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Archaeology at Opita

Three Hundred Years of Continuity and Change

Part Three: Appendices 11-19

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THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makarau

"The boundary of the Opita pa on the ground is a ditch."
Rapata Te Pokiha (Tareranui and Pokiha 1878:328)

It was Rapata Te Pokiha's statement in the Maori Land Court records that prompted the authors, plus students of the 1991 University of Auckland Anthropology Department Archaeological Field School, to investigate the location of Opita pa in a river bend at the junction of the Ohinemuri and Waihou Rivers near Paeroa.

The pa (Maori fortification) proved elusive, but in the search, evidence of a series of nine small kainga (Maori villages) and the pa were uncovered. The main focus of the investigations was on a riverside terrace that contained four overlapping occupations separated by layers of flood silt and sand. Distinctive artefacts and features on this terrace allowed the linking of all the other sites in a chronology spanning 300 years.

These kainga represented intermittent occupation of the Opita area, in which changes and continuities over time were evident. Some of the changes were due to the influence of the new European materials, foods and ideas. Nonetheless, it was clear that Maori often incorporated these new materials into an essentially Maori world. Our understanding of the processes was enriched by information from both Maori accounts and the observations of early European visitors. In the later phases of occupation, this combined information allowed the distinction between foodstuffs cultivated, gathered, hunted, raised and traded; and between goods consumed on the site, prepared and exchanged for external materials; as well as items brought in by outsiders. In other words: the evidence presented a much more complex mix of activities, production and consumption than could have been achieved by archaeological information alone.

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Caroline was a student at the University of Auckland, and her PhD research on Maori settlement along the Waihou River was the reason for the investigation of Opita. Her thesis was later published in 2000 as, *Waihou Journeys: The Archaeology of 400 Years of Maori Settlement*, published by Auckland University Press. She has lectured in archaeology at The University of Auckland and Te Whare Wananga o Awanuiarangi, published academic articles and presented conference papers and seminars, both locally and internationally. Her research questions include how to identify dynamic settlement systems, continuity and change, small-scale cultural changes, and issues of ethnicity and identity using landscape approaches, contextual archaeology and multiple causality.

Recently Caroline Phillips and Harry Allen jointly edited B*ridging the Divide: Indigenous Communities and Archaeology into the 21st Century* (2010) published by Left Coast Press. They are part of a research team studying "The Cultural Significance of Wetlands in Taranaki"; and they previously worked together along the Waihou River on an indigenous training scheme that resulted in the publication *Taskforce Green/University of Auckland Archaeological Project, Waihou River* (1993), published by the Department of Anthropology, University of Auckland.

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Harry is an Australian trained archaeologist, who has conducted archaeological research in New Zealand, Australia and Southeast Asia. Harry Allen recently retired from the Department of Anthropology at Auckland after forty years of teaching, research and research supervision. He is a past Trustee of the New Zealand Historic Places Trust, a past member of its Maori Heritage Council and an Honorary Life Member of the Trust. He has published numerous articles on New Zealand archaeology and the protection of cultural and archaeological heritage. Harry Allen was awarded an ONZM in the 2008 New Year's Honours for his services to archaeology in New Zealand.

The University of Auckland acknowledges the contributions of all authors. This publication has been peer reviewed, and all reasonable efforts have been made to ensure the accuracy of the materials published herein.

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Cover Photograph: The team excavating Squares F and H, Trench C is out of shot to the left, the line of white spoil behind is Trench B and the stopbank and Coromandel Ranges are in the distance. Photograph taken by Harry Allen around mid-February, 1991.

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Archaeology at Opita

Three Hundred Years of Continuity and Change

Part 3

Appendices 11-19

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Appendix 11 Bone Analysis

Stuart Hawkins, Heather Adams, Beverly Butler, Elaine Cooper and Caroline Phillips

Methods

The faunal assemblages were first identified by students as part of the undergraduate paper associated with the Field School: mammal bones by Butler and Cooper; fish and birds by Adams. Subsequently the mammal bone, and some fish bone material included with it, was identified by Stuart Hawkins using the University of Auckland Anthropology Department reference collection with the aid of illustrations (Evans 1993, Getty 1975). The bird bone and other fish bone, identified by Heather Adams with reference to Brian Gill and the Auckland War Memorial Museum Ornithology Reference Collection, and the Faunal Reference Collection, Anthropology Department, were added to these revised identifications.

All identifications were made to the lowest taxonomic level possible. Tentative identifications have the prefix cf and most bones could only be identified as mammal. The bones were quantified using number of identified specimen present (NISP) for all species and, for the pig and dog bones only, the minimum numbers of elements (MNE) and minimum numbers of individuals (MNI) for the construction of an age mortality profile. Pig and dog age at time of death was estimated using rates of epiphyseal fusion and timetables for tooth eruption according to Silver (1969). Modifications such as gnawing, recent breakage, weathering, and butchery patterns were observed and general observations are also reported.

Comparison with the neighbouring sites of Raupa and Waiwhau, and the later excavations along the Puriri Stream was added by Caroline Phillips.

Results

Mammals

A total of 685 mammal bones, bone fragments and teeth were recovered during the Opita excavation. Most of these remains are concentrated in Square F layer 4 in and to a lesser extent in Square H layer 3. Three mammal species were identified including pig (*Sus scrofa)*, dog (*Canis familiaris)* and cattle (*Bos taurus)*.

Many of the bones in Square H layer 3 appeared weathered with rough abraded bone surfaces while the bones in Square F layers 4 to 6 showed little signs of weathering, greater degrees of burning, butchery and gnawing, and most of these bones appeared a dark brown red colour with a smooth bone surface.

There are clear temporal and spatial trends at Opita when looking at NISP relative abundance by provenance unit (Table 1). In Square F, pig bones were found in the upper layers 3 and 4, while dog bones were mostly present in the lower layers 4 to 6. Small amounts of butchered, burnt and gnawed dog bones are present in the lower cultural layers 5 and 6 and declining significantly by layer 4 which coincides with a dramatic concentration of pig bones present in that layer. Cattle bones were found only in Square H layer 3 and Square S layer 2.

Two rat bones were also found in Square F in layer 4. It is not known if they were from an animal living in the deposit, or it was food refuse, or what species they were from.

Table 1: Mammal NISP by provenance

Provenance	*Pig*	*cf Pig*	*Dog*	*cf Dog*	*Cattle*	*Rat*	*Mammal*	*Total*
Sq.F L3	5	1	0	0	0	0	9	**15**
Sq.F L4	111	8	2	0	0	2	407	**530**
Sq.F L5	1	0	2	0	0	0	5	**8**
Sq.F L6	0	0	14	4	0	0	22	**40**
Sq.H L3	5	0	0	0	12	0	44	**61**
Sq.M L4	0	0	5	0	0	0	2	**7**
Sq.S L2	0	0	0	0	1	0	0	**1**
Trench.T 98.9 m	0	0	0	0	1	0	0	**1**
Trench.T	0	0	0	0	0	0	3	**3**
Trench B L3	2	0	0	0	0	0	0	**2**
No prov.	2	4	0	0	0	0	11	**17**
Total	**126**	**13**	**23**	**4**	**14**	**2**	**503**	**685**

Butchery

A wide range of pig elements are represented (Table 2) from pigs aged 2 years and under 1 year (Table 3) indicating that complete sub-adult pigs were killed and eaten on the site.

Table 2: Pig skeletal elements MNE by provenance

Provenance	*Sq.F L3*	*Sq.F L4*	*Sq.F L5*	*Sq.H L3*	*Tr.B L3*	*Unprov.*	***Total***
Cranium	0	1	0	1	0	0	**2**
Mandible	0	2	0	1	0	1	**4**
Unid. tooth fragment	1	0	0	0	1	0	**2**
Atlas	0	1	0	0	0	0	**1**
Cervical vertebra	0	1	0	0	0	0	**1**
Thoracic vertebra	0	2	0	0	0	0	**2**
Scapula	0	1	0	0	0	0	**1**
Humerus	1	1	0	0	0	0	**2**
Ulna	0	2	0	0	0	0	**2**
Radius	0	1	1	0	0	0	**2**
Carpal	0	1	0	0	0	0	**1**
Metacarpal	0	1	0	0	0	0	**1**
5th metacarpal	0	2	0	0	0	0	**2**
Pelvis	0	1	0	1	0	0	**2**
Tibia	0	2	0	0	0	1	**3**
Astragalus	2	2	0	0	0	0	**4**
Calcaneus	0	1	0	0	0	0	**1**
3rd metatarsal	0	1	0	0	0	0	**1**
5th metatarsal	0	2	0	0	0	0	**2**
Phalange intermediate	0	2	0	0	0	0	**2**
Central fused tarsal	0	1	0	0	0	0	**1**
4th tarsal	0	1	0	0	0	0	**1**
Sesamoid	0	2	0	0	0	0	**2**
Total	**4**	**31**	**1**	**3**	**1**	**2**	**42**

Table 3: Pig age at time of death MNI by provenance

Provenance	*No age*	*Less than 1 yr*	*2 years*	*more than 1 yr*	*7-13 months*
Sq.F L3	1	0	0	0	0
Sq.F L4	0	1	1	0	0
Sq.F L5	0	0	0	1	0
Sq.H L3	0	0	0	1	1
Tr.B L3	1	0	0	0	0
Total	**2**	**1**	**1**	**2**	**1**

A number of dog bones show signs of butchery and burning. The dog skeletal element representation based on only a small sample size indicates mostly butchery waste including mostly feet and skull bone fragments (Table 4). Both juvenile and adult dogs appear to have been killed, which offers no clear pattern of dog management (Table 5).

Table 4: Dog skeletal elements (MNE) by provenance

Provenance	*Sq.F L4*	*Sq.F L5*	*Sq.F L6*	*Sq.M L4*	***Total***
Cranium	0	0	1	1	**2**
Mandible	0	1	0	1	**2**
Unidentified tooth fragment	1	0	0	0	**1**
Rib	0	0	1	0	**1**
Scapula	0	0	1	0	**1**
Pelvis	0	0	0	1	**1**
Astragalus	0	0	1	1	**2**
Calcaneus	1	0	0	0	**1**
Metapodial	0	1	4	1	**6**
Phalange proximal	0	0	1	0	**1**
Phalange intermediate	0	0	1	0	**1**
Total	**2**	**2**	**10**	**5**	**19**

Table 5: Dog age at time of death (MNI) by provenance

Provenance	*No age*	*8 months +*	*less than 6*	***Total***
Sq.F L4	1	0	0	**1**
Sq.F L5	1	0	0	**1**
Sq.F L6	0	1	0	**1**
Sq.M L4	0	0	1	**1**
Total	**2**	**1**	**1**	**4**

Most of the cattle elements recovered were carpals and tarsals from Square H layer 3, with a few rib fragments and one ulna from at least two individuals one of which was 3-3.5 years old (Table 6). Many of these bones had been burnt but they also suffered signs of weathering. This represents mostly butchery waste.

Table 6: Cattle MNE by provenance

Provenance	Astragalus	Calcaneus	Intermediate Carpal	Rib	Tibia	Tooth	Central fused tarsal	2nd tarsal	Ulna	***Total***
Sq.H L3	2	1	1	1	0	1	2	1	1	**12**
Sq.S L2	1	0	0	0	0	0	0	0	0	**1**
Tr.T 98.9 m	0	0	0	0	1	0	0	0	0	**1**
Total	**3**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**14**

Fish & Birds

Fishing and bird fowling activities appear to be less important with 114 fish bones (Table 7) and 32 bird bones (Table 8) recovered.

Most of the fish bones were from Square F layers 4 and 6, with a few from Square F layer 5 and Square M layer 4. Five snapper (*Pagrus auratus)* bones were identified from all provenances, three of which were from Square F layer 4. Four shark/ray (Elasmobranchii) cartilaginous vertebrae and a stingray (Myliobatiformes) barb were identified. An eagle ray (Myliobatidae) tooth plate was identified as this family of stingray feed on molluscs and crustaceans rather than plankton and so their teeth are quite distinctive. Most of the shark/ray bones were present in Square F layer 4 with one unprovenanced. The fishing method was probably hook and line, although rays can also be caught by spear as they come close to the shore and rest on the tidal flats.

Table 7: Fish NISP by provenance

Provenanc	*Snapper*	*Shark/ray*	*Eagle ray*	*Sting ray*	*fish*	***Total***
Sq.F L4	3	2	0	0	50	**55**
Sq.F L5	0	1	1	1	0	**3**
SqF L6	1	0	0	0	44	**45**
Sq.M L4	1	0	0	0	9	**10**
No prov.	0	1	0	0	0	**1**
Total	**5**	**4**	**1**	**1**	**103**	**114**

Table 8: Bird NISP by provenance

Provenance	*Duck cf brown teal*	*Tui*	*bird*	***Total***
Sq.F L3	0	0	6	**6**
Sq.F L4	2	0	20	**22**
Sq.F L5	0	0	1	**1**
Sq.F L6	0	0	2	**2**
Sq.M L4	0	1	0	**1**
Total	**2**	**1**	**29**	**32**

Most of the bird bone was from Square F layer 4 with smaller concentrations in Square F layers 3, 5, 6 and Square M layer 4 (Table 8). Only three bird bones were identified to taxa including duck cf brown teal (*Anas aucklandia chlorotis)*, and tui (*Prosthemadera novaeseelandiae)*. These represent wetland and forest environments respectively.

Conclusions

The results demonstrate the gradual decline in traditional Maori subsistence as a result of the adoption of European domesticated mammals into the economy. Dogs were not greatly exploited as indicated by small amounts mostly of butchery waste. The meat-bearing bones were deposited somewhere else. Dog remains decline as domestic European mammals, especially pig suddenly appear in great numbers. Pigs appear to have rapidly assumed a much greater role in Maori subsistence. This site offers a clear archaeological record of the transition of the Maori economy during the contact period, which saw traditional Maori subsistence practices still being undertaken as evidenced by limited quantities of fish and bird bones.

The results, especially from the upper layers of Opita, dating from the 1840s-1880s, differ from those of the neighbouring sites of Raupa and Waiwhau, which were both abandoned by the early 1820s.

In several areas of Raupa the middens were found to contain fish and dog bone, and occasional whale bone (Prickett 1990, 1992). The fish included snapper, eagle ray, kahawai, gurnard, mullet, mackerel, trevally and eel. Dog bone was recovered from a number of different locations and was also formed into artefacts, and waste from that process was found in working areas. Bird bone was only identified from one midden. Four pig bones were found in three areas. No cattle or sheep bones were found.

At Waiwhau small amounts of fish, bird, pig and dog bone were found in the middens (Phillips 1988; Phillips & Green 1991). Fish were identified as snapper, trevally and ray.

The late pre-European or early post-European contact sites along the Puriri Stream had a few fishbones scattered in the midden, with snapper in the lower level of T12/340, and snapper and shark in T12/882 (Bedford 1994). Those Puriri sites dating to the latter part of the nineteenth century also contained introduced species. T12/340 had cow bones from a minimum of two animals with butchery marks on the bones. T12/883 had some snapper and kahawai in the midden (though this shell was used as a foundation for a house and was probably mined from an earlier site). However, the faunal assemblage in T12/883 was dominated by pig bones (44 NISP), and it was clear that pigs were being raised and butchered on the site. In addition there were a few cow and sheep bones, but these may have been purchased butchered portions (apparently cheaper cuts) and did not represent whole animals. A few bird bones were also present, including native brown teal, as well as introduced turkey and chicken.

References

Bedford, S., 1994. Tenacity of the traditional: A history and archaeology of early European Maori contact, Puriri, Hauraki Plains. MA thesis, Department of Anthropology, University of Auckland, Auckland.

Evans, H.E., 1993. *Anatomy of the Dog*. Philadelphia: Saunders Company. 3rd edition.

Getty, R., 1975. *The Anatomy of the Domestic Animals*. Vol 2. Philadelphia: Saunders Company. 5th edition.

Phillips, C., 1988. University of Auckland Field School excavations at Waiwhau, 1987. *New Zealand Journal of Archaeology*, 10:53-72.

Phillips, C., and R.C. Green, 1991. Further archaeological investigations at the settlement of Waiwhau, Hauraki Plains. *Records of the Auckland Institute and Museum*, 28:147-183.

Prickett, N., 1990. Archaeological excavations at Raupa: The 1987 season. *Records of the Auckland Institute and Museum*, 27:73-153.

Prickett, N., 1992. Archaeological excavations at Raupa: The 1988 season. *Records of the Auckland Institute and Museum*, 29:25-101.

Silver, LA., 1969. The aging of domestic animals. In D.R. Brothwell, and E.S. Higgs (eds), *Science in Archaeology: A Survey of Progress and Research.* London: Thames and Hudson, pp.283-302.

Faunal Reference Collection, Anthropology Department, University of Auckland.

Ornithology Reference Collection, Auckland War Memorial Museum

Appendix 12 Charcoal, Fruit Stone and Kauri Gum

Rod Wallace, Caroline Phillips and Jeffrey Mosen

Introduction

Twenty-two charcoal samples, eight fruit stones/kernels and 15 bags of kauri gum were analysed (Figure 1). They were recovered from the Opita excavations and separated from the total midden during wet-sieving in the laboratory.

The analysis of these materials focussed on the local environment, cultural selection and change over time. These results are also compared with those from the neighbouring sites of Raupa and Waiwhau and some riverside sites in the Waikato Basin.

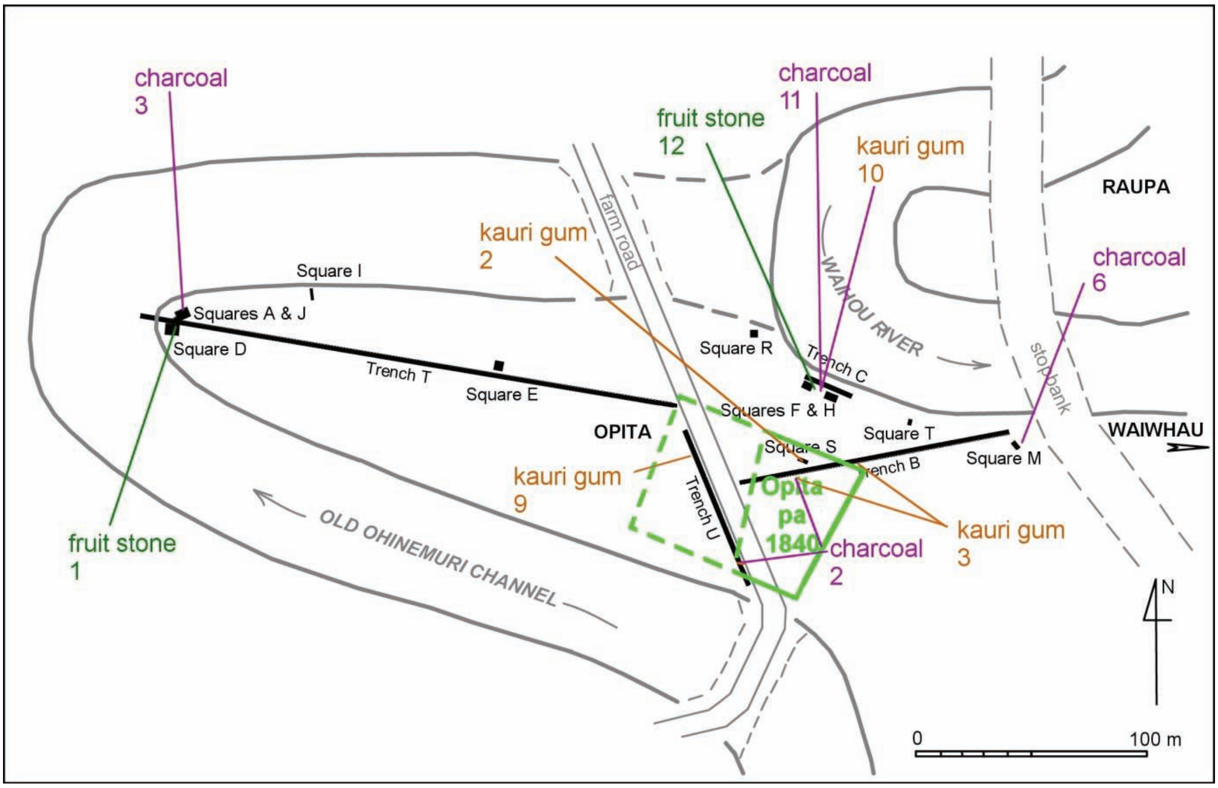

Figure 1. Plan showing location of analysed charcoal, fruit stone and kauri gum samples

Charcoal Analysis

Twenty-two of the 29 recovered charcoal samples were suitable for analysis. Pieces of charcoal from each sample bag were examined under an incident light microscope and identified to species or generic level on the basis of their distinctive cell anatomy. Pieces continued to be identified from each bag until no new species were found. In all, 335 identifications were made and 25 different species were found.

At the time the original identifications were made in 1991 Rod Wallace had only started identifying charcoal. Over the intervening 20 years, his accuracy of species identification has significantly improved.[1] As a consequence, this analysis has been re-viewed for this publication.

The raw results are given in Attachment 1 and are tabulated in Table 1. The numbers recorded reflect the proportions of the species in each sample bag. This is not discrete data as, for example, in sample #133 the 20 pieces of manuka may be the result of one original piece broken into fragments.

Table 1. Identified species in the charcoal samples at the four main locations investigated at Opita.

Species	*# Pieces*	*Totals*	*%*	
Bracken	1	1	0.3%	Fern
Hebe	21	28	8.4%	Small shrubs
Tutu	3			
Coprosma	1			
Five-finger	1			
Olearia	2			
Manuka	163	206	61.5%	Large shrubs and small trees.
Pittosporum	8			
Toro	1			
Mapou	13			
Mahoe	8			
Kanuka	6			
Putaputaweta	7			
Titoki	3	73	21.8%	Large Broadleaf trees
Rewarewa	1			
Taraire	5			
Kohekohe	2			
Mangeao	2			
Puriri	1			
Maire	1			
Rata	9			
Kowhai	18			
Tawa	31			
Totara	2	27	8.1%	Conifers
Matai	25			
Totals	**335**			

1 In hindsight, most samples originally identified as ramarama are more likely to be manuka and those identified as pate (*Schefflera digitata*) are almost certainly tutu (*Coriaria* sp.). In a similar vein a group of species (taraire, kohekohe, mangeao and puriri) have cell patterns which overlap to a significant degree and specific identifications in this group must be regarded as tentative especially where small diameter branch wood is involved and charcoal is broken up into small pieces, as most archaeological material is. Fortunately this uncertainty has little effect on environmental interpretations all four species are large broadleaf trees common in lowland areas.

Overall results

The whole assemblage shows very clear patterns of species abundance (Table 1). The majority (62%) of the charcoal is from a mix of large and shrubs small trees association dominated by manuka (49% of the total charcoal). The other small woody species present were pittosporum, olearia, toro, mapou, mahoe, kanuka and putaputaweta (see Attachment 2 for the scientific names for these tree species). This scrub association is typical of woody vegetation regenerating on open land after forest clearance. However, there was only a limited presence of pioneering species (8%), such as bracken, tutu, hebe, coprosma and five-finger that prevail in the first stages after forest clearance. The remaining 30% of the assemblage consists of broadleaf and podocarp tree species dominated by tawa, matai and kowhai (22% of the total charcoal). The other tree species forming background species, were titoki, rewarewa, taraire, mangeao, kohekohe, puriri, rata, maire, and totara.

This data indicates the sites were located on land largely cleared of forest on which woody vegetation, primarily manuka scrub, was actively regenerating.

Analysis

The samples came from a range of different types of firing events or contexts, settlements and chronological phases. Analysis considered these three parameters.

In addition, it was expected that the charcoal would have originated from the trees and shrubs growing in the immediate vicinity of the sites at the time they were occupied. As such, the samples provided information concerning changes in the vegetation as a result of human impact, when these changes occurred, and what resources were available for the inhabitants of the Opita sites.

Sample context

The samples came from a number of different contexts (Table 2). The majority (13 samples) came from the midden dumping and cooking layers and is the residue of firewood. Four samples were from fires lit during vegetation clearance events[2] (e.g., sample #133). In contrast, charcoal that accumulated in the fills of features, such as pits or ditches, probably included the remains of timber structures, mixed with species that commonly colonise recently abandoned sites, such as the highly combustible bracken and tutu (five samples). Three samples were from postholes, two of which (samples # 413 and # 438) yielded a single species (both kowhai) and are probably the remains of a single post. It is possible that the matai or manuka present in sample from the posthole # 105 was also part of the original post.

In this analysis, a clear picture emerges when the results are grouped into the three categories of: firewood, soil charcoal lens and feature fill (Table 3).

Three-quarters of the charcoal from samples where posts and pit structures are present are from trees, which is twice as much as for the rest of the assemblage. In fact, only four species: manuka, kowhai, tawa and matai represent 75% of the charcoal. This indicates that selection of certain timbers was being practised. It also strongly implies that this charcoal was from structural timbers burnt in post-abandonment fires. This is supported by the fact that bracken and tutu (plants that colonise bare ground) only occur in the Opita assemblage in these samples.

2 Only one of these samples was clearly a local burn-off (133), while the others were either charcoal mixed in the soil (50, 104, 435) and may have been a mixture of charcoal from fireplaces, as well as the burning of old buildings and vegetation.

Table 2. Details of where the analysed charcoal samples came from.

No:	*Sq/Trench*	*Quad/Distance*	*Layer*	*Feature*
104	A	NW	3	charcoal lens
105	A	SE	3	posthole
128	D	?	3	pit fill
354	M	?	4	hangi scoop
355a	M	B	4	hangi scoop
355b	M	B	4	hangi scoop
355c	M	B	4	hangi scoop
522	M	B	4	midden
523	M	B	4	midden
296	H	?	3	hangi scoop
133	F	B7	3	charcoal lens
249b	F	B6	4	midden
248	F	B5	4	midden
250	F	D4	4	midden
356	F	D7	4	hangi scoop
413	F	D7	6	posthole
468	F	D6	6	midden
435	H	?	5	charcoal lens
434	H	Feature 10	5	hangi scoop
438	H	Feature 1	5	posthole
50	B	26	3	charcoal lens
37	U	77.8	3	pa ditch fill

In contrast, the soil charcoal lens samples are dominated (67%) by scrub and small tree species with manuka contributing half the total charcoal present. A broad range of both broadleaf and conifer trees species supplied the remainder of the charcoal, indicating either that some remnants of the original forest remained from the original forest, or that these trees had regenerated on the site along with the scrub. This suggests that before and during occupations the area supported a manuka scrub association plus a smaller component of larger tree species.

A significant proportion (22%) of the wood used in the cooking fires came from forest trees. Manuka accounted for a nearly half of the identifications. Its dominance especially in the midden layers and fire scoops, suggests it was the most common species selected for firewood. Although the choice made by the inhabitants would have been for dryness and quantity rather than species.

Table 3. Charcoal from different sample contexts.

Species	*Feature fills*	*%*	*Soil lens*	*%*	*Firewood*	*%*	*Plant Type*
Bracken	1	2.1%					Fern
Tutu	3	8.3%		1.5%		9.6%	Smaller shrubs
Hebe	1		1		19		
Coprosma					1		
Five-finger					1		
Olearia					2		
Manuka	8	27.1 %	33	65.7 %	122	68.6 %	Larger shrubs and small trees
Pittosporum					8		
Toro			1				
Mapou	2		2		9		
Mahoe	2		1		5		
Kanuka			4		2		
Putaputaweta	1		3		3		
Titoki		37.5 %		31.3 %	3	15.4 %	Large Broadleaf trees
Rewarewa	1						
Taraire					5		
Kohekohe					2		
Mangeao			2				
Puriri					1		
Maire			1				
Rata	1		1		7		
Kowhai	7		1		10		
Tawa	9		16		6		
Totara		25.0 %		1.5%	2	6.4%	Conifers
Matai	12		1		12		
Totals	**48**		**67**		**220**		

Settlement locations

The charcoal samples came from four different settlement areas scattered across the site of Opita: Squares A/D in the west, Square M in the east, Trenches B/U being part of the pa, and Squares F/H on the river terrace (Figure 1 and Tables 1-4).

In Table 4, the results are plotted according to the species found in the four main settlements. The riverbank and area to the east contained a large percentage of forest timber in their firewood, mainly matai and kowhai, with some tawa, taraire and rata. Although the western settlement and the pa contained more forest species, mainly tawa and matai, the sample sizes are too small to read much into these observations.

Chronology

The river terrace occupation in Squares F and H included three phases that ranged in date from approximately 1690 –1890 (listed as Phase II, III and IV in Table 5).

Table 4. Proportions of species in the different Opita settlement areas.

Sites	*Plant type*	*West*		*East*		*River*		*Pa*	
Bracken	Fern	1	2.1%						
Tutu	Smaller shrubs	3	8.5%		5.6%		10.9%		0%
Hebe		1		4		16			
Coprosma						1			
Five-finger				1					
Olearia						2			
Manuka	Larger shrubs and small trees	9	42.6%	55	72.2%	95	65.5%	4	29.2%
Pittosporum				2		6			
Toro						1			
Mapou		3		8		1		1	
Mahoe		3				5			
Kanuka		3				3			
Putaputaweta		2				3		2	
Titoki	Broadleaf trees		23.4%		11.1%	3	21.2%		62.5%
Rewarewa		1							
Taraire						5			
Kohekohe						2			
Mangeao						2			
Puriri						1			
Maire								1	
Rata		1		2		5		1	
Kowhai				4		14			
Tawa		9		4		5		13	
Totara	Large conifers		23.4%	1	11.1%	1	2.3%		8.3%
Matai		11		9		3		2	
Totals		**47**		**90**		**174**		**24**	

The paucity of tutu and bracken and other pioneering species in comparison with the dominance of species representing later stages of vegetation succession indicates cycles of occupation were at intervals long enough for substantial woody vegetation to have developed on the land.

Phase II contained both a range of shrubs and forest trees (including kowhai, tawa and matai), which might indicate that the ground had not been fully cleared during previous occupations. The forest trees were still present locally in Phase III, but there were fewer smaller shrub species that might indicate a longer interval between Phase II and Phase III. Phase IV was notable for only containing manuka. As in the previous location analysis, the number of samples and identifications mean that these results should be +read with caution.

This picture of patches of open land and manuka scrub is similar to that recorded by the first surveyors in 1856 and again in 1879 and 1883, which just precede Phase IV (see Appendix 17). During those times, the nearest large stands of kahikatea bush existed some 200-250 m to the west and south of the Opita settlements and probably included other tree species (i.e. rimu, karaka, hinau, toatoa, totara, kowhai, pukatea and maire). [3]

3 Griffiths and Harris 1972; Phillips 2000a:20.

Table 5. Proportions of forest trees and shrubs in the different phases of the riverbank site.

Phases	*IV*	*%*	*III*	*%*	*II*	*%*	*Plant type*
Hebe					16		
Coprosma			1				
Olearia			2	3.8%		25.4%	Smaller Shrubs
Manuka	32		40		23		
Pittosporum			5		1		
Toro					1		
Mapou			1				
Mahoe		100%	5	70.9%		41.3%	Larger shrubs and small trees
Kanuka			2		1		
Putaputaweta			3				
Titoki			3				
Taraire			3		2		
Kohekohe			2				
Mangeao					2		
Puriri			1				
Rata			5	24.0%		28.6%	Broadleaf trees
Kowhai			5		11		
Tawa			2		3		
Totara			1				
Matai				1%	3	4.8%	Large Conifers
Totals	**32**		**79**		**63**		

Palaeo-Environment

It is expected that the firewood would come from vegetation in the immediate vicinity of the settlements, being collected as part of the daily routine of the inhabitants. The charcoal identifications reveal the species content of the woody vegetation cover in the immediate area at the times the sites were occupied, whereas the charcoal lenses in soil horizons will directly reflect the vegetation on the site when the occupations began, and the samples from pits and ditches are likely to have originated in fires in vegetation regenerating on abandoned occupations.

Distinctive patterns in the charcoal identifications, such as the small occurrence of twig wood and the lack of kahikatea, all say something about the source of the wood used both for firewood and artefacts, and the material burnt to make way for settlement and cultivation.

The scarcity of twigs wood can be interpreted as the use of driftwood for firewood. Only three manuka samples were in twig form, and twigs are generally lost when dead trees are swept down rivers during floods. Fallen trees could have been bought down, in particular by the Ohinemuri River, and deposited on the banks around the junction of the Ohinemuri and Waihou Rivers. However, if this were the case, a much more diverse assemblage would be expected, including at least some of the kahikatea and pukatea that is so typical of forest on the wetter areas of these plains and a wider range of conifers such as kauri, totara, rimu, and tanekaha that would have grown on the nearby hills. Therefore, it must be concluded that river driftwood was not a significant wood source at Opita.

Of the 335 identifications, no evidence of kahikatea was found. As Opita is located in a kahikatea swamp zone, this would suggest either that the kahikatea forest had been cleared from the vicinity, or that it was not regarded as useful for firewood. As stated above, survey plans dating from 1856 show that the riverbanks had largely been cleared of trees, but there were still stands of kahikatea bush nearby. If these kahikatea stands were the source of the other forest trees burnt on site and used for structural timbers, then there appears to have been an avoidance of kahikatea. A recent analysis of a large set of charcoal assemblages from prehistoric Maori garden sites along the Waikato River (Wallace, unpublished data) revealed assemblages dominated by tawa and matai but contained very little kahikatea. This suggests that the wetter areas, which kahikatea occupies, were being actively avoided and that tawa and matai dominated forest was being targeted by Maori presumably because these associations occupied better-drained soils suitable for horticulture.

Discussion

Opita is located on a natural levee of silty soils on the river banks of the Ohinemuri River, a localised micro-environment that was the focus of Maori occupation of the Hauraki Plains. The firewood and soil charcoal lenses charcoal assemblage will most directly reflect vegetation growing on the sites during occupation.

The charcoal results indicate that at the times the sites were occupied the area appears to have been cleared of primary forest well before the settlements were established and to have been re-occupied repeatedly at intervals sufficiently long for a well-developed manuka scrub association with some forest tree species to have developed on the area. Posts used in structures came from matai, tawa, kowhai and manuka, which might have been from trees growing in remnant stands on the flats.

Differences in the locations, phases and types of features all presented variables that were examined to see if there was any variation through space, time and cultural preferences. However, the small number of these samples meant that the interpretations must be read with caution.

Comparison with other sites

Similar conclusions have been drawn from the excavations at the neighbouring sites of Waiwhau and Raupa. At Raupa charcoal from a burn-off in the earliest examined phase principally contained manuka[4] and ramarama (Prickett 1990:101). A later burn-off just prior to the abandonment of the site in 1820 was mainly of coprosma and pate (Prickett 1992: 86). Hangi scoops in one area contained firewood of ramarama, coprosma and matai, and 95% of the matai was composed of twig wood (Prickett 1990: 102). Other firewood from the scoops included mahoe, tawa, mapou and manuka. It was thought that much of the source of the wood was from driftwood, although the twig matai may have been from a tree or branches deliberately brought to the site.

At Waiwhau the main forest tree species were matai and tawa, with small trees and shrubs of which ramarama, manuka and coprosma were common (Phillips and Green 1991: 163). In Area 4 of the excavation between 10-60% of the samples were forest trees, but again the lack of twig wood suggested that it was derived from driftwood. If the ramarama and pate identification are altered as suggested above to manuka and tutu these results are in close accordance with those of Opita especially regarding the range of species present.

A large set of charcoal assemblages of from prehistoric Maori garden sites along the Waikato River have recently been analysed (Wallace, unpublished data from RMA investigations as yet to be reported by the excavators). These revealed that the gardens and settlements were being carved out of virgin bush rather than by re-occupying former sites as was the case at Opita. These assemblages demonstrate that in virtually all these Waikato sites tawa and matai dominated forest was being targeted by Maori for this purpose presumably because it occupied better-drained soils preferred for horticulture.

4 At the time the charcoal from Raupa and Waiwhau was analysed, Rod Wallace identified some samples as ramarama that he would now identify as manuka (see fn 1).

Fruit Stones

The majority of the fruit stones were from peaches, with only a single hinau kernel found in the cultural layer of Square D (Figure 1 and Table 6).

All the peach stones were found in squares F and H within layer 3 or a ditch fill deposit which may have come from layer 3. Some of the stones were grouped while others were more randomly dispersed. This would suggest either that people bought the peaches from elsewhere, ate the fruit and discarded the stones, or that the stones naturally dropped from a nearby peach tree. Peaches were popular trees adopted by Maori soon after their introduction by Pakeha and used in trade with Pakeha (Phillips 2000:58).

Table 6. Location of fruit stones.

No.	*Sq*	*Quad*	*Layer*	*Type*	*Quantity*
143	F	B4	3	peach	2
159	F	C4	3	peach	1
260	H	D16	3	peach	3
314	H	D18	3	peach	2
313	H	D18	3	peach	1
353	H	D16	3	peach	2
324	H	?14	ditch fill	peach	1
149	D		3	hinau	1
Total					**13**

Comparison with other sites

Fruit stones were found at both Raupa and Waiwhau, but these were from hinau and tawa or taraire and karaka (Prickett 1990: 95,102; Phillips and Green 1991: 163). No peach stones were recorded, and as both these sites had been abandoned by 1820, this might indicate that layer 3 at the riverside settlement at Opita was occupied later.

Kauri Gum

Fifteen bags of kauri gum were recovered from the Opita sites and a further piece was found during midden analysis. Of these, fifteen bags were analysed.

Kauri gum was recovered from the post-occupation and later stratigraphic layers, i.e. layers 2, 3 and 4 (Figure 1 and Table 7). The cultural layers in Trench B and adjacent Square S were very thin and disturbed and might have contained mixed materials.

The individual weights of each piece ranged from 0.45 grams to 377.0 grams. Apart from the largest piece only the oxidised crust of kauri gum was recovered.

The gum probably originated from the nearby Coromandel and Kaimai Ranges. It could have been washed down the Ohinemuri River during flooding, especially after the forest had been cleared during the late 19th and early 20th centuries and there was significant erosion.

Table 7. Location, quantity and weight of kauri gum recovered (note the actual location within the squares was not recorded).

No:	*Sq/Trench*	*Quad/Distance*	*Layer*	*Quantity*	*Weight (g)*
8	U	27	2	1	0.5
9	U	25	2	1	26.3
24	U	25	2	1	79.8
27	U	25	1	6	377.2
48	B	26	2	1	23.6
68	B	9	2	1	147.3
80	B	52	3	1	17.0
137	F	?	3	1	5.1
141	F	C7	3	2	5.3
327	F	C5	4	1	0.3
347	F	B5	4	1	0.4
397	F	B4	4	2	44.7
319	H	?14	3	1	1.7
323	H	D14	4	2	11.9
454	S		3	2	21.0
Total				24	

However, the locations that the gum was found in were not all along the riverbank, as would be expected if it was deposited solely during floods, suggesting that much of it, if not all, was brought to the site intentionally. Kauri gum was used by Maori for a number of uses prior to European contact. However, all these examples come from post-European contact layers, and it is most likely that the crusty gum was the residue of processing it for trade.

Kauri gum was exported from New Zealand from the mid-1840s to varnish manufacturers in London and America, and between 1850 and 1900 was Auckland's main export (Te Ara 2011). In Hauraki, gum-digging became a source of income for Maori from the 1860s (Monin 2011: 208).

Comparison with other sites

Kauri gum was found at Raupa (Prickett 1990: 94, 1992: 41, 75). Most appeared to be pieces of the oxidised crust, although three pieces in good condition were also found. They came from different levels of the site dating 1750-1820, and it was thought that they were used for tattooing pigment (citing Te Rangi Hiroa 1966: 296).

References

Butterfield B.G., and B.A Meylan, 1978. *The Structure of New Zealand Woods.* Bulletin 222, Wellington: Department of Scientific and Industrial Research.

Costall J. A., Carter R. J., Shimada Y., Anthony D. and. Rapson G. L. 2006. The endemic tree Corynocarpus laevigatus (karaka) as a weedy invader in forest remnants of southern North Island, New Zealand. *New Zealand Journal of Botany*, 44:5-22.

Fahn, A., 1982. *Plant Anatomy*. Oxford: Pergamon Press. 3rd Edition.

Monin, P., 2001. *This is My Place: Hauraki Contested 1769-1875*. Wellington: Bridget Williams Books.

Phillips, C., 2000. *Waihou Journeys: The Archaeology of Four Hundred Years of Maori Settlement*. Auckland: Auckland University Press.

Phillips, C., 1986. Excavations at Raupa Pa (N53/37) and Waiwhau village (N53/198), Paeroa, New Zealand, in 1984. *New Zealand Journal of Archaeology*, 8:89-113.

