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Local Hydro Potential Assessment Taranaki Region

Prepared for
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Consulting Engineers

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LOCAL HYDRO POTENTIAL ASSESSMENT

Taranaki Region

Prepared for
MINISTRY OF WORKS AND DEVELOPMENT
by
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CONTENTS

1. INTRODUCTION

1.1 Background

In recent years the Ministry of Works and Development, together with the New Zealand Energy Research and Development Committee have initiated a number of studies of the potential for small hydro-electric development in New Zealand. Reports of a number of these studies have already been prepared and are listed in the schedule of References in Section 7 of this Report.

This Report presents the results of a study of the potential for small hydro-electric schemes in the Taranaki Region. The study encompasses that area under the jurisdiction of the following statutory authorities;

- Egmont Electric Power Board
- New Plymouth Municipal Electricity Department
- Taranaki Catchment Commission and Regional Water Board
- Taranaki Electric Power Board
- Waitomo Electric Power Board
- Wanganui-Rangitikei Electric Power Board

The study has been carried out in two stages. First, an office-based study and literature search to identify schemes and recommend schemes worthy of further study. Second, these schemes were then re-appraised with the benefit of further data collection and field inspections. This second stage was carried out in February 1985 and the results of both stages are contained in this report.

1.2 Assessment Methodology

1.2.1 General

In accordance with the Terms of Reference for this study (Appendix E), the assessment of small hydro resources of the Taranaki region follows the broad guidelines and evaluation methodology established by NZERDC Report No.36 'Study of Hydro-electric Potential in Northland': Sections; 3, 4 and 7. These guidelines were modified in minor respects to allow for particular features of the Taranaki region.

1.2.2 Requirements of a Suitable Site

The two fundamental requirements of a site for potential development of a hydro-electric generating station are:

- An adequate and reliably defined flow of water which may include water diverted from adjacent catchments. The economic viability of hydro schemes is sensitive to errors in flow assessment.

- Topography which favours the development of generating head by some combination of dam and conduit. Small hydro installations are likely to be economic only when the water can be made to fall without elaborate and expensive civil engineering works.

Investigations of generation potential should initially concentrate upon these two factors and, if a suitable combination of them exists, proceed to examine the following factors which may have significant effects upon the viability of the scheme:

- Topography favouring the storage of water behind a dam; that is, a valley which is wide and of relatively flat longitudinal gradient upstream of the dam.

- Inundation by the storage lake of areas of productive land, scenic attractions or significant human habitation.

- Requirements of other competing water uses such as:

  ° industrial, agricultural or domestic water supply
  ° residual stream flow required to maintain the biological habitat
  ° alternative hydro-electric schemes
  ° recreational uses of the water resource

- Proximity of the power generation site to centres of electricity demand or to existing transmission lines.

- Interference with public communication routes, notably highways and railways which might require diversion.

- Possible complementary water uses.

- Other environmental factors.

1.2.3 Evaluation of Schemes

A preliminary scanning of potential sites was necessary to identify schemes which exhibited sufficiently suitable engineering and economic characteristics to warrant further study. This was achieved by investigation of the following parameters:-

i) Topography - Location of potential sites and identification of relevant topographical features from available maps and aerial photographs.

ii) Hydrology - Determination of mean and flood flows, and the flow duration characteristics from existing hydrological records.

iii) Engineering - Formulation of a probable hydro-electric development configuration to include:

  ° dam and spillway (or diversion weir)
  ° conduit from intake to power station
  ° power station including turbo-machinery

iv) Costing - Preliminary estimation of the principal scheme components. (If the scheme costs exceeded about $2000/kW (June 1978)* installed at a plant capacity factor of 50%, it was discounted as not warranting further study.)

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* June 1978 costings are required by the Terms of Reference. Based on CCI indices the $2,000/kW represents $4370/kW in June 1984 figures.

Then, having narrowed the field of investigation, the study proceeded to a more detailed appraisal which included:

- A first appraisal of apparent environmental factors.
- Site inspection on the ground and simple survey measurements to identify factors meriting re-appraisal of the preliminary findings.
- Sketching of possible scheme components on the site plans.
- Re-appraisal of capital costs, power available and environmental factors.
- Ranking of schemes worthy of full feasibility study investigations.

2. DESCRIPTION OF STUDY AREA

2.1 General

The area covered by this investigation is shown in Figure 2.1. In the north it extends to the left bank of the Mokau River for a distance of about 20 km from the coast, while to the west it encompasses the Mahakatino River, the Tongaporutu River, the Waitara River and its tributaries. The Patea River, and its tributaries, the Whenuakura River and the Waitotara River where it borders the Matemateaonga Range define the southern extent of the study area. All the rivers that drain the slopes of Mt. Egmont are contained in the western and southern parts.

The study area varies considerably in terms of its physical characteristics as it includes two distinct areas. First, a large number of small mountain streams that drain radially from the slopes of Mt. Egmont to the western coastal lowland and second, the steep and deeply dissected hill country of eastern Taranaki. The Waitara River in the north drains from both these areas as does the Patea River in the south.

2.2 Topography

The Taranaki Region is 4,600 km^2 in area and includes Mt Egmont (2,518 m), Fanthams Peak (1,962 m), the associated lower radial slopes and ring plains together with the foothills of the eastern hill country. The elevation of the Matemateaonga Ranges in the east rises to about 750 m.

The youthful topography of this region is a consequence of the underlying rock types. The recent alluvial deposits form the lower lying, flat areas associated with the major rivers and coastline, while areas underlain by lahar tend to be more undulating and rolling. The sandstone/siltstone sequence has a sharp steep topography particularly where harder interbedded limestones are found.

The rivers in the area have apparently been rejuvenated and appear to be downcutting below their original beds. This is particularly noticeable in the upper reaches of the Waitara and Patea Rivers, suggesting possible uplift of the land mass. Meandering rivers are characterised by spurs on one bank containing thick deposits of alluvium with undercut areas on the opposite bank, exposing the underlying rock.

2.3 Geology

The geology of this region, which has been drawn from the publications listed in Section 3.3.4, is shown in Figure 2.2.

Structurally there appears to be an overall broad syncline situated west of Mt. Egmont with the axis oriented approximately northeast/southwest west of Mt. Egmont. Associated with this feature are major north/south faults such as the Opunake, Manaia and Taranaki faults and more importantly the apparently active east-northeast trending Inglewood fault. The peninsula is dominated by the Mt. Egmont and Poaukai domes and laharic ring plain, whereas to the east the Urenui and Mt. Messenger sandstone/ siltstone sequence is more apparent.

Generally the study region contains three broad lithological types with some variation within each. The lithologies are:

i) Recent alluvial deposits of loose silt, sand, gravel, cobbles and boulders.

ii) Pleistocene lahars ranging from stiff fine brown silt to similarly compact sand, gravels, boulders and organic matter sometimes weakly cemented.

iii) Pliocene sandstone/siltstone consisting of weakly cemented calcite rich, soft interbedded sandstone and siltstone (sometimes fossiliferous) with crosscutting discontinuities from the Urenui Siltstone or Mt. Messenger Sandstone Formations.

For convenience these are all referred to in this report as alluvium, lahar or sandstone/siltstone deposits, respectively.

The likely engineering behaviour of each of the above three groups of material is based upon field examination of exposed material at various sites and general experience with such materials.

2.4 Climate and Stream Flows

Situated on the western side of New Zealand, Taranaki is exposed to weather systems migrating over the Tasman Sea. The predominant westerly airstream makes the Taranaki region one of the windiest in New Zealand. Further, occasional storms of polar or tropical origin affect the region (Thompson, 1981).

The climate of the lower altitude areas of Taranaki is temperate. However with the normal decline in temperature with altitude (about 1°C/100 m), the higher slopes of Mt Egmont experience much lower temperatures, resulting in snow accumulation. The effects of snowmelt on the rivers draining these areas is unmeasured although it is considered to be insignificant because of the small areas of catchment above the snow line.

Rainfall over the Taranaki area is markedly affected by Mt Egmont. Consequently there is high rainfall in the western region compared with the relatively low rainfall recorded in the eastern hill country. Rainfall is well distributed throughout the year but has a definite winter peak in June and July with a seasonal low in the period November to March.

Storm rainfall intensities are higher on the west coast near New Plymouth than on the eastern lowland and southern coastal areas from Stratford to Hawera. Recorded intensities on Mt Egmont are extremely high but these are confined to the upper slopes within the National Park.

Stream flow records reflect the pattern of substantially higher rainfall of the rivers and streams draining from Mt Egmont. Similarly, flood peaks reflect the pattern of high intensity rainfall in the northern and western streams causing flash floods. Overall, however, the recorded floods in the two major rivers, the Waitara and the Patea, are not high by New Zealand standards. Likewise, the suspended sediment concentrations in these rivers are not high compared to other regions.

2.5 Soils

The soils of Taranaki are predominantly yellow-brown loams overlain by ash and sediment from Mt Egmont. Only on the uplands of eastern Taranaki, comprised largely of hill and steepland soils derived from the underlying soft rock, are the yellow brown loams less widespread.

Generally, Taranaki soils are free draining, productive and versatile with light texture and good aeration. These features, combined with the warm local climate provide excellent plant growth conditions.

2.6 Vegetation and Land Use

The Taranaki Ring Plain encircling Mt Egmont supports intensive pastoral farming predominantly dairying although horticultural development, currently a minor landuse, is increasing. Mt Egmont itself lies within the Egmont National Park and is largely bush clad.

On the undulating land between the Taranaki Ring Plain and the hill country to the east, intensive sheep farming for fattening lambs is predominant.

Within the hill country of eastern Taranaki, semi-intensive sheep farming is undertaken on the more accessible land but there is also undeveloped land under scrub or regenerating bush and large tracts of indigenous forest covering the higher areas of the ranges.

In terms of the Landuse Capability Classification, wherein Class I is very good land and Class VIII is land with extreme limitations, the Taranaki Region includes land representative of all of the eight landuse capability classes. However extensive areas of the region are in the arable classes (ie. Classes I to IV) or in Class VI which describes good, fairly stable hill country where soil erosion can be minimised by good pasture establishment and management. There is only a limited amount of Class V land in Taranaki. This describes land that has severe limitations for arable use but has only a slight hazard of erosion under pastoral use.

There is a substantial area of the region, namely in the eastern Taranaki hill country, described as Class VII which is land with severe limitations or hazards under perennial vegetation. In Taranaki these areas are generally steep to very steep lands with reasonably fertile soils but also with potential for severe soil slip and other forms of erosion. Frequently this class of land is unsuitable for grazing as it requires special soil conservation practices. In some cases it may be suitable for forestry but reversion to scrub and bush is sometimes the only alternative.

Class VIII land includes cliff faces, bare rock areas, very steep mountainous land and other such areas with extreme limitations to use. Coastal cliffs along the Taranaki coast and the higher land in the ranges along the eastern edge of Taranaki come within this category.

Farming in the Taranaki region remains an extremely important industry. However there has been rapid growth in the oil and gas industry in the region with the development of high technology gas utilization plants.

2.7 Population

The estimated population of Taranaki as at 31 March 1983 is 105,900 most of whom live in New Plymouth (45,000) or in the townships of Hawera (8,420), Waitara (6,100), Stratford (5,550), Inglewood (2,890), Eltham (2,420), Patea (1,770), Opunake (1,680) and Manaia (1,010) (NZ Official Yearbook, 1984).

2.8 Water and Soil Administration

Administration of the water resources in the Taranaki Region is carried out by the Taranaki Catchment Commission and Regional Water Board which have their offices in Stratford. The Wanganui office of the Water and Soil Division of the Ministry of Works and Development has a wider jurisdiction including the Taranaki area, and there is a branch office in New Plymouth. Data is also collected and analysed at the Water and Soil Science Centre at Aokautere in Palmerston North.

2.9 Power Boards and Existing Hydro Stations

2.9.1 Power Board Statistics

There are five local power authorities in the Taranaki Region and their statistics are given in Table 2.1. Figure 2.3 shows the Power Board's boundaries, transmission lines and load centres.

2.9.2 Existing Hydro Generation Stations

The only existing hydro station in the Taranaki Electric Power Board's area is the Tariki Power Scheme, illustrated in Figure 2.4. The source flow is from Lake Ratapiko into which water is diverted by canal from the Manganui River at Tariki. The powerhouse contains three turbines with a total generating capacity of 4.7 MW and operates at an annual plant factor of 67%.

The New Plymouth City Electricity Department operates the Mangorei Power Scheme which diverts flow from the Waiwhakaiho River by tunnel into Lake Mangamahoe as shown in Figure 2.5. It has four turbines with a total generating capacity of 4.2 MW and operates at an annual plant factor of 54%.

The Egmont Electric Power Board runs a small hydro station at Opunake, illustrated in Figure 2.6, with a maximum generating capacity of 360 kW and an annual plant factor of 46%. A 600 kW station was formerly operated on the Waingongoro River near Hawera but this was closed down and dismantled in 1967 after repeated flooding of the plant. The Patea scheme was commissioned in May 1984 and is illustrated in Figure 2.7. This scheme comprises a 63 m high embankment dam on the Patea River with a generating capacity of 30.7 MW and functions at an annual plant factor of 42%.

2.9.3 Other Electricity Generation Stations

The New Zealand Electricity Department operates New Zealand's largest thermal station at New Plymouth which has a maximum output of 600 MW. Another thermal station using gas is located at Stratford with a total output of 220 MW.

TABLE 2.1 - LOCAL POWER AUTHORITY STATISTICS (FOR STUDY AREA)

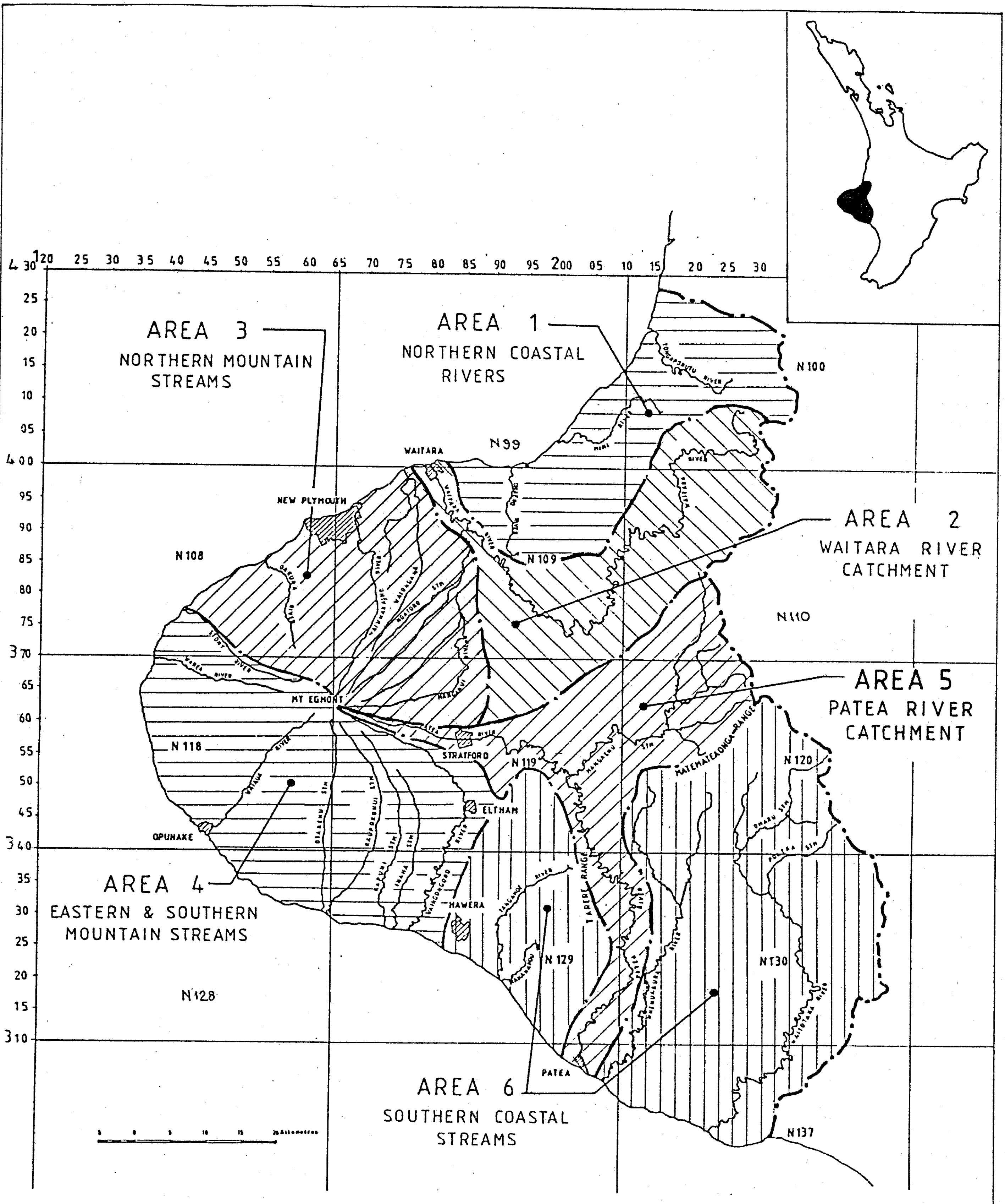
Local Power Authority	Statistics (31 March 1985)								Likely Power Demand Increase (% pa)
	Present Maximum Power Demand (MW)	Annual Usage (GWh)	System Load Factor	No of Substations	Length of Lines (km)	No of Customers	No of Commercial Customers	No of Industrial Customers	
Waitomo E.P.B.	0.3	NA	NA	70	60	250	Note 1	Note 1	Note 1
Taranaki E.P.B.	31.5	188	0.68	1794	2461	13,773	1288	182	Note 2
New Plymouth City Electricity Dept	56	285	0.58	1300	1173	22,746	2320	576	2.5
Egmont E.P.B.	37.0	187	0.60	1448	1760	11,891	1205	61	3.0
Wanganui Rangikikei E.P.B.	11.3	30	0.30	200	300	1,100	100	Note 3	Note 3

Notes:

1: The major load in this area is the Natural Gas Corporations Compressor station and any further increase in demand is likely from other proposed stations.

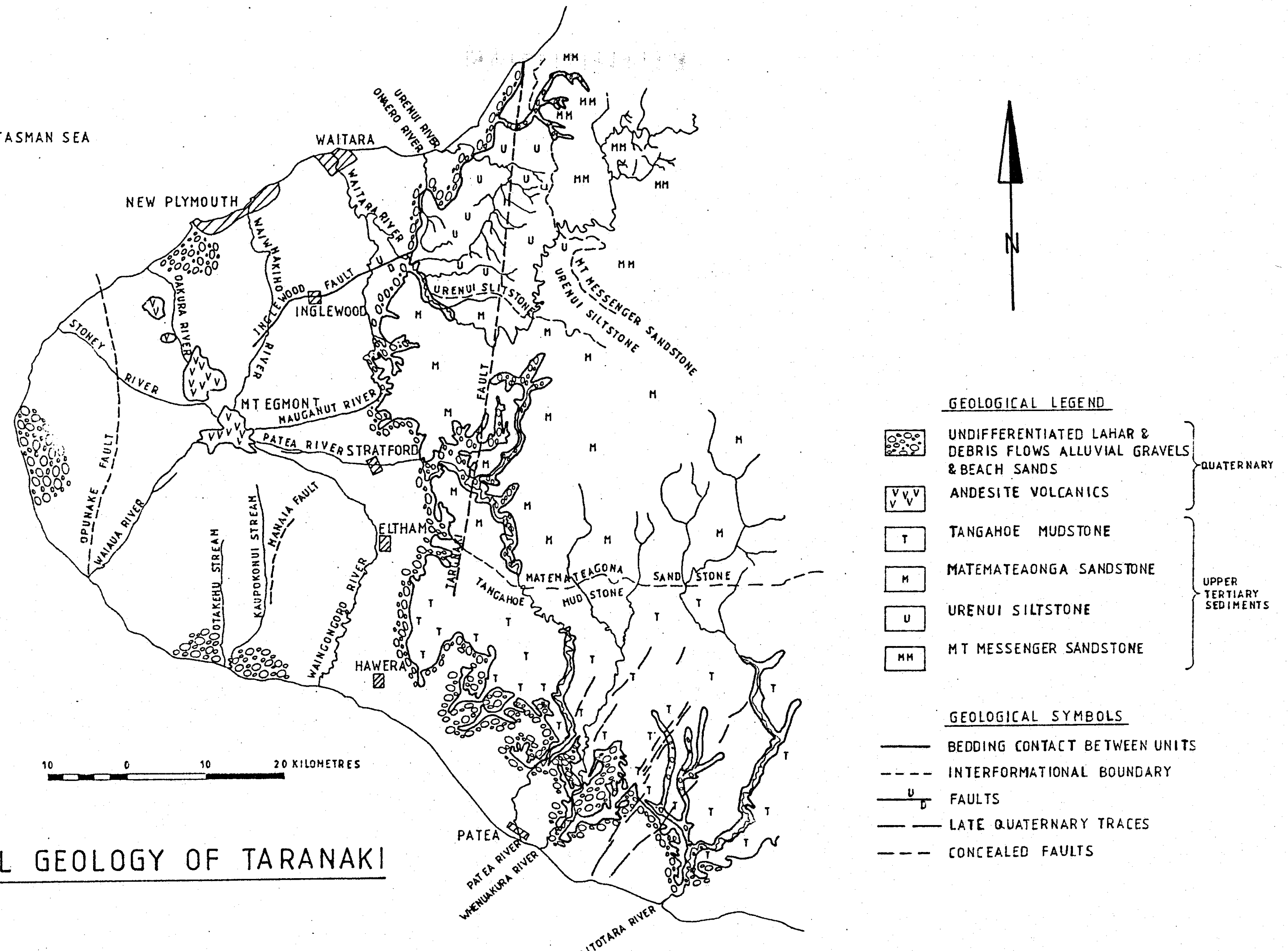
2: With the commissioning of the N.Z. Synthetic Fuel Corporation's Motanui Plant, the maximum demand is expected to increase by 15.5 - 47 MW and annual consumption by 120 GWh. Thereafter, the expected growth rate is 1%.

3: One large industrial consumer, Waipipi Ironsands Limited, uses about 60% of annual consumption and further increases are dependant on their activities.



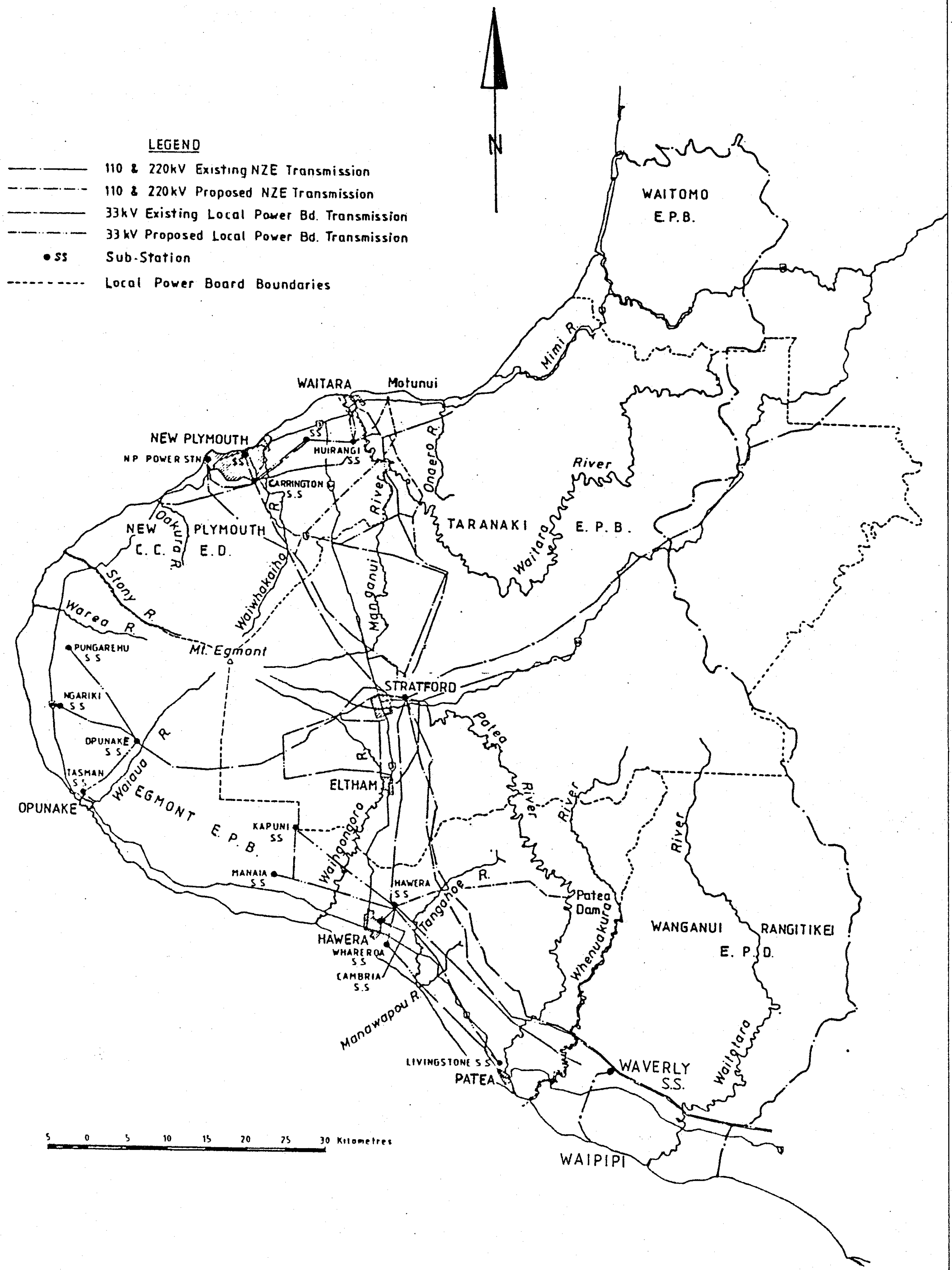
PLAN OF STUDY AREA FOR REGION

FIGURE 2·1



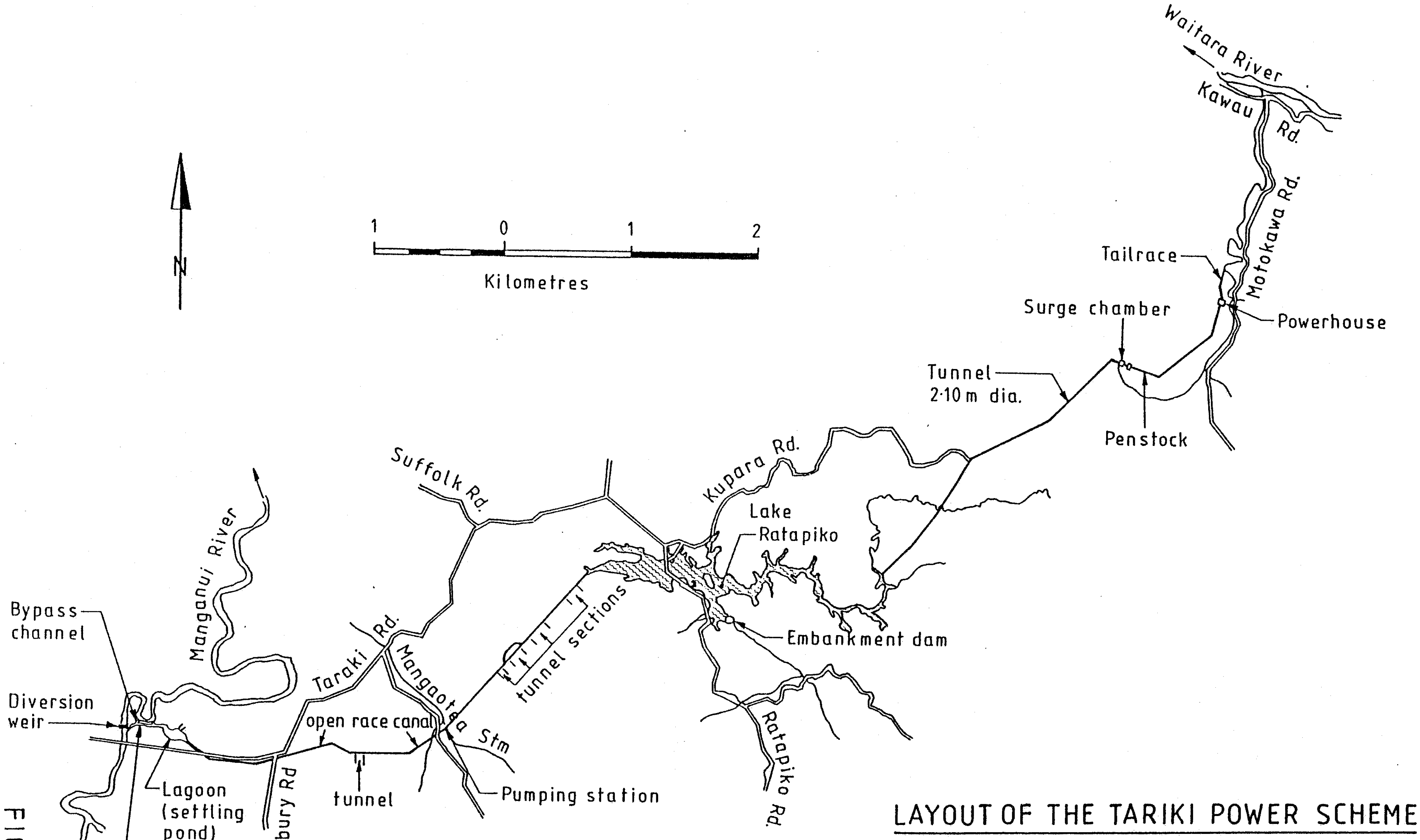
GENERAL GEOLOGY OF TARANAKI

FIGURE 2·2



PRINCIPAL TRANSMISSION LINES AND LOCAL CENTRES

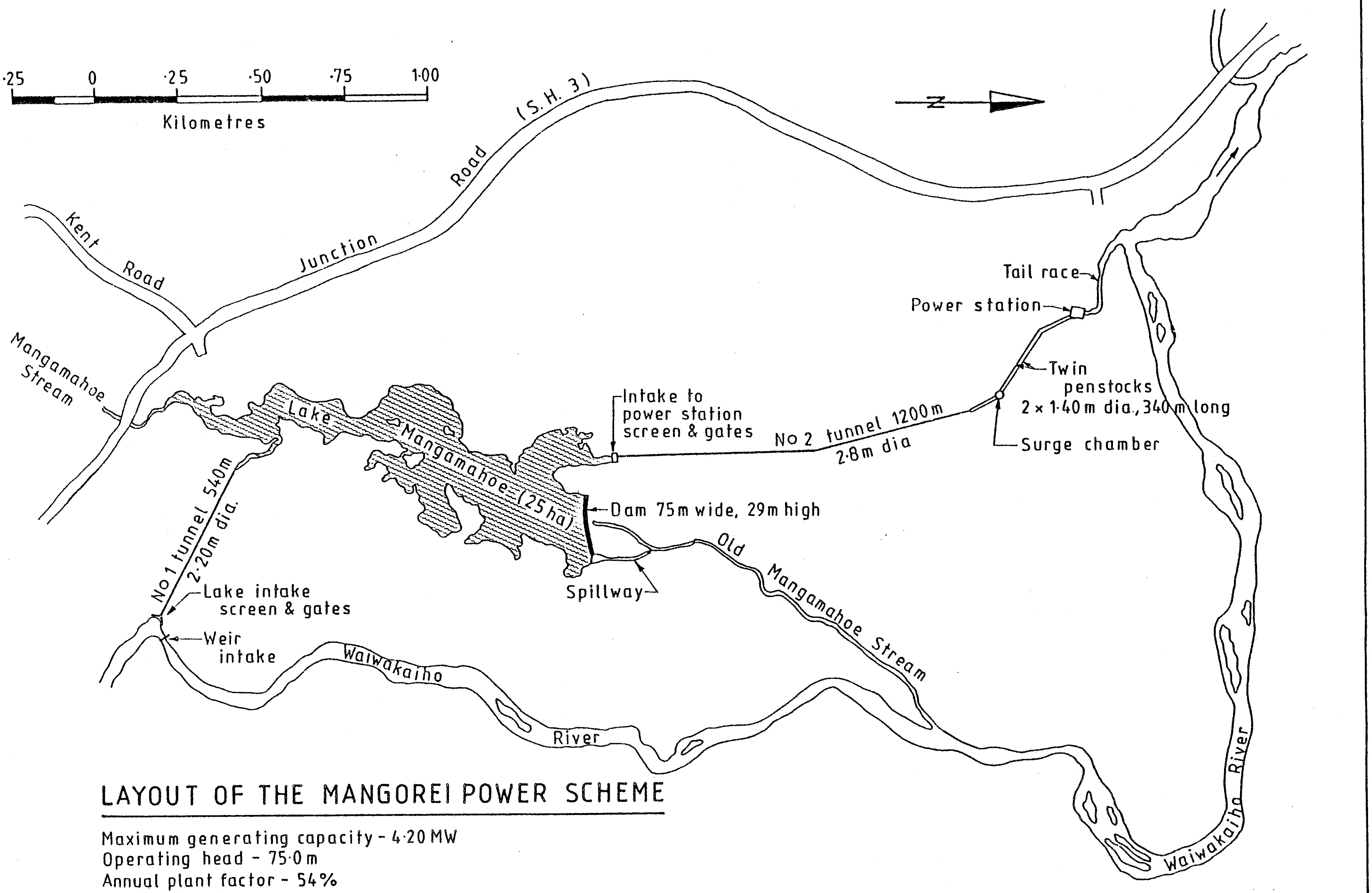
FIGURE 2·3



LAYOUT OF THE TARIKI POWER SCHEME

Maximum generating capacity - 4·7 MW
Operating head - 100 m
Annual plant factor - 67 %

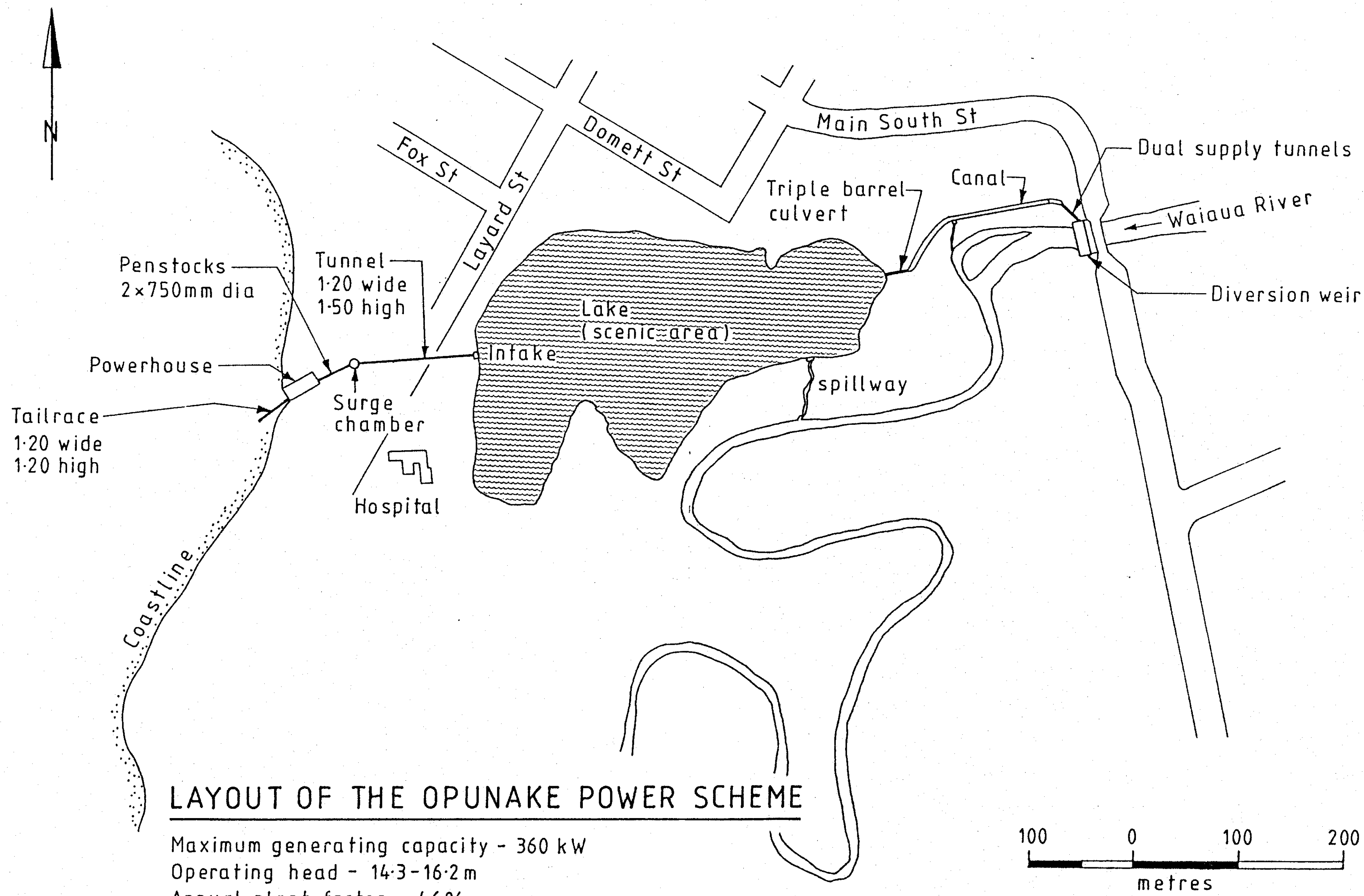
FIGURE 2·4



LAYOUT OF THE MANGOREI POWER SCHEME

Maximum generating capacity - 4·20 MW
Operating head - 75·0 m
Annual plant factor - 54%

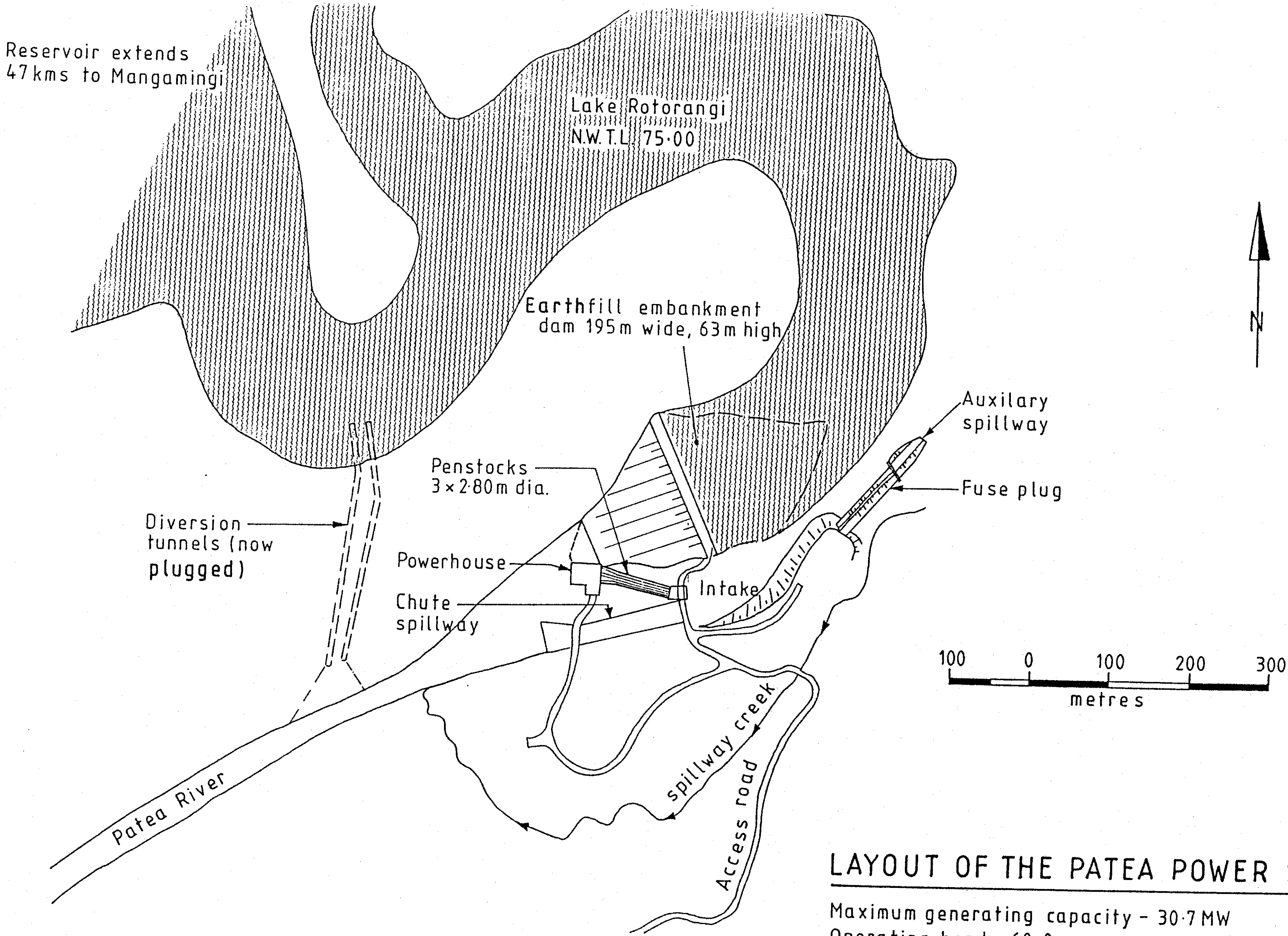
FIGURE 2·5



LAYOUT OF THE OPUNAKE POWER SCHEME

Maximum generating capacity - 360 kW
Operating head - 14·3-16·2 m
Annual plant factor - 46%

FIGURE 2·6



LAYOUT OF THE PATEA POWER SCHEME

Maximum generating capacity - 30·7 MW
Operating head - 60·0 m
Annual plant factor - 42 %

FIGURE 2·7

3. IDENTIFICATION OF HYDRO POTENTIAL

3.1 General Appraisal

Within the study area, the most economic forms of hydro power generation involve the following three scheme types; low head storage schemes on main rivers; catch-water schemes, collecting flow from the high rainfall areas of the ring plain, to gain a high head to discharge into an adjacent catchment; and the augmentation of existing schemes.

