

DRAFT

**THE HYDROLOGY OF THE
WAITAKARURU RIVER AND
MAUKORO CANAL SYSTEMS
AND DRAINAGE OF THE
POUARUA PEAT DOME**

**Prepared by: Guy Russell
Engineering Services Section**

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Waikato Regional Council
Box 4010
HAMILTON EAST

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CONTENTS

ACKNOWLEDGEMENTS	i
CONTENTS	ii
MAPS	iv
FIGURES	iv
TABLES	iv
APPENDICES	v
1 SUMMARY	1
2 PREAMBLE	1
3 BACKGROUND	2
3.1 Waitakaruru Catchment Scheme	6
3.2 Peat Mining	6
4 CONSIDERATIONS	7
4.1 Western Hills Hydrology	7
4.1.1 Rainfall figures	7
4.1.2 Stream Discharges	9
4.2 Plains Hydrology	12
4.2.1 Rainfall figures	12
4.2.2 Plains Design Standards	13
4.3 Arterial Canal Capacities and Flooding	13
4.3.1 Waitakaruru Canal	14
4.3.2 Maukoro Canal	14
4.3.3 Pouarua Canal	17
4.4 Pouarua Peat Dome	18
4.4.1 Historic Surveys	18
4.4.2 Sphagnum Moss Resource	24
4.4.3 Department of Conservation Block	25
4.4.4 Peat Consolidation	27
4.5 Drainage	29
4.5.1 Present Drain Management	31
4.5.2 Future Drainage Proposals for Pouarua Peat Dome Area	31
5 DISCUSSION	33
5.1 Future of Waitakaruru Catchment Scheme	33
5.2 Future of Pouarua Peat Dome	34

6	CONCLUSIONS	35
7	RECOMMENDATIONS	36

MAPS

		Page
MAP 1	Location Map	3
MAP 2	Features of Study Area	4
MAP 3	Location of Pouarua Ground Level Survey 1979 Cross-section Lines	19
MAP 4	Features of Department of Conservation Reserve	26

FIGURES

FIGURE 1	Flood Frequency Analysis, Waitakaruru River at Steen Road	10
FIGURE 2	Pouarua Ground Level Survey 1979 Cross-Section 1	20
FIGURE 3	Pouarua Ground Level Survey 1979 Cross-Section 2	21
FIGURE 4	Pouarua Ground Level Survey 1979 Cross-Section 3	22
FIGURE 5	Pouarua Ground Level Survey 1979 Cross-Section 4	23
FIGURE 6	Influence on Ground Surface of Land Drainage of Peat	30

TABLES

TABLE 1	Maramarua Forest Rainfall Depth - Duration - Frequency Table	7
TABLE 2	HCB Waitakaruru Scheme, Rainfall Depth - Duration - Frequency Table	8
TABLE 3	Adopted Stream Flows and 1974 Waitakaruru Scheme Design Flows	11
TABLE 4	Kerepehi Rainfall Depth - Duration - Frequency Table	12
TABLE 5	Rates of Peat Consolidation	28

APPENDICES

	Page	
APPENDIX A	Pouarua Canal Scheme (With Pump Assisted Gravity Outlet) - Hauraki Catchment Board 1964	37
APPENDIX B	Waihou Valley Scheme, Design Procedure for Drainage Scheme Proposals, I McLeod and M Tait 1975.	67
APPENDIX C	Waitakaruru Catchment Scheme, Hauraki Catchment Board, March 1980, Appendix A, Peat Mining Resources Survey, December 1979.	76
APPENDIX D	"Pouarua Peat Dome, Response to Memorandum of 3 May 1991", Waikato Regional Council Memorandum Dated 7 May 1991, Files 60 65 23A and 60 65 61A.	78
APPENDIX E	"Investigation of Existing and Future Drainage Requirements for the Piako River, Phillips Road to Kaihere Road Subcatchments", Waikato Regional Council Technical Publication 1992/1, February 1992.	82
APPENDIX F	"Draft Schematic Drainage Proposals for Maukoro - Pouarua Area", Environment Waikato Memorandum Dated 22 February 1993, File 83 01 00.	107

1 SUMMARY

The Pouarua peat dome area has been investigated to determine its effectiveness for flood prevention and to determine the impact of land drainage on the peatlands.

The Torehape Block, the Department of Conservation reserve, south of Torehape Road, is considered to be a significant wetland and will eventually contain the only remnant of sphagnum moss peat on the Pouarua peat dome. It is recommended that the reserve is enhanced through drainage re-orientation and the land remains undisturbed.

The remainder of the Pouarua peat dome, north of Torehape Road, is not considered to be a significant wetland and a land drainage scheme is proposed that will allow the area to be developed to farmland. The proposed scheme uses the existing arterial canals for gravity drainage and bases all pumping from the area on Mugeridges outlet. The draft Piako Regional Plan (August 1993) includes a Regional Rule that wetland drainage is a discretionary activity. Therefore, consents for land drainage and subdivision within the Pouarua area should be based on the scheme proposed in this report.

A stopbank is recommended along the east bank of Maukoro canal to replace the high ground levels that the present peat dome provides. The stopbank is necessary to prevent the eastward migration of floodwaters that will occur when ground levels are reduced through peat mining, drainage and consolidation.

2 PREAMBLE

This study has mainly been concentrated on an area of relatively high peatland located on the Hauraki Plains immediately southwest of Ngatea that is known as the 'Pouarua peat dome'. The peat dome covers an area of approximately 50 square kilometres.

This study has been undertaken as a result of requests for information, technical assistance and consents from the following five Environment Waikato customers.

- Two peat mining companies requiring consents to enable mining to occur on the higher areas of the peat dome. The study re-evaluated rainfall and runoff from the Hapuakohe Range and established anticipated flood levels along the Maukoro canal, south of State Highway 2 (SH2).
- Waihou and Piako River Scheme project staff requested an evaluation of the floodgate outlet requirements to the Piako River, between Ngatea and Kaihere Road. These floodgates discharge land drainage water from the eastern edge of the Pouarua peat dome and the clay terrace along the Piako River left (west) bank.
- Landcorp wish to develop, subdivide and offer for sale much of their landholdings from the Pouarua Block. This block covers most of the Pouarua peat dome area except for the southern slopes, which are administered by the Department of Conservation (DoC).

- The Hauraki District Council have requested technical assistance to design a land drainage scheme for the Pouarua area. The scheme was requested to relieve immediate flooding problems adjacent to the Pouarua canal north of SH2, and provide for future land drainage requirements as peat levels consolidate through land development.
- Input to the Piako Regional Plan, that is being prepared by Environment Waikato and is currently in draft form. The Piako Regional Plan addresses resource management issues specific to the Piako and Waitakaruru River catchments. Input was required on management of the Pouarua peat dome area.

Most of the work on these issues overlaps to some extent. This report collates the work into one technical document and ensures that proposals in any one area do not compromise drainage or flood protection in another area. Relevant technical publications have been included in this document as Appendices.

The report has revisited the Pouarua and Waitakaruru Schemes, promoted by the former Hauraki Catchment Board, and re-evaluated the hydrology of the area using rainfall and stream flow records available to date. The basis for design of the floodgates and pumpstations in the area has been established. Relevant design notes and reports are appended.

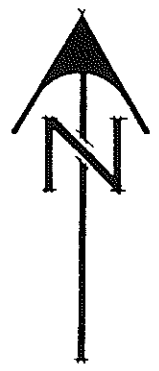
3 BACKGROUND

The area of study is shown on Map 1 and is located in the northwestern corner of the Hauraki Plains. The area includes the sub-catchments of the Hapuakohe range, that drain to the Waikakaruru River and the Maukoro canal, and the Pouarua peat dome area, that drains to the Pouarua canal and Piako River to the east and the Kaihere canal to the south.

The physical nature of the study area ranges from undeveloped peatland and flat pastureland through to steep bush/forest covered hills. (See Map 2). Land use varies from intense horticulture and dairying on the flat land, through grazing on the hill country to forestry on the more erosion prone upper catchment.

Historically the study area contained bush covered hill country and Kahikatea and peat wetlands on the lowlands. The streams emerging from the hills were conveyed across the swamplands in poorly defined meandering channels that eventually drained to the Piako or Waitakaruru Rivers. Heavy rainfall would have resulted in large areas of flooding that remained for many days with the hill stream waters joining to form sheets of water migrating across the wetlands.

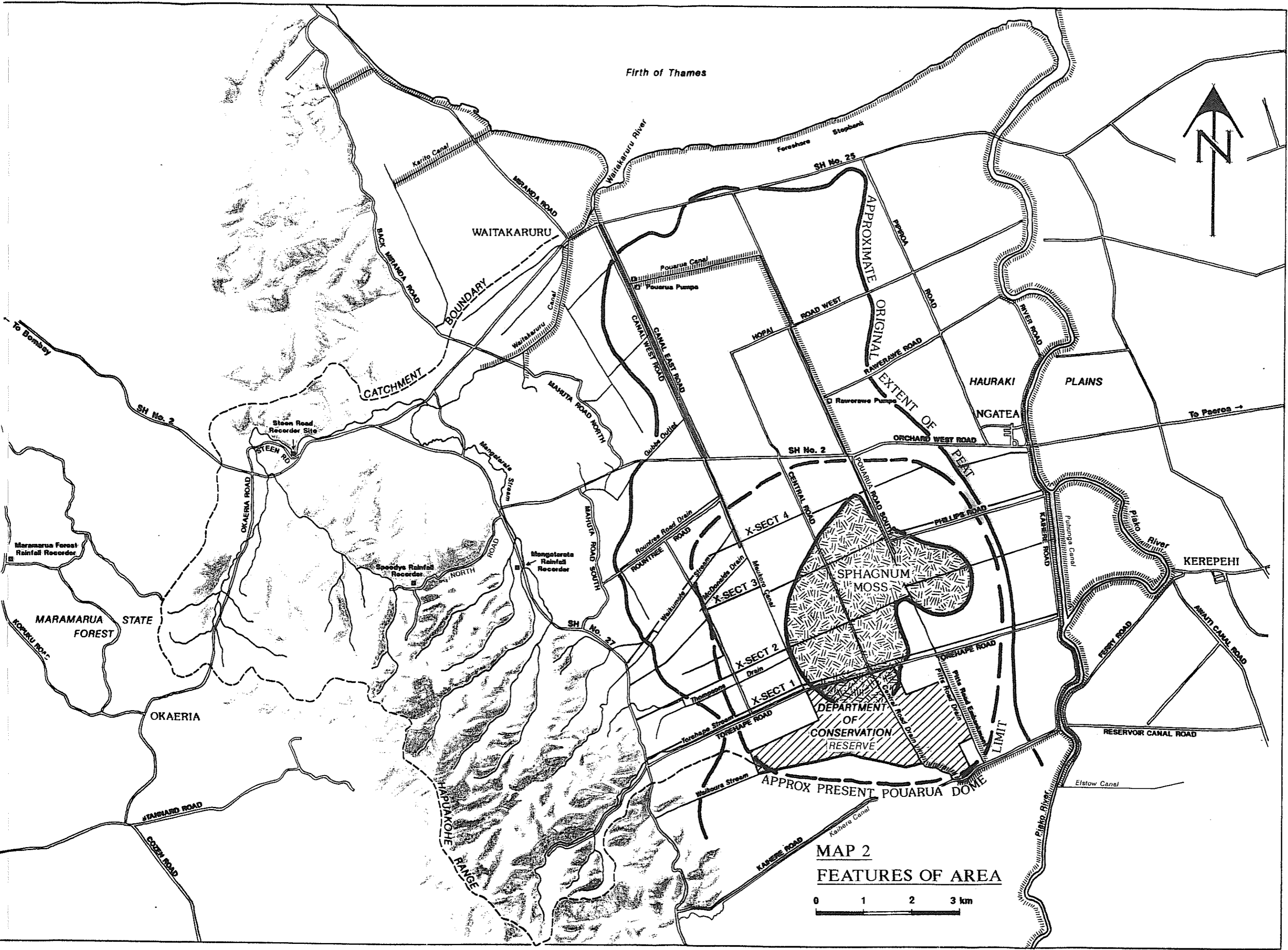
Co-ordinated development of the wetland began after the Hauraki Plains Drainage Act 1908 was passed. Major works resulting from this Act included construction of arterial canals and, in the Pouarua/Waitakaruru area, the Maukoro canal, Waitakaruru canal and Pouarua canals were formed.



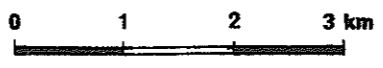
MAP 1.
LOCALITY MAP

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MAP 2
FEATURES OF AREA



The Waitakaruru canal was constructed to convey floodwaters directly from the hills to the sea and provided some improvement on drainage and flood protection to the Hauraki Plains area. In the early 1970's this canal was upgraded, as an interim measure to alleviate flooding, under works termed "Phase A Works" of the proposed Waitakaruru Scheme (ref 3.1).

The Maukoro canal is a tributary of the Waitakaruru River, and has its confluence one kilometre from the Firth of Thames. The canal extends approximately 11 kilometres southward from the Waitakaruru River to Torehape Road, adjacent to the high levels on the west side of the Pouarua peat dome. The canal serves two functions. It is primarily a drainage canal but it also serves as an interception canal for floodwaters emerging from the Hapuakohe ranges. At the southern end of the canal floodwaters that exceed canal capacity have historically been prevented from migrating eastwards by the high ground levels of the Pouarua peat dome. Water has been contained on the western side of the peat dome and is drained northwards by the Maukoro canal. North of State Highway 2 the higher stopbank levels along both sides of the canal contain the floodwaters and convey them to the Firth of Thames.

The Pouarua canal is a tributary of the Maukoro canal. Its functions are as a drainage outlet for areas east of Maukoro canal and as an interception canal for runoff on the east side of the Pouarua peat dome. At present runoff from the northeastern side of the peat dome is conveyed northwards by the Pouarua canal and runoff from the south eastern side of the peat dome is conveyed southwards along the Pouarua canal line that is known as Pitts Road drain. Both these drains on the Pouarua canal line prevent runoff from the peat area east of Maukoro canal from migrating overland to the drainage areas adjacent to the Piako River.

A resource of sphagnum moss peat exists over the higher areas of the peat dome. Historically attempts have been made to drain the higher areas of the peat dome and turn the area into pasture but until recent times these have been unsuccessful. Mining of the sphagnum moss peat, settlement of ground levels due to drainage and the increasing areas of land being used for horticulture and being broken into pastureland is having an effect on drainage and flooding in the area. No major upgrading of arterial canals has been undertaken for over 20 years in most instances, and increasing pressure is being applied to the canal systems through more intensive land use. Applications to mine the higher areas of the Pouarua peat dome have again raised the question of the relevance of the high ground levels, and what those ground levels need to be in order to prevent the eastward migration of floodwaters.

This report reassesses the hydrology and hydraulics of the Hapuakohe ranges taking into consideration records of rainfall and runoff that have been gathered over recent years. Flood flows are modelled in the Maukoro canal to assess its capacity and what flood levels can be expected in the vicinity of the Pouarua peat dome under existing conditions. The future drainage requirements of the flat lands are considered and a proposal is presented that will allow for the planned implementation of drainage upgrading.

3.1 Waitakaruru Catchment Scheme

The study area of this report is within the area of the catchment control scheme promoted by the former Hauraki Catchment Board (HCB) called the Waitakaruru Catchment Scheme.

During the 1960's when the Piako River Scheme was being promoted, the ratepayers of the Waitakaruru catchment area chose not to be included in the Piako River scheme. After flooding in the early 1960's showed the inadequacy of the Pouarua canal system, the Hauraki Catchment Board carried out an investigation and produced a report titled "Pouarua Canal Scheme (with pump assisted gravity outlet)". This report is attached as Appendix A.

Consideration was being given to a comprehensive catchment scheme due to the regular flooding being experienced and in 1968 a preliminary outline of the 'Waitakaruru Scheme' was produced. Part of the preliminary scheme identified some specific works, designed as an interim measure to alleviate some of the worst flooding in the lower catchment, and these works were called "Phase A Works". After Soil Conservation and Rivers Control Council approval and an advance of subsidy for the local share, these Phase A works were carried out between 1970 and 1974. The works included widening the lower Pouarua canal, construction of Rawerawe pump station, widening the Waitakaruru canal and estuary, and moving back and rebuilding the eastern stopbank along the Waitakaruru canal.

The Waitakaruru scheme report was completed and submitted to the Government in 1974. Approval in principle was granted in 1975 but no final approval was given. The HCB was advised some years later by the National Water and Soil Conservation Authority (NWASCA) that a complete re-submittal was required prior to any approval and in 1980 the Waitakaruru Catchment Scheme report was produced and submitted.

No approval for the scheme was ever granted and therefore since the Phase A works were completed, no capital works have been carried out. The potential for flooding of the plains area still exists and in the southern end of the catchment continued land development and peat subsidence is placing more demands on a drainage system that has been recognised as inadequate for over 30 years.

3.2 Peat Mining

A resource of sphagnum peat moss exists towards the southern end of the Maukoro and Pouarua canal systems in the vicinity of Phillips Road and Torehape Road. (See 4.4.2). The mapped extent of the resource covers approximately 1000 hectares and is shown on Map 2. Its locality covers a large portion of the Pouarua peat dome and this area acts as a defence against water by preventing the eastward migration of flood waters. Mining has occurred on the east slopes of the dome since the 1970's. This operation changes the land surface by removing the manuka and scrub cover, physically removing the underlying sphagnum moss peat and on completion, establishing pasture and horticulture. This change has increased the rates of runoff and is increasing the flooding that occurs north of SH2.

No works have yet been carried out to offset the increase in stormwater runoff resulting from peat mining operations. The Hauraki District Council drainage district committees are becoming increasingly concerned with the increased volumes of runoff being discharged into the already overloaded systems. The original Pouarua Scheme still remains relevant but the changing land uses, and changing land levels in the southern portion of the catchment require a reappraisal of drainage requirements. A planned approach to the development of the area is necessary to enable future improvements to be implemented smoothly and without adverse effects.

4 CONSIDERATIONS

4.1 Western Hills Hydrology

4.1.1 Rainfall figures

Rainfall recorders in the Hapuakohe Range/Maramarua area are located at Maramarua Forest headquarters, Mangatarata and at Speedys property near the top of North Road. The record of rainfall figures and the location of each of the recording stations has been scrutinised in order to assess which set of rainfall figures could be adopted as best representative of the Waitakaruru and western hills catchments with a degree of confidence.

The Maramarua Forest site is located at the forest headquarters in the Kopuku Stream valley approximately 10 km west of the study area. The record of 24 hour rainfalls from 1947 to 1980 has been analyzed by the NZ Meteorological Service to provide Table 1.

Table 1 Maramarua Forest Depth - Duration - Frequency Table.

	Duration (hours)	Return Period, T (years)				
		2	5	10	20	50
C75321 Maramarua Forest 1947-1980 (rainfall depth is in millimetres)						
	24	79	108	128	146	170
	48	94	128	151	173	201
	72	98	134	157	180	209

It is considered that due to the elevation of the site at approximately 60 m above sea level, the above rainfall figures may be lower than is experienced in the higher altitude areas of the study area.

The Mangatarata rainfall site is located within the study area in the Mangatarata Valley approximately 1.5 kilometres south of the SH2 - SH27 intersection at an elevation of approximately 30 m above sea level. The record started in mid 1973 and

the highest recorded 24 hour rainfall is 130 millimetres recorded in 1985. It is considered that rainfall at this site is likely to be similar to or slightly less than rainfall at the above Maramarua Forest site and therefore the 1985 rainfall is considered to be approximately a 10 to 20 year, 24 hour event at this site.

Speedys rainfall recorder is located off North Road on the catchment divide between the Waitakaruru and Mangatarata Streams at an elevation of approximately 140 m above sea level. This site is a Regional Council continuous recorder that was installed in December 1985 so there is only 7 years of records available. Comparison for all recordings over 50 millimetres in depth, shows that rainfall at Speedys is from 1.3 to 2.9 times greater than rainfall at Mangatarata, with an average of 1.8 times greater.

In order to adopt a set of rainfall figures that would be indicative of the Hapuakohe Ranges across to Maukoro canal, the physical nature of the area was considered. The area has stream headwaters in steep hill country that rises to 440 m above sea level along the western boundary falling quickly through some rolling grazing land to flat drainage areas along the eastern boundary. Approximately one third of the catchment is above the 100 metre contour and approximately one third of the catchment is below the 20 metre contour. The Mangatarata record is considered to be indicative of rainfall that the middle and lower catchment experiences, with the Speedy's record being indicative of the upper catchment rainfall. For the purpose of calculating peak discharges and hydrographs for the various sub-catchments, rainfall figures similar to Mangatarata (or Maramarua Forest) weighted upwards by a factor of 1.5 is considered appropriate for the study area. The Maramarua 24 hour figures weighted upwards by 1.5 give rainfall figures remarkably similar to those derived in the former HCB, Waitakaruru Catchment Scheme report of March 1980. These figures listed below as Table 2, are therefore confirmed as remaining appropriate for design purposes.

Table 2 H.C.B. Waitakaruru Scheme Rainfall Depth, Duration, Frequency Table.

Duration (hours)	Return Period, T (years)					
	2	5	10	20	50	100
0.5	18	26	31	36	42	47
2	32	46	55	64	75	84
6	53	82	100	118	142	159
24	96	153	191	228	275	311
	Rainfall depth is in millimetres.					

4.1.2 Stream Discharges

Environment Waikato maintains a continuous water level recorder on the Waitakaruru River in the vicinity of Steen Road. The recorder has provided 10 years of flow records from a catchment of 21.8 square kilometres with the river flow passing over a two stage broad crested weir with the primary weir being 7.4 m wide x 1.7 m high.

A flood frequency analysis has been carried out on data obtained from the record and this is shown as a plot on Figure 1. It is noted that local opinion considers there has been a noticeable reduction in flood flows over the last 10 years compared to the previous 10-20 years and this is confirmed when comparing the record of peak discharges with those anticipated in Table 3.

The 1985 peak discharge was recorded as 28.6 cumecs and this, being the largest recorded flow in the assessment, becomes the 10% probability (10 year) flow. The 24 hour rainfall that produced this flow as recorded at Mangatarata, was 130 mm, and is considered to be approximately a 5%-10% probability (10-20 year) rainfall event. The Speedy's recorded 24 hour rainfall of 148 mm when compared to the adopted rainfall figures is approximately a 20%-30% probability (3-5 year) event. The lack of continuous recordings prevents an analysis of the shorter duration rainfalls that would show any higher intensity rainfall.

It is therefore considered that, due to the relatively short length of record, and from the historical knowledge of flooding in the area, the frequency analysis is unconservatively low. Comparison of the flooding that occurred to other ungauged floods tends to rank the 1985 event at approximately a 20-30% probability (3 - 5yr return period) flow but this is a somewhat less likely event than the flows adopted from empirical calculations. The plots of the empirical calculations, the frequency analysis and the adopted flows for the Waitakaruru River at Steen Road are shown on Figure 1.

Each of the hill catchments that are able to freely drain into the Maukoro canal have been assessed in order to calculate anticipated peak flows, and from the various calculations a distribution of flows has been adopted. The smaller drainage catchments that have little or no hill catchment contributing to runoff have been assessed using a drainage standard of 60 mm of runoff over a 24 hour period. The adopted flows together with the 1974 HCB Waitakaruru Scheme design flows are shown for comparison as Table 3.

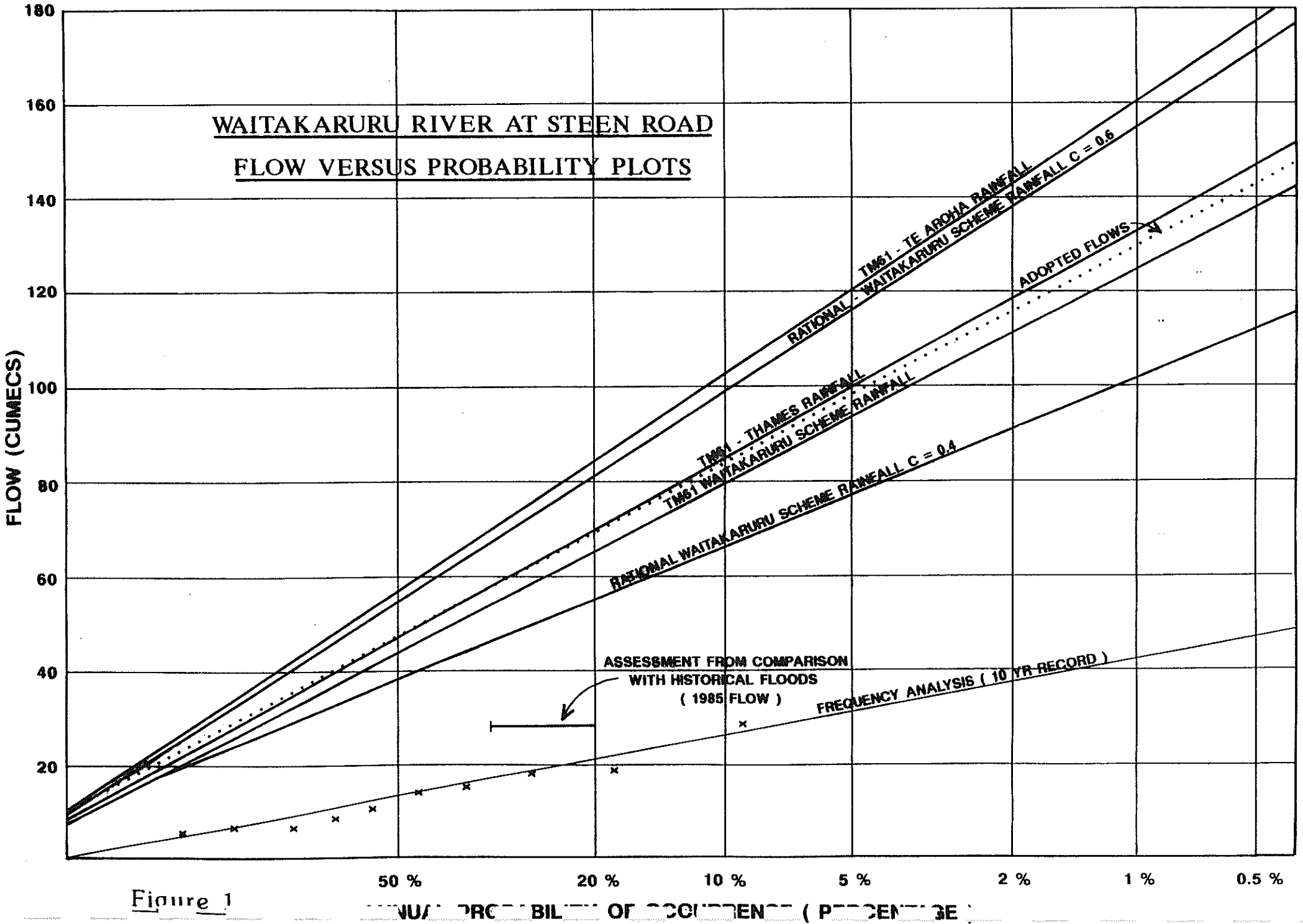


Figure 1

Table 3

Probability of Occurrence in any one year	50%	20%	10%	5%	2%	1%	1974 HCB Report	
							10yr	100yr
Recurrence interval (yrs)	2	5	10	20	50	100		
Catchment 1 Torehape Stream	23	36	44	52	62	70	5.7 controlled	114 100yr
Catchment 2 Thompsons Drain			3.0				1.1	
Catchment 3 McDonalds Drain			2.7				2.3	
Catchment 4 Waikumete Stream	30	43	52	60	72	80	15.6 controlled	160 100yr
Catchment 5 Rountree Road drain	13	20	6.0	30	35	40	8.5	
Catchment 6 Gubbs Drain	9	13	3.2	19	22	25	4.2	
Catchment 7 Waitakaruru @ canal	90	130	155	170	215	240	300	
Catchment 8 Waitakaruru @ Steen Road	47	70	84	98	116	130	-	
Catchment 9 Maukoro canal @ SH2	60	90	110	130	150	170	33.2	
Catchment 10 Total Catchment to Firth							225	

The above table shows that the present reassessment of the anticipated peak flows has resulted in a reduction from those adopted in the 1974 Waitakaruru Scheme Report. This reduction has been influenced to some extent by the 10 years of record at Steen Road, but, the adopted flows still remain somewhat higher than the trends from that record.

The flows adopted in the 1974 report were influenced to some extent by the disastrous storms of 1960 and 1966, which at present appear to have a much lower probability of re-occurrence than has previously been adopted.

The 1974 report indicates that a flow of 130 cumecs (4,600 cusecs) was recorded from the Waikumete Catchment. The catchment area at Maukoro canal is measured at 12.9 square kilometres and using the adopted 1% (100yr) rainfall figures it can be calculated that a runoff co-efficient at 0.95 is necessary in the Rational Method to produce the flow of 130 cumecs. It is considered that this runoff co-efficient is

extreme, and that the high recorded flow was most likely due to a local extreme high intensity rainfall that has a probability of occurrence of less than 1% (greater than 100 yr rainfall).

4.2 Plains Hydrology

4.2.1 Rainfall figures

Rainfall records of the Hauraki plains near the study area have been recorded at Ngatea, Kerepehi and Turua. The records are of 24 hour rainfall figures, with 14 years of record at Ngatea, 55 years of record at Kerepehi and 79 years of record at Turua.