Phillips, C., and R.C. Green, 1991. Further archaeological investigations at the settlement of Waiwhau, Hauraki Plains. *Records of the Auckland Institute and Museum*, 28:147-183.

Prickett, N., 1990. Archaeological excavations at Raupa: the 1987 season. *Records of the Auckland Institute and Museum*, 27:73-153.

Prickett, N., 1992. Archaeological excavations at Raupa: the 1988 season. *Records of the Auckland Institute and Museum*, 29:25-101.

Salmon, J.T., 1980. *The Native Trees of New Zealand. Auckland*: A.H. & A.W. Reed Ltd.

Te Ara-The Encyclopedia of New Zealand, 2011. Kauri gum and gum digging: The industry. http://www.teara.govt.nz/en/kauri-gum-and-gum-digging/

Western, A.C., 1969. Wood and charcoal in archaeology. In D.R. Brothwell, and E. Higgs (eds), *Science in Archaeology: A Survey of Progress and Research*. London: Thames and Hudson, pp.178-187.

Attachment 1: All Charcoal Identifications

Sample #104 – Square A - Quad NW – Layer 3 - charcoal lens

manuka	1
mapou	1
mahoe	1
kanuka	3
putaputaweta	1
matai	1

Sample #105 - Square A - Quad SE – Layer 3 - posthole

bracken	1
manuka	6
mapou	2
putaputaweta	1
matai	2

Sample #128 - Square D - Quad ? – Layer 3 - pit fill

manuka	2
hebe	1
tutu	3
mahoe	2
rewarewa	1
rata	1
tawa	9
matai	8

Sample #354 - Square M - Quad ? – Layer 4 - hangi scoop

manuka	15
mapou	1

Sample #355a - Square M - Quad B – Layer 4 - hangi scoop

manuka	12
hebe	2
five-finger	1
mapou	1
kowhai	2
matai	1

Sample #355b - Square M - Quad B – Layer 4 - hangi scoop

manuka	11
Pittosporum	1
mapou	1
kowhai	1

Sample #355c - Square M - Quad B – Layer 4 - hangi scoop

manuka	3
hebe	1
mapou	2
rata	1
tawa	2
matai	4

Sample #522 –Square M – Quad B – Layer 4 – Spit 2 – midden

manuka	11
Pittosporum	1
mapou	1
kowhai	1

Sample #523 –Square M – Quad B – Layer 4 – Spit 3 – midden

manuka	3
hebe	1
mapou	2
rata	1
tawa	2
matai	4
totara	1

Sample #296 - Square H - Quad ? – Layer 3 - hangi scoop

manuka	12

Sample #133 - Square F - Quad B7 – Layer 3 - charcoal lens

manuka	20

Sample #249b - Square F - Quad B6 – Layer 4 – midden

manuka	14
olearia	2
putaputaweta	3
kohekohe	1
taraire	1
rata	1
kowhai	1
tawa	1
totara	1

Sample #248 - Square F - Quad B5 – Layer 4 - midden

manuka	6
titoki	1
puriri	1
rata	4
kowhai	1
tawa	1

Sample #250 - Square F - Quad D4 – Layer 4 - midden

manuka	15
Pittosporum	1
kanuka	2
titoki	1
taraire	1
kowhai	1

Sample #356 - Square F - Quad D7 – Layer 4 - hangi scoop

manuka	5
coprosma	1
Pittosporum	4
mapou	1
mahoe	5
titoki	1
taraire	1
kohekohe	1

Sample #413 - Square F - Quad D7 – Layer 6 – posthole

kowhai	6

Sample #468 - Square F - Quad B4 – Layer 6 – midden

manuka	10
taraire	2
kowhai	3
matai	3

Sample #435 - Square H - Quad ? – Layer 4 – charcoal lens

manuka	8
hebe	1
toro	1
kanuka	1
mangeao	2
kowhai	1
tawa	3

Sample #434 - Square H – Feature 10 – Layer 4 – hangi scoop

manuka	5
hebe	15
tarata	1

Sample #438 - Square H – Feature 1 – Layer 4 – posthole

kowhai	1

Sample #50 - Trench B - 26 – Layer 3 – charcoal lens

manuka	4
mapou	1
putaputaweta	2
maire	1
rata	1
tawa	13

Sample #37 - Trench U – 77.8 – Layer 3 – pit fill

matai	2

Bracken *Pteridium esculentum*
A very common fern, which can grow in dense stands 4 m high. It quickly colonises ground after clearance by fire and is strongly subject to firing itself. Typically found in charcoal assemblages in the fills of features where it seems to represent fires in vegetation growing on recently abandoned sites.

Coprosma sp.
Shrub or small trees, found in lowland forest throughout New Zealand. There are about 80 species in New Zealand.

Five-finger *Pseudopanax arboreus*
A shrub distributed in lowland throughout North and South Islands.

Hebe sp.
Mainly smaller shrubs. There are about 100 species throughout New Zealand.

Hinau *Elaeocarpus dentatus*
Tree reaching 20 m. Lowland and montane forest, North Cape to Foveaux Strait.

Kahikatea Dacrycarpus dacrydioides
A large forest tree that grows to a height of 55 metres with a trunk exceeding 1 metre diameter. It is dominant in lowland forest and wetlands throughout New Zealand.

Kanuka *Kunzea ericoides*
Small tree up to 15 m distributed North Cape to Foveaux Strait usually forming dense stands regenerating after forest clearance,

Karaka *Corynocarpus laevigatus*
A tree reaching 18 m. Its natural range in appears to be restricted to northern New Zealand but, due to its value as a food source, was distributed by Maori as far south as the Chatham Islands, Banks Peninsula and Westland where it occurs mainly associated with former Maori settlements (Costall et al, 2006).

Kauri *Agathis australis*
A large tree reaching 30 m, with straight massive trunk. Found in lowland and montane forest from North Cape to Maketu and Kawhia.

Kohekohe *Dysolxylum spectabile*
A tree up to 17 m high. Found in lowland forests, North Cape to Marlborough Sounds.

Kowhai *Sophora* sp.
Small trees up to 14 m high, trunk up to 60 cm in diameter. Found in lowland forests especially on river and stream banks and on lake and seashores.

Mahoe *Melicytus ramiflorus*
Small tree distributed throughout the North and South Islands where it is abundant in scrubland and regenerating woody vegetation.

Maire *Nestegis cunninghamii* or *lanceolata*
Trees growing up to 25 m high found in forests throughout the North Island.

Mangeao *Litsea calicaris*
A tree up to 15 m high, with trunk up to 80 cm in diameter. Found in lowland forests near North Cape to East Cape and Rotorua.

Manuka *Leptospermum scoparium*
A shrub or small tree growing up to 8 m high with stems up to 20 cm in diameter. Distributed throughout New Zealand where it forms dense stands following forest clearance.

Mapou *Myrsine australis*
A shrub or small tree found throughout the North and South Islands where it is common in scrubland.

Matai *Prumnopitys spicatus*
A large tree up to 30 m high, trunk up to 1.25 m in diameter. Found in lowland forests throughout the North and South Islands

Olearia sp.
Shrubs or small trees with about 30 species found throughout New Zealand.

Pittosporum sp.
Shrubs or small trees with about 25 species found throughout New Zealand.

Puriri *Vitex lucens*
A tree up to 20 m high with a trunk up to 1.5 m in diameter. Found in coastal and lowland forests. North Cape to Mahia Peninsula.

Putaputaweta *Carpodetus serratus*
Shrub or small tree distributed throughout New Zealand.

Rata (northern) *Metrosideros robustus*
Large tree up to 25 m high with a trunk up to 2.5 m in diameter. Occurs from the Three Kings Islands to the north-west South Island.

Rewarewa *Knightia excelsa*
Large tree up to 30 m high, trunk 1 m or more in diameter. Found in lowland and montane forests, North Cape to Marlborough sounds.

Taraire *Beilschemiedia tarairi*
Tree up to 20 m high, trunk up to 1 m in diameter. Distributed in lowland in lowland forest from near North Cape, southwards to East Cape and Raglan.

Tawa *Beilschmiedia tawa*
Tree growing up to 25 m high with a trunk up to 1 m in diameter. Distributed in lowland and lower montane forests from North Cape to the seaward Kaikoura Ranges.

Titoki *Alectryon excelcus*
Tree up to 17 m high, trunk up to 60 cm in diameter. Distributed in lowland forest in both the North and South Islands.

Toro *Myrsine salicina*
Shrub or small tree coastal to lower montane forests and shrublands.

Totara *Podocarpus totara*
A large tree reaching 30 m high, with massive trunk. Found in lowland and montane forests from North Cape to southeast Otago.

Tutu *Coriaria arborea*
A shrub distributed throughout New Zealand mainly as a pioneering plant of bare ground. It is common in charcoal assemblages usually associated with bracken.

Appendix 13 Analysis of Shell Midden

Harry Allen, Hilary Graham, Helen McCracken and Amanda Young

Shell middens provide a range of information on economic, historical and ecological aspects of the people who lived in past settlements. The material is relatively durable, visible and available in potentially large quantities (Nichol 1988:9-10), and a variety of research questions can be posed using various analytical tests. Middens provide a basis of comparison within and between sites, both spatially and temporally, contributing information on changing patterns of site use, population and the environment. The aims of this study of the Opita shell middens are as follows:

1. To compare the shell material excavated from different areas of the site in terms of appearance, species composition, numbers present and shell size.
2. To explain any differences in these shell samples by considering them as indicators of: function, context, chronology, gathering techniques preference, environment and historical factors.
3. To compare the shell from Opita with that excavated from the neighbouring sites of Raupa, Waiwhau, and those along the Puriri River, to ascertain similarities or differences with midden from these sites.

This analysis starts with a description of the middens, and the context where they were found. The methods of analyses and basic results are then described, followed by the composition of the various samples that were taken. Information derived from the midden is then discussed.

Description of the Opita middens

Shellfish midden was examined in two different parts of the site (Figure 1). The shell was first exposed in Trenches C and M, and adjacent squares were opened up to examine the deposits in more detail. One of the areas had two midden layers and together these represented the three deposits that were analysed.

Trench C

Initially, shell was located eroding from the bank of the former Waihou River channel, at the northern side of the site. A twenty metre section of this bank was cleaned down and the face of this was recorded as Trench C (see section, Figure 2). This revealed a complex stratigraphy including two layers of midden and episodes of ditch construction. Midden occurred in layer 4, where the shell was associated with a fire pit, and in layer 6 where a dense band of shell occurred. A resistivity survey indicated that midden extended south-west from the river bank (see Figure 1). As a result, it was decided to open up Squares F and H adjacent to Trench C to further explore this part of the site.

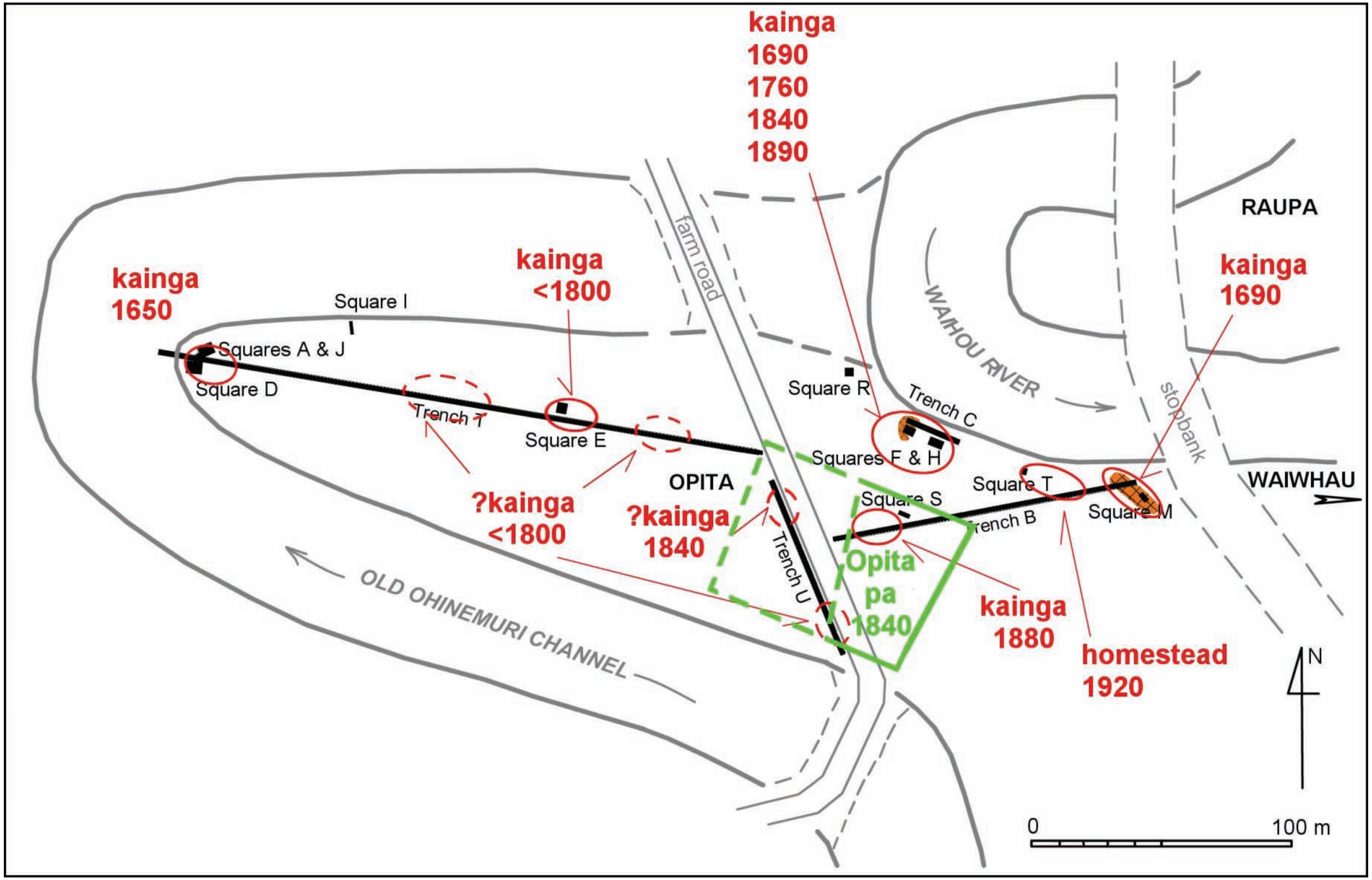

Figure 1. Location of shell middens (in orange) analysed from Opita, showing the extent of

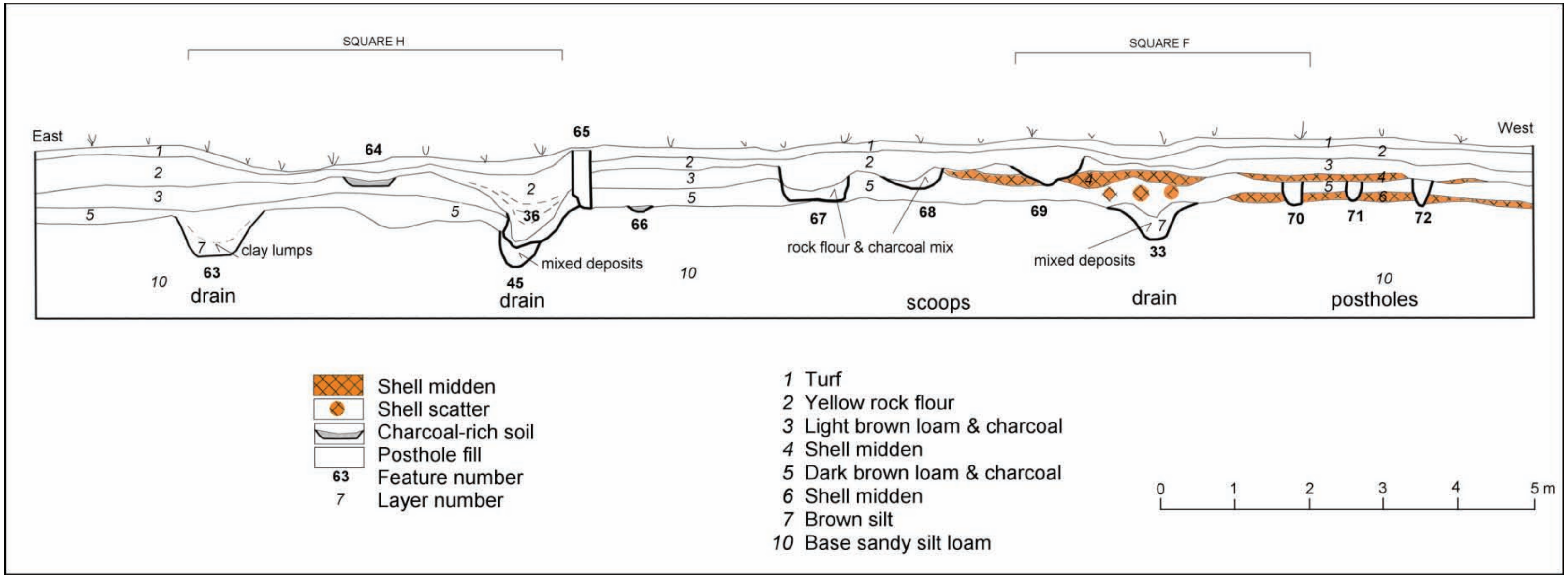

Figure 2. Section of Trench C, showing the layers of midden that were examined in adjacent

Square F

Square F was 4 m long by 3 m wide. Eight layers were present, two of which, layers 4 and 6, contained midden. To assist excavation, Square F was divided into 12 quads, each one metre square (see plan, Figure 3). The sequence was as follows:

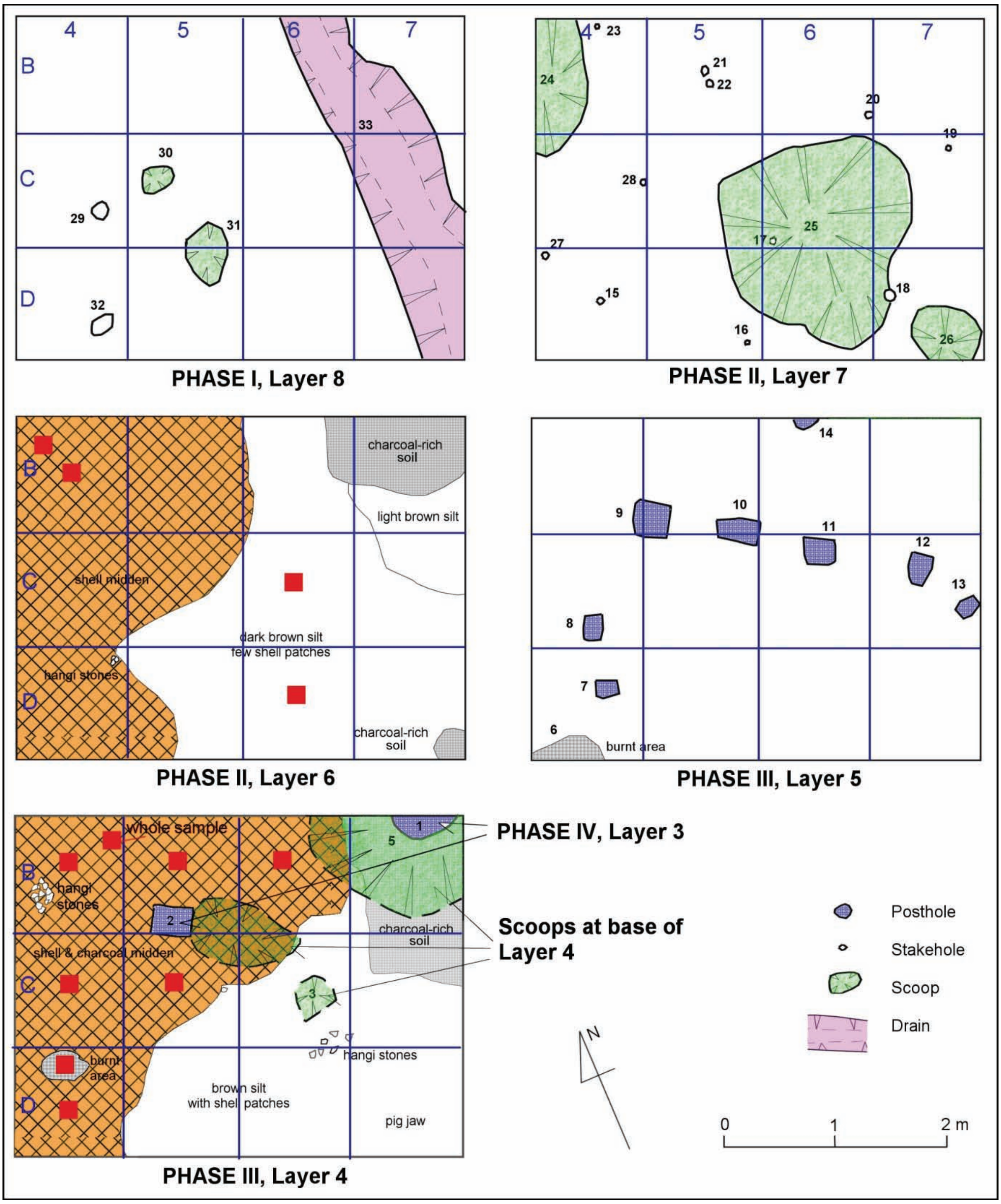

Figure 3: Square F features and location of samples collected from different quads.

Layer 1. Top soil.

Layer 2. Yellow-orange rock flour (mine tailings), a result of processing gold at Waihi, which was then brought down the Ohinemuri River during floods.

Layer 3. Light brown sandy loam cultural layer, 150-200 mm thick, which contained European-derived materials. Hangi stones were also found, but there were no shells.

Layer 4. Shell midden 100 mm thick with varying concentrations of shell was the predominant feature of this layer. European-derived materials were found, similar to those recovered in layer 3, were mainly associated with the concentrated midden. The layer was spatially differentiated and could be divided into three distinct areas:

i The north-east corner of the square contained an area of concentrated charcoal, which when excavated revealed a large hangi pit, with large pieces of charcoal, shattered and whole hangi stones, and clay pipes.

ii The southern half contained brown soil with thinly dispersed patches of shell. This was largely devoid of artefacts.

iii The northern half had a brown charcoal-rich soil with concentrated shell, and was the source of the analysed samples.

A total sample of midden was removed, with additional samples being taken during excavation. Due to the differing depths of midden in the quads, the sizes of these samples varied considerably. However, taking numerous samples provided a comprehensive picture of the midden in this layer (Table 1).

Table 1. Processing of all shell samples collected (note the sample from Square F layer 4 quad C4 may have been combined with that of quad B4).

Square	*Layer*	*Quad/ Feature*	*On site*	*Anthropology laboratory*			
			Wet sieve	*Sieve*	*Species sort*	*Weigh*	*Shell size*
F	4	Total sample B4	X		X	X	
F	4	B4	X	X	X	X	X
F	4	B5	X	X	X	X	
F	4	B6	X	X	X	X	X
F	4	C4	X	X	?	?	?
F	4	C5	X	X			
F	4	D4	X	X	X	X	X
F	4	D4 burnt area	X				
F	6	C6 scoop	X	X	X	X	X
F	6	B4	X	X	X	X	X
F	6	D6 total sample					
F	6	B4 scoop					
M	4	Total sample					
M	4	Spit 1	X	X	X	X	
M	4	Spit 2	X	X	X	X	X
M	4	Spit 3	X	X	X	X	

Layer 5. Dark brown charcoal-enriched soil with very little shell. The layer was also largely devoid of artefacts. A pattern of postholes suggests the presence of a structure, possibly a house.

Layer 6. Lower shell midden, 100 mm thick, with the shell being more concentrated in the north-west half of the square, similar to the area of concentration in layer 4. Artefacts recovered included obsidian, bone, hangi stones and chert, but no European-derived materials. Four samples of shell were collected, including one total sample.

Layer 7. Dark brown charcoal–rich layer, 150 mm thick that contained many features. Artefacts recovered included 23 obsidian flakes, a chert flake, and hangi stones, but no shells.

Layer 8. Underlying undisturbed silty clay with postholes, scoops and a drain. An argillite adze, a piece of greenstone, obsidian and chert flakes, and a hangi stone were associated with these features.

Trench B

Shell midden associated with a fire pit was identified 112-118 m along Trench B. There were hangi stones present and a large quantity of charcoal. Square M was opened up south of the trench to explore the shell layer.

Square M

Square M, measuring 1 x 2 m, was excavated to obtain comparative samples to those from Square F. Test pits showed this midden extended over an area approximately 20 x 6 m (see location Figures 1 & 4). This square was divided in half into quads A and B. Square M consisted of five layers of which only one, layer 4, contained shell midden.

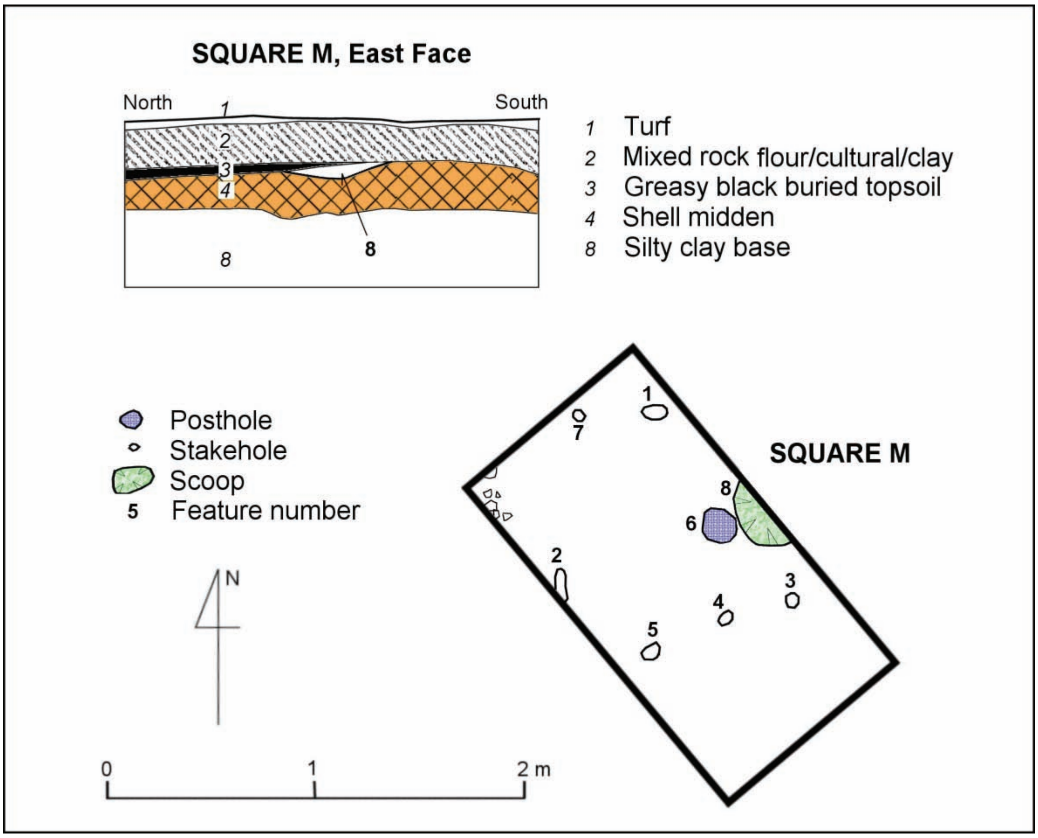

Figure 4. Plan and section of Square M, showing midden and underlying features.

Layer 1. Turf and topsoil, 20 mm in depth.

Layer 2. A clay and rock flour cultural mix, 210 mm in depth.

Layer 3. A greasy black topsoil, 60 mm in depth.

Layer 4. This layer consisted of a 170 mm deep layer of shell midden. Two dog teeth and some fish bones comprised additional food refuse. There were also hangi stones, obsidian and chert flakes, but no European-derived artefacts.

Collection of this midden followed a different process to that in Square F. Due to the fact that the midden was deep and appeared to be fairly uniform it was removed in four spits: Spit 1 = 40 mm deep, Spit 2 = 50 mm, Spit 3 = 50 mm, Spit 4 = 30 mm. The total spit from quad A was collected in each case except for Spit 4 in which the shell was very dispersed and mixed with the underlying clay. A total sample of 25,000 mm^2 from quad A was also collected.

Layer 5. Underlying clay base in which some stakeholes and a posthole were found. These may have originated from above the shell as they were very shallow.

Methods and Results of Analysis

Analysis of samples from Square F layer 4, Square F layer 6 and Square M layer 4 followed the methodology set out below:

a. All samples, except feature and most total samples, were wet sieved at the site using a 5 mm sieve to float off most of the charcoal and remove the soil. The remainder, mostly shell, was dried and bagged.

b. Feature and total samples were taken to the laboratories of the Anthropology Department, University of Auckland, without further treatment.

c. In the archaeology laboratory, all the analysed samples were sieved through two sieves: 7 and 4.5 mm. The resulting 3 fractions (>7 mm, 7-4.5 mm and <4.5 mm) were bagged and labelled.

d. A visual inspection of each sample was undertaken. Categories looked at included wear, evidence of burning and degree of fragmentation. Contextual evidence and immediate impressions reported in the field notebooks and the Finds Book were incorporated into these descriptions.

e. After weighing the smaller fractions they were stored with no further analysis. Although useful information can be derived from these, such as numbers of species, patterns of damage, and the recovery of seeds and land snails, the degree of fragmentation makes this process very time consuming (Nichol 1988).

f. The >7 mm fractions were then sorted into shell, stone, bone, artefacts and residue. Once again these were bagged separately then distributed to the students who were carrying out the separate analyses.

g. The shell from each >7 mm fraction was washed, weighed and classified, apart from a small number of shells which could not be identified due to their high degree of damage, using the Anthropology Department laboratory collection, standard references (Morton and Miller 1968; Powell 1961; Pownall 1971), and advice from Rod Wallace and Professor Morton. The scientific and common names of these species and environment of occurrence are shown in Table 2.

Table 2: Shellfish species identified at Opita, their habitat (Crowe 2007) and place in the diet.

Species	*Common name*	*Location*	*Diet*
Paphies australis	pipi	low tide mud/sand flats	main
Austrovenus stutchburyi	cockle	intertidal mud flats	main
Cominella adspersa	speckled whelk	rocks and mud flats	supplementary
Turbo smaragdus	cats eyes	intertidal rocks	supplementary
Saccostrea cuculata	rock oyster	on low tidal rocks	supplementary
Crepidula monoxyla	white slipper	on rocks low tide to deeper water	incidental
Sigapatella novaezelandiae	circular slipper	on stones or shells at low tide	incidental
Paphies subtriangulatum	tuatua	in sand at low tide sandy beaches	supplementary
Dosinia subrosea	fine dosinia	in sand at low tide	supplementary
Perna canaliculus	green mussel	rocks at low tide	supplementary
Cominella glandiformis	mud whelk	mudflats	supplementary
Hyridella menziesi	fresh-water mussel	running fresh water	supplementary

h. Each species was then subdivided into two groups: complete shells and hinges (in the case of univalve shells those that were ¾ whole were put aside with the complete ones), and fragments. Hinges are the most robust part of the shell so are the most reliable part to use for identification.

i. The majority of shells in all midden samples consisted of pipi (Paphies australis) and cockle (Austrovenus stutchburyi), so further research was done on these shells. Although weighing shells is not a totally accurate method of calculating relative proportions, as it does not take into account loss of weight through calcination and fragmentation especially at the lower levels of the midden (Waselkov 1987), the whole/hinged and fragmented fractions for cockle and pipi were weighed to see if there was any variation in fragmentation that might be due to other post-depositional factors (Table 3).

j. Other species appeared in very small fragmented amounts or as single examples, so detailed further analysis was unwarranted.

Table 3. Weight of midden samples after sorting into species and separating identifiable fragments.

Square	*Layer*	*Quad/ Feature*	*Weight (g)*					*Total*
			Misc	*Whole & Hinge*		*Fragments*		
				Cockle	*Pipi*	*Cockle*	*Pipi*	
F	4	Total Sample	30	220	80	135	15	**480**
F	4	B4	305	1990	1350	1125	115	**4885**
F	4	B5	229	665	215	451	65	**1625**
F	4	B6	118	200	50	187	40	**595**
F	4	D4	72	60	183	70	85	**470**
F	6	B4	295	200	3865	85	865	**5310**
F	6	C6 scoop	2	35	95	10	20	**162**
M	4	Spit 1	92	253	1175	220	295	**2035**
M	4	Spit 2	175	270	1330	240	240	**2255**
M	4	Spit 3	175	175	755	200	345	**1650**
Totals			**271**	**4068**	**9098**	**2723**	**2085**	

k. Although the shell species shown in Table 2 are all potentially edible it is probable that only pipi and cockle were specifically targeted for consumption, and other edible shellfish, such as mussel, oyster, cats eye, tuatua, whelks and dosinia, supplemented the major species when they were available close-by. The remaining species were probably collected incidentally when gathering the other species.

l. Nichol (1988) observed that counting the number of shells "... enhances economy, accuracy and convenience..." (1988:15-17). Therefore, the whole shells and hinges were counted to determine the numbers and proportions of the different species (Table 4). To reach a minimum number (MNI) of bivalves this figure was divided in half.

Table 4. Minimum number and proportions of pipi and cockle in each sample.

Square	*Layer*	*Quad/ Feature*	*MNI (total number divided by 2)*			
			Pipi		*Cockle*	
			No.	*%*	*No.*	*%*
F	4	Total Sample	22	26	63	74
F	4	B4	259	33	535	67
F	4	B5	69	28	179	72
F	4	B6	20	26	57	74
F	4	D4	91	79	24	21
F	6	B4	2184	95	108	5
F	6	Scoop	74	72	29	28
M	4	Spit 1	1087	89	137	11
M	4	Spit 2	1163	85	212	15
M	4	Spit 3	857	90	94	10

m. Size analysis appeared to be the most useful measure for comparing middens from different areas and layers. Samples selected for size analysis came from Square F layer 4 quad B4, Square F layer 6 quad B4 and Square M layer 4 spit 2. The large number of shells in some samples resulted in subsamples being formed by dividing the material (refer to Table 5). The common method[1] of measuring the length of the bivalves was undertaken using callipers, with the results tabled according to 5 mm classes[2] and converted to percentages to enable the easy comparison of the data (see Table 6, measurement locations Figure 5 and graph Figure 6).

1 Nichol (1988:38) suggests reconstructing the shells by matching the outlines of fragments to profiles of whole shells, but this method is extremely time-consuming. Another method is to correlate shell size to hinge size, as hinges are the most robust part of a shell, however that is less accurate as any minor error in measurement, or erosion of the shell, can have a significant effect on the calculated results

2 Thus 21-25 mm long shells were classed as 25 mm, 26-30 mm long were classed as 30 mm etc.

Table 5. Opita shell samples used for shell size analysis.

Sample			Pipi		Cockle	
Square	Layer	Quad/Feature	Total sample	Subsample %	Total sample	Subsample %
F	4	B4	518	50	1070	25
F	4	B6	40	100	118	100
F	4	D4	182	100	48	100
F	6	B4	4368	25	216	100
F	6	C6 scoop	74	100	58	100
M	4	Spit 2	2326	25	242	100

Table 6. Opita size ranges of pipi and cockles in samples and subsamples analysed (see Figure 5).

Square	*Layer*	*Quad/ Feature*	*Pipi size range Length (mm)*	*Cockle size range Length (mm)*
F	*4*	*B4*	*25-65*	*23-38*
F	*4*	*B6*	*25-65*	
F	*4*	*D4*	*25-55*	
F	*6*	*B4*	*20-60*	*15-36*
F	*6*	*C6 scoop*	*20-55*	
M	*4*	*Spit 2*	*20-55*	*20-38*

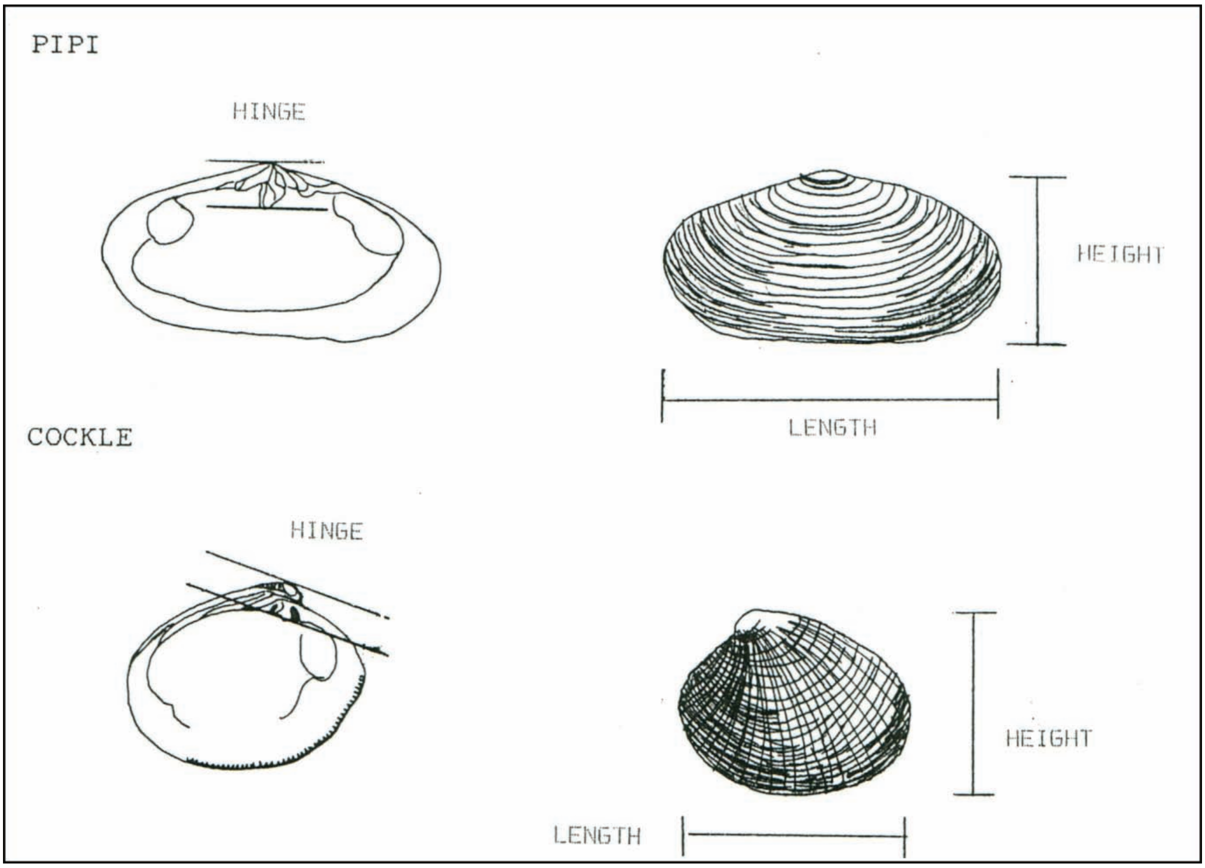

Figure 5. Points of measurements on pipi and cockle shells.