For convenience the study area has been divided into the following:

Area 1	Northern Coastal Rivers
Area 2	Waitara River Catchments
Area 3	Northern Mountain Streams
Area 4	Western and Southern Mountain Streams
Area 5	Patea River Catchment
Area 6	Southern Coastal River

The boundaries of these areas are shown in Figure 2.1. No schemes have been investigated within the Egmont National Park as part of this Study. Other studies have investigated the hydro potential within the Park; these concluded that because of the small catchments involved and hence low yield, the inaccessibility of the area, slope stability problems and the need for long transmission lines and access roads, this type of scheme was not economically viable. Further, environmental factors associated with the implementation of such a scheme would be likely to generate considerable opposition from ad hoc organisations, such as the Catchment Commission, and various government agencies such as the National Parks and Reserves Authority, Maori Affairs and Internal Affairs (Wildlife Division). In addition, the local public and Maori concerns/attitudes about such development would be likely to pose a major constraint to any proposal.

3.2 Previous Studies

Hutton (1958) outlines the various early schemes operated by the New Plymouth City Council, the Inglewood Borough Council, the Opunake Electric Power Board and the Taranaki Electric Power Board.

Consulting engineers, Mandeno Chitty and Bell Ltd presented a preliminary report in October 1964 on the future provision of town water and hydro electric power supply for the New Plymouth City Council. However, none of the provisions of this report were implemented.

In December 1974 consulting engineers, Beca Carter Hollings & Ferner Ltd carried out a water resources survey on behalf of the Egmont Electric Power Board. The potential for hydro development was investigated and as a result of the study, Beca Carter Hollings and Ferner Ltd were commissioned to design a 30 MW scheme on the Patea River. This scheme became operational in May 1984.

3.3 Data Requirements

3.3.1 General

The identification and evaluation of hydro potential requires the collection and analysis of a wide variety of data. The initial identification of possible schemes, the 'preliminary scanning' phase, was undertaken as a desk study making use of information currently available from Governmental agencies.

The subsequent more detailed scheme evaluation phase made use of additional information collected during field inspection visits of the individual sites.

3.3.2 Topography

Topographical data is required to identify hydro-electric potential, especially contour information which enables head and water storage availability to be evaluated. Generating head may be developed in three ways, ie.

- Use of natural falls, rapids etc.
- Impounding water by means of a storage dam.
- Diversion of flow by conveyances to a point of lower elevation, either downstream or an adjacent river.

The following topographical information was collected and examined for this study:

Maps : NZMS 1 Series Topographical Maps (1:63 360)
NZMS 270 Series Topographical Maps (1:25 000)

Aerial Photographs:

NZ Aerial Mapping vertical 'stereo pair' photographs (Lands and Survey Department)

3.3.3 Hydrology

Accurate estimates of river flows are essential to establish the hydro-electric potential of a particular scheme. Long term rainfall records and medium-short term flow records are available for most areas and the larger rivers throughout the Taranaki area. A detailed description of the hydrology is contained in Appendix B.

Hydrological data was made available from MWD, NZ Meteorological Service and Taranaki Catchment Commission (TCC) sources, and included the following:

- Rainfall records
- Evapo-transpiration data
- River flow records
- Flood flow estimates
- Suspended sediment yield data
- Water quality data

3.3.4 Geology

A geological appraisal of possible locations for major civil engineering works is necessary to assess the likely site conditions and highlight possible construction problems. The following sources of geological information were employed.

- NZ Geological Map (Scale 1: 250,000) Sheet 7, Taranaki;
- NZ Geological Map (Scale 1: 250,000) Sheet 10, Wanganui;
- NZ Geological Survey publication entitled: "New Plymouth, Egmont - Manaia" by V.E. Neall;
- Egmont National Park Board publication entitled: "The Volcanic History of Taranaki" by V.E. Neall; and
- NZ Journal of Geology and Geophysics paper: "Tephrachronology and Tephrastratigraphy of Western Taranaki (N108-109), New Zealand" by V.E. Neall (1972).

3.3.5 Other

Information was also collected relating to the following:

- Existing and potential electricity usage
- Existing and proposed power transmission lines
- Land use data (Lands and Survey Department, MWD - National Water and Soil Conservation Authority, TCC)
- Aquatic and wild life (Department of Internal Affairs - Wildlife Service, TCC)
- Recreational usage (TCC)
- Other water users (MWD, TCC)

3.4 Preliminary Scanning Study

A 'preliminary scanning' study following the methodology outlined in Section 1.2.3 identified 33 potential hydro-schemes within the study area. Further details of this study are given in Appendix D.

Approximate costing of all schemes was carried out to eliminate schemes which were clearly uneconomic. Where the cost of a scheme exceeded about $2000/kW (June 1978) installed capacity at a plant factor of 50% (ie. a unit energy cost of about 5.0 c/kW-hr) it was discounted as not warranting further study. On this basis some 16 potential schemes were considered to warrant further investigation.

3.5 Evaluation of Schemes

3.5.1 Field Inspection

Further investigation of schemes started with a field inspection both to confirm the practicability of constructing a scheme similar to that envisaged in the desk study and to collect additional information to enable the scheme configuration and cost estimate to be refined.

In brief, the field inspection involved:

- Meetings with MWD, TCC, local power authorities and Lands & Survey Department to discuss the preliminary study, the availability of further data and the consequences of scheme implementation.

- Measurement of key relative levels; where the topography precluded the use of a theodolite, an aneroid barometer was used.

- Visual confirmation of scheme component location and the effects of reservoir storage.

- Cursory consideration of alternative hydro schemes on the same river reach.

- Identification of local environmental factors.

- Preliminary appraisal of the geology and foundation conditions.

- Taking of photographs.

3.5.2 Estimation of Scheme Potential

Hydrological investigations determine the flow available at each site for hydro generation. The choice of plant factor will decide the maximum diverted flow and thus generating capacity of the scheme. For this study a plant factor of 50% has been adopted as it allows comparison of all the schemes, both in this study and similar studies for other areas throughout New Zealand, on a cost per kilowatt installed basis. Appendix B, Section B 3.3.2 discusses the choice of plant factor for small hydro schemes in more detail. The installed capacity of each scheme has been based on an overall efficiency of 85% for mechanical and electrical equipment.

Further, for schemes that involve diversion of flow away from their natural watercourse, thereby depleting downstream users, the diverted flow has been derived for both no compensation and 10% (of the mean) compensation flow. This enables the cost difference to be established for schemes which will have some degree of flow compensation imposed on them. Also, for schemes incorporating sand traps a further 5% of the mean flow is assumed to be used for flushing or maintenance purposes.

3.5.3 Costing of Schemes

The estimating data used to determine the cost of a scheme, allowing for construction, land acquisition, engineering and administration and a suitable contingency, is contained in Appendix A. This Appendix has been collated from similar small hydro schemes both in New Zealand and overseas. In addition, it has been updated based on the Consultant's experience in the Taranaki Region and elsewhere, including the Patea Hydro Electric Scheme and others involving canal construction.

3.5.4 Ranking of Schemes

All schemes have been ranked on a cost per kilowatt installed basis which provides a first order method of ranking schemes with the same plant factor. Table 3.1 gives the economic limits of each ranking criteria.

TABLE 3.1 - RANKING CRITERIA

Cost/kW (at June 1978)	Approximate cost of energy (c/kW-hr) (at June 1978)	Ranking
< 1000	< 2.5	A - Very attractive
1000 - 1500	2.5 - 3.75	B - Attractive
1500 - 2000	3.75 - 5.0	C - Possibly attractive
> 2000	> 5.0	D - Uneconomic
-	-	E - Economically attractive but with severe environmental constraints

NOTE : $1,000/kW at June 1978 is equivalent to $2185/kW at June 1984 and similarly 2.5 c/kW-hr is equivalent to 5.5c/kW-hr

: Unit cost of energy (c/kW-hr) based on a 3 year scheme implementation period and a 10% discount rate.

A scheme may be deemed to have 'severe environmental constraints' if it is established that the implementation of such a scheme would pose significant implications for the existing environment encompassing physical, biological and social resources at a local or regional level.

Section 4 presents a general appraisal of the hydro potential for each of the schemes identified, followed by an outline of the 'preferred' schemes within each catchment area.

4. HYDRO DEVELOPMENT POTENTIAL OF RIVERS

4.1 Area 1 - Northern Coastal Rivers

This area covers the small rivers in the north of the study area and the streams that rise in the eastern foothills and drain down towards the coast. These include the Mohakatino, the Tongaporutu, the Mimi, the Urenui and the Onaero Rivers and the Waiau Stream.

All of the rivers within the area are small in size and subject to relatively low rainfall. Further, no topographical features exist that allow diversions to neighbouring catchments. There are also no waterfalls that could be considered for potential schemes. Thus, no sites for hydro development either of a 'diversion'* or 'conventional'** type have been identified in this area.

4.2 Area 2 - Waitara River Catchment

4.2.1 General Features

The Waitara River system has the largest single catchment within the jurisdiction of the Taranaki Catchment Commission, with an area of about 1,470 km^2. It consists of two major tributaries: the Waitara River which rises about 450 m above sea level, and the Manganui River which rises about 1,700 m above sea level on the eastern slopes of Mt. Egmont and has a catchment area of 292 km^2. The contribution of the Manganui River to the total flow of the lower Waitara River is far greater than would be expected given its catchment area because it drains an area of high precipitation from the slopes of Mt. Egmont. The hydrological system is further complicated by the diversion of water from the Manganui River into Lake Ratapiko, through the Motukawa power station and into the Waitara River 3.0 km upstream from Tarata.

The eastern area of North Taranaki in which the Waitara River rises is underlain by Upper Tertiary sandstones, mudstones and siltstones. The valley floor is deeply eroded with numerous swamps and small streams. Because of the fine grained and relatively soft nature of these materials, they contribute to a large proportion of the suspended sediment in the Waitara River. The river is actively cutting into the siltstone/sandstone, resulting in increased sinuosity and alluvial terracing.

Downstream of the Manganui River confluence the nature of the bed material changes from alluvial sand to sand and large boulders of volcanic origin, these being derived from the Mt. Egmont catchment.

In the upper catchment landuse consists mainly of dry stock farming, while downstream of the Manganui confluence it changes to dairy farming. Nearer the mouth of the Waitara River there is not only dairy farming but

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* 'diversion' type scheme comprises diversion weir, supply conveyance and remote powerhouse.

** 'conventional' type scheme comprises dam and adjacent powerhouse connected by short penstocks.

also an increasing amount of horticultural development, particularly on the Class I and II land. Landuse in the lower catchment is also characterised by the presence of two large petro-chemical complexes - the methanol plant in the Waitara Valley, and the synthetic petrol plant at Motunui. Both make extensive use of river water for process and discharge purposes.

Water demand in the upper catchment is likely to be low since the predominant users are farmers whereas in the lower part of the catchment the multiplicity of users and dischargers mean water quality and quantity become significant issues. The existing water quality rating of 'good' to 'very good' (Taranaki Catchment Commission, 1984 c:58) as well as allocation decisions may therefore assume increasing importance for both in-stream and out-of-stream users.

Passive and active recreational use of both the Manganui and Waitara Rivers rates highly. Scenic appeal, water quantity and quality, and river-bed character were identified as particular attributes of the Manganui. Canoeing, and trout fishing are popular activities; the upper reaches of the Manganui are valued for their area of fishable water, accessibility and solitude (Taranaki Catchment Commission, 1984 f).

The Waitara River in its lower reaches is used for canoeing, trout fishing, whitebaiting, jet-boating, water-skiing, yachting, rafting and rowing (Taranaki Catchment Commission, 1984 f). Tramping, day walks and picnicing are also likely to be popular activities depending on access to, and natural attractions of, sites.

The preliminary scanning study identified three 'diversion' and four 'conventional' schemes. It was found that the 'diversion' schemes in the upper Waitara were uneconomic because of the cost of providing long diversion tunnels to create the necessary elevation difference. A 65 m high embankment dam, also in the upper Waitara,was considered but was found to be uneconomic owing to the large embankment volumes required, the long transmission lines and access roads and the high degree of flooding in areas upstream. Field appraisal and details of the remaining four schemes, shown in Figure 4.1, are outlined in the following sections (Refer also to Appendix C - photographs).

4.2.2 Scheme 2.4 (Figure 4.2)

Configuration

Within the mid-reaches of the Waitara River there are several locations where low level storage schemes could be developed. A site 2.5 km downstream of the confluence with the Makino Stream has a natural constriction in the river channel suitable for construction of a low level 'conventional' scheme. The topography is suited to a scheme with the following components:

- a 23.5 m high embankment dam across the river channel;

- a diversion canal through the left bank* terrace, after which it could be converted to a gated canal spillway abutted by concrete weir sections to act as the spillway;

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* reference to bank location is made looking downstream

- a reservoir with an area of 2.5 km^2, extending 20 km up the Waitara River with an arm extending some 8 km up the Makino Stream. The reservoir would provide 24 hrs active storage at mean flow. The estimated sedimentation life of the reservoir is 65 yrs based on a mean suspended sediment concentration of 0.039% (in volume) and a trap efficiency of 60%; and

- a power station located near the base of the dam on the right* abutment, with an estimated generating capacity of 5.8 MW at a 50% plant factor.

Engineering Geology

The site is located within the high, steep topography formed on the underlying sandstone/siltstone formation. Soil cover on the hills is thin (1 m), becoming thicker in the river valleys where there are deposits of alluvium. The sandstone/siltstone exposed in the river bottom and valley sides is well bedded, oriented subhorizontal, and stands almost vertically. Discontinuities are present but not common. The overlying alluvium, which may be up to 7 m thick, is unstable at slope angles of 35° - 40°. The Taranaki Fault lies approximately 2 km to the west. Foundations for most structures should be relatively simple and generally shallow but there would be a lack of rock aggregate for construction purposes.

Appraisal

Preliminary cost estimates (Table 5.2) show that this scheme is just beyond the limit of being attractive. However, when considered in the regional economic ranking it rates highly. Two dam-impounding heights (12 and 20 m) have been considered and it has been concluded that the higher dam is more economic. The height of the dam, however, is restricted by first, the extent of flooding which would include Mangaoapa Road and the township of Purangi; second, the suitability of the foundation materials; and third, the shallow slopes of both abutments.

The underlying sandstone/siltstone formations have adequate strength for most types of low dams but the overlying alluvium appears too weak and permeable. This would require treatment or removal of the alluvium for the dam construction.

Because the site is remote from county roads, construction of approximately 8 km of access roads would be necessary. Of this distance 5 km would be across hilly terrain. A 33 kV transmission line would be routed 25 km through to the Stratford sub-station.

The active storage of the reservoir formed behind the dam would be small (24 hours), indicating that the scheme would operate as run-of-the-river. Although the reservoir formed is subject to only limited inundation of Class III land,it will affect the low lying flat pastoral land presently used for haymaking. During low flows, however, it will offer an opportunity for flow regulation which would be beneficial to downstream users. Siltation is not expected to be a problem within the economic life of the reservoir.

Environmental considerations include the likelihood that a low level dam would flood the alluvial terraces, and consequently inundate farm land. In addition, a dam higher than 20 m would flood county roads and Purangi township. This represents a major impact since a decision would be needed on the future locations of each. Impacts on wildlife, recreational uses, and river ecology require further study as any dam is likely to affect all of these to a certain extent.

4.2.3 Scheme 2.5 (Figure 4.3)

Configuration

Approximately 7 km downstream of Tarata township a loop in the Waitara River cuts into the sandstone/siltstone formation providing an opportunity to divert flow into the adjacent Kokohiko Stream, a tributary of the Onaero River. This diversion gains a head of 22 m. The scheme's main components include:

- an 11 m high gravity concrete dam incorporating a spillweir section and stilling basin. During diversion the river would be channelled through openings in the dam base with the dam being constructed in two stages;

- a reservoir with an area of 0.7 km^2 extending 11 km up the Waitara River, but containing most of the flow within the existing river bank. The reservoir formed would provide 7.5 hours active storage at mean flow. Based on a mean suspended sediment concentration of 0.039% and a trap efficiency of 20%, the estimated sedimentation life of the reservoir is 35 years;

- a 5.0 m diameter diversion tunnel, 1150 m long. In addition, a river intake and a surge chamber at the downstream end are necessary. If allowance is made for a 10% compensation flow then the tunnel diameter would be 4.4 m; and

- a power station on the left bank of the Kokohiko Stream, with an estimated generating capacity of 12.5 MW at a 50% plant factor (9.75 MW for 10% compensation flows).

Several portal sites and tunnel alignments were considered. Limited field data indicates a direct routing would be most suitable. In deriving the generating capacity of the scheme it is assumed that the Tariki Power Scheme continues to supplement flows into the Waitara River upstream.

Engineering Geology

At the possible dam site the river is constricted by the underlying siltstone/sandstone strata which is exposed in the river bank. Overlying this is a thicker layer of lahar (10 m+) with interspersed alluvium. The lahar in this area comprises the complete range from fine silt to large boulders. North of the dam site the east bank cliffs rise rapidly and steeply in massive siltstone. This material is strong, as indicated by the unsupported road tunnel near the crest, although there is evidence of instability in the slopes immediately adjacent to the river. Approximately 1 km to the north is the Inglewood Fault. To the east the Onaero River has downcut into the sandstone/siltstone although the overlying lahars within the valley appear to be much thicker.

Foundations in these materials should be relatively straightforward as would normal tunnel excavations within the sandstone/siltstone. However the permeability of the materials would have to be reduced by grouting. Tunnel portal problems could be expected on the base of the erodable cliffs.

Appraisal

Preliminary cost estimates (Table 5.1) show this scheme to be attractive and to be high in the regional economic rankings even when allowance is made for compensation flows.

A low-level concrete dam diversion structure is suitable to cope with the large floods and maintain high operating pool levels. Higher dams will cause extensive flooding of pastoral land, county roads, existing bridges and parts of Tarata. The left abutment comprises lahars which, unless treated, are generally unsuitable for dam construction as they are extremely variable and often very pervious. Higher dams aggravate these problems. Detailed geotechnical investigations will be necessary to appraise the best means of treating the abutments and foundations, primarily to reduce permeability to acceptable limits.

The Kokohiko Stream, which extends downstream to the Onaero River, has a flat gradient and a wide natural river bed flanked by bush-clad sandstone/siltstone ridges. The channel width is about 80-100 m and appears capable of conveying much larger flows than its present catchment would provide. It is envisaged that few channel improvements would be required to convey the diversion flows for this scheme although a detailed study will ascertain the extent of improvement works, ie. channel scour and bank re-vegetation.

Sedimentation problems are inevitable with the small amount of storage provided although these could be reduced by implemeting a regular reservoir sediment flushing programme. The intake area will need to incorporate a sand trap to prevent large size quartz particles entering the tunnel.

The scheme involves approximately 5.0 km of access roads, most of which only requires upgrading of existing farm roads. Access to the intake portal may pose problems as the site is at the base of an actively eroding escarpment.

In view of the existing high water demand in the lower Waitara, this scheme has severe restrictions. The diversion would result in downstream users having a lesser supply to draw upon. Although the Waitara is supplemented with flow from the Manganui River 7.5 km downstream, this scheme will reduce the mean annual flow in the Waitara River from 59.2 m^3/s to 24.8m^3/s, assuming a 10% compensation flow. This may be a major environmental constraint. There are several industrial activities downstream, such as the methanol plant, meatworks, and the synthetic fuels plant, which rely on an adquate flow being available as well as farmers with land adjoining the river. Wildlife habitats, aquatic life and river ecology may also be affected in addition to recreational uses such as canoeing, jet boating and whitebait fishing.

In summary, this scheme is attractive but there are serious environmental constraints associated with diversion of a large river and geotechnical problems in constructing a dam partly in volcanic material.

4.2.4 Scheme 2.6 (Figure 4.3)

Configuration

As an alternative to Scheme 2.5, a scheme on the Waitara River at the same location could be developed without diversion to the Onaero River. This would incorporate the following features:

- an 11 m high gravity concrete dam incorporating a spillweir section and stilling basin. During diversion the river could be diverted through openings in the dam base with the dam being constructed in two stages;

- a reservoir with an area of 0.7 km^2 extending 11 km up the Waitara River but containing most of the flow within the existing river bank. The reservoir formed would provide 2.5 hours active storage at mean flow. The estimated sedimentation life of the reservoir is 35 years based on a mean suspended sediment concentration of 0.039% and a trap efficiency of 20%; and

- a power station on the right bank of the Waitara River incorporated into the concrete dam structure, with an estimated generating capacity of 4.1 MW at a 50% plant factor.

The generating capacity of 4.1 MW assumes that the Tariki Power Scheme continues to supplement flows into the Waitara River upstream.

Engineering Geology

Refer to Engineering Geology under Scheme 2.5.

Appraisal

Preliminary cost estimates for the scheme (Table 5.2) shows it lies between the viable and presently uneconomic hydro potential categories. The flood flows (1 in 1000: Q = 2270 m^3/s) are large and a substantial spillway structure would be required to pass them. On this site there is inadequate width for a low dam to provide a chute or side spillway as part of an embankment type dam. A concrete gravity dam with a fixed, long crest would be suitable although detailed study will indicate the measures necessary to overcome problems of weak foundation strength and excessive seepage associated with construction in volcanic material. A spillway canal over the right bank spur may be possible with a higher dam, but such a scheme would cause extensive inundation upstream (Class IV land) and require a 40 m high dam to be constructed on the lahar material. This option is not considered viable.

Because of the likely sedimentation problems associated with this scheme a gated spillway would be inappropriate. Further, the intake area will need to be kept silt free to prevent large sized quartz particles being carried through the penstocks.

This scheme negates the environmental problems outlined in Scheme 2.5. In addition the reservoir formed provides the opportunity for both recreational usage and storing a limited amount of low flow. Trout, fish, eels and whitebait are unlikely to be affected by this scheme as they are found predominantly further downstream.

4.2.5 Scheme 2.7 (Figure 4.4)

Configuration

A low level scheme utilising the additional inflow from the Manganui River could be developed 3.0 km upstream of the Bertrand Road bridge. The scheme is situated close to the high escarpment area known as Pukerangiora Pa and would incorporate the following features:

- a 12 m high gravity concrete dam, 150 m long, with most of the crest length comprising a spillway and associated dissipating structures. During diversion the river could be channelled through openings in the dam base with the dam being constructed in two stages;
- a small reservoir of 0.95 km^2 in area, extending 8.5 km up the Waitara River but containing all the flow within the existing river bank. During large floods flow would extend onto the adjoining pastoral (Class II and III) land. The reservoir formed would provide 2.5 hours active storage at mean flow. The estimated sedimentation life of the reservoir is 40 years based on a mean suspended sediment concentration of 0.039% and a trap efficiency of 20%; and
- a power station on the left bank terrace of the Waitara River 50 m downstream of the dam structure. The station would have an estimated generating capacity of 7.3 MW at a 50% plant factor.

Engineering Geology

Pukerangiora Pa is located on steep hills of the sandstone/siltstone formation and is capped by lahar. The left abutment will be located on these materials while the right abutment would be placed on a much lower terraced level of weak permeable alluvium, mixed with lahar overlying the sandstone/siltstone. While foundations should not prove too difficult in such materials, extensive treatment would be required to reduce the permeability.

Appraisal

The preliminary costings (Table 5.2) show the scheme to be comparable with other low head schemes on the Waitara River. On a national basis, however, the scheme is probably of marginal economic viability. Relatively high costs are attributable to the need to construct a long concrete spillway to cater for the large flood flows (1 in 1000 : $Q = 2960\ m^3/s$). The low lying adjoining farm land on the right bank restricts the flood rise above the reservoir level. To prevent outflanking of the structure a long spillweir is therefore required, together with some localised bunding.

Other problems associated with this scheme include:

- construction in alluvium/lahar which has low strengths and high premeability, requiring either treatment or removal; and
- possible sedimentation of the reservoir within the economic life of the scheme, although regular reservoir flushing would reduce this likelihood.

Several sites were considered in the field but all would have the same above-mentioned problems. This particular site had exposures of sandstone/siltstone near the river bed and appeared to have fewer large alluvial boulders within the waterway. Consequently, founding the dam and excavating within the river bed should prove easier.

Whitebaiting and eeling are unlikely to be affected by this scheme as they mainly occur further downstream. Canoeing and jet boating will, however, be affected.

The Waitara is suitable for canoeing for approximately 110 km of its length, with rapids near the confluence of the Waitara and Manganui Rivers providing a special challenge. Additionally, the 10 km downstream of this confluence provide a series of rapids with some cliffed areas adjacent to Pukerangiora Pa (Taranaki Catchment Commission, 1984 f).

Jet boating in this area, particularly from the confluence with the Manganui River to the State Highway 3 bridge, is popular. Rocks, shelves, shingle rapids and the Pukerangiora Chute are particular features (Taranaki Catchment Commission, 1984 f).

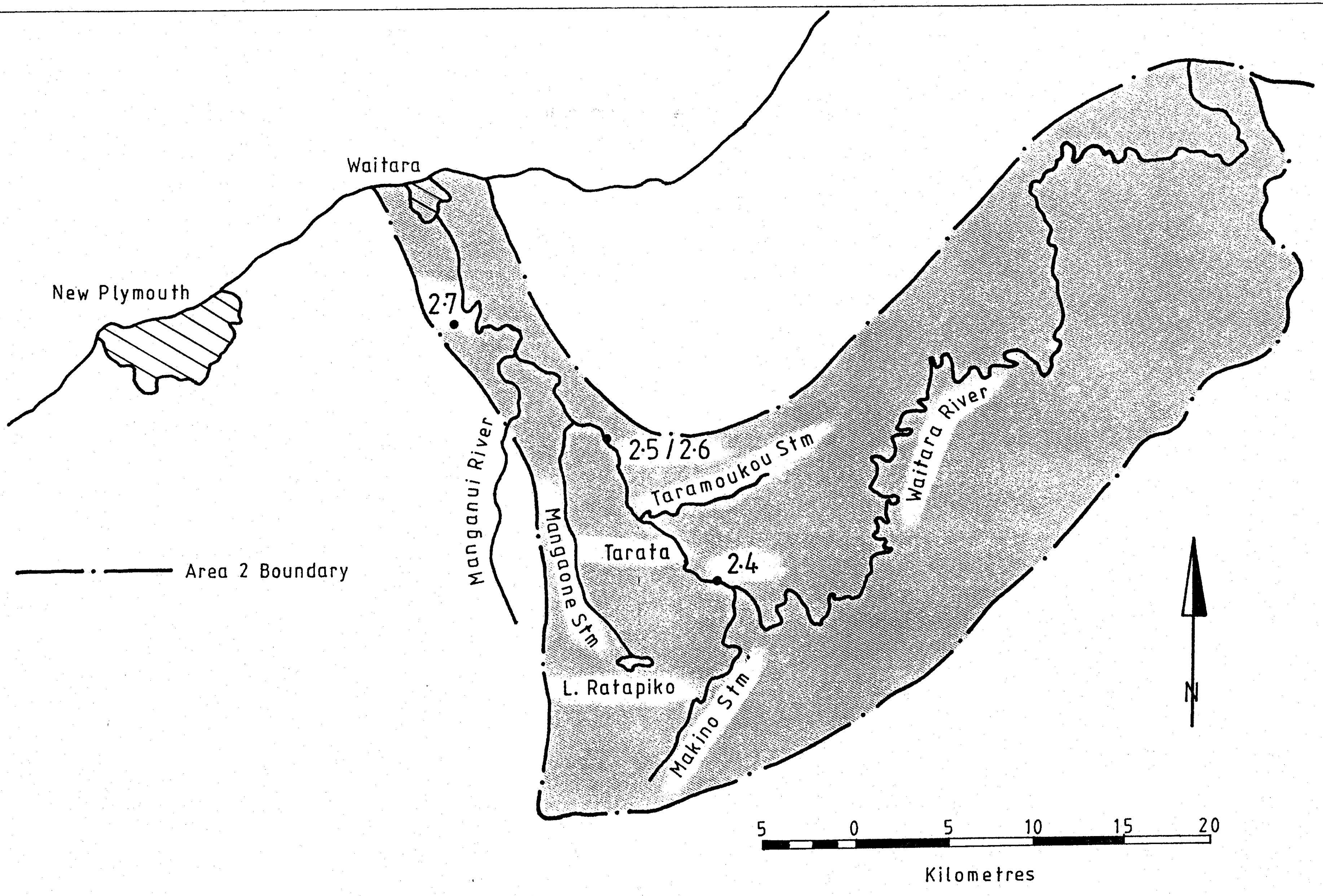
Few environmental problems are envisaged with this scheme although consideration of the needs of canoeists, jet boaters and other recreational users is necessary if any proposal is developed. Also the natural landscape around Pukerangiora Pa, an area of local historic interest, would undergo change.

4.2.6 Summary of Scheme Potential : Area 2

The Waitara River has a relatively high mean flow suitable for low head schemes. Because the River is not incised, and townships and county roads are located near the river bed, high or medium level storage dams do not appear viable. Further, in the reaches below Scheme 2.5 the presence of weak and permeable alluvium overlying lahar preclude construction of such dams.

On the basis of preliminary costings, Scheme 2.5 is the most favourable on the Waitara River. This scheme, however, involves the diversion of flow into the Onaero River and thus there would be severe environmental constraints associated with any development.

The other possible sites have similar economic rankings. High costsings of each are attributable to the need to construct a concrete spillway and stilling basin to cope with the high flood flows. It should also be noted that low head storage schemes will probably experience sedimentation problems within their economic life.