Inspection of the records shows that Ngatea rainfall is based on a relatively short length of record that when tabulated has less rainfall for the 72 hour storms than for the 24 hour storms. Kerepehi is located adjacent to the study area and only 5 kilometres from Ngatea and although the record from Kerepehi shows slightly less rainfall than at Ngatea the 55 years of record is considered to produce more reliable results. Hence the Kerepehi rainfall record has been adopted as representative of the plains area within this study. The record has been analyzed by NZ Meteorological Service to provide the depth - duration - frequency table reproduced as Table 4.

Table 4 Kerepehi Rainfall Depth - Duration - Frequency Table

B75351 Kerepehi 1925-1980 rainfall depth is in millimetres.	Duration (hours)	Return Period, T (years)				
		2	5	10	20	50
	24H	67	96	115	133	157
	48H	78	107	125	143	167
	72H	87	117	137	156	181

These figures are not used for specific design purposes but are most suitably used to rank storm occurrences.

When adopted design standards are compared to the above rainfall figures it can be shown that, if an allowance of up to 20 mm per day loss of water through infiltration is made, and allowing to clear all subsequent runoff within a maximum of three days then the standards will be able to cope with storms with a probability of occurrence in any one year of 10% (10 yr storm).

4.2.2 Plains Design Standards

Design of drains floodgates and pump stations are based on constant rates of runoff over a 24 hour period. The standards have been adopted through observation and experience of different rates and have been found to be satisfactory in other catchments with similar physical characteristics. The general intention of drainage systems in flood times is to clear surface water from the catchment such that pasture kill does not occur.

Standards used for design purposes in the Waitakaruru/Maukoro/Pouarua area are:

- a) Pump station discharge is designed to clear 25 mm of runoff in 24 hours.
- b) Floodgate size is based on 1 square metre of culvert area to 1.7 Square kilometres of catchment.
- c) Internal drains are sized to carry 63 mm of runoff in 24 hours. This apparent higher standard allows for some deterioration between cleanings.

The references for these standards are: Waitakaruru Catchment Scheme, Section 8.4.3(c) and Pouarua Canal Scheme (with pump-assisted Gravity Outlet), Appendix A.

For the Pouarua scheme area it was recognised that subcatchments close to the outlet into Maukoro canal would be able to make better use of gravity outlets than those subcatchments further up the canal system and accordingly there were small alterations made to the pumping standards. Pumps near the canal outlet were sized using a pumping standard of 21 mm of runoff in 24 hours and pumps further up the canal were sized using a standard of 30 mm of runoff in 24 hours.

The Piako River Scheme used the same standards as a basis for design with floodgate standards decreasing North of Ngatea due to the tidal influence and pumpstation standards being decreased when 'gate lock' times are reduced. Each pump site was assessed according to the catchments lowest ground level and what periods of time the river levels stayed above the low ground levels. Factors were used to alter the basic pumping rate. The relevant reference is a former Hauraki Catchment Board publication "Waihou Valley Scheme, Design Procedure for Drainage Scheme Proposals" by I McLeod and M Tait, 1975. This document is attached as Appendix B.

4.3 Arterial Canal Capacities and Flooding

This section gives a brief outline of the existing and possible future features of each of the three main arterial canals.

4.3.1 Waitakaruru Canal

This study has not undertaken a reassessment of the Waitakaruru canal as the requests for technical information did not make this necessary. A re-evaluation of design discharges that takes into consideration 10 years of record at the Steen Road recorder has been undertaken for the Waitakaruru Stream. This re-evaluation has resulted in design peak discharges being approximately half those adopted in the Waitakaruru Catchment Scheme document. The main reason for the large difference in design peak discharges is the method of calculation of peak flows. This study has used empirical calculations based on the streams time of concentration, with the adopted flows weighted downwards a little, due to the 10 years of record at Steen Road. The Waitakaruru Scheme Proposal (May 1974) calculated peak flows using unit hydrograph theory and triangular hydrographs. A storm loss rate of 2.5 mm per hour was used and this is considered to be low, especially as the hydrographs calculated were for the 10% probability storm and not for a storm with a lower probability of occurrence.

A longer period of record may see future evaluations further change the design peak discharges for this stream.

The Waitakaruru Catchment Scheme proposed a design capacity for the canal between Mahuta Road and the Maukoro canal confluence of 184 cumecs. During the early 1970's, the "Phase A Works" of the Waitakaruru Scheme was undertaken as an interim measure to alleviate flooding in the lower catchment. These works included widening of the floodway of the Waitakaruru canal and moving back and re-building the eastern stopbank between Mahuta Road and State Highway 25.

High flows in the Waitakaruru canal are controlled to a great extent by a large ponding area at and above Mahuta Road North. The available storage in this ponding area is considerable being in the order of one million cubic metres.

It is recommended that any proposals for upgrading the Waitakaruru canal should remain with the design promoted in the Waitakaruru Catchment Scheme. This will provide the level of protection specified and based on the present flow analysis, will provide a standard of protection greater than the scheme anticipated.

4.3.2 Maukoro Canal

The Maukoro canal is a man made canal that begins at Torehape Road and drains northward for approximately 11 kilometres to join the Waitakaruru canal approximately 300 m downstream of the State Highway 25 bridge. The canal excavation commenced shortly after 1900 and had an original objective of diverting the Piako River from a point some 24 kilometres south of Waitakaruru. This objective proved to be impractical as the canal was found to be incapable of carrying the peak flows from the Hapuakohe Range, and it found itself on the 'high' ground of the Pouarua peat dome.

Construction of the canal has allowed development of adjacent land. These two factors have resulted in substantial settlement of the peatland. The canal north of SH2 is confined by a stopbank on both banks and each stopbank has a road constructed along its crest. South of State Highway 2 embankments along both sides of the canal are not complete. Streams and drains entering the canal are not floodgated and this occurs as far north as Gubbs outlet. Hillstream water entering the Maukoro canal therefore ponds in and adjacent to the canal, and in flood times surplus flow migrates overland parallel to the canal. In addition to this flooding, the hillstream tributaries are incapable of retaining their flood flows and extensive overland flow occurs from the hills towards the canal.

The high peat dome, with levels up to R.L. 7.0 and 8.0 m above sea level prevents these floodwaters from migrating eastward but at the northern edge of the dome lower ground levels presently allow floodwaters to escape eastward on the southern side of SH2.

The Waitakaruru Catchment Scheme document (1980) concluded that it was impractical to enlarge the capacity of the Maukoro canal due to poor foundations, continuous silting of the canal and the confining limitations of existing roads. The scheme investigation concluded the canal capacity was 43.0 cumecs.

This study has undertaken a computer model of the Maukoro canal using the Ricoda software package. Cross section information used was taken from the 1964 survey shown on the Hauraki Catchment Board drawing Number N565. The embankments along Maukoro canal upstream of SH2, were surveyed in 1990 and the relevant levels are shown on WRC drawing No. 66.

Low bank levels along the east bank of Maukoro canal, upstream of the State Highway No. 2 Bridge, allow overflow when the flow in Maukoro canal through the State Highway No. 2 Bridge is approximately 30 - 35 cumecs. At this flow water levels in the vicinity are between 3.5 - 4.0 m. This overflow is assessed as having an annual probability of occurrence of greater than 50% (i.e. less than 2 year flow).

The hydraulic model showed that at 30 - 35 cumec flow, the water level at the southern end of Maukoro canal at Torehape Road would be at R.L. 5.8 - 6.0 m. This has been assessed as having an annual probability of occurrence of 20% (5 yr flood) at this locality.

Torehape Road, between Maukoro canal and Central Road, has a high level of R.L. 6.05 m. Water levels at the southern end of Maukoro canal which exceed this level will result in flow to the east along Torehape Road, but because of its length and flat gradient, the quantity of overflow along Torehape Road is relatively small. For example, with water level at R.L. 6.5 m, the flow along the road has been assessed at 4 cumecs and with water level at R.L. 7.00, the flow along the road has been assessed at 15 cumecs.

Drainage along each side of Torehape Road creates an overflow eastwards at levels above approximately R.L. 4.5 m, but the weed infested nature of the drains would

limit any flow from the southern end of Maukoro canal to 1 - 2 cumecs. This flow is not considered significant, unless these drains are cleared or enlarged. Water that drains eastward along Torehape Road is conveyed southward to the Kaihere canal and Piako River, via drainage along Central Road and Pitts Road alignments.

Ground surface levels have been established southwards along a formed track that extends through the peat from the southern end of Maukoro canal. The track has a high level of R.L. 6.80 m approximately 1 km south of Torehape Road.

In the central, southern reach of the canal, in the vicinity of Phillips Road drain on the right bank and McDonalds drain on the left bank, low ground levels and open drain connections, allow water from Maukoro canal to pond behind the embankment and migrate northwards, overland, when water levels in the canal reach R.L. 4.3 to 4.5 m. This level is reached when flow in the canal is approximately 30 cumecs but, as water is originating from only the Torehape Stream and Thompsons drain, this phenomena is assessed as having an annual probability of occurrence of 30% (approximately 3 year flow).

The Phillips Road drain that linked Central Road drainage to Maukoro canal, allowed Maukoro canal water to back up to Central Road and pond along the west side of Central Road. When levels rose above R.L. 5.3 m (2% to 5% probability event), canal water would have flowed eastward across Central Road. A condition of the consents granted to allow peat mining to take place adjacent to the Phillips Road drain, was that this drain be blocked to prevent the likely occurrence of overflow of floodwaters to the east from Maukoro canal. This work has been undertaken.

The Pouarua peat dome is considered to be a defence against the eastward migration of floodwaters that exit from the Hapuakohe Range. At the southern end of the Maukoro canal the Torehape Stream is the major tributary that can contribute to flood flows. Anticipated peak flows from the Torehape Stream were therefore modelled in the existing Maukoro canal configuration to ascertain what flood levels are relevant adjacent to the peat dome.

In an extreme event floodwaters will overflow the right stopbank of the Maukoro canal upstream of SH2. Inspection of the right bank levels has resulted in a maximum practical overtopping level of R.L. 5.0 m being adopted as the downstream start level. The Maukoro canal upstream was modelled over a range of flows up to the annual 1% probability (100 year) flow expected in the southern end of the canal. The peak flow at this area has been assessed at approximately 70 to 80 cumecs for a 2 hour duration storm and this flow when modelled in the canal requires a level approaching R.L. 7.0 m at Torehape Road. At this level there is overflow along Torehape Road of approximately 15 cumecs and possibly some overflow to the south.

It is, therefore, considered unlikely that under existing conditions, flood water levels at the southern end of Maukoro canal in the vicinity of Torehape Road will reach a higher level than R.L. 7.0 m. Due to existing embankment levels, it is considered unlikely that peak levels in the Maukoro canal in the vicinity of Waikumete Stream, will reach a level higher than R.L. 5.0 m.

The above levels have been established to determine the maximum flood levels that are likely to occur on the west side of the Pouarua peat dome under existing conditions. The approach to determine these levels has been simplistic using information available, and makes no allowance for the detention effect of the large pond areas that will form, or that some floodwater will migrate northwards out of the Maukoro canal. The levels are therefore considered to be conservative.

As ground levels on the west side of Maukoro canal consolidate and overland flow paths change because of this consolidation, the above levels will become less relevant. As this occurs over the next 30 - 50 years, a re-evaluation of the likely flood levels could be undertaken but a detailed survey would be required to establish the new ground surface boundaries.

Much of the above work was undertaken in response to consent applications to drain the high peat area between Maukoro canal and Central Road to allow peat mining. at mining. The memorandum prepared to assist the consent process that allowed the peat mining, north of Torehape Road, is included in this document as Appendix D.

4.3.3 Pouarua Canal

The Pouarua canal is a man made canal that drains northwards from the eastern side of the Pouarua peat dome. The canal runs parallel to the Maukoro canal and is separated from it by approximately 3 kilometres. The canal turns west to join the Maukoro canal some 2.0 m from its mouth.

At the southern end of the canal, a gradient change or catchment divide occurs between Phillips Road and Torehape Road, such that water on the north side drains to the Maukoro canal and water on the south side drains to the Kaihere canal. The southward draining feature is called Pitts Road drain and its outlet is floodgated.

The Pouarua canal was designed to intercept the runoff from the Pouarua peat dome and prevent this runoff from reaching the relatively low clay land to the west of the Piako River. For many years, it has not been of sufficient dimensions to carry out its function and this is particularly evident north of SH2, where peat settlement has resulted in low ground levels. Here the canal is a drainage canal and consequently in times of heavy rain, runoff from the high peat land to the south, causes flooding on the land to the north where no effective stopbanks exist.

The Pouarua canal is floodgated through three, 1.2 metre square barrels into the Maukoro canal and is therefore dependent on Maukoro canal levels for gravity drainage. The gravity drainage is presently supplemented by two, 0.85 cumec pumps, and two 1.7 cumec pumps, giving a total existing pump capacity of 5.1 cumecs.

The "Pouarua Canal Scheme (with pump-assisted gravity outlet)" was promoted in 1964 by the former Hauraki Catchment Board to upgrade the canal (see appendix A) and this scheme was incorporated into the Waitakaruru Catchment Scheme that was

promoted in 1974 and again in 1980. The works promoted have not, to date, been fully implemented.

The Pouarua scheme was designed to alleviate the flooding that occurred north of State Highway 2 and all of the works were concentrated in this area. The scheme proposed stopbanking the canal from the high peat area at SH 2 to the outlet into Maukoro canal. The outlet floodgate was to be upgraded and the pumping rate from the canal to Maukoro canal was to be increased to 11.5 cumecs. Local land drainage compartments would be floodgated and pumped into the stopbanked Pouarua canal. The canal capacity was designed to cope with a fixed inflow rate of 74 millimetres in 24 hours from the Pouarua peat dome area south of SH 2. The report discussed the possible future works in the high peat catchment and proposed an extension of the stopbanking and pumping scheme as it became necessary.

The Pouarua scheme has not been implemented although Rawerawe pump and the main canal pumps were installed under the Phase A, Waitakaruru works. The scheme remains relevant and development north of SH2 is undertaken with this in mind.

South of SH2, ground consolidation east of the Pouarua canal has increased land drainage problems, and peat mining and development to pasture has increased runoff. Land north of SH2 continues to be inundated with runoff from the high peat area.

The majority of the Pouarua peat dome south of SH2 is owned by Landcorp. Their wish to subdivide and sell portions of their holdings has highlighted the need for a comprehensive long term drainage proposal that will allow development to be undertaken in a sustainable manner that will not increase flooding problems.

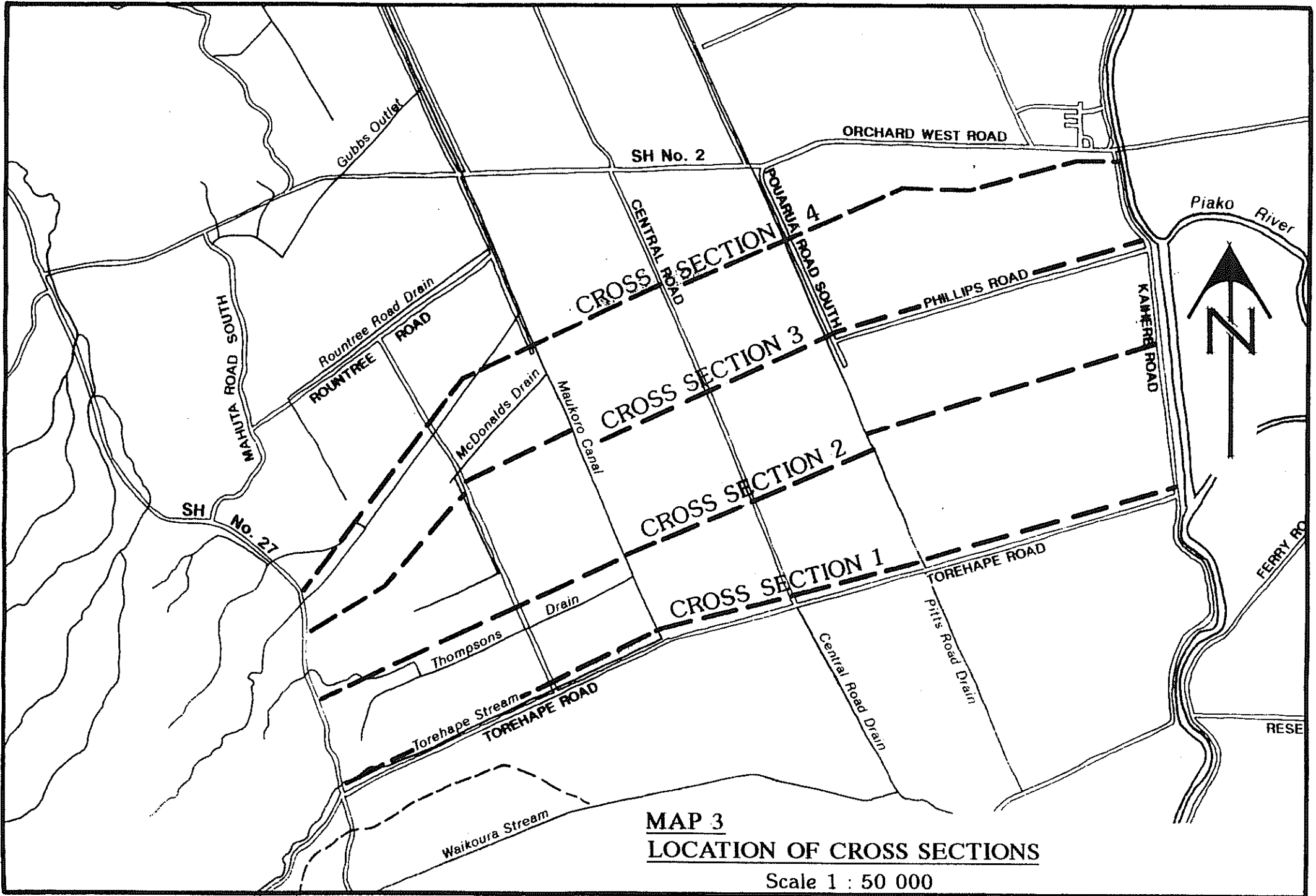
4.4 Pouarua Peat Dome

Southwest of Ngatea township, is an elevated area of peatland known as the Pouarua peat dome. The dome historically would have included all the peatland between the Hapuakohe ranges and the Piako River, but the remnant dome is considered as the area bounded by SH2 in the north, Kaihere Road in the south, Waikumete Road in the west, and the clay terrace along the Piako river in the east. The area of the present dome is approximately 40 - 50 square kilometres (4000 - 5000 hectares).

The high areas of the dome lie between the southern end of Maukoro canal and Central Road and cross sections surveyed over this area in 1990, showed high levels at RL 8.00 m. Low ground levels around the northern and eastern fringe of the dome, are generally at R.L. 2.0 m with lowest levels at R.L. 0.5 m at the eastern fringe.

4.4.1 Historic Surveys

Four cross-section survey lines were established across the Pouarua peat dome by the former Hauraki Catchment Board in 1979. Ground level information was plotted on HCB drawing No. 1880 (6 sheets) and information from ground level surveys undertaken in 1923-24 and 1957, was over plotted on the cross-sections. The cross-sections have been simplified and are shown on Map 3 and Figures 2-5.



MAP 3
LOCATION OF CROSS SECTIONS

Scale 1 : 50 000

POUARUA GROUND LEVEL SURVEYS

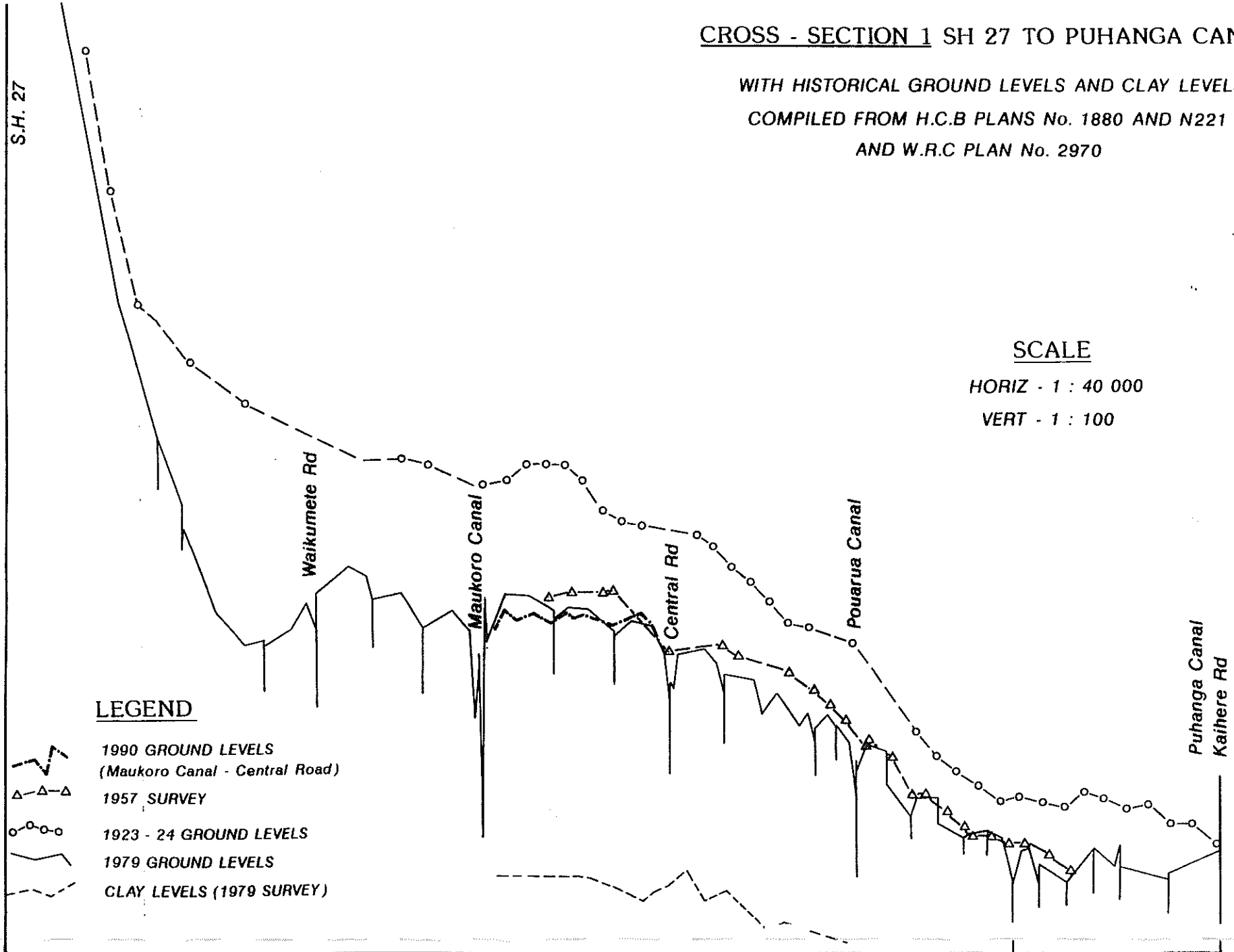
CROSS - SECTION 1 SH 27 TO PUHANGA CANAL

WITH HISTORICAL GROUND LEVELS AND CLAY LEVELS
COMPILED FROM H.C.B PLANS No. 1880 AND N221
AND W.R.C PLAN No. 2970

SCALE

HORIZ - 1 : 40 000

VERT - 1 : 100



POUARUA GROUND LEVEL SURVEYS

CROSS - SECTION 2 SH 27 TO PUHANGA CANAL

WITH HISTORICAL GROUND LEVELS AND CLAY LEVELS
COMPILED FROM H.C.B PLANS No. 1880 AND N221
AND W.R.C PLAN No. 2970

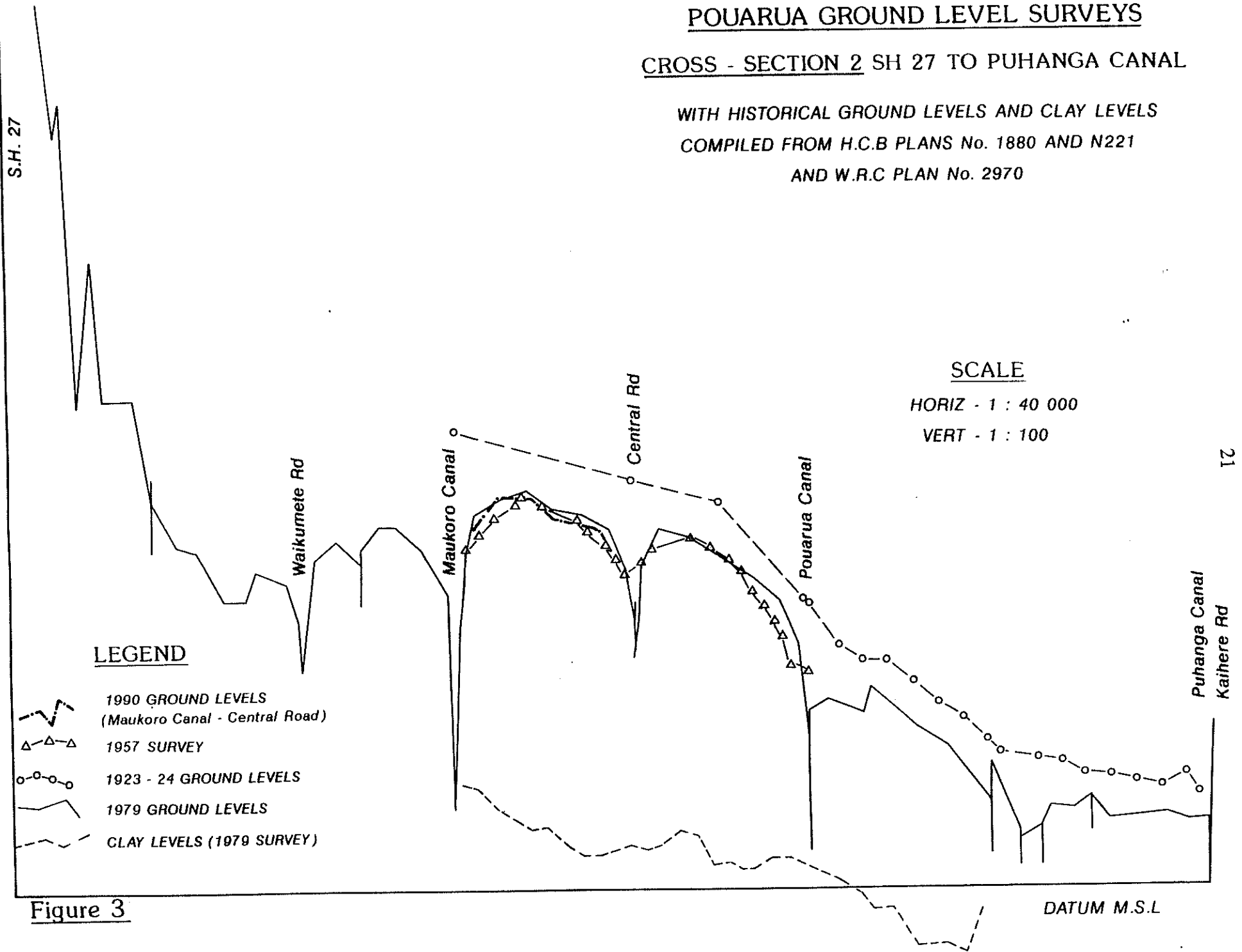


Figure 3

POUARUA GROUND LEVEL SURVEYS

CROSS - SECTION 4 SH 27 TO KAIHERE ROAD

WITH HISTORICAL GROUND LEVELS AND CLAY LEVELS
COMPILED FROM H.C.B PLANS No. 1880 AND N221
AND W.R.C PLAN No. 2970

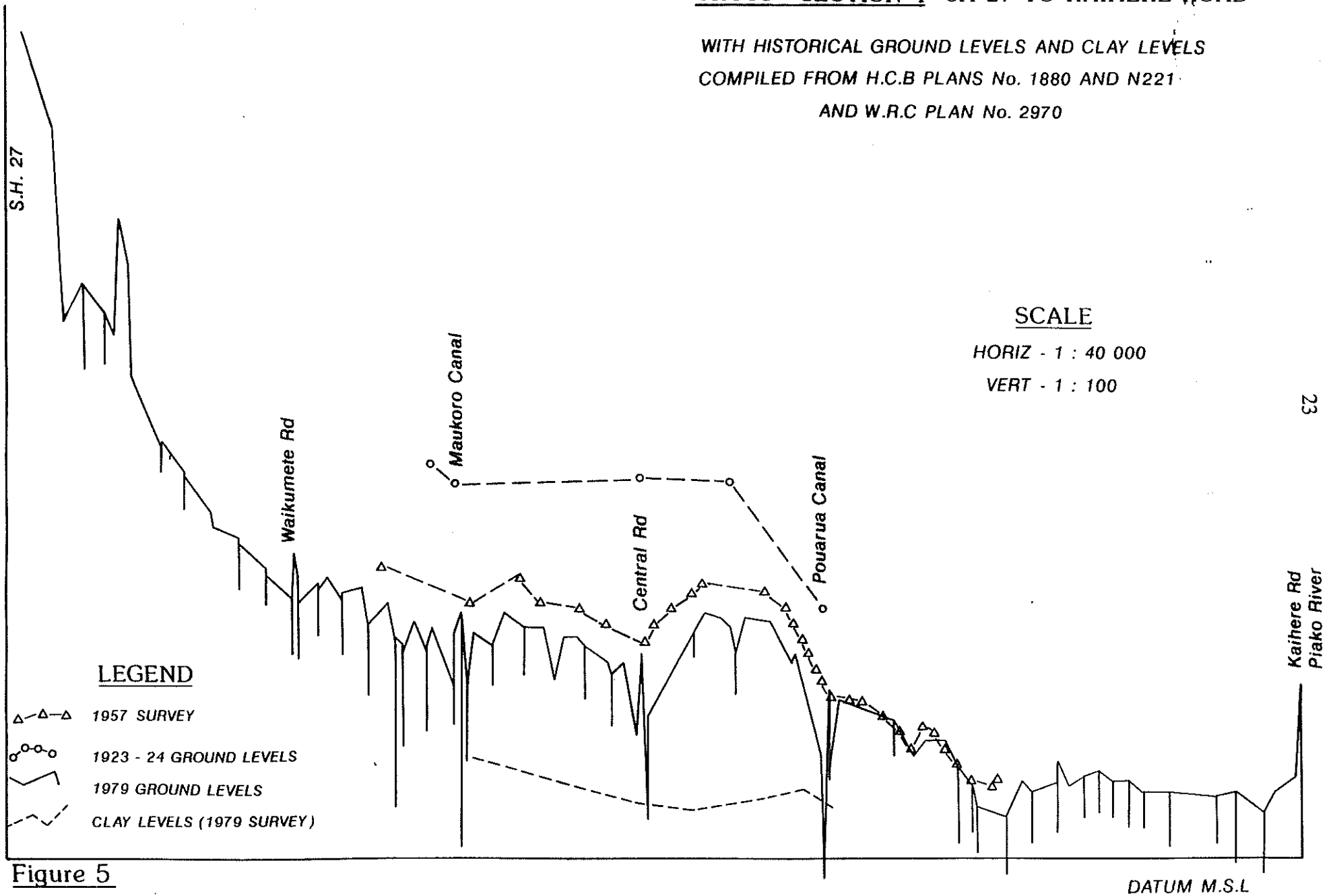


Figure 5

The cross sections clearly show the ground surface shape across the present peat dome and the consolidation that has occurred since the 1923-24 survey. The 1979 survey also included boreholes to determine the type of peat and the underlying clay levels. The clay levels found are also plotted on the cross sections and show the relative depths of peat across the peat dome. The 1957 survey also established contours for the underlying clay and these are shown on HCB drawing No. N221, Sheet 7.