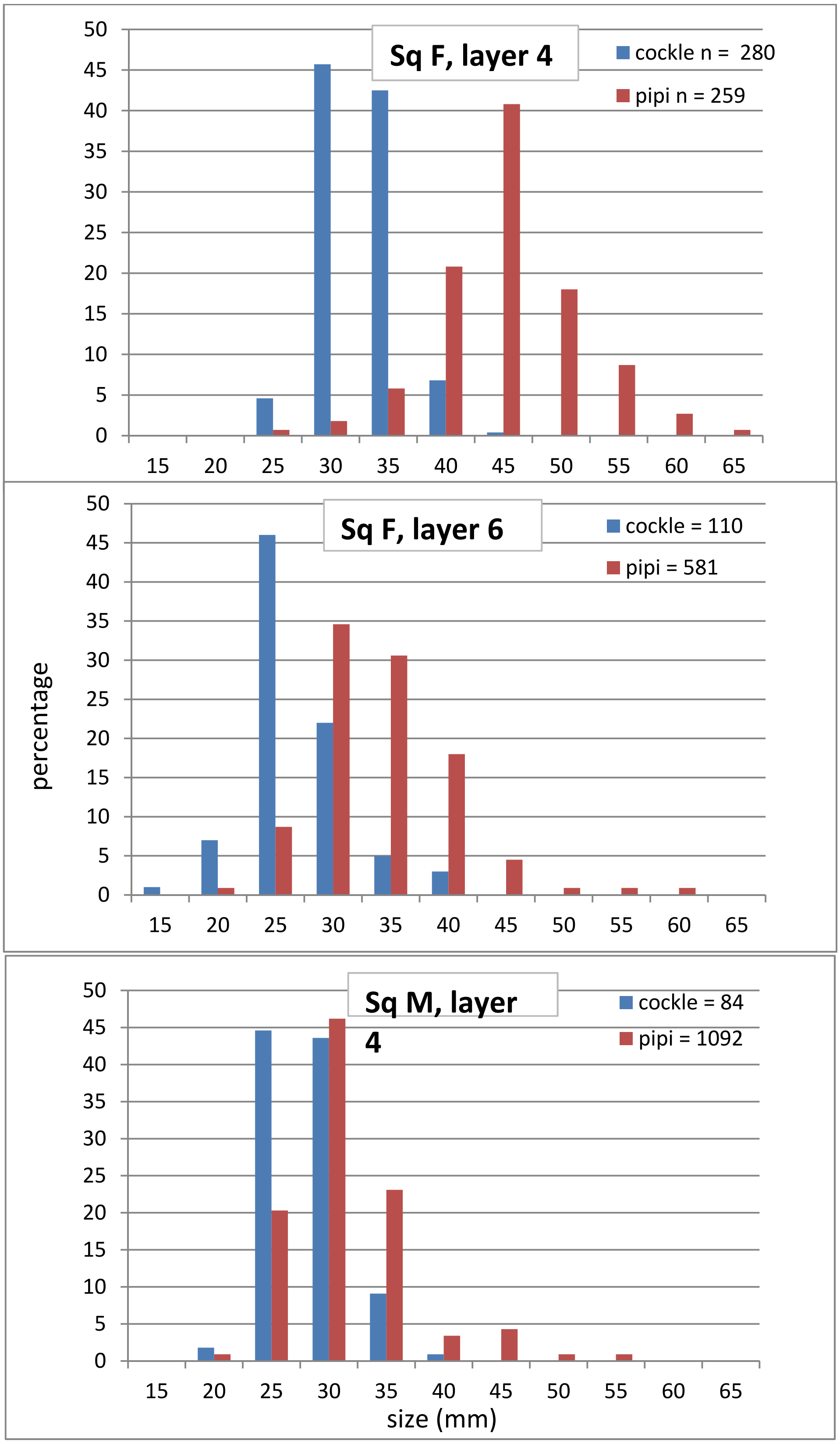

Figure 6. Cockle and pipi size percentages for sample from Square F layer 4 quad B4, Square F layer 6 quad B4 and Square M layer 4 spit 2.

Composition of the Midden Samples

The following is a description of each of the samples.

Square F, layer 4

Quad B4. This area contained the greatest concentration of shell and artefacts within layer 4. A collection of hangi stones was also recovered from this quad, suggesting the location of a cooking area. A visual inspection of the midden revealed shells that were well-preserved, with the growth rings on the cockles being clearly distinct. The shells were mostly cockle (Table 7), with pipi being the next most common. A few fragments of burnt pipi shell showed blackening from charcoal and the residue contained a large amount of charcoal.

Table 7. Composition of sample from Square F, layer 4, quad B4 (& probably C4). Items marked 'p' were included in the fragment weight.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	518	20-60	1350
Cockle	1070	23-38	1990
Green Mussel	8		p
Circular Slipper	1		p
Tuatua	1		p
Oyster	8		p
Fragments			1545
Total	**1606**		**4885**

Quad C4. Midden was collected from this quad but appears to have been lost, and it may have been amalgamated with the shell in quad B4.

Quad D4. Two red-brown burnt patches were visible at the top of the layer and approximately half of the pipi and cockle fragments were a dark greyish/black colour, which suggests that they were burnt. The soil also contained charcoal. The majority of the shells were pipi (Table 8).

Table 8. Composition of sample from Square F, layer 4, quad D4.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	182	25-65	183
Cockle	48	20-25	60
Green Mussel	Cuticle only		p
Fragments			227
Total	**230**		**470**

Quad B5. This quad contained a high concentration of shell of similar quality to that found in the neighbouring quad B4. The shell was mostly cockle (Table 9). A few of the cockle shells displayed markings characteristic of oyster borer predation on the outer side of the shell.

Table 9. Composition of sample Square F, layer 4, quad B5.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	*138*		*215*
Cockle	*358*		*665*
Mussel	*Cuticle only*		*p*
Speckled whelk	*2*		*p*
Oyster	*Fragments only*		*p*
Fragments			*745*
Total	***498***		***1625***

Quad B6. This sample came from a scoop within the midden. Approximately 50% of the shell was fragmented, and it was more worn, chalky and crumbly than the other shell in layer 4. Despite this, there was no burnt shell. The midden was mainly comprised of cockle (Table 10).

Table 10. Composition of sample Square F, layer 4, quad B6

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	40	25-55	50
Cockle	118	20-35	200
Mussel	Cuticle only		p
Mud whelk	1		p
Oyster	Fragment only		p
Fragments			345
Total	**159**		**595**

These four samples contained similar sized pipi and cockle. Three of the samples had similar proportions of pipi (25-32%) and cockle (67-74%) with the smallest sample containing almost the reverse proportions of these principal shells. The degree of crushing varied from 32-58%, which may have related to the degree of burning. The appearance of the shell was also generally similar.

Square F, layer 6

Fire Scoop C6. The shells in this sample were extremely worn and chalky, and the growth rings on the cockles and the hinges on the pipi were barely distinguishable due to wear. They also felt less dense than the shells in layer 6 quad B4, and those from layer 4 (Table 11).

Table 11. Composition of sample Square F, layer 6, scoop.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	148	20-55	95
Cockle	58	15-30	35
Mussel	Cuticle only		
Fragments			34
Total	**206**		**160**

Quad B4. The shells in this quad were mostly pipi (Table 12). All shells were smaller in size, more fragmented and not as well preserved as the shells in layer 4, but were less worn than the shells recovered from the scoop. A large amount of the fragmented pipi showed signs of fire damage. The shells in these two samples were similar in regard to size and appearance, although the proportions varied slightly with 72-95% being pipi. The shells appeared very worn and between 21-23% of the shells by weight were crushed.

Table 12. Composition of sample Square F layer 6, quad B4. Items marked 'p' are included in the fragment weight.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	4368	25-55	3865
Cockle	216	15-36	200
Mussel	2		p
Mud whelk	8		p
Speckled whelks	3		p
White slipper	1		p
Oyster	Fragments only		
Fragments			1245
Total	**4598**		**5310**

Square M, layer 4

The shells in layer 4, Square M were relatively small and there was far more pipi than cockle shell (Tables 13-15). Pipi shells were in relatively good condition, similar to those in Square F layer 4. However approximately 50% of the cockle shell was fragmented. There was a small amount of charcoal intermixed with the midden and many of the pipi fragments showed blackening.

Table 13. Composition of sample Square M, layer 4, Spit 1. Items marked 'p' were included in the fragment weight.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	2174		1175
Cockle	274		253
Mussel	3		p
Mud whelk	2		p
Slipper	1		p
Speckled whelk	1		p
Fragments			607
Total	**2455**		**2035**

Table 14. Composition of sample Square M, layer 4, Spit 2.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	2326	20-55	1330
Cockle	242	20-38	270
Mussel	5		p
Mud whelk	4		p
Speckled whelk	3		p
Circular slipper	1		p
Dosinia			
Fragments			655
Total	**2581**		**2255**

Table 15. Composition of sample Square M, layer 4, Spit 3.

Species	*Total Number*	*Length (mm)*	*Weight (g)*
Pipi	1714		755
Cockle	188		175
Mussel	9		p
whelk	fragments		
White Slipper	3		p
Cats eye	1		p
Tuatua	1		p
Fragments			545
Total	**1916**		**1650**

There was no obvious difference observed in the deposit and the spits represented arbitrary horizontal divisions of the layer. Consequently, it was unsurprising that the results were very similar, with between 88-90% being pipi and approximately 29-33% of the shell by weight being crushed.

Discussion

Information on the relative sizes of shells enables comparison of layers through time, as shell size patterns can indicate changes in preference, the area harvested and method of gathering.

Shell function

There is no evidence that the Opita shell material was used for any purpose other than food. The fact that the shell was found in association with cooking material, such as charcoal, hangi pits, hangi stones and fish and mammal bones, supports this conclusion. The shells did not show a high degree of crushing which might have been the case had the shell been used as the foundation for houses or to enhance gardening soil. Soil analysis failed to find much sediment within the midden layer and this suggests that the shells were not shifted from their initial dumping place (Maurice Hoban, pers. comm. 1991).

This is in contrast to archaeological sites on low-lying lands further downstream on the Waihou River, where settlements were built on artificial mounds constructed from sub-fossil shell banks and supplemented by midden (Phillips 2000:39). Phillips (2000:45,115-8) identifies pa sites such as Orongo and Oruarangi as having artificially-constructed shell mounds to raise the level of their settlements above the frequent episodes of flooding. Raupa Pa may also have had a raised central area built on midden shell, and one of the Puriri sites (T12/883) used older midden as a foundation for an 1880s house site. This use of shell was a technique adopted by Waihou Maori and a departure from the normal practice of dumping food waste away from living areas (Phillips 2000:47).

In addition, at Waiwhau shell and other midden contents were sometimes incorporated into soil used for gardening (Phillips & Green 1991:165).

Midden context

The shell midden at Opita shows some variation in the uses of areas within the site itself. Layers 7 and 8 in Square F reveal drains, scoops and stakeholes, but no midden. Presumably midden-dumping areas at these times were located elsewhere. The midden in Square F layer 6 was dumped as a thick deposit over half of the square indicating the use of this area as a shell dump. Square F layer 5 above again shows a paucity of shell and the presence of a structure, possibly a house. Layer 4 provides evidence for cooking and shell dumping. The plans and sections for Square F demonstrate an alternating pattern of use for this part of the site. Layers 4 and 6 represent areas of food consumption, cooking and refuse dumping, while other layers show a more residential pattern, where cooking and the dumping of food refuse took place elsewhere.

Similarly, Square M layer 4 indicates that this area was also being used for dumping food refuse, possibly at a similar time as Square F layer 6.

The extent of the excavations was not large enough to determine whether midden was the result of a series of family meals, or a single event, such as dumping food waste after a feast.

Chronology

There is a degree of internal consistency in the results of the shell analysis. In terms of the proportions of the major species represented, the samples fall into two groups. The first are those from Square F layer 4, where, apart from the single D4 scoop sample, all samples show a predominance of cockle. By contrast, there are similarities between the composition of shells in Square M layer 4 and those in Square F layer 6, where pipi were the predominant species gathered. This, combined with other archaeological evidence, i.e., the presence of European-derived materials in Square F layer 4 and the absence of such materials from Square M layer 4 and Square F layer 6, suggests that the two latter both belong to the prehistoric period and are possibly contemporaneous.

There is a second change in the composition of the shell middens, which mirrors the change in species and adds further support to grouping the middens. Shells in Square M layer 4 and Square F layer 6 are smaller than those in Square F layer 4: in the first two samples pipi are mainly 30-35 mm in length and cockle are less than 27 mm in length, whereas in Square F layer 4 the majority of pipi are 10 mm longer and the cockle are mostly larger than 27 mm (Figure 6).

Gathering Techniques

In the three samples a broad size range of pipi and cockles was gathered (Figure 6), and are likely to be representative of the natural growth curve of the population rather than conscious selection. Even smaller individuals occurred in the unsorted smaller fractions, and suggests that the shellfish were gathered without regard to size. This is consistent with Michael's (2008) study of *Austrovenus stutchburyi* populations at ten locations around Pauatahanui Inlet, Wellington, where 31 transects were sampled in 2004 and 2007 for intertidal cockle densities and population size structure. The results indicate shellfish populations approximating a normal curve (see Figure 7 for an example) with only one location in which the majority of very small shellfish showed a skewed population.

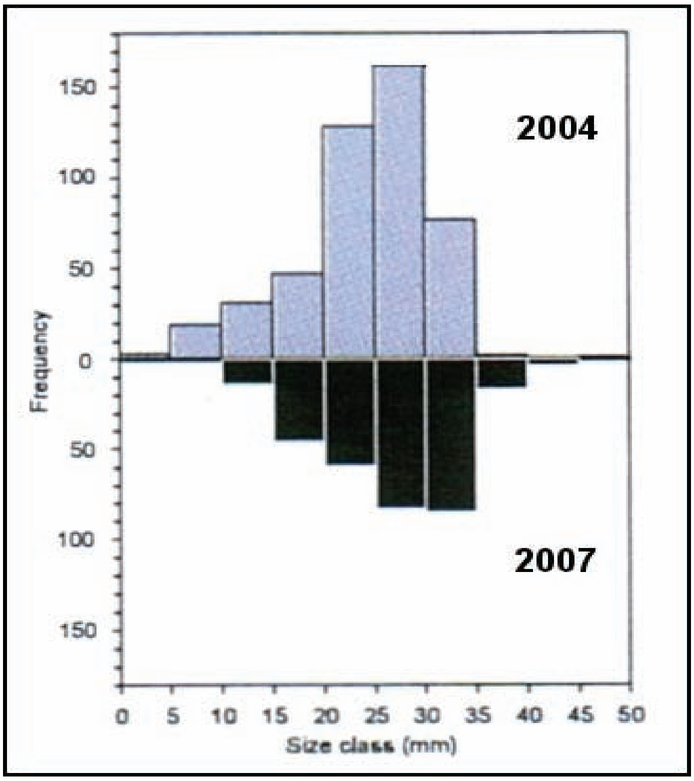

Figure 7. Cockle population data from the upper mid tide at Mana in the Pauatahanui Inlet (from Michael 2008:43).

Shells such as slipper shells (*Maoricrypta monoxyla and Sigapatella novaezelandiae*) are associated with cockle and pipi beds, but were probably not used as food themselves. This supports the conclusion that these shells were gathered up into baskets or raked up en masse along with the targeted species. These shells would not have appeared if careful manual selection was taking place.

The size graphs for pipi and cockle in Square F layer 4 are larger than the other two deposits (Figure 6). This may be attributable to the growth of the shellfish population, due to a period of minimal exploitation, rather than selective gathering. However it is possible that a limited degree of conscious selection was also occurring. Powell (1979:415) notes that the lengths of pipi on New Zealand beaches varied between 48 and 83 mm in length. This is larger than the pipi at Opita. The small size of pipi overall at Opita is probably an indication of considerable long-term predation pressure.

Shellfish preferences

In the 1991 field school report by Graham, McCracken and Young on which this appendix is based, the data was also used to calculate the meat weights represented by the shell to examine the diet. Given the large area of the site and the small extent excavated it was decided that this measure would not provide meaningful results. However, a short discussion of the relative meat returns from pipi or cockles is reasonable.

One possible explanation for the variation in species between the deposits may be that pipi might give greater returns for a lesser expenditure of labour than cockle. In order to test this, it was decided to obtain a small sample of living pipi and cockles. As the Firth of Thames is now so polluted that zoology students had in the past failed to find <u>any</u> cockles (Euan Young pers. comm., 1991), a small sample of pipi and cockles was collected from Petone Beach, Wellington. The shellfish were weighed, boiled, and then the empty shells and the meat weighed (Table 16).

Table 16. Weight of meat obtained from shellfish (all weights in grams).

Shell	*Number*	*Whole shellfish weight*	*Shell weight*	*Meat weight*	*Meat weight % of shell weight*
pipi	8	250	125	25	20%
cockle	10	175	100	20	20%

A similar experiment was carried out by Shawcross (1967) at Whangateau Harbour, just north of Auckland with similar results (pipi = 18% meat weight, cockles 18%) with some variation in terms of cooking time. From these experiments, it would appear that pipi and cockle provide similar returns for a similar investment of labour.

Another reason for the greater number of pipi might be that they are regarded as being more palatable than cockle, although no further investigation was undertaken along these lines.

In addition, as the cockles are mostly smaller than pipi, it is possible that the requirement for collection of fewer shells to achieve a given amount of shellfish meat meant that pipi were preferred over cockle.

Environment

The source of both main species of shellfish is likely to be the Waihou River and the Firth of Thames rather than the coastal beaches of Waihi through the Ohinemuri Gorge. The Waihou River is tidal to near the junction of the Waihou and the Ohinemuri Rivers, and canoes were able to journey to and from the Firth of Thames using these tides.

It is plausible that shellfish and other food items were obtained via exchange, and therefore could have been sourced from a number of different locations. Despite this possibility, it is presumed that the shellfish at Opita came from the mudflats and sandy environments downstream of Hikutaia[3]. Pipi prefer sandy to soft substrates at low tide level, while cockles are more tolerant of muddier conditions at intertidal levels. Given the morphology of the Waihou River, cockles were likely to be available further upstream than pipi, while pipi may have been commonest on the sandy flats at the mouth of the Waihou and around the beaches of the Firth of Thames.

The indications from the midden analysis are that during late prehistoric and early historic times (c.1625-1810) pipi were the preferred food and that people from Opita were travelling some distance to gather them. By contrast, cockles are likely to have been to have been easier to get at a number of locations along the Waihou, a little closer to the site.

The shift in shellfish to a greater proportion of cockles in the upper midden layer at Opita (Square F layer 4) dating to the 1840s may also have been a response to changing river conditions. Phillips (2000:31) documents the silting up of the eastern channel around Tuitahi Island near the mouth of the Waihou River some time in the early nineteenth century to the extent that by 1830 the channel was no longer navigable. Such increasing siltation is likely to have favoured cockles over pipi and the indications are that cockles became the main shellfish gathered during the early historic period.

3 Physical studies indicate that there were no mudflats south of the Hikutaia Stream junction with the Waihou River, 19 km downstream from Opita (Phillips 2000:25). Additionally, Maori evidence presented in the Maori Land Court suggest that shellfish were only gathered downstream of the Matatoki Stream mouth, 31 km downstream from Opita (Phillips 2000: 56)

Historical changes

A number of historical events during the period 1818 to 1830 impacted on the residents of the upper Waihou River. Firstly, around 1818 there was conflict between Ngati Paoa and Ngati Maru, but not Ngati Tamatera, who lived further upstream (Monin 2001:45). Following this, however, there was substantial conflict between the Hauraki tribes and Nga Puhi which culminated in a substantial defeat at Te Totara Pa in 1821. In fear of further attacks, Hauraki Maori left the Waihou Valley and took up residence with relatives in the Waikato, near Horotiu and Maungatautari, where they stayed until they returned to Hauraki in 1831 to reoccupy their territories (Monin 2001:57-74). Between the abandonment of the area and resettlement there was a period of nearly ten years when occupation was minimal on the Hauraki Plains, Coromandel Peninsula and around the Firth of Thames.

This period of absence is reflected in the archaeology of Opita, where Square F layer 6 and Square M layer 4 are presumed to be representative of time prior to the move, and Square F layer 4 is representative of the period after the return from the Waikato.

It is possible that the shellfish beds utilised by the inhabitants of Opita had recovered slightly from the earlier period of exploitation during this period when the Maori population of the area was minimal. The small size of shellfish in layer 6 may represent a shellfish population which was heavily exploited and where shellfish were taken as soon as they reached an acceptable gathering size. The larger shell size demonstrated in Square F layer 4 may represent a less-exploited population where shellfish had had a chance to grow larger. By this time also, either the ecology of the river had changed through siltation, or the people of Opita had less access to more distant pipi beds, and there was a shift from predominantly gathering pipi to a situation where cockles formed the largest proportion of shellfish.

Comparisons with Waiwhau, Raupa and the Puriri Stream Middens

The adjacent site of Raupa shows a similar pattern of shell disposal to that found in Square F at Opita (Prickett 1990:81, 97), where initial occupation in Areas I and II was characterised by structural remains. This was followed by a period in which these areas were used for cooking. Later, dating around 1800 AD, these same areas were utilised for the dumping of food refuse, mostly shell (Phillips 2000). At Waiwhau, midden in Area 4, as at Raupa, had been dumped on an area formerly used for several phases of housing, storage and cooking, before it was used as a dumping ground for food waste around 1810 (Phillips & Green 1991:172).

Shell composition from the midden in Square M layer 4 and Square F layer 6 is similar to the shell content of the middens at both Raupa and Waiwhau. In Areas I and II at Raupa the shell comprised 85-90% pipi with the rest cockle and other species (Prickett 1990:88). At Waiwhau the middens excavated in 1987 and 1988 comprised approximately 80-90% pipi and 10% cockle (Phillips 1988:63; Phillips & Green 1991:182).

The shell material in Areas I and II at Raupa was fragmented, indicating repeated shifting before being finally dumped (Prickett 1990:88,105). At Waiwhau shell and other midden contents were sometimes incorporated into the soil used for gardening (Phillips & Green 1991:165). In contrast, the number of intact shells contained in the Opita midden suggests that the material remained in the area where it was first deposited.

Further down the Waihou, Bedford (1994) provides information on eight middens along the Puriri River, a tributary of the Waihou, which he sampled or excavated (Table 17). The situation was complicated by the fact that a proportion of the shell at these middens was heavily crushed, suggesting that this had been used as fill to build up free-draining surfaces (1994:186), although, unlike Oruarangi and Orongo, none had been derived from sub-fossil shellfish beds (Bedford 1994:107).

Table 17. Shell composition and dating of Puriri middens, from Bedford (1994:92-3,106, 86,201).

Site No.	*Pipi %*	*Cockle %*	*Dating*
T12/879	94	5	late prehistoric or early historic (no European-derived materia , no direct dating)
T12/880	94	4	late prehistoric or early historic (no European-derived material, no direct dating)
T12/882	80	20	late seventeenth to early eighteenth century (no European-derived material, shell radiocarbon date)
T12/ 883	74	22	late seventeenth to early eighteenth century (shell radiocarbon date, midden reused for 1880s house floor)
T12/885	47	52	mid seventeenth century (no European-derived material, shell radiocarbon date)
T12/886	48	47	late prehistoric or early historic (no European-derived materia , no direct dating)
T12/ 318	68	31	late prehistoric/ historic (no direct dating, midden re-used for 1860-70s house floor)
T12/340 D2	77	22	early-mid seventeenth century (no European-derived material, shell radiocarbon date)

The information from Puriri shows that there was more pipi than cockle at seven of the nine middens described, while there was approximately a 50/50 split at T12/885 and T12/886. Variation within the dated sites does not indicate a chronological change in shellfish gathering habits. No other sites of this later period have been excavated to see if this change was universal or restricted to 1840s Opita.

Comparisons between shell middens at Opita, Waiwhau, Raupa and the Puriri sites indicate that during the late prehistoric and early historic period (c. 1625-1810) there was a preference for pipi over cockle at the majority of middens sampled, although Puriri T12/885 is the exception to the rule. However, there are indications of a subsequent increase in the proportion of cockles being gathered at Opita in terms of the evidence from Square F layer 4, dating to the 1840s.

Summary

During the excavation of Opita three main deposits of midden were discovered (Squares F layers 6 and 4, and Square M layer 4. After detailed analysis the following conclusions can be drawn:

a. The composition, appearance and size of the middens from Square F layer 6 and Square M layer 4 are similar: 80-95% of the shells were pipi, in a concentrated deposit. As no European-derived material was found with these deposits, it is likely that these layers both relate to the late prehistoric or early historic period.

b. These middens are also similar to middens excavated at the neighbouring sites of Raupa, Waiwhau and the Puriri River area. The preference for the collection of pipi, supplemented by cockles, appears to be a regional phenomenon up to the early historic c.1810.

c. The small sizes of the shellfish gathered during the late prehistoric and early historic suggests considerable pressure on the beds with the result that the shellfish in the middens are small relative to modern populations.

d. In contrast, the slightly larger sizes of shellfish, in which 67-74% were cockle, recovered from the upper midden layer (Square F layer 4) at Opita are probably the result of a reduction in shellfish gathering during the period 1821 to 1830 when many people from Hauraki took refuge in the Waikato. This gave the beds time to recover slightly.

e. Comparison between all the samples from each deposit indicated that there was a general uniformity within each, and that it was reasonable to make certain interpretations of the systematic similarities and differences between them.

f. The size distribution data obtained for pipi and cockles in all deposits suggests similar patterns of exploitation, and it is probable that non-selective gathering techniques were practised in all cases.

g. The shift from mostly pipi in the middens (Square F layer 6 and Square M layer 4) to mostly cockle (Square F layer 4) is likely to be the result of increased silting around the river mouth. However, it might also reflect the fact that there was less movement up and down the river, or greater difficulty in accessing the pipi shellfish beds around the Firth of Thames during the 1840s.

References

Bedford, S., 1994. Tenacity of the traditional: A history and archaeology of early European Maori contact, Puriri, Hauraki Plains. MA thesis, Department of Anthropology, University of Auckland, Auckland.

Best, S., 1980. Oruarangi Pa: Past and present investigations. *New Zealand Journal of Archaeology*, 2:65-91.

Crowe, A., 2007. *Which Seashell?* Auckland: Penguin.

Michael, K., 2008. *Community Survey of Cockles (Austrovenus stutchburyi) in Pauatahanui Inlet, Wellingto*n. NIWA client Report: WLG2008-39. Wellington: National Institute of Water and Atmospheric Research, Ltd.

Monin, P., 2001. *This is My Place: Hauraki Contested 1769-1875*. Wellington: Bridget Williams Books.

Morton, J.E., and M.E. Miller, 1968. *The New Zealand Seashore*. London: Collins.

Nichol, R..K., 1988. Tipping the feather against a scale: Archaeology for the tail of the fish. Unpublished PhD thesis, Department of Anthropology, University of Auckland.

Phillips, C., 1988. University of Auckland Field School excavations at Waiwhau, 1987. *New Zealand Journal of Archaeology*, 10:53-72.

Phillips, C., 2000a. Waihou *Journeys: The Archaeology of Four Hundred Years of Maori Settlement*. Auckland: Auckland University Press.

Phillips, C., and R.C. Green, 1991. Further archaeological investigations at the settlement of Waiwhau, Hauraki Plains. *Records of the Auckland Institute and Museum*, 28:147-183.

Powell, A.W.B., 1961. *Shells of New Zealand*. Christchurch: Whitcombe and Tombs Ltd. Fourth edition.

Powell A.W.B., 1979. Bivalvia (Bivalves). In A.W.B. Powell, *New Zealand Mollusca: Marine, Land and Freshwater Shells*. Auckland: William Collins Publishers, pp.355-439.

Pownall, G. 1974. *New Zealand Shells and Shellfish Collecting and Eating*. Auckland: Seven Seas Publishing Ltd.

Prickett, N., 1990. Archaeological excavations at Raupa: The 1987 season. *Records of the Auckland Institute and Museum*, 27:73-153.

Prickett, N., 1992. Archaeological excavations at Raupa: The 1988 season. *Records of the Auckland Institute and Museum*, 29:25-101.

Shawcross, W., 1967. An evaluation of the theoretical capacity of a New Zealand harbour to carry a human population. *Tane*, 13:3-11.

Turner, M., 1990. Analysis of shell from N43/1 and N43/2, Ponui Island. Unpublished student essay 03.340, Department of Anthropology, University of Auckland.

Waselkov, G.A., 1987. Shellfish gathering and shell midden archaeology. In M.B. Schiffer, (ed.), *Advances in Archaeological Method and Theory*, 10:93-210.

Appendix 14 An Interpretation of the Paleo-Environment through Soil Analysis

Maurice Hoban and Caroline Phillips

Introduction

Soil samples were recovered during the excavation of the Opita sites, which comprise a fortified village and a number of small undefended settlements, near the present-day township of Paeroa. These samples have been analysed to aid in the reconstruction of the environment, and understand some of the soil processes and the cultural effects upon this system. In addition it was hoped to be able to correlate the Opita sites to each other and to the neighbouring sites of Raupa and Waiwhau (see locations Figure 1), which had been previously excavated (Phillips 1986, 1988; Phillips and Green 1991; Prickett 1990, 1992).

Soils and sediments occur in association with archaeological sites, being what commonly form the natural material. In some cases an archaeological deposit has been reworked by one or more sedimentary processes (Pettijohn, Potter and Siever 1972). This is definitely so at the Opita sites, where the sediments consist of a variety of solid materials (minerals, rock fragments, organic constituents) that have been deposited predominantly by water.

When referring to soils in an archaeological context several generalised questions can be asked:

- does a certain material constitute a natural deposit, consisting of surrounding soils and sediments which have accumulated by natural processes;
- is there evidence to suggest anthropogenic influences, as expressed either in the composition of the deposited materials or in the manner in which material has accumulated;
- how long has it taken for a feature to fill up, and what processes were involved; and,
- is there evidence that the accumulated materials have been altered since they were deposited and, if so, how does it contribute to our understanding of the original composition, geomorphic and palaeo-environmental history of the sites?

Methods and Analysis

Selective sampling was used in Opita: a soil transect to map the course of the old Ohinemuri river outlet; in Trench C to show the progression of different soils; and also in the ditch feature excavated in Square H to determine how it was formed (Figure 1). Other bulk samples collected were more or less at random (Dackombe and Gardiner 1983).

All 49 samples are represented by a sample number,[1] 39 numbers being allocated to all finds and samples in the field, while 10 were assigned later during analysis of the midden.[2]

1 Inadvertently two samples were assigned the same number: these have been renumbered 458a and 458b.

2 Field numbers were 191, 419-26, 458a & b, 460-2, 464-7, 478-81, 483-5, 487-94, 496-501; laboratory numbers assigned during midden analysis were 1500-8.

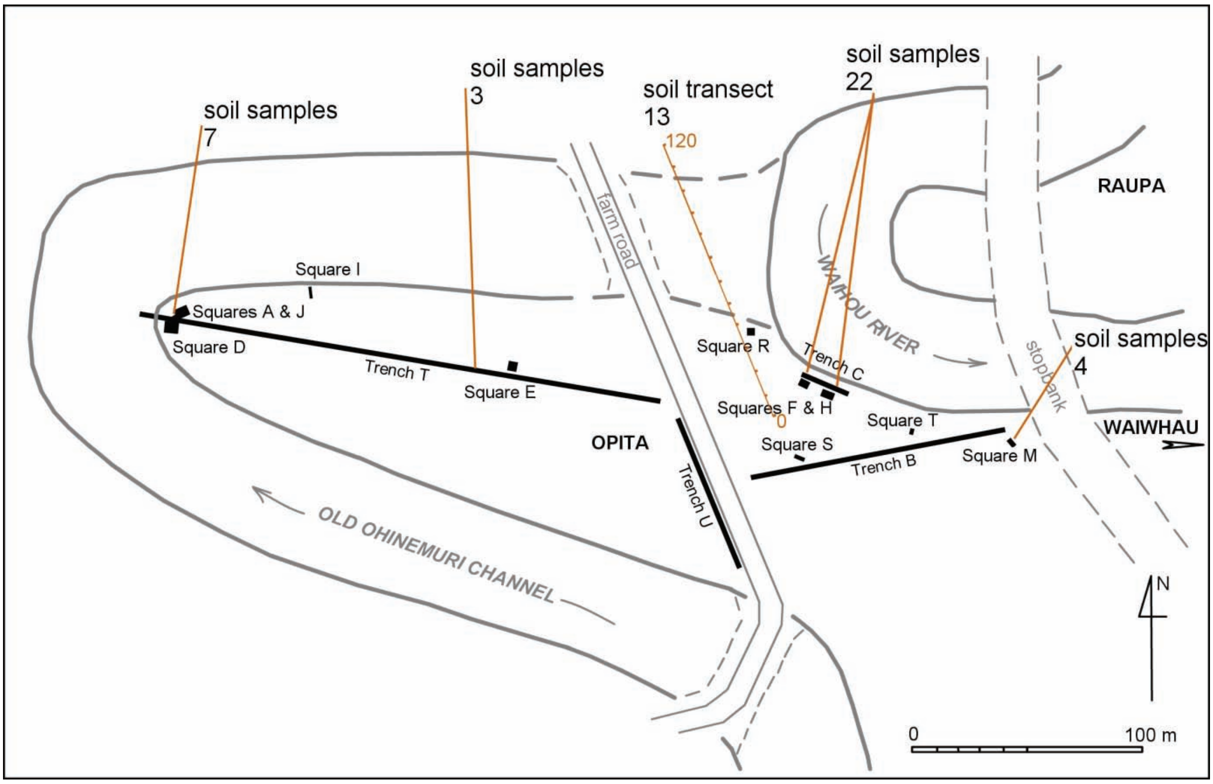

Figure 1. Location of soil samples recovered from the Opita sites.

A series of analyses were undertaken, including:

- description, classification and colour;
- soil moisture;
- pH;
- organic matter and carbon;
- particle size analysis; and
- mineralogical examination.

As only bulk samples were recovered, micromorphology studies, which rely on undisturbed samples, could not be undertaken (Figure 2).

Description, Classification and Colour

Classification of the soils is the most important analysis for reconstructing past environments. Most striking to the eye is the soil colour, which often gives significant information on the physical and chemical agencies involved. Grey or blackish colours most frequently reflect humus conditions, while yellow or reddish shades may reflect chemical alteration. Only in a few cases is the soil colour of mature soils directly determined by the parent material. Additionally, the classes and kinds of humus, soil fauna, chemical reaction, soil texture and size are needed for identification of soil classes.

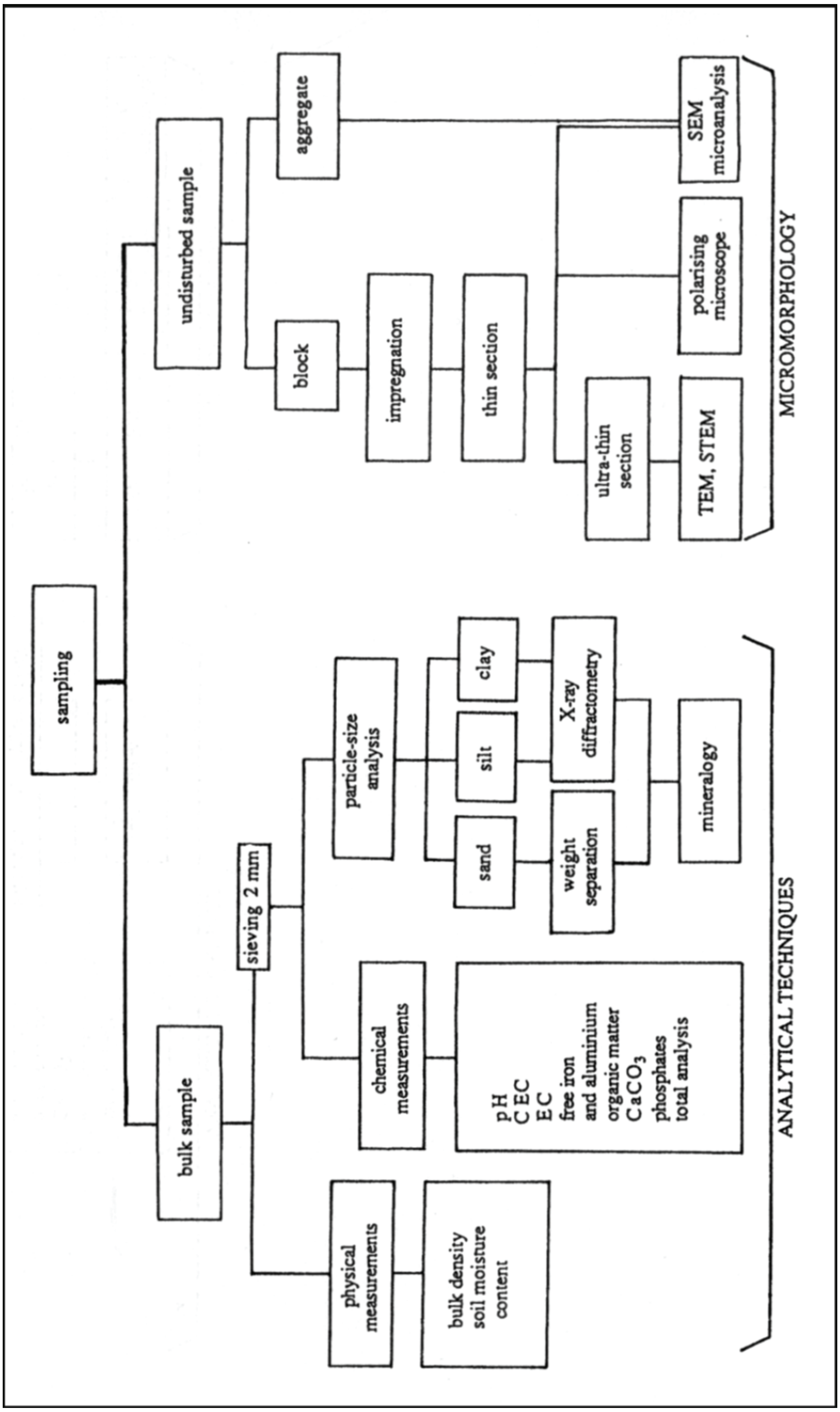

Figure 2. Study techniques for soil analysis in archaeology (Courty et al. 1989)

Descriptions were generated in the field and further remarks were added when the samples were analysed in the laboratory (see Attachment 1). In each unit the dominant colour is described first, with colour variations, soil phenomena (e.g., iron mottles), organic content and anthropogenic materials.

Soil Moisture

Although the moisture content of the soil will have been affected by recent weather conditions, it is important to determine soil moisture because moister soils appear both darker and less firm, thus affecting the descriptions of colour and consistency. The resulting value is used as a correction factor for most physical and chemical analyses.

The results, shown in Attachment 2, are not representative of true moisture values in the field, and do not help in distinguishing between different soils, but this information is needed for calculation in other analyses (Courty et al. 1989).

Determination of pH

The intensity of soil acidity or alkalinity is good for reflecting localised conditions. It should be noted that these results are not always reliable as pH is greatly affected by time and the post-depositional human influences on the soils. However, pH does gives an indication of survivorship for various archaeological materials, so that low pH increases the potential for preservation of pollen in soil, but is not favourable for the survival of carbonate materials like shells and bone (Carver 1971).

The results, shown in Attachment 2, give an improved representation of the spatial differences of natural soils and yield some clues to occupational zones within the site.

Organic Matter and Organic Carbon

Organic matter and organic carbon directly relate to the vegetation that occupied the particular layer being studied. Therefore, vast differences can be expected between forested landscapes as opposed to grasslands (Carver 1971; Metson et al. 1979).

The results, shown in Attachment 3, identify the anthropogenic soils: the midden samples are higher in organic matter, whereas the goldmine sediments (rock flour) are particularly low in organics.

Particle Size Analysis

Mechanical analysis separates the inorganic mineral portion of the soil into classified grades according to particle size and determines their relative proportions by weight. This is a good analysis for confirming the nature, dynamics and environment of sedimentary depositions. When applied to archaeological soils, size analysis is more limited, as the soil has suffered from anthropogenic disturbance or has been mixed with other components. However this analysis is a good reference for soil characterisation, especially if the results are interpreted in conjunction with other analyses (Courty et al. 1989; Ford and Williams 1989).

Sieve and hydrometer analysis were used in this study, to determine the soil particle sizes in the samples. The results were plotted on a cumulative logarithmic curve, in which statistical parameters may be read from it exactly, thus samples can be compared quantitatively according to their median, skewness, kurtosis, etc. Unfortunately, this curve is difficult to read and interpret at a glance, so a frequency curve was added. The frequency curves are chiefly pictorial as no statistical parameters can be read from them, but they give a better representation when comparing samples and constructing conclusions (Folk 1974). The analysis results, cumulative logarithmic and frequency curves are shown in Attachment 4.

The information obtained from this analysis provides the best representation of spatial differentiation of soil type within the Opita sites (Figure 3). It gives clues about the general formation of the sites, and there is evidence of an increased magnitude of flood occurrences seen in the soil transect (Figure 4).