POTENTIAL LOCAL HYDRO SITES IN AREA 2

FIGURE 4·1

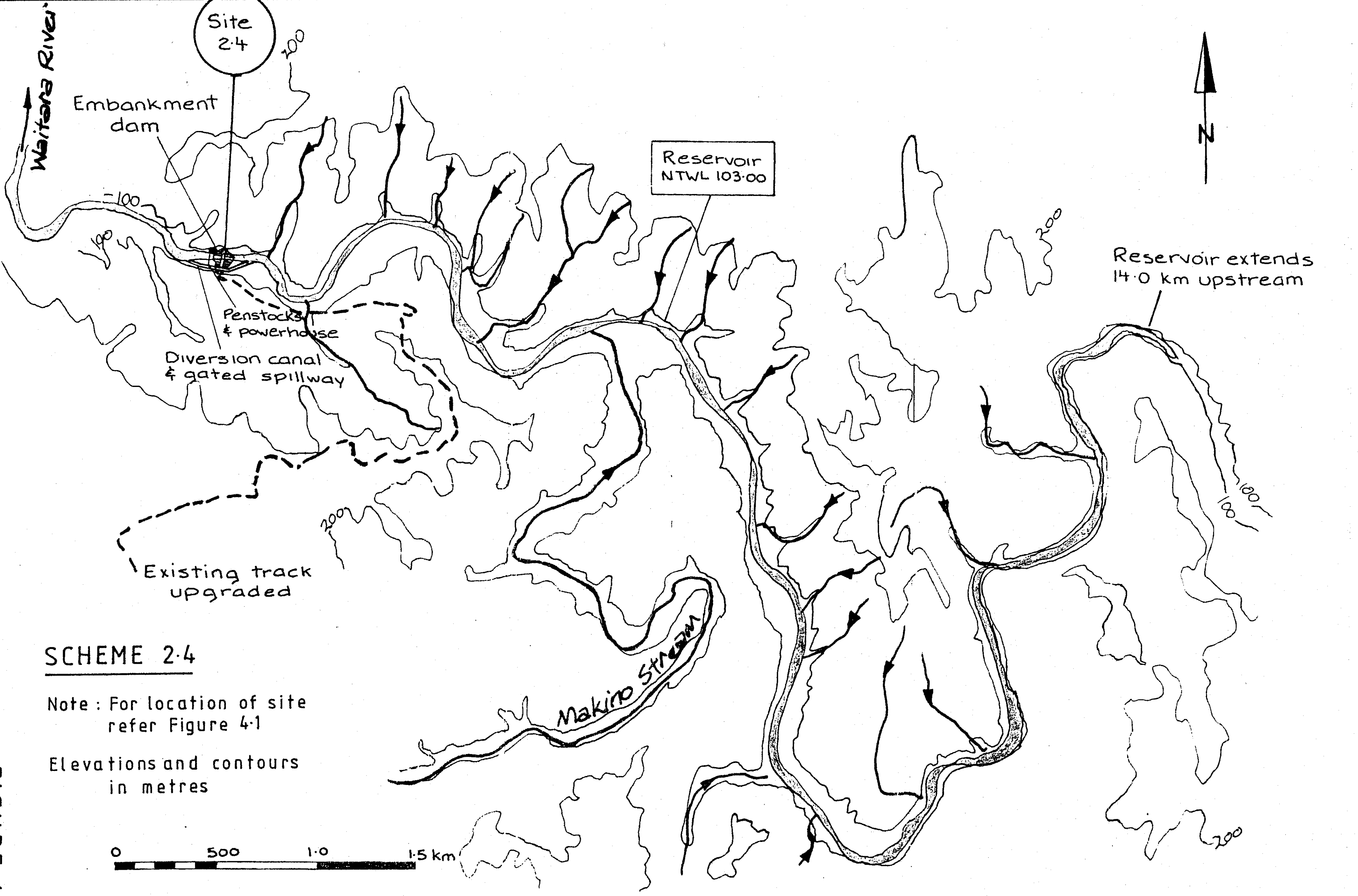
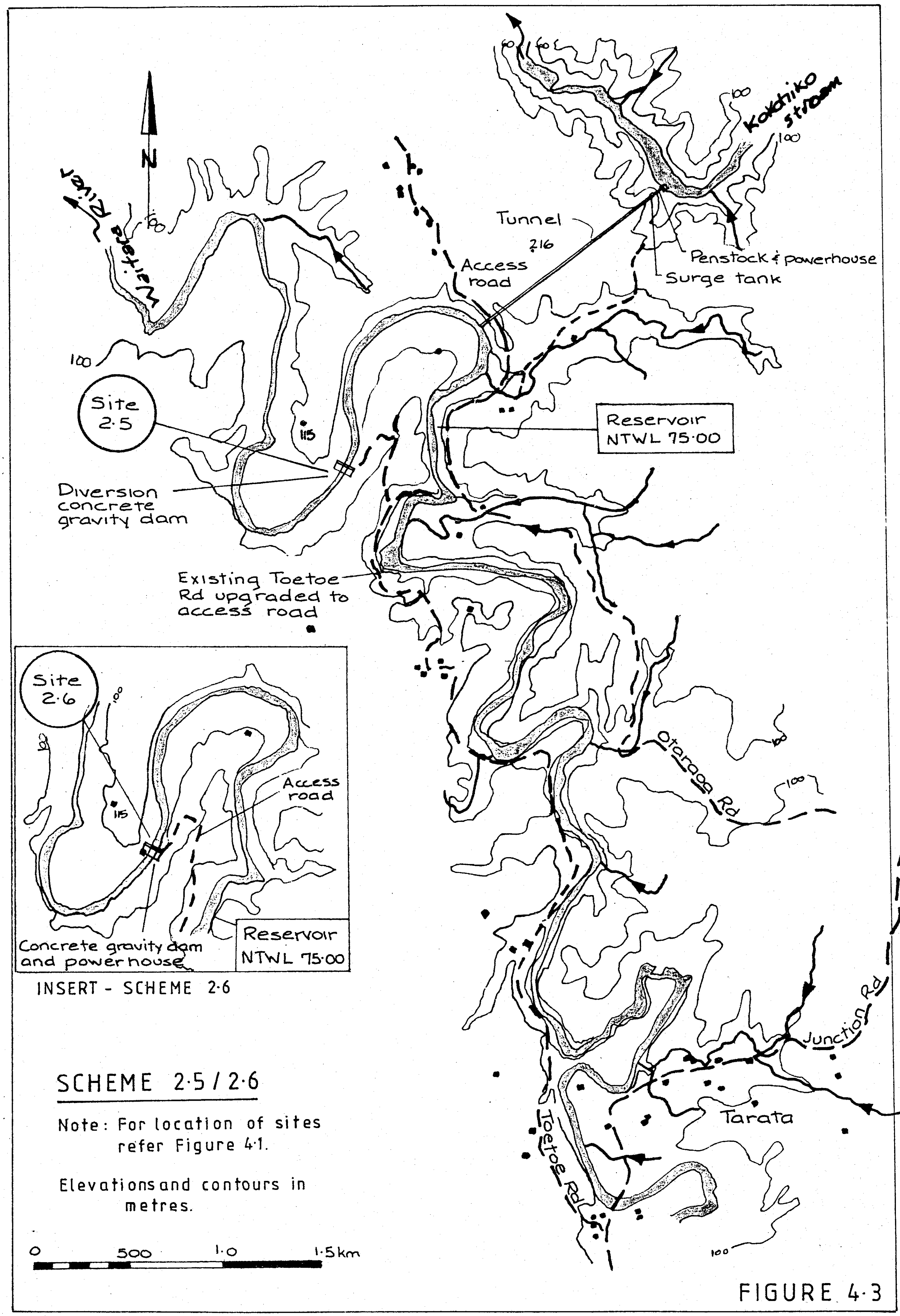

Site 2·4
Embankment dam
Waitara River
N
Reservoir NTWL 103·00
Reservoir extends 14·0 km upstream
Penstocks & powerhouse
Diversion canal & gated spillway
Existing track upgraded
Makino Stream
100
200
SCHEME 2·4
Note : For location of site refer Figure 4·1
Elevations and contours in metres
0
500
1·0
1·5 km

FIGURE 4·2



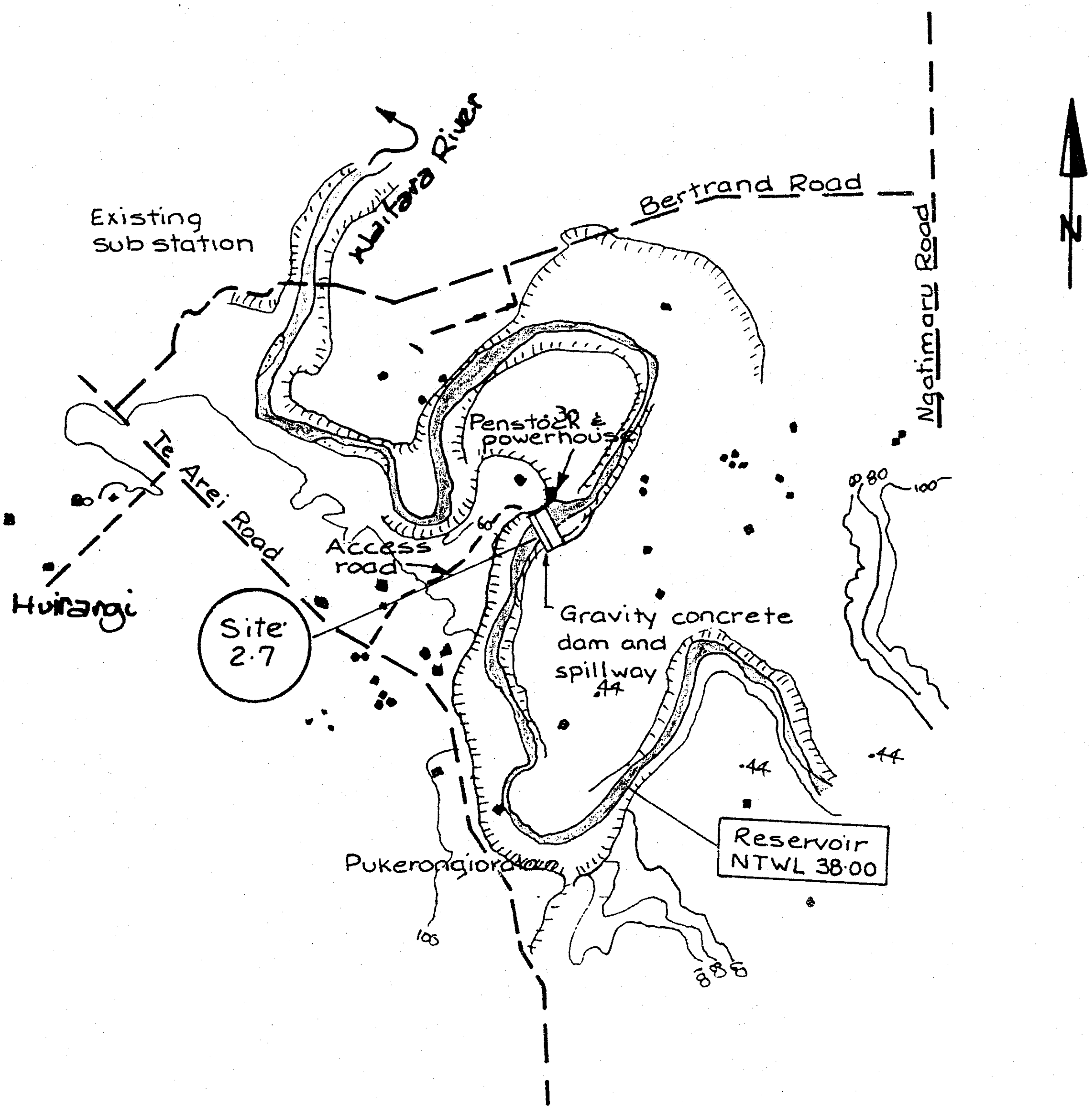
SCHEME 2.5 / 2.6

Note: For location of sites refer Figure 4.1.

Elevations and contours in metres.

0 500 1.0 1.5km

FIGURE 4.3



SCHEME 2·7

Note : For location of site refer Figure 4·1.

Elevations and contours in metres.

FIGURE 4·4

4.3 Area 3 - Northern Mountain Streams

4.3.1 General Features

Area 3 covers the rivers that are under the jurisdiction of the New Plymouth Municipal Electricity Department. These rivers drain from Mt Egmont to the northern coastline of the area, and are bounded by the Stony River in the west and the confluence of the Manganui and Waitara Rivers in the east. The main rivers and streams are:

Kaihihi Stream	Maongaotuku Stream
Katikara Stream	Huatoke Stream
Pitone Stream	Te Henui Stream
Timaru Stream	Waiwhakaiho Stream
Whenuariki Stream	Mangati Stream
Waimoku Stream	Waiongana Stream
Wairau Stream	Ngatoro Stream
Oakura River	Maketawa Stream
Tapuae Stream	Manganui River

Volcanic ashes and rocks, volcanic alluvium and lahar deposits are the dominant geological features with yellow-brown loam soils found on both the flat plains and the gently to strongly rolling lowlands.

Intensive grazing, including dairying, is the major land use at present although there is potential for horticulture, root and green fodder crops and production forestry. Nearer the slopes of Mt Egmont the land is either undeveloped or planted in production forestry which reflects the poorer drainage, soil limitations and erosion potential.

All the main rivers and streams in the area have water users for agricultural and rural water supply purposes. The Kaihihi, Katikara, Waiwhakaiho, Ngatoro and Maketawa Streams have existing commitments to supply industrial users. Further, the Kaihihi, Katikara, Oakura, Ngatoro and particularly the Waiwhakaiho Streams are presently utilised for urban water supply.

The Waiwhakaiho Stream is fished by a large number of whitebaiters who generally use the eastern bank within 1.5 km of its mouth (Taranaki Catchment Commission, 1984 f). None of the other rivers support significant whitebait fisheries.

In terms of recreational usage the rivers in this area are highly rated for their scenic appeal, water quality and range of activities offered.

Runoff from agricultural activities or inputs from farm oxidation pond effluent are not major problems. This is evidenced by the high diversity of fish species found and their wide distribution (Taranaki Catchment Commission, 1984 e).

The preliminary scanning study identified five 'diversion' type schemes. It was found that four of these schemes were worthy of further investigation and these are shown in Figure 4.5. Field appraisal and details of each scheme are outlined in the following sections. (Refer also to Appendix C - Photographs).

4.3.2 Scheme 3.1 (Figure 4.6)

Configuration

A 'diversion' type hydro scheme in the Manganui River is possible by utilising the 65 m fall gained in taking water from Everett Park, bypassing the Manganui/Waitara confluence, and discharging into the Waitara River near Pukerangiora Pa. The Manganui River at Everett Park has a relatively high specific discharge (69 $l/s/km^2$) even though flow is diverted upstream at Taraki (3.64 m^3/s) for use in the Taraki Power Scheme.

The envisaged layout of Scheme 3.1 includes:

- a 3 m high concrete diversion weir;
- a 300 m long low pressure conduit buried within Everett Park, an intake control gate and a sand trap;
- a 6100 m long canal;
- 9 stream diversion intakes along the canal route;
- a forebay area to balance canal and penstock flows; and
- a 300 m long penstock and powerhouse on the left bank of the Waitara River with an estimated generating capacity of 12.3 MW at a 50% plant factor (no compensation flow).

In deriving the generating capacity of the scheme, it is assumed that the Taraki Power Scheme will continue operating and that 5% flushing flows will be required for the sand trap.

Engineering Geology

This scheme, in the Everett Park area, would be sited on and within various lahar flows. These are typically strong, coarse gravel to boulder materials, with a silty sand matrix and can be very permeable. Consequently they are prone to internal erosion or piping. The lahar flows appear to form overlapping terraced areas and the proposed canal would be located within the Waitahi lahars. At the Waitara River and in the forebay and penstock/powerhouse region, the materials are weak lahars with evidence of localised slips. Any construction within these materials is difficult because of the variable geology encountered and weaker sections would require permanent supports for any tunnelling or excavation work carried out.

Appraisal

Preliminary cost estimates (Table 5.1) indicate that this scheme is attractive and is high in the regional economic rankings, even when allowance is made for compensation flows. Relatively high canal costs are associated with impermeable lining, protection for the lining and sub-canal drainage - all of which are considered necessary when constructing through materials found in this area.

There are several advantages of this proposal, including:

- it is economically attractive;

- in general, the topography is well suited to a canal scheme incorporating a forebay area near the powerhouse; and

- it is located close to the Huirangi Sub-station.

However, there are also a number of disadvantages. First, the scheme would entail diverting approximately 6 km of the Manganui River with consequent implications for river flows. This consideration is significant since the river is suitable for a range of recreational activities, particularly trout fishing and canoeing (Taranaki Catchment Commission, 1984 f). Its proximity to local centres and good access also contribute to its popularity with users.

A further consideration involves the intake site. This would be located within Everett Park which is used extensively for a variety of activities, such as bush walks, picnicing, swimming, canoeing and outdoor education. If a proposal proceeded a buried conduit would alleviate some of the environmental concerns, particularly if construction was well supervised and land reinstatement was carefully planned. Local opposition, however, is likely to be intense.

Another disadvantage is that the last section of the required 6100 m long canal, including the forebay, is routed around an escarpment which has experienced localised bank failure. In order to design the canal and forebay over this reach detailed geotechnical investigations would be necessary.

4.3.3 Scheme 3.3/3.4 (Figure 4.7)

Configuration

In the preliminary report these were considered as two separate schemes. However, if scheme 3.3 was implemented by itself it would substantially reduce output from the existing Mangorei Power Scheme. Therefore these two schemes are considered together, and would act as a catch-water system intercepting flow from the Mangaoraka Stream in the east around to the Korito Stream in the west. Flow would then be diverted through penstocks to the Mangorei Stream to gain an overall head of 105 m. The estimated generating capacity produced would be 5.9 MW. Finally, flow would be returned to Lake Mangamahoe where the additional inflow could be used to augment the existing scheme.

Scheme 3.3/3.4 would have the following components:

- a 3000 m long intercepting canal;

- a 12 ha balancing pond and a 1500 m long head race canal;

- 17 stream diversion intakes;

- a 1600 m long penstock and powerhouse on the right bank of the Mangorei Stream;

- a 2400 m long tailrace canal to Lake Mangamahoe; and

- a 340 m long penstock to the existing station, and the installation of an additional turbine.

Engineering Geology

This scheme would be located in the lahars of the Mt Egmont ring plain. These predominantly silty gravels are generally strong but they can also be permeable. Large variations are found within short distances.

The high permeability suggests that small weirs can be built without too many problems although shallow cutoffs may be required in sections of the river bed or at abutments. All canals should have battered sides or be fully supported, and any permanent water carrying structures should be fully lined to prevent erosion and water loss. Low loaded foundations can generally be supported on spread footings, but heavier loadings may require more substantial support.

Appraisal

Preliminary cost estimates (Table 5.1) indicate that this scheme is uneconomic. Relatively high costs are associated with the canal and penstocks for a low yield as the catchments involved are small. Unless there is potential for mutiple use of the scheme, for example, supplementing irrigation flows downstream, it is unlikely to be viable.

However, one of the implications of this scheme if it proceeded is that a catch-water system would abstract water from connecting streams and thus reduce downstream flows in each. Therefore, apart from the economics of this scheme, the environmental constraints could also severely reduce the attractiveness of developing any proposal further.

4.3.4 Scheme 3.4a (Figure 4.7)

General

This scheme was not considered in the initial report. Following the field appraisal and study of earlier reports on the Mangorei Scheme (Mandeno Chitty and Bell, 1964) it is apparent that the main power tunnel to the surge tank has reserve capacity, while the supply tunnel from the Waiwhakaiho River is currently at its limit. Further, the flow records for the Waiwhakaiho at SH 3 and the performance records of the power station indicate that the Waiwhakaiho diversion weir spills a considerable amount of flow, as shown below.

Mean flow for Waiwhakaiho catchment into Lake Mangamahoe (including Mangamahoe Catchment)	8.7 m^3/s
Flow to produce maximum output (4.25 MW)	7.1 m^3/s
Flow to produce mean energy output (20 GW-hr/annum)	3.8 m^3/s

Thus, the generating capacity of the existing scheme could be increased by making greater use of the river flow. However, it is recognised that the shortage of active storage within Lake Mangamahoe, particularly at peak periods, is a constraint on the present system and would require consideration if the scheme proceeded.

Configuration

The envisaged scheme would comprise the following additional components:

- a 1250 m long canal, diverting excess flow from the Waiwhakaiho River to the Mangamahoe Stream; and

- a 340 m long penstock to the existing station and installation of a 2.8 MW turbine and associated electrical equipment. There is already provision for future penstock connection at the existing surge chamber.

Engineering Geology

The geology of the area around the canal is similar to that of Scheme 3.3/3.4.

Appraisal

Preliminary cost estimates (Table 5.1) show this scheme is attractive if no compensation flows are required. However if compensation flows in the order of 10% of the mean flow are needed, then it would probably be of marginal economic viability when considered on a national scale. It should be noted that there is no allowance for compensation flows downstream with the present arrangement.

Lake Mangamahoe is currently used by the New Plymouth City Council for both hydro power and water supply purposes. Increasing the inflows into the reservoir will affect their respective outputs, and operational studies would be necessary to derive the optimal levels. Such studies should take into account:

- operating sequences for power demand and water supply;
- reservoir storage;
- canal and up catchment storage; and
- river inflows and their water quality.

In addition, an assessment of the hydraulic capacity, structural integrity and safety of the existing components would be necessary. Upgrading may be required.

Flows in the Waiwhakaiho River above Lake Mangamahoe are generally insufficient for canoeing. Downstream of the Mangorei power station, however, the river is canoeable year round (Taranaki Catchment Commission, 1984 f). The most popular section is the tailrace from the power station to where it enters the Waiwhakaiho River at the Meeting-of-the-Waters Scenic Reserve (Taranaki Catchment Commission, 1984 f). Scheme 3.4a would continue to provide flow within this section of the river.

Trout fishing and whitebaiting are also popular activities on the Waiwhakaiho, and it also rates highly for its educational and historical value (Taranaki Catchment Commission, 1984 f). Diversion of water from the river may affect these activities to a greater or lesser extent depending on quantities of water taken, seasonal requirements of river users and the tolerance of fish species to habitat modification associated with lower flows.

4.3.5 Scheme 3.5

Augmentation of Taraki Hydro Scheme

A number of proposals to increase the generating capacity of the existing Taraki hydro scheme have been suggested. Generally these involve intercepting flows from rivers and streams east of the Manganui River and diverting them into Lake Ratapiko. This would provide the potential to increase the generating capacity.

Field appraisal has indicated that the present components of the scheme are already operating at the limits of their hydraulic capacity. The head race canal has a measured capacity of 5 m^3/s; the main power tunnel to the surge chamber operates most efficiently at 3.35 m^3/s with high losses thereafter. Thus, it was concluded that complete duplication of components, ie. main head race canal, power tunnel, penstock and turbine, would be required to augment the existing scheme.

As reported in the preliminary report this would clearly be uneconomic.

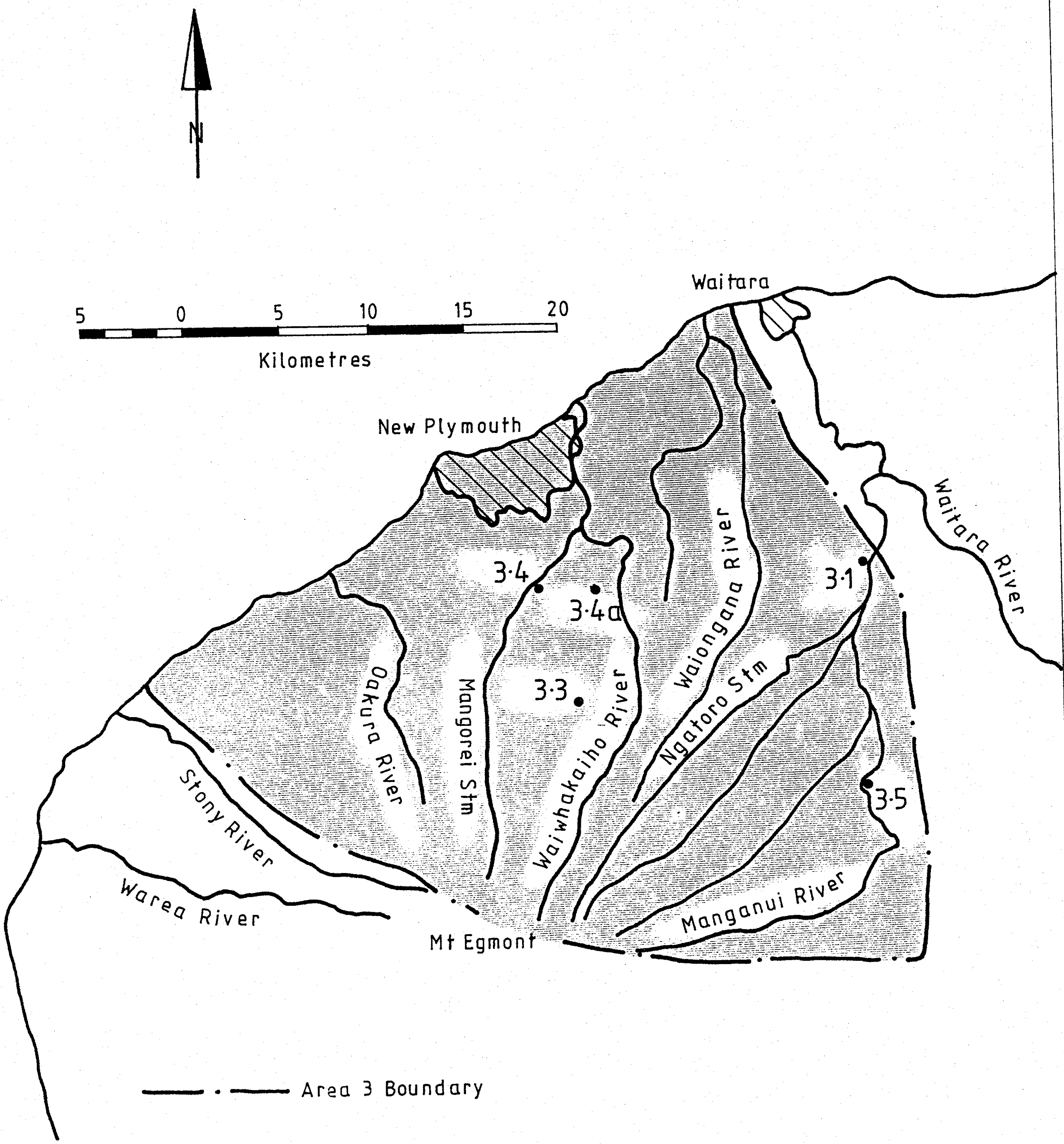
4.3.6 Summary of Scheme Potential: Area 3

High rainfall and runoff are characteristics of this area, as are the numerous small rivers and streams draining Mt Egmont. To collect the flow from several catchments and to create the necessary elevation differences to establish a moderately sized hydro scheme, long canals and penstocks are required. The viability of these 'diversion' type schemes is dependent on the canal construction which, considering the volcanic materials present, will need to have an impermeable lining, protection for the lining, and underdrainage. Constant monitoring will also be necessary.

Canal costings have been analysed in detail and the unit costs are presented in Appendix B.

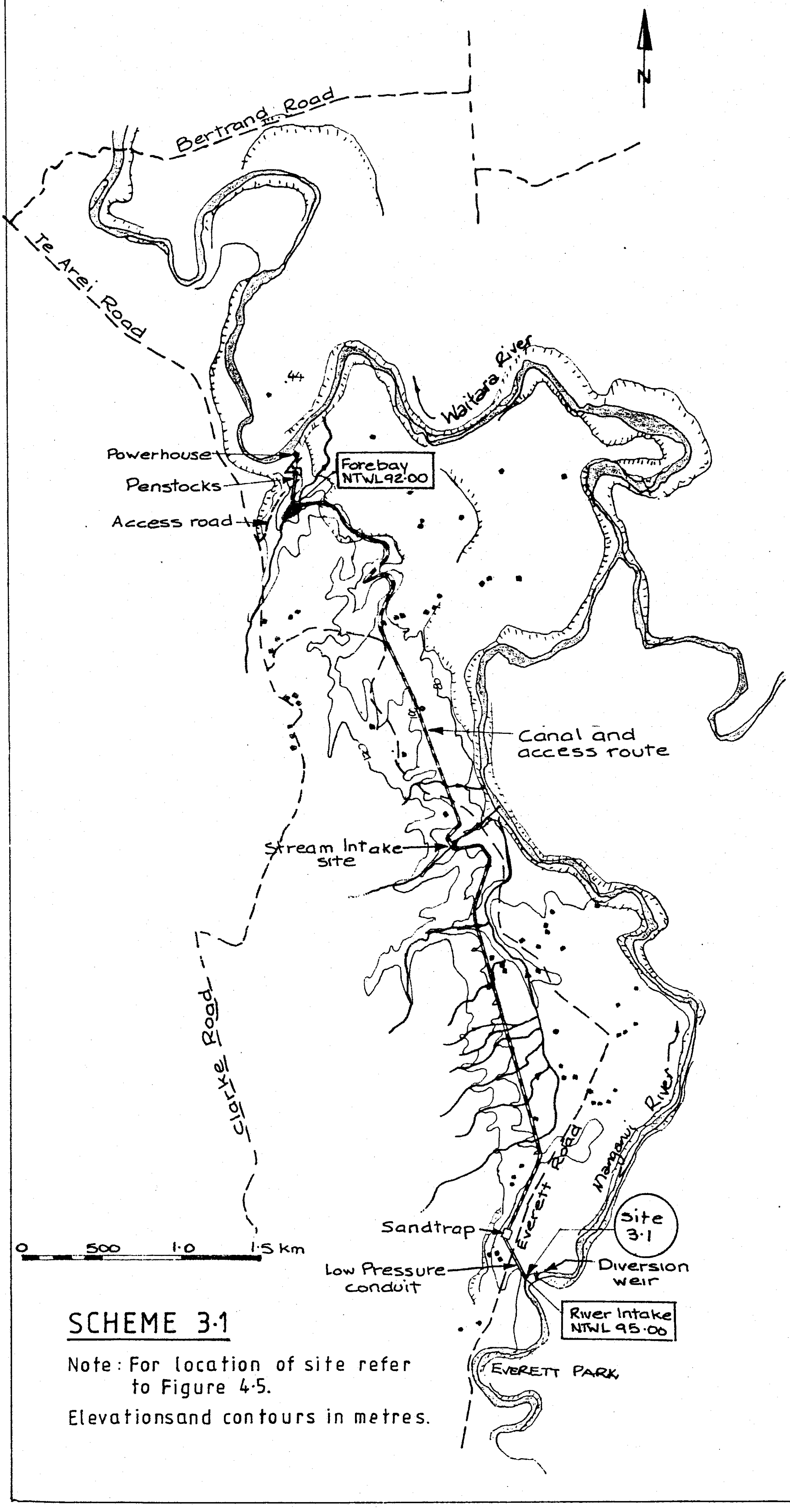
Scheme 3.4a, in which the existing Mangorei power scheme would be increased by an additional 2.3 MW, appears the most economically attractive option. Operational studies are necessary to confirm its viability because the present scheme is operated as a peaking station and also because water is drawn from Lake Mangamahoe for urban water supply purposes.

Scheme 3.1 would be economic to develop only if constructional problems concerning the location of the canal and forebay can be resolved. Local opposition regarding environmental issues is likely, particularly since the scheme involves constructing a diversion within a park and reducing flows in the lower reaches of the Manganui River.



POTENTIAL LOCAL HYDRO SITES IN AREA 3

FIGURE 4.5

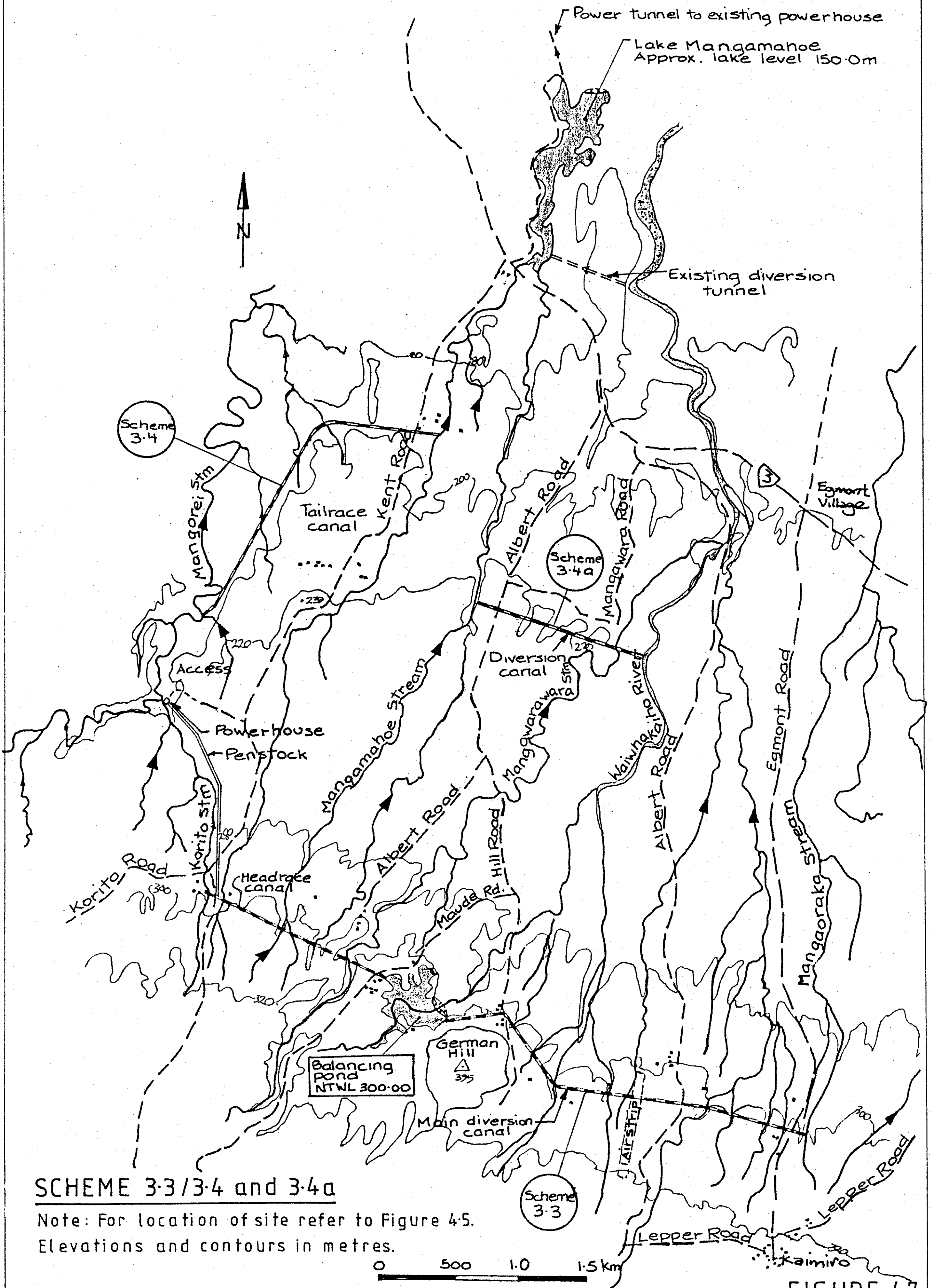


SCHEME 3·1

Note: For location of site refer to Figure 4·5.

Elevationsand contours in metres.

FIGURE 4·6



SCHEME 3·3/3·4 and 3·4a

Note: For location of site refer to Figure 4·5.
Elevations and contours in metres.

FIGURE 4·7

4.4 Area 4 - Western and Southern Mountain Streams

4.4.1 General Features

Radial drainage from the slopes of Mt Egmont produces many streams of similar size reaching the lower plains. These streams derive much of their flow from the upper slopes where the annual rainfall can be as high as 8,000 mm. In general, the water courses are fairly uniformly graded in the upper reaches but the gradient reduces nearer to the coast. The streams have cut shallow valleys in the surface but are occasionally entrenched in gullies up to 10 m deep. Of the numerous mountain streams and rivers in this area, the following are the major ones:

- Stony River
- Waiweranui Stream
- Warea River
- Kapoaiaia Stream
- Waitotoroa Stream
- Okahu Stream
- Oaonui Stream
- Otahi Stream
- Waiaua River
- Mangahume Stream
- Taungatara Stream
- Punehu Stream
- Ouri Stream
- Oeo Stream
- Otakeho Stream
- Kaupokonui Stream
- Kapuni Stream
- Inaha Stream
- Waingongoro River

Topography ranges from relatively steep slopes near Mt Egmont to flat areas on the coast with yellow-brown loam and Egmont brown loam soils predominating. The geology is dominated by volcanic deposits.

Present landuse includes intensive grazing, cereal cropping and reversion to scrub. Horticulture, root and green fodder crops and production forestry are potential landuses although on the gently to strongly rolling lowlands cropping is severely limited by rainfall and the possibility of serious sheet and rill erosion.

Industrial water users, including the Maui Onshore Development and the Kapuni natural gas and ammonia urea plant, abstract from the Oaonui, Kaupokonui, Kapuni and Inaha Streams and the Waingongoro River. Of these, the Kaupokonui and Kapuni Streams and the Waingongoro River also have commitments to urban water supply users.

In terms of scenic appeal all stretches of the Stony River rate close to the maximum. Water quality, attractiveness of the vegetation and character of riverbanks and riverbed are particular features (Taranaki Catchment Commission, 1984 f). The Waingongoro is valued for its recreational value because of its proximity to several local population centres as well as the range of activities it supports.

Canoeing is a significant recreational use of the Waingongoro River, particularly because of its close location to Hawera. It is the most popular river in South Taranaki for this activity.

Many of the rivers in this area are highly valued trout fisheries. These include the Stony, Warea, Waiaua, Kaupokonui and Waingongoro rivers. Catch rate, fish size, fishable water area, and ease of access are characteristics of these rivers although it is difficult to rank the relative importance of each because many of them are valued for differing reasons and because some are either of greater local or regional significance than others (Taranaki Catchment Commission, 1984 f).

There is considerable variation in habitat quality of the rivers. For example, the Stony River has well oxygenated water with no significant organic enrichment whereas parts of the Kaupokonui and Inaha streams receive large amounts of organic waste, reflected by the presence of a typical organic-enrichment associated invertebrate community (Taranaki Catchment Commission, 1984 e).

The preliminary scanning study identified nine 'diversion' type schemes. Most of these were found to be uneconomic, mainly because of the high costs associated with diversion canals and penstocks to capture only moderate flows. However, four were worthy of further investigation and these are shown in Figure 4.8. Field appraisal and details of each scheme are outlined in the following sections. (Refer also to Appendix C - Photographs).

4.4.2 Schemes 4.5 and 4.7

Configuration

The mid and lower reaches of the Waingongoro River, which has an average gradient of 5 m/km and noticeable meandering, affords potential for several 'diversion' type schemes. Schemes 4.5 and 4.7 are two such schemes.

Scheme 4.5 (Figure 4.9) comprises the following components:

- a 3 m high concrete diversion weir;
- a canal intake and sand trap;
- a 3150 m long canal; and
- a 250 m long penstock and powerstation on the left bank of the river, with an estimated generating capacity of 2.75 MW at a 50% load factor (2.4 MW for 10% compensation flows).

Scheme 4.7 (Figure 4.10) has two options. The first (scheme 4.7a) is to discharge into the Waingongoro River 4 km upstream of the river mouth, while the second option (scheme 4.7b) is to discharge at sea level with the canal terminating on the coastal cliff line. Both have similar components as shown below:

i) Scheme 4.7a
- a 3m high concrete diversion weir;
- a canal intake and sand trap;
- a 3300 m long canal; and
- a 200 m long penstock and powerstation on the left bank of the river, with an estimated generating capacity of 2.1 MW with a 50% load factor (1.9 MW for 10% compensation flows).

ii) Scheme 4.7b
- a 3 m high concrete diversion weir;
- a canal intake and sand trap;
- a 5200 m long canal including an inverted siphon across SH 45; and
- an underground powerstation sited within the cliff-line, with a conduit tailrace to the sea. The estimated generating capacity would be 4.6 MW at a 50% load factor (4.3 MW for 10% compensation flows).

Engineering Geology

Both of these schemes are located in the Kapanui Formation. This formation comprises conglomerates, sand, coal seams and volcanic ash, and is similar to the weaker lahar deposits to the north. Dense gravel and sand/silt deposits with organic material are characteristic of both, as are their strength and relative permeability. The major difference between this formation and the lahars, however, is the lack of the coarser, boulder-sized fragments. These features suggest that although excavation would be easier, all open excavations would have to be either supported or battered and lined.

Sandstone/siltstone occurs at depth and is particularly prominent at Ohawe Beach where the Waingongoro River meets the sea. Here the lahar cover is about 20 m thick and lies directly over the siltstone. Within this coastal section both types of material are unstable because of the influence of the groundwater table, wind and sea. Erosion due to both failure of the lahar and slabbing of the siltstone is estimated at 2 m per 10 years.

Appraisal

Preliminary cost estimates (Table 5.1) show that these schemes are uneconomic. Relatively high costs are associated with the long canals to gain a small head difference and a low power output.

Benefits conferred by these schemes include the opportunity for multiple use of river water for irrigation and industrial purposes, both of which are expanding in this area. In addition the daily flow duration curves indicate that up to 80% of the river flow can be diverted for a 50% load factor, suggesting that high flow utilisation is possible.