A survey on three of the four cross-section lines was undertaken in 1990 over the area of the peat dome, between Maukoro canal and Central Road. The information is plotted on WRC drawing No. 2970 and is also shown on figures 2 - 4.

4.4.2 Sphagnum Moss Resource

The high areas and the eastern side of the Pouarua peat dome contain a resource of sphagnum moss peat. The extent of the resource has been mapped and is shown on HCB drawing No. 1880, sheets 1 - 6. (See also Map 2). The mapped area covers approximately 1000 hectares and the resource has been mined for commercial sale since the early 1970's. A peat mining resources survey was undertaken in December 1979 (see Appendix C) and this concluded the volume of the resource to be 4.0 to 5.0 million cubic metres of minable sphagnum moss peat.

The area of sphagnum moss peat varies in thickness from 0.1 m around the fringes of the mapped area to 0.9 m at its deepest in the Central Road area. Inspection of the area between Maukoro canal and Central Road, in 1991, found that areas removed from the influence of land drainage had a watertable close to the ground surface and that the sphagnum moss was growing.

East of Central Road the area of sphagnum moss peat has largely been removed by mining or is presently uneconomical to mine. The area west of Central Road and north of Torehape Road has recently gained approval to be mined with a large buffer strip remaining along the western and southern boundaries. The buffer strip is intended to retain the high ground levels that prevent the eastward migration of floodwater from the Maukoro canal system. When the areas presently being mined are exhausted, the only remaining sphagnum moss peat of any significance is within the buffer strip around the present operation and within the block of high land administered by the Department of Conservation (DoC) south of Torehape Road.

Formation of a stopbank along the eastern side of Maukoro canal may eventually allow the buffer area to be mined and would most likely result in all land north of Torehape Road being established in pasture. At present, as no commitment has been made to formalise a stopbank along Maukoro canal, conditions on consents that allow peat mining to occur require that on completion of mining, all land drainage is blocked and the area is re-seeded with Manuka/Kanuka slash and allowed to revert back to scrub. This is intended to minimise any further consolidation of ground levels until such time as a stopbank along Maukoro canal is formalised. This reseedling could possibly result in sphagnum moss re-establishing itself.

The eventual mining of all sphagnum moss peat north of Torehape Road will result in a small remnant of approximately 100 hectares (10% of original resource) within the DoC block of land being the only remnant of sphagnum moss peat of any significance that is known to exist in the North Island. Environment Waikato support the retention of this area in an unmined state.

4.4.3 Department of Conservation Block

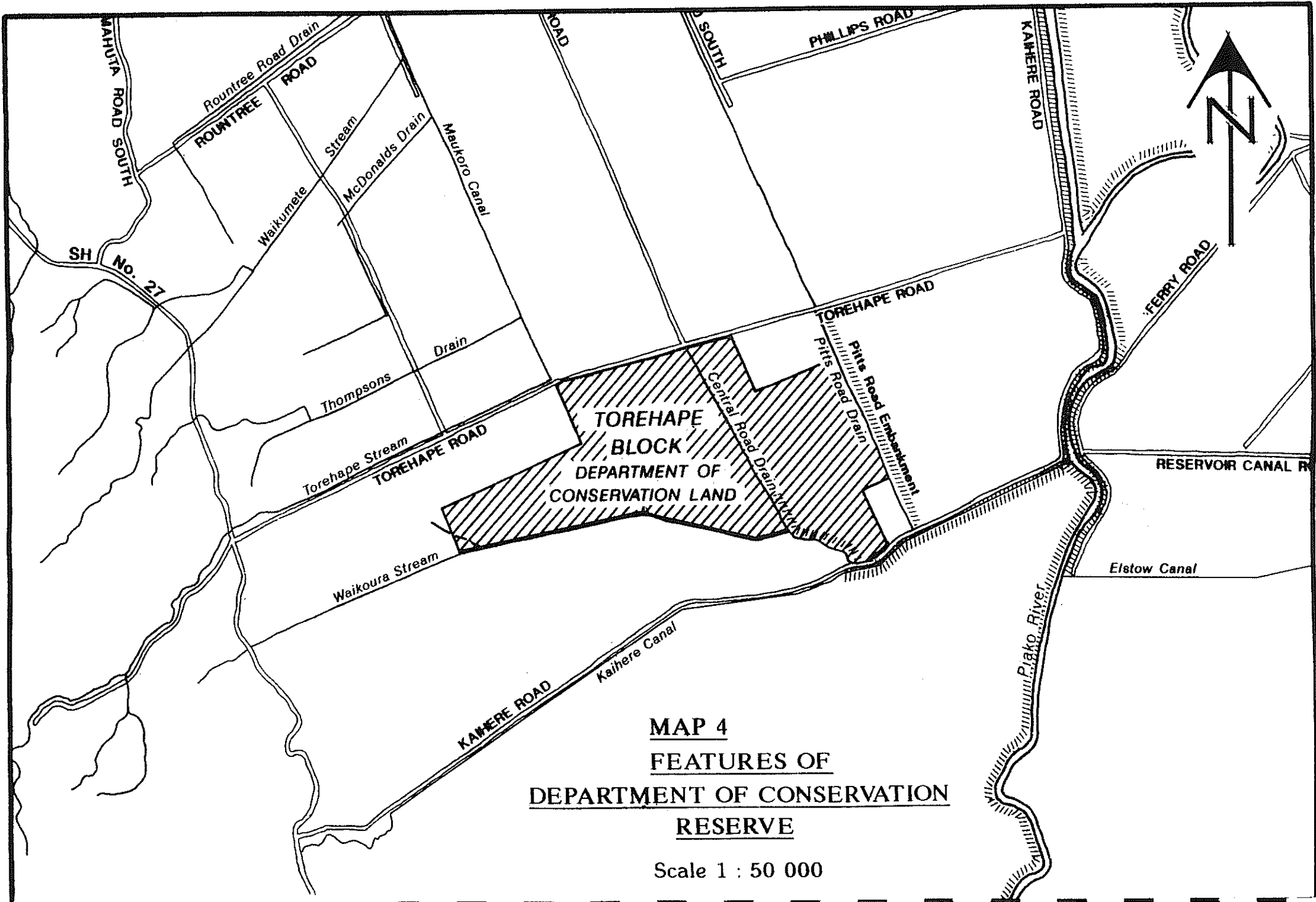
A large block of approximately 620 hectares of land on the southern area of the Pouarua peat dome has been allocated to the Department of Conservation. The block generally is bounded on the north by Torehape Road, on the east by Pitts Road drain and along the south by the Waikoura Stream (see Map 4). The land is called the Torehape Block and was granted reserve status in July 1993. The ground surface has levels at R.L. 7.0 m immediately south of the Maukoro canal and these levels generally fall in a southerly and easterly direction to approximately R.L. 2.0 m in the southeastern corner adjacent to Pitts Road.

The Kaihere canal, on the south side of Kaihere Road is open to the Piako River and floodwaters from the river are therefore able to have free access to the southern areas of the DoC reserve. A stopbank exists along the north bank of the Kaihere canal and up the north bank of the Waikoura Stream to high ground adjacent to the present drain along the Central Road line. This keeps the Piako River waters from inundating the Pitts Road drain area. High peat levels within the DoC reserve adjacent to the Waikoura Stream, prevent the northward migration of floodwaters. Maintenance of these high ground levels is vital if it is to continue to be a barrier to floodwaters.

Design flood levels within the Kaihere canal are at approximately R.L. 3.60 m. The present drain along the Central Road line allows floodwaters to back up to the Torehape Road area, as there is no outlet control on this drain. At Torehape Road the drain inverts are at approximately R.L. 2.3 m and the road crest is at approximately R.L. 5.0 m. Although it is apparent that Piako River floodwaters have access into the drainage systems, overland flows can not yet occur.

The drain along the central road line through the DoC reserve splits the block in two and causes consolidation of the peat. If left as it is consolidation will result in the requirement of some capital expenditure to prevent backflow of floodwaters. The drain is considered to be an anomaly within a conservation area of this nature, and DoC staff support proposals to divert the drainage water and block the drain at both ends. (See section 4.5.2).

The Department of Conservation consider the Torehape block has high ecological and botanical values. In particular, the area contains the large jointed rush (*Sporodanthus traversii*); a rare endemic orchid (*Calochinus Robertsonii*) and a number of other threatened or endangered plants. The New Zealand fernbird and spotless crane are among the many native bird species recorded in the area.



MAP 4
FEATURES OF
DEPARTMENT OF CONSERVATION
RESERVE

Scale 1 : 50 000

The Waikato Regional Council's Draft Regional Policy Statement (December 1992) has objectives to protect and enhance significant wetlands (4.3.5) to maintain and enhance ecosystems and habitats (4.10.1) and to ensure the preservation and enhancement of areas of significant indigenous vegetation (4.10.2). The Waikato Regional Council's Draft Piako Regional Plan (August 1993) classes the Torehape block as an unmodified or rehabilitated peat land that is ecologically significant (Section 7.2.1) and therefore the area is to be preserved and enhanced.

4.4.4 Peat Consolidation

Most of the Hauraki Plains between the Hapuakohe Range and the Piako River levees was originally part of a vast peat swamp. Ground levels would have gently sloped from the hills to the Piako River with local depressions and shallow watercourses draining to the Piako and Waitakaruru Rivers. The sphagnum moss peat dome area would have been a high feature of the Hauraki Plains.

Early settlement of the Hauraki Plains started the cycle of drainage and land consolidation. Canals were excavated to allow drainage and development to occur.

The earliest recorded extensive survey of the Pouarua area was undertaken in 1923 - 24. At this time the main arterial canals had been excavated and consolidation had already started. The second major survey was undertaken by the former Hauraki Catchment board in 1957. This survey also determined the underlying clay levels east of Maukoro canal. Four cross-section lines were established across the peat dome from SH27 to the Piako River in 1979 and this survey also mapped the extent of the sphagnum moss peat resource. Three of these cross-sections were re-surveyed in 1990, between the Maukoro canal and Central Road.

The location of the four cross-sections is shown on Map 3 and the historical ground level information along each of the cross-sections is shown on Figures 2 - 5.

The figures show that the entire dome area consolidated substantially between the 1923-24 survey and the 1957 survey. Consolidation averaged 1800 millimetres over the 33 year period giving an average consolidation rate of 55 mm/year. The consolidation rates varied over the dome. The least amount of consolidation occurred east of Pouarua canal where approximately 1.0 metre occurred (30 mm/year). The greatest amount of consolidation occurred in the Central Road area at the northern end of the dome (X-Sections 3 and 4), where up to 3.0 m of consolidation occurred (90 mm/year).

The 1979 survey shows a change in the pattern of consolidation since 1957. Little or no consolidation occurred east of Pouarua canal. The little that did occur was along the eastern fringe of the dome adjacent to the Piako River clay terrace.

Between Maukoro canal and Pouarua canal cross-section 4 consolidated approximately 0.9 m (39 mm/year), cross-section 3 consolidated little (24 mm/year), cross-section 2 did not change and may have risen a small amount in some localities. Cross-section 1 consolidated approximately 0.6 m (29 mm/year).

The 1990 survey shows a continuation of the above pattern with cross-section 3 consolidating a further 0.5 m (50 mm/year), and cross-sections 1 and 2 consolidating a further 0.18 m (16 mm/year). Some areas of cross-section 1 and 2, near the higher portion of the peat dome have again not consolidated and may have risen a small amount.

Consolidation of the peatland appears to be directly related to land drainage and development. The higher areas of cross-sections 3 and 4 and areas west of Maukoro canal that have been drained and developed, have consistently consolidated. In the area between Maukoro canal and Pouarua canal, approximately 3.5 m of consolidation has occurred between 1923 - 24 and 1990, giving an average consolidation rate of 53 mm/year. The area east of Pouarua canal is presently poorly drained and after the initial consolidation between 1923-24 and 1957, has consolidated little. The higher areas of the peat dome between Maukoro canal and Central Road, that are removed from the influence of land drainage, have consolidated little since 1957, and in some areas, where the sphagnum moss peat was observed to have been growing, ground levels could have risen up to 0.1 to 0.2 m.

Rates of peat consolidation calculated are shown in Table 5. Clay levels beneath the Pouarua peat dome dip gently away from the Hapuakohe hills towards the Piako River. Boreholes show that clay levels along Maukoro canal are generally at R.L. 1.5 to 2.0 m and clay levels along the Pouarua canal are generally at mean sea level. East of Pouarua canal, the clay levels fall to -1.0 to -1.5 m before rising to +1.5 m at the edge of the Piako River clay terrace.

Table 5 Rates of Peat Consolidation

	CROSS-SECTION			
	1	2	3	4
1923-24 - 1957 (33 years)				
Maukoro - Pouarua	57 mm/yr	53 mm/yr	62 mm/yr	70 mm/yr
East of Pouarua	32 mm/yr	No record	36 mm/yr	No record
Average	45 mm/yr	-	51 mm/yr	-
1957 - 1979 (22 years)				
Maukoro - Pouarua	29 mm/yr	None	24 mm/yr	39 mm/yr
East of Pouarua	None	No record	20 mm/yr	No record
Average	18 mm/yr	-	22 mm/yr	-
1979 - 1990 (11 years)				
Maukoro - Central Road	16 mm/yr	16 mm/yr	50 mm/yr	-
1923-24 - 1990 (66 years)				
Maukoro - Central Road	42 mm/yr	40 mm/yr	53 mm/yr	-

Implementation of a comprehensive drainage scheme for the Pouarua peat dome area would cause further ground consolidation and eventually a large basin will form based on the underlying clay levels. The depth of peat varies from 6 - 7 m in the Central Road area to 3 - 3.5 m along the eastern edge of the dome, and based on a consolidation rate of 50 mm/year, the eastern edge could consolidate over 70 years and the higher areas are expected to remain as peat for a minimum of 140 years, or until after the year 2130.

Design of pumping stations should include an assessment of the ground consolidation expected over the life of the pumpstation. Pumpstations should have a minimum expected life of 50 years. This is then used to provide sufficient depth of sump and flexibility to change operating levels to ensure maximum pump efficiency and adequate water level controls over the expected life of the pumpstation.

4.5 Drainage

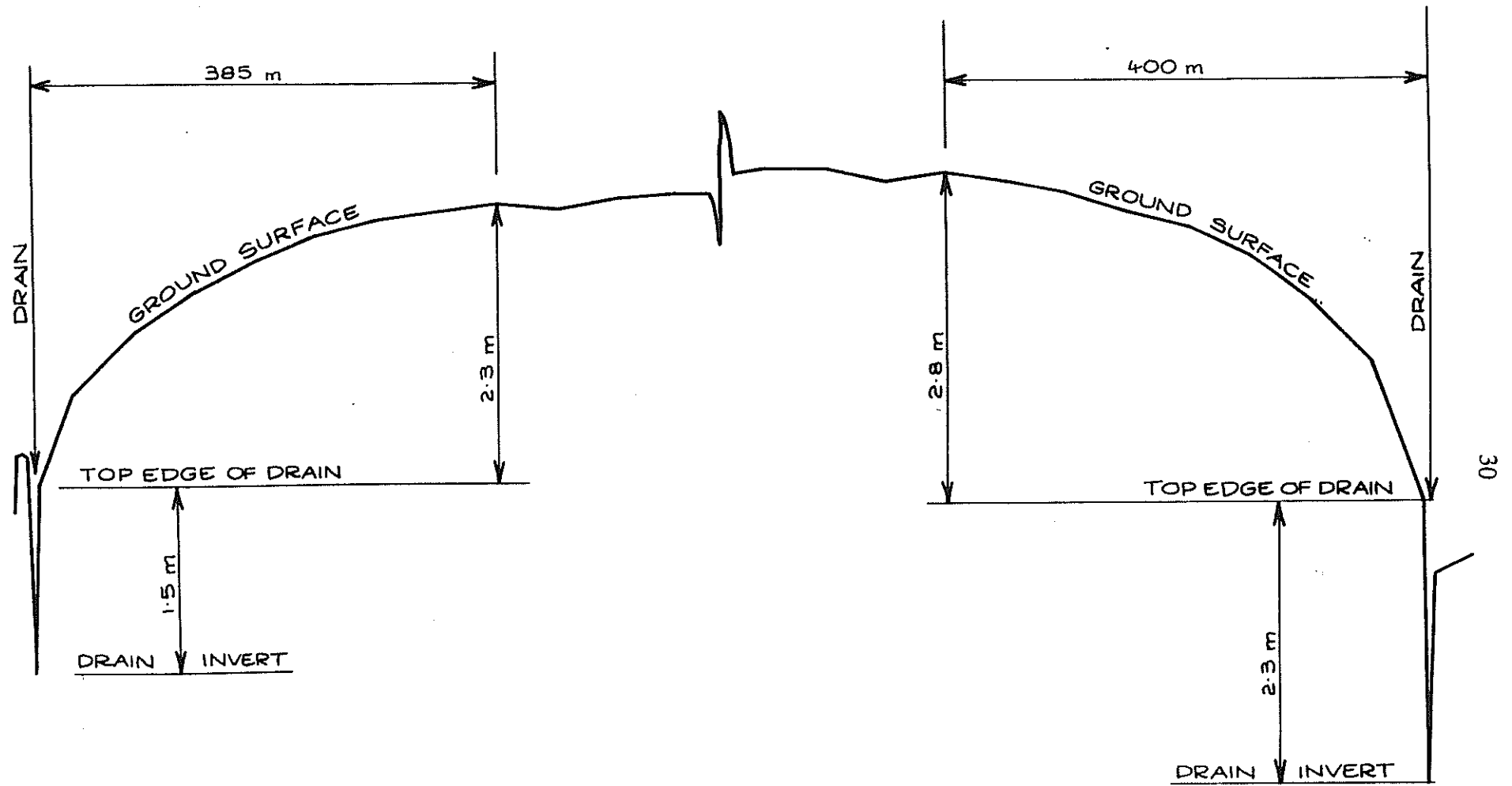
It is apparent from Section 4.4.4 that the rate of peat consolidation is directly related to land drainage, notwithstanding the direct loss of ground level due to peat mining. The effect of land drainage is to lower the water table below the ground surface and allow the peat to consolidate as a result of the following:

- reduction in volume due to dry mass of peat not being able to support itself after the removal of water;
- compaction effect on dry peat due to stock and machinery;
- oxidisation of peat and breaking down of its structure.

The long term, nett result, is the complete loss of peat with the eventual ground contour following the underlying clay shape.

Surveyed lines show that a drain influences the shape of the ground surface for some distance either side of the drain. The ground surface assumes a 'parabolic curve' shape and a typical arterial drain, approximately two metres deep, will influence ground levels up to 400 m from the drain. Survey has shown that ground levels can fall 2.5 to 3.0 m over a 400 metre wide strip on each side of a drain. Two cross-sections surveyed in 1991, across the ground surface west of Central Road are shown on Figure 6 to indicate the influence of land drainage on the ground surface.

Because of the shape of peat land either side of drains, surface water moves readily to the drains and is conveyed within these "peat valleys" to arterial canals and low areas, relatively quickly. In times of heavy rainfall, surface flooding on peatland is therefore not common, but flooding does occur adjacent to drains and canals and at downstream low areas.



INFLUENCE ON GROUND SURFACE
OF DRAINAGE
OF PEAT LAND

Figure 6

Location of drains and management of the drainage system can have a major influence on the rate of ground consolidation and the pattern of flooding in peat areas. A well designed and correctly located drainage system will result in a consolidation regime that does not change flooding patterns and ensures a sustainable system of drains, pumps and floodgates. Conversely, a poorly designed and located drainage system will result in differential consolidation rates, changing flooding patterns, and assets that can become redundant before their design life is completed.

Two drains in the existing network have been identified to cause long term flood management problems. Both drains are formed across high peat areas, are causing a local peat valley, and allow floodwaters from separate catchments access into the upper Pouarua area. The first drain is along the Phillips Road alignment between Central Road and Maukoro canal (see Section 4.3.2) and this drain has been filled as a condition of the consents that allowed peat mining. The second drain is along the Central Road alignment through the DoC reserve and discharges into the Waikoura Stream (see Section 4.4.3). Closure of this drain is included in the drainage proposals for the area (Section 4.5.2).

4.5.1 Present Drain Management

A main network of land drainage is in place on the Pouarua peat dome area. The network is based on the Maukoro and Pouarua canals with community drains primarily following road alignments and property boundaries. No scheme of land drainage has previously been promoted for the area. Therefore, the network has developed in a piecemeal manner through demand. The present network has been adequate but the demand for more intensive land use and subdivision has necessitated a re-evaluation of the present system. (See Section 4.5.2).

Discussions with Hauraki District Council staff and drainage committee members has confirmed that drain maintenance is carried out mainly by spraying and mechanical excavation. Mechanical excavation is used as little as possible and mainly occurs when drain capacity becomes deficient through ground consolidation. Spraying and hand cleaning is preferred to prevent drain enlargement and deepening that would occur through regular mechanical cleaning. This maintenance policy helps to reduce the rate of peat consolidation as drain sizes are kept to a minimum. The policy is supported by Environment Waikato.

4.5.2 Future Drainage Proposals for Pouarua Peat Dome Area

Much of the Pouarua peat dome has undergone a change in land use over the last 10-20 years through peat mining and land development. Consents granted in 1991 have allowed the remaining block of land north of Torehape Road to be mined for peat, and although conditions on those consents require it to be returned to scrub cover with no drainage, ground consolidation is still expected to occur. Frequent overtopping of the east bank of Maukoro canal presently occurs and ground consolidation will increase the frequency and extent of overtopping. The formalisation of a stopbank along the east bank of Maukoro canal may eventually result in the entire area east of the canal being developed. Little value is placed on

the area by DoC staff if it is left in its undeveloped state. Full development is supported by the Hauraki District Council.

The Draft Piako Regional Plan classes the Pouarua peat dome north of Torehape Road as a modified peatland. Modification has occurred through development for peat mining, agriculture and horticulture. The draft Piako Regional Plan recognises the flood defence importance of the Pouarua peat dome and that management of the dome needs to be planned to ensure its best possible use. The drainage proposal included in this report is noted in the draft regional plan as being relevant for development of the Pouarua peat dome (Section 7.2.2)

Land development has increased flooding problems north of SH2 and a drainage scheme for the Pouarua block has been requested. Investigations commenced in 1991 and initially focused on the drainage requirements for the area that presently drains to the Piako River east of Pouarua canal. In February 1992, WRC Technical Publication 1992/1, titled "Investigation of Existing and Future Drainage Requirements for the Piako River, Phillips Road to Kaihere Road Subcatchments", was published in draft form. This report was initiated because of concerns with the adequacy of floodgated outlets to the Piako River. The report concluded the existing floodgates are adequate and identified some future requirements for the low peat area when consolidation occurs. The report is included in this document as Appendix E.

Requests from Landcorp for district council approval to subdivide some of their blocks of land south of State Highway 2 drew comment about the possible future requirements for drainage and the necessity to create a "reserve/easement" strip of land along the main canal alignments. This strip was considered to be necessary if the Pouarua Canal Scheme proposals were extended south of the State Highway (see Appendix A Chapter VI). The Pouarua canal scheme has not been fully implemented, and at present there are no known proposals to complete the scheme north of SH2. It therefore became obvious that a reassessment of drainage in the area was required to see if development could be allowed without worsening the flooding that occurs north of SH2.

Meetings commenced in October 1991, to discuss the Pouarua peat area drainage and the meetings have included the Hauraki District Council Mayor, Councillors, Community Board members and staff members, Hauraki West Drainage Committee members, Landcorp staff, DoC staff and Environment Waikato staff. A preliminary assessment of drainage requirements was completed in March 1992. Discussions and suggestions of alternatives has resulted in the promotion of a scheme, in February 1993, that allows the development of land south of SH2 while alleviating the flooding problems north of SH2. The proposal is detailed in an Environment Waikato memorandum titled "Draft Schematic Drainage Proposals for Maukoro - Pouarua Area", File 83 01 00, 22 February 1993, and is included in this document as Appendix F.

Briefly, the scheme proposes normal drainage to remain as at present, utilising gravity drainage, with higher runoff rates overflowing eastward to a proposed pump

station at Muggeridges drain. This will provide some relief to low land north of SH2 as each area will be managing their own runoff when gravity drainage ceases.

The draft proposals have been circulated to the district council, drainage committees, Landcorp, and DoC, for comment and submissions. The only submission received to date has been from the West Drainage Committee. This committee has verbally requested that the drain along the Central Road line, through the DoC land, be retained as long as is practical. (See Section 4.5).

The decision to block and divert the drain is to be made at local level (ie. by drainage committee or district council), but, any delay in undertaking the recommendation will bring forward the need to provide further floodgate capacity into the Kaihere canal and an extension of the stopbank along the Waikoura Stream. The blocking and diversion would be recognised as enhancing the Torehape Block reserve and could support any consent applications to implement drainage. The draft Piako Regional Plan includes as a Regional Rule that drainage or drainage maintenance within the Torehape Block is a prohibited activity. This indicates that closure of this drain is imminent.

Section 7.4 of the Draft Piako Regional Plan outlines the strategy for management of the areas wetlands. Drainage becomes a discretionary activity and therefore consents are required for the implementation of drainage works. Consent for the scheme outlined above, would be best obtained as a comprehensive single consent, rather than several consents for each part of the works, as it allows for public input to the proposed scheme and enables the cost of the consent process to be minimised.

5 DISCUSSION

5.1 Future of Waitakaruru Catchment Scheme

The Waitakaruru Catchment Scheme promoted by the former Hauraki Catchment board in 1980, remains relevant. The proposals in this report for drainage on the Pouarua dome south of SH2, do not significantly change the catchment scheme proposals, but 'tidy up' the southern area of the Pouarua canal scheme. This area did not have a specific drainage proposal.

The result is that each area of the Hauraki Plains, North of Kaihere Road and west of the Piako River, will have a scheme of works that is able to be implemented as local demand dictates. Some works are required to separate drainage catchments in flood times (Maukoro canal east stopbank, floodgate in Pouarua canal at SH2) but the implementation of these will result in each area having to deal with their own rainfall runoff and not accept water from separate areas.

The proposals for the Maukoro canal remain relevant. A stopbank along the eastern side of the canal will prevent floodwaters from migrating eastward. The canal capacity remains unchanged and the Waitakaruru Catchment Scheme proposals to construct detention dams on the hill streams is still considered to be the best option

to prevent frequent flooding adjacent to the Maukoro canal. Large flood events will still result in high water levels along the southern end of Maukoro canal.

All works necessary to implement the schemes or any portion of the schemes is referred to or appended to this report, including design notes and standards for design that have been used by the former Hauraki Catchment Board.

5.2 Future of Pouarua Peat Dome

The work undertaken in this report has identified maximum expected flood levels along Maukoro canal west of the present peat dome under existing conditions. Embankment levels necessary to maintain protection if the peat dome were to be degraded or removed have been provided. Any embankment considered would need to include prevention of the movement of floodwaters around the southern end, along Torehape Road. Erection of an embankment would allow the development of the higher areas of the dome and commence the process of drainage and consolidation.