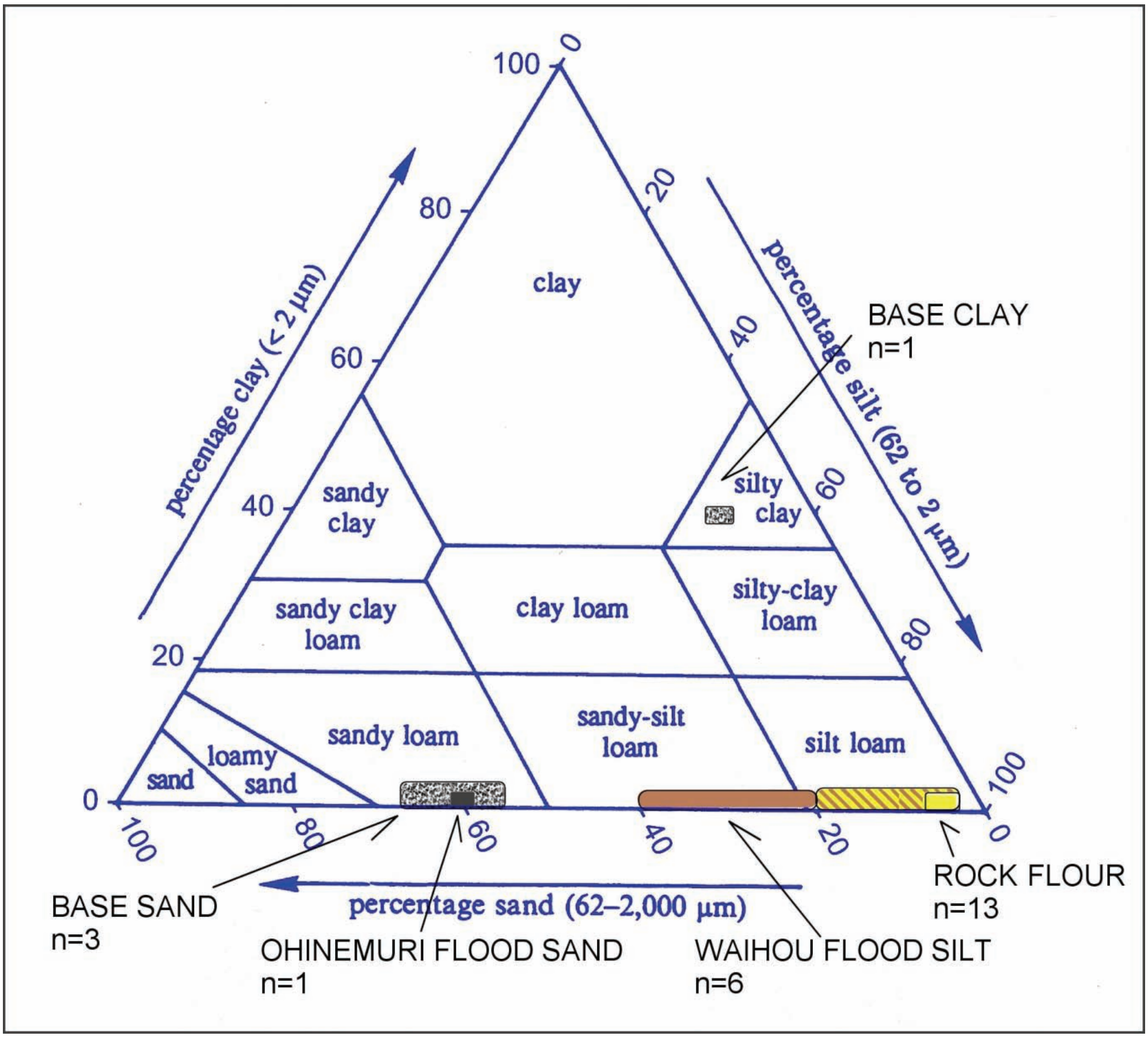

Figure 3. The position of the soils from the Opita sites within the sediment triangle (from Courty et al. 1989). Several of the rock four layers were extremely uniform while others appeared to have been mixed, shown as a hatched area. The base deposits beneath the cultural layers are very close to the single Ohinemuri flood deposit and distinct from the Waihou sediments. The cultural and feature fill layers are within the sandy-silt and silt loam categories.

Mineralogical Examination

For a complete mineralogical examination of the Opita samples, undisturbed soil samples are required (Courty et al. 1989), but an analysis of the major minerals and their approximate abundance in each of the samples was undertaken to determine the variation present and to distinguish between the rock flour and other layers.

Overall the most abundant mineral was quartz (see Attachment 5), but this is not unusual for an alluvial system. However, the presence of metals, including gold and silver, is a clear signature of the rock flour deposits.

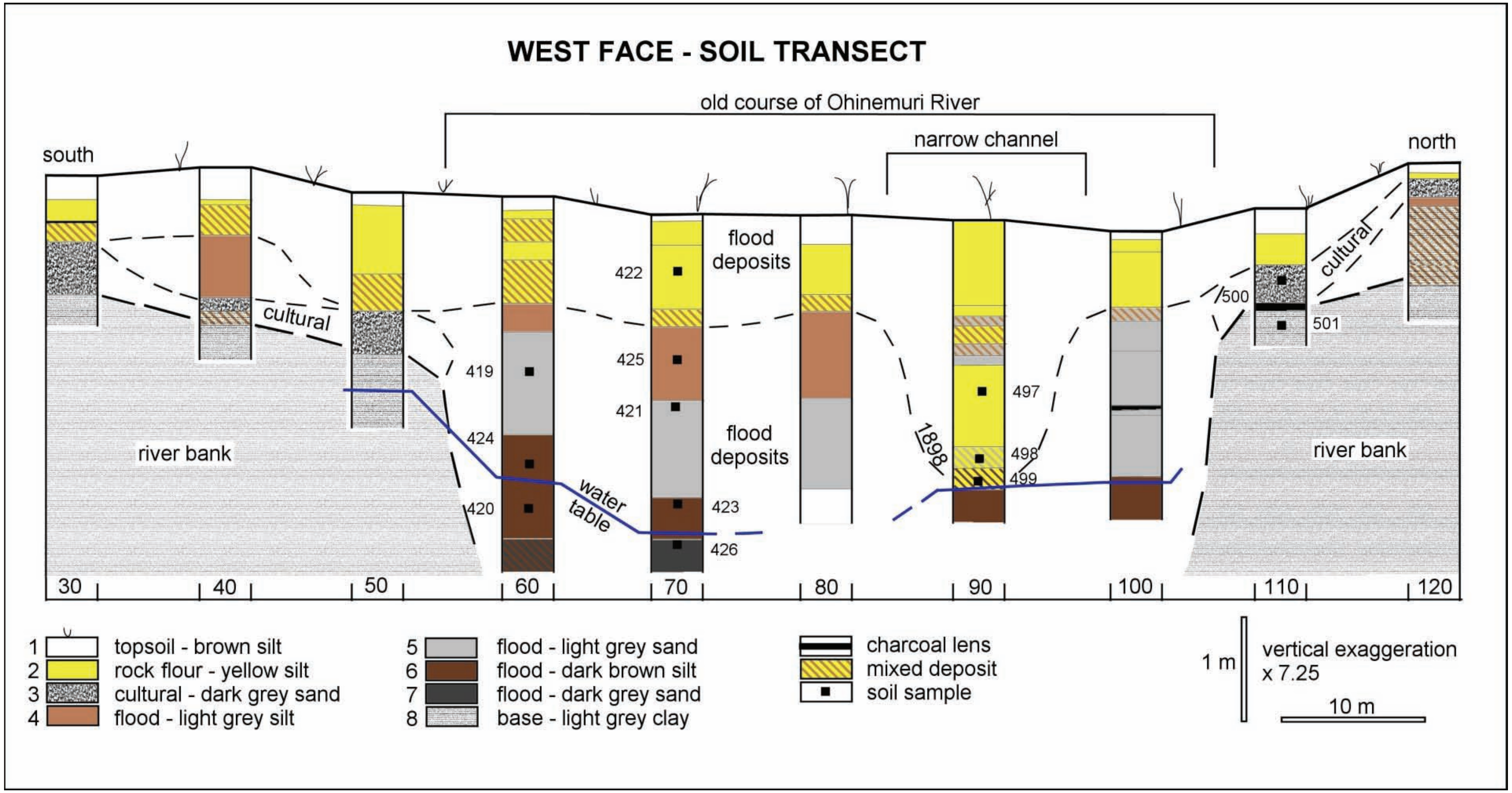

Figure 4. Soil transect across the former Ohinemuri River channel.

Interpretation of Results

At Opita, when differentiating between natural and anthropogenic deposits, pH, organic matter, grain size and mineralogy seem to be the best indicators (Table 1). Generally these studies should be used in conjunction, as it is the interpretation of the combined results, rather than those of individual analyses, that can answer archaeological questions.

The percentage of organic matter in the cultural deposits is greater than other deposits, whereas there are minimal organic constituents in the rock flour layers. This is backed up by the observation that the natural sediments have a small modal grain size, and have accumulated during flood events (Figure 3). It is only the very thin topsoil that has naturally formed from other processes such as humification, and the shallow depth is due to the fact that the pasture has only grown since the last flood ten years previously in 1981.

As the full analyses were not undertaken on the midden samples (except in Trench C), the interrelationships between the two midden layers of Trench C and Square M could not be determined. However, it was observed that the shell midden deposits, which were rich in calcium carbonate, had a relatively low pH value of between 7.2 and 7.8. This seems to have been caused by the extremely low pH of the natural soils which surrounded the anthropogenic deposits, indicating leaching into the midden layers. These results have serious implications on the preservation of shell and bone items in the sites.

A question arose about the processes involved in the formation of the shell dumps. If rubbish was placed randomly on the site and then accumulated later into one midden dump, then natural sediments would be accumulated with them. However, if the midden was placed straight into a dump the percentage of natural minerals like quartz and feldspars would be low. The results show low quantities of natural minerals, so it suggests that the midden dumps were predetermined zones.

Various historical anthropogenic influences affecting natural soil formation or preservation are known. Maori used fire to clear areas of forest for cultivation and settlement, especially along the major rivers, and Rev. Samuel Marsden described the local scene in 1820 as, "... rich, adorned here and there with lofty pines. Some small farms were cultivated for potatoes, upon which the poor slaves were at work" (Elder 1932:256).

But it seems the European played a more significant role in the construction of the current soil sequence. Coinciding with the gold mining in the Karangahake Gorge and Waihi around the headwaters of the Ohinemuri River was the extensive removal of forest in the Coromandel and Kaimai Ranges. These combined activities caused unprecedented erosion events from the late 1890s, polluting river systems with sediment, and so increasing the magnitude of flood events. Moreover, the sediments contained potent minerals and chemicals used in the gold extraction processes. From the mineralogical analysis it can be seen that the rock flour layers consisted of large amounts of fine quartz coinciding with smaller amounts of trace metals: lead, zinc, copper, silver, cadmium and very fine gold dust particles. Chemical constituents would also have been high in these layers, with cyanide being used in the extraction of the gold (Barber 1985).

This increase in the magnitudes of floods caused rapid burying of the former cultural evidence and hence preservation of the sites. In addition, the general morphology of the landscape has changed dramatically since the occupation by Maori at Opita: particularly the siltation and narrowing of the river channels, rechannelling of the Waihou River and construction of stopbanks. It was because of the threat of a new round of destructive flood protection measures that Waiwhau and Raupa were excavated (Phillips 1986).

Table 1. Key analyses of the soil samples from the Opita sites (next page).

Location	*Layer*	*No.*	*pH*	*Organic*	*Metal*	*Description*	*Colour*	*Soil Type*
Area D	1	479	4.41	13	0	topsoil	grey brown	sandy-silt loam
Area D	2	478	4.43	7	10	rock flour	grey orange	silt loam
Area D	3	480	4.58	13	0	cultural	black brown	sandy loam
Area D	4	481	4.31	11	0	base	brown	sandy loam
Trench T 15	2	483	4.30	12	6	rock flour	grey orange	sandy-silt loam
Trench T 15	3	484	4.90	15	0	cultural	black brown	sandy-silt loam
Trench T 15	4	485	5.01	13	0	base	grey brown	sandy loam
Trench T 130	2	460	5.45	11	4	rock flour	yellow brown	sandy-silt loam
Trench T 130	3	465	5.08	11	0	cultural	dark brown	sandy-silt loam
Trench T 130	4	463	5.21	15	0	base	grey brown	loamy sand
Soil Transect 70	2	422	4.30	4	0	rock flour	yellow brown	silt loam
Soil Transect 90	2	497	5.43	3	8	rock flour	yellow brown	silt loam
Soil Transect 110	3	500	5.43	15	0	cultural	dark brown	sandy-silt loam
Soil Transect 70	4	425	4.35	12	0	flood deposit	grey brown	sandy-silt loam
Soil Transect 60	5	419	4.70	11	0	flood deposit	brown	silt loam
Soil Transect 70	5	421	4.70	11	0	flood deposit	grey brown	sandy-silt loam
Soil Transect 90	2	498	4.52	3	6	rock flour	grey orange	sandy-silt loam
Soil Transect 90	2&5	499	4.49	12	5	rock flour	black brown	sandy-silt loam
Soil Transect 60	6	424	4.38	13	0	flood deposit	grey	sandy-silt loam
Soil Transect 60	6	420	4.07	14	0	flood deposit	dark brown	sandy-silt loam
Soil Transect 70	6	423	4.58	12	0	flood deposit	dark brown	sandy-silt loam
Soil Transect 70	9	426	5.06	9	0	flood deposit	brownish grey	sandy loam
Soil Transect 110	7	501	5.78	15	0	base	light grey	silty clay
Trench C 4-5	1	487	5.24	21	0	topsoil	grey brown	sandy-silt loam
Trench C 4-5	2a	488	4.84	4	8	rock flour	yellow brown	sandy-silt loam
Trench C 4-5	2b	489	4.91	4	7	rock flour	yellow orange	sandy-silt loam
Trench C 4-5	3	496	6.80	13	0	cultural	black brown	sandy loam
Trench C 4-5	4	490	7.19	15	0	midden	black brown	sandy-silt loam
Trench C 4-5	5	491	7.02	14	0	flood deposit	dark brown	sandy loam
Trench C 4-5	6	492	6.89	13	0	midden	dark brown	sandy loam
Trench C 4-5	7	493	6.78	12	0	feature fill	black brown	silt loam
Trench C 4-5	8	494	6.66	14	0	cultural	grey orange	loamy sand
Square F	4	191	7.42	17		midden		
Square F	4	1501	7.76	14		midden		
Square F	4	1504	7.22	39		midden		
Square F	4	1506	7.28	19		midden		
Square F	4	1508	7.49	24		midden		
Square F	6	1507	7.26	20		midden		
Trench C 13.5	2a	458b	5.73	3	7	rock flour	yellow brown	silt loam
Trench C 13.5	2b	462	5.26	4	7	rock flour	grey orange	silt loam
Trench C 13.5	9a/b	467	5.43	10	0	feature fill	dark brown	sandy-silt loam
Square H ditch	2a	458a	4.19	3	0	rock flour	yellow brown	silt loam
Square H ditch	2b	466	5.13	7	6	rock flour	grey orange	silt loam
Square H ditch	9a	461	5.31	9	0	feature fill	brown grey	silt loam
Square H ditch	9b	464	5.34	8	0	feature fill	grey brown	silt loam
Square M	4	1500	7.77	19		midden		
Square M	4	1502	7.75	13		midden		
Square M	4	1503	7.87	12		midden		
Square M	4	1505	7.72	14		midden		

These depositional events suggest an approximate date in which the old course of the Ohinemuri was flowing. It seems from the depth of the rock flour at one point along the soil transect that water had been flowing, at least intermittently, immediately prior to the 1890s flood events, although the narrow channel could have been man-made (see discussion in attached report).

In general the soils were naturally thin and poor, washed from steep slopes as quickly as the rock was weathered. The fertility they had was in the vegetation they supported. When Maori and, later and to a larger degree, Europeans removed this growth, the fertility was lost too. It is suggested that Maori added fertility by spreading ash and organic matter over the cultivated areas (Cumberland 1981). This hypothesis seems to be backed up by the colour of the cultural soils, being richly brown with a high organic matter content.

In the neighbouring sites of Raupa and Waiwhau different flood deposits were observed, and these were compared to the three flood sediments recorded at Opita, in Trench C and the adjacent Squares F and H.

- Layer 7 was a 10 cm thick pumiceous silt loam (493) that filled many of the lowest features. This could be the same as the c.1720 silt loam probably from the Waihou River seen at Raupa[3].
- Layer 5 was a 20 cm thick sandy loam (491), and could be the same as 1810 flood deposit sand from Ohinemuri which lapped both Waiwhau and Raupa.
- Layer 3 was a 15 cm sandy loam (496), and was probably deposited around 1880 due to forest clearance along the Ohinemuri River[4].

The Maori population also influenced the localised landscape, creating large ditches for defence, digging pits for cooking and storage and designating areas for refuse tips. Maori were also influenced by the resources. When excavating the Opita sites it was clear that there had been an integrated settlement within the old river bend, based on the resources for defence, communication, transport and cultivation.

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References

Ball, D.F., 1964. Loss on ignition as an estimate of organic matter and organic carbon in non-calcareous soils. Journal of Soil Science, 15:84-92.

Barber, L., 1985. No Easy Riches: A History of Ohinemuri County, Paeroa and Waihi, 1885-1985. Paeroa: Ray Richards Publisher and Ohinemuri County Council.

Butzer, K., 1971. Environment and Archaeology: An Ecological Approach to Prehistory. New York: Aldin Atherton.

Carver, R., 1971. Procedures in Sedimentary Petrology. New York: John Wiley.

Cornwall, I., 1958. Soils for the Archaeologist. London: Phoenix House Ltd.

Cotter, M., 1975. From Gold to Green: Paeroa and District's First 100 Years, 1875-1975. Paeroa: Paeroa Borough Council.

Courtney, F., and S. Nortcliff, 1977. Analysis techniques in the study of soil distribution. Progress in Physical Geography, 1:40-64.

Courty, M., Goldberg, P., and R. Macphail, 1989. Soils and Micromorphology in Archaeology. Cambridge: Cambridge University Press.

Cumberland, K., 1981. Landmarks. Surry Hills, New South Wales: Reader's Digest.

Dackombe, R., and V. Gardiner, 1983. Geomorphological Field Manual. London: George Allen and Unwin.

3 This sediment was found at Raupa between Phases 1 & II, which were dated c.1690 & 1750 respectively.

4 This flood occurred some time between 1810 and 1890 when the rock flour deposits started coming down the Ohinemuri River, but artefacts present in this and the preceeding layers, together with the known bush clearances from the mid 1870s, can probably refine this event to around 1880.

De Bakker, H., 1970. Purposes of soil classification. Geoderma, 4:195-8.

Elder, J.R., 1932. The Letters and Journals of Samuel Marsden, 1765-1838. Dunedin: A.H. Reed.

Feldgate, M., 1988. A reconstruction of the pre-European environment of the Raupa/Waiwhau area. Unpublished research essay, Field Methods in Archaeology 03.340, University of Auckland, Auckland.

Folk, R.L., 1980. Petrology of Sedimentary Rocks. Austin: Hemphill Publishing Company.

Ford, D., and P. Williams, 1989. Karst Geomorphology and Hydrology. London: Unwin Hyman.

Fraser, C., 1910. The Geology of the Thames Subdivision. New Zealand Geological Survey, Bulletin 10, Wellington: Government Printer.

Gerrard, A., 1981. Soils and Landforms: An Integration of Geomorphology and Pedology. London: George Allen and Unwin.

Gradwell, H., and K.S. Birrell, 1979. Soil Bureau Laboratory Methods. C. Methods for Physical Analysis of Soils. New Zealand Soil Bureau Scientific Report, 10C.

Harrison, S., 1987. Soil Science 1, Laboratory Work. Unpublished Laboratory Manual, Waikato University.

Harrison, S., 1988. Soil Science 2, Laboratory Work. Unpublished Laboratory Manual, Waikato University.

Hewitt, A., 1989. New Zealand Soil Classification (Version 2.0). Dunedin: Department Scientific and Industrial Research.

Hilton, M., 1984. Laboratory manual for the textural analysis of sediments and the chemical analysis of soils, plants and waters. Unpublished Laboratory Manual, Department of Geography University of Auckland, Auckland.

Kermode, L., 1973. Geological Resources. National Resources Survey Part VII, Waikato-Coromandel-King Country Region. Wellington: Town and Country Planning Division and Ministry of Works, pp.63-72.

Metson, A., L. Blakemore, and D. Rhodes, 1979. Methods for the determination of soil organic carbon: A review, and application to New Zealand soils. New Zealand Journal of Science, 22: 205-28.

Munsell, 1965. Standard Soil Colour Chart (Munsell Scale). Tokyo: Nippon Shikisaisha Ltd.

Nash, D., 1988. Evidence and implications of flooding at Waiwhau T13/756, Field Methods in Archaeology. Unpublished research essay, Field Methods in Archaeology 03.340, University of Auckland.

Pettijohn, F., P. Potter, and R. Siever, 1972. Sand and Sandstone. Berlin: Springer-Verlag.

Phillips, C., 1986. Excavations at Raupa Pa (N53/37) and Waiwhau village (N53/198), Paeroa, New Zealand, in 1984. New Zealand Journal of Archaeology, 8:89-113.

Phillips, C., 1988. University of Auckland Field School excavations at Waiwhau, 1987. New Zealand Journal of Archaeology, 10:53-72.

Phillips, C., and R.C. Green, 1991. Further archaeological investigations at the settlement of Waiwhau, Hauraki Plains. Records of the Auckland Institute and Museum, 28:147-183.

Prickett, N., 1990. Archaeological excavations at Raupa: The 1987 season. Records of the Auckland Institute and Museum, 27:73-153.

Prickett, N., 1992. Archaeological excavations at Raupa: The 1988 season. Records of the Auckland Institute and Museum, 29:25-101.

Smith, R., and K. Atkinson, 1975. Techniques in Pedologv: A Handbook for Environmental and Resource Studies. London: Elek.

Tucker, M., (ed.) 1988. Techniques in Sedimentology. Oxford: Blackwell Scientific Publications.

Attachment 1 starts over page.

Attachment 1: Description, Classification and Colour

Sample Number	Field Description	Initial Weight (grams)	Laboratory Description	Sample Number	Colour Number (Munsell Colour Chart)	Colour Description (Given by the Munsell Colour Chart)	Comments on Colour
424	ST 60m Dark Grey Silt Layer	1015.5	Moist	424	Hue 10yr (4/4) N 5/0	Brown Grey	Oxidised Outside Colour (4 – 5mm) Inside Colour
419	ST 60m Brown Silt Layer	413.4	Moist Inside	419	Hue 10yr (6/3) N 5/0	Grey Yellowish Orange Brown	Inside Colour Oxidised Outside Layer (4 – 20mm)
420	ST 60m Dark Grey Layer	831.5	Moist, Containing small Amounts of Organic Matter	420	Hue 10yr (3/3)	Dark Brown	Containing some Darker Brown Mottles
423	ST 70m Dark Grey Silt, from 274cm	652.7	Moist	423	Hue 10yr (3/4)	Dark Brown	
426	ST 70m Dark Grey Sandy Silt, from 314cm	867.5	Slightly Moist, Coarse Grains	426	Hue 2.5y (4/2)	Yellowish Brownish Grey	
425	ST 70m Brown Silt Mottles, from 140cm	301.5	Slightly Moist	425	Hue 7.5yr (5/3) Hue 7.5r (4/6)	Grey Brown Red	Red Mottles
421	ST 70m Grey Water Logged Silt, from 180cm	496.2	Very Moist	421	Hue 7.5yr (5/3)	Grey Brown	
422	ST 70m Rockflour Layer	567		422	Hue 10yr (6/8)	Strong Yellowish Brown	Extreme Variations in Rockflour Colour, Depending on its intensity
499	St 90m Dark Grey Silt Sand, wiht Organic Matter, from 251cm	582.8	Very Moist, Alot of Fiborous Organic Matter	499	Hue 10yr (3/2)	Black Brown	
497	ST 90m Rockflour, Very Yellow with Grey Mottles, 140 – 201cm	1043	Very Moist	497	Hue 7.5yr (5/8) Hue 1.5y (5/2)	Light Brown Yellowish Brownish Grey	Outside and Mottles Inside, Contains Charcoal Pieces
498	ST 90m Light Grey with Dark Grey Organic Matter, from 233cm	1429.4	Moist	498	Hue 2.5y (7/0) Hue 5yr (6/6)	Grey Wite Grey Orange	Inside Oxidised Outside
501	ST 110m Grey Clay Base, from 100cm	304.9	Very Compact, Hard to Break, Very Fine Grained	501	Hue 2.5y (7/2)	Light Yellowish Grey	
500	ST 110m Dark Brown, Cultural?, from 54cm	674.4	Slightly Moist	500	Hue 7.5yr (3/4)	Dark Brown	

Sample Number	Field Description	Initial Weight (grams)	Laboratory Description	Sample Number	Colour Number (Munsell Colour Chart)	Colour Description (Given by the Munsell Colour Chart)	Comments on Colour
494	Area C Layer 8 – Clay and Cultural Mix	514	Crumbly	494	Hue 7.5yr (7/0) Hue 5yr (6/6)	Grey White Grey Orange	Some Variation in Colour Oxidised Outside Colour (4 – 5mm)
488	Area C Upper Layer 2 – Rockflour	1153.3		488	Hue 10yr (6/6)	Strong Yellowish Brown	
493	Area C Layer 7 – Clay Silt	506.5	Dry and Crumbly	493	Hue 7.5yr (3/2)	Black Brown	
492	Area C Layer 6 – Midden Layer	468.2	Associated Shell, not very Moist, Crumbly	492	Hue 7.5yr (3/3)	Dark Brown	
491	Area C Layer 5 – Silt Fill Between the Two Middens	468.8	Sparce Organic Matter Crumbly	491	Hue 7.5yr (3/4)	Dark Brown	
489	Area C Layer 2 – Lower Rockflour Layer	958.7	Sparse Organic Matter	489	Hue 10yr (7/3)	Grey Yellowish Orange	
490	Area C Layer 4 – Shell Midden and Silt	500.8	Shell Material, Sparse Org–anic Matter, Charcoal Motle	490	Hue 7.5yr (2/3)	Black Brown	Black Charcoal Mottle
496	Area C Layer 3 – Silt and Rockflour Mix	429.9	Sparse Organic Matter Damp, not Crumbly	496	Hue 7.5yr (2/3)	Black Brown	Colour, Depending on its intensity
467	Area C 115cm Layer 3 – Bottom of Dithch Feature, Next to Area H	683.4	Crumbly, Charcoal Pieces	467	Hue 7.5yr (3/3) N 4/0	Dark Brown Dark Grey	Speckles
487	Area C Layer 1 – Topsoil	389.4	Alot of Organic Matter, Damp	487	Hue 5yr (5/4)	Grey Reddish Brown	
462	Area C 100cm, Next to Area H Layer 2 – Rockflour Mix at Bottom of Ditch Feature	1229.5	Very Moist	462	Hue 5yr (5/4)	Grey Reddish Brown	Large Variation in Colour
458 b	Area C 50cm, Next to North/West Corner of Area H Layer 2 – Rockflour from Ditch Feature	768.7		458	Hue 10yr (6/8)	Strong Yellowish Brown	Some Variation in Colour
460	Trench T 130m Layer 2 – Rockflour 10cm Deep	419.1	Some Organic Matter, Damp	460	Hue 10yr (6/6) Hue 2.5yr (3/2)	Strong Yellowish Brown Black Reddish Brown	Some Variation in Colour
463	Trench T 130m Layer 4 – 50cm, Basal	479.8	Not so Crumbly	463	Hue 5yr (4/3)	Grey Reddish Brown	
465	Trench T 130m Layer 3 – Cultural	831	Damp	465	Hue 5yr (3/3)	Dark Reddish Brown	
485	Trench T 15m Layer 4 – Silty Sand Loam, Mottled Basal	629	Sparse Organic Matter, Damp	485	Hue 10r (3/4) Hue 10yr (5/1)	Dark Red Yellowish Brownish Grey	Large Variation in Colours Mottles
483	Trench T 15m Layer 2 – Rockflour 10cm	390	Organic Matter, Dry	483	Hue 7.5yr (7/3)	Grey Orange	Some Variation in Colour
484	Trench T 15m Layer 3 – Cultural 25cm	976.8	Organic Matter, Charcoal Pieces, Stones, Dry	484	Hue 5yr (2/4)	Black Reddish Brown	Mottles of Differing Colours

Sample Number	Field Description	Initial Weight (grams)	Laboratory Description	Sample Number	Colour Number (Munsell Colour Chart)	Colour Description (Given by the Munsell Colour Chart)	Comments on Colour
481	Area D Layer 4, Silty Sand Loam, South Wall 25cm deep	514.3	Sparse Organic Matter Sparse Charcoal, Dry	481	Hue 10yr (4/6)	Brown	
480	Area D Layer 2, Thrown form Pit, west wall 10cm deep	616.9	Some Organic Matter Dry	480	Hue 10yr (2/3)	Black Reddish Brown	
479	Area D Layer 1, Topsoil	347.4	Some Organic Matter Dry	479	Hue 7.5yr (6/3)	Grey Orange	
478	Area D Layer 2, Rockflour, west wall 5cm deep	158.5	Sparce Organic Matter	478	Hue 7.5yr (7/3)	Grey Orange	A Little Colour Variation
464	Area H Layer – Dithch Fill at Base of Ditch	321.4	Moist	464	Hue 7.5yr (5/4)	Grey Brown	
461	Area H Layer – Ditch Base, 40cm from west wall, 120cm deep	807.6	Very Moist, Mottles	461	Hue 10yr (4/1) 10pb (1/1)	Yellow Brownish Grey Purplish Black	Mottles
458 a	Area H Layer 2, Rockflour in ditch, 40cm west, 40cm deep	628.1	Damp	458	Hue 10yr (6/6)	Strong Yellowish Brown	Variation in Colour Viens
466	Area H Layer – Ditch Fill Rockflour 40cm west, 90cm deep	762	Wood, Iron Veins	466	Hue 5yr (6/4)	Grey Orange	Large Variation in Colour Ferric Coloured Viens
1500	Area B, Square M Layer 4, Spit 2, Quadrant B, Midden	1200.9	Wet Sieved, Alot of very small shell fragments, moist	1500			
1501	Area C, Square F Layer 6, Sector B4, >4.5mm Midden	2194.8	Dry sieved	1501			
1502	Area B, Square M Layer 4, Spit 2, Quadrant B, > 4.5mm Midden	344.5		1502			
1503	Area B, Square M Layer 4 Spit 2, Quadrant B, >4.5 Midden	403.5	Wet Sieved at Site	1503			
1504	Area C, Square F Layer 4, Sector B6 >4.5mm Midden	632.8	Wet Sieved?, Alot of Organic Matter (Charcoal)	1504			
191	Area C, Square F Solid Sample >4.5mm Suth 0 – 300mm east 600 – 1000	1900.2	Wet Sieved, Small Shell Fractions, Moist	191			
1505	Area B, Square M Layer 4, Spit 2 Quadrant B >4.5mm Midden	610	Very Shelly	1505			
1506	Area C, Square F Layer 4, Sector D4 >4.5mm Midden	736.6	Dry and Shelly	1506			
1507	Area C, Square F Layer 6, Fire Scoop Wet Sieved Midden >4.5mm	283.6		1507			
1508	Area C, Square F Layer 4 Sector B4 >4.5mm Midden	724.9		1508			

Attachment 2: Soil Moisture and pH

Determination of soil pH and moisture factor

Sample Number	Air Dry Soil Weight + Tray (grams)	Oven Dry Soil Weight + Tray (grams)	Moisture Factor	Ph in Distilled Water	Ph with Potassium Chloride Added
424	24.28	23.6	1.03	4.53	4.38
419	20.94	20.51	1.02	4.92	4.7
420	87.33	84.44	1.03	4.3	4.07
423	98.16	95.16	1.03	4.61	4.58
426	28.51	27.85	1.02	5.36	5.06
425	39.7	38.19	1.04	4.65	4.35
421	24.46	23.82	1.03	5.26	4.7
422	47.63	47.12	1.01	4.79	4.3
499	81.98	79.76	1.03	4.5	4.49
497	26.53	26.34	1.01	5.79	5.43
498	33.74	33.49	1.01	4.69	4.52
501	41.47	39.14	1.06	6.5	5.78
500	38.63	37.06	1.04	6.06	5.48

Sample Number	Air Dry Soil Weight + Tray (grams)	Oven Dry Soil Weight + Tray (grams)	Moisture Factor	Ph in Distilled Water	Ph with Potassium Chloride Added
494	145.84	136.28	1.07	7.43	6.66
488	128.72	127.19	1.01	5.57	4.84
493	68.36	65.54	1.04	7.59	6.78
492	137.88	131.26	1.05	7.57	6.89
491	127.41	125.07	1.02	7.63	7.02
489	70.04	68.22	1.03	5.83	4.91
490	45.98	44.37	1.04	7.49	7.19
496	132.84	127.71	1.04	7.21	6.8
467	47.11	45.56	1.03	6	5.43
487	153.92	151.17	1.02	5.52	5.24
462	41.48	40.95	1.01	5.85	5.26
458 b	54.61	52.83	1.03	5.73	4.9

Determination of soil pH and moisture factor

Sample Number	Air Dry Soil Weight + Tray (grams)	Oven Dry Soil Weight + Tray (grams)	Moisture Factor	Ph in Distilled Water	Ph with Potassium Chloride Added
460	54.64	53	1.03	5.88	5.45
463	130	122	1.07	6.35	5.21
485	134.34	126.57	1.06	6.2	5.08
465	58.84	56.75	1.04	5.88	5.01
483	69.04	67.13	1.03	4.79	4.3
484	70.04	68.22	1.03	5.81	4.9
481	63.57	61.12	1.04	5.08	4.31
480	64.74	61.84	1.05	5.65	4.58
479	75.28	72.66	1.04	4.8	4.41
478	29.73	29.16	1.02	5.09	4.43
464	33.64	32.95	1.02	5.93	5.34
461	36.83	35.94	1.02	6.16	5.31
458 a	57.6	57.01	1.01	4.19	4.61
466	32.12	31.49	1.02	5.76	5.13

Determination of soil pH

Sample Number	Ph in Distilled Water	Ph with Potassium Chloride Added
1500	8.12	7.77
1501	8.02	7.76
1502	8.05	7.75
1503	7.9	7.87
1504	7.4	7.22
191	7.74	7.42
1505	8.03	7.72
1506	7.53	7.28
1507	7.5	7.26
1508	7.78	7.49

Attachment 3: Organic Matter and Organic Carbon

Determination of organic matter and carbon content

Sample Number	Oven Dry Soil Weight + Crucible (grams)	Ignited Soil Weight + Crucible (grams)	Organic Matter Content (grams)	Organic Matter Content (%)	Organic Carbon Content (%)
424	26.767	25.499	1.268	12.68	4.05
419	25.233	24.089	1.144	11.44	3.47
420	27.468	26.022	1.446	14.46	4.88
423	25.533	24.302	1.231	12.31	3.88
426	28.728	27.835	0.893	8.93	2.30
425	25.234	23.992	1.242	12.42	3.93
421	26.465	25.386	1.079	10.79	3.17
422	25.726	25.35	0.376	3.76	0.00
499	26.441	25.203	1.238	12.38	3.91
497	24.036	23.741	0.295	2.95	0.00
498	24.066	23.756	0.31	3.1	0.00
501	25.731	24.276	1.455	14.55	4.92
500	31.086	29.618	1.468	14.68	4.99

Sample Number	Oven Dry Soil Weight + Crucible (grams)	Ignited Soil Weight + Crucible (grams)	Organic Matter Content (grams)	Organic Matter Content (%)	Organic Carbon Content (%)
494	24.071	22.648	1.423	14.23	4.77541
488	31.077	30.687	0.39	3.9	0
493	25.233	24.055	1.178	11.78	3.63126
492	28.722	27.461	1.261	12.61	4.01887
491	25.53	24.164	1.366	13.66	4.50922
489	25.838	25.472	0.366	3.66	0
490	24.081	22.627	1.454	14.54	4.92018
496	27.469	26.215	1.254	12.54	3.98618
467	26.779	25.767	1.012	10.12	2.85604
487	26.445	24.36	2.085	20.85	7.86695
462	25.554	25.137	0.417	4.17	0.07739
458 b	25.856	25.598	0.258	2.58	0

Grain size preference sheet

Grain Phi	Size microns	Description
−2	4000	granules
−1.5	2830	
−1	2000	
−0.5	1410	sand
0	1000	
0.5	710	
1	500	
1.5	350	
2	250	
2.5	177	
3	125	
3.5	88	
4	62.5	
4.25	53	Silt
4.5	44	
4.75	37	
5	31.3	
5.5	26.72	
6	15.62	
6.5	12.61	
7	7.8	
7.5	5.4	
8	3.86	
8.5	3.18	
9	2.1	Clay
9.5		
10	0.98	

Preparation of grain size analysis through 4 Phi wet sieve

Sample Number	Total Weight of Soil (grams)	Fraction < 4 Phi for Dry Sieve Analysis	Fraction > 4 Phi for Hydrometer Analysis
424	100	38.22	61.78
419	100	53.34	46.66
420	100	26.18	73.82
423	100	30.47	69.53
426	100	68.56	31.44
425	100	38.62	61.38
421	100	31.4	68.6
422	100	19.37	80.63
499	100	45.42	54.58
497	100	30.5	69.5
498	100	53.63	46.37
501	100	12.26	87.74
500	100	39.88	60.12
494	100	89.54	10.46
488	100	56.95	43.05
493	100	22.83	77.17
492	100	77.56	22.44
491	100	77.26	22.74
489	100	48.69	51.31
490	100	48.88	51.12
496	100	72.66	27.34
467	100	36.35	63.65
487	100	72.92	27.08
462	100	30.37	69.63
458 b	100	24.38	75.62
460	100	39.98	60.02
463	100	79.5	20.5
485	100	77.46	22.54
465	100	51.4	48.6
483	100	29.16	70.84
484	100	42.36	57.64
481	100	74.62	25.38
480	100	73.5	26.5
479	100	51	49
478	100	22.1	77.9
464	100	16.18	83.82
461	100	24.56	75.44
458 a	100	24.38	75.62
466	100	10.64	89.36

Graiin Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 424 C (Amount in Sieve)	Sample 424 C% (Cummulative from Original 100g)	Sample 419 C (Amount in Sieve)	Sample 419 C% (Cummulative from Original 100g)
-2	4000	0	99.45	0	87.42
-1.5	2830	0	99.45	0	87.42
-1	2000	0	99.45	0	87.42
-0.5	1410	0.11	99.45	0	87.42
0	1000	0.15	99.34	0.01	87.42
0.5	710	0.6	99.19	0.03	87.41
1	500	1.07	98.59	0.09	87.38
1.5	350	1.96	97.52	0.32	87.29
2	250	2.88	95.56	1.46	86.97
2.5	177	4.65	92.68	5.74	85.51
3	125	6.65	88.03	10.22	79.77
3.5	88	8.14	81.38	10.65	69.55
4	62.5	11.46	73.24	12.24	58.9

Grain Phi	Size microns	Sample 420 C (Amount in Sieve)	Sample 420 C% (Cummulative from Original 100g)	Sample 423 C (Amount in Sieve)	Sample 423 C% (Cummulative from Original 100g)
-2	4000	0	98.18	0	99.57
-1.5	2830	0.02	98.18	0	99.57
-1	2000	0.25	98.16	0	99.57
-0.5	1410	0.66	97.91	0.01	99.57
0	1000	1.59	97.25	0.05	99.56
0.5	710	2.18	95.66	0.11	99.51
1	500	2.74	93.48	0.17	99.4
1.5	350	2.49	90.74	0.28	99.23
2	250	1.68	88.25	0.6	98.95
2.5	177	1.5	86.57	2.03	98.35
3	125	2.34	85.07	7.75	96.32
3.5	88	3.23	82.73	8.67	88.57
4	62.5	5.68	79.5	10.37	79.9

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 426 C (Amount in Sieve)	Sample 426 C% (Cummulative from Original 100g)	Sample 425 C (Amount in Sieve)	Sample 425 C% (Cummulative from Original 100g)
-2	4000	0	99.96	0	98.81
-1.5	2830	0	99.96	0	98.81
-1	2000	0	99.96	0	98.81
-0.5	1410	0.03	99.96	0.02	98.81
0	1000	0.11	99.93	0.1	98.79
0.5	710	0.42	99.82	0.4	98.69
1	500	0.97	99.4	0.73	98.29
1.5	350	2.45	98.43	1.22	97.56
2	250	5.76	95.98	1.7	96.34
2.5	177	13.94	90.22	2.18	94.64
3	125	23.37	76.28	6.19	92.46
3.5	88	12.8	52.91	9.97	86.27
4	62.5	8.67	40.11	14.92	76.3