There are, however, several disadvantages to be considered. First, it would be uneconomic to develop these schemes as stand alone plants. Other users would need to be assured before any proposal proceeded. A second consideration concerns the forebay area to balance canal and penstock flows. There do not appear to be any sites suitable for this and thus the canal will require extra storage by maintaining the bank level at the same elevation. Canal costs will accordingly be higher.

The Waingongoro River is an important recreational asset to Taranaki. It is close to several local population centres, has very good access and offers a range of recreational activities (Taranaki Catchment Commission, 1984 f).

Whitebaiting is confined to the lower reaches of the river, especially within 100 m of the river mouth, and any hydro scheme development may restrict this activity. This is a significant point since the river is the most important whitebaiting river in South Taranaki in terms of the number of whitebaiters fishing it, and its reputation for consistent catches.

Canoeing and trout fishing are also popular activities that may be affected by a hydro scheme. The former takes place mainly in the lower reaches to the river mouth, whilst the latter occurs over its entire length. Deep pools and fast rapids provide protection and food to sustain large numbers of trout at present (Taranaki Catchment Commission, 1984 f) and any diversion would need to ensure that adequate compensation flows were available to maintain these features.

A final consideration is that the southern coastline in the area is rapidly eroding and is unstable. Any underground cavern as required for scheme 4.7b would need to overcome these geological problems.

4.4.3 Scheme 4.8

Opunake Power Station

A report prepared by Beca Carter Hollings and Ferner Ltd in 1974 recommended the installation of an additional 0.5 MW plant at a 45% plant factor, and the diversion of the Mangahume River into the Waiaua River upstream of the SH 45 bridge. For this study the hydrology has been re-evaluated and the mean flows in the Mangahume and Waiaua Rivers at the diversion are estimated at 2.25 m^3/s and 1.15 m^3/s respectively. Details of various schemes that could utilise these flows are given below.

Table 4.1 - Upgrading of Opunake Power Scheme

	Without Diversion (ie. existing)				With Diversion			
	A	B	A	B	A	B	A	B
Diverted Flow (m^3/s)	3.1	2.6	3.6	3.0	4.7	3.9	5.4	4.5
Output (kW)	395	330	450	380	595	495	690	570
Plant Factor (%)	50	50	45	45	50	50	45	45
Energy (GWh/a)	1.72	1.44	1.77	1.50	2.61	2.16	2.72	2.25
Additional Capacity (kW)	35	-	90	20	235	135	330	210

NOTE : A - no compensation flow
B - 10% compensation flow

Table 4.1 indicates that although there is the possibility of refining the existing station operation, the modifications would not increase the present generating capacity to any large extent (ie. greater than 0.5 MW).

4.4.4 Scheme 4.9 (Figure 4.9)

Recommissioning of old power station on the Waingongoro River

Existing Configuration

The old power station on this river was built in 1902 with an installed capacity of approximately 0.6 MW. After being flooded on a number of occasions, the station was finally shut down in 1967. Records kept by the former South Taranaki Power Board show the Waingongoro station generated an average 2.9 GWh of electricity annually.

It appears that the original ogee weir structure, which is about 20 m long with an overall fall of 3.5 m, is in sound condition. However, the sluice gate and flow compensation valves on the left abutment of the weir are presently inoperable. The existing steel-lined tunnel (2.4 m x 2.4 m) runs for 50 m underneath Normanby Road and emerges on a steep face of the downstream river bank. No machinery parts or structures seem reusable, and the machine hall and associated structures would require complete rebuilding.

Re-commissioning

Reconstruction of the powerhouse would allow the station to be upgraded. Flow records at Eltham Road (35004) and SH 45 (35005) indicate that the mean flow at this site would be 6.5 m^3/s, and with total flow utilisation a diverted flow of 10.4 m^3/s could be achieved.

If allowance is made for 10% compensation flows (ie. 0.65 m^3/s to the downstream reach) then the diverted flow would be 9.6 m^3/s. Additionally, this river has a steady base flow and is well suited to a run-of-river hydro scheme.

New works required to recommission this station include:

- restoration work to the existing dam including de-silting, constructing a 'fuse plug' embankment on the right abutment to increase flood capacity, reconstructing a small retaining wall on the right abutment which has completely collapsed, and replacing the sluice gate and flow compensation valves;

- reconstructing the intake and replacing the lining on the existing tunnel;

- installing a surge chamber and penstocks;

- rebuilding the power station on the existing site with an estimated generating capacity of 1.3 MW at a 50% plant factor (or 1.2 MW with 10% compensation flows);

- access to the powerhouse from Normanby Road; and

- constructing an 11 kV transmission line to the Hawera sub-station.

Appraisal

Preliminary cost estimates (Table 5.1) show this scheme is attractive, and is high in the regional economic rankings. Further, since many of the required works already exist there should be fewer problems obtaining water rights for the operation of the station.

The floor level of the new powerhouse would be located at a higher level than previously and, in combination with river training works, should reduce potential flood damage.

Particular attention to repairing the fish ladder on the right abutment and maintaining a silt free entrance into it is required.

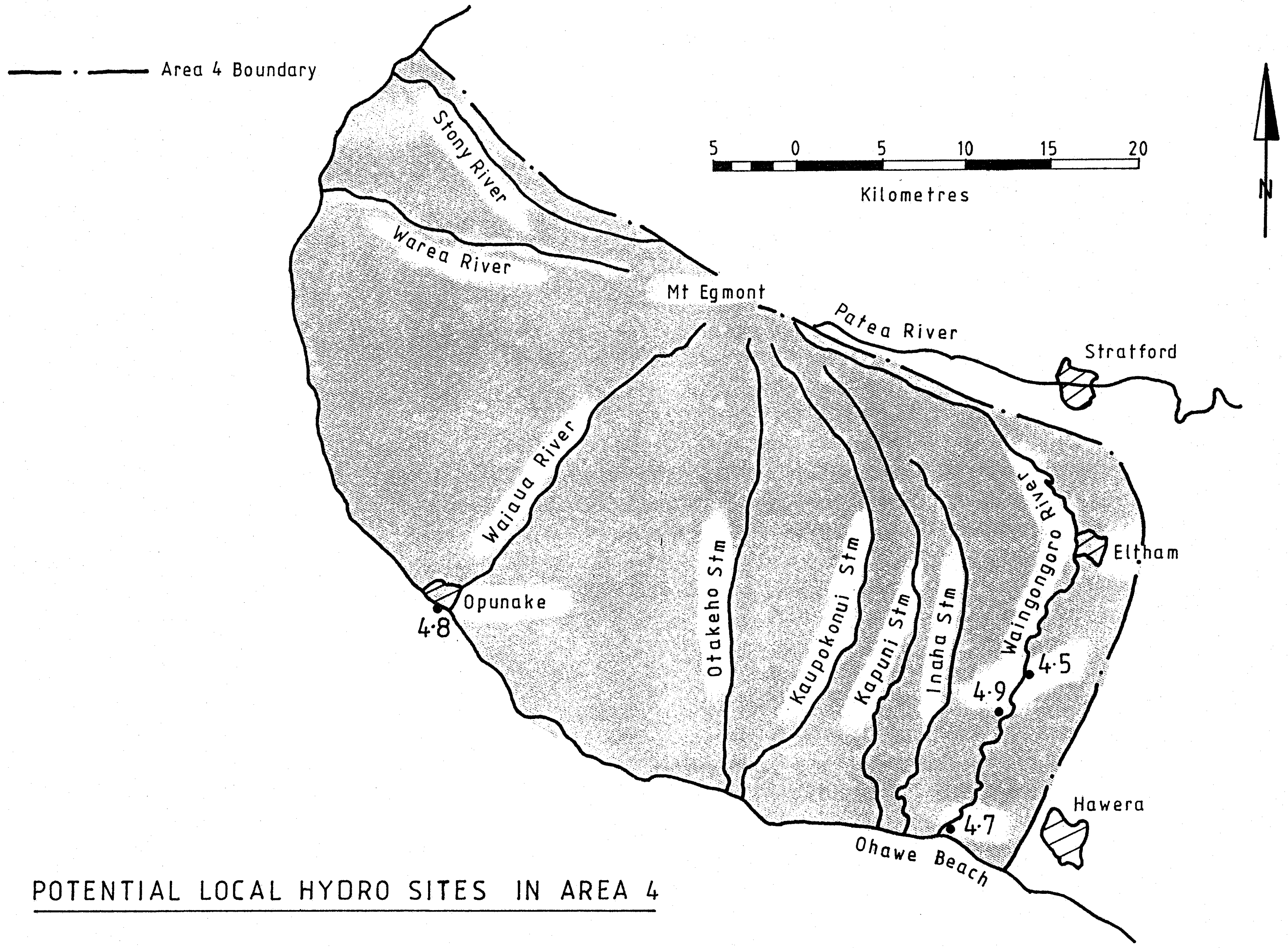
Overall, the option of recommissioning the old station is quite straightforward and merits further detailed study.

4.4.5 Summary of Scheme Potential

This area is similar in topography to Area 3 except that the streams tend to be shorter and the total runoff less. Consequently, nearly all the schemes appear to be uneconomic.

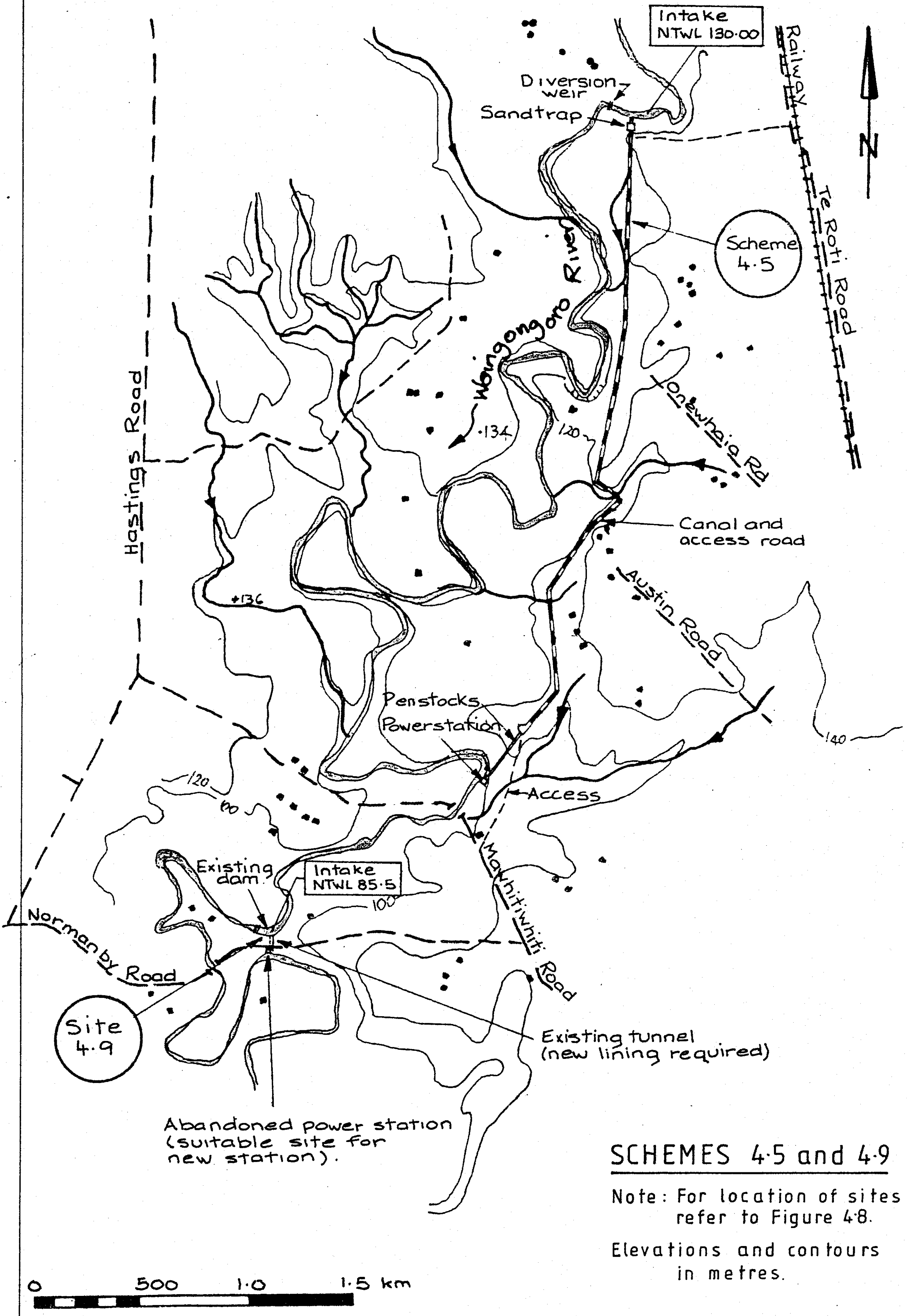
The exception is the option of recommissioning the abandoned power station on the Waingongoro River. This option would be relatively straightforward to implement, and the installed capacity would be of the order of 1.1-1.3 MW.

If the 'diversion' type canal systems on the Waingongoro River could provide for both irrigation and hydro uses then they may increase their economic rankings. However, this river already has a commitment to water supply users, and also there is a water right application pending by the Eltham County Council to abstract water for town supply. Additionally, the river is popular for a range of recreational activities.



POTENTIAL LOCAL HYDRO SITES IN AREA 4

FIGURE 4·8

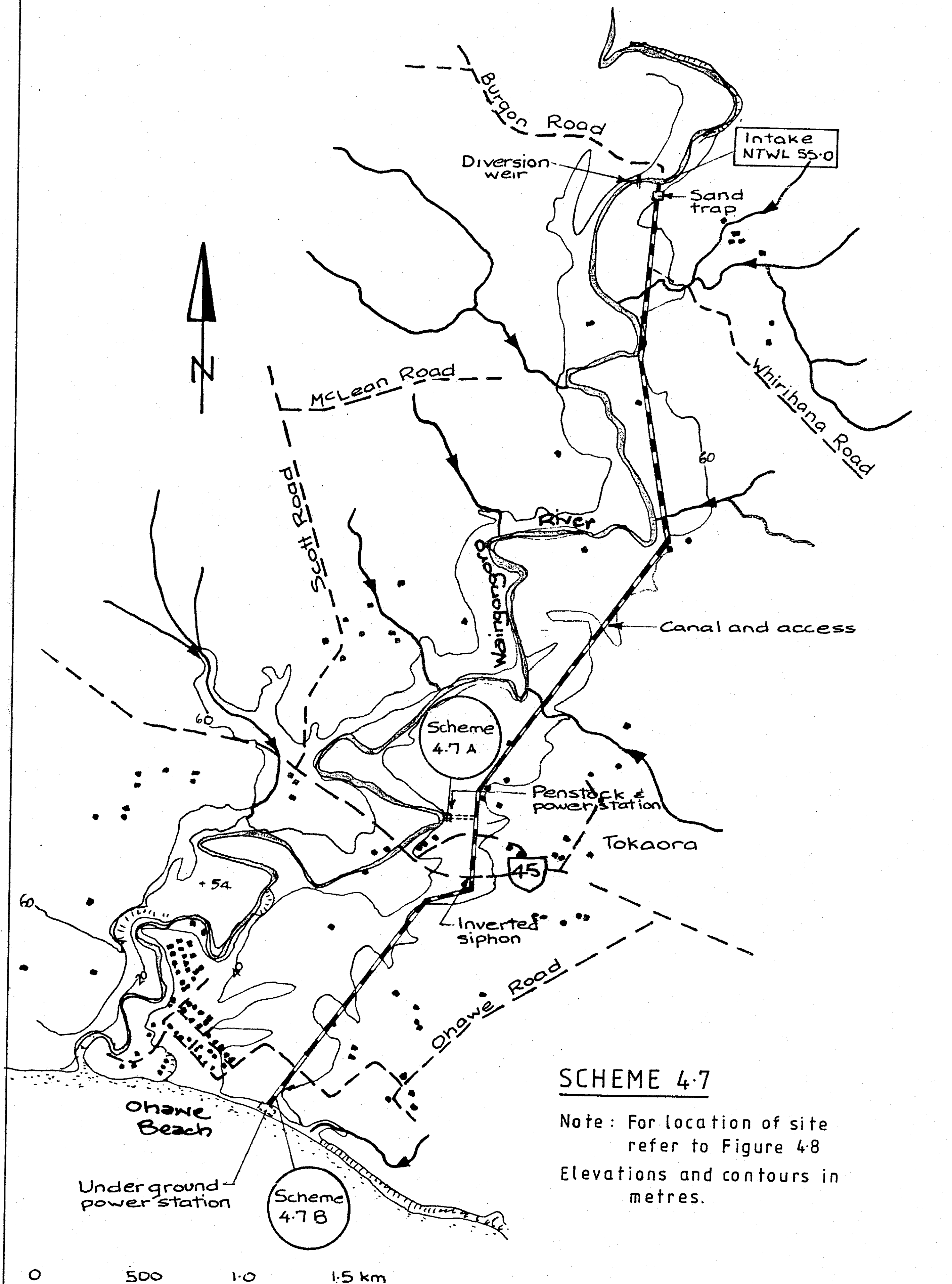


SCHEMES 4·5 and 4·9

Note: For location of sites refer to Figure 4·8.

Elevations and contours in metres.

FIGURE 4·9



SCHEME 4·7

Note : For location of site refer to Figure 4·8

Elevations and contours in metres.

FIGURE 4·10

4.5 Area 5 - Patea River Catchment

4.5.1 General Features

The Patea River originates on the eastern side of Mt Egmont and flows down through Stratford and into the inland hill country where it is joined by a major tributary, the Mangaehu Stream. The combined river flows to the southeast initially and then runs south through a deeply incised meandering valley to reach the coast at Patea. The river length is 143 km from Patea to the source on Mt Egmont. From the Mangaehu tributary the distance is 164 km from the source to the sea. The catchment is in the path of the predominant north westerly winds and has consistent rainfall throughout the year. Average annual rainfall is about 2,000 mm and varies from extremely heavy on Mt Egmont, where the average annual rainfall exceeds 8,000 mm, to moderate at Glennui Station, where the average annual rainfall is 1,407 mm. At Te Wera on the Mangaehu Stream, the average annual rainfall is 1,806 mm.

Hydro-electric development has been considered previously over the upper 70 km reach of river, which is under the jurisdiction of the Taranaki Electric Power Board. In the 1920's the Taranaki Electric Power Board carried out investigations into the hydro power potential of the river north of Mangamingi but no details can now be obtained. Any proposals must have been dropped in favour of the Motukawa scheme. An initial survey was presented to the Egmont Electric Power Board in December 1974 by Beca Carter Hollings & Ferner Ltd and, as a result of this survey, the Patea Hydro Scheme proceeded to construction and was commissioned in May 1984. The scheme is situated 41 km upstream from the river mouth and has an installed capacity of 30.7 MW.

Landuse near the Patea River mouth, particularly on the flat river terraces, is characterised by deep fertile soils supporting intensive grazing, horticulture, cereal cropping, and root and green fodder crops. Further inland the topography changes to moderately steep hill country used principally for grazing. Steepland soils consist of yellow brown earths and yellow brown loams. Steep to very steep slopes of sandstone/siltstone are found at the boundaries of the catchment and there is potential for severe soil slip and moderate debris avalanche erosion. Grazing, reversion to scrub or undeveloped areas are the dominant land uses.

The upper Patea is the main source of water supply for the township of Stratford.

A range of recreational activities are suitable on this river, the most important being trout fishing. Although it is not fished by a large number of anglers, those that do fish it return frequently to make it one of the most used waterways of the Taranaki ring plain (Taranaki Catchment Commission, 1984 f). Access, area of fishable water, scenic beauty and solitude also contribute to its recreational value.

Canoeing is limited to a small area and is only possible during times of high flows.

Fish access is poor because of the barrier created by the Patea dam. Although an eel pass has been built beside the dam, other fish species (except possibly the koaro) will not be able to negotiate this pass

(Taranaki Catchment Commission, 1984 e). Such an impediment prevents the passage of migratory fish and could result in a decline in species populations because essential habitats may become inaccessible.

The preliminary scanning study identified one 'diversion' and two 'conventional' type schemes. A storage scheme on the Mangaehu Stream proved uneconomic to develop because of the moderate flows associated with this stream. The two remaining schemes are considered further in the following sections and are shown in Figure 4.11. (Refer also to Appendix C - photographs).

4.5.2 Scheme 5.1 (Figure 4.12)

Configuration

The steady fall and moderate flow of the Patea River below Stratford provide a potential site for a 'diversion' type scheme. This would involve both canal and tunnel structures.

Included in this scheme would be:

- a 3 m high concrete diversion weir;
- a canal intake and sand trap;
- a 3150 m long canal through some deep excavation (20m);
- a 600m long, 2.30 m diameter, tunnel; and
- a 550 m long penstock and powerstation on the right bank of the river with an estimated generating capacity of 3 MW at a 50% load factor (2.6 MW for 10% compensation flows).

Engineering Geology

This scheme would be located on the sandstone/siltstone sequence which is overlain by lahar varying from 5-30 m in thickness. Small weir structures of 2-3 m height should not pose problems in terms of support or possible leakage. Isolated deposits of alluvium on the river banks would require treatment or removal because of their generally high permeability and low strength.

Any canal cuts would probably be quite deep. Excavation in lahar, particularly tunnelling, is difficult due to its variability, and permanent water carrying structures would require an impermeable lining.

Low loaded structures may be founded on or within the lahar, but higher loaded structures should be supported on the sandstone/siltstone.

Appraisal

Preliminary cost estimates (Table 5.1) show this scheme to be uneconomic. Relatively high costs are attributable to the large earthwork volumes required in routing the canal through undulating countryside, the necessity for a headrace tunnel through higher ground, and the need for long penstocks from the canal headrace to the powerhouse.

It is unlikely that a diversion type scheme in the upper Patea River would have sufficient advantages in providing other uses to offset its poor economic ranking.

4.5.3 Scheme 5.3 (Figure 4.13)

Configuration

The upper reaches of the Patea River are not as deeply incised as the middle reaches, where the Patea dam is located. However, approximately 1.7 km upstream of the Mangamingi Bridge, just beyond the backwater from the Patea Dam, there is a site suitable for a storage dam with an overall height up to 64 m. The river channel itself is about 30 m deep.

A steep escarpment, about 155 m high, with some scree deposits at the base forms the right abutment, whilst the left abutment is terraced with a covering of alluvial deposits and is generally steep enough for an embankment type dam to be economically viable.

For a dam higher than 38 m a substantial perimeter embankment would be required in a saddle located on the left bank, 650 m from the main channel.

Three dam heights have been considered, and these are detailed below.

Table 4.2 - Details for Scheme 5.3 Options

Impoundment height (m)	30	50	64
Area of reservoir (km^2)	1.1	3.9	8.0
Active storage detention time at mean flow (days)	0.7	4	10
Sedimentation life of reservoir (yrs)	340	1300	3300
Installed Capacity (MW)	9.7	18.0	25.2

Common to all schemes would be the following components:

- Diversion culverts through the right bank founded on the sandstone. To reduce the costs of culverts the cofferdam could be incorporated into the main embankment;
- A chute spillway, with upstream gates, positioned on the left abutment. In addition, an emergency 'fuse plug' embankment located near the perimeter embankment; and
- A power station located near the base of the dam, between the main channel and the chute spillway.

Engineering Geology

A sandstone/siltstone basement overlain by lahar restricted to the Patea River valley is the predominant geology of this area. Approximately 3 km west lies the NNE/SSW trending Taranaki Fault.

The proposed right abutment would be against a steep-sided, presently unstable, high slopes of sandstone/siltstone covered with loose scree near the bottom and possibly some slipped material. Lahar covered with recent alluvium and underlain by sandstone/siltstone at approximately 5-10 m depth characterises the geology of the left abutment. The groundwater table is apparent on the left bank, being generally located at the interface between the lahar and sandstone/siltstone, as evidenced by the recent slips generated on the river banks in this area.

Any major structure should be founded on the underlying sandstone/siltstone basement to provide equal and adequate support for both abutments and to restrict losses caused by seepage through the overlying more permeable alluvium and lahar. Cutoffs within the sandstone/siltstone may also be necessary, especially where discontinuities are more prevalent.

Excavation of the alluvium and scree should prove relatively easy. The sandstone/siltstone could be ripped in the upper layers but the harder sections, together with any interbedded limestone, would require the use of specialist rock breaking equipment or blasting. Tunnels or canal diversions through the lahar material would require batters or supports and should be fully lined. No temporary support would be necessary for excavations in the sandstone/siltstone, but permanent support is needed where these structures might be affected by steep hydraulic gradients from the impounded reservoir.

Appraisal

Preliminary cost estimates (Table 5.2) show this scheme to be attractive, with a high regional ranking. The recently commissioned Patea Dam has a completed cost of $1050/kW (June 1978) at a 42% plant factor, which suggests that this scheme has a comparable ranking. Costings indicate that the optimum scheme would have an overall dam height of 30-50 m. The latter option would produce more energy with greater reliability but would pose significant environmental problems. These include the flooding of alluvial terraces (Class III land) presently used as pastoral land, minor flooding to county roads, namely Raupuha and Soldiers Roads, and restricting passage of migratory fish.

The advantages of this scheme are, first, the area has a topography and geology similar to that of the Patea Dam site so that any physical problems should be overcome with the benefit of construction experience in these materials.

Second, the reservoir formed would be a recreational asset providing opportunity for a wide range of activities. Further, because it would be located near the population centres of Stratford and Eltham it is likely to be well patronised.

Another advantage of the scheme is that sources of rockfill from which an embankment dam can be constructed may be found near the dam site.

It is also pertinent that the Stratford load centre is located approximately 15 km from the site, and the load demand would be able to absorb the power produced. The higher dam schemes will provide a greater degree of flow regulation and thereby supplement the energy supply during higher tariff peak periods more easily. This, however, would need to be balanced against both economic and environmental considerations. There will also be the benefit of operating this scheme in conjunction with the existing Patea Scheme. With the increased amount of storage, it may result in the Patea Scheme operating more effectively during peak periods, at least on a daily basis but perhaps also on a weekly basis.

Finally, emergency floods could be channelled through the saddle on the left bank via a fuse plug/auxiliary spillway.

A number of disadvantages of this scheme can also be cited. Extensive flooding of valuable pastoral land and some minor county roads has already been noted.

Design of an appropriate fish pass would be required. It has been noted that although an eel-pass has been built beside the present Patea Dam, other fish species may not be able to negotiate the pass (Taranaki Catchment Commission, 1984 d). This could have adverse implications for species numbers and diversity, particularly since the Patea River is popular for trout fishing.

Considerable ground preparation work in grouting or cut-off trenches may be necessary in areas where the old river bed has left a layer of permeable alluvium.

As the site is located on a relatively straight reach of the Patea River, long diversion tunnels would be required. However, diversion would be achieved by having culverts located in the dam foundation, and these would be filled on completion of dam construction. To make this type of diversion system economic the cofferdams would need to be incorporated into the main embankment. Hence fill areas and the number of earth moving machines within the dam site would be restricted, increasing the complexity of construction of the works.

Finally, consideration should be given to the impact of a further dam on the Patea River for local residents. The river is used for a variety of recreational activities and has a high scenic and historical value, with good access and facilities provided (Taranaki Catchment Commission, 1984 f). Construction of another dam and reservoir similar to the Patea Dam and Lake Rotorangi may arouse opposition since these structures have only recently become operational, and any additional hydro development might be regarded as an unacceptable reduction of those values outlined above.

4.5.4 Summary of Scheme Potential

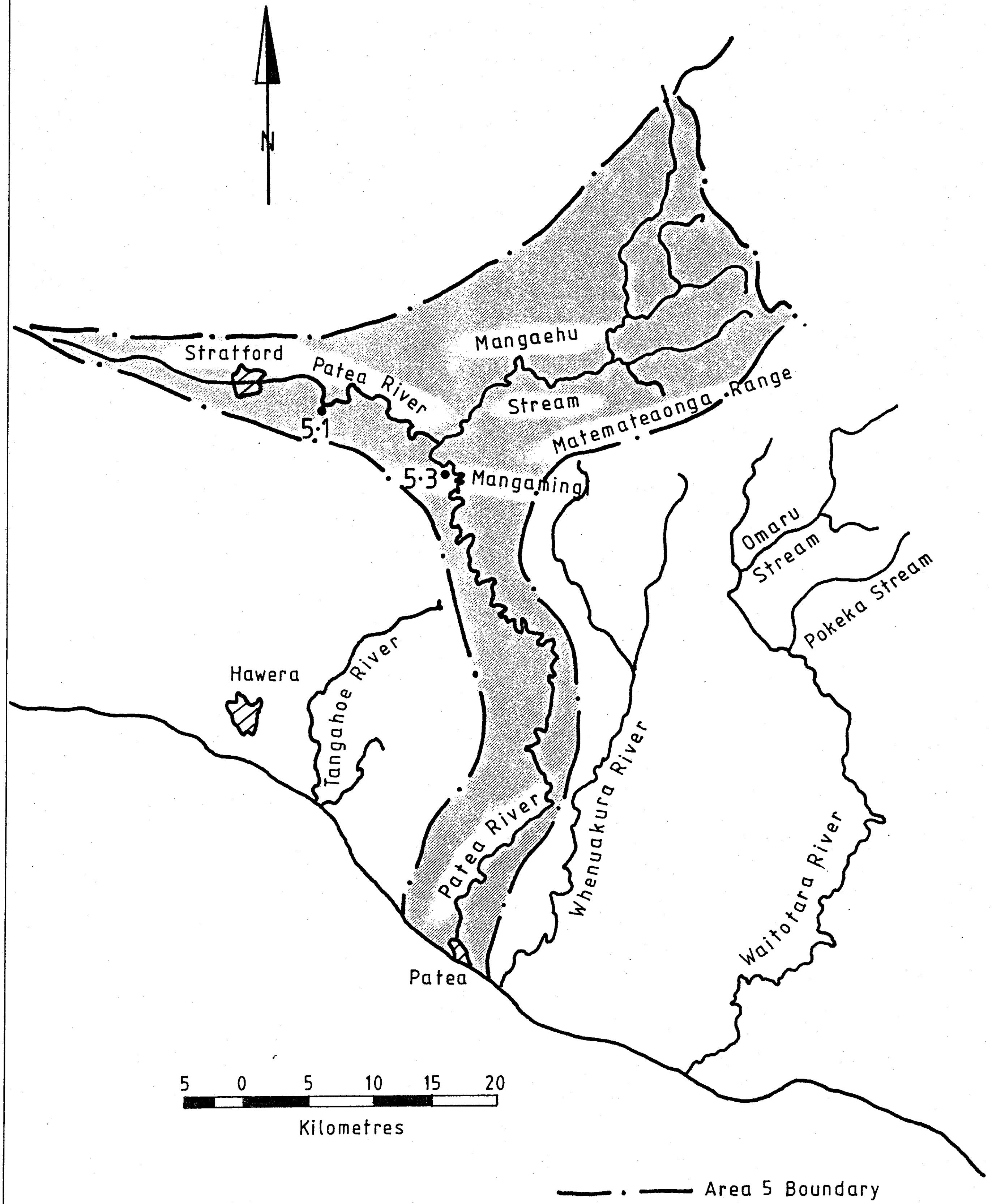
It appears that the upper reaches of the Patea River above the confluence with the Mangaehu Stream are unsuitable for hydro development. This also applies to the Mangaehu Stream.

Upstream of Lake Rotorangi there is opportunity to develop a 'conventional' hydro scheme similar to the existing Patea Dam scheme, with an installed capacity of up to 25 MW.

The geology of the river valley, comprising alluvial and volcanic deposits underlain by the sandstone/siltstone sequence, will probably dictate the overall dam height (in the range of 30-50 m) and thus power output (10-18 MW).

Environmental implications of any scheme would be similar to those experienced with the Patea Dam: loss of pastoral land, re-establishment of roads and bridges, development of a silt-laden delta at the upstream end of the reservoir, provision for continued fish passage up and down stream, and the creation of an impoundment for recreation activities.

Finally, it is considered that the lower reaches of the River below the existing Dam are unsuitable for hydro schemes.



POTENTIAL LOCAL HYDRO SITES IN AREA 5

FIGURE 4·11

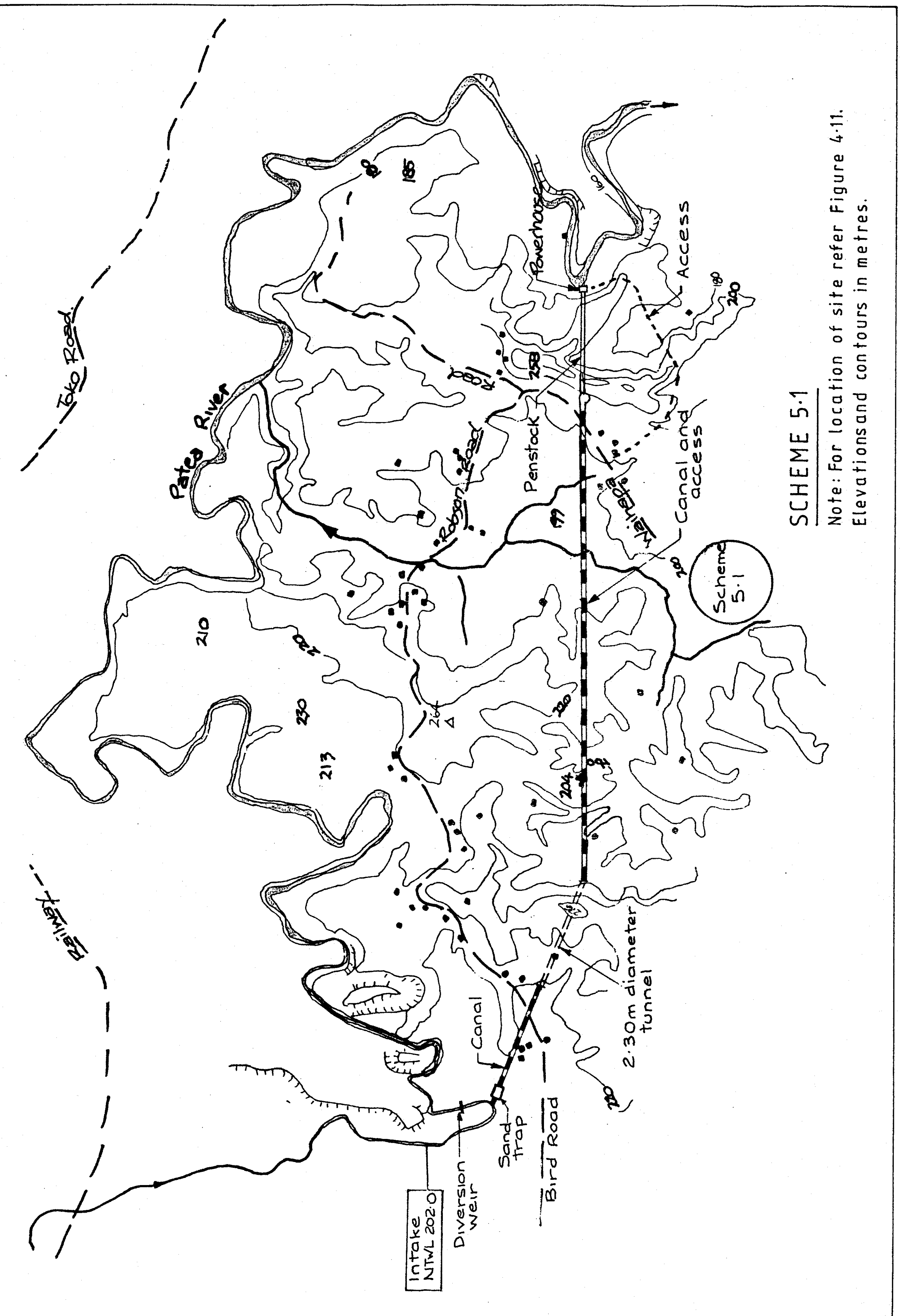
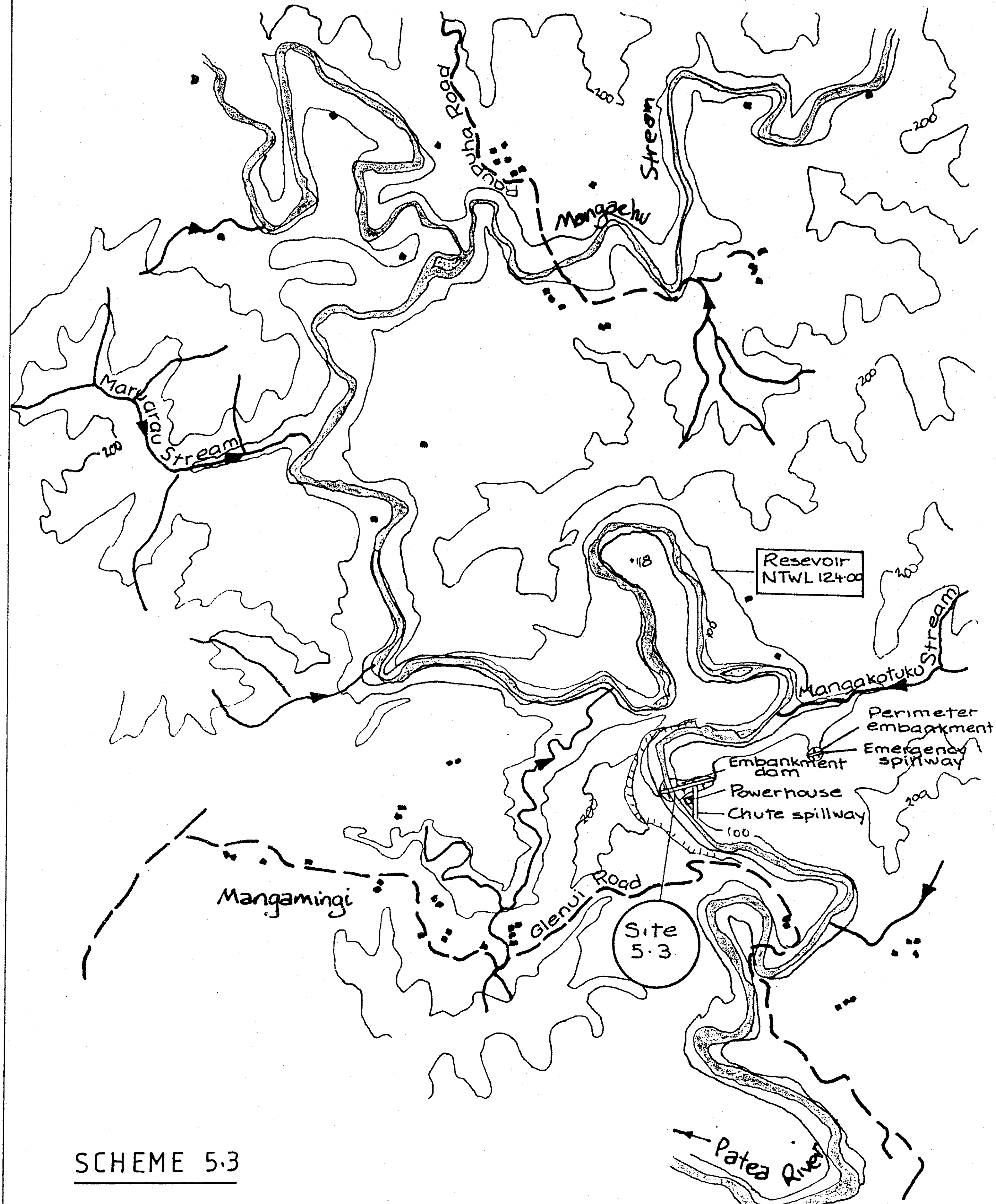

SCHEME 5·1
Note: For location of site refer Figure 4·11.
Elevations and contours in metres.
Toko Road
Patea River
Railway
Robson Road
Road
Penstock
Powerhouse
Access
Canal and access
Scheme 5·1
2·30m diameter tunnel
Canal
Sand Trap
Bird Road
Diversion weir
Intake NTWL 202·0
210
230
213
185
200
264
204
258

FIGURE 4·12



SCHEME 5·3

Note: Reservoir level shown is NTWL 124.0m but lower dam heights have similar economic rankings.