Implementation of the drainage scheme outlined in this report will improve drainage to the east of the Pouarua canal line. Consolidation over the entire dome, north of Torehape Road, will occur at a relatively even rate. Ground levels will therefore reduce in a manner that maintains the eastward fall, from Maukoro, and floodwaters will migrate towards the proposed pump at Muggerridges outlet.

Eventually the DoC reserve will contain the only high ground levels as the developed portion of the dome consolidates. Ground levels within this block of land require monitoring to ensure Piako River water is prevented from migrating north from the Kaihere canal into the consolidating drainage basins.

Consolidation of peatland west of Maukoro canal and a change in canal capacity due to gradient changes may promote a re-evaluation of the relevant flood levels along Maukoro canal in the future. It is considered unlikely that a re-evaluation will recommend higher flood levels as consolidation will lower overflow levels and increase pond storage volumes.

Continued consolidation will result in a basin forming with ground levels east of Pouarua canal at 1 to 1.5 m below mean sea level. This is expected to occur in approximately 70 years and areas below mean sea level will be entirely dependent on pumping to maintain ground water levels low enough to support pasture. This report has not considered the potential for saline water intrusion into the groundwater due to land drainage pumping below mean sea level. the proposed pump station on Muggerridges drain has presently been located some 1100 - 1200 m from the Piako River and any effect on saline intrusion should be addressed in the consent process for the whole proposed scheme.

At present the Pouarua peat dome area has few residential buildings on it due to the large land holdings and low productivity of the area. Implementation of a drainage scheme and subdivision of the land will result in a demand to construct additional residential buildings within the area. A flood risk will remain, as drainage schemes

have a limited standard. Building consents need to consider the consolidating peat levels and the change to flooding characteristics that implementation of the proposed scheme will initiate.

6 CONCLUSIONS

Reassessment of rainfall and runoff from the Hapuakohe Ranges, has resulted in confirmation of rainfall figures used in the former Hauraki Catchment Board, Waitakaruru Catchment Scheme report, but, stream discharges adopted are approximately half those adopted in the catchment scheme report.

The existing Maukoro canal system south of SH2 has a limited flow capacity with water flowing from the canal during floods assessed as having a probability of occurrence of greater than 50% (ie. less than a 2 year flood).

Modelling of anticipated flood flows in Maukoro canal, has shown that it is unlikely that, under existing conditions, flood water levels at the southern end of Maukoro canal in the vicinity of Torehape Road, will reach a level higher than R.L. 7.0 m and due to existing embankment levels, it is considered unlikely that peak levels in Maukoro canal at Waikumete Stream will reach a level higher than R.L. 5.0 m. Any embankment proposed to replace the Pouarua peat dome would, as a minimum, be required to provide protection against floods that could achieve those levels unless further investigation shows other levels are relevant. Any proposal would need to include prevention of the movement of floodwaters along Torehape Road.

Formation of an adequate stopbank along the east bank of Maukoro canal will allow the development of the Pouarua peat dome north of Torehape Road. Mining of sphagnum moss peat from within this area, will result in 10% of the original resource remaining as a remnant within the new DoC reserve.

Environment Waikato supports the retention of this remnant of sphagnum moss peat, as it is the only significant area in the North Island.

The DoC reserve has high ground levels that prevent Piako River floodwaters from migrating north. The Central Road drain through this reserve, should be closed and diverted to prevent the possibility of the backflow of floodwaters.

The Pouarua canal scheme has not been fully implemented and land north of SH2 continues to be inundated by runoff from the higher peat land south of SH2. Development of the peat dome is increasing the flooding that occurs. Drainage and development of the peat dome causes the ground surface to consolidate at approximately 50 millimetres per year. To minimise consolidation rates, drain maintenance is mainly undertaken by spraying with a minimum of mechanical cleaning.

A land drainage scheme is proposed that will allow development of the Pouarua peat dome north of Torehape Road and limit the rainfall runoff that migrates north of SH2.

The scheme is based on pumping at Muggeridges outlet and includes overflow of water to Muggeridges from the Pouarua canal line when water levels exceed low ground levels north of SH2. The proposed scheme has the support of the Hauraki District Council, the local drainage committee, landcorp and the Department of Conservation staff.

Implementation of a drainage scheme will eventually result in the loss of the peatland and a shallow basin will form with ground levels along the eastern fringe as low as R.L. - 1.5 m.

7 RECOMMENDATIONS

That the Department of Conservation reserve south of Torehape Road remains undisturbed and that drainage through the reserve is blocked and diverted.

That the drainage scheme, based on pumping at Muggeridges outlet, as proposed in this report, is used as a basis for design of future works and gaining the necessary consents.

That a stopbank is constructed along the east bank of Maukoro canal to provide protection from anticipated flood levels, (R.L. 7.0 at Torehape Road and R.L. 5.0 at Waikumete Stream), before consents are granted that will result in the accelerated consolidation of ground surface levels between Maukoro canal and Central Road.

APPENDIX A

HAURAKI CATCHMENT BOARD

POUARUA CANAL SCHEME

(WITH PUMP-ASSISTED GRAVITY OUTLET)

For Control of Flooding and Development of Drainage

The report is set out under the following headings:-

		Page
I	Location, General Description of the area, Historical Information etc.	38
II	The Problem and Discussion of Possible Alternatives	41
III	Recommended Scheme with Brief Description and Summarized Estimate	46
IV	Specification with Explanatory Notes	48
V	Detailed Estimate	57
VI	Possible Future Works in the High Peat Catchment	59
VII	Appendices	
	1 Flood Records and Basis of Flood Design	61
	2 Hydraulic Design	63
	3 Sketch Plan	
	Drawings	
	No. 221, Sheet 6, Contour Plan of surface levels	
	No. 221, Sheet 7, Contour Plan of clay levels	
	No. 471A, Plan showing existing and future catchment and main contours	
	No. 471B, Locality Plan showing main scheme works	
	No. 472A, Cross-sections	
	No. 473A, Longitudinal Section	

Te Aroha

August 1964.

I LOCATION, GENERAL DESCRIPTION, HISTORICAL INFORMATION

The Pouarua canal, together with the large Maukoro canal is located in the peat lands which lie between the Piako River and the Western Hills. The peat zone commences a short distance south from Waitakaruru and extends to point south from Patetonga, over a distance of some 12 miles, although the section now under consideration is that, very approximately between Kaihere Ferry Road and Waitakaruru being a distance of some 8 miles.

North from Kaihere Ferry Road, with some exceptions, the general lie of the peat lands comprises a slope to both the North and to the East (i.e. towards the sea and the Piako River).

The run-off, in particular, from the Western Hills, but also the peat lands is considerable, and right from the earliest days of land settlement in the Hauraki Plains, the development of canals in this area was commenced, both to drain the peat and to intercept the streams issuing from the Western hills and so relieve the clay lands and shallow peat areas bordering the Piako River. This purpose was and has been achieved largely by the development of the Maukoro canal which is nearest to the hills and extends some seven miles southwards from Waitakaruru and which discharges into the mouth of the Waitakaruru River a short distance north from the Thames-Pokeno State Highway.

The Pouarua canal was commenced as a secondary waterway at a later date, about 1930, with, so far as is known, the double object of intercepting peat run-off from areas east from the Maukoro canal and providing the peat lands with a drainage outlet. This canal, which is tributary to the Maukoro runs roughly from South to North with an East-West length connecting it to the Maukoro canal.

Catchment of Pouarua canal:

The catchment of the Pouarua canal is almost all peat land and roughly is defined by the Maukoro canal in the West and the higher clay land adjacent to the Piako River in the East. This catchment is unstable in the sense that surface levels have subsided very appreciably since the commencement of settlement in the Hauraki Plains. Levels show that the amount of subsidence over the last 30 years has averaged something like five feet over the whole catchment, with of course many local variations. It is this substance both in the past and an almost certain continuation into the future which is the essence of the present condition of the canal and a good part of its catchment, when it is realised that canal outlet levels to the sea via the Maukoro canal have probably not altered materially over the same period.

Peat (ground surface) and underlying estuarine clay levels:-

Some appreciation of the peat and clay levels is essential to an understanding of the problem involved. Clay levels are generally higher in the West being 5.0 above MSL bordering the Maukoro canal. These levels generally tend to dip towards the Pouarua canal line to the vicinity of MSL and (generally) to rise to the vicinity of between 1

and 3 feet above MSL in the lands east from the canal, with finally the edge of the catchment being marked by an abrupt rise out to the higher lands adjacent to the Piako River. The general pattern with a number of exceptions is thus a basin with the canal tending to be located over the lowest clay levels. It must be noted however that there are several areas in the catchment where clay levels are below MSL and in a few cases as low as 6 feet below MSL.

Peat levels vary from as low as 3 to 5 feet above MSL to up to 25 feet above MSL, the general pattern being that the high peat land is found south from Orchard West Road and the low land north from this point. Reference should be made to Drawings N.221, Sheets 6 & 7 for peat and clay contours (as in 1957).

Present Canal

The present canal comprises a fairly well developed channel from the floodgates (into the Maukoro canal) to the vicinity of the 6 mile point, with channel development dropping off sharply south from this point. A continuous stopbank also exists on the east bank commencing in the higher peat in the vicinity of the 5 mile point and extending virtually to the floodgates. The west bank is, for practical purposes, not stopbanked at all.

A study of the peat contours will show that the peat levels near the canal in the vicinity of the 7 mile point are some 15 feet above MSL and that these drop (on the east side) to about 5.0 above MSL near the 5 mile point with rather higher levels on the west side. Peat or ground levels then drop still further moving north along the canal, down to in places 2 to 3 feet above MSL.

Apart from particular areas the lowest average clay levels approximate MSL and it will therefore be noted, firstly, that quite substantial areas (i.e. with ground levels of 2 to 3 feet above MSL) are unlikely to subside a great deal further, and secondly, that, almost inevitably, much larger areas north from Orchard West Road can be expected to subside to these relatively low levels, over the next twenty or thirty years.

Historical

Since work commenced on the canal about 1930 efforts have been made to develop a canal which would:

- a) Prevent peat run-off from flowing on towards the Ngatea clay lands; and
- b) To provide a drainage channel for the peat catchment (without internal flooding).

This has involved fairly regular re-excavation, to establish canal dimensions and depth, to erect the eastern stopbank between the outlet floodgates and Orchard West Road, and to match subsiding peat surface levels.

Until more recent years (a) above was achieved reasonably successfully although lack of canal development particularly south from the 7 mile point has long permitted quite

substantial flood run-off to outflank the canal system. More latterly the eastern stopbank has also been topped at several points between the 2 mile and 4 miles marks. The net result has been ponding of increasing frequency and severity on the low lands on the eastern side of the canal.

With respect to (b) above the slowly subsiding peal levels north from 5 mile mark (between the Pouarua and Maukoro canals) have permitted direct internal flooding due to canal overflow (no stopbanks) over an increasing area (about 1500 acres at present), and the gradual disappearance of essential drainage freeboard.

Summary

It will be seen that while average surface levels in critical areas remained above a certain level and regular development of the canal proceeded, it has been comparatively easy to control the situation. However, the situation has never been static and it has been inevitable that, due to continued subsidence, the time would arrive when the canal, even with continued channel development, could not maintain its original functions, let alone improve on them. Indeed the situation has deteriorated to the extent that much needed channel development in the higher peat lands in the south cannot be permitted without aggravating flooding, loss of drainage etc. in the northern area.

II THE PROBLEM AND DISCUSSION OF POSSIBLE ALTERNATIVE SOLUTIONS

Inspection of the contour maps shows that the catchment divides roughly along the Orchard West Road into what is called the low catchment (north from the road) and the high catchment (south from the road).

Canal outlet levels are governed by flood and tide levels in the Maukoro canal at the outlet floodgates, and these can rise to RL 7.0 feet or more, above MSL. The problem in its simplest form is there three-fold.

- (i) The need to deliver the relatively rapid flood run-off from the higher catchment to the Maukoro canal (or other safe outlet) without either overflow to the east or internal flooding in the northern low land.
- (ii) The need to provide permanent drainage free-board for the low lands of the catchment, under both flood and average conditions.
- (iii) The need for a solution which recognises that ground surface levels are not static and which either in the first instance provides adequately for future subsidence or permits planned additions as required.

The scheme now recommended, known as the "Pouarua Canal Scheme with Pump Assisted Gravity Outlet" makes the most use of the canal and existing stopbanks on the present line and is in effect a proposal based on the principle of double banking the canal, from its outlet upstream to meet the high peat in the vicinity of Orchard West Road, with the addition of high capacity, low head pumps, the function of which is to commence flood discharge into the Maukoro canal earlier than would be the case with a straight gravity outlet, and to a large extent, to take the place of additional ponding volume.

In arriving at this decision a number of possible alternative solutions were considered, as described below.

A. DIVERSION OF UPPER CATCHMENT WATERS INTO MAUKORO CANAL AT ORCHARD WEST ROAD

In principle this alternative comprises the diversion of the upper part of the canal into the Maukoro canal by means of a diversion channel located in the vicinity of the south side of Orchard West Road, thus discharging run-off from the high peat catchment directly into the Maukoro canal, without first traversing the low peat areas. Such a scheme would, in addition, mean the operating of the lower or severed section of the Pouarua canal as a pump drainage canal.

However, in spite of a number of apparent advantages, such as the possibility of operating an effective pumped canal in the lower reaches (in the absence of the high peat country runoff), such a scheme has several serious drawbacks, the most important of which are:

- i) The Maukoro canal has a much steeper flood gradient than the Pouarua canal and the diversion under discussion would require to be designed against a flood outlet level of at least 11.0 feet above MSL. This means in effect, that present Pouarua canal flood levels would require to be raised substantially, upstream of the point of diversion, to make the scheme effective.
- ii) As the peat continued to settle, substantial diversion banks would be required, which could, in theory, lead to stopbanks 12 to 15 feet in height. In fact, however, the diversion would cease to be a practical proposition after peat settlement had reached a certain point, when a situation would develop which would be precisely similar to that now existent in the lower reaches of the canal.

In short the diversion could only be regarded as a fairly expensive interim proposition.

- iii) The Maukoro canal at Orchard West Road, is barely adequate for its present needs and would require substantial enlargement if the diversion were to be seriously considered.

The possibility of a diversion along the lines discussed above, cannot therefore be recommended.

B. DIVERSION OF CANAL INTO PIAKO RIVER

Two possibilities have been considered:

Firstly: a diversion to the river in the vicinity of Phillips Road;

Secondly: a diversion to the river commencing near 2M 27C along a line roughly parallel to and north from Hopai Road.

1 Phillips Road Diversion

A brief investigation suggested a tentative line for a canal on the north side of Phillips Road, double stopbanked, with floodgates into the river.

Various complications exist in constructing the stopbanks over an area with low clay levels, and the entry into the Piako River would be at a rather congested site. Works on the undiverted section of the canal would of necessity be similar to those for the scheme now recommended, with the exception, that a minimal amount of work would be required on channel improvement and stopbank construction.

A scheme based on a diversion of this nature appears to be quite sound but does not have any great advantages over the recommended scheme.

Costs are likely to be substantially greater than for the recommended scheme and special difficulties exist in developing a new channel through peat where the underlying clays are below MSL.

Future maintenance of an extra two miles of canal, plus extra floodgates are also points to be considered.

This diversion is not therefore recommended.

- 2 **Diversion Commencing at 2M 27c on Pouarua Canal:** The tentative line considered for this diversion leaves the canal about 40 chains south from the bend in the canal, and follows a line more or less parallel to Hopai Road, to meet the Piako River some 60 chains south from the Pipiroa Bridge.

The diversion would require parallel stopbanks and a floodgate structure into the river apart from a bridge on the Pokeno-Waihi State Highway, plus substantial alterations to the local drainage pattern.

Nevertheless such a scheme also appears to be quite sound and would provide better outlet conditions than exist into the Maukoro canal although the length of the diversion would tend to counteract this to some degree. However, although no precise estimate is available, it seems inevitable that costs would be appreciably higher than on the recommended scheme, if for no other reason than that the two proposals are very similar in general outline, other than that the diversion now under discussion includes substantially greater channel excavation, a larger road bridge, and very considerable property disturbance.

Other disadvantages include an additional four miles of canal for maintenance purposes, plus new drains.

A further point, the significance of which is difficult to assess, would be the reduction of flow in the Maukoro canal, from the point of view of natural flushing in a canal which has a siltation problem.

For these reasons it did not seem that the diversion would have sufficient advantages to merit abandoning the use of the existing canal line.

C. **DIRECT PUMPING OF THE CANAL (INTO MAUKORO CANAL):**

This approach to the problem envisages transforming the canal into a large pumped, feeder drain, discharging through a major pump station into the Maukoro canal, with internal canal levels kept sufficiently low to provide gravity drainage for all parts of the canal catchment.

There are certain advantages in a solution of this type and the possibilities have been carefully examined. Conclusions are, however, that there are a number of serious drawbacks. Some of these are:-

- i) The need to maintain outlet levels in the vicinity of mean sea level, would mean pumping a very high proportion of the total runoff, hence high running costs.
- ii) Heavy canal excavation to provide the necessary canal section at the depths needed to maintain low canal levels, plus some flood storage.
- iii) The power requirements of the pump station would be excessive, probably well over 500 h.p.
- iv) Total capital costs likely to equal the costs for a gravity scheme.

Thus no worthwhile savings in capital cost are apparent, with the added disadvantages of higher maintenance charges, and possibly, less flexibility in dealing with flood flows.

A solution of this nature has therefore been discarded.

D. STRAIGHT GRAVITY OUTLET INTO MAUKORO CANAL ALONG THE EXISTING LINE:

A scheme was produced on these lines and put forward for consideration in 1963, but is now withdrawn on account of cost (£264,000).

The main points of this scheme were:

- i) A double stopbanked canal on the present line, from the outlet to 4M 5C (Orchard West Road) with sufficient height of stopbanks to allow a 2 foot freeboard above a design flood 25% greater in magnitude than that which occurred in September 1960 (the largest flood since the canal was constructed).
- ii) A large floodgate structure into the Maukoro canal, with a capacity corresponding to the design flood above.
- iii) Provision for gravity and pumped drainage into the canal from the internal low-land areas.
- iv) The enlargement of that part of the Maukoro canal below the Pouarua outlet, with extension of the State Highway Bridge.
- v) Enlargement of the upper reaches of the Pouarua canal as far south as Torehape Road.

This scheme was, and still is, considered to be sound in principle and a suitable framework to accommodate future variations in catchment conditions.

Unfortunately, however, the cost is very high in relation to the area of land concerned. Careful study has failed to show a method whereby this particular solution can be sufficiently modified so as to result, both in a substantial saving in cost and at the same time maintain a reasonable design standard.

The full gravity scheme has therefore been abandoned in favour of a modified gravity scheme involving the use of a "pump assisted" outlet.

A point which requires a little further clarification is that whereas banks of about the level of the average of those in existence on the right bank of the canal, could be expected to withstand overflow for relatively short periods, as the bank level increases above this level, the effects of possible overflow become more serious. There would be increased tendency to scour, and the volume of impounded water which could escape from a breach would be larger. It was for this reason that a 2 foot freeboard was considered to be essential on the above scheme, as well as to make provision for settlement over a 20-25 year period.

III RECOMMENDED SCHEME FOR POUARUA CANAL WITH PUMP ASSISTED GRAVITY OUTLET

Discussion of Scheme, Objects, Brief Description, Summarised Estimate

A. DISCUSSION OF SCHEME

In some respects, this scheme, with modified design standards of flood flow represents a compromise between a "straight gravity" scheme and one based entirely on canal pumping. It seeks to take advantage of a situation where, if a method can be devised for the control of the higher storm run-off then comparatively low canal stopbanks will provide safe gravity discharge conditions on most other occasions.

Thus the concept of a "pump assisted" gravity scheme has emerged in which the internal pumps remain to carry out the function of low land drainage into the canal and the discharge into the Maukoro canal, though normally by gravity, would be assisted, in times of heavy run-off, by large capacity, low head flood pumps. The latter, would, in effect, take over the function of the main outlet floodgates during periods of high flood levels in the Maukoro canal.

This concept enables very substantial economies to be achieved both in stopbank reconstruction and in other directions. For instance the existing stopbank on the right bank is then generally of sufficient height and dimensions with only a small amount of work over very limited lengths.

B. OBJECTS

The objects of the scheme are briefly stated as follows:-

- 1) To eliminate or reduce overflow of floodwaters from the higher peat onto lands on both sides of the canal.
- 2) To prevent or minimize flooding or ponding of waters on the lower half of the canal catchment, on both sides of the canal over an area approaching 3000 acres.
- 3) To provide effective drainage in the lower half of the catchment area, approaching 5000 acres (including the 3000 acres in (2) above).
- 4) To permit the effective development of a drainage system in the southern and higher part of the catchment without resultant dangers in the lower areas. (Approximately 3000 acres distinct from the 5000 acres in (3) above).
- 5) To provide a canal system complete with stopbanks, culverts, pumps etc. in recognition of the fact that surface levels are not stable in the catchment and will continue to drop.

C. BRIEF DESCRIPTION OF SCHEME

The scheme provides for the further development of the canal mainly on the principle of gravity discharge but supported by the construction of a major flood pump station at the outlet in to the Maukoro canal.

This means in effect that the canal will have a "pump assisted" outlet and that canal flood levels will cease to be dependent on flood levels in the Maukoro canal.

Inclusive of the main flood pump station, the Scheme in principle, comprises the completion of a system of limited height return stopbanking from the confluence of the two canals, southwards to the higher peat country in the vicinity of Orchard West Road together with provision for pump assisted drainage from the lower parts of the catchment into the stopbanked canal.

The concept thus permits:

- Firstly:** retention of the principle of a gravity discharge canal, other than in times of high run-off.
- Secondly:** substantial use of the existing stopbanks and other improvements in their present form.
- Thirdly:** independent pump drainage into the canal from the lower parts of the catchment, in a form which can be extended as ground levels settle.

Proposed Scheme Works include: Construction of major flood pump station at canal outlet; channel excavation over 7.5 miles of canal; construction or reconstruction of some 6 to 7 miles of stopbanking; construction of a number (up to 11) new floodgated culverts, probably of 36" diameter; construction of four new pump stations (30-35 cusecs); new internal drain to feed 60 cusec pump station and miscellaneous items i.e. moving power lines, small culverts, land compensation etc. Provision is also made for replacement of the present floodgated outlet into the Maukoro canal which may not be necessary for several years.

Summarized Estimate:

	£
Pouarua canal earthworks	30,000
Major flood pump station at outlet	38,000
Provision for replacement of outlet floodgates	8,000
Internal floodgated culverts	8,000
Internal flood pump stations	33,000
Miscellaneous, including land compensation, fencing, removal of power lines etc.	<u>13,000</u>
Total	<u>£130,000</u>

IV POUARUA CANAL SCHEME - WITH PUMP ASSISTED GRAVITY OUTLET: SPECIFICATION

1. Channel Reconstruction

- a) **0M 00C TO 2M 00C (Maukoro canal to a point south of Polands Corner):**

Dimensions:

Water depth 11.5 feet.

Invert at 0M00C R.L. -5.0 ft. Invert at 2M00C R.L. -4.15 ft.

Bottom width of channel 12.0 ft.

Batters 2 horizontal to 1 vertical.

Berm level - unspecified. Machine track to be formed 20 ft. clear of top of enlarged channel.

Channel gradient .00008 ft. per foot or .85 feet in 2 miles.

- b) **2M 00C to 2M 10C Transition Section:**

Dimensions:

At 2M 00C Invert R.L. -4.15 ft. Bottom width 12 ft.

Batters 2 horizontal to 1 vertical.

At 2M 10C Invert R.L. -4.63 ft. Bottom width 24ft.

Batters 2 horizontal to 1 vertical.

Berm width 50 ft. (left bank only).

- c) **2M 10C to 4M 56C (Orchard West Road):**

Dimensions:

Water Depth 12.0 ft.

Invert at 2M 10C R.L. -4.63 ft. Invert at 4M 56C R.L. -4.30 ft.

Bottom width of channel 24 ft.

Batters 2 horizontal to 1 vertical.

Berm level unspecified. Spoil heaps to be removed to provide material for banks.

Berm width, left bank only. 2M 10C to 2M 62.5C 50 feet.

2M 62.5C to 4M 56C 70 feet.

Channel gradient .000024 ft. per foot or .33 ft. in 2M 46C.

d) **4M 56C to 5M 40C:****Dimensions:**

Depth below design flood gradient 8.7 ft.
 Invert at 4M 56C R.L. -1.0 ft. at 5M 40C R.L. +0.20 ft.
 Bottom width of channel 8 ft.
 Batters 2 horizontal to 1 vertical.
 Channel gradient .000285 ft. per foot or 1.20 feet in 64 chains.

e) **5M 40C to 6M 0C (Phillips Road):****Dimensions:**

Depth below design flood gradient 8.7 feet.
 Invert at 5M 40C R.L. +0.20 ft. at 6M 0C R.L. 0.95 ft.
 Bottom width of channel 6 feet.
 Batters 2 horizontal to 1 vertical.
 Channel gradient .000285 ft. per foot or 0.75 feet in 40 chains.

f) **6M 0C to 6M 40C:****Dimensions:**

Depth below design flood gradient 7.0 ft.
 Invert at 6M 0C R.L. +2.65 ft. at 6M 40C R.L. +3.40 ft.
 Bottom width of channel 7 feet.
 Batters 2 horizontal to 1 vertical.
 Channel gradient .000285 ft. per foot or 0.75 feet in 40 chains.

g) **6M 40C to 7M 0C:****Dimensions:**

Depth below design flood gradient 7.0 feet.
 Invert at 6M 40C R.L. +3.4ft. at 7M 0C R.L. +4.16 ft.
 Bottom width of channel 5 feet.
 Batters 2 horizontal to 1 vertical.
 Channel gradient .000285 ft. per foot or 0.76 ft. in 40 chains.

h) **7M 0C to 7M 45C (Torehape Road):****Dimensions:**

Depth below design flood gradient 6.5 ft.
 Invert at 7M 0C R.L. +4.66 ft., at 7M 45C R.L. +5.50 ft.
 Bottom width of channel 5.0 ft.

Batters 2 horizontal to 1 vertical.

Channel gradient .000285 ft. per foot or 0.84 ft. in 45 chains.

i) **7M 45C to 8M 0C (South of Torehape Road):**

Dimensions:

Minor reconstruction and grading of channel only. (Catchment decreases to a few acres).

Notes:

- a) Reference should be made to the appropriate appendix for details of hydraulic design.
- b) Major channel works are in the reach 0M 00C to 4M 56C. Works south from this reach are of a more minor nature for the purpose of developing an adequate channel in the high peat catchment.
- c) Consideration of channel sizes and gradients etc. in conjunction with required volumes of spoil for stopbank reconstruction indicated that a uniform design gradient and channel from 0M 00C to 4M 56C would result in a very large surplus of spoil in the lower two miles and a corresponding deficiency in the upper two and three-quarter miles. Gradients and channel dimensions have therefore been adjusted to minimise this feature although there is still some deficiency in the 2 miles to 3 miles length. Berm widths on the left bank in the section between 2M 00C and 4M 56C have been varied to suit the circumstances, over the greater part being governed by the location of the stopbank adjacent to the road formation.

A short transition section is provided immediately south of the 2M point.

2. **Stopbank Construction and Reconstruction:**

0M 00C to 2M 00C - Left bank and 0M 00C to 1M 60C Right bank:

Dimensions:

Minimum top width 10 ft. at R.L. 7.35.

Side slopes canal side 2 horizontal to 1 vertical, land side 4 horizontal to 1 vertical.

Berm width 20 ft. minimum at unspecified level.

1M 60C to 2M 0C Right Bank:

Dimensions:

Existing bank of sufficient height and dimensions. No reconstruction necessary.

2M 00C to 2M 62.5C (Hopai Road) Left Bank:**Dimensions:**

Top width 10 ft.

Top level at 2M R.L. + 7.35 ft. at 2M 62.5C R.L. + 7.45 ft.

Batters - canal side - 2 horizontal to 1 vertical.

Landward side - 4 horizontal to 1 vertical.

Key trench 10 ft. wide and 1 ft average depth below higher part of bank.

Location approximately 85 ft. west of centreline of reconstructed canal.

2M 00C to 4M 56C (Orchard West Road) Right Bank:**Dimensions:**

Top width 6 ft.

Top level at 2M R.L. +7.35 ft., at 4M 56C R.L. + 7.70 ft.

Batters - 2 horizontal to 1 vertical.

Existing bank to be left in present position and raised only where required.

2M 62.5 to 4M 56C (Orchard West Road) Left Bank:**Dimensions:**

Top width 6 ft.

Top level at 2M 62.5C R.L. + 7.45 ft., at 4M 56C R.L. + 7.70 ft.

Batters - 3 horizontal to 1 vertical.

No key trench.

Location as close to road formation as practicable with provision for water-table maintenance. (Approximately 110 ft. from centreline of reconstructed canal).

Methods of Construction:**0M 00C to 2M 00C Left Bank and 0M 00C to 1M 60C Right Bank:**

Firstly a reasonably level machine track shall be formed by bulldozer of sufficient width to allow a 20 ft. wide track after channel excavation is complete. Spoil from this shall be spread on the landward side of the existing spoil banks and compacted.