Grain Phi	Size microns	Sample 421 C (Amount in Sieve)	Sample 421 C% (Cummulative from Original 100g)	Sample 422 C (Amount in Sieve)	Sample 422 C% (Cummulative from Original 100g)
-2	4000	0	100.07	0	99.89
-1.5	2830	0	100.07	0	99.89
-1	2000	0	100.07	0	99.89
-0.5	1410	0	100.07	0.17	99.89
0	1000	0.02	100.07	0.19	99.72
0.5	710	0.02	100.05	0.43	99.53
1	500	0.07	100.03	0.27	99.1
1.5	350	0.25	99.96	0.36	98.83
2	250	0.85	99.71	0.43	98.47
2.5	177	3.03	98.86	0.58	98.04
3	125	9.27	95.83	0.85	97.46
3.5	88	9.07	86.56	2.14	96.61
4	62.5	8.89	77.49	13.84	94.47

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 499 C (Amount in Sieve)	Sample 499 C% (Cummulative from Original 100g)	Sample 497 C (Amount in Sieve)	Sample 497 C% (Cummulative from Original 100g)
−2	4000	0	99.42	0	98.85
−1.5	2830	0	99.42	0	98.85
−1	2000	0	99.42	0	98.85
−0.5	1410	0.15	99.42	0.11	98.85
0	1000	0.16	99.27	0.15	98.74
0.5	710	0.24	99.11	0.37	98.59
1	500	0.28	98.87	0.38	98.22
1.5	350	0.48	98.59	0.39	97.84
2	250	1.51	98.11	0.39	97.45
2.5	177	4.63	96.6	0.42	97.06
3	125	8.56	91.97	0.92	96.64
3.5	88	11.32	83.41	4.19	95.72
4	62.5	17.51	72.09	22.03	91.53

Grain Phi	Size microns	Sample 498 C (Amount in Sieve)	Sample 498 C% (Cummulative from Original 100g)	Sample 501 C (Amount in Sieve)	Sample 501 C% (Cummulative from Original 100g)
−2	4000	0	98.83	0	99.84
−1.5	2830	0	98.83	0	99.84
−1	2000	0	98.83	0	99.84
−0.5	1410	0.02	98.83	0	99.84
0	1000	0.06	98.81	0.03	99.84
0.5	710	0.21	98.75	0.21	99.81
1	500	0.35	98.54	0.81	99.6
1.5	350	0.42	98.19	1.7	98.79
2	250	0.56	97.77	2.2	97.09
2.5	177	1.09	97.21	2.72	94.89
3	125	5.84	96.12	1.87	92.17
3.5	88	17.04	90.28	1.47	90.3
4	62.5	26.87	73.24	0.89	88.83

Grain Phi	Size microns	Sample 500 C (Amount in Sieve)	Sample 500 C% (Cummulative from Original 100g)	Sample 494 C (Amount in Sieve)	Sample 494 C% (Cummulative from Original 100g)
−2	4000	0	99.03	0	99.47
−1.5	2830	0	99.03	0	99.47
−1	2000	0	99.03	0.17	99.47
−0.5	1410	0.11	99.03	3.72	99.3
0	1000	0.2	98.92	9.05	95.58
0.5	710	1	98.72	14.65	86.53
1	500	2.1	97.72	10.46	71.88
1.5	350	3.83	95.62	9.42	61.42
2	250	4.88	91.79	7.79	52
2.5	177	5.21	86.91	8.07	44.21
3	125	5.72	81.7	9.97	36.14
3.5	88	6.78	75.98	8.99	26.17
4	62.5	9.08	69.2	6.72	17.18

Grain Phi	Size microns	Sample 488 C (Amount in Sieve)	Sample 488 C% (Cummulative from Original 100g)	Sample 493 C (Amount in Sieve)	Sample 493 C% (Cummulative from Original 100g)
−2	4000	0	99.74	0	99.97
−1.5	2830	0	99.74	0	99.97
−1	2000	0	99.74	0.01	99.97
−0.5	1410	0	99.74	0.14	99.96
0	1000	0.05	99.74	0.31	99.82
0.5	710	0.25	99.69	0.79	99.51
1	500	0.59	99.44	1.13	98.72
1.5	350	0.64	98.85	1.96	97.59
2	250	0.64	98.21	3.95	95.63
2.5	177	0.88	97.57	4.1	91.68
3	125	6.56	96.69	3.71	87.58
3.5	88	20.69	90.13	3.17	83.87
4	62.5	26.39	69.44	3.53	80.7

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 492 C (Amount in Sieve)	Sample 492 C% (Cummulative from Original 100g)	Sample 491 C (Amount in Sieve)	Sample 491 C% (Cummulative from Original 100g)
-2	4000	0	99.51	0	99.01
-1.5	2830	0.19	99.51	0	99.01
-1	2000	1.13	99.32	0.38	99.01
-0.5	1410	3.65	98.19	2.68	98.63
0	1000	7.8	94.54	5.39	95.95
0.5	710	10.27	86.74	8.32	90.56
1	500	9.31	76.47	7.29	82.24
1.5	350	7.94	67.16	6.38	74.95
2	250	7.08	59.22	6.11	68.57
2.5	177	6.55	52.14	8.25	62.46
3	125	8.8	45.59	10.07	54.21
3.5	88	7.37	36.79	9.85	44.14
4	62.5	6.98	29.42	11.85	34.29

Grain Phi	Size microns	Sample 489 C (Amount in Sieve)	Sample 489 C% (Cummulative from Original 100g)	Sample 490 C (Amount in Sieve)	Sample 490 C% (Cummulative from Original 100g)
-2	4000	0	99.75	1.25	99.56
-1.5	2830	0	99.75	0.7	98.31
-1	2000	0	99.75	0.47	97.61
-0.5	1410	0	99.75	0.63	97.14
0	1000	0.03	99.75	0.52	96.51
0.5	710	0.09	99.72	1.03	95.99
1	500	0.17	99.63	1.39	94.96
1.5	350	0.21	99.46	1.89	93.57
2	250	0.26	99.25	2.98	91.68
2.5	177	0.38	98.99	5.52	88.7
3	125	4.36	98.61	9.44	83.18
3.5	88	19.35	94.25	10.41	73.74
4	62.5	23.59	74.9	12.21	63.33

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 496 C (Amount in Sieve)	Sample 496 C% (Cummulative from Original 100g)	Sample 467 C (Amount in Sieve)	Sample 467 C% (Cummulative from Original 100g)
-2	4000	0	99.23	0	99.21
-1.5	2830	0	99.23	0	99.21
-1	2000	0	99.23	0.02	99.21
-0.5	1410	0	99.23	0.04	99.19
0	1000	4.36	99.23	0.21	99.15
0.5	710	6.5	94.87	1.01	98.94
1	500	6.14	88.37	2.49	97.93
1.5	350	4.69	82.23	4.23	95.44
2	250	4.55	77.54	4.81	91.21
2.5	177	6.8	72.99	4.71	86.4
3	125	12.78	66.19	4.74	81.69
3.5	88	13.41	53.41	5.22	76.95
4	62.5	12.66	40	8.08	71.73

Grain Phi	Size microns	Sample 487 C (Amount in Sieve)	Sample 487 C% (Cummulative from Original 100g)	Sample 462 C (Amount in Sieve)	Sample 462 C% (Cummulative from Original 100g)
-2	4000	0	99.92	0	99.64
-1.5	2830	0	99.92	0	99.64
-1	2000	0	99.92	0	99.64
-0.5	1410	0.06	99.92	0.07	99.64
0	1000	0.14	99.86	0.19	99.57
0.5	710	0.59	99.72	0.42	99.38
1	500	0.77	99.13	0.64	98.96
1.5	350	1.32	98.36	0.73	98.32
2	250	1.32	97.04	0.73	97.59
2.5	177	2.16	95.72	0.84	96.86
3	125	11.57	93.56	2.03	96.02
3.5	88	26.03	81.99	6.7	93.99
4	62.5	28.88	55.96	17.66	87.29

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 458 b C (Amount in Sieve)	Sample 458 b C% (Cummulative from Original 100g)	Sample 460 C (Amount in Sieve)	Sample 460 C% (Cummulative from Original 100g)
−2	4000	0	99.82	0	102.53
−1.5	2830	0	99.82	0	102.53
−1	2000	0	99.82	0.13	102.53
−0.5	1410	0.01	99.82	0.78	102.4
0	1000	0.01	99.81	3.27	101.62
0.5	710	0.05	99.8	5.77	98.35
1	500	0.08	99.75	6.96	92.58
1.5	350	0.11	99.67	6.21	85.62
2	250	0.14	99.56	5.22	79.41
2.5	177	0.25	99.42	4.52	74.19
3	125	0.92	99.17	3.61	69.67
3.5	88	4.05	98.25	3.08	66.06
4	62.5	18.58	94.2	2.96	62.98

Grain Phi	Size microns	Sample 463 C (Amount in Sieve)	Sample 463 C% (Cummulative from Original 100g)	Sample 485 C (Amount in Sieve)	Sample 485 C% (Cummulative from Original 100g)
−2	4000	0	99.43	0	99.4
−1.5	2830	0	99.43	0	99.4
−1	2000	0.68	99.43	0.2	99.4
−0.5	1410	4.39	98.75	2.92	99.2
0	1000	9.97	94.36	5.35	96.28
0.5	710	12.85	84.39	9.24	90.93
1	500	11.79	71.54	8.03	81.69
1.5	350	9.34	59.75	6.67	73.66
2	250	7.39	50.41	5.98	66.99
2.5	177	5.66	43.02	7.5	61.01
3	125	6.84	37.36	10.08	53.51
3.5	88	5.25	30.52	9.61	43.43
4	62.5	4.77	25.27	11.28	33.82

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 465 C (Amount in Sieve)	Sample 465 C% (Cummulative from Original 100g)	Sample 483 C (Amount in Sieve)	Sample 483 C% (Cummulative from Original 100g)
−2	4000	0	99.45	0	97.45
−1.5	2830	0	99.45	0	97.45
−1	2000	0.09	99.45	0.02	97.45
−0.5	1410	0.55	99.36	0.13	97.43
0	1000	1.59	98.81	1.15	97.3
0.5	710	5.59	97.22	2.54	96.15
1	500	7.34	91.63	3.73	93.61
1.5	350	7	84.29	4.02	89.88
2	250	7.53	77.29	3.66	85.86
2.5	177	6.72	69.76	3.24	82.2
3	125	4.32	63.04	3.12	78.96
3.5	88	4.07	58.72	2.84	75.84
4	62.5	6.05	54.65	2.16	73

Grain Phi	Size microns	Sample 484 C (Amount in Sieve)	Sample 484 C% (Cummulative from Original 100g)	Sample 481 C (Amount in Sieve)	Sample 481 C% (Cummulative from Original 100g)
−2	4000	0	99.23	0	101
−1.5	2830	0.15	99.23	0.05	101
−1	2000	0.68	99.08	0.08	100.95
−0.5	1410	1.22	98.4	0.24	100.87
0	1000	2.54	97.18	0.6	100.63
0.5	710	4.56	94.64	2.15	100.03
1	500	6.02	90.08	4.67	97.88
1.5	350	6.54	84.06	9.09	93.21
2	250	5.22	77.52	14.06	84.12
2.5	177	4.84	72.3	14.95	70.06
3	125	3.96	67.46	15.19	55.11
3.5	88	3.2	63.5	8.46	39.92
4	62.5	2.66	60.3	6.08	31.46

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 480 C (Amount in Sieve)	Sample 480 C% (Cummulative from Original 100g)	Sample 479 C (Amount in Sieve)	Sample 479 C% (Cummulative from Original 100g)
-2	4000	0	99.22	0	100.22
-1.5	2830	0.05	99.22	0	100.22
-1	2000	0.26	99.17	0.07	100.22
-0.5	1410	1.31	98.91	0.48	100.15
0	1000	4.1	97.6	2.2	99.67
0.5	710	10.28	93.5	7.33	97.47
1	500	10.63	83.22	8.79	90.14
1.5	350	9.8	72.59	7.83	81.35
2	250	8.84	62.79	6.03	73.52
2.5	177	8.42	53.95	5.32	67.49
3	125	7.13	45.53	4.61	62.17
3.5	88	5.66	38.4	3.85	57.56
4	62.5	6.24	32.74	4.71	53.71

Grain Phi	Size microns	Sample 478 C (Amount in Sieve)	Sample 478 C% (Cummulative from Original 100g)	Sample 464 C (Amount in Sieve)	Sample 464 C% (Cummulative from Original 100g)
-2	4000	0	99.82	0	99.86
-1.5	2830	0	99.82	0	99.86
-1	2000	0.07	99.82	0	99.86
-0.5	1410	0.19	99.75	0	99.86
0	1000	0.77	99.56	0.02	99.86
0.5	710	1.86	98.79	0.09	99.84
1	500	3.17	96.93	0.18	99.75
1.5	350	3.78	93.76	0.46	99.57
2	250	3.04	89.98	0.68	99.11
2.5	177	2.54	86.94	0.83	98.43
3	125	2.57	84.4	1.04	97.6
3.5	88	2.05	81.83	3.23	96.56
4	62.5	1.88	79.78	9.51	93.33

Grain Size Analysis, Greater than 4 Phi Dry Sieve Procedure

Grain Phi	Size microns	Sample 461 C (Amount in Sieve)	Sample 461 C% (Cummulative from Original 100g)	Sample 458 a C (Amount in Sieve)	Sample 458 a C% (Cummulative from Original 100g)
-2	4000	0	99.86	0	99.82
-1.5	2830	0.03	99.86	0	99.82
-1	2000	0.05	99.83	0	99.82
-0.5	1410	0.09	99.78	0.01	99.82
0	1000	0.29	99.69	0.01	99.81
0.5	710	0.7	99.4	0.05	99.8
1	500	1.02	98.7	0.08	99.75
1.5	350	1.84	97.68	0.11	99.67
2	250	2.63	95.84	0.14	99.56
2.5	177	2.69	93.21	0.25	99.42
3	125	2.46	90.52	0.92	99.17
3.5	88	3.49	88.06	4.05	98.25
4	62.5	9.13	84.57	18.58	94.2

Grain Phi	Size microns	Sample 466 C (Amount in Sieve)	Sample 466 C% (Cummulative from Original 100g)
-2	4000	0	99.74
-1.5	2830	0	99.74
-1	2000	0	99.74
-0.5	1410	0.04	99.74
0	1000	0.12	99.7
0.5	710	0.45	99.58
1	500	0.52	99.13
1.5	350	0.62	98.61
2	250	0.6	97.99
2.5	177	0.46	97.39
3	125	0.42	96.93
3.5	88	0.9	96.51
4	62.5	6.25	95.61

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 424

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	53.25	54.85	54.55	9.7	53.25	32.14	43.71
1	50.5	52.02	51.72	9.7	56.08	23.32	31.72
2	45.75	47.12	46.82	9.7	60.98	17.20	23.39
4	39	40.17	39.87	9.7	67.93	12.83	17.46
10	24	24.72	24.42	9.7	83.38	8.99	12.23
30	4.5	4.64	4.34	9.7	103.46	5.78	7.87
60	3	3.09	2.79	9.7	105.01	4.12	5.60
120	1.5	1.55	1.25	9.7	106.55	2.93	3.99
180	1	1.03	0.73	9.7	107.07	2.40	3.27
420	0.75	0.77	0.47	9.7	107.33	1.57	2.14
1320	0	0	0	9.7	107.8	0.89	1.21

Sample 419

Time (T) Minutes	Hydrometer Reading (C)	Amount Settled (%C)	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	51.5	52.53	52.23	9.7	55.57	32.83	44.65
1	48.5	49.47	49.17	9.7	58.63	23.85	32.43
2	42.5	43.35	43.05	9.7	64.75	17.72	24.10
4	35.5	36.21	35.91	9.7	71.89	13.20	17.96
10	22	22.44	22.14	9.7	85.66	9.12	12.40
30	11.75	11.99	11.69	9.7	96.11	5.57	7.58
60	8.5	8.67	8.37	9.7	99.43	4.01	5.45
120	6	6.12	5.82	9.7	101.98	2.87	3.90
180	5.5	5.61	5.31	9.7	102.49	2.35	3.20
420	4	4.08	3.78	9.7	104.02	1.55	2.11
1320	3.75	3.83	3.53	9.7	104.27	0.88	1.19

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 420

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	64.5	66.44	66.14	9.7	41.66	28.43	38.66
1	63	64.89	64.59	9.7	43.21	20.47	27.84
2	58.5	60.26	59.96	9.7	47.84	15.23	20.72
4	52.5	54.08	53.78	9.7	54.02	11.45	15.57
10	35.25	36.31	36.01	9.7	71.79	8.34	11.35
30	0.25	0.26	−0.04	9.7	107.84	5.90	8.03
60	0.1	0.1	−0.2	9.7	108	4.18	5.68
120	0.1	0.1	−0.2	9.7	108	2.95	4.02
180	0.1	0.1	−0.2	9.7	108	2.41	3.28
420	0	0	−0.3	9.7	108.1	1.58	2.15
1320	0	0	0	9.7	107.8	0.89	1.21

Sample 423

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	59.5	61.29	60.99	9.7	46.81	30.13	40.98
1	54.75	56.39	56.09	9.7	51.71	22.40	30.46
2	49.5	50.99	50.69	9.7	57.11	16.64	22.63
4	41	42.23	41.93	9.7	65.87	12.64	17.19
10	28.75	29.61	29.31	9.7	78.49	8.73	11.87
30	6.5	6.7	6.4	9.7	101.4	5.73	7.79
60	3.25	3.35	3.05	9.7	104.75	4.12	5.60
120	1.75	1.8	1.5	9.7	106.3	2.93	3.99
180	3	3.09	2.79	9.7	105.01	2.38	3.24
420	1.5	1.55	1.25	9.7	106.55	1.57	2.13
1320	1.5	1.55	1.25	9.7	106.55	0.88	1.20

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 426

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	27	27.54	27.24	9.7	80.56	39.53	53.76
1	25.5	26.01	25.71	9.7	82.09	28.22	38.38
2	21.25	21.68	21.38	9.7	86.42	20.47	27.84
4	17	17.34	17.04	9.7	90.76	14.84	20.18
10	11.75	11.99	11.69	9.7	96.11	9.66	13.13
30	5.25	5.36	5.06	9.7	102.74	5.76	7.84
60	2.5	2.55	2.25	9.7	105.55	4.13	5.62
120	2.25	2.23	1.93	9.7	105.87	2.93	3.98
180	1.75	1.79	1.49	9.7	106.31	2.39	3.26
420	1	1.02	0.72	9.7	107.08	1.57	2.14
1320	0.5	0.51	0.21	9.7	107.59	0.89	1.21

Sample 425

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	69	71.76	71.46	9.7	36.34	26.55	36.11
1	65	67.6	67.3	9.7	40.5	19.82	26.96
2	60.5	62.92	62.62	9.7	45.18	14.80	20.13
4	49	50.96	50.66	9.7	57.14	11.77	16.01
10	19	19.76	19.46	9.7	88.34	9.26	12.59
30	7	7.28	6.98	9.7	100.82	5.71	7.76
60	6	6.24	5.94	9.7	101.86	4.06	5.52
120	4.25	4.42	4.12	9.7	103.68	2.89	3.94
180	3.5	3.64	3.34	9.7	104.46	2.37	3.23
420	3	3.12	2.82	9.7	104.98	1.56	2.12
1320	2	2.08	1.78	9.7	106.02	0.88	1.20

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 421

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	59.75	61.54	61.24	9.7	46.56	30.05	40.87
1	54.75	56.39	56.09	9.7	51.71	22.40	30.46
2	49.25	50.73	50.43	9.7	57.37	16.68	22.69
4	42	43.26	42.96	9.7	64.84	12.54	17.05
10	29.5	30.39	30.09	9.7	77.71	8.68	11.81
30	14	14.42	14.12	9.7	93.68	5.50	7.48
60	10.25	10.56	10.26	9.7	97.54	3.97	5.40
120	7.75	7.98	7.68	9.7	100.12	2.84	3.87
180	7.25	7.48	7.18	9.7	100.62	2.33	3.17
420	5.5	5.67	5.37	9.7	102.43	1.54	2.09
1320	5	5.15	4.85	9.7	102.95	0.87	1.18

Sample 422

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	65	65.65	65.35	9.7	42.45	28.70	39.03
1	55.5	56.06	55.76	9.7	52.04	22.47	30.56
2	40.5	40.91	40.61	9.7	67.19	18.05	24.55
4	25	25.25	24.95	9.7	82.85	14.17	19.28
10	10	10.1	9.8	9.7	98	9.75	13.26
30	4	4.04	3.74	9.7	104.06	5.80	7.89
60	2.75	2.78	2.48	9.7	105.32	4.13	5.61
120	2	2.02	1.72	9.7	106.08	2.93	3.98
180	2	2.02	1.72	9.7	106.08	2.39	3.25
420	1	1.01	0.71	9.7	107.09	1.57	2.14
1320	1	1.01	0.71	9.7	107.09	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 499

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	46.75	48.15	47.85	9.7	59.95	34.10	46.38
1	40	41.2	40.9	9.7	66.9	25.47	34.64
2	34.75	35.79	35.49	9.7	72.31	18.73	25.47
4	30.5	31.42	31.12	9.7	76.68	13.64	18.55
10	16.75	17.25	16.95	9.7	90.85	9.39	12.77
30	2.5	2.58	2.28	9.7	105.52	5.84	7.94
60	1.5	1.55	1.25	9.7	106.55	4.15	5.64
120	0.75	0.77	0.47	9.7	107.33	2.95	4.01
180	1	1.03	0.73	9.7	107.07	2.40	3.27
420	0	0	−0.3	9.7	108.1	1.58	2.15
1320	0	0	−0.3	9.7	108.1	0.89	1.21

Sample 497

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	58.25	58.83	58.53	9.7	49.27	30.92	42.05
1	46	46.46	46.16	9.7	61.64	24.45	33.25
2	32.25	32.57	32.27	9.7	75.53	19.14	26.03
4	20.5	20.71	20.41	9.7	87.39	14.56	19.80
10	9.5	9.6	9.3	9.7	98.5	9.77	13.29
30	6.75	6.82	6.52	9.7	101.28	5.72	7.78
60	4.5	4.55	4.25	9.7	103.55	4.09	5.56
120	3	3.03	2.73	9.7	105.07	2.91	3.96
180	2.25	2.27	1.97	9.7	105.83	2.39	3.25
420	2	2.02	1.72	9.7	106.08	1.57	2.13
1320	2	2.02	1.72	9.7	106.08	0.88	1.20

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 498

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	35	35.35	35.05	9.7	72.75	37.57	51.09
1	28	28.28	27.98	9.7	79.82	27.83	37.84
2	21	21.21	20.91	9.7	86.89	20.53	27.92
4	15	15.15	14.85	9.7	92.95	15.01	20.42
10	9	9.09	8.79	9.7	99.01	9.80	13.33
30	5.25	5.3	5	9.7	102.8	5.77	7.84
60	3.5	3.54	3.24	9.7	104.56	4.11	5.59
120	2.25	2.27	1.97	9.7	105.83	2.92	3.98
180	1.5	1.52	1.22	9.7	106.58	2.40	3.26
420	0.25	0.25	−0.05	9.7	107.85	1.58	2.15
1320	0.25	0.25	−0.05	9.7	107.85	0.89	1.21

Sample 501

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	68	72.08	71.78	9.7	36.02	26.43	35.95
1	66	69.96	69.66	9.7	38.14	19.23	26.16
2	65	68.9	68.6	9.7	39.2	13.79	18.75
4	64.5	68.37	68.07	9.7	39.73	9.82	13.35
10	63	66.78	66.48	9.7	41.32	6.33	8.61
30	58	61.48	61.18	9.7	46.62	3.88	5.28
60	53.5	56.71	56.41	9.7	51.39	2.88	3.92
120	48.75	51.68	51.38	9.7	56.42	2.14	2.90
180	45	47.7	47.4	9.7	60.4	1.80	2.45
420	38	40.28	39.98	9.7	67.82	1.25	1.70
1320	31.25	33.13	32.83	9.7	74.97	0.74	1.01

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 500

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	29.25	30.42	30.12	9.7	77.68	38.82	52.80
1	26.5	27.56	27.26	9.7	80.54	27.95	38.01
2	23.25	24.18	23.88	9.7	83.92	20.17	27.44
4	19.75	20.54	20.24	9.7	87.56	14.57	19.82
10	14.25	14.82	14.52	9.7	93.28	9.51	12.94
30	9.75	10.14	9.84	9.7	97.96	5.63	7.65
60	7.75	8.06	7.76	9.7	100.04	4.02	5.47
120	5.5	5.72	5.42	9.7	102.38	2.88	3.91
180	4.25	4.29	3.99	9.7	103.81	2.37	3.22
420	3	3.12	2.82	9.7	104.98	1.56	2.12
1320	2	2.08	1.78	9.7	106.02	0.88	1.20

Sample 494

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	9.75	10.43	10.13	9.7	97.67	43.53	59.20
1	9.5	10.17	9.87	9.7	97.93	30.82	41.92
2	9.25	9.9	9.6	9.7	98.2	21.82	29.68
4	9	9.63	9.33	9.7	98.47	15.45	21.02
10	5.5	5.89	5.59	9.7	102.21	9.96	13.54
30	3.75	4.01	3.71	9.7	104.09	5.80	7.89
60	1.75	1.87	1.57	9.7	106.23	4.14	5.64
120	1	1.07	0.77	9.7	107.03	2.94	4.00
180	0.5	0.54	0.24	9.7	107.56	2.41	3.27
420	0.25	0.27	−0.03	9.7	107.83	1.58	2.15
1320	0.25	0.27	−0.03	9.7	107.83	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 488

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	37.75	38.13	37.83	9.7	69.97	36.84	50.11
1	28.5	28.79	28.49	9.7	79.31	27.74	37.72
2	22	22.22	21.92	9.7	85.88	20.41	27.76
4	15.75	15.91	15.61	9.7	92.19	14.95	20.33
10	8.5	8.59	8.29	9.7	99.51	9.82	13.36
30	3.75	3.79	3.49	9.7	104.31	5.81	7.90
60	2.25	2.27	1.97	9.7	105.83	4.14	5.63
120	2	2.02	1.72	9.7	106.08	2.93	3.98
180	1.5	1.52	1.22	9.7	106.58	2.40	3.26
420	0.75	0.76	0.46	9.7	107.34	1.57	2.14
1320	0.25	0.25	−0.05	9.7	107.85	0.89	1.21

Sample 493

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	65	67.6	67.3	9.7	40.5	28.03	38.12
1	63	65.52	65.22	9.7	42.58	20.32	27.64
2	58.25	60.58	60.28	9.7	47.52	15.18	20.65
4	52.75	54.86	54.56	9.7	53.24	11.36	15.45
10	42.75	44.46	44.16	9.7	63.64	7.86	10.69
30	31.25	32.5	32.2	9.7	75.6	4.94	6.72
60	26.25	27.3	27	9.7	80.8	3.61	4.92
120	21	21.84	21.54	9.7	86.26	2.64	3.59
180	18	18.72	18.42	9.7	89.38	2.19	2.98
420	12.5	13	12.7	9.7	95.1	1.48	2.02
1320	10.25	10.66	10.36	9.7	97.44	0.85	1.15

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 492

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	24	25.2	24.9	9.7	82.9	40.10	54.54
1	22.25	23.36	23.06	9.7	84.74	28.67	38.99
2	18.5	19.43	19.13	9.7	88.67	20.74	28.20
4	15.5	16.28	15.98	9.7	91.82	14.92	20.29
10	9	9.45	9.15	9.7	98.65	9.78	13.30
30	7	7.35	7.05	9.7	100.75	5.71	7.76
60	5	5.25	4.95	9.7	102.85	4.08	5.55
120	3.25	3.41	3.11	9.7	104.69	2.91	3.96
180	1.75	1.84	1.54	9.7	106.26	2.39	3.25
420	1	1.05	0.75	9.7	107.05	1.57	2.14
1320	0.75	0.79	0.49	9.7	107.31	0.89	1.21

Sample 491

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	20	20.4	20.1	9.7	87.7	41.25	56.10
1	19.5	19.89	19.59	9.7	88.21	29.25	39.78
2	19.25	19.64	19.34	9.7	88.46	20.71	28.17
4	15	15.3	15	9.7	92.8	15.00	20.40
10	8.5	8.67	8.37	9.7	99.43	9.82	13.36
30	5.5	5.61	5.31	9.7	102.49	5.76	7.83
60	3.25	3.32	3.02	9.7	104.78	4.12	5.60
120	2	2.04	1.74	9.7	106.06	2.93	3.98
180	1.5	1.53	1.23	9.7	106.57	2.40	3.26
420	0.75	0.77	0.47	9.7	107.33	1.57	2.14
1320	0.5	0.51	0.21	9.7	107.59	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 489

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	42.5	43.78	43.48	9.7	64.32	35.32	48.04
1	34.75	35.79	35.49	9.7	72.31	26.48	36.02
2	26.5	27.3	27	9.7	80.8	19.80	26.92
4	20.75	21.37	21.07	9.7	86.73	14.50	19.72
10	13	13.39	13.09	9.7	94.71	9.58	13.04
30	6.75	6.95	6.65	9.7	101.15	5.72	7.78
60	4.75	4.89	4.59	9.7	103.21	4.08	5.56
120	4.5	4.64	4.34	9.7	103.46	2.89	3.93
180	3	3.09	2.79	9.7	105.01	2.38	3.24
420	1.75	1.8	1.5	9.7	106.3	1.57	2.13
1320	0.75	0.77	0.47	9.7	107.33	0.89	1.21

Sample 490

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	45	46.8	46.5	9.7	61.3	34.49	46.90
1	42	43.68	43.38	9.7	64.42	25.00	34.00
2	36.75	38.22	37.92	9.7	69.88	18.41	25.04
4	29	30.16	29.86	9.7	77.94	13.75	18.70
10	20.5	21.32	21.02	9.7	86.78	9.17	12.48
30	13	13.52	13.22	9.7	94.58	5.53	7.52
60	9.75	10.14	9.84	9.7	97.96	3.98	5.41
120	7.75	8.06	7.76	9.7	100.04	2.84	3.87
180	6.25	6.5	6.2	9.7	101.6	2.34	3.18
420	4.25	4.42	4.12	9.7	103.68	1.55	2.10
1320	2.75	2.86	2.56	9.7	105.24	0.88	1.20

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 496

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	25.25	26.26	25.96	9.7	81.84	39.85	54.19
1	23	23.92	23.62	9.7	84.18	28.58	38.86
2	19.75	20.54	20.24	9.7	87.56	20.61	28.03
4	16	16.64	16.34	9.7	91.46	14.89	20.25
10	9.25	9.62	9.32	9.7	98.48	9.77	13.29
30	6.75	7.02	6.72	9.7	101.08	5.72	7.77
60	4.25	4.42	4.12	9.7	103.68	4.09	5.57
120	2.75	2.86	2.56	9.7	105.24	2.92	3.97
180	2.25	2.34	2.04	9.7	105.76	2.39	3.25
420	1.5	1.56	1.26	9.7	106.54	1.57	2.13
1320	1	1.04	0.74	9.7	107.06	0.89	1.21

Sample 467

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	58.75	60.51	60.21	9.7	47.59	30.38	41.32
1	54.25	55.88	55.58	9.7	52.22	22.51	30.61
2	47.25	49.14	48.84	9.7	58.96	16.91	23.00
4	39.5	40.69	40.39	9.7	67.41	12.79	17.39
10	30.5	31.42	31.12	9.7	76.68	8.62	11.73
30	20	20.6	20.3	9.7	87.5	5.32	7.23
60	15	15.45	15.15	9.7	92.65	3.87	5.26
120	12.25	12.62	12.32	9.7	95.48	2.78	3.78
180	10.25	10.58	10.28	9.7	97.52	2.29	3.12
420	8	8.24	7.94	9.7	99.86	1.52	2.07
1320	4.25	4.38	4.08	9.7	103.72	0.87	1.19

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 487

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	23	23.46	23.16	9.7	84.64	40.52	55.11
1	21.75	22.19	21.89	9.7	85.91	28.87	39.26
2	16	16.32	16.02	9.7	91.78	21.10	28.69
4	9.75	9.69	9.39	9.7	98.41	15.45	21.01
10	6.5	6.63	6.33	9.7	101.47	9.92	13.49
30	2.75	2.83	2.53	9.7	105.27	5.83	7.93
60	0.75	0.77	0.47	9.7	107.33	4.17	5.67
120	0.25	0.26	−0.04	9.7	107.84	2.95	4.02
180	0.25	0.26	−0.04	9.7	107.84	2.41	3.28
420	0	0	−0.3	9.7	108.1	1.58	2.15
1320	0	0	−0.3	9.7	108.1	0.89	1.21

Sample 462

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	58.75	59.38	59.08	9.7	48.72	30.74	41.81
1	50.5	51.01	50.71	9.7	57.09	23.53	32.00
2	39	39.39	39.09	9.7	68.71	18.25	24.83
4	27.75	28.03	27.73	9.7	80.07	13.93	18.95
10	15	15.15	14.85	9.7	92.95	9.50	12.91
30	8.5	8.59	8.29	9.7	99.51	5.67	7.71
60	6.25	6.31	6.01	9.7	101.79	4.06	5.52
120	5	5.05	4.75	9.7	103.05	2.89	3.93
180	4.25	4.29	3.99	9.7	103.81	2.37	3.22
420	4	4.04	3.74	9.7	104.06	1.55	2.11
1320	3.75	3.79	3.49	9.7	104.31	0.88	1.19

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 458 b

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	63	64.89	64.59	9.7	43.21	28.95	39.38
1	51.5	53.05	52.75	9.7	55.05	23.11	31.43
2	36.75	37.85	37.55	9.7	70.25	18.46	25.10
4	22.5	23.18	22.88	9.7	84.92	14.35	19.52
10	11	11.33	11.03	9.7	96.77	9.69	13.18
30	4.5	4.64	4.34	9.7	103.46	5.78	7.87
60	2.75	2.83	2.53	9.7	105.27	4.13	5.61
120	2.5	2.58	2.28	9.7	105.52	2.92	3.97
180	2	2.06	1.76	9.7	106.04	2.39	3.25
420	1.25	1.29	0.99	9.7	106.81	1.57	2.14
1320	0.75	0.77	0.47	9.7	107.33	0.89	1.21

Sample 460

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	54.25	55.88	55.58	9.7	52.22	31.83	43.29
1	49.75	51.24	50.94	9.7	56.86	23.48	31.94
2	35.5	36.57	36.27	9.7	71.53	18.63	25.33
4	22	22.66	22.36	9.7	85.44	14.39	19.58
10	13.5	13.91	13.61	9.7	94.19	9.56	13.00
30	6.25	6.44	6.14	9.7	101.66	5.73	7.80
60	5.25	5.41	5.11	9.7	102.69	4.07	5.54
120	3.75	3.86	3.56	9.7	104.24	2.90	3.95
180	3.25	3.35	3.05	9.7	104.75	2.38	3.23
420	2	2.06	1.76	9.7	106.04	1.56	2.13
1320	0.5	0.52	0.22	9.7	107.58	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 463

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	19	20.33	20.03	9.7	87.77	41.26	56.12
1	18.25	19.53	19.23	9.7	88.57	29.31	39.86
2	17	18.19	17.89	9.7	89.91	20.88	28.40
4	15	15.45	15.15	9.7	92.65	14.99	20.39
10	11.25	11.59	11.29	9.7	96.51	9.68	13.16
30	6.5	6.96	6.66	9.7	101.14	5.72	7.78
60	4.25	4.55	4.25	9.7	103.55	4.09	5.56
120	3.25	3.48	3.18	9.7	104.62	2.91	3.95
180	3	3.21	2.91	9.7	104.89	2.38	3.23
420	1.25	1.34	1.04	9.7	106.76	1.57	2.14
1320	0.5	0.54	0.24	9.7	107.56	0.89	1.21

Sample 485

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	20.75	22	21.7	9.7	86.1	40.87	55.58
1	18.5	19.61	19.31	9.7	88.49	29.30	39.84
2	16	16.96	16.66	9.7	91.14	21.02	28.59
4	13	13.78	13.48	9.7	94.32	15.12	20.57
10	7.75	8.23	7.93	9.7	99.87	9.84	13.39
30	4.5	4.77	4.47	9.7	103.33	5.78	7.86
60	3.5	3.71	3.41	9.7	104.39	4.11	5.59
120	2.5	2.65	2.35	9.7	105.45	2.92	3.97
180	1.75	1.86	1.56	9.7	106.24	2.39	3.25
420	0.25	0.27	−0.03	9.7	107.83	1.58	2.15
1320	0	0	−0.3	9.7	108.1	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 465

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	32	33.28	32.98	9.7	74.82	38.10	51.81
1	31.25	32.5	32.2	9.7	75.6	27.08	36.83
2	28.5	29.64	29.34	9.7	78.46	19.51	26.53
4	24.5	25.48	25.18	9.7	82.62	14.15	19.25
10	19.5	20.28	19.98	9.7	87.82	9.23	12.55
30	14	14.56	14.26	9.7	93.54	5.50	7.48
60	10.5	10.92	10.62	9.7	97.18	3.96	5.39
120	8.25	8.58	8.28	9.7	99.52	2.84	3.86
180	6.5	6.76	6.46	9.7	101.34	2.34	3.18
420	5	5.2	4.9	9.7	102.9	1.54	2.10
1320	3.25	3.38	3.08	9.7	104.72	0.88	1.19

Sample 484

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	29.25	29.25	28.95	9.7	78.85	39.11	53.19
1	26.5	26.5	26.2	9.7	81.6	28.13	38.26
2	23.25	23.25	22.95	9.7	84.85	20.29	27.59
4	19.75	19.75	19.45	9.7	88.35	14.64	19.91
10	14.25	14.25	13.95	9.7	93.85	9.54	12.98
30	9.75	9.75	9.45	9.7	98.35	5.64	7.67
60	7.75	7.75	7.45	9.7	100.35	4.03	5.48
120	5.5	5.5	5.2	9.7	102.6	2.88	3.92
180	4.25	4.25	3.95	9.7	103.85	2.37	3.22
420	3	3	2.7	9.7	105.1	1.56	2.12
1320	2	2	1.7	9.7	106.1	0.88	1.20

Sample 483

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	65	66.95	66.65	9.7	41.15	28.25	38.43
1	64	65.92	65.62	9.7	42.18	20.23	27.51
2	61.5	63.35	63.05	9.7	44.75	14.73	20.04
4	52.25	53.82	53.52	9.7	54.28	11.47	15.60
10	37.25	38.37	38.07	9.7	69.73	8.22	11.18
30	21	21.63	21.33	9.7	86.47	5.29	7.19
60	14	14.42	14.12	9.7	93.68	3.89	5.29
120	9	9.27	8.97	9.7	98.83	2.83	3.84
180	7	7.21	6.91	9.7	100.89	2.33	3.17
420	3	3.09	2.79	9.7	105.01	1.56	2.12
1320	2.25	2.3	2	9.7	105.8	0.88	1.20

Sample 481

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	22	22.88	22.58	9.7	85.22	40.66	55.30
1	20.75	21.85	21.55	9.7	86.25	28.92	39.34
2	17	17.68	17.38	9.7	90.42	20.94	28.48
4	12.25	12.74	12.44	9.7	95.36	15.21	20.68
10	8.75	9.1	8.8	9.7	99	9.80	13.33
30	4.75	4.94	4.64	9.7	103.16	5.78	7.85
60	3.25	3.38	3.08	9.7	104.72	4.11	5.60
120	1.75	1.82	1.52	9.7	106.28	2.93	3.99
180	1.75	1.82	1.52	9.7	106.28	2.39	3.25
420	1.25	1.3	1	9.7	106.8	1.57	2.14
1320	0.25	0.26	−0.04	9.7	107.84	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 480

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	22.5	23.63	23.33	9.7	84.47	40.48	55.05
1	22.25	23.36	23.06	9.7	84.74	28.67	38.99
2	19.75	20.74	20.44	9.7	87.36	20.58	27.99
4	14.25	14.96	14.66	9.7	93.14	15.03	20.44
10	10.5	11.03	10.73	9.7	97.07	9.70	13.20
30	7	7.35	7.05	9.7	100.75	5.71	7.76
60	4.5	4.73	4.43	9.7	103.37	4.09	5.56
120	3.5	3.68	3.38	9.7	104.42	2.91	3.95
180	2.5	2.63	2.33	9.7	105.47	2.38	3.24
420	2	2.1	1.8	9.7	106	1.56	2.13
1320	1	1.05	0.75	9.7	107.05	0.89	1.21