For location of site refer Figure 4·11

Elevations and contours in metres.

FIGURE 4·13

4.6 Area 6 - Southern Coastal Rivers

The rivers in this area include those that drain to the coast south of Hawera but do not have their origins in the Mt Egmont ring plain area; namely the Tangahoe River, Manawapau River, Waikaikai Stream, Mangaroa Stream, Kaikura Stream, Whenakura River, Wairoa Stream and the Waitotara River. Of these rivers ony the Whenakura and Waitotara Rivers, which drain from the Matemateaonga Range, offer any potential for hydro development.

The preliminary scanning study identified two schemes, a possible waterfall site (Scheme 6.1) and a canal diversion (Scheme 6.4), as warranting further investigation. Field appraisal, however, indicated that there is no waterfall at the Scheme 6.1 site. Also, the construction of a canal adjacent to the Pokeka Stream in the steep, bush clad and remote area of Scheme 6.4 is not viable.

In summary, the southern coastal rivers do not offer potential for hydro development either as individual schemes or by diversion into the Patea River basin.

5. CONCLUSIONS

5.1 Appraisal of Hydro-Electic Scheme Potential

This section reviews the potential of individual schemes on a nationwide basis and makes outline recommendations for further investigations. Table 5.1 presents a summary of the physical features and 'first estimate' costs for all 'diversion' type schemes. Similarly, Table 5.2 presents the same information for 'conventional' type schemes. The location of each scheme is shown in Figure 5.1. It is emphasised that all sites would require further, more detailed study to establish the feasibility of developing each site. The review of environmental issues in this report is primarily based on a literature search. These issues, however, would need to be addressed in detail specific to each location before any final assessment could be made.

Schemes can be classified according to the ranking categories given in Table 3.1. This study has identified 8 schemes in the Taranaki Region which are estimated to be below the economic limit of $2000/kW (June 1978) suggested by the MWD. For the Taranaki region, these schemes are either attractive (Table 5.3), possibly attractive (Table 5.4), and attractive but with severe environmental constraints (Table 5.5).

All the low level storage schemes on the Waitara exhibit a similar ranking indicating that the high river flows attribute more to the schemes potential than the salient features of any particular site. Scheme 2.5, a diversion of the River into the nearby Onaero River catchment, is attractive but poses environmental problems particularly as the lower Waitara is 'water short' and demand for water is increasing in this rapidly developing area.

The rivers and streams draining Mt Egmont offer little in the way of major potential hydro development. While the rainfall is high, the number of streams is numerous with each one contributing a relatively small flow. Also, the development of schemes within these volcanic areas would pose quite severe construction problems. Nevertheless, two schemes involving augmentation of existing schemes (one of which is now abandoned) appear attractive and warrant further study. Scheme 3.1, a diversion of the Manganui in to the Waitara River, is viable. However, there would be environmental problems in diverting the river through Everett Park and potential construction problems in routing a canal through an area where there is evidence of existing slope instability.

On the basis of economic and engineering feasibility, Scheme 5.3 on the Patea River exhibits the most realistic potential for 'major' hydro development within the study area. The envisaged scheme would be similar to that of the existing Patea Scheme. Its overall height and thus output would be dictated by the suitability of the underlain materials to found the embankment structure. Also the advantages of a higher dam, ie. larger output and degree of flow regulation, need to be compared with the environmental issues including inundation of valuable pastoral land, the impact of another dam on the Patea River and the impounding lake as a recreational asset to local communities.

Because most of the schemes in this study are small, their impact on the environment tends to be site specific to local areas. These are discussed in Section 4.0. On a regional basis, the type of hydro scheme under consideration could offer:

i) increased recreation opportunity by offering more choice; and

ii) greater regional autonomy amongst local power authorities in providing their own source of power to their consumers.

It remains to estimate the total hydro generation potential which might conceivably be developed economically within the study area. For all the 'attractive' schemes, including those with environmental constraints, the potential is some 170 GWh. This is below the current Local Power Authorities' requirement, which is about 690 GWh.

5.2 Recommendations for Further Studies

According to the guidelines set by the Committee on Local Authority Hydro Development (CLAHD) the next study phase to implement a particular hydro scheme is a 'preliminary feasibility' study. "... This is work undertaken at a particular reach of river in order to determine the most favourable site and establish basic economic and technical parameters to a reasonable degree of reliability. As part of these studies, the intention to investigate development should be advertised to enable the public and interested bodies to comment." The decision on whether to proceed to the next study phase lies with the Local Power Authority.

In order that a 'preliminary feasibility' study can be undertaken it is recommended that the good data base of climatic and hydrological information already established be maintained. This data base could be supplemented by the following: updating the suspended sediment rating curve for the Waitara River at Tarata, establishing whether the bed load sediments at Tarata and Mangamingi are significant, and taking total sediment samples on one of the rivers that drain directly from Mt Egmont to enable the sediment movement characteristics to be derived for rivers of this type. The Waiwhakaiho River upstream of SH3 would be a suitable site because it has an established flow gauging station and no weirs located upstream.

TABLE 5.1 - PRELIMINARY APPRAISAL OF HYDRO SCHEMES "DIVERSION" TYPE

River	Scheme No.	Diversion Site Grid Ref.	Powerhouse Grid Ref.	Catchment Area (km²)	Mean Flow (m³/s)	Diverted Flow (m³/s)	Canal Length (m)	Net Head (m)	Output		Cost		Rank[6]
									Power (MW)	Energy (GW h/a)	$Mill	$ /kw	
Waitara	2.5	N109 910847	N109 927862	820	38.2	48.2	1150[3]	30.9	12.5	54.8	16.9	1350	E
						38.2[4]			9.75	42.7	14.6	1490	
Manganui	3.1	N109 846847	N109 832911	275	18.9	23.8	6100	62.0	12.3	53.9	15.9	1290	E
						19.2[4]			9.9	43.4	14.4	1450	
Several	3.3		N109 669794	41	6.1	7.9	4500	95	5.9	25.8	12.0	2040	D
						6.1[4]			4.8	21.0	10.8	2240	
	3.4	N109 670800	N109 692862	17	2.1	3.3	2500	72	2.0	8.8	16.2[5]	2050	D
						2.7[4]			1.6	7.0	14.8[5]	2310	
Waiwhakaiho	3.4A	N109 706799	N109 692862	NA	NA	4.7	1250	72	2.8	12.2	3.2	1130	B
						2.7			1.6	7.0	2.6	1610	
Waingongoro	4.5	N129 828396	N129 823363	130	6.0	9.5	3150	36.5	2.75	12.0	6.26	2280	D
						8.5[4]			2.4	10.5	5.86	2440	
Waingongoro	4.7A	N129 802326	N129 791291	186	6.8	11.0	3300	24.0	2.1	9.2	5.97	2840	D
						10.2[4]			1.9	8.3	5.68	2990	
	4.7B	N129 802326	N129782275	186	6.8	11.0	5300	53.0	4.6	20.1	10.42	2260	D
						10.2[4]			4.3	18.8	9.98	2320	
Waingongoro	4.9	N129 810335	N129 810334	170	6.5	10.4	50	15.1	1.3	5.7	1.68	1290	B
						9.6			1.2	5.3	1.59	1330	
Patea	5.1	N119 924549	N119 972546	105	5.5	8.1	3150	47.0	3.0	13.1	8.43	2810	D
						6.9[4]			2.6	11.3	7.81	3000	

NOTE:
1: At June 1978 cost levels (MWD Construction Cost Index 952)
2: Sized for Plant capacity factor of 50%
3: Diversion Tunnel
4: Diversion Scheme allowing for 10% (of mean) compensation flow
5: Includes cost of Scheme 3.3
6: See Table 3.1

TABLE 5.2 - PRELIMINARY APPRAISAL OF HYDRO SCHEMES - "CONVENTIONAL" TYPE

River	Scheme No.	Dam Site Grid Ref	Catchment Area (km^2)	Mean Flow (m^3/s)	Diverted Flow (m^3/s)	Reservoir		Net Head (m)	Output		Cost		Rank[4]
						Top WL (m)	Area (ha)		Power[2] (MW)	Engery (GW h/a)	$ Mill	$ /kW	
Waitara	2.4[3]	N109 980762	635	27.5	35.0	103.0	250	20	5.8	25.4	9.34	1610	C
Waitara	2.6	N109 910847	820	38.2	48.2	75.0	70	10	4.1	17.7	7.22	1780	C
Wairara	2.7	N109 831924	1100	57.9	80.0	38.0	95	11	7.3	32.0	12.60	1720	C
Patea	5.3	N119 033494	730	25.7	38.8	104.0	113	30	9.7	42.5	12.10	1270	B
					43.2	124.0	392	50	18.0	78.8	24.0	1330	
					47.3	138.0	800	64	25.2	110.6	38.3	1520	

Notes:

1: At June 1978 cost levels (MWD Construction Cost Index = 952)

2: Sized for plant capacity factor of 50%

3: Two dam heights considered.

4: See Table 3.1

TABLE 5.3 - ATTRACTIVE SCHEMES (Rank B)

Scheme No.	River	Local Power Authority	Dependance on other scheme (See Note 1)	Power (MW)	Annual Energy (Gwh)	Comment
3.4A	Waiwhakaiho	New Plymouth City	a	2.8	12.2	Augmentation of Mangorei Hydro Scheme
4.9	Waingongoro	Egmont	a	1.3	5.7	Recommission of old station
5.3	Patea	Taranaki	a	9.7	42.5	Moderate level storage (higher scheme also viable)
		(Total		13.8	60.4)	

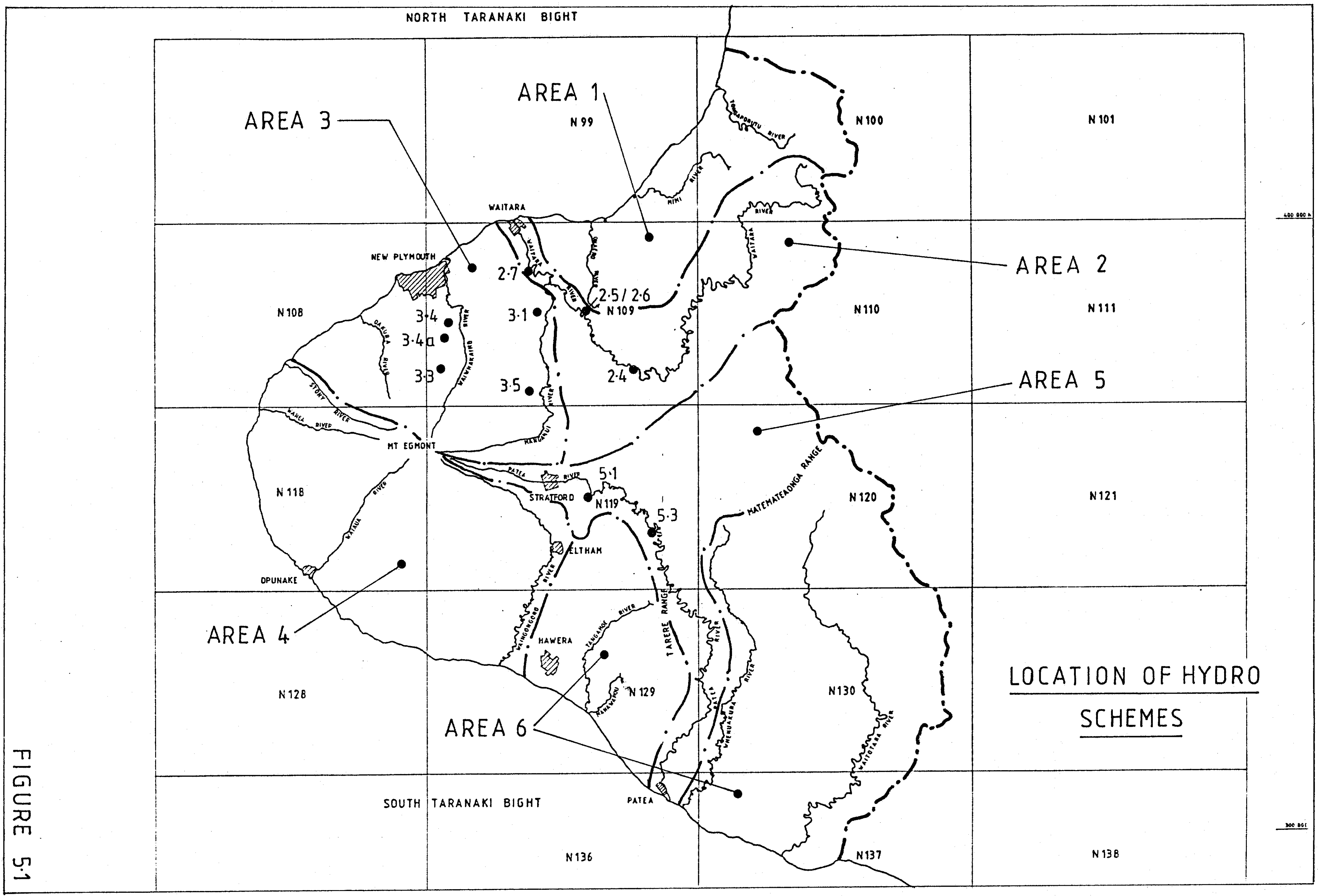
TABLE 5.4 - POSSIBLE ATTRACTIVE SCHEMES (Rank C)

2.4	Waitara	Taranaki	b	5.8	25.4	Low level storage
2.6	Waitara	Taranaki	b(2.5)	4.1	17.7	Low level storage
2.7	Waitara	Taranaki	b(3.1)	7.3	32.0	Low level storage
		(Total		17.2	75.1)	

TABLE 5.5 - ATTRACTIVE SCHEMES WITH SEVERE ENVIRONMENTAL CONSTRAINTS (Rank E)

2.5	Waitara	Taranaki	a(2.6)	12.5	54.8	Low level storage/ diversion diverting major river
3.1	Manganui	New Plymouth City	a(2.7)	12.3	53.9	Run of river - long canals canal routed through park
		(Total		24.8	108.7)	

NOTE:
1: a - Constructed independently
b - Precludes scheme ( )
2: At June 1978 cost levels (MWD Construction Cost Index 952)
3: At 50% unregulated plant factor



NORTH TARANAKI BIGHT
SOUTH TARANAKI BIGHT
LOCATION OF HYDRO SCHEMES
AREA 1
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
N 99
N 100
N 101
N 108
N 109
N 110
N 111
N 118
N 119
N 120
N 121
N 128
N 129
N 130
N 136
N 137
N 138
2·7
2·5 / 2·6
2·4
3·1
3·4
3·4a
3·3
3·5
5·1
5·3
WAITARA
NEW PLYMOUTH
MT EGMONT
STRATFORD
ELTHAM
HAWERA
OPUNAKE
PATEA
MATEMATEAONGA RANGE
TARERE RANGE
MIMI RIVER
WAITARA RIVER
WAIWHAKAIHO RIVER
OAKURA RIVER
STONY RIVER
WAHEA RIVER
MANGANUI RIVER
PATEA RIVER
KAUPOKONUI RIVER
WAINGONGORO RIVER
TANGAHOE RIVER
MANAWAPOU RIVER
WHENUAKURA RIVER
WAITOTARA RIVER

FIGURE 5·1

6. ACKNOWLEDGEMENTS

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(1) Ministry of Works and Development, Wanganui.

(2) Water and Soil Division, Ministry of Works and Development, Wellington, Auckland and Wanganui

(3) Taranaki Catchment Commission and Regional Water Board.

(4) New Zealand Meteorological Service, Wellington.

(5) Aokautere Science Centre, Ministry of Works and Development, Palmerston North.

(6) Egmont Electric Power Board.

(7) Taranaki Electric Power Board.

(8) New Plymouth City Council, Electricity Department.

(9) Wanganui Rangitikei Electric Power Board.

(10) Waitomo Electric Power Board

(11) Lands and Survey Department, New Plymouth

(12) Wildlife Service, New Plymouth

7. REFERENCES

Barrowclough Associates (1981): Wairoa Region - Study of Hydro-electric Potential (Stage II)

Beable, M.E.; McKerchar, A.I. (1982): Regional Flood Estimation in New Zealand. Water and Soil Technical Publication No. 20

Beca Carter Hollings and Ferner Ltd (1974): Water Resources Survey, Egmont Electric Power Board

Beca Carter Hollings and Ferner Ltd (1977): Hydro Electric Investigation of the Patea River - Environmental Impact Report

Beca Carter Hollings and Ferner Ltd (1978): Patea Hydro Electric Scheme - Detailed Investigation on Project Feasibility

Beca Carter Hollings and Ferner Ltd (1978): Patea Hydro Electric Scheme - Addendum Report

Beca Carter Hollings and Ferner Ltd (1979): Patea River Hydrology and Flood Study

Beca Carter Hollings and Ferner Ltd (1979): Manganui-A-Te-Ao River Hydro Electric Development - Initial Report on Feasibility for Wanganui Rangitikei Electric Power Board

Chow, V.T. (1964): Handbook of Applied Hydrology - A Compendium of Water Resources Technology. McGraw - Hill Inc. New York.

Christian. R.; Walter K.M. (1984): Index to Hydrological Stations in New Zealand. Water and Soil Miscellaneous Publication No 67.

Duffill Watts and King Ltd (1983): Small Hydro Electric Resource Assessment - Southland.

Dymond, J.R.; Henderson, R.D. (1980): Synthesis of Flow Data for Three Streams in Taranaki. Aokautere Science Centre

Dymond, J.R.; Henderson, R.D. (1980): Report on the Hydrology of Four Potential Hydro Electric Sites in Taranaki. Aokeutere Science Centre

Dymond, J.R. (1980): Rainfall and Runoff in Representative Basins of the Wanganui District. Aokeutere Science Centre

Dymond, J.R. (1981): Low Flow Map of Taranaki Ring Plain. Aokeutere Science Centre

En Consult Technology Ltd (1981): A Report on Low Flow Estimation for the Waitara River.

E.R. Garden and Partners (1981): Stewart Island Energy Survey.

Finkelstein, J. (1961): Estimation of Open Water Evaporation in New Zealand. New Zealand Journal of Science (Sept. 1961): 506-522.

Huggett, W.H. (1952): New Plymouth and its Electricity Supply. The New Zealand Electrical Journal (March 25): 199-204.

Hutton, L.B.; Stace, F.N. (eds) (1958): Engineering History of Electric Supply in New Zealand. Wellington Electrical Supply Authority.

Mandeno Chitty and Bell Ltd (1963): Power and Water Supply. Report to the New Plymouth City Council.

Mandeno Chitty and Bell Ltd (1964): Preliminary Report on Future Provision for Town Water and Hydro-Electric Power Supply. Report to the New Plymouth City Council.

Mandeno Chitty and Bell Ltd (1980): South Canterbury Region Local Hydro Development Assessment.

Mandeno Chitty and Bell Ltd (1980 a): Assessment of Hydro Potential for Local Authority Development Dannevirke Region

Mandeno Chitty and Bell Ltd (1980 b): South Canterbury Region Local Hydro Development Assessment.

Mandeno Chitty and Bell Ltd (1981): Small Hydro Electric Potential West Poverty Bay Region. N.Z.E.R.D.C. Report No. 66.

McKerchar, A.I.; Dymond, J.R. (1980): Low Flows in Taranaki. Report No. W5137. Science Centre, Christchurch.

Morrissey, W.B. (1972): Water Resources Mapping Using Isoclines of Potential Average Annual Specific Discharge. Report No. W5324. Ministry of Works and Development, Christchurch.

Morrissey, W.B. (1972): Water Resources Mapping Using Isoclines of Potential Average Annual Specific Discharge (with particular reference to the Egmont-Taranaki regions). Paper presented at the Water Resources Symposium. Hamilton. November 1972.

Murray North Partners Ltd (1981): Small Hydro Electric Resource Assessment Hauraki. N.Z.E.R.D.C Report No 63.

National Water and Soil Conservation Organisation (1979): New Zealand Land Resource Inventory Worksheets N99, 100, 108, 109, 110, 118, 119, 120, 129 and 136, 137, 130.

National Water and Soil Conservation Organisation (1981): Taranaki - Manawatu Region: Land Use Capability Extended Legend.

Neall, V.E. (1974): The Volcanic History of Taranaki. Egmont National Park Board, New Plymouth

New Zealand Atlas (1976): Government Printer. Wellington.

New Zealand Official Yearbook (1984): Government Printer. Wellington.

Royds Sutherland McLeay (1980): Hydro-Electric Resource Assessment of the Chatham Islands.

Royds Sutherland McLeay (1981 a): Small Hydro-Electric Potential of Marlborough.

Royds Sutherland McLeay (1981 b): Small Hydro-Electric Potential of North Canterbury.

Royds Sutherland McLeay (1982 a): Small Hydro-Electric Potential of the Otago Electric Power Board District.

Royds Sutherland McLeay (1982 b): Small Hydro-Electric Potential of the Waitaki Electric Power Board District.

Southern Energy Group, Christchurch (1979): Small Hydro Electric Potential of Nelson. N.Z.E.R.D.C. Report No. 47.

Taranaki Catchment Commission and Regional Water Board (1980): Stony to Waiwhakaiho - A report on flow characteristics in five rivers. Stratford.

Taranaki Catchment Commission (1980): Hydrology Water Resource Investigations Petrochemical Development, Tikorangi. Stratford.

Taranaki Catchment Commission: The Impact of Present and Future Users on Flows in the Waitara River (draft). Stratford.

Taranaki Catchment Commission (1983): Flooding in Taranaki 1954 to 1980. Taranaki Catchment Commission and Regional Water Board Technical Report 83-6. Stratford.

Taranaki Catchment Commission (1984 a): Surface Hydrology. Taranaki Ring Plain Water Resources Survey. Stratford.

Taranaki Catchment Commission, (1984 b): Groundwater Hydrology. Taranaki Ring Plain Water Resources Survey. Stratford

Taranaki Catchment Commission (1984 c): Water Quality. Taranaki Ring Plain Water Resources Survey. Stratford.

Taranaki Catchment Commission (1984 d): Land and Water Use. Taranaki Ring Plain Water Resources Survey. Stratford.

Taranaki Catchment Commission (1984 e): Freshwater Biology. Taranaki Ring Plain Water Resources Survey. Stratford.

Taranaki Catchment Commission (1984 f): Recreation. Taranaki Ring Plain Water Resources Survey. Stratford.

Thompson, C.S. (1981): The Climate and Weather of the Taranaki region. New Zealand Meteorological Service Miscellaneous Publication 115(9). Wellington

Tonkin and Taylor (1978): Study of Hydro Electric Potential in Northland. N.Z.E.R.D.C. Report No. 36.

Tonkin and Taylor (1979): Assessment of Local Hydro-Electric Potential East Cape, N.Z.E.R.D.C. Report No. 40.

Tonkin and Taylor (1980): Assessment of Local Hydro-Electric Potential Horowhenua.

Tonkin and Taylor (1981 a): Assessment of Local Hydro-Electric Potential Hawkes Bay Region.

Tonkin and Taylor (1981 b): Assessment of Local Hydro-Electric Potential Wairarapa.

Tonkin and Taylor (1981 c): Assessment of Local Hydro-Electric Potential Wellington/Hutt.

Tonkin and Taylor (1982 a): Assessment of Local Hydro-Electric Potential Buller (Phase II).

Tonkin and Taylor (1982 b): Assessment of Local Hydro-Electric Potential Waikato.

Waugh, B.J.: Water Recharge Areas of Mt Egmont and its Associated Ring Plain Water and Soil Division, Ministry of Works and Development, New Plymouth.

APPENDIX A

COSTING INFORMATION

APPENDIX A

COSTING INFORMATION

A.1 INTRODUCTION

The various schemes may be broken down into the following basic components:

- Powerhouse, Civil
- Powerhouse, Mechanical and Electrical Equipment
- Intakes
- High Pressure Penstocks
- Low Pressure Pipelines
- Canals
- Tunnels
- Dams
- Dam Diversion
- Spillways
- Surge Chambers
- Roading
- Bridging
- Transmission Lines
- Land
- Establishment, Engineering and Administration

For preliminary costing of small hydro schemes it has been found convenient to derive 'parameter' costing procedures based upon the costs of comparable structures and components from small schemes actually constructed. The major components may be identified in terms of basic parameters such as the estimated installed generating capacity, the maximum diverted flow, the nett operating head, and the approximate dimensions of the components.

A number of parametric equations for the cost estimation of these various components have been derived in previous studies (see Schedule of References); these have been adopted in this Report. This cost procedure ensures that the scheme cost estimates presented in this Report are directly comparable with those of previous Reports in this series. The parametric costing equations utilise the Ministry of Works & Development's Construction Cost Index (CCI), as published by the Department of Statistics. This allows costs to be readily updated to allow for the effects of inflation. The costing in this Report has been based upon CCI = 952, as at June 1978. It may be adjusted to any other date (a) by multiplying the costs in this Report by the factor $\frac{CCI\ (a)}{952}$, where CCI (a) is the Index applicable to the date (a).

To verify the costing data, actual costs of various schemes (including the Patea Hydro Scheme) with which Beca Carter Hollings & Ferner Ltd have been involved were compared to costs derived from the parametric equations. Although there may be variation from the results of the equations from component to component, the overall total costs of the schemes have been found to be in agreement within reasonable limits of accuracy. A cost comparison for the Patea Scheme is given in Section A4.

A.2 TOTAL CAPITAL COST

For the total cost of components of a scheme, the following costs are added to the total estimated cost of components:

Engineering and Administration:		10%
Contingency:	(a) Electrical and Mechanical Equipment	10%
	(b) General Civil Works	15%
	(c) Civil works founded on siltstone/ sandstone	20%
	(d) Civil works founded on volcanics	25%

The Contingency Sum is an estimating margin to allow for the approximations inherent in this type of costing exercise.

A.3 COST OF SCHEME COMPONENTS

A.3.1 Powerhouse Civil

The cost for the civil components of the powerhouse including the switchyard can be derived using the family of curves shown in Figure A1. The curves assume a favourable site adjacent to the river. Adjustments should be made where site topography is either particularly difficult or easy. The cost is given by:

Cost (\$) = Kp x CCI x P

where Kp = powerhouse factor as shown in Figure A1
and P = installed capacity in megawatts

A.3.2 Powerhouse Mechanical and Electrical Equipment

The total cost of generating plant associated with the powerhouse, including the cost of turbines, generator, governor and controls, transformers and switchgear and all ancillary equipment is given by:

Cost (\$) = Km x CCI x P

where Km = mechanical and electrical plant factor as shown in Figure A2
and P = installed capacity in megawatts

(The curves in Figure A2 follow the general cost law (\$) = 1250 x CCI x $P^{0.7}$ x $H^{-0.25}$ where P = installed capacity in megawatts and H = head in metres.)

A.3.3 Intakes

The total cost of an intake on a small stream with a run of river scheme which includes the weir, screens, stoplogs and gates is given by:

Cost (\$) = 100 x CCI x $Q^{0.5}$

where Q is the maximum diverted flow in m^3/sec.

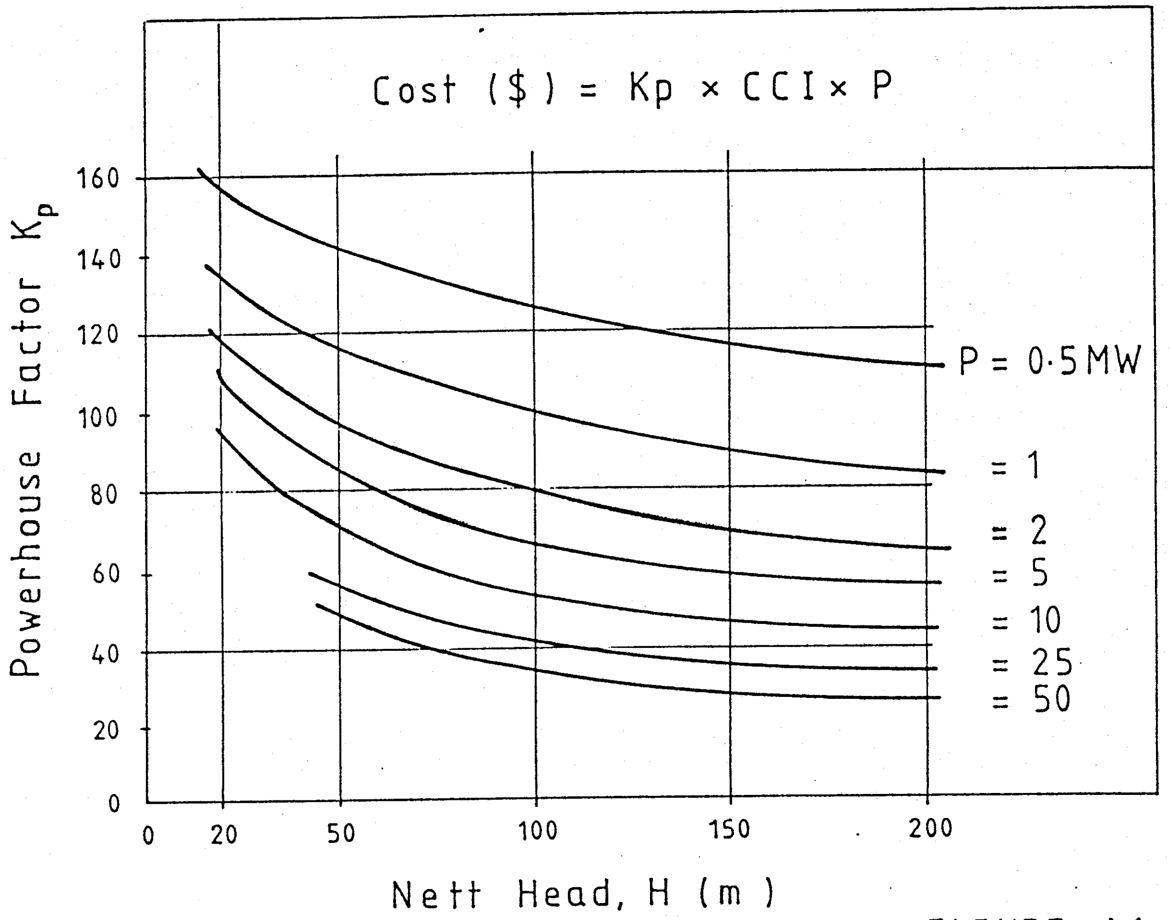


FIGURE A1

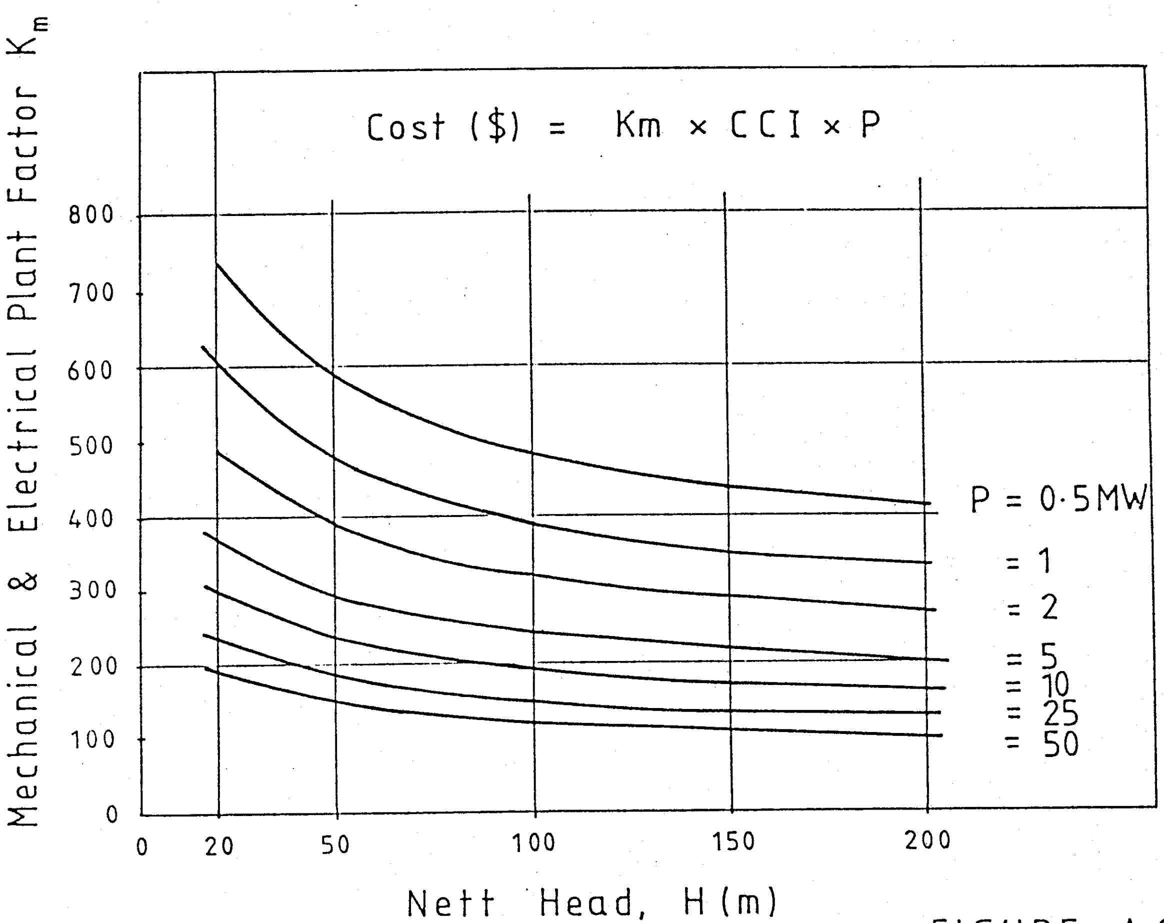


FIGURE A 2

For larger rivers with dam storage, the intake has been costed as for a reservoir intake or an intake at the end of a canal. Cost is given by:

$$\text{Cost}~(\$) = 10 \times CCI \times Q$$

where Q is the maximum diverted flow in m^3/sec.

Where a control gate is required at the canal intake, the overall cost can be increased to:

$$\text{Cost}~(\$) = 15 \times CCI \times Q$$

A.3.4 Penstocks

For high head schemes considered in this study conventional steel penstocks have been adopted, assuming a flow velocity of 3.5 to 4.5 m/s. The total cost of the penstocks including all pipework, foundations, anchorage, drainage and finishing is given by:

$$\text{Cost}~(\$) = \frac{CCI}{800} \times Q\,(H+80)L$$

where Q = maximum flow, m^3/sec
H = gross head, m
L = length of penstock, m

The above costs can vary where slopes are not steep and foundations are easily provided by applying a factor between 0.75 and 1.0 to the above equation. In cases where a minimum anchorage is required, or where the pipeline can be buried without high excavation, a factor of 0.6 to 0.8 can be applied to the above equation.

Long penstocks will have additional costs associated with controlling water-hammer and governing problems.