Secondly, channel excavation shall be completed by dragline, spoil being dumped at least 20 ft. clear of the edge of the new channel. Spoil dumps shall not be permitted to rise above R.L. +10.0 within 30 feet of the canal. Material above this level must be re-handled immediately.

When sufficiently dry, banks shall be trimmed to an even surface of at least specified height and width. As far as possible, where a surplus exists, spoil shall be spread so that the level is fairly uniform on both sides at R.L. +8.0.

It is expected that there will be a substantial surplus from channel excavation above that required to form the specified banks. Any lengths where a deficiency occurs must be constructed to specified dimensions by scrapers operating from the nearest area of surplus.

When passing houses, disturbance shall be kept to a minimum and surplus spoil removed to at least two chains from the houses.

2M 00C to 2M 62.5C Left Bank:

Firstly a key trench shall be dug in the peat centrally on the line of the stopbank, the material from the trench being placed at the toes of the proposed stopbank batters to retain wet spoil from the channel as far as possible. The key trench shall be 10 ft. wide and an average of 1 ft. deep. Stumps encountered in this trench shall be placed on the landward side clear of the bank.

Secondly a machine track shall be formed by removing the existing spoil dump on the left bank of the canal and dumping it on the line of the new bank.

Thirdly channel excavation shall be carried out to specified dimensions, the material being dumped on the line of the new bank. Additional width being excavated where the design section is insufficient to meet bank requirements.

Fourthly after the material is sufficiently dry it shall be trimmed to the specified stopbank dimensions.

2M 62.5C to 4M 56C Left Bank:

Along this length the new bank shall be formed adjacent to the existing road formation. No key trench will be necessary.

Firstly, a machine track shall be formed by excavating the existing spoil dump on the left bank of the canal, the material being placed on the line of the new bank.

Secondly, channel excavation shall be carried out, the material being placed on the line of the new bank. Where necessary additional width shall be excavated to provide bank material.

Thirdly, after the material has dried sufficiently it shall be trimmed to specified bank dimensions. An evenly graded watertable shall be formed connecting to floodgated outlets.

2M 00C to 4M 56C Right Bank:

Low spots on this bank aggregating some 60 chains in length shall be brought up to design dimensions by cartage from the nearest source of satisfactory spoil and compacted.

Notes:

In estimating material required for bank quantities the following percentages of reduction have been applied to cut quantities:

Existing dry clay spoil in dump	15%
Wet clay in channel	40%
Peat	60%

In addition bank quantities on the left bank have been increased by 20% in allowance for peat settlement beneath the bank.

3. Floodgate and Pump Structure at Outlet:

This structure will be designed in detail when sufficient information regarding pumps is available. In the meantime it is considered that the structure will be on the general lines of the flexible floodgate structures designed for the Piako River Scheme, with the addition of the following features:-

- 1) Provision to house two 200 cusec pumps on the inlet end with adequate screen area and provision for sealing off the pump intake against canal levels for removal of pumps etc.
- 2) A curved outlet structure of concrete of sufficient length to deflect the flow downstream and to provide for any hydraulic jump to take place within the structure.

Minimum length of barrel 56 ft.

Minimum size twin 60" pipes.

Pumps (outlet of Pouarua Canal):

Capacity two 200 cusec pumps, low head.

Type: Axial flow horizontal spindle. Preliminary consideration suggests submersible electric motors.

H.P. Very approximately 200-225 H.P. per unit.

The scheme is not necessarily dependent on horizontal spindle pumps but at this stage there seem to be certain advantages such as better flow conditions, lower deadweight, some use of outlet culvert for gravity discharge purposes etc.

Provision has been made in the estimate for a large floodgate structure (probably twin 72" pipes or equivalent) to replace the existing three barrel 48" x 48" structure when the latter, or the existing bridge, reaches the end of its useful life. The proposed floodgate would be located under the road thus eliminating the bridge.

4. Floodgated Culverts (Internal Drainage Areas):

Provisionally it is estimated that the following floodgated culverts will be required (probably corrugated steel culverts 30 ft. to 40 ft. in length with cast iron flaps):

Right Bank:	0M 20C	36" diameter	
	0M 77C	36" diameter	
	4M 60C	2/36" diameter	
Left Bank:	0M 71C	2/36" diameter	Central Drain
	1M 55C	1/36" diameter	
	2M 62C	2/36" diameter	Hopai Road
	<u>3M 65C</u>	2/36" diameter	Rawerawe Road
Total		11/36"	

Notes:

- i) Culvert sizes in relation to catchment areas are discussed in the Appendix.
- ii) A provisional layout of catchments to be served by the various culverts is indicated on Drawing No.471B.

5. Pump Stations (Internal Drainage Areas):

Provision shall be made for four new pump stations, the locations and sizes of which shall be provisionally as follows:-

Pumping into Pouarua canal:

1)	Right bank	1M 65C	35 cusec	Settlers Drain
2)	Right bank	3M 67C	35 cusec	Rawerawe Road
3)	Right bank	4M 60C	35 cusec	Orchard West Road
4)	Left bank	3M 67C	35 cusec	Rawerawe Road

Notes:

- i) If the two drainage areas on the left bank (areas Nos. 1 and 2) are considered as combined, it may be desirable to alter the siting of No.4 pump above to the vicinity of Hopai Road (2M 62C).

- ii) The existing 60 cusec installation will become an internal drainage pump for Area No.1 discharging directly into the Maukoro canal. In the design of the installation this function was borne in mind.
- iii) The new structures shall be of the general design of those recently built under the Piako Scheme i.e. of precast concrete units supported on piles with steel and timber superstructure.
- iv) The pumps shall be electrically driven axial flow pumps of approximately 35 cusec capacity with automatic control as recently supplied under the Piako Scheme.
- v) A provisional layout of catchments to be served by the various pumps is shown on Drawing No.471B.

6. Reconstruction of Internal Drainage System:

The only work to be included under the scheme is a connection in Area No. 1 from Central Drain to the 60 cusec pump station near the Pouarua canal outlet, a length of some 85 chains. The steps would be as follows:-

- a) Construct new drain from Central Drain to 60 cusec pump station, approximately 18,000 cubic yards, along line indicated on Drawing No. 471B.
- b) Seal present approach drain from Pouarua canal to 60 cusec pump station.

Dimensions of new drain:

Bottom width 6 ft.

Invert levels at pump R.L. -1.8, at Central Drain R.L. -0.7.

Batters 1¼ horizontal to 1 vertical.

7. Miscellaneous Items:

a) Power Lines - 0M to 1M 60C Left Bank:

A high tension electric power line is located close to the canal and would be within dangerous proximity of the projected canal works on the left bank. Allowance is therefore being made for the moving of this power line a safe distance to the south over a length of approximately 1¼ miles.

b) Land Compensation:

This will now be limited in the lower reaches to the length of 0M 00C to 2M 62.5C on the left bank and 0M 00C to 1M 60C on the right

bank. Over these lengths it would still be advisable to acquire a reserve three chains in width (present reserve is one chain wide only). The area involved is therefore some 35 to 40 acres, of which some 4 acres is Crown land.

However in the length south of Orchard West Road it is considered essential to set aside an adequate reserve to allow for future works and steps should be taken in the unalienated Crown Land to secure the position.

c) **Drain Culverts, Fencing, Removal of Trees etc:**

Allowance has been made in the estimate for new drain crossings, re-erection of fences and the removal of trees.

POUARUA CANAL SCHEME - WITH PUMP ASSISTED GRAVITY OUTLET

ESTIMATE

	Unit	Quantity	Rate	Amount	
Channel Excavation and (2) Stopbank Construction					
(a) 0M 00C - 2M 00C (Right Bank 1M 60C - 2M 00C remains as at present)					
Formation of machine track	1.chs	300	£3	900	
Formation of bank with material excavated from channel	c.yds	36,200	2/3	4,073	
Trimming and compaction of bank	1.chs	300	£3	<u>900</u>	5,873
(b) 2M 00C - 4M 56C (Orchard West Road)					
(i) Left Bank:					
Excavation of key trench 2M 00C - 2M 62.5C	c.yds	1,500	1/6	116	
Excavation of berm material and placing on bank	c.yds	14,350	1/6	1,076	
Excavation of channel material and placing on bank including additional widening for bank requirements	c.yds	65,000	3/3	10,563	
Trimming and compaction of bank	1.chs	216	£4	<u>864</u>	12,619
(ii) Right Bank:					
Cartage of material to raise bank where required	c.yds	2,000	12/6	<u>1,250</u>	1,250
(c) 4M 56C - 8M 00C					
Channel enlargement	c.yds	18,000	2/9	2,475	
Removal of willows	1.chs	230	£6	<u>1,380</u>	3,855
(3) Pump Structure at Outlet (Twin 60" Culverts):					
Pump 2/200 cusec	Item			12,000	
Capitalised standing charges	"			18,000	
Replacement of existing floodgates	"			2,000	
				<u>7,000</u>	39,000
(4) Internal Floodgated Culverts					
36" diameter	No.	11	£600	6,600	6,600

(5) Internal Pump Structures and Pumps

35 cusec	No.	4	£7000	28,000
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(6) Reconstruction of Internal Drainage System

Area no. 1 connection to 60 cusec pumps	c.yds	18,000	1/9	1,575
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(7) Miscellaneous Items

Removal and re-siting of power lines	Item			2,600
Land compensation	"			5,000
Removal and re-erection of fences, removal of trees etc.	"			2,000
Dismantling of existing culvert at outlet	"			200
Miscellaneous culverts, crossings etc.	"			<u>1,000</u>

109,572

Contingencies 15%

16,431

126,007

Engineering 3%

3,990**TOTAL****£130,000**

VI POSSIBLE FUTURE WORKS IN THE HIGH PEAT CATCHMENT (South from Orchard West Road)

The solution provided by the Scheme, for the low peat areas, is of a permanent nature, and should need only maintenance, plus possibly some minor stopbank topping, which could in any case, probably be a product of canal maintenance.

With the high peat lands (south of Orchard West Road) the position is rather different. In this case, although the general design is permanent, the effective life of the present Scheme, in relation to the high peat areas, is conditioned by the rate of subsidence of surface levels.

These surface levels are, over the bulk of the area, R.L. 15 ft. above M.S.L. or higher, reaching R.L. 25 ft. above M.S.L. in places.

The effectiveness of the Scheme will not be seriously affected until land levels over appreciable areas fall below R.L. 9 - 10 ft above M.S.L.

Nevertheless, subsidence can be expected in the future, although the rate at which this will occur cannot be predicted with any accuracy as it is dependent on many factors. However, if the past thirty years can be accepted as a criterion, the average total subsidence could be of the order of perhaps 5 ft.

It therefore seems likely that, although some works may be required in the fringe areas immediately south from Orchard West Road, along the canal line and in the east, the recommended Scheme should be adequate for a substantial period of years, probably as long as thirty years.

Possible future works therefore fall into two categories:

Firstly: those which are a possibility within the 30 year period.
Secondly: eventual long term development.

Within the 30 year period:

a) **Right Stopbank:**

This has already been constructed as a formed and metalled road which is believed to be of adequate height for some 30 to 40 chains or so south from Orchard West Road. Extension or raising of this road to cope with peat settlement in the 30 year period is considered to be a fairly minor item.

b) **Left Stopbank:**

Construction of some 40 to 50 chains of stopbank of limited height may be required within the period. This is connected with the problem of the fairly large proportion, some 35 - 40%, of the upper catchment run-off which at present flows down the south side of Orchard West Road. It will be a number of years yet before the question of stopbanking in this vicinity will arise, and any solution which is

proposed now could very well be nullified by changes in the catchment pattern in the intervening period.

c) **Internal Drainage:**

The provision of floodgates and at a later date, pumps, would have to be considered at the same time as the extension of stopbanks. It is very unlikely that peat settlement will be so rapid in the area south of Orchard West Road, that any further pumps will be required within the period. In the area of low clay levels east of the canal, the condition will eventually arise when high-head or double stage pumping may be required. However this is unlikely to occur within the period.

The timing and extent of expenditure under the above headings cannot be assessed with any accuracy, and no direct provision has been made in the scheme estimate. It seems unlikely however that it will assume any substantial proportions.

Eventual Long Term Development:

If it is accepted that much of the peat will eventually disappear from the high peat lands, then the catchment of the Pouarua canal will form a large shallow depression between the Maukoro canal (in the west) and the higher clay country adjoining the Piako River (in the east) with the Waikoura Stream forming the southern boundary. The total area so involved would approximate 13,700 acres.

The principles on which the canal scheme is based, where the canal traverses the existing low peat areas, namely extension of canal stopbanks together with floodgates and pump assisted drainage, could be slowly extended over the catchment as needed. As such, this would constitute a logical extension of the canal scheme now put forward for consideration.

It is however, impossible to forecast when this stage will be reached. It is further a matter for serious consideration, as to whether future land development policy should be such as to endeavour to arrest the rate of subsidence or whether it would be preferable to assume that more or less total subsidence was inevitable and plan accordingly.

Available evidence suggests that fairly rigid control of ground water levels is probably essential, if any real effort is to be made towards the arresting of the rate of subsidence. However, the considerable variation in present surface levels, plus a lack of water storage will make such an undertaking most difficult in practice.

It seems possible, therefore, that some form of total subsidence may well be inevitable, although the final stages could be delayed for a very long period of years.

VII APPENDIX 1**FLOOD RECORDS****November 1952:**

No actual water levels available, but reports of overflow over eastern stopbank in Hopai Road - Settlers Drain area. Water moved northwards from south of Orchard West Road to Settlers Drain across low lying land on the east bank. This flood probably reached levels similar to those of June 1960, but peat settlement in the intervening years would result in somewhat greater depths of flooding in the later flood.

July 1953:

Water level reached 4.8 at Rawerawe Road on 5/7/53.

June/July 1956:

Extensive period of water levels high enough to prevent drainage of low lying areas.

June/July 1960:

Heaviest flooding recorded up to this date. Overflow took place over the eastern stopbank in the vicinity of Hopai Road and freeboard was negligible on other parts of this bank southwards to Orchard West Road. Flooding took about a week to recede in the area to the south of the outlet (left bank of canal) and had not disappeared in the Rawerawe Road area (right bank) when the second storm of July 4-5 occurred, although there had been continuous pumping at this point.

Stages reached, in terms of mean sea level in the June flood were as follows:-

Orchard West Road Bridge	6.63
Overflow near Hopai Road	5.80
Central Road Drain Outlet	5.4
Pouarua canal floodgate	5.4

An area of approximately 1000 acres on the left bank and some 1500 acres on the right bank was flooded on this occasion.

September 1960:

This was undoubtedly the heaviest flood so far recorded in the Pouarua canal catchment. Following the exceptionally heavy rainfall of 14 September, overflow occurred at a number of points on the right bank, that at Hopai Road being the heaviest. On the left bank the area inundated was some 1300 acres, and on the right bank some 1700 acres. Stages reached were as follows:-

Orchard West Road Bridge	7.85 (midnight 14/9/60)
1M 75C peg (15 chains south of Polands Corner)	6.17 (16/9/60)
Floodgates at outlet	6.03 (1340 hours 15/9/60)

A current meter gauging was done at R.L. 6.44 at Orchard West Road Bridge at 11.10 hours on 15/9/60, giving a discharge of 165 cusecs. Shortly afterwards at 12.38 hours a gauging was done at the outlet, giving a discharge figure of 113 cusecs. At the time of the first gauging therefore the ponded volume was still increasing, and the peak level at the outlet was recorded at 6.03 at 1340 hours on 15/9/60, shortly after the gauging.

The peak flow at Orchard West Road Bridge was computed by taking into account the increased slope, hydraulic radius and cross sectional area compared with that at time of gauging, and was estimated to be approximately 600 cusecs from a catchment area of approximately 2800 acres. A further check was provided by the volume of ponded water at the peak of ponding approximately 1000 acre feet on the left bank (computed from ground contours of the 1957 survey) and making allowance for discharge which had occurred through the gates and overflows over the right bank up to the time of peak ponding volume. When the total area contributing to this ponding volume is taken into account, a peak flow of the same order is indicated.

The total volume of run-off in this flood was approximately 2¾" most of which occurred in 24 hours. The peak flow of 600 cusecs at Orchard West Road Bridge estimated above, represented a maximum rate of runoff at 5.1" in 24 hours.

Although the catchment above this point could be classed as flat there is appreciable fall, and the natural tendency of artificial drains in peat to draw the surface level down in their vicinity would result in a runoff potential higher than that for clay land of similar general slope.

July 1961:

This flood was intermediate in volume and severity between those of September 1960 and June 1960. The level of the floodgates reached 5.8. The areas flooded could be roughly interpolated in proportion from the outlet levels of the previous floods.

A current meter gauging of 67 cusecs at 10.30 hours on 18/7/61 was made at Orchard West Road Bridge probably about 24 hours after the peak flow at this point.

APPENDIX 2

HYDRAULIC DESIGN

The hydraulic design of the scheme is based on the following sets of conditions:-

- i) **Without Freeboard:** The capacity would be equivalent to a sustained inflow from the higher peat area (3000 acres) of 450 cusecs plus a pumped inflow from the low lands of 140 cusecs.

Under these conditions the discharge into the Maukoro canal would be 400 cusecs through the outlet pumps plus approximately 190 cusecs gravity flow through the floodgates.

The contributing area of higher peat would be the whole of the catchment south of Orchard West Road (2800 acres) plus a small area north of this road of medium to high peat which would discharge through floodgates even at high canal levels. The rate of runoff would be equivalent to 3.6 inches in 24 hours or 0.15 inches per hour.

Alternatively, fairly short peaks of inflow up to 600 cusecs from the high peat could be accommodated, making use of canal storage. The estimated storage available between stopbanks between R.L. +3.0 and R.L. +7.35 (overflow level) is 185 acre feet. An inflow of 600 cusecs from 3000 acres represents a runoff of 0.2" per hour.

The frequency of the occasions when the canal would operate without freeboard is estimated to be between 5 and 10 years.

- ii) **With 1 foot Freeboard:** The capacity would be equivalent to a sustained inflow from the high peat area (3000 acres) of 360 cusecs plus a pumped inflow from the lowlands of 140 cusecs. From the high peat, this inflow represents a rate of runoff of 0.12 inches per hour or 2.9 inches in 24 hours.

Under such conditions the outlet level of the Pouarua canal would fluctuate between about R.L. +5.5 and +6.0. In addition to the discharge of 400 cusecs there would be an estimated floodgate discharge of 100 cusecs.

The frequency of such conditions would be approximately about once in 3 years. On four occasions during the past 12 years those conditions have been equalled or exceeded.

Note:

The flood of September 1960 would have been of a magnitude roughly equivalent to (i) above when under the scheme the canal would have operated without freeboard. The three floods of November 1952, June 1960 and July 1961 would have approximated the conditions of (ii) above when the canal, under Scheme conditions would have operated with a limited freeboard.

Channel Dimensions and Capacities:

The gradient in the first two miles is steeper than in the remainder in order to reduce the surplus excavation in the 0M - 2M section and to roughly balance cut and fill quantities in the upper length. There will still be some widening necessary to produce the required bank quantity in the reach from 2M 30C to 3M 0C where land levels and clay levels are low.

	Main Channel	Berm	Total
0M 00C - 2M 00C Section			
Area	402.5 sq.ft.		
Hydraulic radius	6.34 ft.		
Mannings "n"	.03		
Slope	.00008		
Velocity	1.51 ft per sec		
Q	608 cusecs	Neglected	608 cusecs

2M 00 - 3M 70 Section:

Area	576 sq ft	189 sq.ft.	
Hydraulic radius	7.40 ft.	3.0 ft.	
Mannings "n"	.03	.035	
Slope	.000024	.000024	
Velocity	.92 ft. per sec.	.43 ft. per sec.	
Q	530 cusecs	81 cusecs	611 cusecs

For channel reconstruction above Orchard West Road a flow of 565 cusecs from the upper catchment has been assumed at the bridge, slightly less than the total which the channel can carry immediately downstream of this point (since the proposed pump at this road intersection on the right bank is assumed to be delivering 35 cusecs). Since some 930 acres of the upper catchment discharges to the drain which follows the southern side of Orchard West Road, the flow in the main canal is reduced as follows:-

Section	4M 56C to 5M 40C	374 cusecs
	5M 40C to 6M 00C	348 "
	6M 00C to 6M 40C	225 "
	6M 40C to 7M 00C	194 "
	7M 00C to 7M 45C	162 "

Continuous Discharge Capacity:

The maximum continuous discharge capacity from the canal can be considered as the sum of (i) the maximum flow that can be delivered by the canal itself i.e. 600 cusecs, reduced by the flow from one pump for two, two hour periods plus (ii) the discharge from the 60 cusec pump station discharging directly into the Maukoro canal (on a 20 hour basis this reduces to 50 cusecs). The capacity is therefore 620 cusecs or 1.96" in 24 hours on a catchment of 7500 acres.

Operation of Outlet Pumps:

It is intended that, in the main, the scheme should operate as a gravity outlet, the outlet pumps being brought into operation only when serious floods are imminent. From this angle automatic starting of the pumps should be arranged to operate only when the canal level reaches a point above any normal tide fluctuation. Since the canal is designed to deliver the total pump output at +5.0 it is considered provisionally that the first pump should cut in at +3.0 and the second at +4.5. Cut out levels would be dependent on surge conditions at the intake but provisionally the higher one would be set at about +4.0.

Consideration of necessary submergency of pumps indicates that it is unlikely that the pumps could operate at all below +2.5.

Effect of Outlet Pumps on Internal Drainage Areas:

Provided that one of the outlet pumps can be operated to levels as low as +3.0 this would permit gravity flow through floodgates into the canal from those areas nearest to the outlet. This has been taken into account in internal pump capacities. Areas Nos.1 and 2 combined have a total pump capacity of 79 cusecs on 2300 acres (20 hour operation), equivalent to .82" in 24 hours. The remaining pumped areas (on the right bank) have a pump capacity of 1.16" in 24 hours.

A flood such as that of September 1960, with runoff totalling 2¾" would result in ponding levels in the various internal drainage areas as follows:-

Areas Nos. 1 and 2 combined	2300 acres	R.L. +5.7
" " 3	450 "	R.L. +5.8
" " 4	600 "	R.L. +4.1
" " 5	600 "	R.L. +3.45
" " 6	600 "	R.L. +6.3

These figures indicate that areas 4 and 5 are unlikely to receive much drainage through floodgates into the canal when the pumps have reduced the outlet level to +3.0, but areas 1 and 2, 3 and 6 would derive substantial benefit from such a reduced level. Area No.6 however which has particularly low clay levels will reach the stage some years hence when it will be in a worse position than Areas No.s 4 and 5.

Maukoro Canal Levels:

Levels of more than R.L. +6.5 in the Maukoro canal at the Pouarua canal outlet are rare. Although there is no definite record of the Maukoro canal outlet exceeding R.L. +6.0 at this point in the three large floods of June and September 1960 and July 1961, there is a probability that a level of at least R.L. +6.3 was reached in the September 1960 flood. However, tidal levels up to R.L. +7.0 have been reached at times of exceptionally high tides, but these fortunately have not coincided with storms.

Basis of Design of Pump and Floodgate Capacity: (Internal Areas)

Since land levels in the catchment are not stable, it is rather difficult to design culvert capacity on a rational basis. As peat land settles, that time may come when the floodgates in some parts of the scheme will almost cease to be operative. In the meantime however, the provision of floodgates is necessary and practicable, and the waterway required has been based on a capacity 40% to 50% greater than that being provided under the Piako Scheme at the mouth of the Piako River (where tidal range is greater). On the Pouarua canal this is equivalent to a 36" floodgate to about 280 acres.

Floodgates of the corrugated steel type, of heavy gauge and with anti corrosion treatment are favoured as having the following advantages:

- i) **Ease of installation:** It is expected that complete installation of a 36" culvert in one day will be possible.
- ii) **Structural Flexibility:** On the poor subsoil, rigidity is not desirable.
- iii) **Flexibility of Installation:** This type of structure is adaptable to changing land levels as it can easily be dug out and lowered or completely removed to another site, if required. A number of existing floodgated concrete culverts on the right bank can be incorporated into the scheme, as this bank is remaining insitu.

When considering pump capacity, the area has been compared with the Kerepehi Block adjacent to the Piako River where floodgate action in the larger floods is non-existent. A capacity of about 1" of runoff in 24 hours is not excessive in these conditions, where lesser capacities could mean that not infrequently surface waters from one storm are not disposed of before the next storm arrives and areas remain inundated for 10 days or more.

Since land levels over a large part of the catchment may drop to R.L. +2.0 or even lower, and the outlet pumps are not expected to reduce the level below +2.5 it is evident that eventually the drainage from a considerable area will be entirely dependent on pumps.

It will be noted that Area No.1 near the outlet has a lower capacity than the other pumped areas, mainly because this area can take advantage of the relatively lower canal level and can make more use of floodgate discharge.

APPENDIX B**WAIHOU VALLEY SCHEME****DESIGN PROCEDURE FOR DRAINAGE SCHEME PROPOSALS****1. Basic Information to be Obtained**

Define catchment area and subcatchment boundaries as they exist. This requires a knowledge of the existing pattern of main drains. At least a field inspection will be required. Basically flat or gently sloping areas, particularly those which are subject to flooding or may be suitable as ponding areas, will require levelling to determine typical ground levels and drain bed levels. At the same time the bed width and top width of the main drains and borrowpit drains should be measured to enable an assessment of the drain cross-sectional areas. Important bridge and culvert inverts should also be levelled. All bridge and culvert sizes should be measured even if not levelled.

Obtain the sizes and invert levels of all existing floodgates. Discuss past flooding with any local people or other staff members who may be able to assist with local knowledge.

Study any reports and photographs detailing past floods.

2. Preliminary Draughting

Prepare a plan of the whole catchment area with sufficient roads, townships, property boundaries etc, to make the plan reasonably identifiable.

Plot the river and all main streams and drains on this plan and show all spot levels, invert levels, culvert sizes, etc, referred to above under basic information. Contour this at about 0.2 metre centres at least up to the maximum ponding level, and up to river stopbank level in some cases.

Also plot cross-sections and long sections of the main drains. Use the same scale as the plan for the longitudinal sections. (In most cases these will have to be prepared from very limited information but that is better than nothing).

3. Preliminary Planning

Establish the possible position and size of all new outlets and of the system of the main drains if this is to be changed.

Show these and any new sub-catchment boundaries on the plan.

4. Run-off

Consider the effect of local storms of different durations and return frequencies.

Choose appropriate rainfall patterns on the catchment as design storms. Refer to plan No. 1373.

Use of the photos and maps available to assess the relevant catchment characteristics of slope, soil type and cover. From this and any other information of assistance, decide upon the rainfall losses due to infiltration, etc, for each sub-catchment. Measurements of this information from similar catchments are the most useful basis for such assessments but in the absence of such data refer to "Design of Small Dams", page 37 to 39 and Appendix A, USNE, "Handbook on Hydrology", chapter 3.10 and "Applied Hydrology" by C Toebes.

Then if no specific data in similar catchments is available, follow the methods outlined in "Design of Small Dams", chapter 2, or USNE "Handbook on Hydrology", chapters 3.15 to 3.19 inclusive, to estimate the times of concentration and to prepare hydrographs (triangular) for the individual sub-catchments. These may then be combined as appropriate and routed down to the outlet (eg USNE Wilson method, pages 3.17 to 19).

The end result will be a plot for each storm of flow against time for the flow reaching the outlet. Check the peak flow obtained, using TM61. Also reconsider the choice of storms in the light of the results obtained and analyze others if this now seems desirable.

5. Storage

A stage-volume plot will be required to show the storage capacity of the borrowpit and main drains and flooded paddocks, if any. For practical purposes it will probably prove necessary to limit the length of main drains considered for this purpose to something in the order of 1 kilometre. The unit of volume recommended is the cubic metre. A rainfall of 1mm on 1 hectare is a volume of 10m^3 . (The usual imperial volume of an acre-inch or cusec-hour equals 102.79m^3).

6. River Levels

Details of this stage-time relationship of river levels for various storms are required. There may be records of these but more generally they will have to be assessed from whatever limited information is available. The effect of tides must be taken into account where appropriate.

River levels higher than ground levels in the drainage area being considered can obviously lead to flooding. Therefore the lengths of the times that river levels can be higher than ground levels are important and of more interest in this regard than peak river levels. Charts illustrating such times have been prepared for the Waihou River at both Puke Bridge and Netherton. The lengths of time for which various flows may

be exceeded on such charts apply to other places on the river as long as no substantial tributaries alter the river flow between the point being considered and the point of origin of the chart being used. Similar charts can be prepared for other recorder sites.

Stage discharge curves for the rivers at various points of interest can be prepared from Brickells data even if no other information is available and these are useful. Several have already been prepared for the floodgate sites downstream of Puke Bridge.

7. Discharge from Outlets

The rating curves which have been drawn up in particular for the 60" pipes (but which also give the discharges from some other pipe sizes for some conditions of flow) enable the determination of the instantaneous flow through such pipes for any given pair of water levels on the inlet and outlet sides.

Routing procedures should be used to determine the discharge hydrographs. That is to say, a step by step calculation for say 1 or 3 hour intervals. A separate calculation will be necessary for each combination of the three variables, river flood, local storm and the relative timing of the start of each.