Sample 479

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	44.75	46.54	46.24	9.7	61.56	34.56	47.00
1	42	43.68	43.38	9.7	64.42	25.00	34.00
2	39.25	40.82	40.52	9.7	67.28	18.06	24.57
4	33.25	34.58	34.28	9.7	73.52	13.35	18.16
10	22.5	23.4	23.1	9.7	84.7	9.06	12.33
30	11.25	11.7	11.4	9.7	96.4	5.58	7.59
60	7.5	7.8	7.5	9.7	100.3	4.03	5.48
120	4.25	4.42	4.12	9.7	103.68	2.89	3.94
180	3.25	3.38	3.08	9.7	104.72	2.38	3.23
420	2.25	2.34	2.04	9.7	105.76	1.56	2.13
1320	0.25	0.26	−0.04	9.7	107.84	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 478

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	66	67.32	67.02	9.7	40.78	28.13	38.25
1	65	66.3	66	9.7	41.8	20.14	27.39
2	63	64.26	63.96	9.7	43.84	14.58	19.83
4	55.5	56.61	56.31	9.7	51.49	11.17	15.20
10	39.5	40.29	39.99	9.7	67.81	8.11	11.03
30	20	20.4	20.1	9.7	87.7	5.33	7.24
60	12	12.24	11.94	9.7	95.86	3.94	5.35
120	7	7.14	6.84	9.7	100.96	2.86	3.89
180	4.5	4.59	4.29	9.7	103.51	2.36	3.21
420	3.75	3.83	3.53	9.7	104.27	1.55	2.11
1320	0.5	0.51	0.21	9.7	107.59	0.89	1.21

Sample 464

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	65	66.3	66	9.7	41.8	28.48	38.73
1	64	65.28	64.98	9.7	42.82	20.38	27.72
2	53.5	54.57	54.27	9.7	53.53	16.11	21.91
4	42.75	43.61	43.31	9.7	64.49	12.51	17.01
10	28	28.56	28.26	9.7	79.54	8.78	11.95
30	16	16.32	16.02	9.7	91.78	5.45	7.41
60	11.25	11.48	11.18	9.7	96.62	3.95	5.38
120	8.5	8.67	8.37	9.7	99.43	2.84	3.86
180	5.5	5.67	5.37	9.7	102.43	2.35	3.20
420	3.5	3.57	3.27	9.7	104.53	1.55	2.11
1320	1.5	1.53	1.23	9.7	106.57	0.88	1.20

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

Sample 461

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	63	64.26	63.96	9.7	43.84	29.16	39.66
1	59.5	60.69	60.39	9.7	47.41	21.44	29.16
2	51.5	52.53	52.23	9.7	55.57	16.42	22.33
4	43	43.86	43.56	9.7	64.24	12.48	16.97
10	32	32.64	32.34	9.7	75.46	8.56	11.64
30	21.25	21.68	21.38	9.7	86.42	5.29	7.19
60	16.25	16.58	16.28	9.7	91.52	3.85	5.23
120	12	12.24	11.94	9.7	95.86	2.78	3.79
180	10.5	10.71	10.41	9.7	97.39	2.29	3.12
420	7.5	7.65	7.35	9.7	100.45	1.52	2.07
1320	5.5	5.61	5.31	9.7	102.49	0.87	1.18

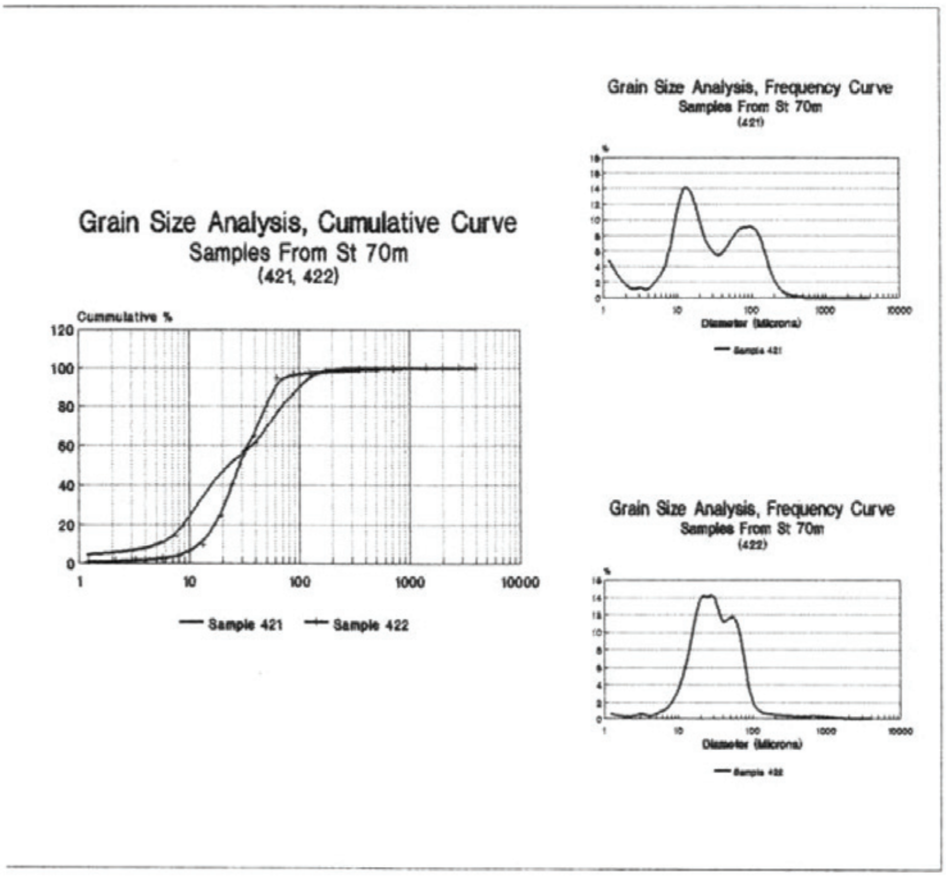
Sample 458 a

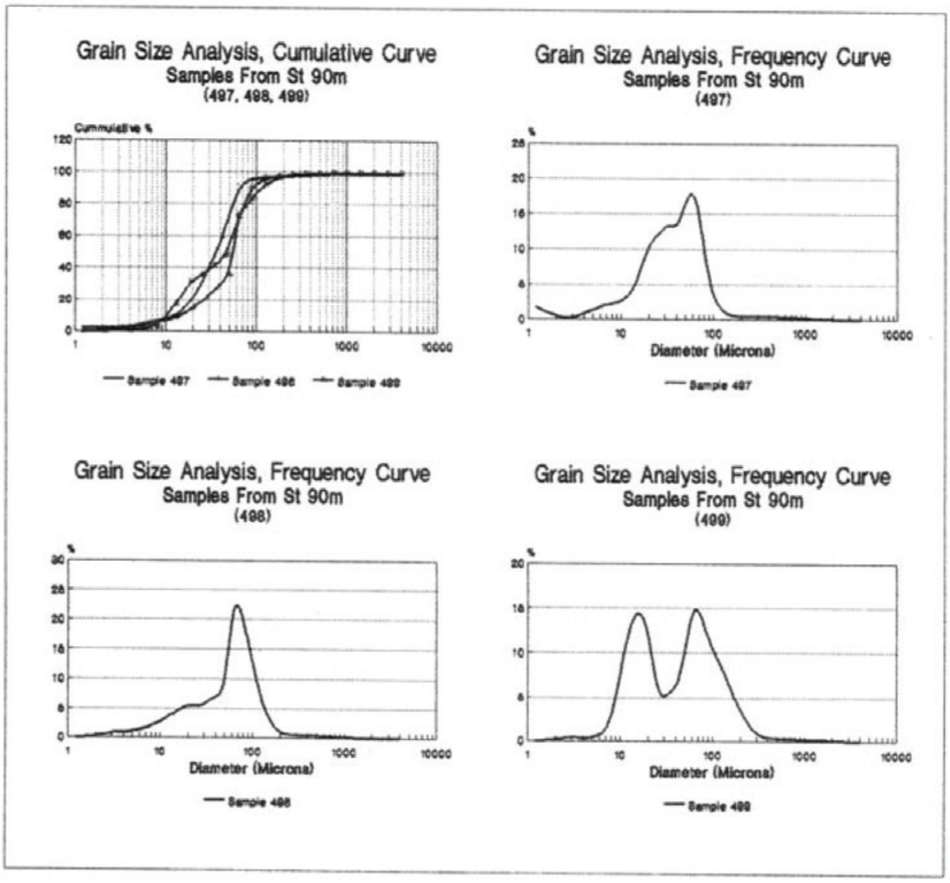
Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	63	64.89	64.59	9.7	43.21	28.95	39.38
1	51.5	53.05	52.75	9.7	55.05	23.11	31.43
2	36.75	37.85	37.55	9.7	70.25	18.46	25.10
4	22.5	23.18	22.88	9.7	84.92	14.35	19.52
10	11	11.33	11.03	9.7	96.77	9.69	13.18
30	4.5	4.64	4.34	9.7	103.46	5.78	7.87
60	2.75	2.83	2.53	9.7	105.27	4.13	5.61
120	2.5	2.58	2.28	9.7	105.52	2.92	3.97
180	2	2.06	1.76	9.7	106.04	2.39	3.25
420	1.25	1.29	0.99	9.7	106.81	1.57	2.14
1320	0.75	0.77	0.47	9.7	107.33	0.89	1.21

Grain Size Analysis, Less than 4 Phi Hydrometer Procedure

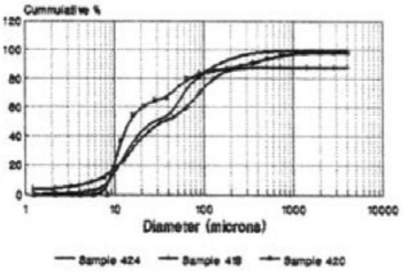
Sample 466

Time (T) Minutes	Hydrometer Reading (C)	Moisture Factor Adjusted	Temperature Adjusted	Viscosity (P)	Height (H)	Square PH/T	Diameter (X)
0.5	68	69.36	69.06	9.7	38.74	27.41	37.28
1	64	65.28	64.98	9.7	42.82	20.38	27.72
2	56.5	57.63	57.33	9.7	50.47	15.65	21.28
4	44.25	45.14	44.84	9.7	62.96	12.36	16.80
10	25.75	26.27	25.97	9.7	81.83	8.91	12.12
30	14	14.28	13.98	9.7	93.82	5.51	7.49
60	10.5	10.71	10.41	9.7	97.39	3.97	5.40
120	6.5	6.63	6.33	9.7	101.47	2.86	3.89
180	6	6.12	5.82	9.7	101.98	2.34	3.19
420	3	3.06	2.76	9.7	105.04	1.56	2.12
1320	1.5	1.53	1.23	9.7	106.57	0.88	1.20

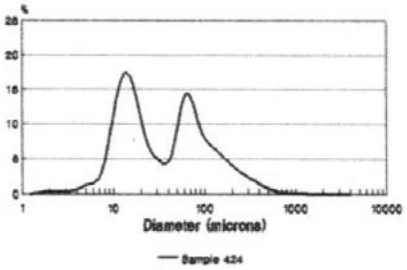

Grain Size Analysis, Cumulative Curve
Samples From St 70m
(421, 422)
Cummulative %
Sample 421
Sample 422
Grain Size Analysis, Frequency Curve
Samples From St 70m
(421)
Diameter (Microns)
Grain Size Analysis, Frequency Curve
Samples From St 70m
(422)
Diameter (Microns)


Grain Size Analysis, Cumulative Curve
Samples From St 90m
(497, 498, 499)
Cummulative %
Sample 497
Sample 498
Sample 499
Grain Size Analysis, Frequency Curve
Samples From St 90m
(497)
Diameter (Microns)
Sample 497
Grain Size Analysis, Frequency Curve
Samples From St 90m
(498)
Diameter (Microns)
Sample 498
Grain Size Analysis, Frequency Curve
Samples From St 90m
(499)
Diameter (Microns)
Sample 499

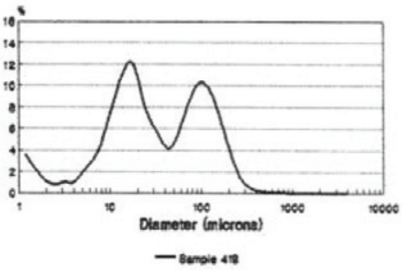
Grain Size Analysis, Cumulative Curve
Samples From St 60m
(424, 419, 420)



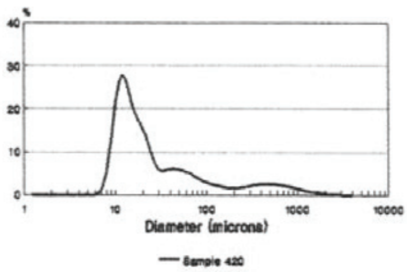
Grain Size Analysis, Frequency Curve
Sample From St 60m
(424)



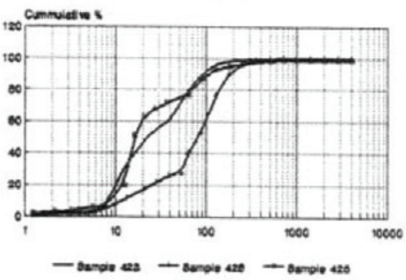
Grain Size Analysis, Frequency Curve
Sample From St 60m
(419)



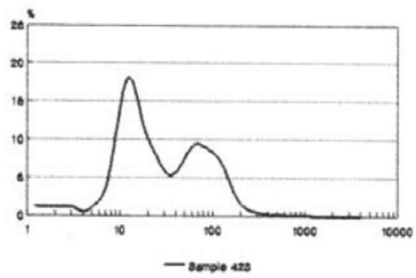
Grain Size Analysis, Frequency Curve
Sample From St 60m
(420)



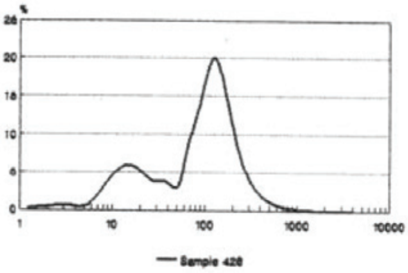
Grain Size Analysis, Cumulative Curve
Samples From St 70m
(423, 426, 425)



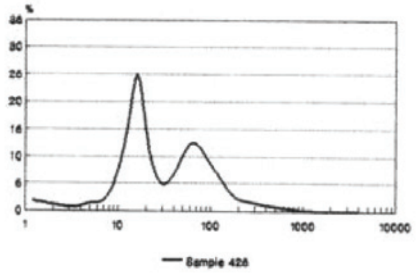
Grain Size Analysis, Frequency Curve
Samples From St 70m
(423)

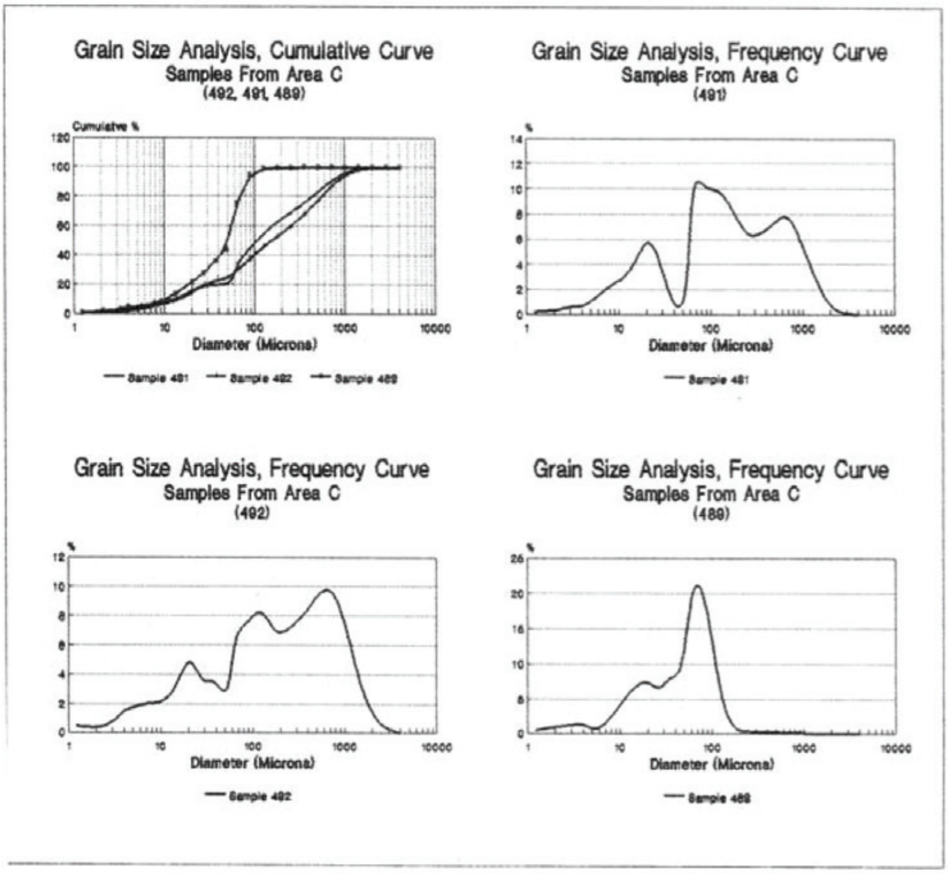


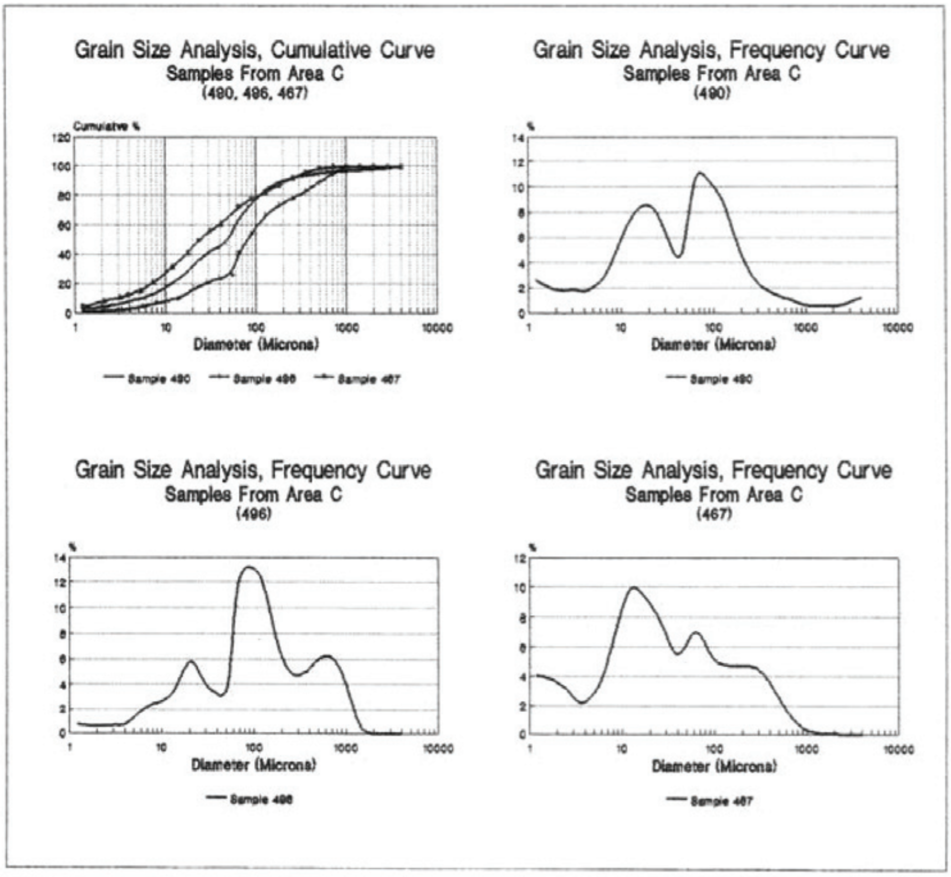
Grain Size Analysis, Frequency Curve
Samples From St 70m
(426)

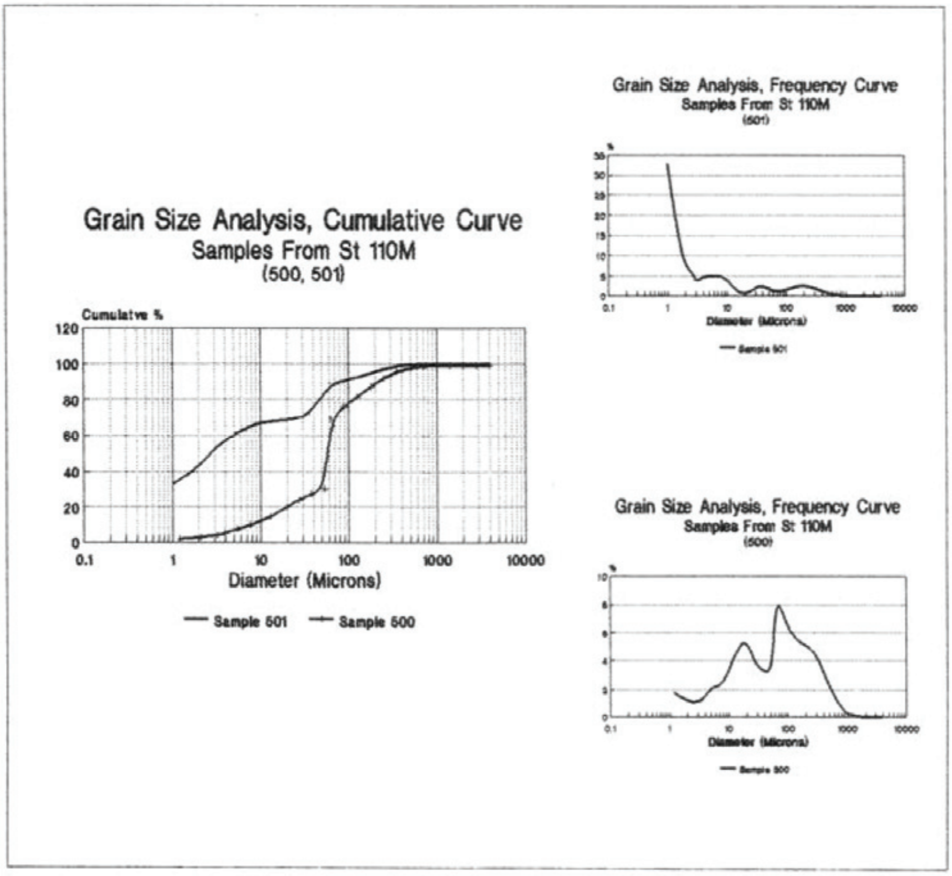


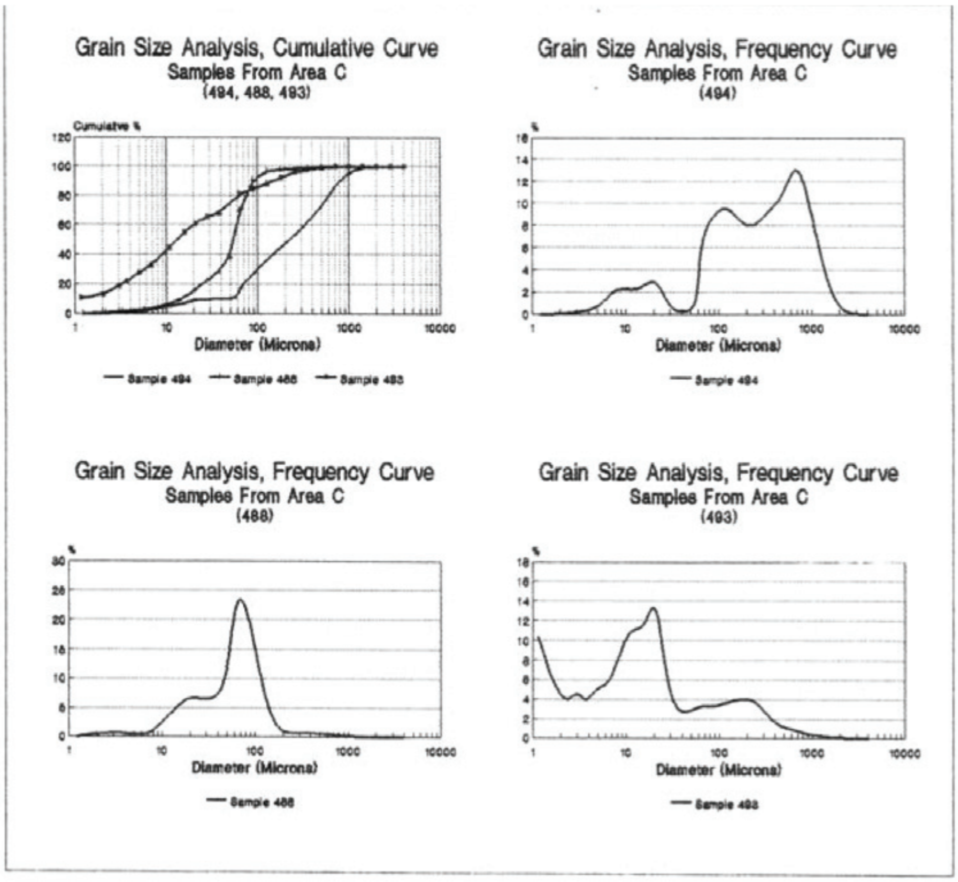
Grain Size Analysis, Frequency Curve
Samples From St 70m
(425)

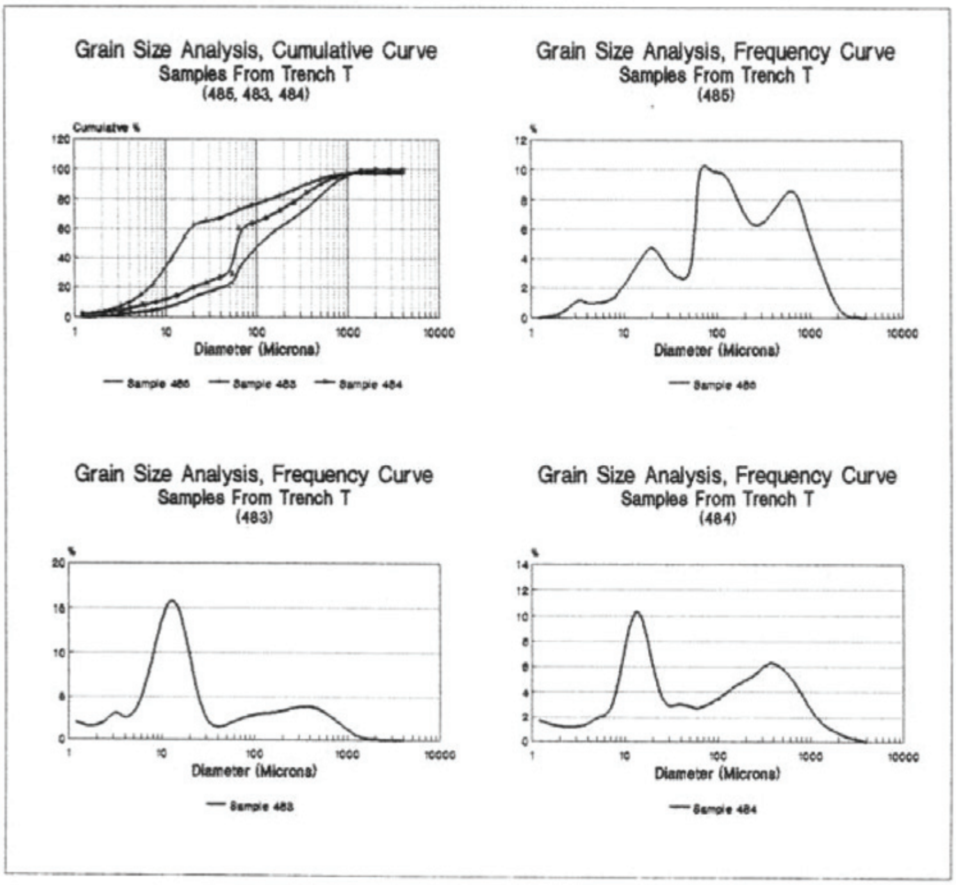



Grain Size Analysis, Cumulative Curve
Samples From Area C
(492, 491, 489)
Cumulative %
Diameter (Microns)
Sample 491
Sample 492
Sample 489
Grain Size Analysis, Frequency Curve
Samples From Area C
(491)
Diameter (Microns)
Sample 491
Grain Size Analysis, Frequency Curve
Samples From Area C
(492)
Diameter (Microns)
Sample 492
Grain Size Analysis, Frequency Curve
Samples From Area C
(489)
Diameter (Microns)
Sample 489

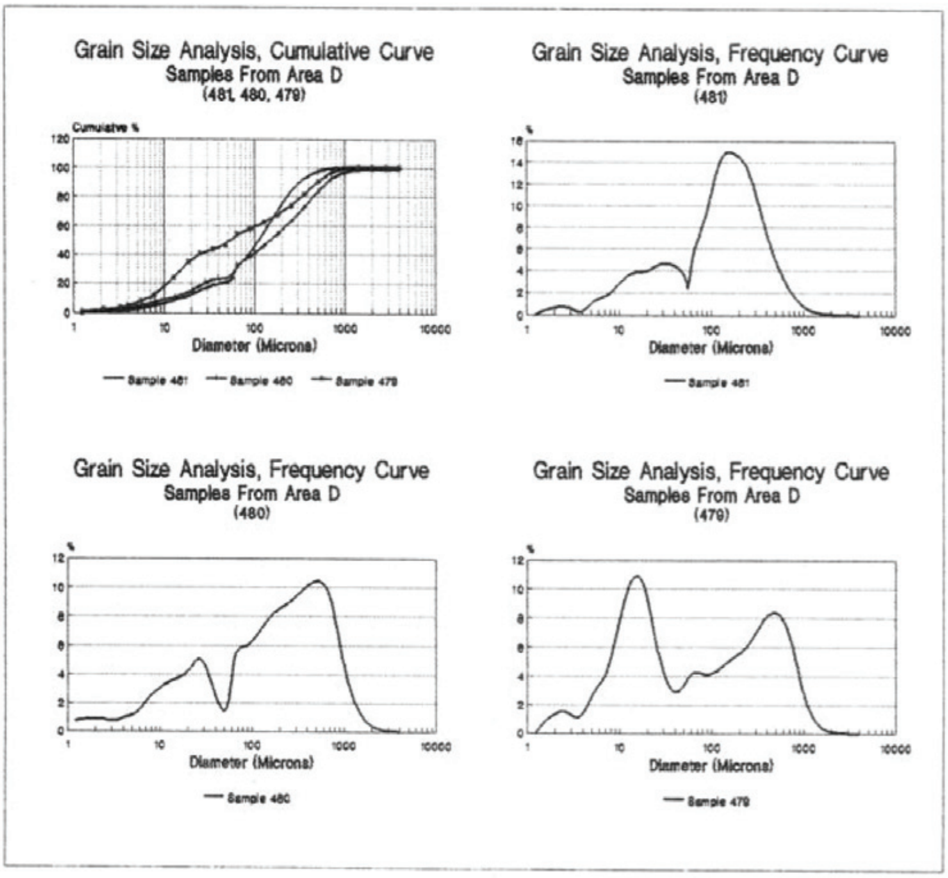

Grain Size Analysis, Cumulative Curve
Samples From Area C
(490, 496, 467)
Cumulative %
Diameter (Microns)
Sample 490
Sample 496
Sample 467
Grain Size Analysis, Frequency Curve
Samples From Area C
(490)
Diameter (Microns)
Sample 490
Grain Size Analysis, Frequency Curve
Samples From Area C
(496)
Diameter (Microns)
Sample 496
Grain Size Analysis, Frequency Curve
Samples From Area C
(467)
Diameter (Microns)
Sample 467


Grain Size Analysis, Cumulative Curve
Samples From St 110M
(500, 501)
Cumulative %
Diameter (Microns)
Sample 501
Sample 500
Grain Size Analysis, Frequency Curve
Samples From St 110M
(501)
Diameter (Microns)
Sample 501
Grain Size Analysis, Frequency Curve
Samples From St 110M
(500)
Diameter (Microns)
Sample 500

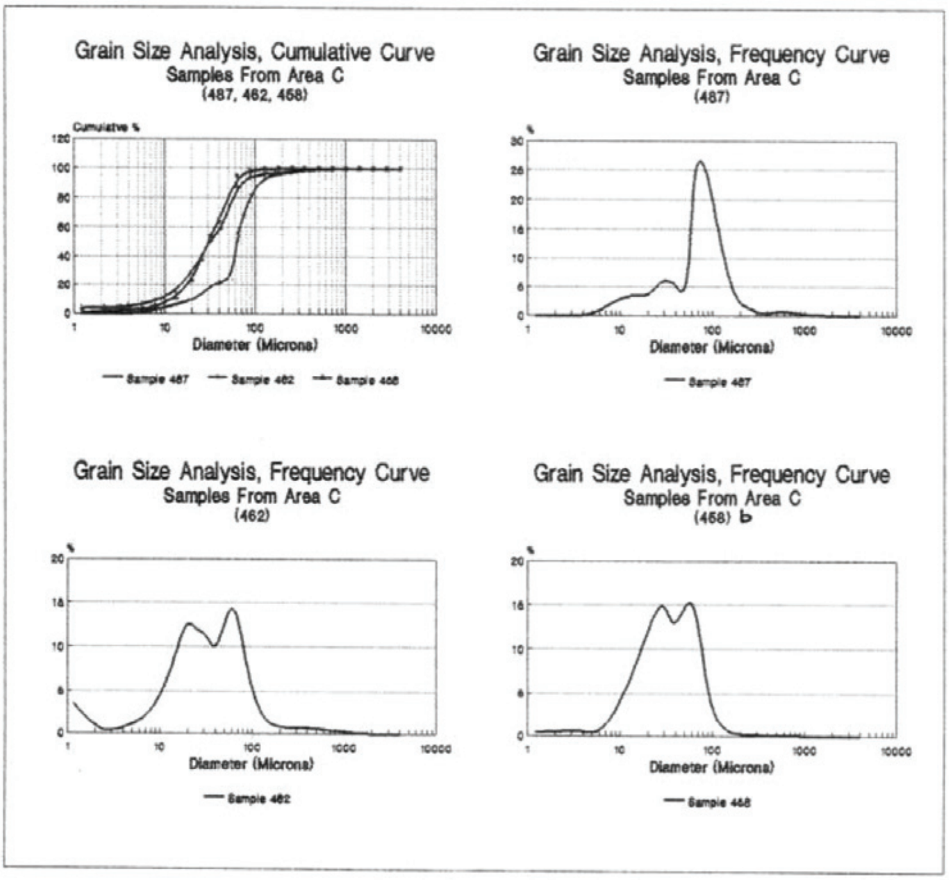

Grain Size Analysis, Cumulative Curve
Samples From Area C
(494, 488, 493)
Cumulative %
Diameter (Microns)
Sample 494
Sample 488
Sample 493
Grain Size Analysis, Frequency Curve
Samples From Area C
(494)
Diameter (Microns)
Sample 494
Grain Size Analysis, Frequency Curve
Samples From Area C
(488)
Diameter (Microns)
Sample 488
Grain Size Analysis, Frequency Curve
Samples From Area C
(493)
Diameter (Microns)
Sample 493

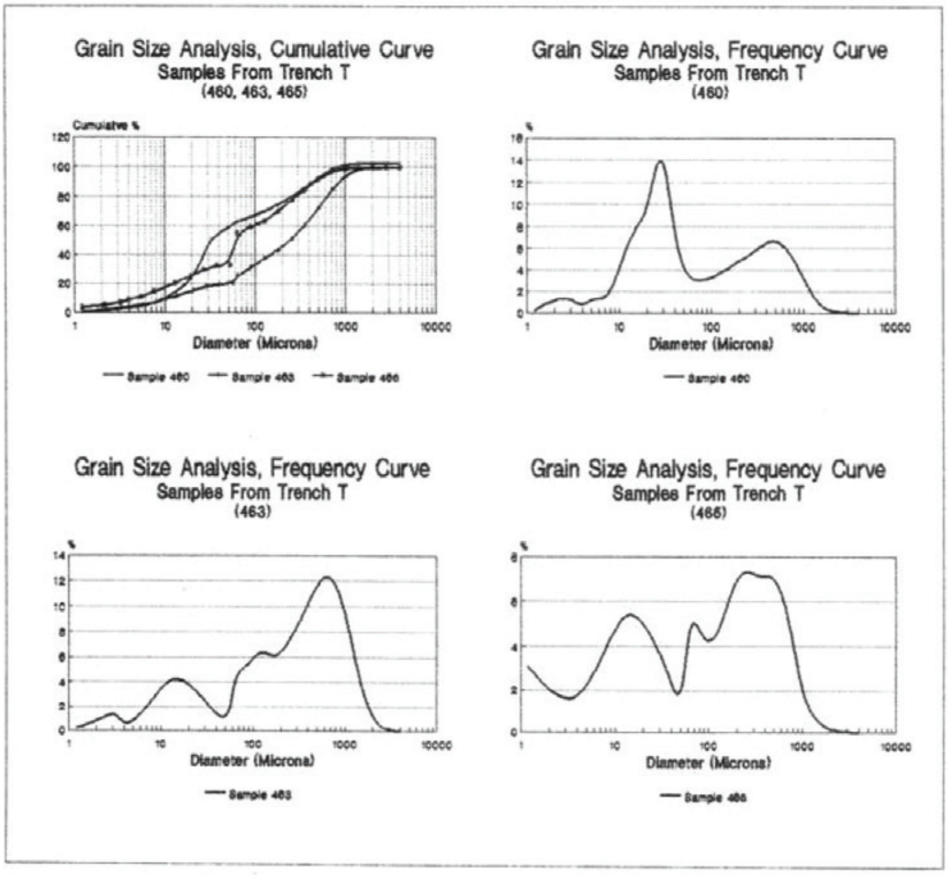


Grain Size Analysis, Cumulative Curve
Samples From Trench T
(485, 483, 484)
Cumulative %
Diameter (Microns)
Sample 485
Sample 483
Sample 484
Grain Size Analysis, Frequency Curve
Samples From Trench T
(485)
%
Diameter (Microns)
Sample 485
Grain Size Analysis, Frequency Curve
Samples From Trench T
(483)
%
Diameter (Microns)
Sample 483
Grain Size Analysis, Frequency Curve
Samples From Trench T
(484)
%
Diameter (Microns)
Sample 484

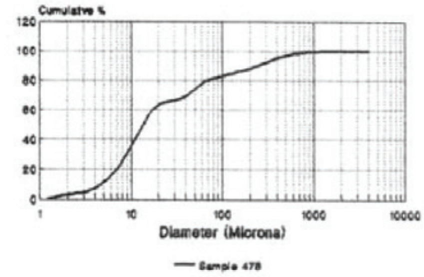


Grain Size Analysis, Cumulative Curve
Samples From Area D
(481, 480, 479)
Cumulative %
Diameter (Microns)
Sample 481
Sample 480
Sample 479
Grain Size Analysis, Frequency Curve
Samples From Area D
(481)
%
Diameter (Microns)
Sample 481
Grain Size Analysis, Frequency Curve
Samples From Area D
(480)
%
Diameter (Microns)
Sample 480
Grain Size Analysis, Frequency Curve
Samples From Area D
(479)
%
Diameter (Microns)
Sample 479

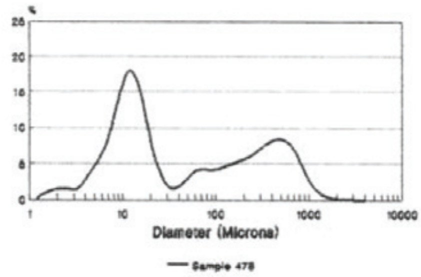

Grain Size Analysis, Cumulative Curve
Samples From Area C
(487, 462, 458)
Cumulative %
Diameter (Microns)
Sample 487
Sample 462
Sample 458
Grain Size Analysis, Frequency Curve
Samples From Area C
(487)
Diameter (Microns)
Sample 487
Grain Size Analysis, Frequency Curve
Samples From Area C
(462)
Diameter (Microns)
Sample 462
Grain Size Analysis, Frequency Curve
Samples From Area C
(458) b
Diameter (Microns)
Sample 458


Grain Size Analysis, Cumulative Curve
Samples From Trench T
(460, 463, 465)
Cumulative %
Diameter (Microns)
Sample 460
Sample 463
Sample 465
Grain Size Analysis, Frequency Curve
Samples From Trench T
(460)
Diameter (Microns)
Sample 460
Grain Size Analysis, Frequency Curve
Samples From Trench T
(463)
Diameter (Microns)
Sample 463
Grain Size Analysis, Frequency Curve
Samples From Trench T
(465)
Diameter (Microns)
Sample 465

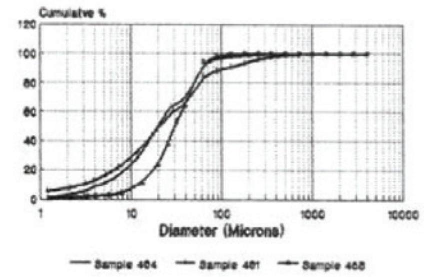
Grain Size Analysis, Cumulative Curve
Samples From Area D
(478)



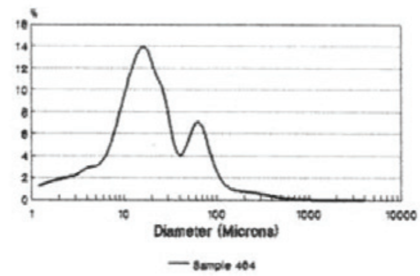
Grain Size Analysis, Frequency Curve
Samples From Area D
(478)



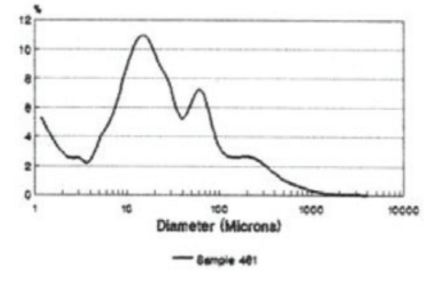
Grain Size Analysis, Cumulative Curve
Samples From Area H
(464, 461, 458)



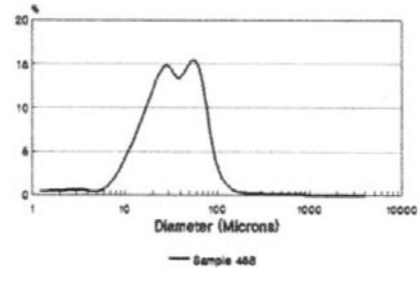
Grain Size Analysis, Frequency Curve
Samples From Area H
(464)



Grain Size Analysis, Frequency Curve
Samples From Area H
(461)



Grain Size Analysis, Frequency Curve
Samples From Area H
(458) a



Attachment 5: Mineralogical Examination

Mineral Composition of Soil Samples

Sample Number	Approx % Quartz	Approx % Hematite	Approx % Lead, Zinc	Approx % Gold	Approx % Silver
424	35	20	0	0	0
419	30	25	0	0	0
420	40	25	0	0	0
423	40	30	0	0	0
426	45	10	0	0	0
425	45	10	0	0	0
421	30	30	0	0	0
422	60	5	0	0	0
499	50	25	3	1.5	0.5
497	60	20	4	3	1
498	20	40	2	4	0
501	40	30	0	0	0
500	40	25	0	0	0
494	25	30	0	0	0
488	50	20	3	2	3
493	30	20	0	0	0
492	25	30	0	0	0
491	30	20	0	0	0
489	60	10	2	8	1.5
490	20	20	0	0	0
496	70	5	0	0	0
467	30	10	0	0	0
487	30	20	0	0	0
462	40	20	2	3	2
458 b	50	10	5	1	0
460	50	10	3	0.5	0
463	25	25	0	0	0
485	30	15	0	0	0
465	50	5	0	0	0
483	60	5	2	1	3
484	40	20	0	0	0
481	25	30	0	0	0
480	30	20	0	0	0
479	30	10	0	0	0
478	50	10	3	4	2.5
464	30	20	0	0	0
461	30	20	0	0	0
458 a	40	10	0	0	0
466	50	15	3	2	1

Appendix 15 Miscellaneous

Caroline Phillips

Sixteen miscellaneous objects were found at Opita. This category included 11 fragments of burnt clay, three coprolites and two leather items (Table 1).