A.3.5 Low Pressure Pipelines

For schemes involving a low pressure pipeline with a head of less than 20 m, the cost of a concrete pipe, including excavation, laying, jointing and backfilling, is given by:

$$\text{Cost}~(\$) = \frac{CCI}{12.5} \times QL$$

where Q = maximum flow, m^3/sec
L = length of pipe, m

A.3.6 Canals

Canal costs vary widely, depending on soil type, groundwater conditions and the size of works. Recent experience in New Zealand suggests that most hydro canals will need to be fully lined, particularly in volcanic materials. The following costs, which have been derived from unit costs for an impermeable membrane lining, concrete protection, sub-canal drainage and bulk earthworks with a maximum haul distance of 1.0 km, are given by:

$$\text{Cost}~(\$) = Kc \times CCI \times L$$

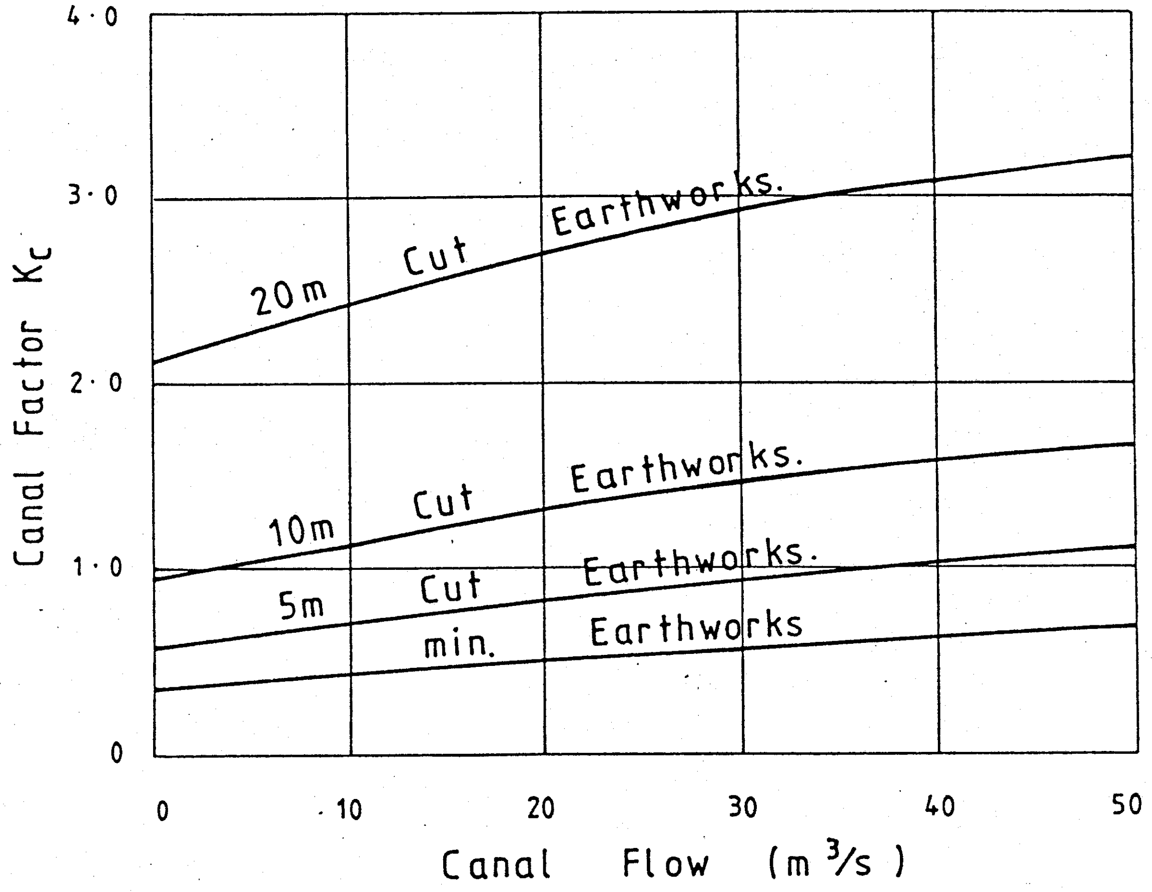


FIGURE A 3.

where Kc = canal factor, determined from Figure A3
L = canal length, m

A.3.7 Tunnels

Tunnel costs vary widely with geological conditions. An estimate of tunnel costs is given by:

$$\text{Cost } (\$) = K_T \times CCI \times L$$

where K_T = tunnel factor, determined from Figure A4
L = Tunnel length, m

These costs are for a hard rock tunnel driven by conventional explosives with supports of 15% arch ribs and 15% anchor bolts.

The above costs should be adjusted, where appropriate, by a length factor, a geological factor and a support factor within the following ranges:

Length factor	1.0 to 2.0
Geological factor	1.0 to 1.5
Support factor	1.0 to 1.3

If the tunnel length is shorter than 1,000 m, the length factor shown in Figure A5 is adopted.

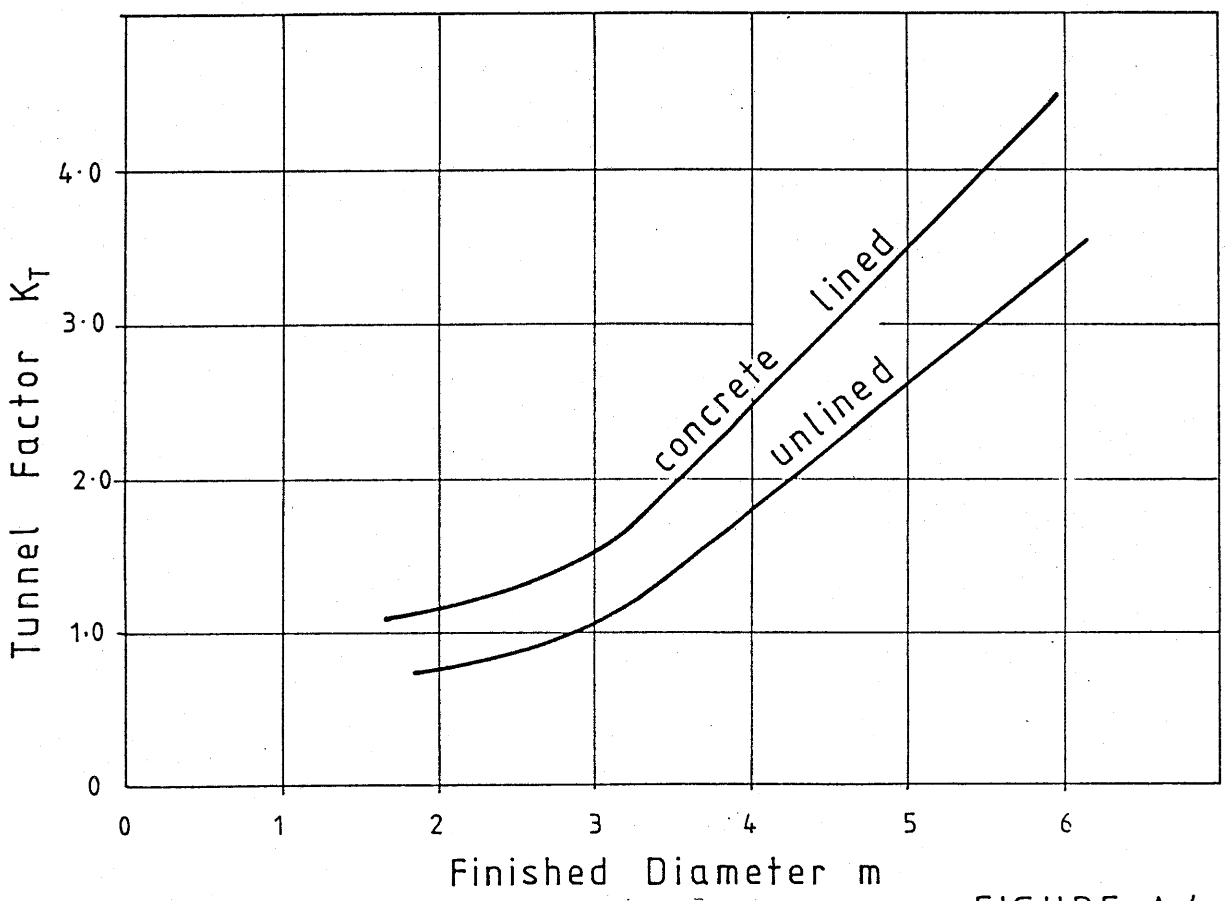


FIGURE A 4.

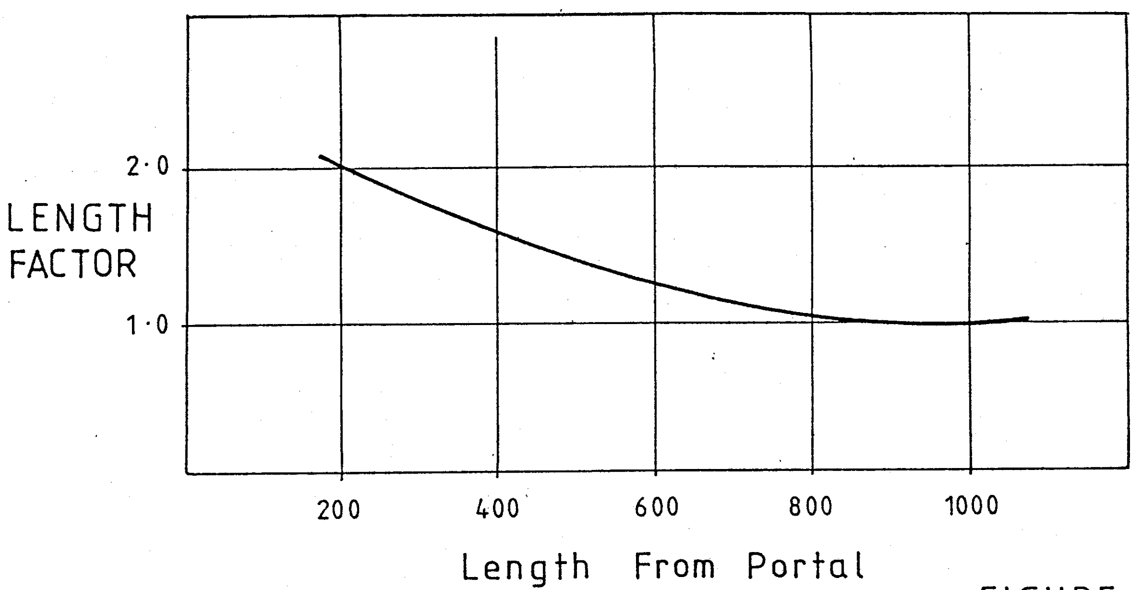


FIGURE A5.

Where more difficult tunnelling is expected, for example in variable materal (e.g. lahar material) with locally crushed zones, a geological factor between 1.0 and 1.5 is used.

Where tunnels are fully supported a factor of 1.3 is used.

For river diversion tunnels with unfavourable geological conditions and for high velocities that require permanent lining, the lining costs given from Figure A5 are increased up to a factor of 3.

A.3.8 Dams

In hydro schemes where the head is created by the damming of a river, one of the major costs involved is in construction of the dam. The cost is difficult to estimate accurately without a detailed investigation of the site. For a preliminary estimate of dam costs, an estimate of the dam volume is calculated from approximate dimensions of the structure as determined from field survey. For embankment dams both the upstream and downstream faces are slopes assumed to be 1V:2.5H. Likewise, for concrete gravity dams the upstream face was assumed to be vertical with the downstream face at 1V:0.8H.

Then the dam cost is given by:

$$\text{Cost } (\$) = K_D \times CCI \times V$$

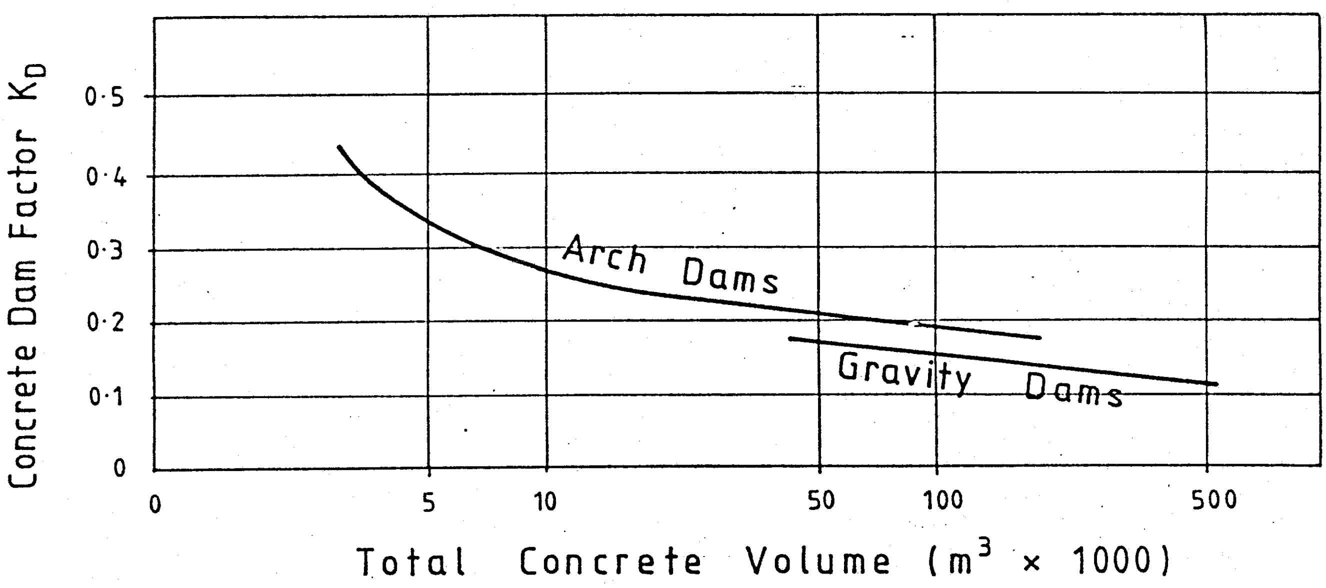


FIGURE A6

For concrete arch or gravity dams, K_D is determined from Figure A6. For embankment dams K_D = 0.006, which for a value of CCI = 952, gives a cost of $6 per cubic metre.

The costs as estimated above include the cost of site clearing, excavation and construction. Spillways, tunnels and river diversions have been costed separately.

A.3.9 Dam Diversions

The cost of various types of diversion works are outlined below:

(a) Culvert diversions under a dam including cofferdams, channels, and stilling basins. The cost is given by:

$$\text{Cost (\$)} = 2.8 \times \text{CCI} \times H\, Q_f^{0.5}$$

where Q_f = diversion design flood flow, m^3/sec
H = dam height, m

(b) Open canal diversions can be costed as given in Section A.3.6.

(c) Tunnel diversions can be costed as in Section A.3.7. This is an "all-in" cost including cofferdams, temporary flood bypass canals and stilling basins.

A.3.10 Spillways

In dam storage schemes, the spillway is often one of the major costs. Extensive hydrological, hydraulic and geological studies are required for their design. As a preliminary cost the following equation is used and includes the cost of control gates, channel lining and stilling basin works.

$$\text{Cost (\$)} = 2.2 \times \text{CCI} \times H\, Q_f^{0.5}$$

where H = dam height, m
Q_f = design flood flow, m^3/sec

However, if a concrete dam is used (either arched or gravity) and the spillway structure is incorporated within the dam structure, the following spillway cost is added to the dam cost (as determined in Section A.3.8):

$$\text{Cost (\$)} = 0.8 \times \text{CCI} \times H\, Q_f^{0.5}$$

A.3.11 Surge Chambers

Many different factors control the design of surge chambers. The height and diameter are dependent on conduit length, diameter, flow, friction, turbine control valve, and the size of any throttle. The cost of a chamber would also vary depending on the material used for its construction and on geological conditions.

The following equation has been used as an approximate cost estimate:

$$\text{Cost (\$)} = 250 \times \text{CCI} \times P^{0.75} \times h^{-0.25}$$

where P = installed capacity, MW
h = level difference between conduit centre line at the chamber and the upstream reservoir level (m).

A.3.12 Roading

The cost of road construction for average topographical conditions is given by:

$$\text{Cost (\$)} = K_R \times CCI \times L$$

where L = length of road, km
K_R = Road Factor as given in Table A1

TABLE A1 - ROAD COSTS

	VALUES OF ROAD FACTOR K_R
State Highway	150
Primary County Road	100
Secondary County Road	50

Where topography is either easy or difficult, a factor ranging from 0.8 to 1.2 can be applied to the above equation.

A.3.13 Bridging

A preliminary cost estimate for bridges to county road standards can be given by:

$$\text{Cost (\$)} = 5 \times CCI \times \left[\frac{W}{9.45}\right]^{0.6} \times L$$

where W = width of bridge, m
L = length of bridge, m

A.3.14 Transmission

Transmission lines are taken either to the nearest substation,if it could be identified, or the closest load centre. Table A2 can be used to estimate the transmission voltage for the given power output and distance.

TABLE A2 - TRANSMISSION VOLTAGES, kV

POWER (MW)	TRANSMISSION DISTANCES (KM) 10	20	40
0 - 2	11	11 - 33	33
2 - 5	11 - 33	33	33
10 - 20	33	33	33 - 66
20 - 30	33	33 - 66	66 - 110
30 - 50	33 - 66	66 - 110	110

The costs for standard transmission voltages allowing for average topography and single circuit lines is given by:

$$\text{Cost (\$)} = K_V \times CCI \times L$$

where L = length, km
K_V = voltage factor, as given in Table A3

TABLE A3 - TRANSMISSION COSTS

TRANSMISSION VOLTAGE	VOLTAGE FACTOR K_V
11 kV	6
33 kV	10
66 kV	14
110 kV	35

A.3.15 Land

Land costs vary throughout each region depending on land use. The cost of land is given by:

$$\text{Cost (\$)} = K_L \times CCI \times A$$

where A = area in hectares

The value of K_L varies from 0.5 for hilly, bush-clad farmland in the back country areas of Waitara and Patea to 3.0 for the intensively farmed area around the ring plain, namely Inglewood, Stratford, Eltham and Hawera.

A4 COMPARISON OF COSTS FOR THE PATEA SCHEME

Table A4 lists the actual and derived costs using the parametric equations for the Patea Scheme as at June 1978 (CCI=952).

TABLE A4 - ACTUAL AND DERIVED COSTS FOR THE PATEA SCHEME

Item	Actual Cost ($M)	Derived Cost ($M)
Powerhouse - Civil	2.42	1.46
Powerhouse - Mech. & Elect.	4.54	4.54
Intake	2.72	1.07
Penstocks	1.53	1.20
Tunnels	3.49	4.00
Dam	11.36	7.60
Spillway	2.51	3.69
Transmission	0.78	0.83
Roading	0.51	0.62
Bridging	0.28	0.27
Contingency	-	4.29
Total Cost	30.15	29.57

APPENDIX B

HYDROLOGY

APPENDIX B

HYDROLOGY

B.1 INTRODUCTION

In assessing the potential development of a hydro scheme, hydrological investigations are necessary to determine the flow characteristics of the rivers and streams in the area. This appendix outlines the hydrological investigations carried out to determine the potential of hydro schemes in the Taranaki region. Many of the rivers have gauging stations and many papers have been written on the hydrology of this area. Hydrological investigations included the collection and analysis of existing data supplied by the Taranaki Catchment Commission and Regional Water Board, the Ministry of Works and Development and the New Zealand Meteorological Service.

In studies of this nature the recorded data requires some adjustment before it can be related to the potential hydro sites. The hydrological analyses concentrated on estimating the mean flow and duration characteristics to determine the installed capacity and energy output of potential schemes, and design flood flows to determine spillway capacity. Analyses of sediment yield as an indication of possible sedimentation problems in reservoirs, in addition to water quality were also considered in order to assess possible turbine equipment damage.

It was fortunate that the storage type schemes investigated in this study have well established gauging stations nearby, recording river flow and intermittent suspended sediment concentrations. This enabled scheme outputs to be estimated and potential sedimentation problems to be highlighted with some confidence.

The 'diversion' type schemes in the Northern Mountain Stream Area and along the Waingongoro River generally have gauging stations of lesser record length (4-10 years) in their vicinity. In general, these recorded flows were in good agreement with the derived water balance flows and thus the scheme output could also be estimated with some confidence.

B.2 CLIMATOLOGY

B.2.1 Data

Climate and rainfall observations are made or administered by a number of agencies in the study area including the NZ Meteorological Service (NZMS) and Ministry of Works and Development (MWD). The location of sites at which records are available are shown in Figure B1 and the availability of climate and rainfall data is summarised in Tables B1, B2 and B3.

B.2.2 Climate

In general, the study area has a temperate, maritime climate influenced by stormy weather. Within the lower altitude areas of Taranaki, temperatures average 11-14°C and sunshine exceeds 2150 hours annually. However, with the normal decline in temperature with altitude (1°C/100 m) the higher altitude slopes of Mt Egmont experience much lower temperatures, resulting in snow accumulation during the winter months of the year. The prevailing winds are from the north-west and west in spring and summer and from the south and south-east in the autumn and winter. Relative humidity averages 81% with little variability throughout the year. The mean monthly temperature, sunshine, humidity and wind at New Plymouth Airport are shown in Figure B2.

B.2.3 Rainfall

Rainfall over the Taranaki area is markedly affected by Mt Egmont. Consequently there is high rainfall in the western region compared with the relatively low rainfall recorded in the eastern hill country. Rainfall is well distributed throughout the year but has a definite winter peak in June and July with a seasonal low in the period November to March.

The NZMS isohyet map of mean annual rainfall (1941-70) is shown in Figure B1 and indicates that the rainfall varies from extremely heavy on Mt Egmont with annual rainfall exceeding 8000 mm to moderate rainfalls of about 1200 mm on the coast near Hawera.

TABLE B1 - CLIMATIC STATIONS

Station Number	Location	Latitude	Longitude	Elevation (m)	Variables Recorded*	Records from
C94001	New Plymouth	39°04'	174°05'	49	T,F,RH,S,P	1864-1973
C94003	New Plymouth	39°04'	174°05'	55	T,F,RH,VP,P	1974
C94011	New Plymouth Airport	39°01'	174°11'	27	T,F,RH,VP,S WV,P	1944
C94262	Te Wera Forest	39°14'	174°36'	180	T,F,RH,VP,P	1955

* Temperature (T), Relative Humidity (RH), Sunshine hours (S) Wind Velocity (WV), Rainfall (P), Frost (F), Vapour Pressure (VP)

TABLE B2 - AUTOMATIC RAINGAUGE STATIONS

Station Number	Met Number	Station Name	River Name	Map Reference	Elevation (m)	Recording Authority	Records From
941310	C9413A	Tarata	Waitara	N109925802	92	WGWS	1965
942212	C9422C	SH3	Manganui	N119831649	332	WGWS	1974
943010	E9430A	Auroa Rd	Punehu	N118630504	372	WGWS	1969
943113	E9431D	Pembroke Rd	Manganui	N119748599	564	WGWS	1971
849710	C8497A	Moki Rd	Waitara	N100291020	230	WGWS	1965-81
943310	E9422A	Tariki Rd	Manganui	N109840725	229	WGWS	1962-73

TABLE B3 - RAINFALL STATIONS

Station Number	Location	Latitude	Longitude	Elevation (m)	Records from
C84691	Te Matai Aria	38° 37'	174° 54'	37	1919-1962
C84761	Mohakatino-Mokau	38° 43'	174° 37'	46	1931
C84891	Ohura	38° 51'	174° 59'	152	1918
C94001	New Plymouth	39° 4'	174° 5'	49	1864-1973
C94003	New Plymouth	39° 4'	174° 5'	55	1974
C94011	New Plymouth Aero	39° 1'	174° 11'	27	1944
C94021	Waitara	39° 0'	174° 14'	6	1920
C94102	Upper Mangorei	39° 11'	174° 4'	366	1899-1938
C94111	Lower Mangorei	39° 6'	174° 6'	119	1922
C94121	Lepperton	39° 6'	174° 13'	131	1925
C94122	Inglewood	39° 10'	174° 14'	200	1909
C94171	Whangamomona	39° 9'	174° 45'	155	1905-1940
C94221	Riversdale	39° 12'	174° 13'	249	1882-1956
C94222	Tariki Hydro	39° 13'	174° 16'	235	1923
C94261	Ngatimaru	39° 12'	174° 37'	-	1889-1920
C94262	Te Wera Forest	39° 14'	174° 36'	180	1955
E93271	Cape Egmont	39° 17'	173° 45'	8	1930
E93481	Opunake	39° 27'	173° 51'	27	1889-1962
E94332	Stratford	39° 20'	174° 19'	262	1892
E94333	Stratford - Dem. farm	39° 20'	174° 18'	311	1960
E94313	Stratford - Mtn House	39° 18'	174° 07'	846	1963
E94401	Riverlea	39° 26'	174° 4'	259	1913
E94521	Ohawe	39° 35'	174° 13'	61	1889-1964
E94621	Hawera	39° 36'	174° 17'	105	1920
E94741	Patea Freezing Works	39° 46'	174° 29'	8	1906
E94743	Patea	39° 45'	174° 28'	43	1968
E94761	Waverley	39° 46'	174° 36'	-	1926-1966
E94791	Waitahinga	39° 45'	174° 57'	396	1905
E95902	Wanganui	39° 56'	175° 3'	22	1890

Storm rainfall intensities, shown in Table B4, indicate higher intensities on the west coast near New Plymouth than the eastern lowland and southern coastal areas from Stratford to Hawera. The recorded intensities on Mt Egmont are extremely high but these would appear to be confined to the upper slopes of the National Park.

TABLE B4 - MAXIMUM RECORDED RAINFALL DEPTH - DURATION DATA

Station Number	Location	Maximum recorded rainfall (mm) for durations:							
		(minutes)				(hours)			
		10	20	30	60	2	6	12	24
C94001	New Plymouth (1862-1973)	-	-	-	-	-	-	-	330
C94011	New Plymouth Aero (1948-1978)	25	42	64	81	90	131	222	358
E94311	Dawson Falls (1933-1977)	-	-	-	-	-	-	-	504
E94332	Stratford (1951-1978)	31	46	52	77	83	105	163	258
E94512	Manaia Dem. Farm (1959-1977)	-	-	-	-	-	-	-	175
E94521	Ohawe (1930-1964)	-	-	-	-	-	-	-	138

B.2.4 Evaporation

Evaporation data is collected at Normanby (E94526) and Manaia Demonstration Farm (E94512) and these are summarised in Table B5. Adjustment for raised pan values of evaporation to estimate open water and pasture values have been calculated using Finkelstein (1961). The pasture values are representative of summer conditions and assume that the water is available to evaporate or to transpire. In the higher altitude regions of Mt Egmont, where the ambient temperatures are lower, it is expected that the corresponding evaporation will be lower (Morrissey, 1972). However, it also depends on aspect (eg. sunny side), the snow cover and slope, all of which can increase effective solar radiation and thus evapotranspiration. Taking all these factors into account the overall annual evapotranspiration for the area will probably range between 600-800 mm. For the purpose of this study, in estimating mean annual flow from the water balance equation an evapotranspiration rate of 700 mm per year has been adopted.

TABLE B5 - POTENTIAL EVAPORATION ESTIMATES

Station	Surface Type	Average Monthly Evaporation (mm)												
		J	F	M	A	M	J	J	A	S	O	N	D	Annual
MANAIA E94512 (1975-84)	Raised pan	170	140	112	76	55	37	40	51	80	105	140	160	1158
	Open water(Est)	117	97	77	52	38	26	28	35	55	72	97	110	800
	Pasture(Est.)	94	77	62	42	30	20	22	28	44	58	77	88	637
NORMANBY E94526 (1978-84)	Raised pan	184	145	111	66	46	31	33	47	70	101	136	153	1122
	Open water(Est)	127	100	77	46	32	21	23	32	48	70	94	106	774
	Pasture(Est.)	101	80	61	36	25	17	18	26	38	55	75	84	617

B.3 RIVER HYDROLOGY

B.3.1 Data

B3.1.1 Data Requirements:

An indication of the long term mean flow is necessary to determine the hydro potential of a particular site. Once the potential of a site has been measured, then flow duration characteristics are necessary to assess the installed capacity and energy output of the scheme. To obtain a representative sample of flows in a stream about 10 years of flow data are needed. In many areas of New Zealand such length of record is not available and therefore certain assumptions based on regional characteristics as well as specific climatic and catchment data have to be made. It should be noted that some of the lengths of gauged flow records are short with these records commencing post - 1980 (see Table B6). For the South Taranaki region this also coincides with one of the driest periods on record when comparison is made with long-term rainfall records. These years are therefore not representative of the long-term mean river flows in this area, and adjustment for long-term hydrological trends has been made.

For the purpose of assessing hydro generating potential, the following river hydrology data are ideally required for each scheme:

- Long term river flow and duration characteristics : for estimating installed capacity and annual energy output.
- Design Flood Flow : for spillway sizing
- Sediment Yield : for reservoir siltation estimates
- Water Quality : to assess effects on the operation of schemes

B3.1.2 Data Availability:

All the river gauging stations throughout the study area are listed in Table B6 and shown in Figure B3; these are available on MWD-TIDEDA computer files. Only some of these stations are relevant to providing river flows and flow duration characteristics for potential hydro sites.

Suspended sediment measurements have been taken at Tarata (Waitara) and Mangamingi (Patea) enabling flow-sediment discharge rating curves to be established. No bed load samples are available.

An extensive water quality data collection programme has been instigated by TCC concentrating on the Ring Plain Area and this data is presented in one of the Water Resources Survey Reports (Taranaki Catchment Commission, 1984 c).

TABLE B6 - Recording River Flow Station

Site Number	River Name	Station Name	Map Reference	Area sq km	Recording Authority	Begin & End
34202	Whenuakura	Nicholson Rd	N137 109 078	871	TCC	83
34307	Patea	Mangamingi	N119 039 487	740.2	TCC	75
34308	Patea	Skinner Rd	N119 912 578	87.5	TCC	78
34309	Mangaehu	Road Br.	N119 022 521	421	TCC	78
34801	Tawhiti	Redoubt	N129 865 299	42	TCC	82
35004	Waingongoro	Eltham Rd	N119 855 469	46.7	TCC	74
35005	Waingongoro	SH 45	N129 788 289	200.5	TCC	80
35006	Maingatoki	Hastings Rd	N119 803 446	20	TCC	83
35201	Kapuni	SH 45	N129 726 318	41.0	TCC	80
35506	Kaupokonui	Glen Rd	N129 665 329	62.6	TCC	78
35507	Hupati	Railway Culvert	N119 689 411	2.7	TCC	81 83
36001	Punehu	Pihama	N128 507 387	29.5	WGWS	70
37101	Okahu	Ngariki Rd	N118 493 543	7.6	WGWS, TCC	80
38002	Stony	Mangatete Rd	N108 487 711	43.6	WGWS, TCC	79
38401	Timaru	SH 45	N108 507 797	26.9	WGWS, TCC	80
38501	Oakura	Surrey Hill Rd	N108 549 839	39.0	WGWS,	79
38904	Huatoki	Mill Road	N108 647 909	20.7	WGWS,	81
38905	Mangaotuku	Rainsford St	N108 625 910	9.7	WGWS	81
39201	Waiwakaiho	SH 3	N109 709 822	58.0	WGWS, TCC	80
39402	Mangaoraka	Corbett Rd	N109 755 921	46.4	TCC	75
39403	Waiongona	SH 3A	N109 776 875	36.2	TCC	80
39501	Waitara	Tarata	N109 924 805	725	WGWS	68
39503	Waitara	Bertrand Rd	N109 821 932	1120	TCC	80
39506	Motukawa	Tail Race	N109 942 768	32.7	WGWS	72
39508	Manganui	SH 3	N119 831 649	11.3	WGWS	72
39510	Ngatoro	SH 3	N109 786 778	11.6	TCC	75
39511	Maketawa	SH 3	N109 798 752	18.7	TCC	80
33311	Tangarakau	Tangarakau	N110 394 975	238	WGWS	61 69
35504	Kaupokonui	Opunake Rd	N119 717 513	8.2	TCC	82 83
38001	Stony	Okato	N108 456 750	45.7	WGWS, TCC	77 79
38601	Tapuae	SH 45	N108 562 863	32.4	TCC	79 80
39401	Waiongana	Waitara Intake	N109 774 883	41.6	WGWS, TCC	75 80
39504	Manganui	Tariki Rd	N109 843 727	80	WGWS	62 74
39509	Ngatoro	Bedford Rd	N109 756 756	9.86	WGWS, TCC	75 80

B.3.2 Mean Flows

B3.2.1 Flow Records:

Long term mean specific discharges for gauged rivers range from 125 litres/s/km^2 in the ring plain area to about 30 litres/s/km^2 for the Mangaehu Stream draining from the eastern area of Taranaki. This variability of specific discharge is a result of the high rainfall around Mt Egmont and further indicates the need to estimate mean flows for a particular site from nearby gauging stations.

B3.2.2 Water Balance:

To determine the long term mean flow Qo, the short term mean flow from the gauging stations has been adjusted by the ratio of the rainfall for the flow record period over the rainfall for the long term period.

Example : from the gauging records for the period 1978-1984, the mean observed flow was 12.5 m^3/sec. For the same period, the average annual rainfall is 2,120 mm and for the long term period (1941-1970) the average annual rainfall is 2,050 mm. The long term mean observed flow is therefore 12.1 m^3/sec.

This is necessary because the use of short term observed flow data without comparison with long term climatic data can produce misleading results.

The annual mean flow, using a simple water balance relationship, was derived for each gauging station. The relationship can be expressed as:

$$R = P - E$$

(ie. Runoff = Precipitation - Potential Evaporation)

and

$$Q_E = \frac{AR}{31536}$$

where P = mean annual rainfall based on proportioning the isohyets in Figure B1 over the catchment area (mm).
E = evaporation rate, assumed as 700 mm per year.
R = annual runoff (mm).
A = catchment area (km^2).
Q_E = estimated annual mean flow (m^3/sec).

A comparison of the long term observed flow (Q_O) with the estimated flow (Q_E) for the gauging stations appropriate to the hydro schemes considered in this study is given in Table B7. In general, the comparison is in good agreement. The exceptions are Site Nos 34307 and 39501 which were probably over estimated because the rainfall over the eastern hill area is over estimated on the isohyetal map (Figure B1). Also, this discrepancy may be due to the groundwater catchments being smaller than the surface water catchments, thus giving an overestimation of river flow. Nevertheless, the differences at each of the gauging stations are within 10% of each other.

The long term mean flows for a potential hydro scheme were derived using the water balance relationship and were then adjusted by the ratio of (Q_O/Q_E) obtained from nearby gauging stations.

TABLE B7 - COMPARISON MEAN OBSERVED AND ESTIMATED FLOWS

Site Number	River Name	Station Name	Area (km^2)	Observed Flow (m^3/s) Short term	Long term	Estimated Flow (m^3/s)
34307	Patea	Mangamingi	740.2	24.2	26.0	28.2
34308	Patea	Skinner Rd	87.5	4.8	5.2	5.5
35004	Waingongoro	Eltham Rd	46.7	2.7	2.9	2.7
35005	Waingongoro	SH 45	200.5	6.0	6.9	7.4
36001	Punehu	Pihama	29.5	1.2	1.2	1.2
39201	Waiwhakaiho	SH 3	58.0	7.4	7.4	7.3
39501	Waitara	Tarata	725.0	28.6	30.3	33.4
39503	Waitara	Bertrand Rd	1120.0	53.8	59.2	60.4
39508	Manganui	SH 3	11.3	1.4	1.4	1.4
39510	Ngatoro	Sh 3	11.6	1.2	1.2	1.2
39511	Maketawa	SH 3	18.7	2.2	2.2	1.9
39504	Manganui	Tariki	80.0	6.3	6.3	6.6

: For Site 39501 the mean annual discharge from the Tariki Power Scheme have been subtracted from the observed flow.

B.3.3 Flow Utilisation

B3.3.1 Flow Distribution Curves:

In determining the generating capacity of a hydro electric scheme, flow duration curves are necessary to estimate the maximum diverted flow. In some instances flow duration characteristics at the actual scheme site were not available and therefore a flow distribution curve from rivers nearby with similar hydrological conditions were adopted. The flow duration curve is usally presented in a dimensionless form Q over Q mean (based on mean flow) versus percentage of time flow exceeded. The flow duration curves for the Taranaki region were drawn up in this form and plant factor curves were constructed by integrating the flow duration curves. This assumes that all flow up to the selected flow can be used for hydro generation. In addition, plant factor curves were derived allowing for non-utilisation of 10% of the mean flow to enable cost estimates to be made for 'diversion' type schemes for which regular compensation flows will be imposed and which would probably be of this order. Refer to Figures B4 to B14.

For 'diversion' schemes having less than a day's storage, flow duration curves of daily mean flows were used to derive the plant factor curves. However, for 'storage' schemes, which may have more than a day's active storage (at mean flow), flow duration curves of weekly mean flows were considered. Allowance for flow regulation in this way is considered to be adequate for the purpose of this study, but for more detailed analyses a reservoir operational study should be undertaken.

B3.3.2 Plant Factors:

To allow for a direct comparison on an economic basis a 50% plant factor has been adopted to estimate the generating capacity of a scheme.

It should be noted that small hydro projects with limited storage capacity will need to operate in conjunction with the available river flows. To this end it may not be possible to have an operating plant factor corresponding to the system load factor. To derive the optimal plant factor the following need to be assessed; seasonal flow characteristics of the river, the available storage, load duration requirements of the load centre and the bulk tariff rates. In general, experience has shown that for small hydro schemes of the type investigated in this study the optimal plant factor will be in the order of 40-50%.

B.3.4 Flood Flows

An estimate of flood flows is required for sizing of spillways and diversion works in dam storage schemes. To obtain preliminary estimates the Regional Flood Estimation Method (RFE) - North Island West Coast (Water and Soil Publication No. 20, 1982) was initially adopted. However, when deriving mean annual floods by this method it was found that they were overestimated by up to a factor of 3.0 when compared to the gauged annual flows. The following, slightly modified method, was therefore adopted.

- mean annual floods (Q_g) for the gauging station were calculated from the flow records;

- mean annual floods for the hydro scheme were determined by transposition of the gauged values (Q_g) in proportion to the area to the power of 0.82 in accordance with RFE equation; and then

- design floods were predicted using the regional frequency curve characteristics derived in RFE relating floods of given return period to mean annual floods. For floods larger than the 1 in 100 year event the countrywide frequency curve was used.