8. Presentation of Results of Routing Calculations

Plot the various hydrographs of volume in storage against a time base. In the first instance these should be all plotted on the one graph to give an immediate comparison between the results. A similar plot of pondage level could be plotted as an alternative or as an extra if desirable, but in many cases the changes in level are too gradual to effectively illustrate the flood pattern.

9. Design of Internal Drains

Drains in catchments which are in the central zone of the Hauraki Plains and which are basically flat shall be designed for a runoff of 38mm per day steady flow.

For any other catchments use all available data to produce hydrographs of runoff plotted against time for the annual 3 hour storms and use the peak flows from these hydrographs in designing the corresponding lengths of drain. An alternative method for obtaining this design capacity which is sometimes more convenient is to use 70% of the peak of the 2 year 3 hour storm. In either case assume the storm occurs on a fully saturated catchment so that the runoff equals the rainfall.

If a quicker method is required, a more approximate solution may be obtained by adopting the average runoff over a 24 hour period from saturated catchment subjected to a five year 24 hour rainfall.

10. Design of Floodpump Capacities

The method proposed for calculating floodpump capacities is based on the coincidence of the five year recurrence interval period of total floodgate lock (t hours) with the five year return period rainfall of duration t hours.

The steps are:-

- i) Calculate the catchment area served by the pump (A hectares)
- ii) Use the river stage-discharge curve for the pump site to choose the river flow equivalent to a river level at low tide equal to the lowest ground level to be drained if this is near the river or an appropriate lower level if the lowest ground to be drained is such a distance from the river that there will be a significant fall in the channel to the river
- iii) Read off the 5 year recurrence interval length of total gate lock (t hours) corresponding to the above flow
- iv) Calculate the catchment runoff from a 5 year rainfall storm of duration t hours (r mm)
- v) Pump capacity - the method of calculating this depends upon the duration t hours
 - (a) If this exceeds 72 hours then the pump capacity should equal the average rate of runoff for the length of gate lock

allow for only 20 hours pumping per day

$$Q = \frac{.00335 Ar}{t} \text{ cumecs}$$

- (b) if the length of gate lock is less than 72 hours then allow the pump 3 working days to clear the runoff

$$Q = 0.0000465 Ar \text{ cumecs}$$

NB See Appendix II

APPENDIX I

DESIGN PROCEDURE FOR DRAINAGE SCHEME PROPOSALS

Notes on the Design Capacity of Drains

Piako Scheme Design Standard

Where the whole catchment is basically flat as on the central Hauraki Plains, local flooding is generally uniformly distributed and consequently is not likely to drown stock, damage the pasture or cause other serious problems. In these circumstances it seems reasonable to design the drainage system to cope with 3 day storms.

Property owners and other persons concerned with the drainage of such areas are apparently satisfied with systems which have been designed to discharge a runoff of 38mm per day. Such a daily rainfall can be expected approximately twice each year. However, if the basis of design of these systems is thought of in terms of a 3 day storm then the accepted design standard is 114mm in 3 days and this is the 5 year 72 hour rainfall for the central plains.

From this point of view the accepted design standard for the central plains of 38mm per day is therefore the 5 year 72 hour rainfall assumed to fall on a saturated catchment and to be discharged at a uniform rate over the three day period.

Alternatively a runoff of 114mm from a dry catchment could result from as much as 211mm of rainfall if up to 97mm is allowed for losses (ref NZ Engineering, volume 23, No. 2, page 47). This is a 100 year 72 hour rainfall.

Piako-Waihou Comparison

A runoff of 38mm per day is not considered to be a satisfactory basis for the design of drainage systems for catchments which are not predominantly flat. In such catchments any runoff in excess of the drain capacity can quickly accumulate on the lower ground to considerable depths and so be a hazard to stock, pasture, etc, on such low lands. Flooding of this type for even a few days at 6 monthly intervals is not a reasonable design standard. Furthermore this type of catchment is generally subject to heavier rainfalls and shorter times of concentration than those in the central plains zone.

Waihou Scheme Design Standards

The basic design flow adopted for recent designs has been the peak flow of the annual 3 hour storm runoff hydrograph. The type of rainfall used depends on the location of the catchment and is shown on plan No. 1373. The methods outlined in Chapter II of "Design of Small Dams" were used in conjunction with local rainfall data to produce synthetic hydrographs.

An analysis of these design flows from a few catchments in the Paeroa type rainfall zone showed that they equal the average flow over a 24 hour period of the runoff from a saturated catchment resulting from a 24 hour rainfall with a recurrence interval of from 2½ to 7½ years, ie approximately the 5 year 24 hour rainfall.

A similar analysis of the Kurere which is in the Waihi type zone showed that the peak of the annual 3 hour hydrograph matched the 15 year 24 hour rainfall on the above basis.

APPENDIX II

Notes on the Basis of Design Floodpump Capacities

Other Scheme Design Standards

The pumping coefficients for stations in the Piako River catchment vary from 6mm to 25mm per day. These cover a range of conditions from those in which the tidal cycle almost always permits some gravity discharge to those where the floodgates may be locked for 2 or 3 weeks continuously and water is at the same time seeping in through the old stopbanks.

The coefficient used for pumps in the Whakatane River catchment was 28mm per day. (See NZ Engineering, February 1968).

Modified Piako Method

The average figure for the Piako catchment may be taken as 19mm per day, and this will be taken as applying to a site where the 10 year river flow can lock the outlet for a continuous period of 2 days. A method was devised of arriving at a coefficient for any site by comparison with the above. The above coefficient was multiplied by both a rainfall factor and a river factor. The rainfall factor is shown on plan 1373. The river factor was 1.0 in the above typical case, was 1.25, 1.5 and 2.0 for 5 year, 2 year and 1 year respective return periods for the same gate lock as above, and was 0.0 in cases where river levels very rarely lock the gates for a complete tidal cycle. This method gave reasonable results and is a useful check on the recommended method.

Waihou Scheme Design Method

The method outlined in the notes is recommended but if the basic data needed for that method is not available the method described above may be used.

Comparison of Methods

A comparison between the two different methods is set out below. Imperial units have been used because the purpose of this action is a comparison with past practice. Different types of catchment have been chosen to give a range of comparisons. Some of the proposals detailed below have since changed or discarded but the calculations are included for comparative purposes only.

Pump Catchment		River Mileage of Outlet	River Flow to Lock the Floodgate	Return Period of 2 day Gate Lock	5 Yearly Period of Gate Lock	5 Yearly Rainfall of to Hours Duration	
Name	Type	m. c	Cusecs	Years	t hours	Inches	mm
Katinga	Rolling to flat	9m 70c	42,000	100+			
Alexanders	Rolling to flat	15m 32c	11,500	90	29	5.5	140
H Drain	Flat	17m 77c	11,000	77	32	3.7	94
Kurere Stream	Steep	19m 74c	8,500	17	100	12.4	315
Matai	Hilly to flat	20m 27c	9,000	22	88	8.8	224

Pump Catchment		Modified Piako Method			Proposed Method		
Name	Area	Daily Runoff to be Pumped		Corresponding 20 Hour Pump Capacity	Calculated Pump Capacity	Equivalent Daily Runoff to be Pumped	
	Acres	Inches	mm	Cusecs	Cusecs	Inches	mm
Katinga	3130	0	0	0	0	0	
Alexanders	2750	1.06	27	146	146	1.06	27
H Drain	8000	0.86	22	345	240	0.60	15
Kurere Stream	1960	3.19	81	136	161	3.78	96
Matai	1670	1.63	41	312	240	1.25	32

APPENDIX C

APPENDIX "A"PEAT MINING RESOURCES SURVEY DECEMBER 1979GENERAL

A large proportion of the flat lands within the Waitakaruru Catchment Scheme area is peatland. Within this peatland, the peat ridge, located mainly between the Maukoro and Pouarua Canals, includes an area of sphagnum moss peat deposits.

A survey has now been carried out by the Hauraki Catchment Board as part of the Waitakaruru Catchment Scheme investigations into the extent of *Sphagnum* moss deposits. This will permit an evaluation of the potential for commercial peat mining in the area. Only sphagnum peat has been mapped in the present survey. It is possible, although considered unlikely, that sphagnum deposits may occur elsewhere in the Waitakaruru peatlands, but a more comprehensive survey would be required to confirm, or otherwise. It is also possible that another commercially useful peat, *Dicranella* peat, may occur in the area, but this has not been specifically searched for in the present survey. It is also acknowledged that restiad peat itself also has some commercial value as a mined resource, but this was not taken into account in the present survey.

FIELD SURVEY

The Board located four survey lines to traverse the flat lands from the western foothills to the Piako River in the east. (ref. aerial photo plans H.C.B. No. 1880 sheets 1-2). These were accurately positioned and levelled and referred to as sections 1-4, see H.C.B. plan No. 1880 sheets 3-6.

Under my supervision, core sampling and identification of the various peat layers was carried out to determine depth and area of sphagnum deposits. In addition, the underlying clay depth was also recorded and each bore logged for position and level in terms of Mean Sea Level datum. Stratigraphy based upon the cores located on the transect lines was checked and confirmed by intermediate probes which are not marked on the transects.

FINDINGS

Based on the results of the survey, and assuming that a depth of 0.1 metres or greater of unconsolidated *Sphagnum* moss peat is necessary to confer 'mining potential' upon an area, it is estimated that the *maximum* extent of the economically viable *Sphagnum* reserves, within the area of the survey, does not exceed 1000 hectares. From the depths indicated by the bores, and using this area of 1000 hectares, approximately 4.0 to 5.0 million cubic metres of sphagnum moss peat is potentially available for mining.

CONCLUSIONS

The figure of 1000 hectares, containing 4.0 to 5.0 million cubic metres of minable sphagnum moss peat is, in my considered opinion, as accurate an assessment of this resource as this type of survey permits in the time available.

Keith Thompson.

KEITH THOMPSON,
University of Waikato,
HAMILTON

APPENDIX D

WAIKATO REGIONAL COUNCIL

Memorandum

File: 60 65 23A, 60 65 61A

DATE: 7 May 1991

TO: Section Manager, Consents

FROM: Senior Technical Officer, Engineering Rivers & Drainage

SUBJECT: **Pouarua Peat Dome, Response to Memorandum of 3 May 1991**

Each of your requests have been responded to below as listed. A full report is programmed for completion at the end of May 1991.

- 1 The existing capacity of the Maukoro canal has been assessed to have a greater than 50% probability (less than 2 yr flood) of overtopping the right bank between the existing Peat Dome and State Highway No. 2. The reach of canal at the southern end through the Pouarua peat dome has been assessed to be able to pass all flows without any overland flow across the peat dome. At flows with a probability of occurrence of less than 10% (greater than 10 yr flood) some overflow will occur eastward along Torehape Road but the quantities will be relatively small and drainage for this overflow will be generally southward along Central Road and Pitts Road alignments.

From the above it can be concluded that the remaining Pouarua peat dome is a defense against the eastward migration of floodwaters until the dome levels fall below anticipated Maukoro canal levels at the northern end of the dome towards State Highway No 2.

The effect of the dome is to retain floodwaters from the Torehape Stream and drainage areas north of Torehape Road, on the western side of Maukoro canal, until they are able to drain northwards along Maukoro canal or overland through lower areas on the western side of Maukoro canal. Ground formations are such that peat shrinkage through drainage has resulted in wide shallow valleys along each drain that are able to store runoff until normal drainage along Maukoro canal or overland flow in a northerly direction and some flow along Torehape Road occurs. Reduction of the peat dome levels below anticipated flood levels would result in overland flow

eastward to Central Road and possibly to the upper area of Pouarua canal. Drainage from these areas is both northwards to the Pouarua canal basin and southwards to the Kaihere canal and Piako River system.

- 2 Low bank levels along the right bank of Maukoro canal, upstream of the State Highway No. 2 bridge, allows overflow when the flow in Maukoro canal through the State Highway No. 2 Bridge is approximately 30 - 35 cumecs. Water levels in the vicinity of overtopping at this flow are between 3.5 - 4.0 m.

The hydraulic model showed that at 30 - 35 cumec flow, the water level at the southern end of Maukoro canal at Torehape Road would be at RL 5.8 - 6.0 m. This has been assessed as being a 20% probability (5 yr) flood at this locality.

Torehape Road, between Maukoro canal and Central Road, has a high level of RL 6.05 m. Water levels at the southern end of Maukoro canal above this level will result in flow to the east along Torehape Road, but because of its length and flat gradient, the quantity of overflow along Torehape Road is relatively small. For example, with water level at RL 6.5 m, the flow along the road has been assessed at 4 cumecs and with water level at RL 7.00 m the flow along the road has been assessed at 15 cumecs.

Drainage along each side of Torehape Road creates an overflow, eastwards at levels above approximately RL 4.5 m, but the overgrown nature of the drains would limit any flow from the southern end of Maukoro canal to 1 - 2 cumecs. This flow is not considered significant, unless these drains are cleared or enlarged. Water that drains eastward along Torehape Road is conveyed southward to the Kaihere canal and Piako River, via drainage along Central Road and Pitts Road alignments.

Levels have been continued southwards along a formed track that extends through the peat from the southern end of Maukoro canal. The track has a high level of RL 6.80 m approximately 1 km south of Torehape Road.

The long section survey of Maukoro canal stopbank and ground levels (WRC Drg. No. 66) carried out south of State Highway No. 2 in August 1990, shows that significant overflow of the right bank of Maukoro canal north of the existing peat dome would be occurring in the vicinity of Waikumete Stream at RL 5.00 m. The Maukoro canal upstream from this locality was modelled over a range of flows up to the 1% probability (100 yr) flow expected in the southern end of the canal. The peak flow at this area has been assessed at approximately 100 cumecs for a 2 hr duration storm and this flow when modelled in the canal requires a level of RL 7.0 m at Torehape Road. At this level, there is overflow along Torehape Road of approximately 15 cumecs and possibly some overflow to the south. It is therefore considered unlikely that under existing conditions, water levels at the southern end of Maukoro canal in the vicinity of Torehape Road will reach a higher level than RL 7.0 m, and, due to existing embankment levels, it is considered unlikely that peak levels in Maukoro canal in the vicinity of Waikumete Stream will reach a higher level than RL 5.0 m.

- 3 Under existing situations, the role of the Pouarua Peat Dome is expected to remain unchanged but it is anticipated that with more rapid settlement of land around the dome, its crest may remain at a more elevated level than the anticipated peak flow levels in Maukoro canal.

Settlement of Torehape Road and land to the west of Maukoro canal is likely to result in lower anticipated peak flood levels as flood waters will more readily escape east along Torehape Road and north along settling land on the west of Maukoro canal.

Scrutiny of the location of the four cross-section lines that were established in 1979, reveals that in the area north of Torehape Road, between Maukoro canal and Central Road, where drainage is established, adjacent ground levels have settled but where no drainage is established, ground levels have settled little and some areas have not settled. The southern three cross-section lines were re-surveyed in 1990 and while all three showed some settlement, the degree of settlement appears related to the amount of drainage. Specifically, Cross-section 3 is located approximately 100 m from a 2 m deep drain running parallel to the cross-section and has 1 m deep drains traversing the cross-section line at 230 m intervals. This cross-section has settled from 0.1 to 0.8 metres over the last 11 yrs.

Cross-section 1 is located approximately 100 m from the Torehape roadside drain and is traversed by two old drains that have all but filled in. This cross-section has settled a maximum of 0.4 m and where the old drains are located, appears to have risen approximately 0.1 m over the last 11 yrs.

Cross-section 2 appears to be influenced only by Maukoro canal and Central Road at each end. Settlement is again 0.4 m maximum near the Central Road end and ground levels appear to have remained the same along the high area near the Maukoro canal end over the last 11 yrs.

It is anticipated that this trend will continue, and if no drainage is established through the high area of the dome, it is expected to remain high while the surrounding pasture land settles, and settle at a lower rate as the surrounding drainage gradually influences the dome.

The capacity of Maukoro canal is likely to reduce as settlement flattens its gradient in the southern end but the amount of out of channel, or overland flow, will increase as peat settlement occurs. Provided future development is planned to retain existing flooding patterns, and drainage from and through the Pouarua peat dome is stopped, it is considered that the existing effect of the dome as a "defense against water" can be maintained and even improved.

- 4 Works that are considered able to better facilitate the role that this area plays in flood management in this vicinity are:
- (a) Delineation of a peat dome management area and closing of all access to the area by stock or grazing animals.

- (b) Re-routing the drain that bisects the dome at the northern end of Smiths license area to run north along Central Road and then traverse to Maukoro canal at the northern boundary of the peat dome management area. The northern boundary of this drain may require stopbanking and the outlet to Maukoro canal may require a floodgate. A low embankment should be formed along the southern side of the drain to Maukoro canal, to block drains from the management area and to retain surface runoff on the management area. The drain that exists through the peat should be backfilled.
- (c) All existing drainage from the management area should be blocked and preferably backfilled. Drains on the landward side of the Maukoro canal right stopbank should be backfilled.
- (d) The practicality of weirs in roadside drains along Torehape Road and Central Road should be investigated to maintain water levels as high as practicable, bearing in mind the integrity of the road embankment.
- (e) Maintenance of roadside drains to be kept to a minimum, and preferably just the occasional spray to control weeds.
- (f) Future development to pastureland be encouraged on the area west of Maukoro canal to maintain the northerly migration of floodwaters through relative land settlement rates.

If you have require any further elaboration, please do not hesitate to contact Guy Russell of the Engineering Services Section.

WM Mulholland
Acting Manager Engineering Rivers & Drainage

APPENDIX E

**INVESTIGATION OF EXISTING AND FUTURE
DRAINAGE REQUIREMENTS FOR THE PIAKO
RIVER, PHILLIPS ROAD TO KAIHERE ROAD
SUBCATCHMENTS.**

Prepared by: Guy Russell
Engineering Services Section

February 1992

Waikato Regional Council
Box 4010
HAMILTON EAST

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Representatives of the Hauraki Plains drainage committees, staff and members of the Hauraki District Council for information and advice on drainage features and problems.

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CONTENTS

ACKNOWLEDGEMENTS		i
CONTENTS		ii
TABLES		iv
MAPS		iv
1 SUMMARY		88
2 BACKGROUND		88
3 DRAINAGE CHARACTERISTICS		89
3.1 Description of Area		88
3.2 Existing Drainage		90
4 INVESTIGATION		93
4.1 Floodgates		93
4.1.1 Phillips Road Floodgate Replacement		95
4.2 Pumpstations		95
5 DISCUSSION OF FUTURE DRAINAGE		96
5.1 Pumping to Pouarua Canal Line		96
5.2 Pumping to Muggeridges Drain		100
6 CONCLUSIONS		102
7 RECOMMENDATIONS		103

TABLES

	Page
I Schedule of Existing Floodgates and Pumps	91
II Schedule of Existing Floodgates, Catchment Areas and Outlet Standards	94
III Schedule of Floodgates, Probable Future Catchment Areas and Outlet Standards	101

MAPS

1 Locality Map	89
2 Location of Existing Floodgates, Pumpstations, Drainage and Subcatchments	92
3 Contour Plan of Clay Levels	98
4 Probable future Subcatchments and Recommended Drainage Services	99

1 SUMMARY

This investigation has found that there is adequate floodgate capacity within the study area to cope with gravity drainage requirements and that any replacement floodgate at the Piako River Phillips Road site should have a minimum outlet area of 3.6 square metres. This is designed to cope with diversion to Phillips Road of the rural portion of the Ngatea township floodgate.

Gravity drainage improvements can be provided for the low peat area by utilising the Muggeridge drain and floodgate system and any future pumping requirements would best serve the area if it was also based on the Muggeridge system.

2 BACKGROUND

As part of the maintenance of the Piako River Scheme standards discussion has arisen on the necessity to replace the existing Phillips Road floodgates with a new floodgate structure. An inspection of the existing structure is proposed to ascertain its integrity and estimate its expected life.

This report is the result of an investigation into existing and possible future drainage requirements for the block of land that lies between the Piako River and Pouarua canals to the East and West and Ngatea township and Kaihere canals to the north and south (see map 1). The report recommends a size and invert level for any replacement floodgate at the Piako River end of Phillips Road and recommends a future pattern of drainage that should provide adequate drainage for the area as anticipated settlement of the peatlands occurs.

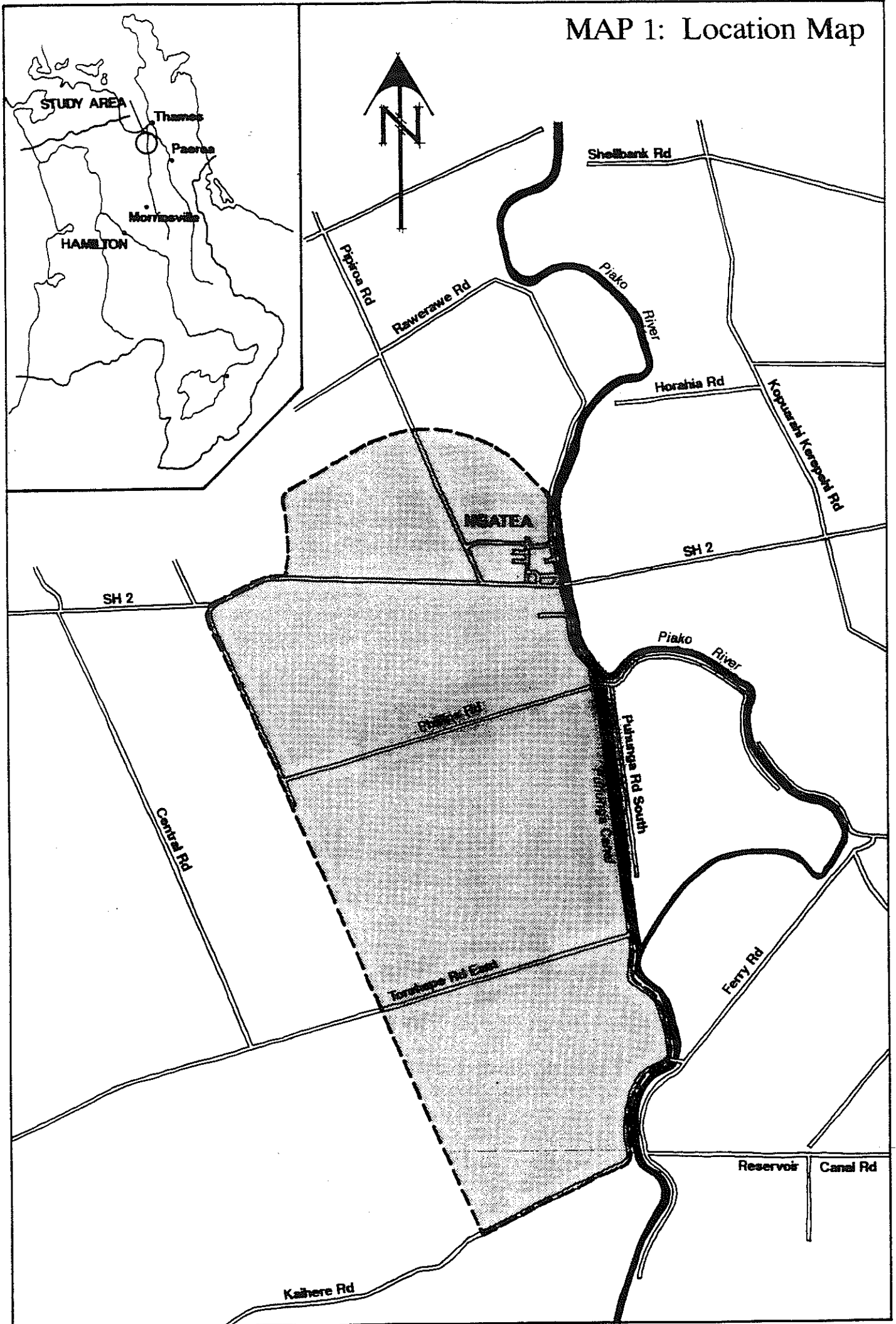
3 DRAINAGE CHARACTERISTICS

3.1 Description of Area

The study area borders the left bank of the Piako River and extends across to encompass the eastern fringe of the Pouarua peat dome that has been isolated from the remainder of the dome by construction of drainage along the Pouarua canal line. The peat area between Phillips Road and Torehape Road contains the existing highest ground levels in the study area and present drainage is generally from the peat area eastwards towards the Piako River. Drainage along the Pouarua canal line falls from the higher peat both northwards to the Pouarua floodgate and pump stations that discharge into the Maukoro canal, and southwards to the Pitts Road floodgate that discharges into the Kaihere canal, a tributary of the Piako River.

Farmland along the Piako River side of the study area is presently at approximately R.L 1.3 - 1.8 metres and has clay foundations that are relatively stable as far as consolidation is concerned. In comparison the peatland along the Pouarua side of the study area has ground levels that range from as low as R.L. 0.9 metres up to the higher ground levels of R.L 4.0 metres. The peat is consolidating at a relatively high rate (estimated at approximately 50mm per year) and in the lower areas gravity drainage is becoming difficult to provide.

MAP 1: Location Map



Historic surveys of the area have shown that the clay levels beneath the peat are generally at mean sea level along the Pouarua canal line with a basin down to - 0.6 to - 0.9 metres between Pouarua canal and the clay land (see Map 3). Deeper 'holes' within this basin have clay levels as low as - 1.8 metres below mean sea level. Continued peat consolidation will therefore result in ground surface levels forming a basin along the eastern side of the Pouarua canal that will not be able to effectively be drained by gravity and will require pumping assistance.

Eventually stopbanking will be required along the entire length of the Pouarua canal and drainage that presently gravitates to the canal will require floodgating and some pumping as and when it can be afforded.

3.2 Existing Drainage

At present, most drainage is conveyed eastward toward the Piako River with the outlets consisting of floodgates and some pumping. The exception is at Kaihere, where a small floodgate and pump serves a local low area and is drained southward into the Kaihere canal, and north of Phillips Road where a few small floodgates (0.5 and 0.6 metre diameter) drain local areas into the Pouarua canal (see Map 2).

Four of the eight floodgates in the study area that drain into the Piako River have been replaced with new floodgate structure since 1988. A schedule of the existing floodgates and pump stations together with their size and invert is provided below as Table 1

Low tide levels in the Piako River at Kaihere Landing have been recorded to normally range between -0.3m to the lowest of -0.5m. An average low tide level is -0.4m. At Ngatea levels as low as -1.0 metres can be expected. Gravity drainage is therefore only practical to drain water levels to say -0.3m to -0.6m adjacent to the Piako River and to approximately mean sea level (msl) in the peat area that lies between one and three kilometres from the Piako River.

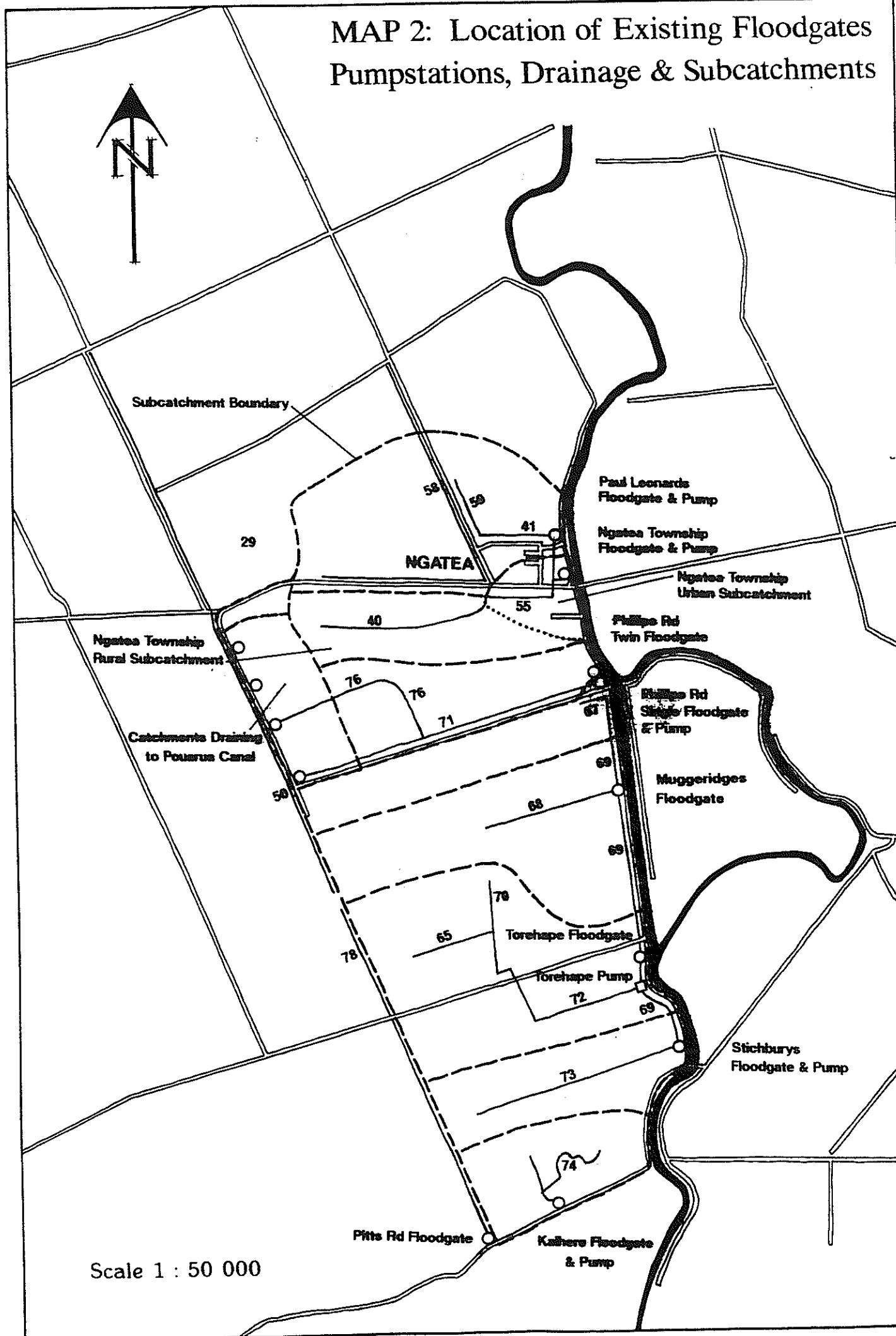
At present ground levels generally fall from the Pouarua canal line eastward across to the Piako River. There is no known outlets, south of Phillips Road that drain the peat area to the east of Pouarua canal line, westward back into the Pouarua canal/Pitts Road drain systems. It is considered that gravity drainage in this area would be most efficient if it is continued to be conveyed directly eastward to the Piako River rather than into the Pouarua/Pitts Road system. The reasons for this are that the distance to the river outlets is shorter and that the outlet inverts are able to be maintained deeper, going direct to the Piako River rather than out the Pitts Road floodgate.

