 km
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	65 m 15.8 m^3/sec 11.1 MW 49 Gwh 2A	60-65
Issues	Suitability of Intake site & stilling basin Open race crosses some challenging ground in second half. Need to think about 2 powerhouse option although probably not sufficient head. A longer penstock is the other alternative. There dose not appear to be any storage on the race line but this should be looked at on site visit.	
Environmental	River is popular fishing spot Race would be through Native Bush	
Assessment	Leave in for Site Visit	

Site Visit 20 Dec.
Potential intake site is further upstream than indicated in initial map study. It is approx. 300m above bend where there is solid rock . A stilling basin could be located in a terraced area below. Getting water away from the Intake could be a major problem.

Race alignment would require some major cuts to access the top of the terraces. Contours disguise some big scarps. Race would also be through native bush.

Powerhouse and tailrace site is Ok

A very picturesque river particularly up towards the intake and could imagine there would be considerable opposition on environmental grounds.

Scheme Name	**Alexander River**	
NZMS 260 Map Reference	Sheet J33	
Brief Description	Intake at 320 m level near hut 3.5km open race to penstock with powerhouse below on the Grey River.	
Some Dimensions	Penstock Penstock Length Road to PH	1.6 m 400 7.0 km ?
	Ex MWD	SJM Check
Head Installed Flow Installed Capacity Output Ranking ex MWD	100 m 4.1 m^3/sec 3.4 MW 15 Gwh 3B	100m
Issues	Suitability of Intake site. Some challenging country for parts of open race Protection of Powerhouse on Grey. Relatively small scheme and isolated from electrical grid.	
Assessment	Delete from study	

Scheme/River Name		Consider Further	Details ex MWD Report				Technical Issues	Non Technical	Rank MWD Report
			Flow	Head	MW				
Schemes Not being considered further									
Buller River Schemes		No						Conservation Order Covers all of this catchment	
Lake Christabell		No	0.9	150	1.1	T	Sealing Lake and Intake in Moraine	In Ecology Reserve	5C
Upper Grey	1	n	17	50	7.1	R	These 3 Upper Grey schemes involve large volumes with modest head	Isolation	4B
Upper Grey	2	n	40	30	10	R	and long race/canals		3B
Upper Grey	4	n	73	30	18	R			2A
Upper Grey	3	n	65	65	35	D	Siltation Of Dam		2B
Roaring Meg		No	0.9	150	1.1	R	Very Steep/Access		3B
Ahaura	1	y	52	30	13	R	Intake Concerns, Head for Stilling basin	Isolation	3B
Ahaura	2	No	145	35	42	D	Siltation of dam	Gorge is in Amenity Area	1A
Taramakau		No	200	50	50		Getting a reliable Intake. Can only see this working as a series of powerhouses with a very large canal	Major issue of water clarity for discharge to Brunner	
Arahua	1	No	36	60	18	T	Uncertainty over Intake Site & Stilling Basin. Relatively low head for Tunnel.	Maori Issues and river ownership	1A
Arahua	2	y	53	30	13	R	Intake & high bedload to deal with. Very low head.	Large Race(canal) & impact on Land Use	3B
Kaniere and Styx		No						Environmental & impact on Trustpowers existing scheme	

Scheme/River Name		Consider Further	Details ex MWD Report				Technical Issues	Non Technical	Rank MWD Report
			Flow	Head	MW				
Schemes Not being considered further									
Kokotahi		No				T	Only 30 - 40m head with 2km Tunnel		
Mikonui		No	42	70	24	D	High Bed Load. Siltation behind Dam	Flooding Valley	3B
Poerua		No	22.4	50	9.4		Limited Head		5B
Butler		No	9.6	275	22.5		Access to site. Huge sediment load.		1A
Alexander River		y	4.1	100	3.4	R	Intake Site and Race Alignment	Historic Water Race & PS ? Isolation and small size	3B
Taipo		y	54	75	33	R/T	Intake & Tunnel. Check on Head, more like 55m	Popular Tramping /Canoeing spot ? prefeasibility work	2A
Falls Creek			2	155	2.5	R	Two ph scheme	Too small	

No

Scheme/River Name	Consider Further	Details ex MWD Report				Technical Issues	Non Technical	Rank MWD Report
		Flow	Head	MW				
Schemes Further South								
Not being considered further								
Jumbo Creek	n	2	440	7.2	T	Intake & Tunnel. Geology?	No demand or Transmission	3B
Makawhio	n			13.1	T	Intake & Tunnel. Geology?	No demand or Transmission	2B
Moeraki	y	12	90	8.8	R	Excellent scheme but….	Well away from Transmission and load. In scenic area	1A
Tartare	n	4	180	5.9	T	Intake & Tunnel. Degrading river bed.	In Westland Nat Park	4C
Waikukupa	n	5	130	5.5	T	Intake & Tunnel. Degrading river bed.		5D

Scheme/River Name	Consider Further	Details ex MWD Report Flow	Head	MW		Technical Issues to be consider in next stage.	Non Technical Issue to Investigate	Rank MWD Report
Schemes for Site Inspection								
Rough River	y	20.5	65	11.1	R	Intake site then Race.	Fishing River	2A
Big River	y	7.1	60	3.5	R	Intake Site & level, then Race. Storage availability		5C
Toaroha	y	14.5	210	25	T	Intake Site and access. Tunnel locations. Options for Powerhouse site		1A
Waitaha	y	48	100	40	T	Intake Site and access. Tunnel locations. Options for Powerhouse site.		1A
Kakapotahi	y	17.4	115	17	R/T	Intake Site, Race Alignment & Tunnel		1A
Amethyst	y	2.5	400	8	T		At Prefeasibility Stage	2B