The burnt clay is thought to have resulted from fires, especially hangi. Four pieces were associated with midden in Square F and one piece with midden in Square M. Three pieces were found in the upper deposits in trench T and may have been caused by burning of trees during farming operations.

The coprolites were all found in Square F from layers 3 and 4.

Thin degraded leather was found in Square S in the rock four layer and might have been from some clothing that became incorporated in the soil during the early farming era (c.1920). The other leather object was the sole and heel of a work boot, also very degraded. It was found in Square H in the ditch fill in association with cans and other metal in layer 3, dated by glass bottles and its relation to the rock flour as c.1890.

No further research was undertaken on any of these items.

Table 1. List of miscellaneous objects found at the Opita sites.

Sample No.	*Trench*	*Distance (m)*	*Square*	*Unit*	*Layer*	*No. Items*	*Type*
14	T	108.7			1	1	Burnt clay
17	T	110			2/3	2	Burnt clay
55	T	140.3			3	1	Burnt clay
45	T	165.2				1	Burnt clay
241			H	?	3	1	Burnt clay
395a			F	D5	6	1	Burnt clay
399			F	C4	6	3	Burnt clay
288b			M		1	1	Burnt clay
199			F	C4	3	1	Coprolite
381			F	D7	4	1	Coprolite
348			F	B6	4	1	Coprolite
317			H	?14	3	1	Leather boot frag.
456a			S		2	1	Leather fragment

Appendix 16 Tobacco vs Alcohol during the Early Contact Period[1]

Stuart Bedford

The fact that by the 1840s the use of alcohol and tobacco was widespread amongst Maori communities who lived near an area of concentrated European settlement is generally accepted. However many writers believe that alcohol was initially disliked by Maori and that this was the reason for tobacco being more readily accepted at an earlier stage (the early acceptance of tobacco is refuted by at least one historian, Eldred-Grigg 1984:97).

That it was simply a dislike of alcohol that slowed its initial acceptance, as compared to tobacco, seems a rather simplistic argument. Other factors such as availability, level of exposure, social acceptability and the relative cost of the drugs should also be taken into account.

There are numerous early accounts attesting to the popularity and widespread use of tobacco. In 1830 Marsden stated that "the Bay Maoris valued tobacco and pipes so highly that they were willing to give anything they possessed in exchange" (Elder 1932:481). When being questioned by a House of Commons committee investigating New Zealand, John Watkins, a surgeon in New Zealand between 1833-34, was asked whether the Maoris were "more pleased with Trinkets and Baubles or with Articles of Utility", he replied "They were more pleased with Articles that supplied their Necessities", continuing however to say "Tobacco certainly is a frivolous Thing, but they were more pleased with that than with anything else" (Watkins in B.P.P. 1968 Vol. 1:14).

George Butler Earp (a resident in New Zealand from 1839-1842), being cross-examined by the House of Commons Committee, was asked "Do the natives use it [tobacco] much?" He replied "They do a great deal". Asked about the imposition of taxes on tobacco he replied "that is one which I think should be touched very deliberately, as tobacco is largely consumed by the natives, and if you impose a heavy tax upon it, you prevent his getting what has now become almost indispensable to him" (Earp in B.P.P. 1968 Vol. 2:126,148).

On a visit to Hicks Bay in 1838 Colenso noted neat plantations of taro and tobacco (Porter 1974:59). A traveller in 1839 commented that Rotorua Maori were making their own pipes and growing their own tobacco (Howe 1973:43).

Tobacco was widely accepted as a trade item for land and payment for work from earliest contact. Watkins discussed land transactions with the missionaries and mentions amongst other things pipes and tobacco being traded. He discusses the hiring of men and in exchange "supplying them with a pair of trousers or a shirt every month and giving them a few other small payments such as tobacco pipes" (Watkins in B.P.P. 1968 Vol. 1:41). In 1830, 120 pounds of tobacco and 250 pipes were included in the purchase price of the land for the Waimate mission station (Wilson 1985:146).

There were several reasons for this general acceptance of tobacco, ahead of alcohol, from the 1820s. Tobacco was seen as a socially more acceptable drug and didn't have the same stigma attached to it as alcohol. It seems that even the missionaries had few qualms about using tobacco frequently as a trade item. In contrast, repeated sermons on the evils of alcohol may have slowed its initial acceptance. The formation of a Temperance Society set up by missionaries in the Bay of Islands in the 1830s was "directed to limit the Use of ardent Spirits amongst the Natives" according to Dandeson Coates, secretary of the Church Missionary Society, and Rev. John Beecham, secretary of the Wesleyan Missionary Society (Coates and Beecham in B.P.P. 1968 Vol. 1:182).

1 When Stuart Bedford was analysing the glass and clay pipes, he noticed a contrast between the numbers of tobacco pipes in the first historic layer of Square F and the numbers of glass bottles in the layer above, and undertook research which suggested a difference in the early acceptance by Maori of tobacco versus alcohol.

Tobacco must have been more easily transported, firstly to New Zealand and then around the countryside, thereby making it more easily obtainable than alcohol. It appears that Maori also began growing tobacco from an early stage. Tobacco may have been a lot cheaper relative to alcohol and seen as better value, an issue highlighted in the following exchange. When Watkins was asked whether spiritous liquors were generally introduced in New Zealand, he replied that "they are". And when asked "Are the Natives often in a State of Intoxication?" he replied "The Chiefs are frequently seen in a State of Intoxication, but the others are not able to purchase spirits sufficiently; they are anxious to get something of more Value" (Watkins in B.P.P. 1968 Vol. 1:20).

It may be that Maori generally did not on brief acquaintance like most kinds of alcohol. Some did not see liquor frequently enough to grow to like it. However those who lived on ships or close to centres of European settlement where alcohol was freely consumed certainly took up drinking (Shawcross 1966:337).

Whatever the reasons for the early acceptance and popularity of one drug before the other are, the differences should be reflected in the archaeological record, as they are at Opita.

References

Coates, D., and Rev. J. Beecham, 1968. Minutes of Evidence. British Parliamentary Papers: Reports from Select Committees on New Zealand with Minutes of Evidence, Appendix and Indices, 1837-1840. Vol. 1. Shannon: Irish University Press. Reprinted 1968, pp.180-275.

Earp, G.B., 1968. Minutes of Evidence. British Parliamentary Papers: Reports from Select Committees on New Zealand with Minutes of Evidence, Appendix and Indices, 1837-1840. Vol. 2. Shannon: Irish University Press. Reprinted 1968, pp.91-158.

Elder, J.R., 1932. The Letters and Journals of Samuel Marsden, 1765-1838. Dunedin: A.H. Reed.

Eldred-Grigg, S., 1984. Pleasures of the Flesh: Sex and Drugs in Colonial New Zealand. Wellington: A.H. Reed.

Howe, K.R., 1973. The Maori responses to Christianity in the Thames-Waikato region 1833-40. New Zealand Journal of History, 7:28-46.

Porter, F., 1974. The Turanga Journals 1840-1850: Letters and Journals of William and Jane Williams Missionaries to Poverty Bay. Wellington: Victoria University Press.

Shawcross, K., 1966. Maoris of the Bay of Islands 1769-1840: A study in changing Maori attitudes to Europeans. M.A. thesis University of Auckland.

Watkins, J., 1968. Minutes of Evidence. British Parliamentary Papers: Reports from Select Committees on New Zealand with Minutes of Evidence, Appendix and Indices, 1837-1840. Vol. 1. Shannon: Irish University Press. Reprinted 1968, pp.12-32.

Wilson, O., 1985. From Hongi Hika to Hone Heke: A Quarter Century of Upheaval. Dunedin: McIndoe.

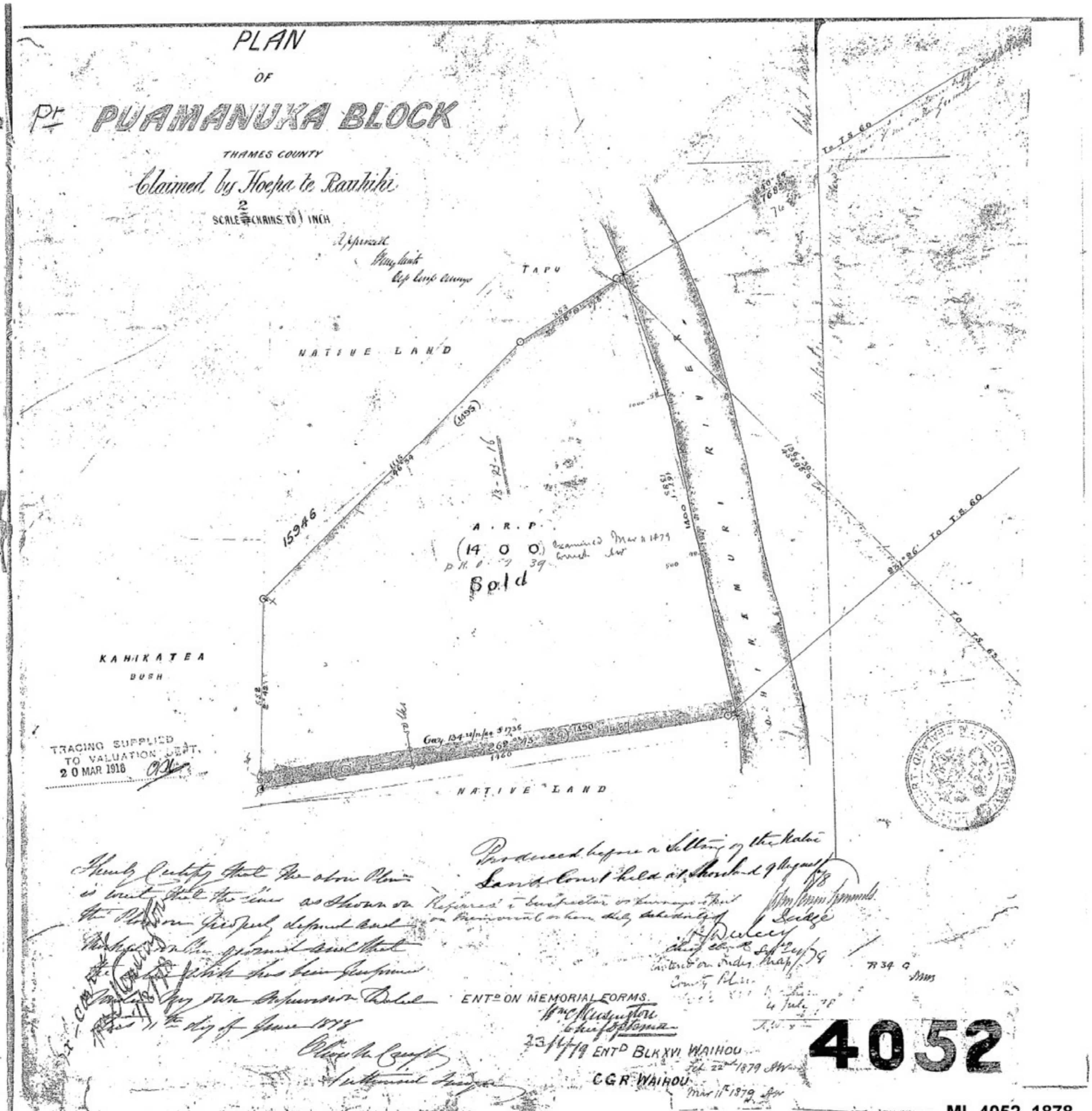
Appendix 17 Early Survey Plans

OLC 120 – 1856 199
OLC 120 detail 200
ML 4052 – 1878 201
ML 4193 – 1878 202
ML 4382 – 1879 203
ML 4382 detail 204
ML 4389 – 1879 205
SO 3421 – 1883 206
SO 3421 detail 207
SO 3582 – 1883 208
ML 6248 – 1890 209
ML 6966 – 1903 210
ML 6967 – 1903 211
ML 8178 – 1911 212
ML 10590 – 1917 213
ML 11460 – 1919 214


PLAN
of
LAND-CLAIM
situate on the
THAMES-RIVER
the property of
OPUKEKO
605.3.0
THAMES RIVER
120

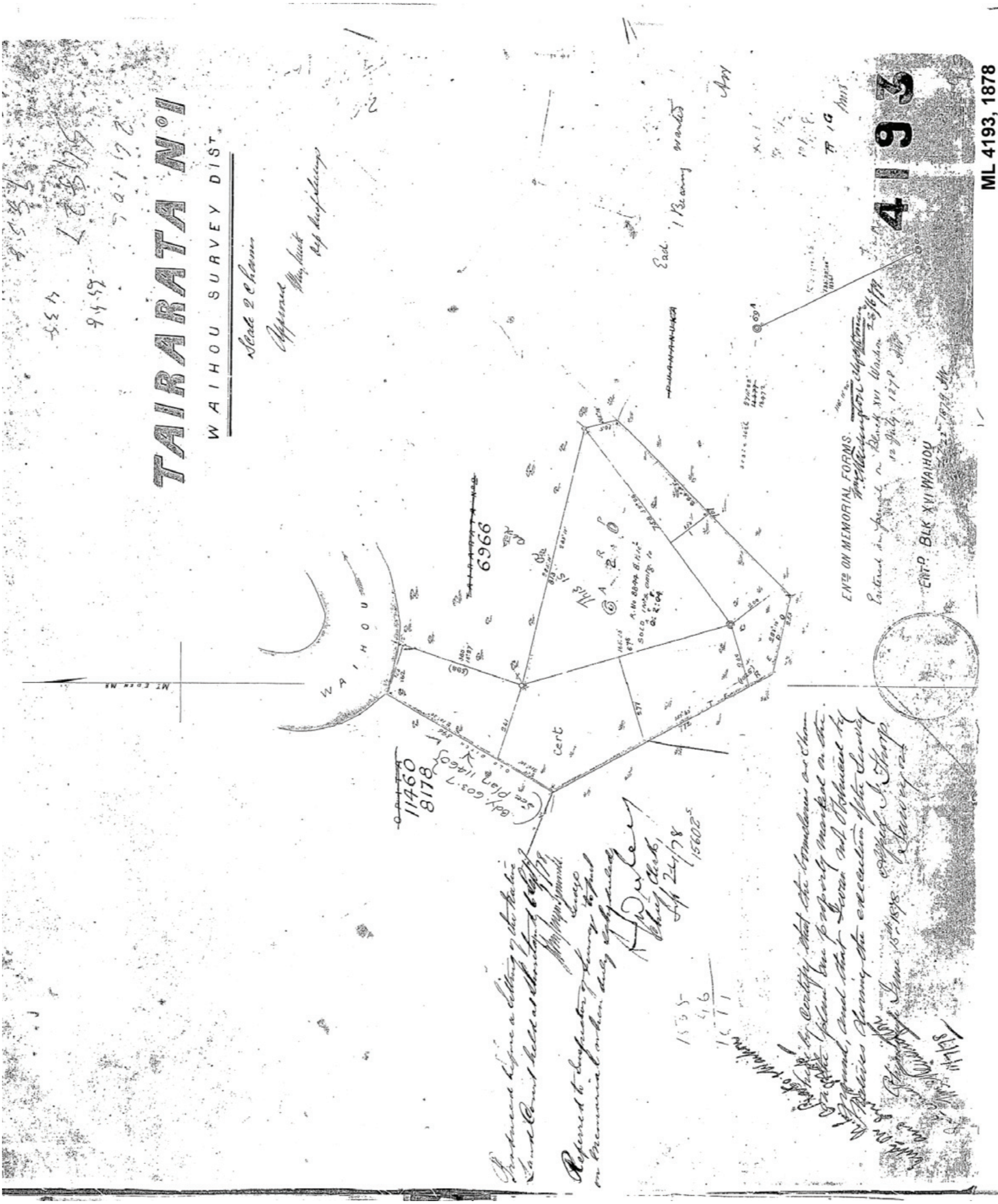
OLC 120, 1856

detail OLC 120, 1856

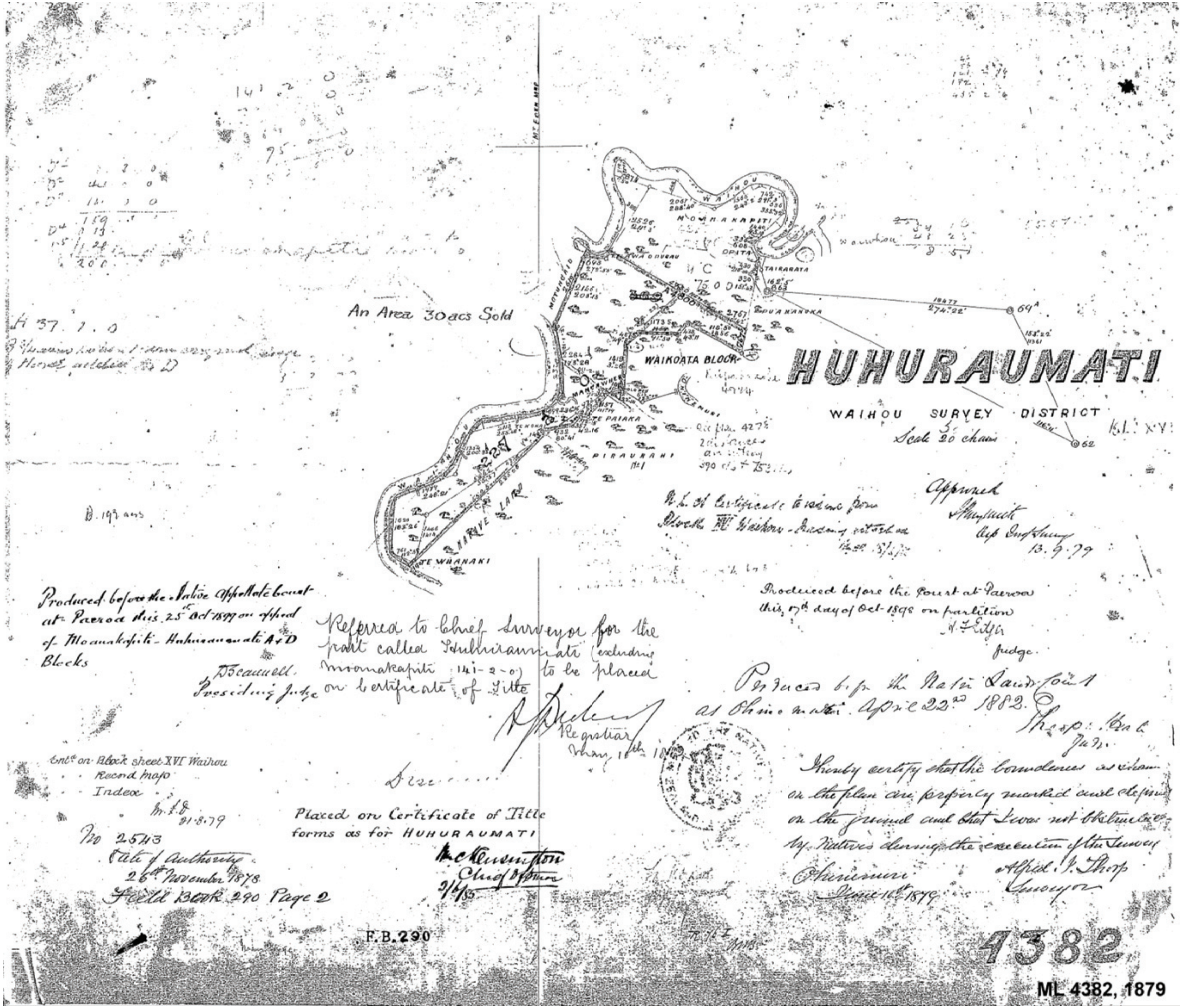


PLAN
OF
Pt PUAMANUKA BLOCK
THAMES COUNTY
Claimed by Hoepa te Rauhihi
SCALE 2 CHAINS TO 1 INCH
TAPU
NATIVE LAND
KAHIKATEA
BUSH
A. R. P.
(14 0 0)
Sold
NATIVE LAND
TO T.S. 60
TO T.S. 60
TO T.S. 63
TRACING SUPPLIED TO VALUATION DEPT.
20 MAR 1916
ENTD ON MEMORIAL FORMS.
ENTD BLK XVI WAIHOU
CGR WAIHOU
4052

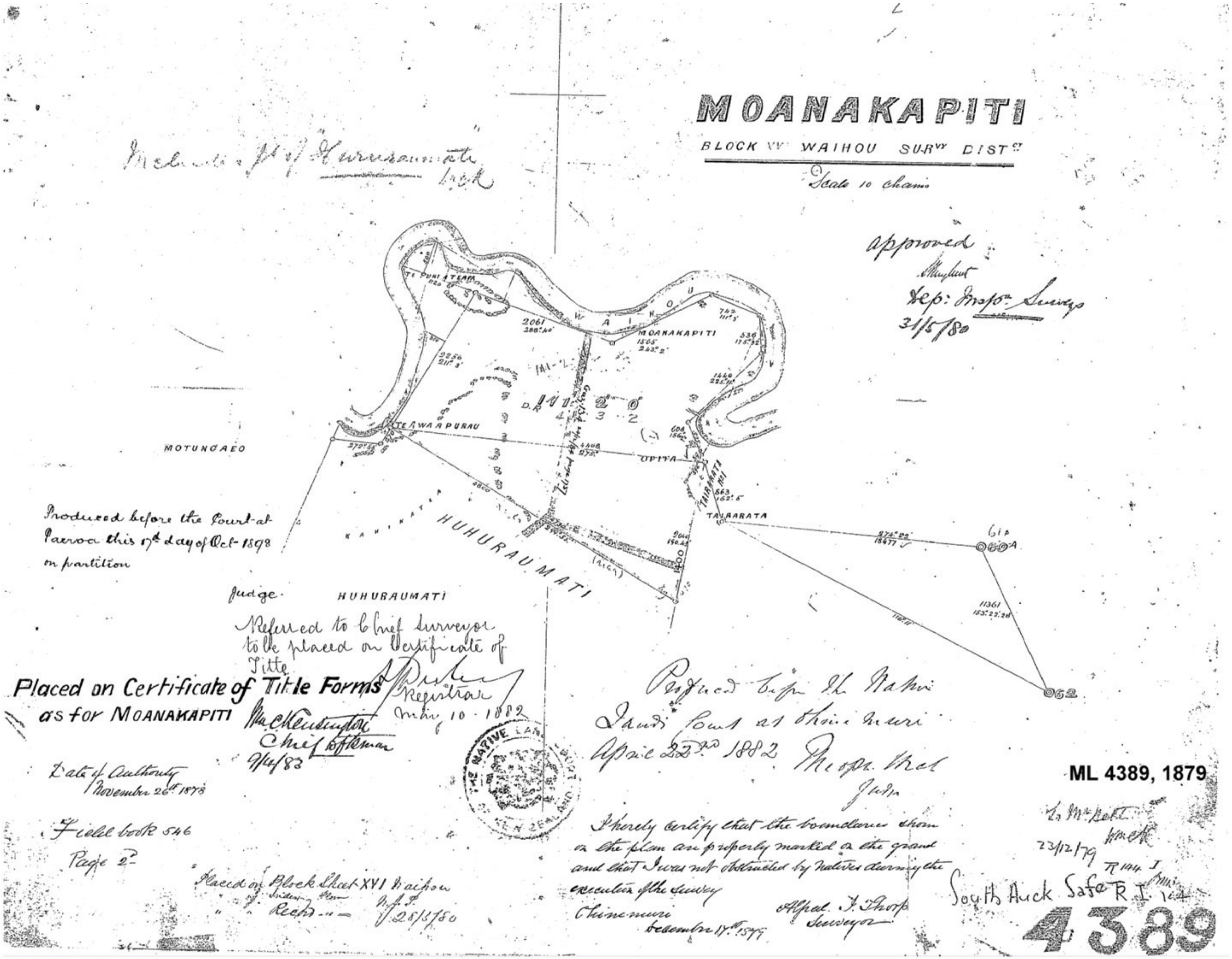
ML 4052, 1878

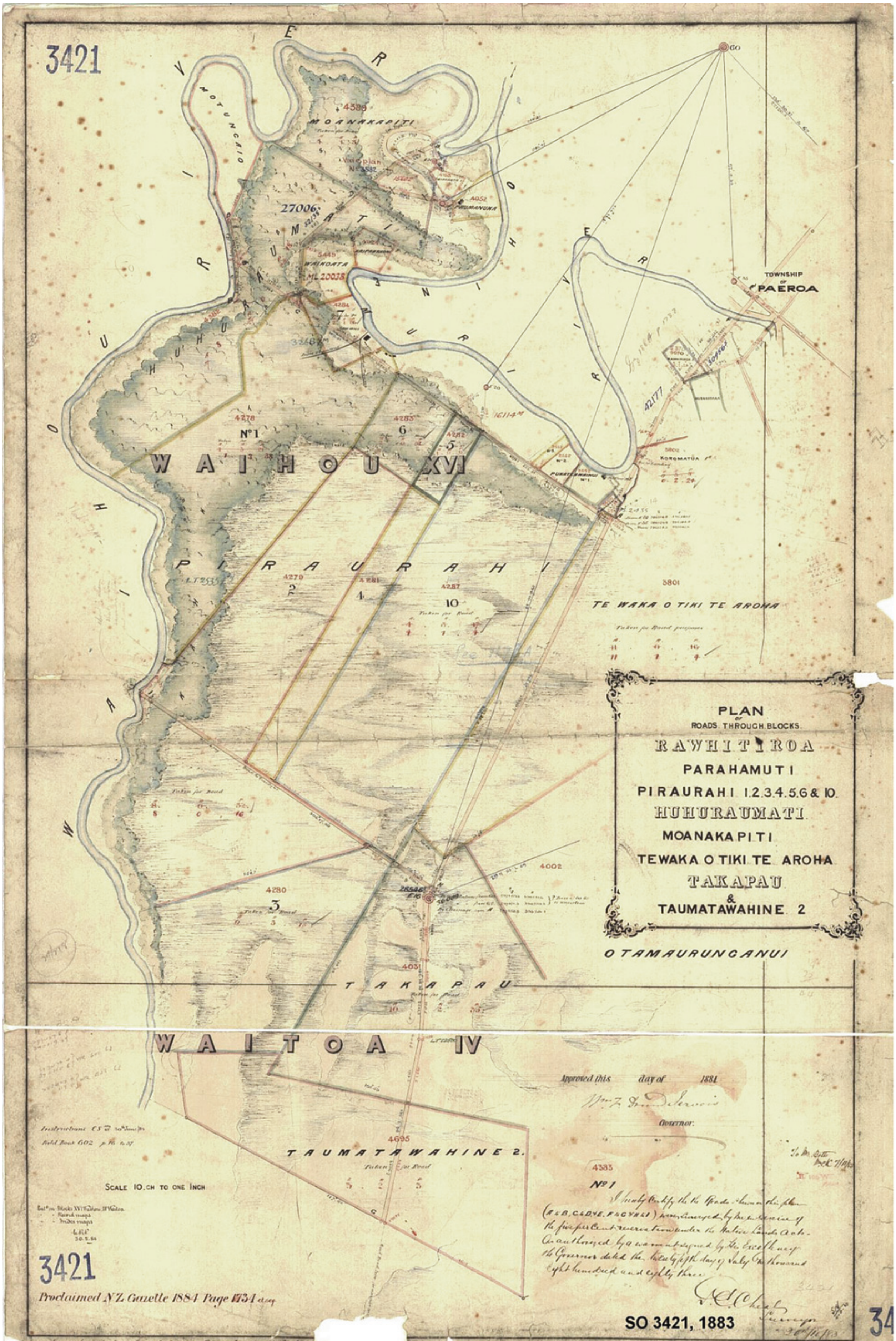


TAIRARATA No 1
WAIHOU SURVEY DISTT
Scale 2 Chains
WAIHOU
6966
11460
8178
Cert
ENTD ON MEMORIAL FORMS
ENTD BLK XVI WAIHOU
4193
ML 4193, 1878

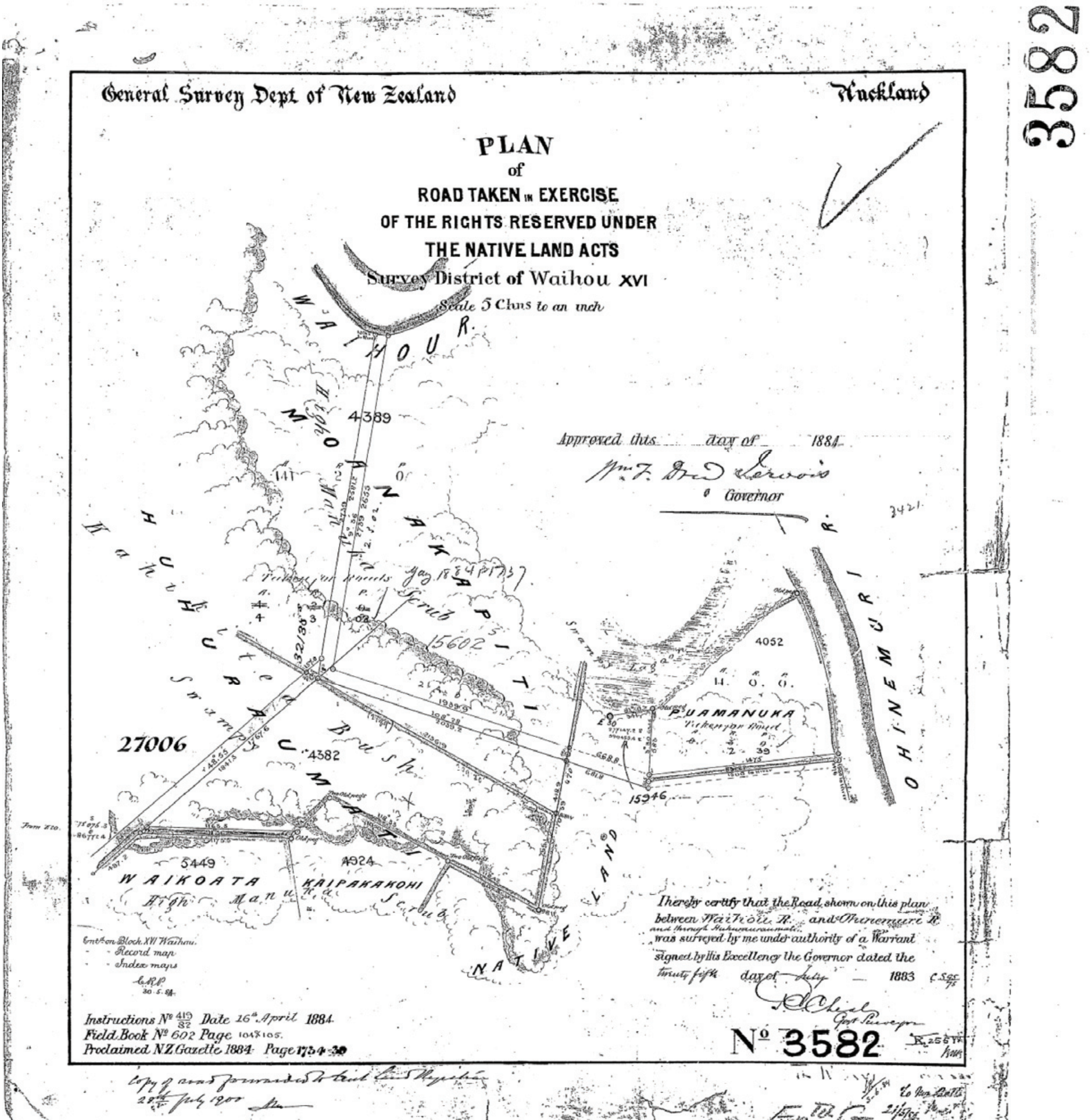

HUHURAUMATI
WAIHOU SURVEY DISTRICT
Scale 20 chains
An Area 30acs Sold
WAIKOATA BLOCK
MOANAKAPITI
OPITA
TAIRARATA
TE PAIAKA
PIRAURAHI No 1
NATIVE LAND
TE WHANAKI
WAIHOU
Approved
13.9.79
Produced before the Native Appellate Court at Paeroa this 25th Oct 1897 on appeal of Moanakapiti - Huhuraumati A & D Blocks
Presiding Judge
Referred to Chief Surveyor for the part called Huhuraumati (excluding Moanakapiti 141-2-0) to be placed on Certificate of Title
Registrar
Produced before the Court at Paeroa this 17th day of Oct 1898 on partition
Judge
Produced before the Native Land Court at Ohinemuri April 22nd 1882.
I hereby certify that the boundaries as shown on the plan are properly marked and defined on the ground and that I was not obstructed by Natives during the execution of the Survey
Ohinemuri
June 11th 1879
Alfred J. Thorp
Surveyor
Entd on Block sheet XVI Waihou
Record map
Index
21.8.79
No 2543
Date of Authority
26th November 1878
Field Book 290 Page 2
Placed on Certificate of Title
forms as for HUHURAUMATI
Chief Surveyor
F.B.290
1382
ML 4382, 1879

detail ML 4382, 1879

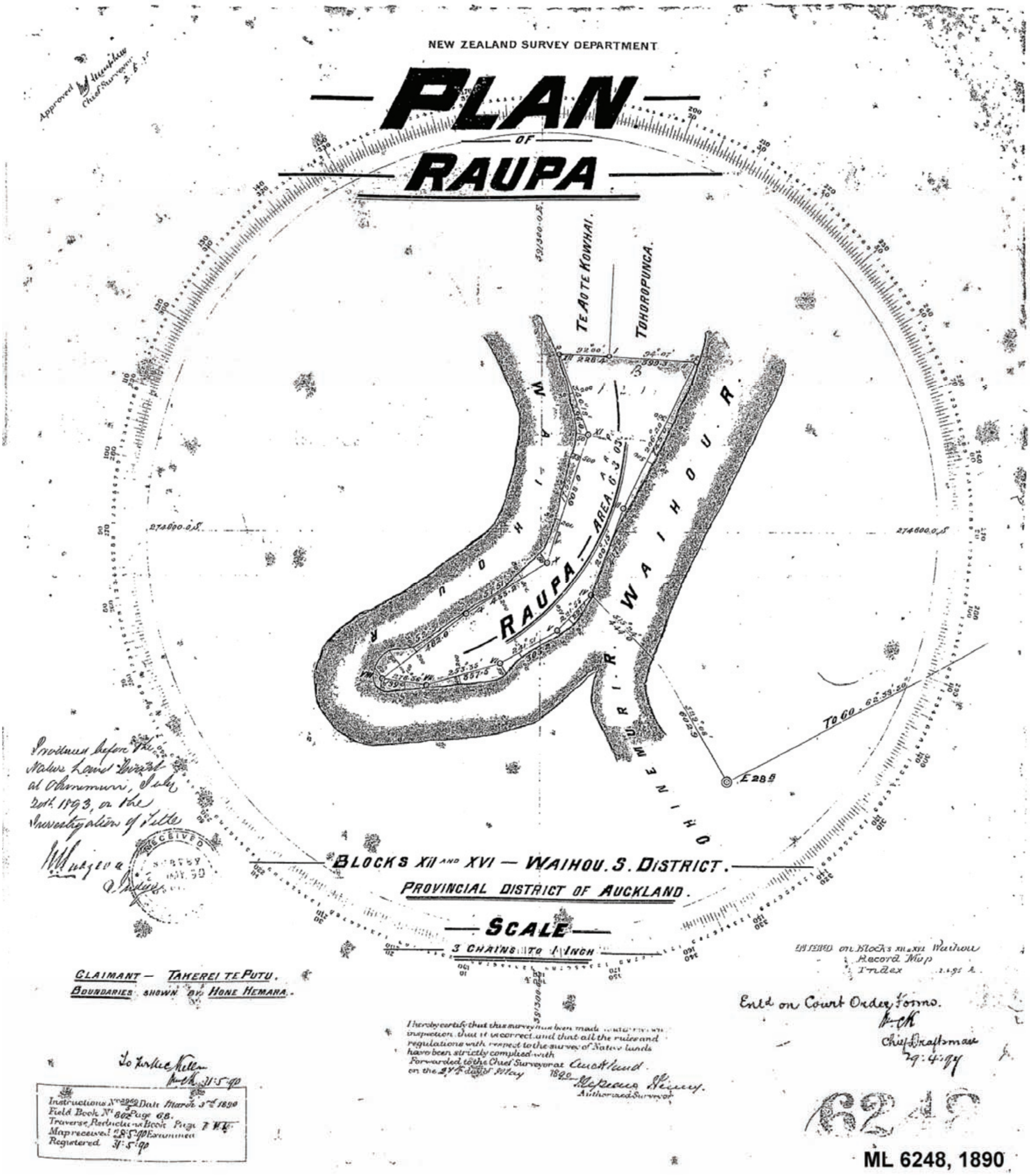

MOANAKAPITI
BLOCK XVI WAIHOU SURVY DISTT
Scale 10 chains
Approved
31/5/80
WAIHOU
MOANAKAPITI
TE PUHI ATEAPA
TE WAA PURAU
MOTUNGAEO
OPITA
TAIRARATA
KAHIKATEA
HUHURAUMATI
Produced before the Court at Paeroa this 17th day of Oct 1898 on partition
Judge
Referred to Chief Surveyor to be placed on Certificate of Title
Registrar
May 10 1882
Placed on Certificate of Title Forms as for MOANAKAPITI
Chief Draftsman
9/4/83
Date of Authority November 26th 1878
Field book 546
Page 2
Placed on Block Sheet XVI Waihou
25/3/80
April 22nd 1882
Judge
I hereby certify that the boundaries shown on the plan are properly marked on the ground and that I was not obstructed by natives during the execution of the survey
Ohinemuri
December 17th 1879
Alfred J. Thorp
Surveyor
THE NATIVE LAND COURT
NEW ZEALAND
ML 4389, 1879
23/12/79
South Auck Safe R I
4389