Peat settlement is presently reaching the stage where the eastern edge of the peatland that borders the Piako River clay land has consolidated to have low ground levels at RL 0.9 metres. These low peat ground levels are approximately 0.5 - 1.0 metre below the clay ground levels that lie between the peat and the Piako River. The low areas are reported to be increasing as consolidation continues and gravity drainage is less able to provide adequate freeboard between drain water levels and pasture levels. It is considered that the maintenance of pasture or any more intensive use of the peatlands to the east of the Pouarua canal line will require pump assisted drainage.

Table I

	Floodgate Name	Floodgate Type	Floodgate Dimensions (Metres)		Outlet Area (M ²)	Invert (metres RL)
North	Paul Leonards	twin pipes	1.5 diameter		3.65	-0.78
U	Ngatea Township (new)	pipe and wall f/g	1.8 dia + 1.83 x 1.5 f/g		2.75	-1.00
P	Phillips Road twin	twin box culverts	1.2 square		2.88	-1.00
S	Phillips Road single	single box culvert	1.2 square		1.44	-0.64
T	Muggeridges (new)	pipe and wall f/g	1.8 dia + 1.83 x 1.5 f/g		2.75	-0.76
R	Torehape (new)	pipe and wall f/g	1.8 dia + 1.83 x 1.5 f/g		2.75	-0.42
E	Stitchbury's	single pipe	1.2 diameter		1.17	
A	Kaihere (new)	single pipe	1.2 diameter		1.17	-0.50
M						
South						
	Pumpstation name	Pump No	Capacity		24hr runoff pumping rate (mm)	LEPL
			Cusecs	Cumecs		
North	Paul Leonards	22	40	1.13	15	-1.00
	Ngatea Township	6	22	0.62		+1.00
	Phillips Road	9	21	0.59	6	+1.50
	Torehape Road	8	35	1.00	14	-1.50
	Stitchburys	18	30	0.85	14	-0.50
South	Kaihere	7	12	0.34	14	-

MAP 2: Location of Existing Floodgates Pumpstations, Drainage & Subcatchments



The processes of approving any subdivision and sale of the peatland should include considerations for the requirements of pumping, future stopbanking and drainage as a condition of subdivision approval.

4 INVESTIGATION

The area covered in this study includes three firm boundaries, the Piako River along the eastern boundary, Kaihere canal along the southern boundary and the Picts Road/Pouarua canal line along the western boundary. The study area has no firm northern boundary but it was extended north wards to include the Paul Leonard floodgate and pumpstation so that an overlap with the northern series of outlets would be created that allowed any shortfalls, or overcapacity from the northern area to be included in the consideration.

Floodgate design in the Piako River system has been based on observations and experience with standards being developed based on various outlet areas per unit of catchment area. These standards were then adopted for use in design. Similar methods are used for pumpstation design. A search of the former Hauraki Catchment Board files has found a paper (unsigned and not dated) written during the early 1960's and titled 'Notes on hydraulic Design of floodgates. This paper has been reproduced as Appendix I.

Based on the standards listed in Appendix I this study has adopted as a basis for design a standard of 37 acres of catchment runoff per square foot of floodgate outlet area (160 hectares/m² of floodgate outlet area).

4.1 Floodgates

The existing drainage network has been developed over the years by the relevant local drainage authorities and is presently maintained by the Hauraki District Council under guidance from local drainage committees. The existing system has operated satisfactorily to date with most of the drainage being provided by floodgates. This has been reinforced by the four new floodgates, that have been constructed since 1988, remaining in the location of the original floodgates, but providing larger outlet areas and usually at a deeper invert.

Hauraki Plains District Council staff have indicated that there is a preference for the rural drainage that presently passes through Ngatea township to be diverted across to Phillips Road floodgate to avoid the maintenance of large deep drains in an urban area and to keep urban and rural runoff separate. This request has been incorporated in the options outlined.

Table II below schedules the existing floodgates, their outlet areas, their existing catchment areas and their allowable catchment areas as calculated using the standard of 160 hectares per square metre of floodgate outlet area. The right hand side of the table looks at outlet standards and various catchments are bracketed to show how existing outlet standards compare when catchments are considered together.

Areas have been digitised from boundaries established on a 1:10,000 scale aerial photograph flown in November 1977.

Table II

Floodgate Name	Existing floodgate area (M ²)	Existing Catchment area (ha)	Allowable catchment area	Existing outlet standard (ha/m ²)
Paul Leonards	3.67	370	590	101
Ngatea Township (urban)	2.75	60	440	22
Ngatea Township (rural)		180		87
Phillips Road Twin	2.88	210	460	73 134
Phillips Road Single	1.44	190	230	132 149
Muggeridges	2.75	360	440	131
Torehape	2.75	480	440	175 157
Stitchburys	1.13	240	180	212 172
Kaihere	1.13	140	180	124
TOTALS	18.5	2230		

The overall picture shows that under the existing situation there is more than sufficient outlet area of floodgates for the total area of catchment, however there are some local anomalies.

Paul Leonards floodgate catchment area was estimated from the Hauraki District Council drainage area map No 252 and the above table shows that the catchment has a high standard of outlet area at 101 hectares per square metre.

Map 2 shows how the existing Ngatea township floodgate catchment has been divided into a rural and an urban subcatchment to enable an assessment to be made of the proposal to divert the rural area across to Phillips Road. If the rural portion of the catchment is diverted, the remnant urban catchment would have a very high standard of outlet area but would be able to better cope with the more rapid urban runoff.

Diversion of the rural portion of the Ngatea township catchment is able to be accommodated by the two existing Phillips Road floodgates. The existing outlet standard would become 134 hectares per square metre of outlet area. In considering this, the rear of the Phillips Road twin and Ngatea catchments, for some 800 metres from Pouarua canal, were omitted from the measured area as this block of land presently has gravity drainage to Pouarua canal via four small floodgates located between Phillips Road and State Highway No. 2.

The four southern floodgates (Muggeridge's, Torehape, Stitchburys and Kaihere) have an adequate overall standard of 157 hectares per square metre but individually Stitchburys and Torehape have too little capacity and Muggeridges and Kaihere have too much capacity. A linkage drain presently exists along Kaihere Road and this helps to balance the capacities of Muggeridges and Torehape floodgates. The present link drain is deep and there is some concern at its size when it is located adjacent to a road. Replacement of the present link drain could be affected by extending the present drain No. 70 to link with drain No. 68 (Muggeridges) and upgrading them accordingly. An advantage of this proposal is to provide the low peat area with two alternative gravity outlets.

4.1.1 Phillips Road Floodgate Replacement

Table II shows that the existing Phillips Road floodgates have adequate outlet area and Table I shows the invert to be adequate when compared to the new floodgates that have been installed. It would therefore only appear necessary to replace Phillips Road floodgate if there is shown to be some structural inadequacy.

The catchment that remains to drain to the Phillips Road floodgates (including Ngatea township rural area) totals 580 hectares. Any replacement of the floodgates would therefore require a new structure to have a minimum outlet area of 3.6 square metres. This can be achieved by a wall type of floodgate with twin openings, each 1.22 metres wide by 1.5 metres high or twin pipes, each 1.51 metres diameter.

Invert level of a new floodgate at Phillips Road should be maintained at RL-1.00 metres (Tararu datum) unless it is considered practical to locate the floodgate at a deeper invert.

If Ngatea township floodgate rural area is not diverted to Phillips Road floodgate site then any required new floodgate area at Phillips Road is 2.50 square metres. This can be provided by using the standard wall type of floodgate with an opening of 1.83 metres wide by 1.5 metres high, or a culvert of 1.8 metres diameter. Invert level should be maintained at RL-1.00 metres.

4.2 Pumpstations

A total of six pumping stations presently exist to provide drainage relief during high river levels. The pumps are listed in Table I and the information on this table was taken from the former Hauraki Catchment Board drawing No 1010 sheet 2.

Calculations to size pumping stations in this reach of the river have made allowances for the length of time floodgates may be locked that prevents gravity drainage from the lowest ground levels (for details on the design process see former HCB publication "Waihou Valley Scheme, Design Procedure for Drainage Scheme Proposals" by I McLeod and M Tait, 1975). At present, pumping rates are set to cope with approximately 14mm of runoff over 24 hours. This standard is lower than some other Piako River Scheme pumpstations but is mainly due to the higher ground levels that existed at the time of design and the shorter floodgate lock periods expected in this tidal reach of the river.

Settlement of the peatlands east of the Pouarua canal line will eventually result in low ground levels approaching mean sea level. At this level, floodgate lock that prevents gravity drainage can be expected for periods in excess of 7 days and the maximum rate of pumping the scheme provides will need to be installed. This rate allows for 25mm of runoff in 24 hours, but pump capacities are increased to cope with the volume of water over a 20 hour period to allow for the effects of ripple control on the power supply.

Installation of a pumpstation to provide drainage for the peat area will be driven by the demand to subdivide and develop the peat lands. The present lack of financial assistance for this type of activity requires that all capital and maintenance work is funded by those who benefit from the work. A new pumpstation would therefore be entirely funded by the locals but planning for this work should exist to ensure a co-ordinated approach is taken.

5 DISCUSSION OF FUTURE DRAINAGE

This study has identified the required size for a replacement floodgate at the Phillips Road site where drainage outfalls into the Piako River. The replacement culvert supports the existing drainage network that generally falls from the peatlands adjacent to the Pouarua canal line across to the Piako River. It is considered that to take advantage of deeper outlet inverts and shorter drainage paths, gravity drainage should be maintained towards the Piako River.

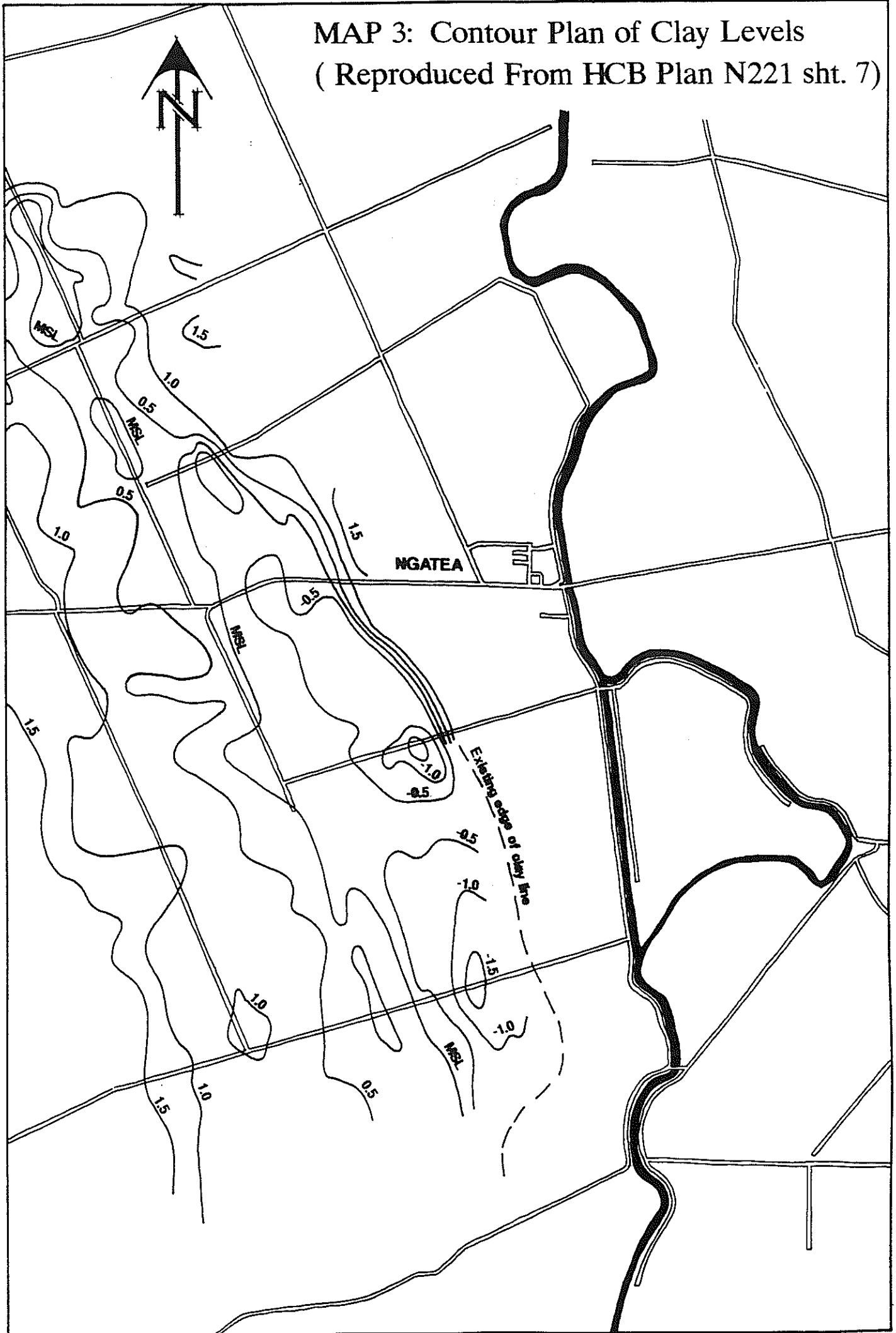
Future land development and settlement will result in a low basin adjacent to the Pouarua canal line with ground levels approaching mean sea level. When this occurs drainage patterns will alter and existing drainage catchments will change. It is considered that there is sufficient floodgated outlets to satisfy future gravity outlet demands but pumping will need to be increased to serve the lower peat basin. Map 3 shows contours of underlying clay levels and Map 4 indicates the likely future drainage catchments and shows the preferred pumpstation location that could serve the peat area. Two options are discussed below but no cost alternatives have been considered at this stage.

5.1 Pumping to Pouarua Canal Line

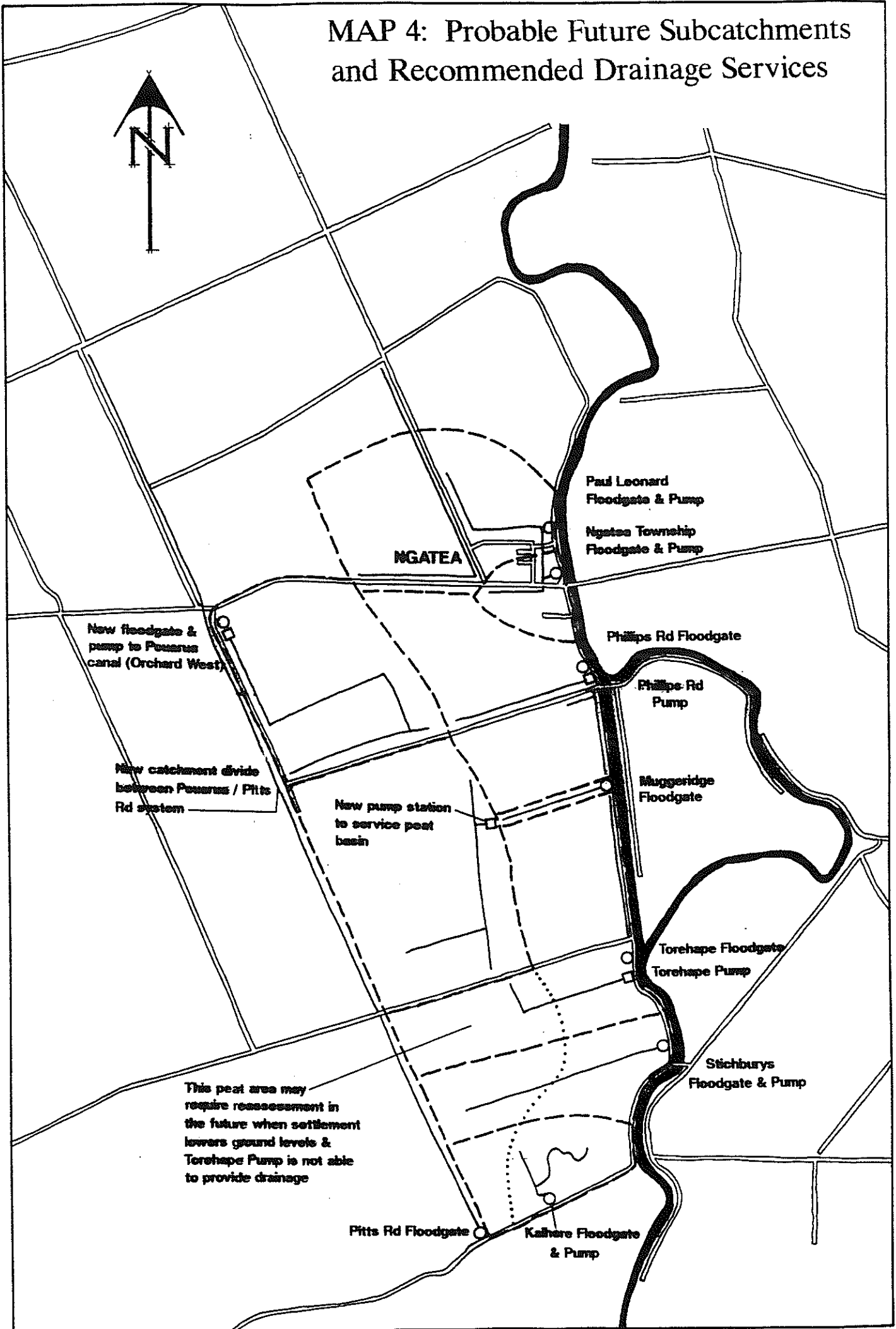
The low basin that will form in the peat area has as its western boundary the Pouarua canal line. At present the area from Phillips Road north drains to Pouarua floodgate and pumpstations that discharge into the Maukoro canal. The canal line in the Torehape Road vicinity drains in a southerly direction to Pitts Road floodgate and into

the Kaihere canal. The present divide between the Pouarua system and the Pitts Road system lies between Phillips Road and Torehape Road but the local drainage authorities have indicated they would like to shift the divide to Phillips Road. This will ensure that water draining from the peat mined areas west of Pouarua canal line drain south to Pitts Road rather than north to existing low lying farmland in the Hopai and Rawerawe areas.

MAP 3: Contour Plan of Clay Levels (Reproduced From HCB Plan N221 sht. 7)



MAP 4: Probable Future Subcatchments and Recommended Drainage Services



This small extension to the Pitts Road catchment drainage will result in any discharge from the future low basin to the east being conducted out Pitts Road floodgate.

Conveying drainage to the Pitts Road system has some advantages after all peat consolidation has occurred but while the western area of peat remains high there are practical difficulties in achieving this option. The land slope is to the east and will remain so during consolidation. This means ponding in low areas will accumulate away from the Pouarua/Pitts road line and a large drain will be required to convey it back through the high peat ground to a pumpstation. The pumpstation sump invert level will most likely be required to be as deep as RL -2.0 to -3.0m and with existing ground level at RL +3.0 to +4.0_m the feeder drain may need to be 5 to 6 metres deep. This depth is impractical to maintain.

If this option was to be pursued it would be prudent to excavate the drain to the Pouarua/Pitts road line at an early stage and progressively increase its size to encourage local consolidation that may allow such a deep invert to be maintained.

This option would also result in stopbanking along the eastern side of the Pouarua/Pitts road canals being required at an earlier stage, firstly due to consolidation in the vicinity of the pumpstation and secondly due to more rapid consolidation of the peat due to construction of drains that would occur more directly to the pumpstation combined with increased frequency of maintenance of the Pitts Road system.

This option appears the least favourable of the two discussed.

5.2 Pumping to Muggeridges Drain

The western edge of the clay along the Piako River will eventually become a terrace approximately 1.5 metres high. This option discusses pumping drainage water from the consolidating peat area up into the present Muggeridges drain to then discharge by gravity to the Piako River.

This proposal maintains the present drainage orientation and would see the enlargement and extension of the present drain No. 70 to become the main collecting drain as it is located in the lowest portion of the consolidating basin. A pumpstation would be located at the western end of Muggeridges drain to lift drainage from the peat basin, up onto the clay terrace. Muggeridges drain will require upgrading and confining by stopbanks to convey the pumped water to the Piako River. In order to prevent this water flowing to other floodgate and pump catchments the stopbanks are proposed to be constructed up to a Piako River 10% probability of occurrence flood (10 year flood) level. This level has briefly been assessed as RL 2.50 metres approximately 1.0 metres above existing clay ground level but the level requires confirmation.

The advantages of this option are that pumping occurs directly from the pond area, and the floodgates that have been constructed to gravity drain the existing drainage catchments can be fully utilised as outlets to the river when peat consolidation occurs. All water that presently drains to the Piako River is maintained to drain in the same direction. The presently higher, western ends of the floodgate catchments will have

their drainage re-oriented to a pumpstation and will outfall via Muggeridges floodgate. The existing clay catchment that drains to Muggeridges floodgate is able to be re-oriented to Phillips Road floodgate to the north and Torehape floodgate to the south. Some drainage will require blocking to prevent the clay terrace draining westward into the peat basin.

Location of a pumpstation at the edge of the clay terrace is considered the best alternative as it will be sited directly adjacent to the pond that forms and will not require a sump as deep as would be necessary if the pump was located at the Piako River or at Pitts Road drain. The alternative of locating the pump at the river would eventually require Muggeridges drain to be deepened to levels of approximately -2.0 to -3.0 metres to effectively drain the peat basin to any pumps. The above option, based on Muggeridges floodgate therefore appears the most favourable of the two discussed.

Eventually the area south of Torehape Road may consolidate to the extent where the present Torehape pump is unable to provide adequate drainage and a new pumpstation or a deepening of the existing pumpstation will be required. The existing Torehape pumpstation has a lowest efficient pumping level of RL -1.50 metres and should be adequate for some time yet. Decisions for this area will best be considered when these problems arise in the future, but a similar concept to the use of Muggeridges drain could be developed using either the Torehape floodgate or Stitchbury's floodgate. When this occurs either Torehape pump or Stitchbury's pump will become redundant and could be used in the new pumpstation.

Table III below schedules the floodgates together with probable future catchment areas and their relevant probable outlet standards.

Table III

Floodgate Name	Floodgate Area (m ²)	Probable future Catchment area (hectares)	Probable future Outlet Standard ha/m ²	Comments
Paul Leonards	3.67	330	90	Some of the rear will drain to Pouarua canal
Ngatea Township	2.75	60	22	Urban catchment
Orchard West	2.19 (required)	350	160	Peat basin pumped up into Pouarua canal
Phillips Road	3.60	360	100	Clay catchment, north and south of Phillips Road
Muggeridges	2.75	470	171	Peat basin pumped up into Muggeridges drain
Torehape	2.75	400	145	Mainly clay catchment with some peat south of Torehape Road
Stitchburys	1.13	240	212	Peat at rear of catchment
Kaihere	1.13	140	124	Remains mainly unaltered

A pumpstation at the western end of Muggeridges drain to serve the future peat basin will need to have a minimum discharge capacity of 1.63 cumecs to pump 25mm of runoff over a 20 hour period. For the same discharge standard a pumpstation in the Orchard West location shown on Map 4 will need to have a minimum capacity of 1.21 cumecs. It is considered that these pumpstations should be twin pump structures to allow a two stage installation as peat consolidation occurs, and eventually for there to be a duty pump and a flood pump.

6 CONCLUSIONS

This study has found the following list of conclusions:

- i) The design standard for floodgate outlets in this study area has been adopted as 160 hectares of catchment area to 1.0 square metre of floodgate outlet area.
- ii) There is presently sufficient floodgate outlet capacity draining the area on the left bank of the Piako River between Ngatea and Kaihere canal that extends back to the Pouarua canal line.
- iii) The rural area that presently drains to the Ngatea township floodgate is able to be accommodated by the present Phillips Road floodgates without reducing the outlet standard below design standards.
- iv) The existing Phillips Road twin floodgate has its invert at RL-1.00 metres. This is considered to be adequate as the tidal range would not allow much advantage if the invert was located deeper.
- v) Replacement of the existing Phillips Road floodgate is therefore only considered necessary if an inspection reveals structural inadequacies.
- vi) When Phillips Road floodgate is replaced, the new floodgate should have a minimum outlet area of 3.60 square metres. This can be achieved by a wall type of floodgate with twin openings, each 1.22 metres wide by 1.5 metres high or twin pipes, each 1.51 metres diameter. Any new floodgate should have its invert no higher than RL-1.00 metres.
- vii) Discussion on drainage of the consolidating peat that lies between the Pouarua canal line and the Piako River clay has concluded that present gravity drainage may be improved by extending the present drain No 70 in a northward direction to connect it to Muggeridges drain No 68. Muggeridges drain will require upgrading to take advantage of its deeper invert of RL-0.76 metres.
- viii) Eventual consolidation of the peat will result in ground levels lower than mean sea level and a requirement to provide drainage by pumping. Discussion has concluded that the area would best be served by a pumpstation located at the western end of Muggeridges drain (No 68) on the edge of the clay terrace. Stopbanks formed along both sides of Muggeridges drain will allow pumping

to continue up to a 10% probability (10 year) flood level in the Piako River of approximately RL 2.50 metres.

7 RECOMMENDATIONS

- i) Replacement of the Phillips Road floodgates should only be undertaken if the existing floodgates have structural inadequacies.
- ii) Any new floodgate at the Phillips Road site should have a minimum outlet area of 3.60 square metres and its invert located no higher than RL-1.00 metres.
- iii) Drainage of the peat area to the east of the Pouarua canal line is best achieved by using the Muggeridge drain and floodgate system.

APPENDIX I**HAURAKI CATCHMENT BOARD****NOTES ON HYDRAULIC DESIGN OF FLOODGATES****1 Invert Levels**

It is desirable in the interests of drainage to make invert levels of floodgate structures correspond approximately to low water levels of the river or waterway into which they discharge. Additional depth, to provide for some waterway in the structure at low tide conditions is desirable but has to be balanced against capital costs and additional maintenance of drains and outlet channels.

As a general principle it has been taken that the floodgate should be capable of accommodating its full discharge capacity without the necessity of flooding the lower lying lands in the vicinity and that the invert level should be approximately at the low water levels which can be expected on the completion of the scheme works. An invert level of -3.5ft has been adopted for the structures from the mouth to Settlers Drain (No 13) after which the inverts will follow a gradient rising to approximately -2.5ft at Ngatea.

2 Floodgate Diameters and Spacing**General Principles of Design**

The general basis of design for flat river side lands such as occur on the west bank of the Piako River in the Hauraki Plains West Drainage District has been to allow for a discharge of 1½" to 2" on the catchment, river levels being assumed to have risen at a rate rather more rapid than has been the case in the past, due to the anticipated accelerating effects of the scheme itself. It is an important point that as much gravity drainage as possible should be available in the first day or two of the storm period since it is much less costly both in capital and operating costs, to dewater by floodgate than by pump.

The discharge figure of 1½" to 2" is not thought to be too large because farm drainage methods have been developing over the last decade and main drains will in all probability, be gradually developed to carry about 2½" runoff. Under low river conditions, the floodgates will discharge approximately this amount.

There is a point for each stage of the river along its length where low tide levels correspond with ground levels. Upstream of this point gravity drainage ceases to operate completely under these particular conditions of river flow. Up to Ngatea it has been considered that there would be some gravity drainage up to a flow of about 5000 cusecs. South of Ngatea such a flow causes a cessation of gravity drainage, and floodgate capacity must be considered in relation to smaller floods.

In arriving at some general basis for consideration of floodgate capacity, the provision of pumps was allowed for above the 4M 40C mark.

Taking the above factors into account, the following catchment areas were considered as reasonable for a 48" diameter single floodgate (other pipe sizes pro-rata according to cross-sectional area of pipe).