Table B8 lists the design floods for storage schemes considered in this study. The flood flows estimated using this method compared well with the flood derived from a detailed flood study for the Patea Scheme. Further, the highest flood recorded at Tarata is 944 m^3/s in February 1971 during which time New Plymouth experienced one of its worst floods in memory and severe flooding and slips occurred in the north-east Taranaki back country (Taranaki Catchment Commission, 1983). This flood would correspond to a 1 in 20 year event according to the RFE method, indicating that the floods adopted are not likely to be underestimated.

TABLE B8 - DESIGN FLOODS FOR STORAGE SCHEMES

Scheme Number	Catchment Area (km^2)	No of years of records at station	Design Floods (m^3/s)			
			Mean Annual	1 in 30	1 in 100	1 in 1000
2.4	635	16	490	930	1130	1760
2.5/2.6	820	16	630	1200	1470	2270
2.7	1100	5	830	1570	1920	2970
5.3	730	8	360	690	840	1300

For this study, 30 year return period floods were used to size diversion works; 100 year return period floods were used to size spillways in locations where emergency spillways could be sited; and 1000 year return period floods were used to size spillways where they needed to accommodate the entire flood flow.

B.3.5 Sedimentation

Sedimentation studies are important for projects of this nature to assess sediment accumulation in reservoirs and hence effective operational life of the scheme. Intakes should be designed to prevent sand sized or larger sediment entering the penstock and causing damage to turbo machinery.

Field studies indicated that the main source of suspended sediment in the main rivers are the tertiary siltstone/sandstones originating in the upper Waitara catchment for the Waitara River, and likewise the Matemateaonga Range for the Patea River. In the smaller rivers of the ring plain area, there are large boulders of volcanic origin scattered about the river bed but the flow itself is relatively clear. It is considered that the main source of boulders and large sized sediment in these rivers is bank erosion during floods of the lahar material from which the smaller material is transported away leaving a well armoured river bed. The existing diversion weirs throughout this area were observed to have some accumulation of boulder-size, well-armoured material upstream but few deposits of sand-size sediment.

The estimated annual suspended sediment yield for the Waitara River at Tarata and the Patea River at Mangamingi are given in Table B9. The likely sedimentation life of the storage reservoirs was estimated using those derived sediment concentrations and an appropriate trap efficiency. This can be expressed as a function of storage capacity to annual flow volume (Chow, 1964).

TABLE B9 - SUSPENDED SEDIMENT YIELDS FOR PATEA (MANGAMINGI) AND WATARA (TARATA)

Year	Patea at Mangamingi 10^3 tonnes	Waitara at Tarata 10^3 tonnes
1969	-	197
1970	-	445
1971	-	584
1972	-	281
1973	-	346
1974	-	419
1975	77.2	529
1976	122	463
1977	114	500
1978	63.9	474
1979	72.8	408
1980	81.1	-
1981	23.3	-
1982	49.4	-
1983	26.8	-
Mean Annual Yield (10^3t)	70.0	422.4
Mean Annual Yield (10^3 m^3)	58.3	352
Mean Annual Flow (10^3 m^3)	819,936	901,930
% $\frac{\text{Sediment}}{\text{Flow}}$	0.007	0.039

The 'diversion' type schemes will need to incorporate a sand trap at the river intake to prevent deposition of sediment within the downstream canal, and to prevent transporting of sediment through to the turbines. The sand trap will necessitate periodic flushing for which 5% of the mean flow was assumed to be used for this purpose. This will result in a slightly reduced generating capacity.

Unless regular sluicing is employed, storage schemes will cause sediment starvation to the downstream reaches. Likely problems include downcutting, bank erosion, beach erosion and loss of shingle supplies where rivers are used for this purpose.

B.3.6 Water Quality

The water quality rating for rivers throughout the region is described as good to very good (Taranaki Catchment Commission, 1984c), although point source inputs from agricultural activities and industrial discharges may reduce this rating in local reaches. This is particularly the case for the lower Waitara where there are increasing pressures for effluent discharges and water abstractions.

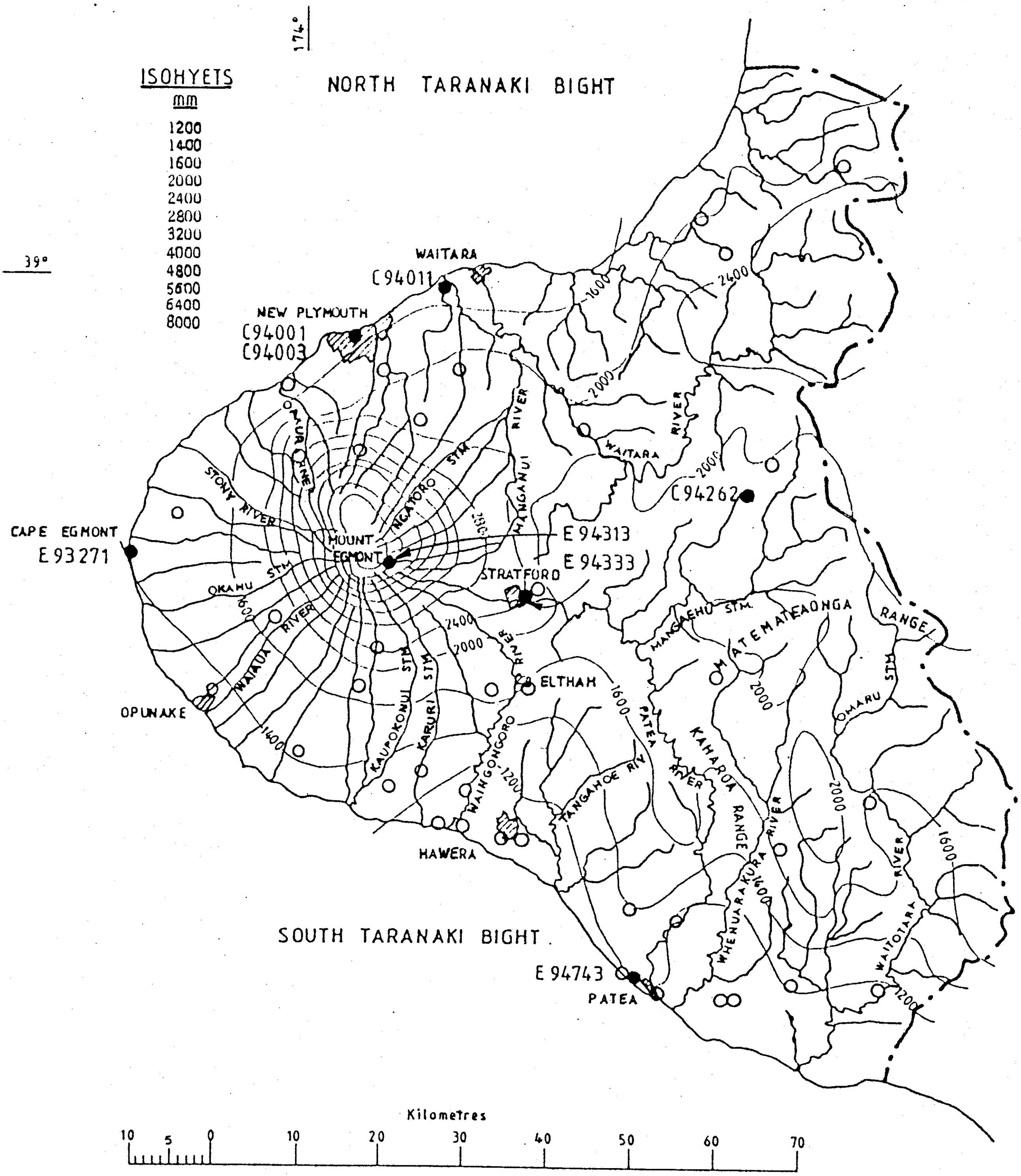
The maintenance of perimeter vegetation on the banks behind impoundments is important since it acts as a buffer to absorb some of the contaminants present in the flow. However, prior to impoundment the reservoir basin should be cleared of vegetation because if left it is subject to anaerobic decay and could allow contaminants to concentrate. This could increase the wear on turbines by, for example, corrosion.

B.4 COMPENSATION FLOWS

For hydro schemes involving the diversion of rivers, water requirements for other water uses need to be considered namely, downstream fauna and flora, industry, local farmers, irrigation and other users. This can often be provided for as hydro schemes require peak generation during winter when other demands for water can readily be met as river flows are higher. During the lower summer flows when water is scarce generation of electricity is not generally at a premium and therefore water may be available for other users. However, in areas where the Power Board is supplying a large proportion of industry, demands may be distributed evenly throughout the year. All these factors need to be considered before compensation flows can be fully assessed.

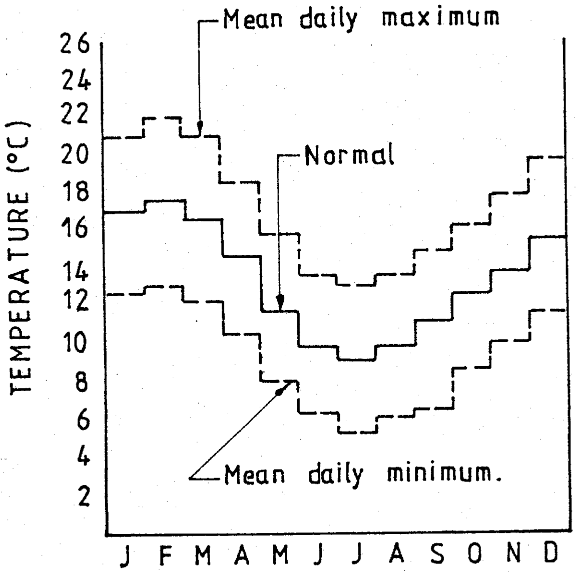
For this study the generating capacity and thus overall costs for 'diversion' type schemes were estimated allowing for a 10% (of the mean) compensation flow. This enables an assessment of the cost penalty in providing 'diversion' type schemes which will have compensation flows imposed on them. Storage schemes will also require compensation flows, but energy can still be produced even if only to supplement base loads.

It is emphasised that the actual compensation flow imposed on a scheme can only be determined after detailed environmental and water resources studies, specific to each site, have been carried out. Such studies will need to form the basis of the Water Right application.

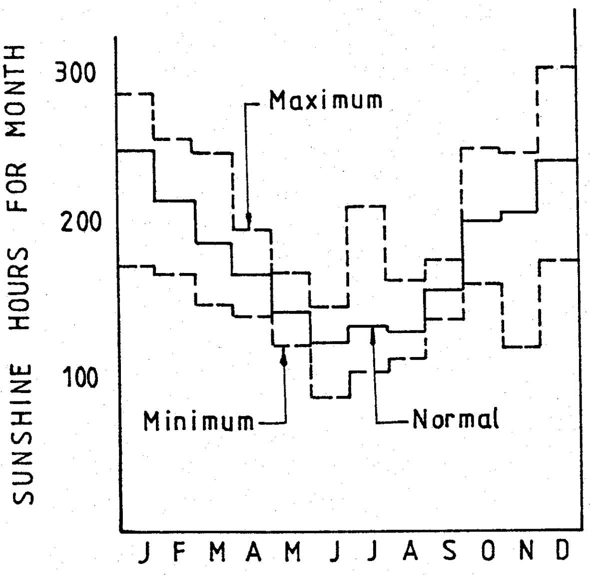


RAINFALL STATIONS AND MEAN ANNUAL RAINFALL ISOHYETS

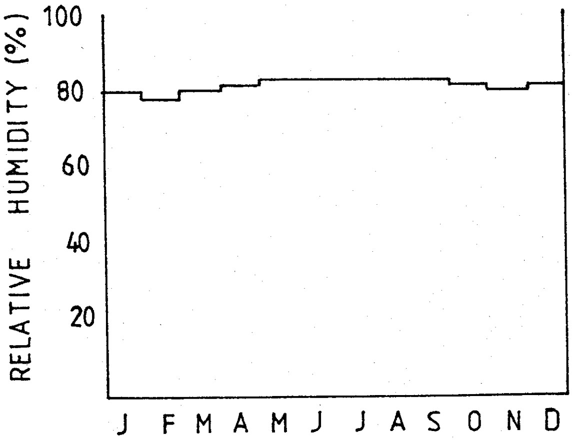
FIGURE B1



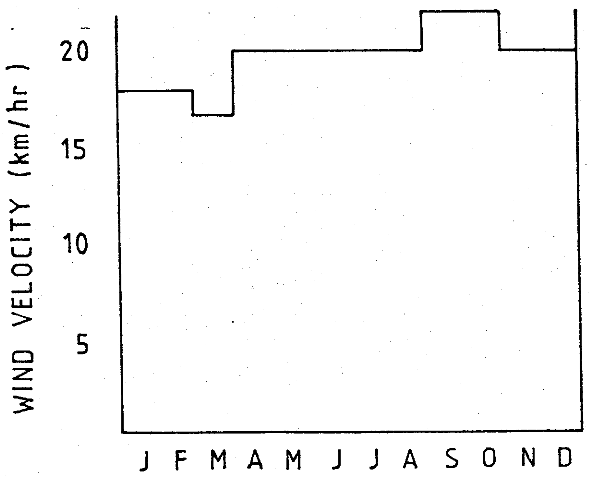
Mean monthly temperature for New Plymouth (1944–80)



Mean monthly sunshine hours for New Plymouth (1972–80)



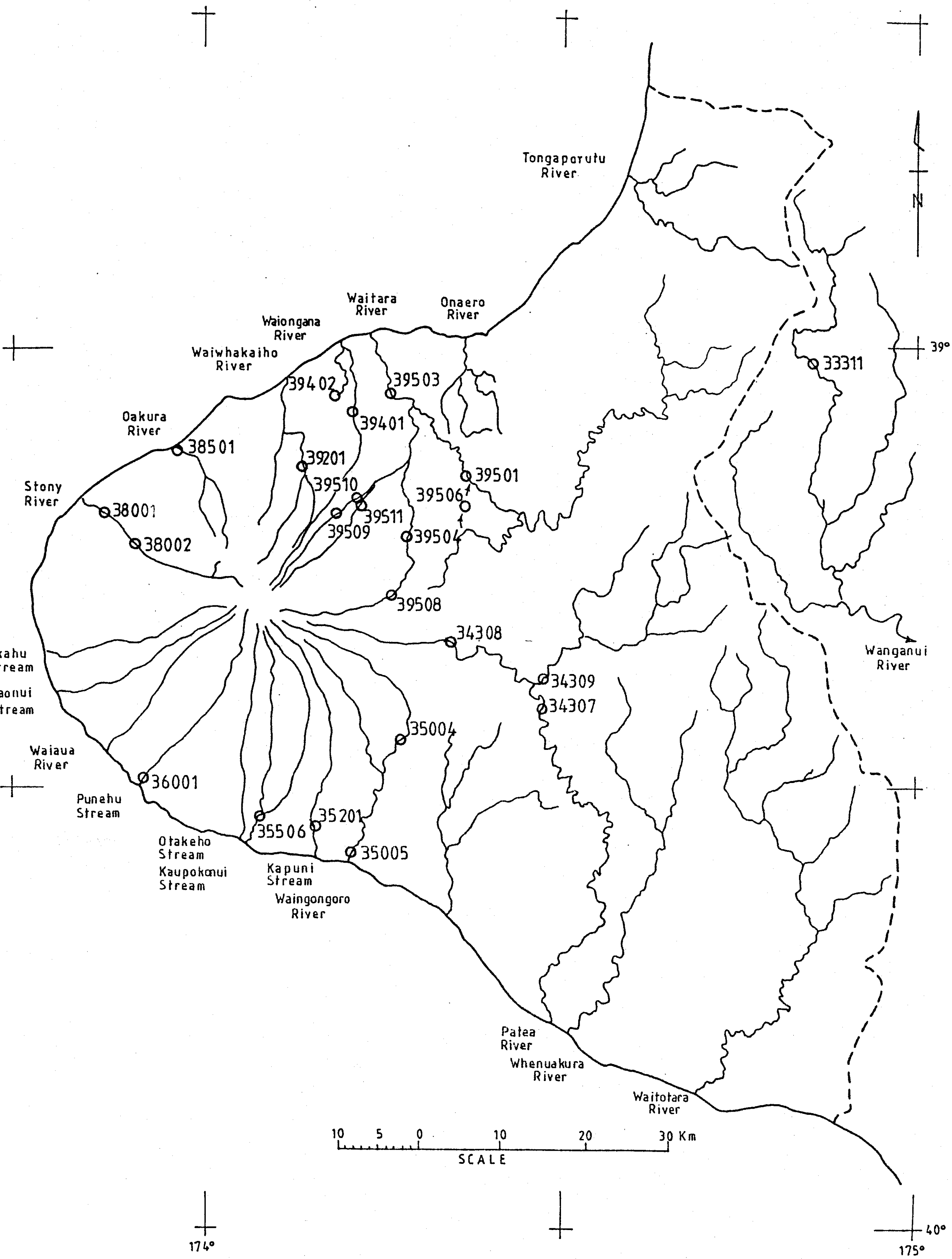
Mean relative humidity for New Plymouth Airport. (1968–80)



Mean wind velocity for New Plymouth (1968–80)

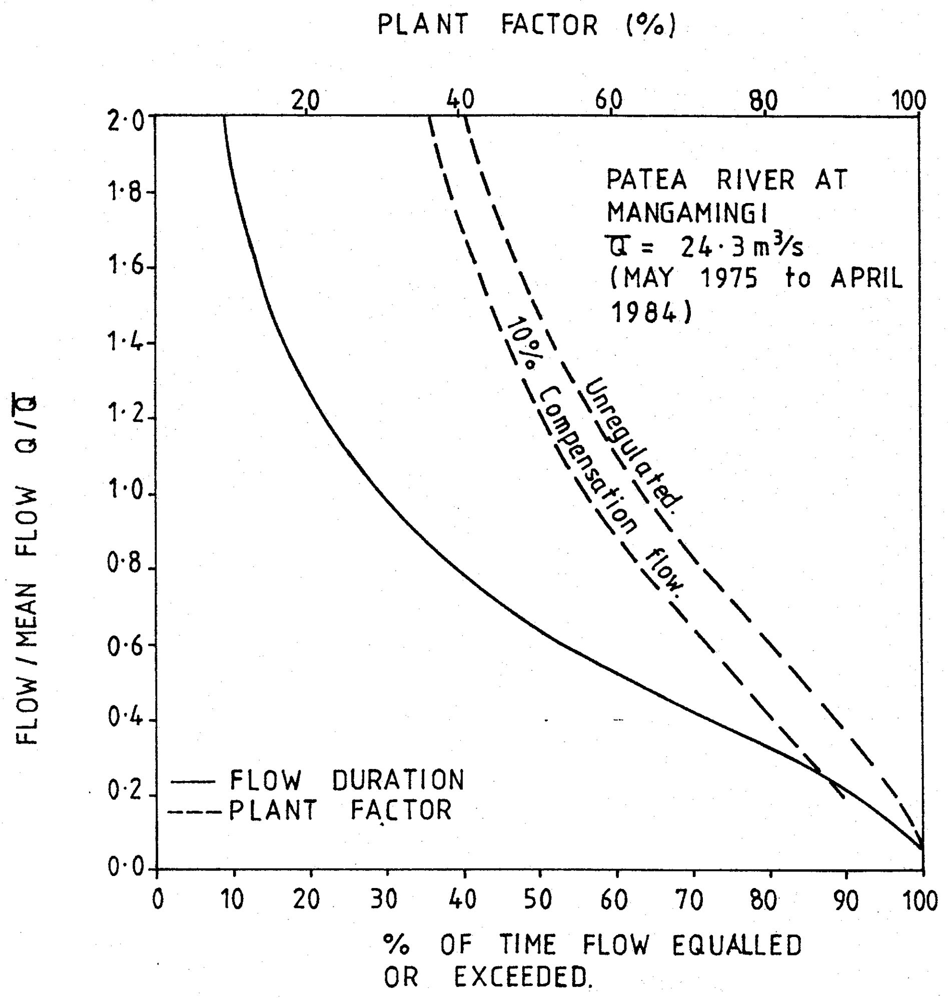
CLIMATE CHARACTERISTICS – NEW PLYMOUTH

FIGURE B2



MAIN HYDROLOGICAL GAUGING STATIONS

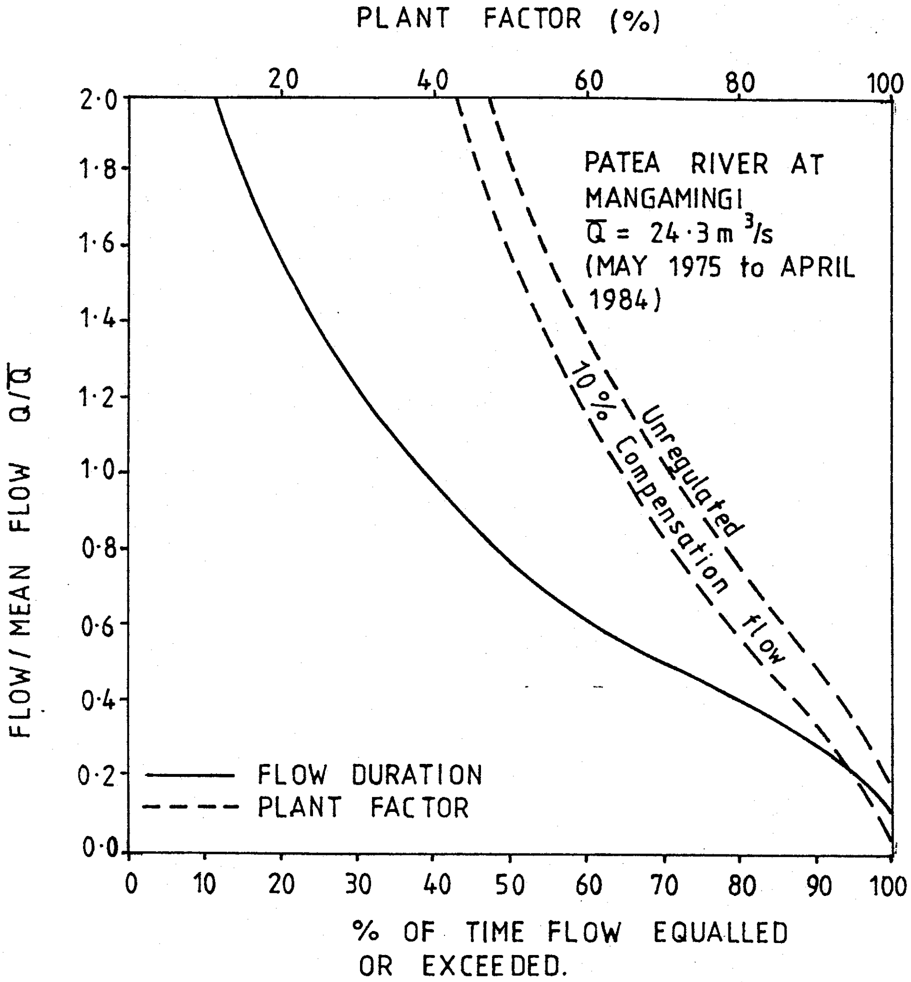
FIGURE B3



FLOW DURATION AND PLANT FACTOR CURVES FOR PATEA RIVER AT MANGAMINGI.

SITE Nº 34307

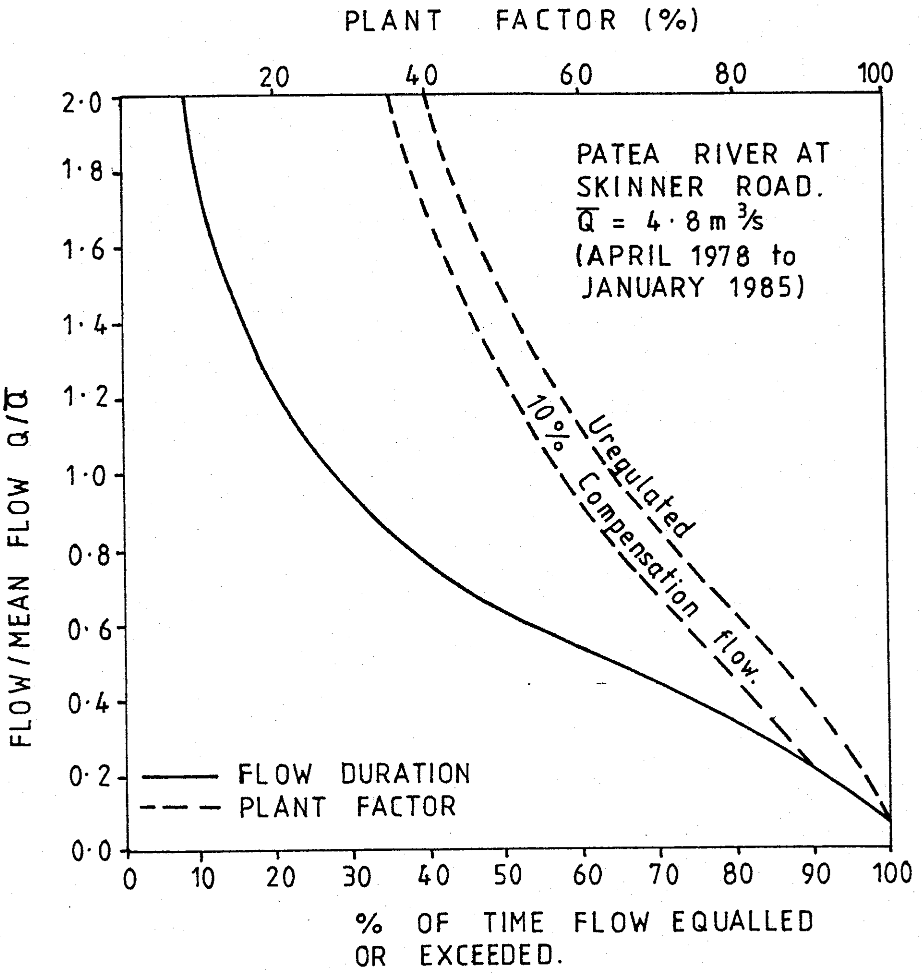
FIGURE B 4



FLOW DURATION AND PLANT FACTOR CURVES FOR PATEA RIVER AT MANGAMINGI (WEEKLY FLOWS)

SITE N° 34307

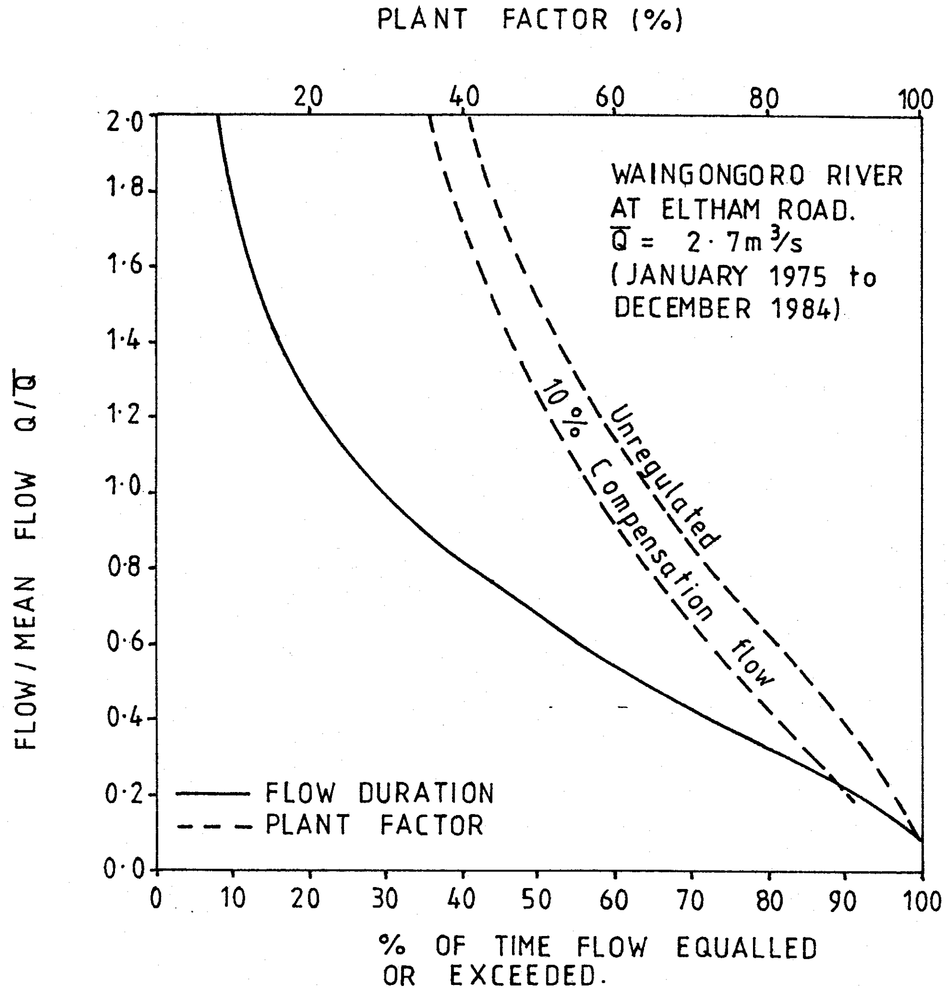
FIGURE B 5



FLOW DURATION AND PLANT FACTOR CURVES FOR PATEA RIVER AT SKINNER ROAD.

SITE N° 34308

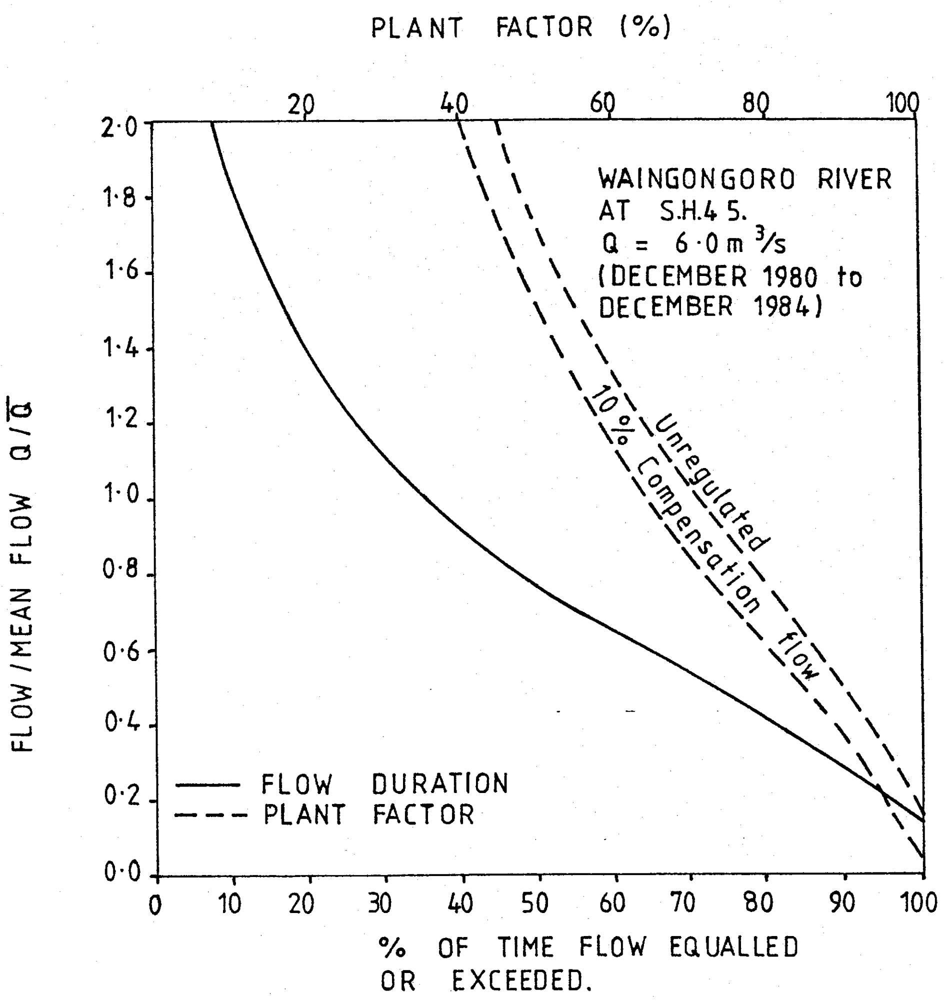
FIGURE B 6



FLOW DURATION AND PLANT FACTOR CURVES FOR WAINGONGORO RIVER AT ELTHAM ROAD.

SITE Nº 35004

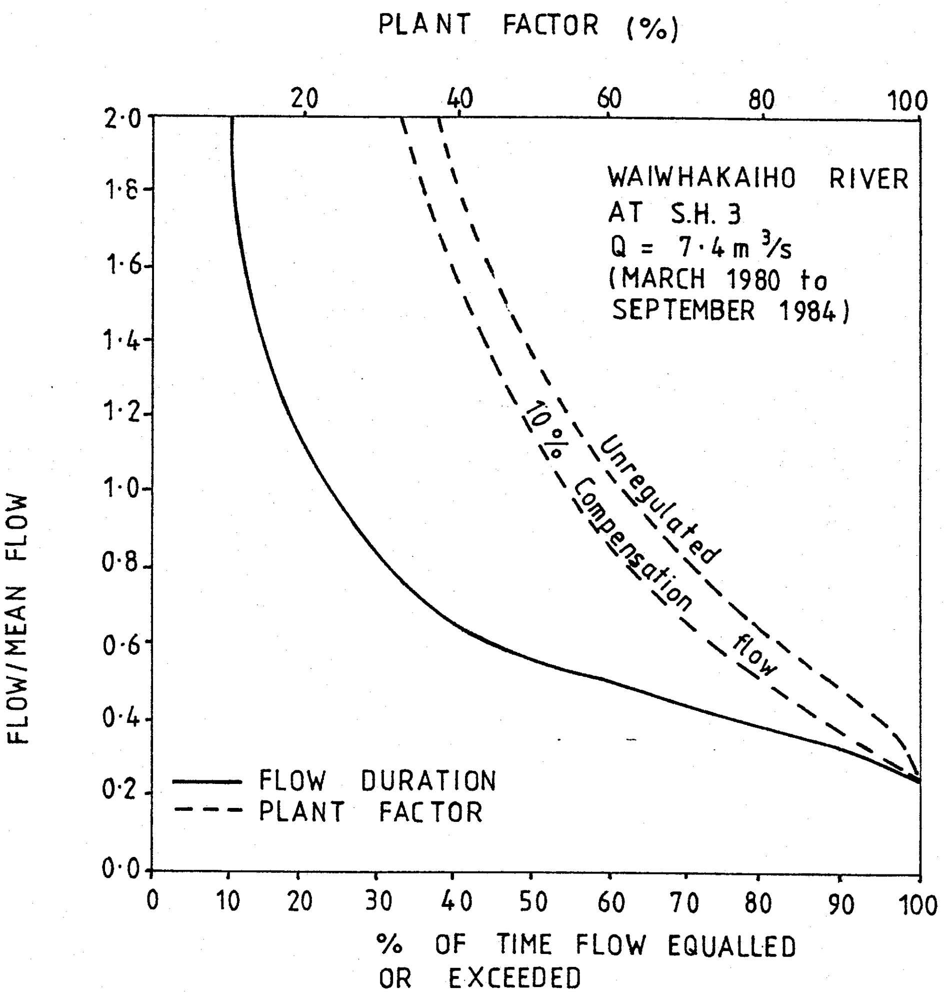
FIGURE B 7



FLOW DURATION AND PLANT FACTOR CURVES FOR
WAINGONGORO RIVER AT S.H. 45

SITE N° 35005

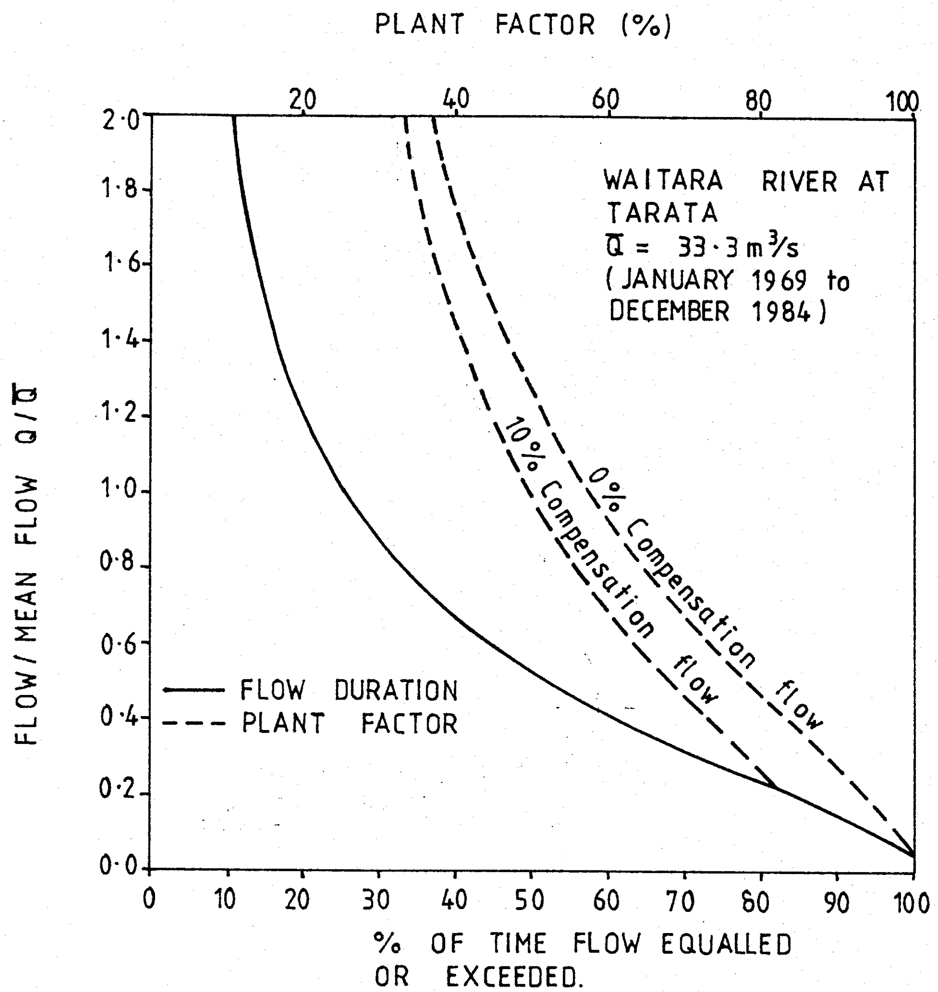
FIGURE B 8



FLOW DURATION AND PLANT FACTOR CURVES FOR WAIWHAKAIHO RIVER AT S.H. 3

SITE No 39201

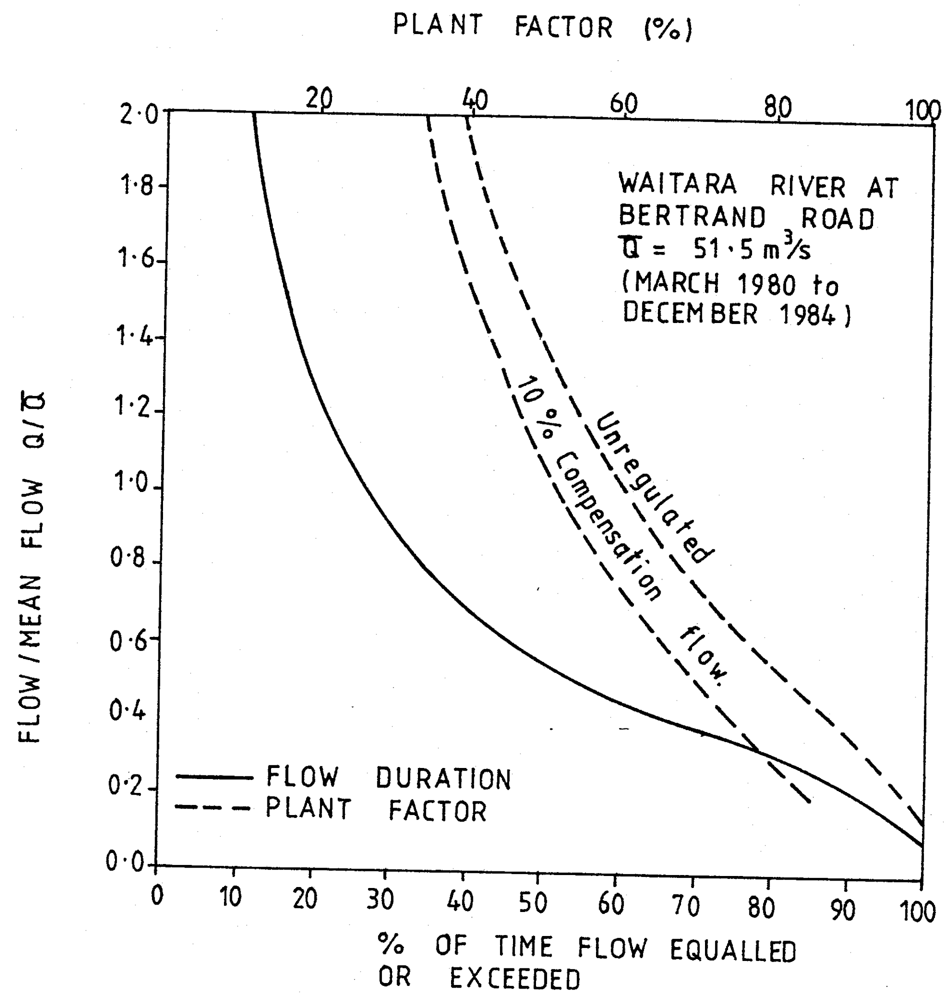
FIGURE B 9



FLOW DURATION AND PLANT FACTOR CURVES FOR WAITARA RIVER AT TARATA.

SITE Nº 39501

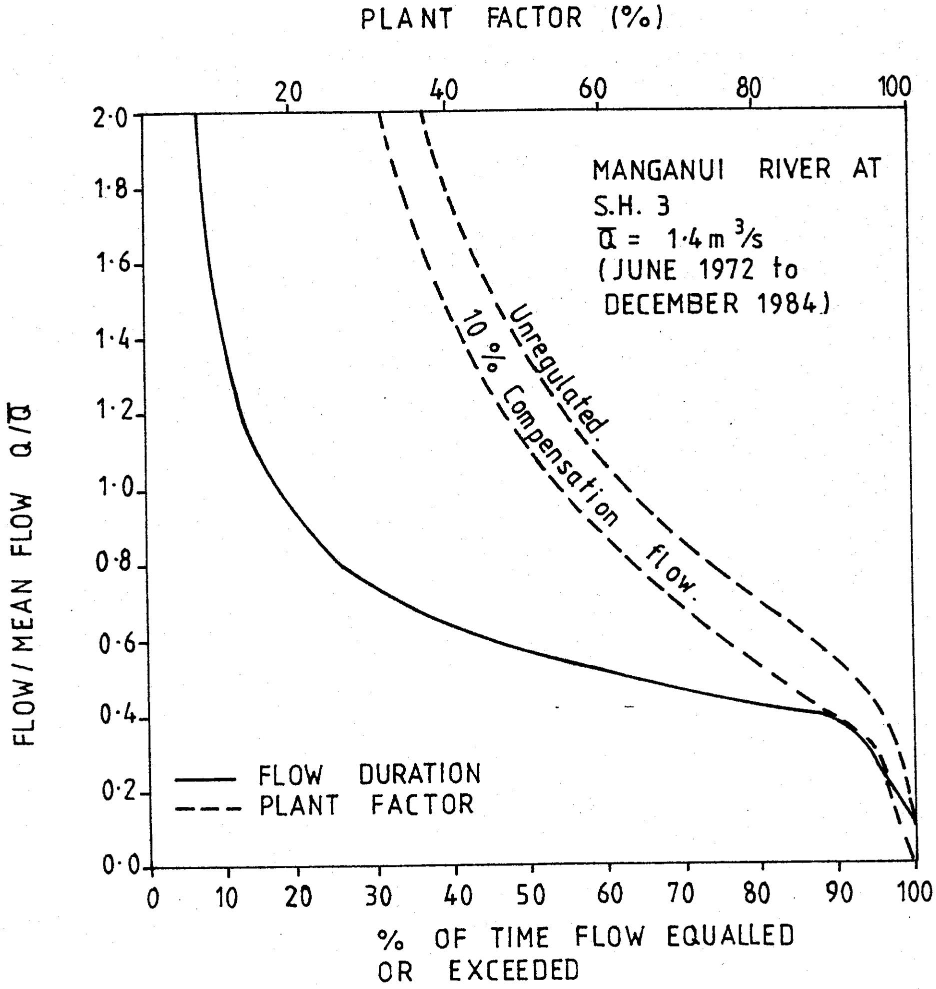
FIGURE B 10



FLOW DURATION AND PLANT FACTOR CURVES FOR WAITARA RIVER AT BERTRAND ROAD

SITE N° 39503

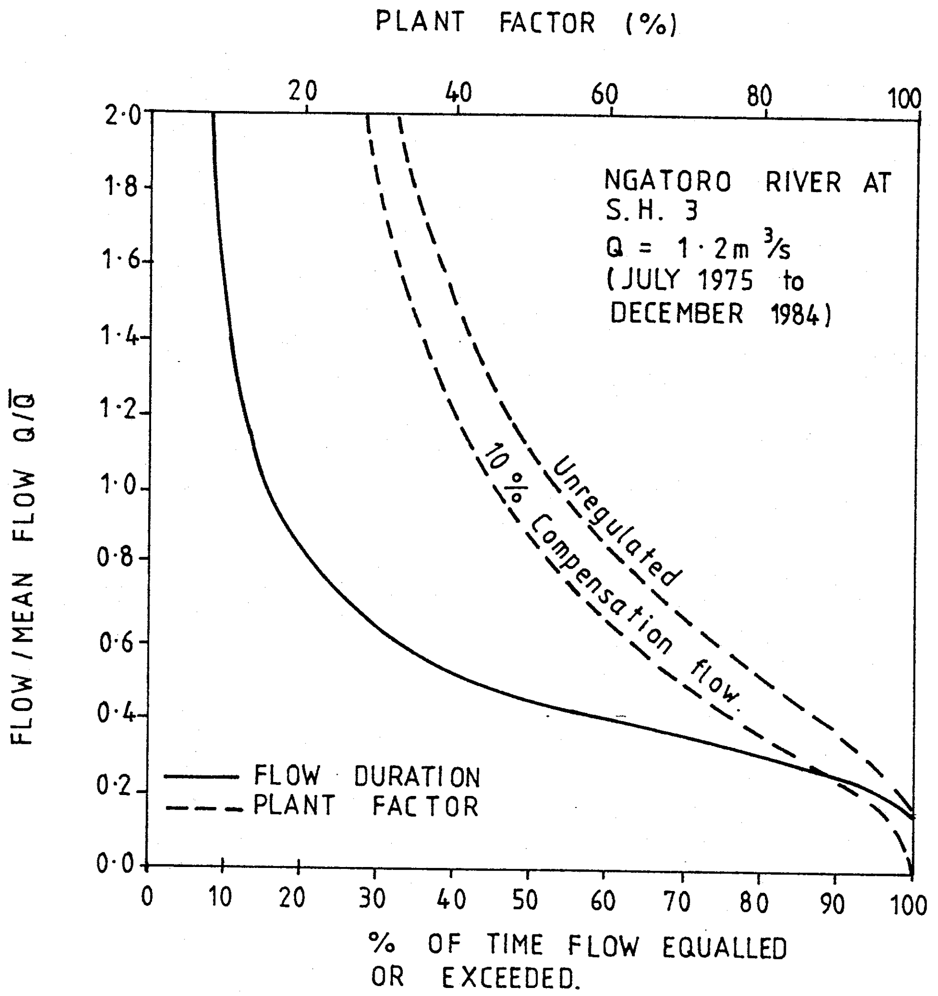
FIGURE B 11



FLOW DURATION AND PLANT FACTOR CURVES FOR MANGANUI RIVER AT S.H. 3

SITE N°. 39508

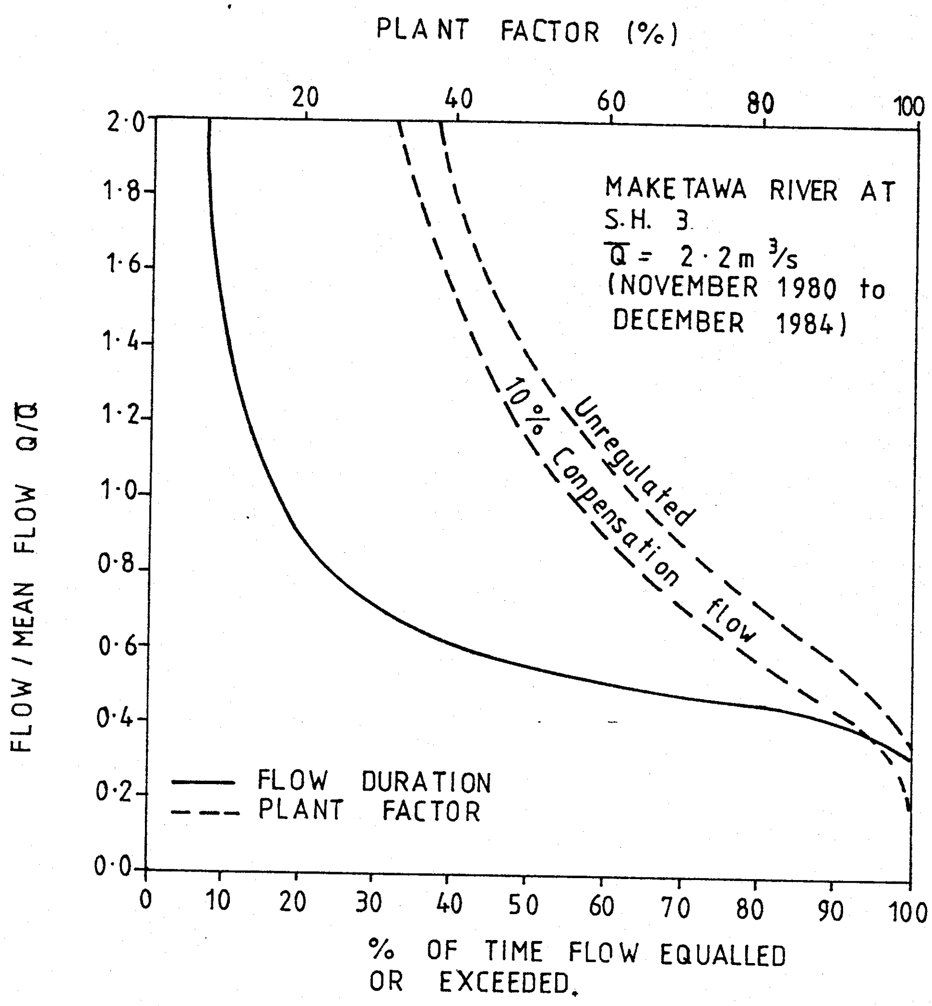
FIGURE B 12



FLOW DURATION AND PLANT FACTOR CURVES FOR NGATORO RIVER AT S.H. 3

SITE N° 39510

FIGURE B 13



FLOW DURATION AND PLANT FACTOR CURVES FOR MAKETAWA RIVER AT S.H. 3

SITE N° 39511

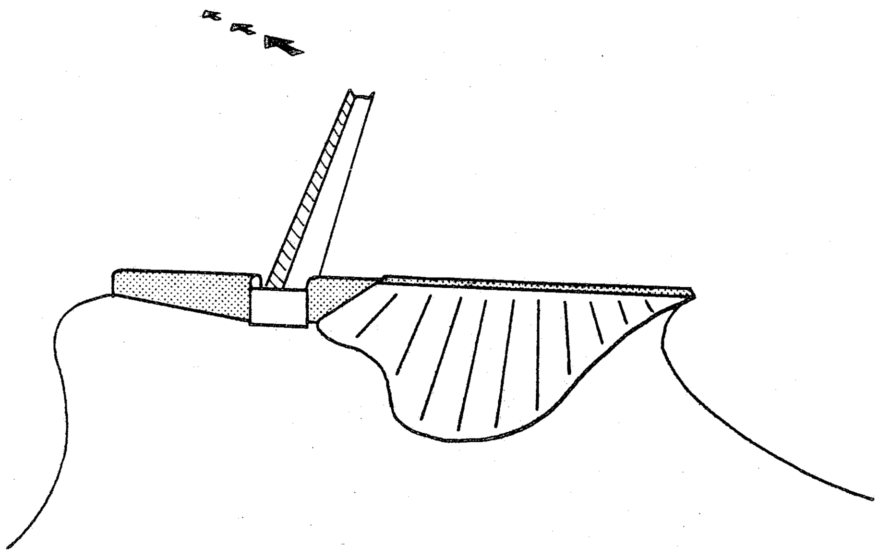
FIGURE B 14

APPENDIX C

PHOTOGRAPHS

APPENDIX C

PHOTOGRAPHS

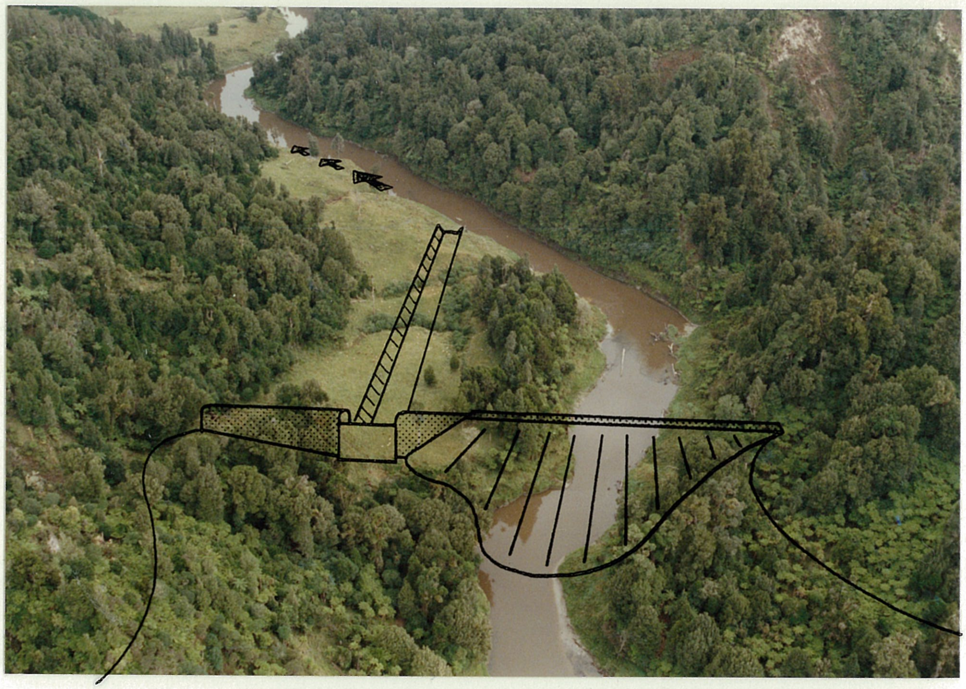


SCHEME 2.4

Embankment dam with concrete spilweir sections and gate on the Waitara River.

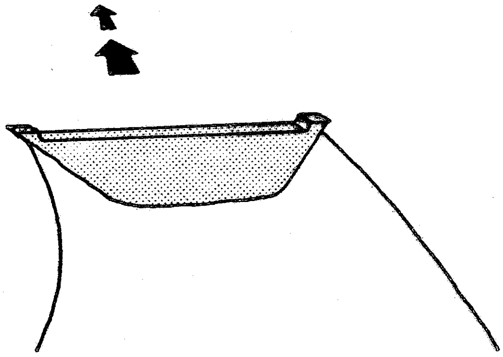
Exposure of 'lahar' material, common to study area.

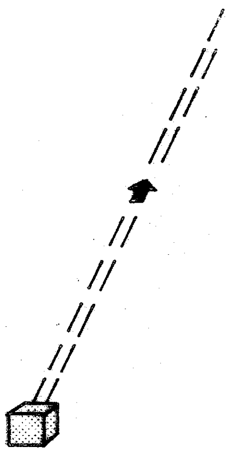
SCHEME 2.4

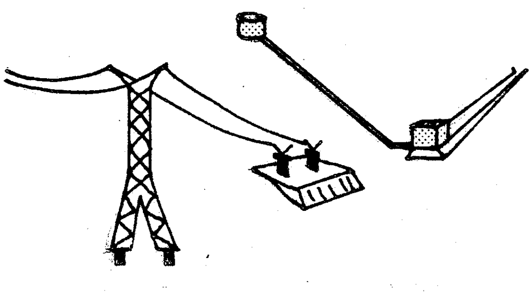


Embankment dam with concrete spilweir sections and gate on the Waitara River.

Exposure of 'lahar' material, common to study area.







SCHEME 2.5/2.6

Concrete gravity dam on the Waitara River

SCHEME 2.5

Tunnel portal site

SCHEME 2.5

Powerhouse site on Kohohiko Stream, a tributary of the Onaero

SCHEME 2.5/2.6

Concrete gravity dam on the Waitara River

SCHEME 2.5

Tunnel portal site

SCHEME 2.5

Powerhouse site on Kohohiko Stream, a tributary of the Onaero


Site

SCHEME 2.7

Impounding area viewed from Pukerangiora Pa.

SCHEME 3.1

Intake site in Everett Park

SCHEME 3.1

Last reach of canal with forebay in the foreground

SCHEME 2.7

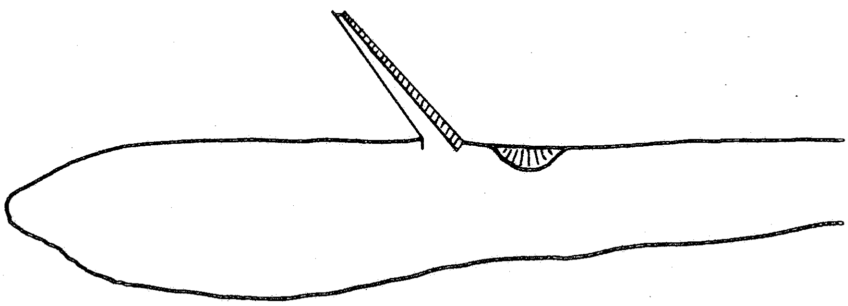
Impounding area viewed from Pukerangiora Pa.

SCHEME 3.1

Intake site in Everett Park

SCHEME 3.1

Last reach of canal with forebay in the foreground



SCHEME 3.3/3.4

Balancing pond and head race towards Korito Road

SCHEME 3.4A

Augumentation of Mangorei Hydro Scheme (Lake Mangamahoe)

SCHEME 4.5/4.7

The Waingongoro River. Typical topography over which the canals would tranverse

SCHEME 3.3/3.4

Balancing pond and head race towards Korito Road

SCHEME 3.4A

Augumentation of Mangorei Hydro Scheme (Lake Mangamahoe)

SCHEME 4.5/4.7

The Waingongoro River. Typical topography over which the canals would tranverse

SCHEME 4.7B

South Taranaki Coastline.

SCHEME 4.9

Existing dam on the Waingongoro

SCHEME 4.9

Abandoned Powerhouse

SCHEME 4.7B

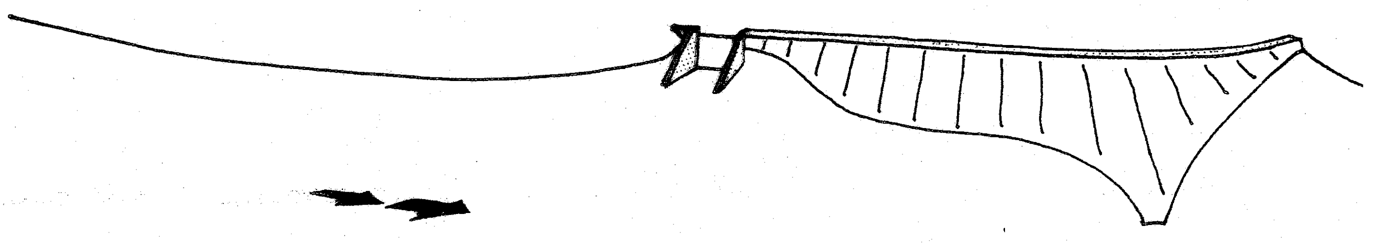
South Taranaki Coastline.

SCHEME 4.9

Existing dam on the Waingongoro

SCHEME 4.9

Abandoned Powerhouse



SCHEME 5.1

Typical 'rolling' country over which canals would tranverse

SCHEME 5.3

Embankment dam across Patea River

SCHEME 5.1

Typical 'rolling' country over which canals would tranverse

SCHEME 5.3

Embankment dam across Patea River

APPENDIX D

POTENTIAL SCHEMES IDENTIFIED

IN STAGE I ANALYSIS

APPENDIX D

POTENTIAL SCHEMES IDENTIFIED IN PRELIMINARY REPORT

D.1 STUDY OBJECTIVE

The objective of this stage of the study was to identify, on the basis of a desk top study, sites that offered opportunity for local supply authority hydroelectric development in Taranaki. An economic limit of $2,000/kW (June 1978) was suggested by the Ministry of Works and Development as a guideline in establishing the attractiveness of potential schemes.

D.2 STUDY METHOD

As a first step the following supply authorities were consulted for information and details of previous studies of hydro-electric potential in their area:

i) the Manawatu Catchment Board;
ii) the Manawatu-Oroua Electric Power Board;
iii) the Rangitikei-Wanganui Catchment Board;
iv) the Wanganui-Rangitikei Electric Power Board;
v) the King Country Electric Power Board;
vi) the Taranaki Catchment Commission;
vii) the New Plymouth Municipal Electricity Department;
viii) the Taranaki Electric Power Board; and
ix) the Egmont Electric Power Board.

Topographical information was obtained from the New Zealand Lands & Survey 1:63,360 scale maps. Rainfall data was obtained from the New Zealand Meteorological Service Office in Wellington. River flow and hydrological data was obtained from the Ministry of Works and Development and also the Taranaki Catchment Commission. Geological information was obtained from the NZ Geological Survey 1:250,000 scale maps.

For convenience the region was subdivided into six areas of interest. These were:

Area 1	Northern Coastal Rivers
Area 2	Waitara River Catchment
Area 3	Northern Mountain Streams
Area 4	Western and Southern Mountain Streams
Area 5	Patea River Catchment
Area 6	Southern Coastal Rivers

The following factors were then assessed over these regions:

a) Hydrology - Mean and flood flows and flow duration characteristics of the major streams.

b) Topography - River gradients; river channel constrictions; natural falls.

c) Geology - Tertiary sandstone and siltstone, volcanics, alluvial plains.

A range of sites was then selected and studied in the following sequence:

- Tentative site selection;
- Investigation of any larger scale maps of the sites that were available;
- Determination of the general scheme components;
- Approximate costing of the scheme from the component costs;
- Appraisal of environmental factors; and
- Ranking of schemes worthy of further detailed investigation.

D.3 STUDY FINDINGS AND RECOMMENDATIONS

A number of locations were identified as potential sites for local hydro-electric development. These are shown in Table D1.

Using the Ministry of Works and Development's guideline of $2,000/kW (June 1978) as the basis for ranking possible schemes, the range of options was narrowed down to 16. These schemes were further divided into the following rankings: (Refer to Table D1)

A) those that appear attractive and warrant more detailed investigation;

B) those that require further investigation to establish their attractiveness;

C) those that appear attractive but have severe environmental constraints; and

D) those that are clearly uneconomic.

It was recommended that preliminary field appraisal of the 16 schemes identified should be carried out as a subsequent study. Field appraisal would include geological and geotechnical evaluation of the potential sites, together with sufficient topographical information for confirmation of the size of scheme elements to enable a more accurate assessment of costings. The likely environmental constraints associated with potential schemes would also be outlined in the report, as well as the possibility of multiple use of river waters.

TABLE D1 : POTENTIAL SCHEMES IDENTIFIED IN PRELIMINARY ANALYSIS

Scheme No.	Map Ref.	River or Stream	Installed Capacity (MW)	Cost ($/KW)	Ranking
Waitara River Catchment					
2.1	N100 166 006 (intake)	Waitara	5.0	2,060	D
2.2	N110 105 907 (intake)	Waitara	14.4	2,256	D
2.3	N110 143 892	Waitara	12.5	2,290	D
2.4	N109 982 762	Waitara	7.3	1,390	A
2.5	N109 909 845 (intake)	Waitara	20.0	980	C
2.6	N109 909 845	Waitara	5.0	1,580	B
2.7	N109 831 923	Waitara	8.0	1,430	A
Northern Mountain Streams					
3.1	N109 850 855	Manganui	11.1	1,290	C
3.2	N109 818 897	Mangaonaia	20.2	2,240	D
3.3	N109 669 795	Mangorei	7.7	1,530	B
3.4	Modify existing Mangamahoe Scheme	Mangorei	10.3	1,680	B
3.5	Increase capacity of existing Motukawa Scheme	Ngatoro	11.9	Variable	B
3.6	N108 585 804 (intake)	Oakura	1.0	2,530	D
Western and Southern Mountain Streams					
4.1	N108 487 711 (intake)	Stony	4.0	2,120	D
4.2	N118 555 557 (intake)	Waiaua	34.8	2,820	D
4.3	N129 658 327 (intake)	Kaupokonui	3.8	2,640	D
4.4	N119 842 425 (intake)	Waingongoro	2.8	2,110	D
4.5	N129 828 396 (intake)	Waingongoro	3.6	1,730	B
4.6	N129 822 364 (intake)	Waingongoro	2.1	3,500	D
4.7	N129 803 330 (intake)	Waingongoro	4.0	2,000	B

APPENDIX D - CONT

Scheme No.	Map Ref.	River or Stream	Installed Capacity (MW)	Cost ($/KW)	Ranking
4.8	Upgrade Opunake power station	Waiaua	0.5	1,710	B
4.9	Recommission old Station	Waingongoro	1.0	1,000	A
Patea River Catchment					
5.1	N119 924 550 (intake)	Patea	4.2	1,860	B
5.2	N119 032 523	Mangaehu	2.5	2,660	D
5.3	N119 033 494	Patea	12.0	1,760	B
Southern Coastal Rivers					
6.1	N130 191 316	Whenuakura	1.3	1,380	C
6.2	N130 141 148	Whenuakura	6.5	4,210	D
6.3	N130 328 340	Waitotara	6.0	2,770	D
6.4	N130 328 351	Pokeka	1.1	1,670	B
6.5	N130 141 148 (intake)	Whenuakura	8.2	4,020	D
6.6	N130 194 297 (intake)	Whenuakura	7.9	3,040	D
6.7	N130 173 342 (intake)	Whenuakura	12.3 GWh* pa	8.5 c/kwh	D
6.8	N130 200 345 (intake)	Moeawatea Stream	18.8 GWh* pa	9.5 c/kwh	D
6.9	N130 283 377 (intake)	Waitotara	43.8 GWh* pa	10.0 c/kwh	D

* Based on cost of energy

At June 1978 cost levels (MWD Construction Cost Index 952)

APPENDIX E

TERMS OF REFERENCE

APPENDIX E

REGIONAL ASSESSMENT OF HYDRO POTENTIAL FOR LOCAL AUTHORITY DEVELOPMENT - STAGE 2

BRIEF FOR CONSULTANT'S STUDY (Retyped from MWD copy)

E.1 INTRODUCTION

This brief describes the requirements for a study to be conducted to identify in very approximate terms the opportunities for local authority hydro-electric development in part of the Wanganui MWD District region. The Stage 1 report has been completed and the Stage 2 report selects from the Stage 1 report the more attractive sites and examines them in greater detail.

E.2 SCOPE

a) A Study Region:

The study is to consider hydro-electric development opportunities within the following boundaries:

Taranaki Catchment Commission

This embodies the territories of the regional water board and the following power boards:

- Waitomo Electric Power Board
- Taranaki Electric Power Board
- New Plymouth Municipal Electricity Department
- Egmont Electric Power Board
- Wanganui-Rangitikei Electric Power Board

The Consultant is to consider the possibilities of diversion of water from outside this study region into the region but, to avoid duplication of effort in respect to studies being conducted in neighbouring regions, the Consultant is required not to consider the possibilities of diversion of water out of the study region. The downstream consequences of any diversion must be identified in both the catchments concerned.

b) Size of Schemes:

The Consultant is to ascertain from the Ministry of Works and Development what reaches of waterways within the area are currently being considered as likely hydro-electric developments by the State; such reaches are to be excluded from the regional study (and are to be shown in the report as having been explicitly excluded). In general the study should consider potential schemes which could have capacities between 0.5 MW and 50 MW. In addition, schemes larger than 50 MW should be considered only if development by the State has not been stated as being likely.

c) Limits:

Study is to be directed as identifying hydro-electric opportunities whose development would not be economically excessive. For the purposes of this study, reaches of waterways which are likely to involve more than $2000/kW capital cost to develop at June 1978 prices are to be regarded as uneconomical.

d) Scheme Practicability:

In any scheme considered, development by a local authority (or authorities) should appear to be practicable. The merits of hydro potential identified should be assessed in terms of existing or foreseeable electricity load centres.

E.3 STUDY OBJECTIVE

The overall objective of the hydro potential assessment for each region is to identify, with a minimum expenditure of time and money, all the apparently attractive opportunities for local supply authority hydro-electric development. This survey has been divided into two stages. In the Stage 1 report sites or reaches of waterways likely to meet economic criteria were identified and separated into broad ranking categories.

In the Stage 2 study the objective is to refine and expand the hydrological, topographical, geological, and costing data presented in the Stage 1 report.

E.4 METHOD OF STUDY

For an understanding of the overall Stage 1 and Stage 2 requirements some guidance on methods to be followed is given in NZERDC Report No. 36 "Study of Hydro-electric Potential in Northland" (Sections 3, 4 and 7). These should be studied. The following "method" guidance relates closely to Section 7.2.2 of this NZERDC report.

Having tentatively selected sites, the study then proceeds using available maps and data through a cycle of:

- Prepare base Plans for field work.
- Site inspection including some simple survey measurements. Before entering on to any land, the consultant shall have discussions with the District Property Officer, MWD, Wanganui, who shall if required obtain permission for such entry.
- Sketching possible scheme components on the site plans.
- Re-appraisal of tentative sites and consideration of adjacent sites in the light of the site inspection.
- Re-appraisal of preliminary findings including capital costs, power available and environmental factors.

- Ranking of schemes worthy of further investigations in detail.

This Stage 2 study entails inspection on the ground where practicable of all sites listed in the following tables of the Stage 1 Report.

1. Table 2.1.

2. Table 2.2 - The consultants are to use their judgement as to which schemes are investigated in the range \$1500/kW to \$2000/kW (June 1978 prices and MWD Construction Cost Index 952).

3. Table 2.3.

This inspection is a brief on-site check of possibilities identified in the office and should involve:

- Approximate measurement of key relative levels of simple instrument work.

- Visual confirmation of scheme component locations and the possibilities for reservoir storage.

- Cursory consideration of alternative hydro schemes on the same river reach.

- Identification of local environmental factors.

- Very preliminary appraisal by an engineering geologist who is to be included in the engineering inspection party.

- The taking of photographs.

The Consultant is expected to discuss with the Catchment Commission questions of competing water use, regional sediment yields and new data availability. If it is appropriate, other local authorities should also be consulted on matters which affect them.

E.5 FORM OF REPORT

The results of the study are to be recorded in a report; 30 copies of which are to be supplied to the client in photocopied typescript with a titled cover and with all plans and figures enclosed.

This Stage 2 Report should:

- Document all available relevant hydrological, topographical and geological information including any new information available since the completion of the Stage 1 Report. Any of this information which is not present in the report itself is to be referenced in an enclosed bibliography.

- Describe the local hydro potential of the complete study region on a systematic catchment by catchment basis.

- Indicate those sites or reaches of waterway which appear to be sufficiently attractive to warrant further consideration and list sites initially considered but later rejected.

- Rank individual sites or reaches in terms of apparent economic merit.

- Identify significant unknowns requiring further site investigation before the worth of some localities can be assessed.

- Describe briefly the method of scheme cost estimating used and comment on the reliability and limitations of any estimates.

- Identify non-economic factors which could affect the overall merits of developing a particular site.

NZERDC Report No. 40 provides a good model for a Stage 2 Report. The scope and format of report No. 40 should be closely followed.

In summary, the report should incorporate the findings from the Stage 1 Report and the site inspections and should provide further documentation on items listed in Schedule A attached.

The evaluation of possible schemes in economic terms is expected to be in very approximate terms only. To assist consistency in the ranking of sites the following ground-rules should be followed:

1. Costs should be at June 1978 prices (MWD Construction Cost Index 952). When calculating the equivalent present day costs, use CCI 952 and CCI 2180 (September 1984).

2. Estimated capital cost should include all tangible economic costs to the nation incurred by the development of the hydro project (including transmission, land and compensation costs, engineering, and an adequate contingencies allowance). The capital cost should exclude interest during construction.

3. The installed capacity of plants generally should be assumed to yield an average annual plant factor of about 50%. For sites having particular attributes the selection of a higher or lower plant factor may be obviously preferable, in which cases these should be so indicated.

4. The likely availability of daily storage or longer term storage should be indicated.

5. Sites should be evaluated in terms of capital cost per installed kW and the total annual output in GWh should be estimated.

Sites should be classified according to the following categories:

A	Very attractive	\$1000/kW or less
B	Attractive	\$1000-\$1500/kW
C	Possibily attractive	\$1500-\$2000/kW
D	Probably uneconomic	\$2000/kW or more
E	Economically attractive but with severe environmental constraints.	

Above costs are at June 1978 prices (MWD Construction Cost Index 952).

In listing the sites, or reaches of waterways, which have attractive hydro-electric potential, the report should note any which are mutually exclusive, ie. where the potential at one site is precluded or reduced by the development at another site.

E.6 CONDITIONS OF CONSULTANT'S ENGAGEMENT

The Consultant for this study will be engaged by and be responsible to the District Commissioner of Works Wanganui as client.

Reports and financial accounts will be submitted on a regular basis.

The basis of charges will be fees on a time basis in accordance with the NZ Institution of Engineers Conditions of Engagement and Scales of Minimum Fees for Consulting Engineers, Document A, 1976 and agreed amendments.

The report is to be completed by mid August 1985.

The Consultant is to make available at the time of his commissioning a budget of costs itemised into staff time, disbursements, printing, etc.

The Consultant is to provide a draft copy of his report to the client who will authorise the printing of the final report. The Consultant will be required to present his draft report before a meeting of Local Body and MWD Representatives.

SCHEDULE A

ITEMS FOR ADDITIONAL DOCUMENTATION IN PHASE I ASSESSMENT

1. Definition of electric power boards within the region - boundaries, power demand, and transmission lines.

2. Reference to previous hydro studies and existing hydro-electric power development.

3. A systematic catchment by catchment discussion of each river's hydro potential. The complete study region should be covered comprehensively in this way.

4. Scheme description on a systematic basis. Each scheme description should follow logically on from the catchment description so that demonstrably no significant hydro prospects have been overlooked in the assessment. A scheme description should include:

   - relevant hydrological and topographical information
   - significance of reservoir storage, regulation, and sedimentation
   - discussion of alternative hydro possibilities on the same river reach
   - site geology
   - local environmental factors
   - site photographs

5. Power potential assessment methodology including:

   - Use of flow data in preliminary site identification
   - Calculation of estimated power potential for particular sites

6. A review and update of hydrology appendices

7. MWD and the Catchment Commission shall carry out low flow gaugings if requested to do so by the consultants.