REACH OF PIAKO RIVER	CATCHMENT FOR A SINGLE 48" FLOODGATE	STANDARD
From mouth to Pipiroa Bridge (2M15c)	720 acres	57acres/sq ft or 250ha/m ²
At Rawerawe Road (4M65C)	580 acres	46 acres/sq ft or 200 ha/m ²
At Ngatea (7M60C)	460 acres	37 acres/sq ft or 160ha/m ²

Average values for existing structures were interpolated in terms of this table and the location of additional structures tentatively decided. It is very difficult on flat land with an inter-connecting network, to determine the catchment for any particular drain or floodgate.

An inspection of floodgates in June of this year indicated that their condition was worse than had previously been thought, particularly on the eastern side of the river. Some of the main faults, apart from inadequacy of size are:

- a) Structure far too short to carry the size of bank now proposed;
- b) Settlement has caused pipes to move relative to each other, thus giving conditions for potential failure. Several near failures have occurred recently from this cause, heavy leakage causing erosion of bank above the joint;
- c) Settlement has caused a sag near the centre of the pipe. This by itself would not be very serious but it leads to the condition of b) above;
- d) Some corrosion of concrete and in some cases steel exposed and corroded, and cracking of wing and headwalls;
- e) Structure too near to proposed edge of river in new scheme;
- f) Invert level too high;
- g) Leakage occurring underneath and around structure.

Many of the structures have been in service for over 40 years.

In the Hauraki United Drainage District a terrace of higher country runs generally parallel to the river at a distance from it, varying from a few chains to over a mile. The terrace lands, of a different soil type, require more intensive drainage in order to make the land reasonably productive. The result has been that contouring and farm drain development on the terrace country has, during recent floods caused abnormally heavy run-off on to the low flats bordering the river.

A case therefore exists on the east bank for a greater discharge capacity than on the west bank and provision is made for twin floodgates on the three major drains in the reach which carry a considerable proportion of higher terrace run-off. It is essential that this runoff be discharged into the river with the least possible delay.

It also happens that on the east bank, below Ngatea there are more faulty undersized and badly situated structures than on the other, consequently a greater proportion of the new construction will be required on the east bank.

ER6070

APPENDIX F

ENVIRONMENT WAIKATO

Memorandum

File 83 01 00

DATE 22 February 1993

TO Project Manager and Operations Manager, Waihou/Piako Projects

FROM Senior Technical Officer, Engineering, Rivers & Drainage

SUBJECT DRAFT SCHEMATIC DRAINAGE PROPOSALS FOR MAUKORO -
POUARUA AREA

1 INTRODUCTION

Land development and applications to subdivide parts of the Landcorp, Central Road block, has initiated requests for a drainage scheme for the area. In March 1992, a memorandum outlining a preliminary assessment of drainage requirements was circulated to the Regional Council's Waihou/Piako Project staff, District Council staff, drainage committee representatives, Landcorp and Department of Conservation staff for comment. A meeting of representatives was held in Ngatea on 21 April 1992 to discuss the proposals, and an alternative was promoted that based all pumping from the area on the Muggeridge drain system.

The proposal based on Muggeridge's drain was preferred and this memorandum is a draft outline of the scheme, for discussion and adoption in principal by the affected parties. Copies of this memorandum are being circulated to Hauraki District Council staff.

The area covered in these proposals includes the block of land south of State Highway 2 and east of Maukoro canal across to the Piako River (see Map 1). The area east of the Pouarua canal/Pitts Road drain line has been investigated in the Waikato Regional Council's Draft Technical Publication 1992/1, and the conclusions and recommendations from that report have been incorporated in this proposal. Some minor modifications to the probable future subcatchment drainage have been

made to allow all pumping from the low peat areas to be based on Muggeridge's drain.

2 POUARUA SCHEME

The area north of State Highway 2 that drains to the Pouarua and Maukoro canals has been investigated during the 1960's and a scheme for this area produced by the former Hauraki Catchment Board titled 'Pouarua Canal Scheme (with pump assisted gravity outlet)' was produced. This proposal remains relevant and the standards for floodgate outlets and pump-stations remains adequate.

Briefly, the scheme proposed limited height stopbanks along both sides of the Pouarua canal up as far as State Highway 2 with compartments of land either side of the stopbanked canal having gravity outlets to the canal and pumping up into the canal during flood times. The Pouarua canal outlet into Maukoro canal was to be a large gravity outlet assisted by pumps during high levels in Maukoro canal.

The area south of State Highway 2 was to gravity drain into the stopbanked reach of Pouarua canal as ground levels in this area were above the stopbank levels proposed along Pouarua canal. While this remains the situation to date, peat consolidation will result in ground levels reducing to be less than the proposed stopbank levels and further considerations are necessary to address this. Also the increased runoff from development of the peat through mining and conversion to pasture has accelerated runoff rates and worsened the flooding situation in the Rawerawe and Hopai areas as the proposed Pouarua Scheme has not been constructed.

3 SURROUNDING FEATURES

The study area is enclosed by four features, and each provides a specific function that enables the area of concern to be developed while providing drainage and flood protection. The four features are outlined below and shown on the attached sketch plan of the area.

3.1 Southern End Protection from Piako River

The southern end of the study area is prone to flooding from the Piako River. Protection is presently provided by stopbanking along Kaihere Road to the Waikoura Stream, and a stopbank along the Waikoura Stream left bank that continues northwards to meet high ground adjacent to the present drain along the Central Road line. The present Department of Conservation (DOC) block of land contains the high ground adjacent to the Waikoura Stream that prevents the northward migration of floodwaters and the maintenance of these high ground levels is vital if it is to continue to be the barrier to floodwaters.

The present drain along the Central Road line bisects the DOC land and allows Piako River water to back up to Torehape Road. At present, road levels and ground levels are sufficiently high so that flooding does not occur, but eventually this drain

will become a problem. This report recommends that the drain is blocked near its downstream end to allow the continuation of the Waikoura stopbank across the drain as necessary, and that the Central Road drainage that presently uses the drain is diverted across to Pitts Road drain along a convenient boundary, north of Torehape Road (see 5.1). The redundant drain through the DOC block of land can either act as a stormwater buffer, or be filled.

3.2 Protection from Western Hills Runoff

At present the high ground levels of the Pouarua Peat Dome between Maukoro canal and Central Road prevent the eastward migration of floodwaters from the western hills. Reduction of these ground levels through peat consolidation reduces the degree of protection the high ground levels provide, therefore drainage and development of the land between Maukoro canal and Central Road should only be permitted if a stopbank is constructed along the eastern side of Maukoro canal.

Investigations have shown the relevant flood levels along Maukoro canal that a 1% probability flood (100 year flood) could attain are RL 7.00m at Torehape Road, RL 5.00m at the confluence of Maukoro canal and Waikumete Stream and RL 4.50m at State Highway 2 under existing conditions. This situation would see flood waters overtopping the Maukoro canal right bank in the Waikumete Stream area, as will happen at present. Replacement of existing ground levels with a stopbank to the above levels will provide for approximately the status quo through the southern area and some improvement in the northern area. As peat consolidation occurs on the western side of Maukoro canal the degree of protection provided by any eastern Maukoro stopbank will increase. Future re-appraisal may result in an alteration to the required stopbank levels as ground levels and flooding patterns change with peat consolidation.

3.3 Pouarua Canal Scheme

North of State Highway 2 the Pouarua canal scheme (with pump assisted gravity outlet) still remains relevant. Proposals to improve drainage in this area are to be based on the scheme proposals. This scheme was to be implemented as part of the Waitakaruru scheme but the lack of approval by Central Government has resulted in the overall scheme not proceeding.

Drainage improvements in this area should be based on the Pouarua scheme proposals and standards. The proposals are detailed in the former Hauraki Catchment Board report and on drawings number 471, 472 and 473A.

Under present conditions, runoff from the study area, west of Pouarua canal, is conveyed north to the Pouarua canal scheme area. As scheme proposals have not been completed the canal capacity is rapidly exceeded and flooding of the low lying land occurs.

3.4 Piako River

The eastern boundary of the study area is the Piako River and the drainage areas of the clay land along the western side of the river that drain into the Piako River. This area was investigated in early 1992 to ascertain the drainage requirements and floodgate outlets for the block of land between the Pouarua canal/Pitts Road drain line and the Piako River. The report produced is titled "Investigation of Existing and Future Drainage Requirements for the Piako River, Phillips Road to Kaihere Road Subcatchments" by G. Russell, February 1992. The report identified the probable future subcatchments and recommended some drainage services that may be required when peat consolidation creates two distinct areas to be drained (low peat basin and higher clay ridge).

This study incorporates the findings of the above report and recommends some small changes to the drainage within the peat basin area.

4 STUDY AREA FEATURES

The above four features enclose the study area and are shown on MAP 1.

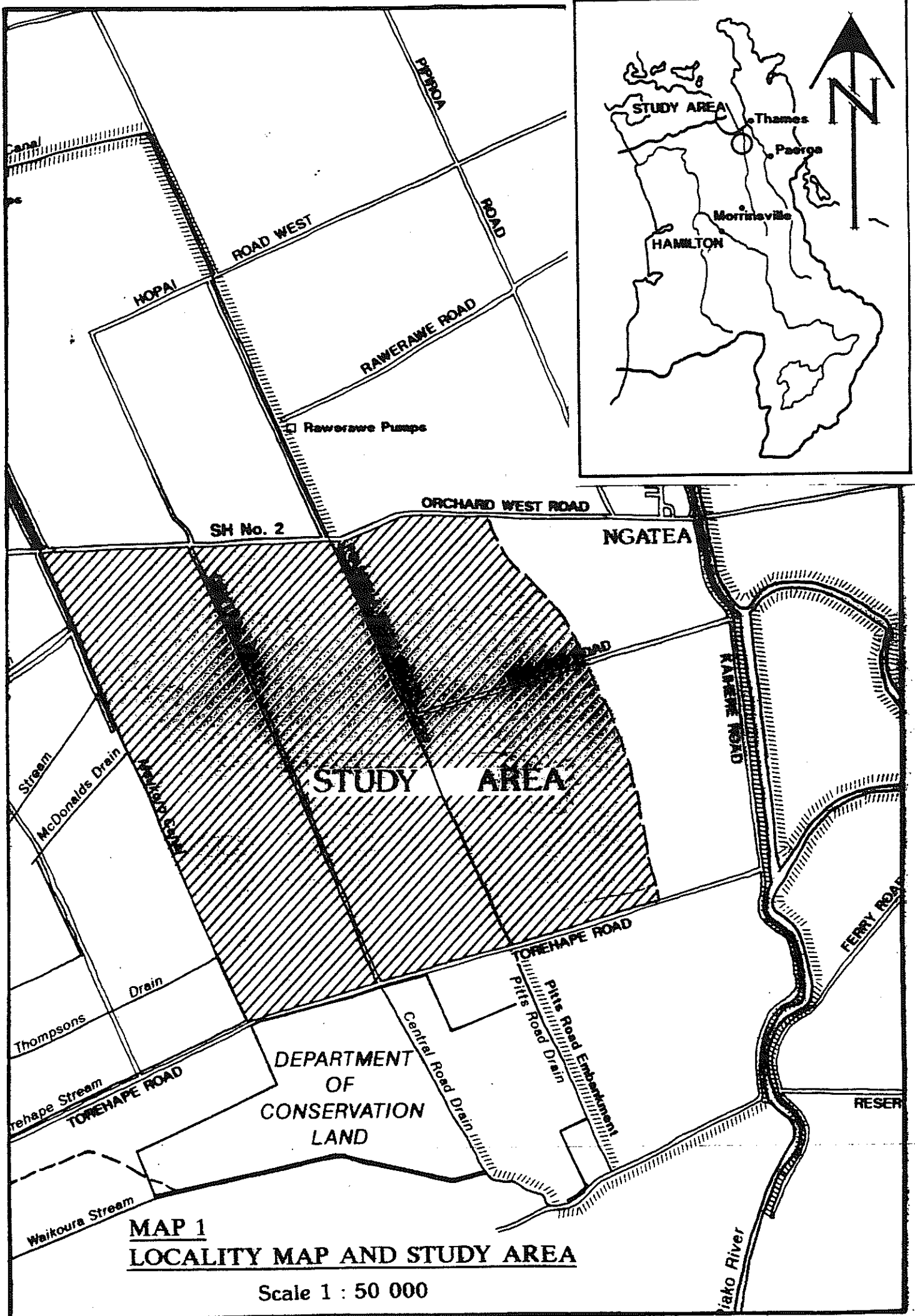
4.1 Existing Ground Contours

The study area is largely the top and eastern side of the Pouarua peat dome. Existing ground levels in the south-eastern corner of the study area are as high as 8 metres above mean sea level and the ground surface levels fall to approximately 2 metres along State Highway 2 and as low as 1 metre above mean sea level adjacent to the clay terrace at the eastern boundary.

Existing drainage at the north-western corner is conveyed into the Maukoro canal, drainage along the southern boundary is taken to the Kaihere canal with the remainder going eastward. The Pouarua canal intercepts eastward draining water and conveys it northwards into the Hopai area. Drainage East of the Pouarua canal is conveyed across towards the Piako River.

4.2 Underlying Clay Contours

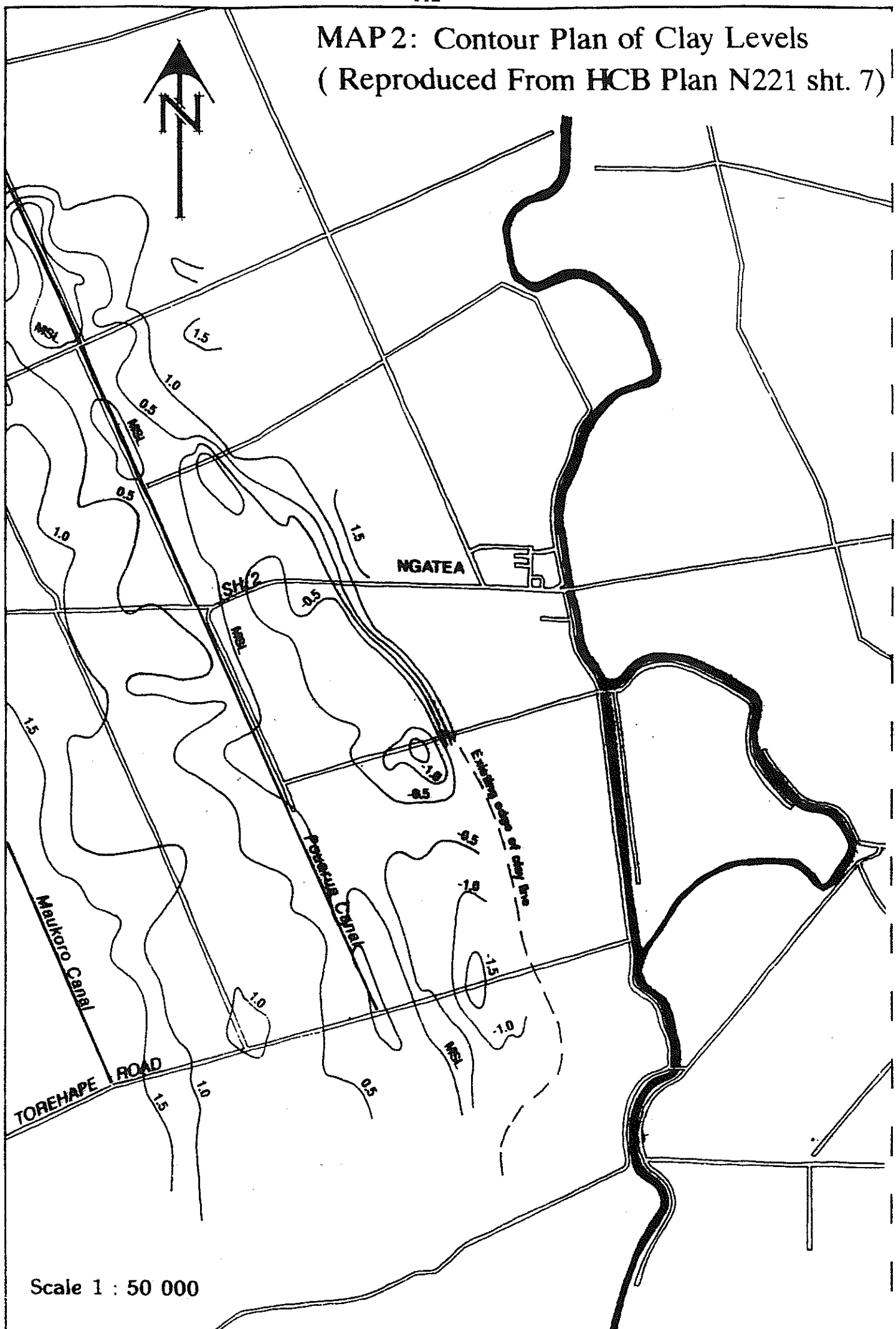
Map 2 shows contours of the underlying clay surface levels. Contours generally run parallel to the Maukoro canal and Pouarua canal lines. Levels fall from approximately 1.5 metres above mean sea level at Maukoro canal through mean sea level at Pouarua canal to be approximately 1 metre below mean sea level along the edge of the clay terrace adjacent to the Piako River. It can therefore be assumed that when all the peat has consolidated or oxidised the ground surface level will fall from the west to the east.



MAP 1
LOCALITY MAP AND STUDY AREA

Scale 1 : 50 000

MAP 2: Contour Plan of Clay Levels (Reproduced From HCB Plan N221 sht. 7)



Scale 1 : 50 000

4.3 Gravity Drainage

Under normal drainage conditions (i.e. drains less than bank full), all land that is above, say, mean sea level can drain to the Piako River or the Maukoro canal by gravity. Land below mean sea level will need to be provided with drainage through pumping. This means that in the long term, the study area east of Pouarua canal will need to be provided with pumping for normal drainage, while the area west of Pouarua canal can continue to drain by gravity. At present all of the study area drains through gravity with some assistance by pumping to the Piako River for the low areas to the east.

The present dome shape of the ground surface means that on the west side of Pouarua canal, drainage in the southern half of the study area goes south to the Kaihere canal, and drainage in the northern half of the study area goes north to the Hopai area. This general pattern is to remain.

4.4 Pumping

In times of high runoff rates, or when gravity outlets are closed, ponding occurs on low land outside the study area. Drainage that goes north along the Pouarua canal floods low land in the Hopai area. The rate and volume of runoff has increased with peat mining and development to pasture and consequently pumping is required to clear floodwaters. These floodwaters are presently cleared to the Maukoro canal via Pouarua floodgate and pumps.

High runoff rates that migrate south along the Pitts Road drain pond behind stopbanks in a largely undeveloped corner and drain to the Kaihere canal through Pitts Road floodgate. It is unlikely that a pumpstation will be required at this site as it is adjacent to the DOC block of land.

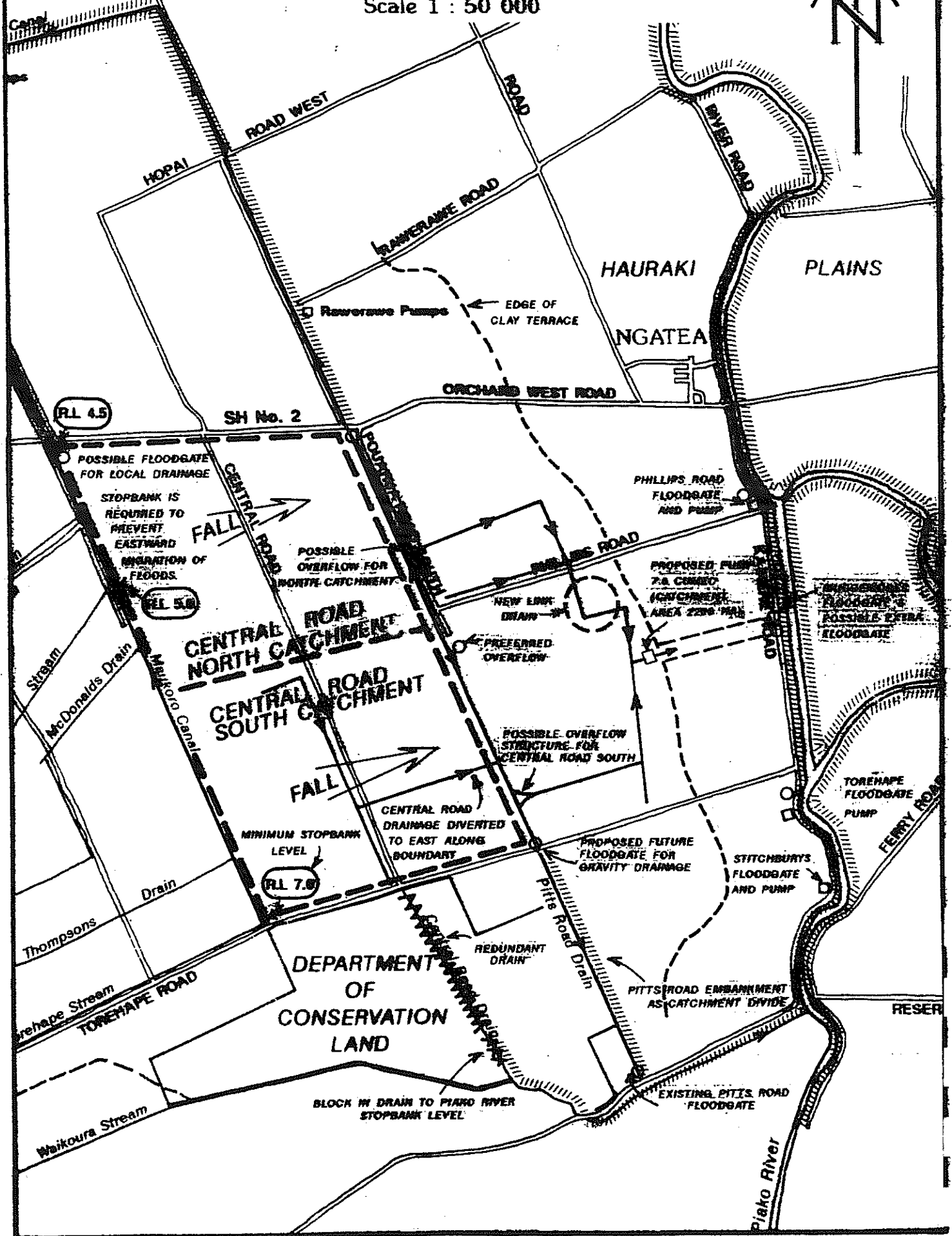
The area east of Pouarua/Pitts Road line has ground levels as low as 1 metre above mean sea level and presently is drained via Phillips Road floodgate and pump and via Muggeridges floodgate. This area will require more pumping in the future as ground levels reduce.

5 PROPOSALS

The proposals are shown on MAP 3 and generally follow existing ground contours with consideration of the underlying clay contours that will eventually dominate the direction of drainage. Normal drainage is to make as much use of gravity outlets as is practical. Pumping from the study area is to be based on Muggeridge's drain that discharges to the Piako River.

MAP 3 SCHEMATIC DRAINAGE PROPOSALS FOR POUARUA PEAT DOME AREA

Scale 1 : 50 000



5.1 Central Road Drainage

The southern Central Road drain that extends through the DOC block of land is presently a direct link to the Piako River (see 3.1). Existing drainage along both sides of Central Road as far as Torehape Road can remain but this drainage is to be diverted across to the Pitts Road drain. A drain alignment removed from Torehape Road, should be chosen along a convenient property boundary and Map 3 indicates the preferred locality. Drainage along the western side of Central Road will need to be culverted to the eastern side of Central road when the drain through the DOC land is blocked. This may necessitate Pitts Road floodgate size being doubled, but if present drainage patterns are maintained, the extra floodgate area will eventually be required in the existing Central Road drain.

5.2 Pitts Road Drain

This drain is to continue its present function as long as is practical. The blocking of the Central Road drain through the DOC block may necessitate an extra floodgate at this locality but future demands and performance will determine its worth.

Peat consolidation will eventually require pumping to be installed and this is proposed to be located at Muggeridges. An overflow structure will be required from the drain north of Torehape Road to allow floodwaters to travel eastward to Muggeridges. A floodgate may be necessary beneath Torehape Road to prevent runoff from the DOC block from travelling north to the overflow structure.

Timing for construction and relevant levels for any overflow structure will be determined by future surface settlement and the requirement for pumping. It may be practical to construct only one overflow structure for runoff from both the northern and southern Central Road catchments (see 5.3), but future surveys and investigation will be required before any decision can be made. At present this study is proposing two separate structures as there are two directions of drainage along the Pouarua/Pitts Road line. (Central Road north area drains north via Pouarua canal and Central Road south area drains south via Pitts Road.)

5.3 Pouarua Canal

Drainage that travels northward along the Pouarua canal is presently causing flooding problems in the Hopai area. The proposals for this canal is to retain the ability to use gravity drainage during normal drainage conditions, but when runoff begins to cause flooding, the runoff from south of State Highway 2 shall overflow eastward from the canal and travel to the proposed pump station at Muggeridges.

An overflow structure is therefore required for floodwaters to travel eastward, and with the present drainage configuration and gradients, the probable best location is between State Highway 2 and Phillips Road. A location south of Phillips Road would be preferable, but more specific investigation is required to site the structure.

It is proposed that the overflow structure would operate when water levels in the Pouarua canal north of State Highway 2 began to cause flooding. From the Pouarua canal survey undertaken in 1962 (HCB drg No. 473A), low bank levels along the canal north of State Highway 2 are at 1.3 to 1.4 metres. It would therefore initially appear appropriate to set an overflow level in the vicinity of 1.2 metres. Further investigation is required to determine the nature and location of any overflow structure.

The overflow structure level and potential canal water levels north of State Highway 2, mean that a floodgate will be required in the Pouarua canal at State Highway 2.

Construction of the overflow structure should only be undertaken when pumping to Muggeridge's drain has been installed to cope with the overflow water.

5.4 Area East of Pouarua Canal

This area of land has been considered in the February 1992 report "Investigation of Existing and Future Drainage Requirements for the Piako River, Phillips Road to Kaihere Road Subcatchments". That report identified the existing drainage and the probable future drainage services that would be required when peat consolidation reduced ground levels.

This study proposes a change to the drainage configuration for the area between Phillips Road and State Highway 2. The change includes providing a drainage link to the proposed pump station at Muggeridges to allow high runoff rates to be pumped. While ground levels are still relatively high, the existing outlets to both the Pouarua canal and to the Phillips Road floodgates and pump are to be utilised, however, a floodgated control will be required at the western end of the clay terrace on Phillips Road drain, to prevent drainage of water from the clay terrace back to the proposed Muggeridges pump.

The area south of Torehape Road and east of Pitts Road, may also require reassessment in the future when settlement lowers ground levels and Torehape Pump is not able to provide drainage. It is considered that this area would also be best served by a linkage to the proposed Muggeridges pump or a relocation of either Stinchbury's pump or Torehape pump at the western edge of the clay terrace.

5.5 Implementation

With the exception that areas north of State Highway 2 become flooded with runoff from the study area, the present drainage system is adequate, but continually requires upgrading. The most recent upgrading was undertaken to Muggeridge's drain to provide improved gravity drainage to the low peat area west of the Piako River clay terrace. This area is likely to require drainage assistance through pumping in the near future.

The most likely order of implementation visualised at this stage is:

- i) Connection of Central Road drainage across to Pitts Road. Includes culvert beneath Central Road and blocking redundant drain.
- ii) Completion of stopbank along eastern bank of Maukoro canal. Local floodgates can be incorporated in this work.
- iii) Construction of a pumpstation at the western end of Muggeridges drain, to cope with local drainage (1.7 cumecs).
- iv) Connection of area north of Phillips Road and construction of second unit at Muggeridges pumpstation (extra 1.2 cumecs).
- v) Construction of overflow structure in east bank of Pouarua canal and linking to Muggeridges pump for the northern Central Road catchment. Includes construction of a floodgate in Pouarua canal at SH2 and further pumping at Muggeridges. (A further 2.4 cumecs but depends on catchment that will overflow.)
- vi) Construction of overflow structure in east bank of Pouarua canal to connect the southern Central Road catchment with Muggeridges pump. Includes construction of a floodgate in Pitts Road drain at Torehape Road and further pumping at Muggeridges (a further 2.3 cumecs).

More detailed investigation may show that one overflow structure is practical. A single overflow structure should be located midway between State Highway 2 and Torehape Road and when the Central Road south area requires access to pumping, drain regrading of the upper Pitts Road drain will connect drainage with the overflow structure.

Parts iii), iv), v) and vi) or any lesser combination, could be constructed at the same time, and this may be more convenient for the pumpstation construction. The total pumpstation capacity is 7.6 cumecs based on 25 millimetres of runoff over a 20 hour period.

6 STANDARDS FOR DESIGN

Floodgate outlet areas are to be based on the Piako River Scheme standard for the area south of Ngatea ie one square metre of floodgate area to 160 hectares of catchment.

Pump station sizes have been estimated based on a runoff of 25mm being pumped over 20 hours. This figure may require increasing or decreasing depending on the length of time that the floodgated outlets remain locked closed during high outlet water levels (see former HCB publication "Waihou Valley Scheme, Design Procedure for Drainage Scheme Proposals" by I McLeod and M Tait, 1975).

Stopbanks or embankments should have a minimum top width of 3.5 metres with side slope batters of 3 metres horizontal to 1 metre vertical.

Design of drains is to allow for a runoff of 38mm (1½") in 24 hours, recognising that with cleaning and maintenance this will eventually become approximately 64mm (2½") runoff in 24 hours.

Guy Russell

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