3421
MOANAKAPITI
27006
WAIKORTA
ML 20038
TOWNSHIP of PAEROA
N°1
WAIHOU XVI
PIRAURAHI
TE WAKA O TIKI TE AROHA
PLAN of ROADS THROUGH BLOCKS
RAWHITIROA
PARAHAMUTI
PIRAURAHI 1.2.3.4.5.6 & 10.
HUHURAUMATI
MOANAKAPITI
TEWAKA O TIKI TE AROHA
TAKAPAU
&
TAUMATAWAHINE 2
OTAMAURUNGANUI
TAKAPAU
WAITOA IV
TAUMATAWAHINE 2.
Approved this day of 1884
Governor.
SCALE 10 CH TO ONE INCH
3421
Proclaimed N.Z. Gazette 1884 Page 1734 et seq
SO 3421, 1883

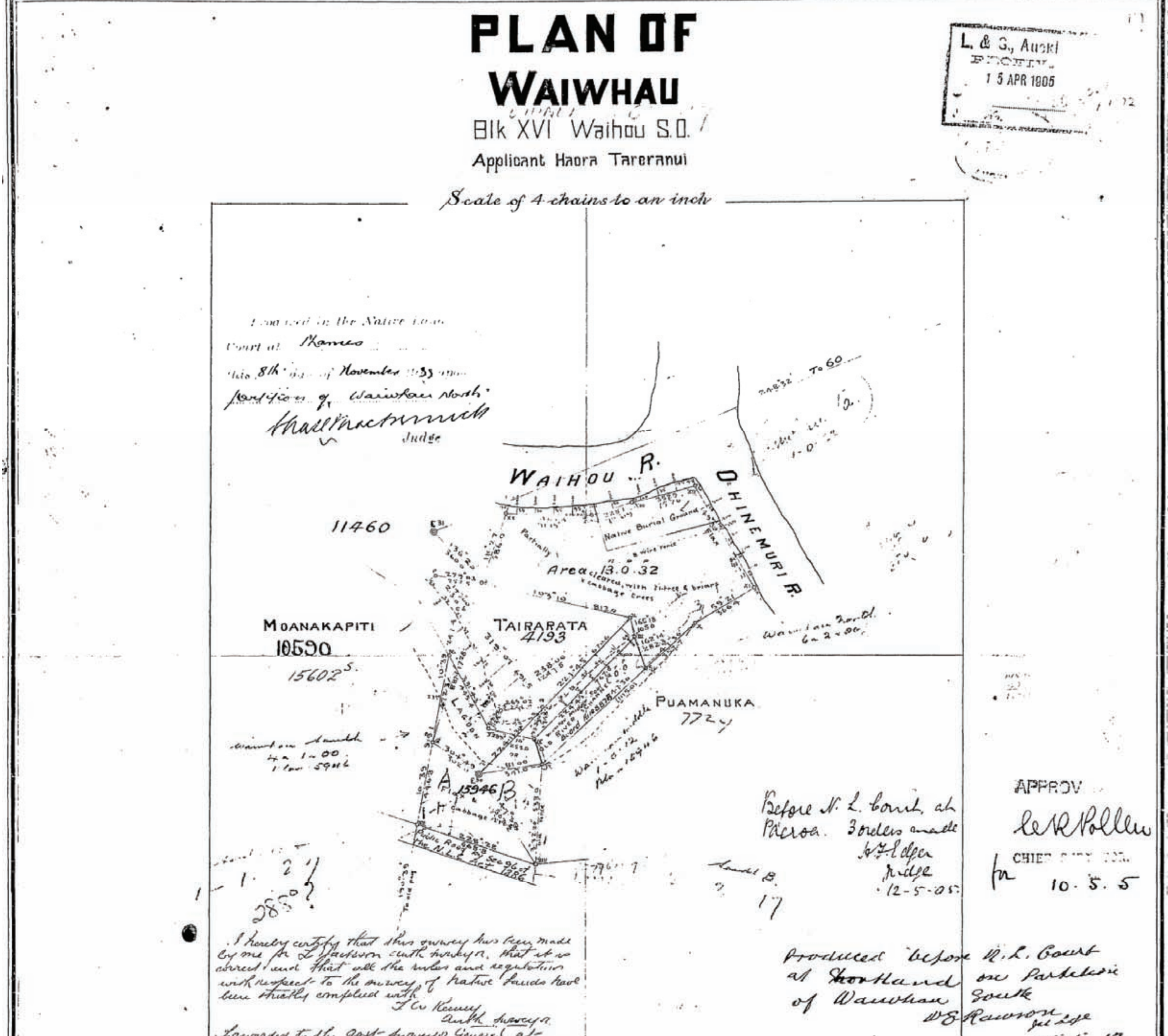

4389
MOANAKAPITI
Vide plan
No 3582
15602
4193
4052
PAUMANUKA
27006
5449
WAIKOATA
ML 20038
4284
SAW MILL


3582
General Survey Dept of New Zealand
Auckland
PLAN
of
ROAD TAKEN IN EXERCISE
OF THE RIGHTS RESERVED UNDER
THE NATIVE LAND ACTS
Survey District of Waihou XVI
Scale 5 Chns to an inch
WAIHOU R.
MOANAKAPITI
HUHURUMATI
OHINEMURI R.
PUAMANUKA
WAIKOATA
KAIPAKAKOHI
NATIVE LAND
Scrub
Bush
Swamp
High Manuka Scrub
4389
15602
4382
27006
5449
4924
4052
15946
Approved this day of 1884
Governor
I hereby certify that the Road shown on this plan between Waihou R. and Ohinemuri R. was surveyed by me under authority of a Warrant signed by His Excellency the Governor dated the twenty fifth day of July 1883
Govt Surveyor
Instructions No 419/82 Date 16th April 1884
Field Book No 602 Page 104 & 105
Proclaimed NZ Gazette 1884 Page 1734-38
No 3582
Entd on Block XVI Waihou
Record map
Index maps

SO 3582, 1883

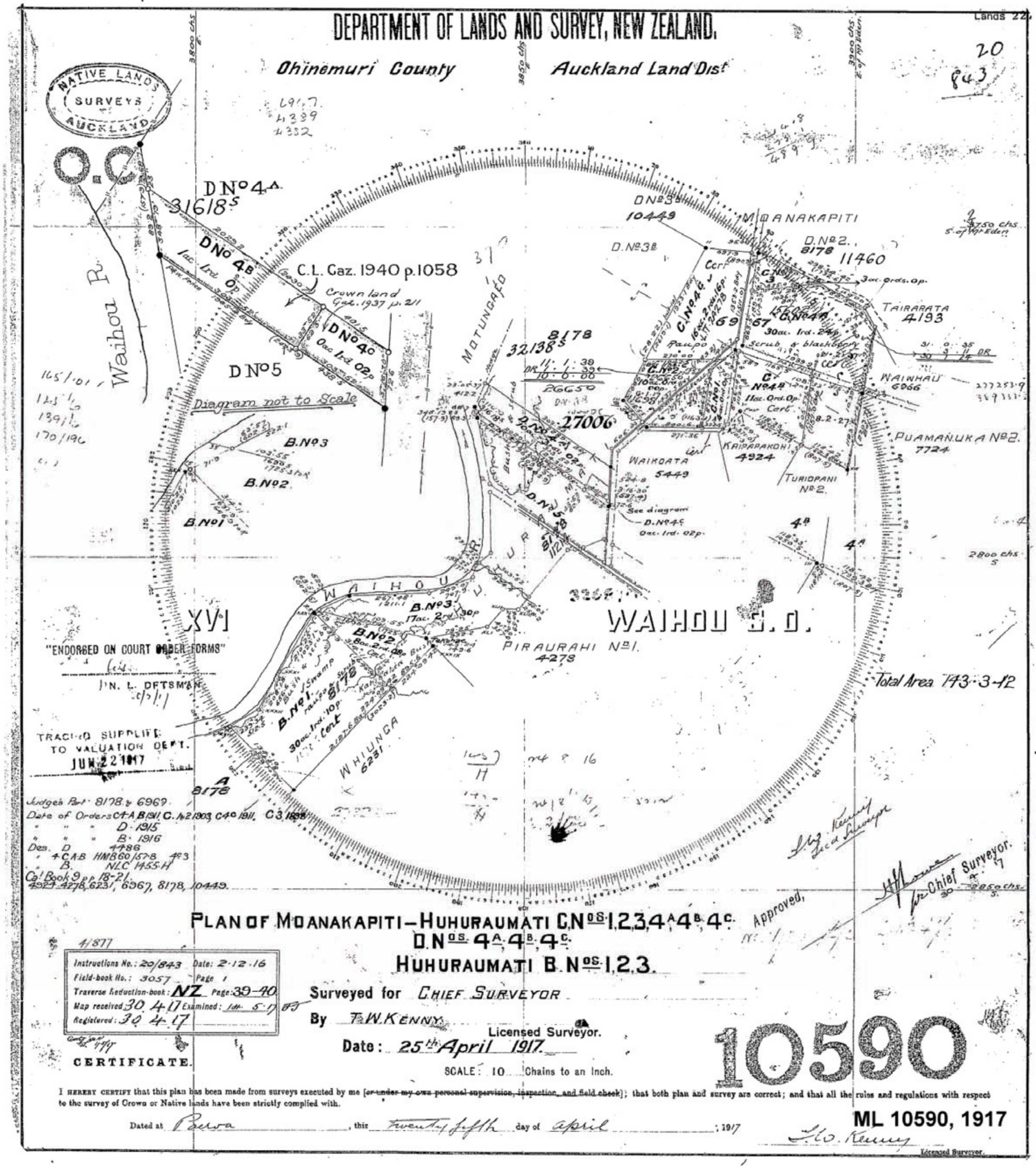


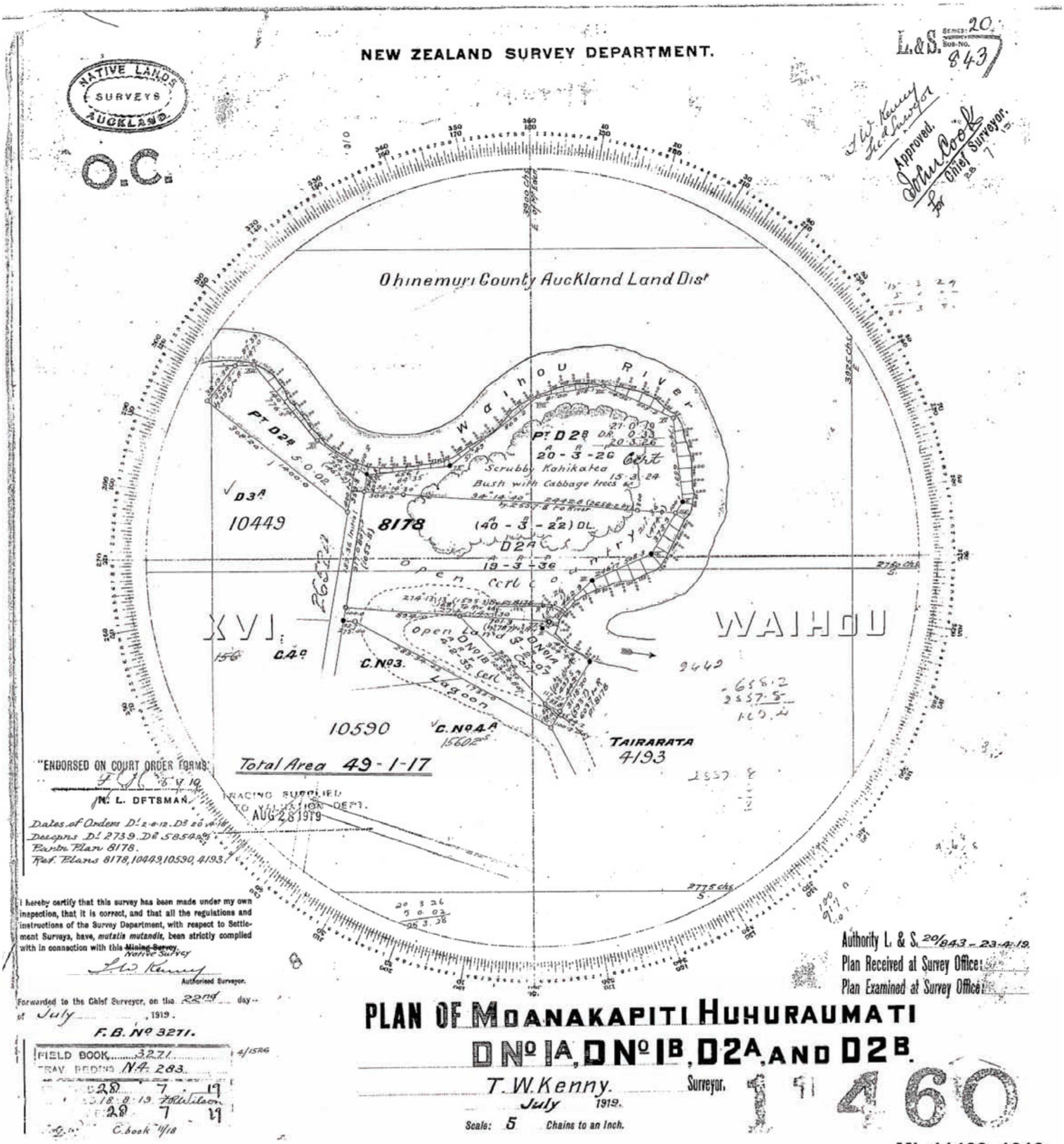
NEW ZEALAND SURVEY DEPARTMENT
PLAN OF RAUPA
TE AOTE KOWHAI
TOHOROPUNGA
RAUPA — AREA 6 3 03
WAIHOU R.
OHINEMURI R.
E 28 9
To 60 . 62.53.50
BLOCKS XII AND XVI — WAIHOU S. DISTRICT.
PROVINCIAL DISTRICT OF AUCKLAND.
SCALE
3 CHAINS TO 1 INCH
CLAIMANT — TAHEREI TE PUTU.
BOUNDARIES SHOWN BY HONE HEMARA.
I hereby certify that this survey has been made under my own inspection, that it is correct, and that all the rules and regulations with respect to the survey of Native lands have been strictly complied with.
Forwarded to the Chief Surveyor at Auckland on the 24th day of May 1890
Authorized Surveyor
Instructions No 2960 Date March 3rd 1890
Field Book No 802 Page 68.
Traverse Reductions Book Page
Map received 28.5.90 Examined
Registered 31.5.90
Entd on Court Order Forms.
Chief Draftsman
29:4:97
ML 6248, 1890


PLAN OF
WAIWHAU
Blk XVI Waihou S.D.
Applicant Haora Tareranui
Scale of 4 chains to an inch
L. & S., Auckl
15 APR 1905
Judge
WAIHOU R.
OHINEMURI R.
Native Burial Ground
11460
Area 13.0.32
MOANAKAPITI
10590
15602S.
TAIRARATA
4193
PUAMANUKA
772
A
15946
B
APPROV
10. 5. 5
Before N. L. Court at Paeroa. 3 orders made
Judge
12-5-05
Produced before N. L. Court at Shortland on Partition of Waiwhau South
25. 5. 17.
1903
20 MAR 1916
FIELD BOOK
TRAV. REDTNS. BV-24
RECEIVED 27. 4. 03
EXAMINED
REGISTERED 27. 4. 03
XVI Waihou
Ohinemuri
6966
ML 6966, 1903
17. 7. 03.


PLAN OF
HUHURAUMATI AND MOANA-KAPITI "C"
BLK XVI WAIHOU S.D.
Applicant – Haora Tareranui
Scale – 5 chains to an inch
MOANA–KAPITI
10449
HUHURAUMATI
No 4 A
10590
Area 80-1-06
D.R. 5-1-06
75-0-00
WAIWHAU
Worked-out Kahikatea Bush grown up with Scrub and Cabbage Trees
WAIKOATA
KAIPAKAKOHE
PUAMANUKA No 2
APPROVED
CHIEF SURVEYOR
Authority L&S 4469 10-2-03
6967
ENTERED on Block
Record Map Waihou
Index Ohinemuri
Selection
FIELD BOOK
TRAV. BV-26
27-4-03
24-4-03
TRACING SUPPLIED VALUATION DEPT.
ML 6967, 1903

XII
For repegging of bdy. between D2 & D3 see File 21/456 folios 1197 & 1198 and Field Book No. 4712 page 50
Chief Surveyor
6.3.39
WAIHOU R.
MOANAKAPITI
MOTUNGAEO
HUHURAUMATI-MOANAKAPITI C.
WAIWHAU
6966
TAIRARETA
4193
27006
10590
Plan 6967
Plan 5449
WAIKOATA
Plan 4278
PIRAURAHI No 1
WAIHOU R.
All hanging traverse chained & observed twice.
WAIHOU S.D.
XVI
WHIUNGA
27324
I hereby certify that this plan has been made from surveys executed by me; that both plan and surveys are correct; and that all the rules and regulations with respect to the survey of Native Lands have been strictly complied with.
Dated at Paeroa, this 28th day of November 1911.
T. W. Kenny
Licd. Surveyor.
APPROVED
CHIEF SURVEYOR
4. 12. 11.
PLAN OF
SUBDN MOANAKAPITI-HUHURAUMATI.
OHINEMURI COUNTY. AUCKLAND LAND DISt.
Surveyed by T. W. Kenny.
Scale of 10 Chains to 1 Inch.
Authority No. 14632
F.B. No. 2001
ML 8178, 1911


DEPARTMENT OF LANDS AND SURVEY, NEW ZEALAND.
Lands 22
Ohinemuri County
Auckland Land Dist
NATIVE LANDS SURVEYS AUCKLAND
O.C
D No 4A
31618S
D No 4B
1ac. 1rd. 0p.
D No 4C
0ac. 1rd. 02p
C.L. Gaz. 1940 p.1058
Crown land Gaz. 1937 p. 211
D No 5
Waihou R.
Diagram not to Scale
B. No 3
B. No 2
B. No 1
MOTUNGAIO
8178
32138S
27006
D.No 3
10449
D.No 3B
MOANAKAPITI
D.No 2.
8178
11460
C.No 4C
C.No 4A
30ac. 1rd. 24p.
Scrub & blackberry
Paupo
TAIRARATA
4193
WAIHAU
6966
C No 4B
11ac. 0rd. 0p.
Cert
KAIPAPAKOHI
4924
WAIKOATA
5449
See diagram D.No 4C 0ac. 1rd. 02p.
PUAMANUKA No 2.
7724
TURIOPANI No 2.
4B
4A
WAIHOU
XVI
WAIHOU S.D.
B.No 3
17ac. 2rd. 30p
B.No 2
PIRAURAHI No 1.
4278
Total Area 143-3-12
"ENDORSED ON COURT ORDER FORMS"
J.N. L. DETSMAN
B.No 1
Swamp
8178
30ac. 1rd. 10p.
Cert
WHIUNGA
6231
TRACING SUPPLIED TO VALUATION DEPT.
JUN 22 1917
A
8178
Judges Pet. 8178 & 6969.
Date of Orders C4A B 1911, C. No 2 1903, C4C 1911, C3 1898
" " " D 1915
" " " B 1916
Des. D 4486
4 C.A.B. HMB 60/57-8 4C3
B. NLC 1455 H
Cd Book 9 pp 18-21
4924 4278, 6231, 6967, 8178, 10449.
Approved,
for Chief Surveyor.
PLAN OF MOANAKAPITI–HUHURAUMATI C.Nos 1,2,3,4A,4B,4C.
D.Nos 4A,4B,4C.
HUHURAUMATI B.Nos 1,2,3.
Instructions No.: 20/843 Date: 2.12.16
Field-book No.: 3057 Page 1
Traverse Reduction-book: NZ Page 39-40
Map received 30.4.17 Examined:
Registered: 30.4.17
Surveyed for CHIEF SURVEYOR
By T.W. KENNY
Licensed Surveyor.
Date: 25th April 1917.
SCALE: 10 Chains to an Inch.
10590
CERTIFICATE.
I HEREBY CERTIFY that this plan has been made from surveys executed by me [or under my own personal supervision, inspection, and field check]; that both plan and survey are correct; and that all the rules and regulations with respect to the survey of Crown or Native lands have been strictly complied with.
Dated at Paeroa, this Twenty fifth day of April, 1917
Licensed Surveyor.
ML 10590, 1917



ML 11460, 1919

Appendix 18 Missionary Accounts of Opita

Suzanne Loughlin

[In 1990, Suzanne Loughlin researched missionary records in preparation for an archaeological survey of the west bank of the Waihou River she undertook with Andrew Crosby (Crosby and Loughlin 1991). As I was researching Opita at the time she made special note of any references to Opita, and the following is a transcript of her notes – Caroline Phillips 29/8/2011].

Opita

First mention is 1846 – neither Raupa nor Opita nor Waiwhau are mentioned in mss [missionary] accounts 1832-1846.

1846 Annual report of Hauraki Mission by Charles Dudley

"From Oct. 6th to Nov 8th … visited the natives at … Opita … administered the Holy Communion."

1847 Extracts from Journal of Archdeacon W. Williams

"Sept. 1 … walked on to Opita, a village which used to have a good number of inhabitants, but now that peace is established the natives disperse in small parties over a wide district."

1849 Letters of Rev. Charles Dudley

May 1849 to Mr Venn

"[October 1848] I spent Sunday at Opita. Conducted divine service in the native chapel in the morning, and evening, - and baptised 5 infants."

[next day had service at Joshua Thorp's house – a settler living near Opita]

1856 Journal of Rev. Lanfear

Date unknown – written in 1856

"… ago when the tribes of Tauranga under A[dn] Brown and the tribes of Hauraki with myself met at Opita … the people were earnestly desirous that I should accompany then in order to prevent their having any misunderstandings with Tauranga."

?1857 Journal of Rev. Lanfear

"Opita is now an almost deserted pa, but the people having notice of my coming assembled there to meet me and I staid [sic] with them until the 7th … baptised 5 adults and four children and had much [?] converse with the people and teachers [?]."

"April 3rd "Left home in company with several canoes to attend a meeting of the tribe with the people of Tauranga in order to make peace".

"April 4th "Arrived at Belmont, the residence of Joshua Thorp Esquire. This being the place approved for the meeting and about two or three miles from Opita".

These journal entries by Lanfear probably relate to the peace between Ngati Tamatera and other peoples around Paeroa, including Te Uriwha who lived at Opita, and Ngaiterangi of Tauranga in April

1851. Therefore the journal shown as ?1857 should probably be 1871, while the start of the entry in the 1856 journal "…ago ….", should probably be "Five years ago …." (Caroline Phillips comments 29/8/2011).

References

Church Missionary Society. Ms. Letters, journal, reports. Church Missionary Society, London. Microfilms held by Auckland University Library, Auckland.

Crosby, A. and S. Loughlin, 1991. Site survey report: West bank of the lower Waihou River. Unpublished report to the Regional Office of the New Zealand Historic Places Trust, Auckland.

Appendix 19 Land Ownership and Landowners

Caroline Phillips

The land on which the Opita settlements were situated passed through the Maori Land Court and eventually changed from being in Maori title to freehold title, at which point it was sold to pakeha farmers. Initially it passed through several hands, principally Henry Bush and William Keys, but by 1939 it was all in the Rasmussen family, who still own it today. Research into the history of land ownership has involved viewing the survey plans and titles (see Tables 1-12 and Figures 1 & 2).

A brief biography of each of these principal owners has been prepared, based on newspaper and other archival information. In particular, it was hoped to find out who might have owned what has been interpreted as a possible burnt homestead found in Trench B.

Land Ownership

The Opita settlements occurred on parts of three Maori land blocks: Tairarata, Moanakapiti & Huhuraumati and Waiwhau. These were surveyed for Maori Land Court hearings from 1878, and subsequently were subdivided before freehold title was eventually issued in the names of one or more Maori landowners: Tairarata in 1878 to Rapata te Pokiha and 12 others; Moanakapiti & Huhuraumati D1A to [?] Rangipataka and another; Moanakapiti & Huhuraumati D1B to Ngawiki Poraiti; and Waiwhau North between 1917 and 1933 (titles could not be found due to illegible handwriting).

Tairarata was initially sold to Henry Bush in 1920, briefly held by William Keys, but by the end of the same year had been acquired by Rudolf Rasmussen. It remains in the Rasmussen family.

The two small Moanakapiti & Huhuraumati blocks were acquired by Henry Bush and Philip Brenan in 1920 and both were transferred to William Keys in the same year. He retained them with a mortgage, but eventually transferred his interest to the Crown in 1928 (he had other blocks in the area which were also sold at this time). The land was then leased to Grace Keys, his wife, and ten years later she bought the land back. However, the following year (1939) it was purchased by Christian and Rudolf Rasmussen. It also remains in the Rasmussen family.

Waiwhau was subdivided into three, North, Middle and South. Waiwhau North which contained the pa and urupa was retained in Maori ownership until 1988 when it was acquired by the Crown for the flood protection works. Its title was registered and was sold after the works had been completed, when the Rasmussen family purchased it.

The following tables show the history of land ownership for the different blocks relating to Opita and the immediate surrounds (see Figures 1 & 2). Note that all titles are prefixed SA for South Auckland Land District.

Table 1. Tairarata 1 (A - contains some of Opita settlements)

68/30	19 Jun 1878	title issued in name of Rapata te Pokiha and 12 others
	16 Sep 1920	**Henry Robertson Bush**, clerk of Thames
	5 Nov 1920	William David Keys, farmer of Paeroa
323/282	18 Nov 1920	Rudolf Rasmussen, farmer of Paeroa
	current owners	Karen Rigmore Rasmussen, Karl Christian Rasmussen, Paul Erhardt Rasmussen

Table 2. Moanakapiti & Huhuraumati D2B

180/22	20 Apr 1918	title issued in name of Rawinia Manukau (1 share) and Rangitekii Paaka (21½ shares)
	29 Nov 1935	transfer of Rangitekii Paaka interest to **Henry Robertson Bush** of Thames
	17 Apr 1936	succession of Rawinia Manukau deceased interest to Laura Myfanwy Lewis
	21 Oct 1936	transfer of Laura Myfanwy Lewis interest to **Grace Keys**, wife of William David Keys, settler
674/266	20 Apr 1936	transfer to Henry Robertson Bush (21½ shares), clerk of Thames and Grace Keys (1 share), wife of William David Keys, settler
	16 May 1938	transfer Bush shares to Grace Keys, married woman
	29 Aug 1939	transfer to Christian Alexander Rasmussen and Rudolf Rasmussen, farmers Paeroa
42C/411	3 Nov 1988	Karen Rigmore Rasmussen, Karl Christian Rasmussen, Paul Erhardt Rasmussen

Table 3. Moanakapiti & Huhuraumati D3A

16?/176	1 May 1916	title issued to Rawiritiki Paaka
366/175	**7 Feb 1923**	transfer of **Arthur Thomas Simmons**, Paeroa, farmer
	26 Jan 1925	transfer to Eleanor Simmons, his wife
	13 Jun 1934	purchased by the Crown, provisions of the Small Farms (Relief of Unemployed Act 1932/33)
	current	Resurveyed incorporated with part of Moanakapiti C

Table 4. Moanakapiti & Huhuraumati C2B

145/6	24 August 1916	title issued to Meha te Moananui and others
322/270	**11 May 1921**	transfer of **William David Keys** of Paeroa, farmer
	18 Oct 1928	transfer to the Crown
		under provisions of the Small Farms (Relief of Unemployed Act 1932/33)
		Resurveyed incorporated with part of Moanakapiti & Huhuraumati D, see Blk XVI, Waihou SD, sec 43 & 8

Table 6. Moanakapiti & Huhuraumati C4C

165/101	25 Jul 1911	title issued to Denis Foley and others
364/201	**16 Dec 1922**	transfer of **William David Keys** of Paeroa, farmer
	26 Jan 1923	transfer to Arthur Thomas Simmons, Paeroa, farmer
	26 Jan 1925	transfer to Eleanor Simmons, his wife
	13 Jun 1934	purchased by the Crown, provisions of the Small Farms (Relief of Unemployed Act 1932/33)
		Resurveyed incorporated with part of Moanakapiti & Huhuraumati D, see Blk XVI, Waihou SD, sec 18

Table 7. Moanakapiti & Huhuraumati C3

453586		Maori freehold land
453587	6 Nov 2008	title issued to Hikaiti, Paora, Pell Witika whanau ~50 shareholders

Table 8. Moanakapiti & Huhuraumati C4A

139/16	26 Oct 1903	title issued to Haora Tareranui & 2 others
300/286	**20 Jan 1920**	transfer to **Henry Robertson Bush** and **William David Keys**
683/200	6 May 1937	transfer to Christian Alexander Rasmussen and Rudolf Rasmussen, farmers Paeroa
	current	Karen Rigmore Rasmussen, Karl Christian Rasmussen, Paul Erhardt Rasmussen

Table 5. Moanakapiti & Huhuraumati D1A, D1B & D2 (contains Opita pa and most of settlements)

303/55 (D1A)	2 Jul 1912	title issued in name of ? Rangipataka and another
	18 Feb 1920	transfer to **Henry Robertson Bush**, of Paeroa, Civil Servant
	24 Nov 1920	transfer to William David Keys, of Paeroa, farmer
	18 Oct 1928	transfer to the Crown
306/218 (D1B)	2 Jul 1912	title issued in name of Ngawiki Poraiti
	24 May 1920	transfer to **Philip Edward Brenan**, of Paeroa, accountant
	3 Nov 1920	transfer to William David Keys, of Paeroa, farmer
	18 Oct 1928	transfer to Crown
486/172 (also includes D1A, D1B, D2A, D3B)	?	under provisions of the Small Farms (Relief of Unemployed Act 1921/22)
	1 Oct 1928	lease to Eleanor Simmons, wife of Arthur Thomas Simmons, Paeroa, farmer
	16 Apr 1928	transfer lease to Lilian Marie Ross, wife of Hector Ross of Auckland, commercial traveller,
	16 Apr 1928	transfer lease to Grace Keys, wife of William David Keys, farmer
182/133 (inc.D1A, D1B, D2A, not D3B)	14 May 1938	transfer freehold to Grace Keys, wife of William David Keys, farmer
704/184	19 Oct 1938	(title issued) to Grace Keys, wife of William David Keys, farmer
	29 Aug 1939	transfer to Christian Alexander Rasmussen and Rudolf Rasmussen, both of Paeroa, farmers
	current	Karl Christian Rasmussen, Paul Erhart Rasmussen and Karen Rigmore Rasmussen

Table 9. Blk XVI, Waihou SD, sec 18

See previous		owned by the Crown
811/12	1 Jul 1943	lease to Frank Barratt, Mill Road Paeroa, farmer
5C/1413	15 Dec 1971	lease to Eric Charles Olsen, farmer Paeroa
20C/741	1 Jul 1976	transfer to Eric Charles Olsen, farmer Paeroa
42C/409	3 Nov 1988	Kahikatea Meadows (Paeroa) Ltd

Table 10. Blk XVI, Waihou SD, sec 43 & 8

See previous		owned by the Crown
20D/788		Not viewed
30D/20	16 Nov 1983	transfer to Morrinsville-Thames Valley Co-op Dairy Co
	3 Nov 1988	transfer to Christian Alexander Rasmussen, farmer Paeroa, and Karen Rigmore Rasmassen, his wife
42C/409	3 Nov 1988	Kahikatea Meadows (Paeroa) Ltd

Table 11. Pt Waiwhau (Waiwhau North & Middle inland side of stopbank, includes some of Opita settlements & Waiwhau Pa)

3D/601	24 Mar 1988	acquired by the Crown for River Control Purposes
H803602	18 Mar 1992	title issued to Waikato Regional Council
50A/368 (inland)	18 Mar 1992	transfer to Karl Christian Rasmussen and Paul Erhardt Rasmussen
572/97 (riverside & pa)	?date	transfer to Hans Karl Flesch-Golanz and Mere Lorraine Flesch-Golanz

Table 12. Waiwhau South

183/57	1905	title issued to Haora Tareranui & 2 others
	31/10/1938	transfer to Grace Keys and Henry Robertson Bush
704/79	31/10/1938	transfer to?Karl Christian Rasmussen and Paul Erhardt Rasmussen
	current	Karen Rigmore Rasmussen, Karl Christian Rasmussen, Paul Erhardt Rasmussen

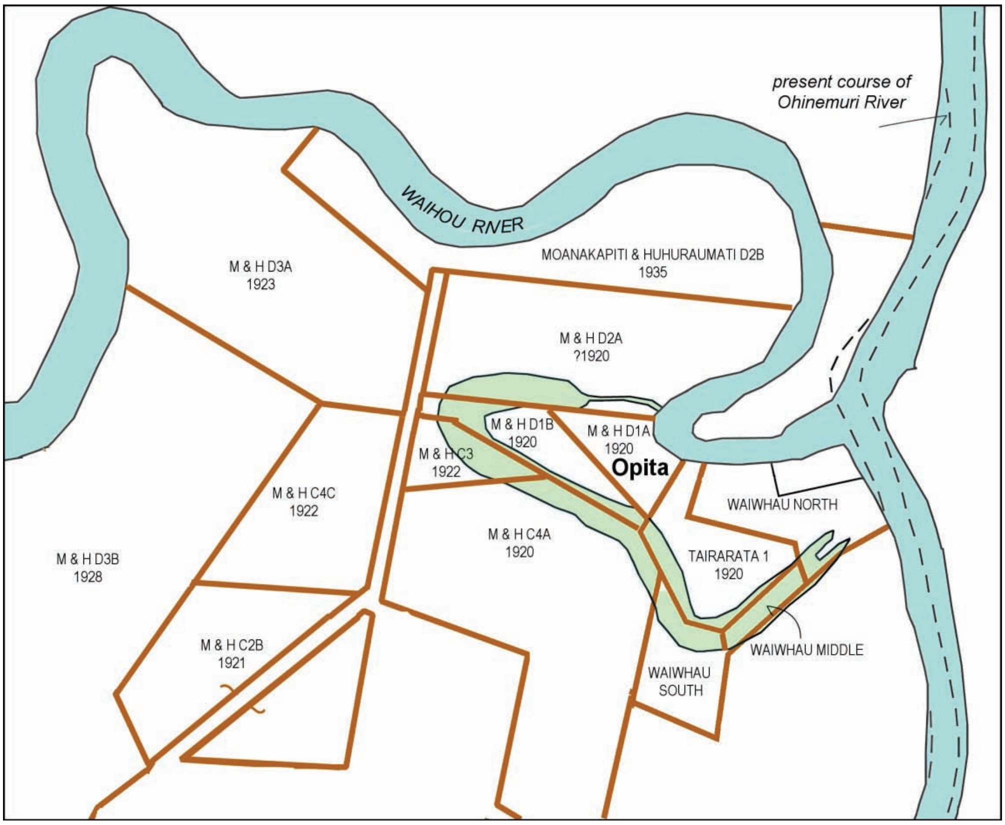


Figure 1. Map showing location of the different land blocks adjacent to Opita, c. 1920, with the dates showing when they were originally purchased by pakeha farmers, flowing rivers in blue and lagoon in green.

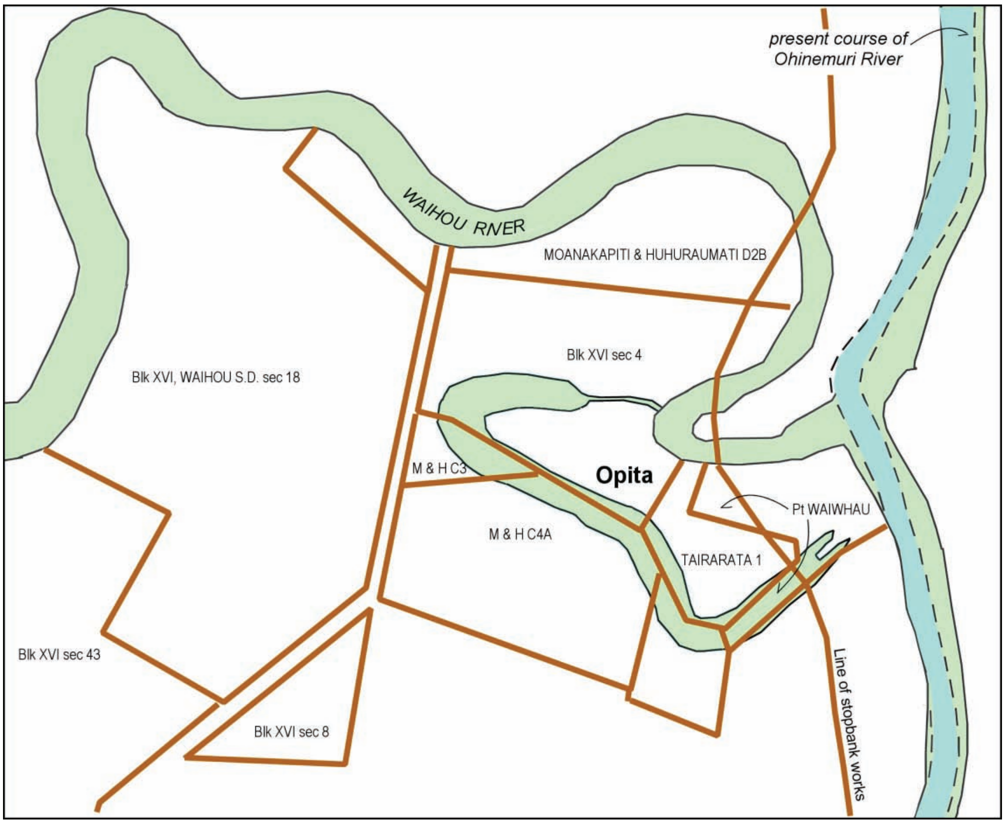


Figure 2. Map showing current land blocks adjacent to Opita, established mainly after 1940, and the boundary of the 1984 stopbank works.

Landowners

Henry Robertson Bush

Henry Bush was born in 1878 and died in 1947, aged 69 (BDM Online). Bush was highly involved in the public affairs of Te Aroha, Paeroa and Thames. He first appears in PapersPast as a councillor in Paeroa Borough Council in 1917 (*Ohinemuri Gazette* 26/1/1917). He was secretary of Hauraki A & P Show, and treasurer of Paeroa Tennis Club (*Ohinemuri Gazette* 26/2/1917, 13/9/1918). In 1918 he was on a committee assisting Maori influenza cases at a special hospital set up in Te Aroha to take the large number of infectious cases and applied to be on the Thames Hospital Board in 1919 (*Ohinemuri Gazette* 20/11/1918). That year he was also the retuning officer for the poll on National Prohibition (*Ohinemuri Gazette* 11/4/1919).

From 1902-1918 he was the clerk of the court, at the Wardens and Magistrates Court in Te Aroha, when he was promoted to clerk of the Court in Thames (*Ohinemuri Gazette* 11/12/1918). It was in these roles that he oversaw freehold land titles being issued, and it appears that he decided to purchase land from the Maori owners. Bush was 42 years old or more when he began to purchase farm lots near Opita and was listed as a clerk or public servant in the title deeds (see above). In most cases, he purchased them with Grace Keys or William Keys, or soon afterwards sold them to one of them, and it seems likely that the Keys farmed the land.

Grace and William David Keys

Grace Keys may have been the daughter of Henry Bush, but no evidence of a birth under that name occurs in New Zealand records, nor is there a record of her marriage. She died in 1968 aged 66 (bdmhistoricalrecords.dia.govt.nz).

William Keys was born in 1890 (BDM Online) and died in 1955 aged 65 and has a military grave in Waikumete Cemetery (Auckland Council). Keys also appears in the newspaper a number of times. He enlisted in 1916 (*Ohinemuri Gazette* 8/11/1916), and was a trooper in the 1st NZEF NZ Mounted Rifles during WWI. In 1920, he purchased land near Opita, when his occupation was farmer (see titles above). In the same year he represented the settlers affected in the 'flood expansion area' to the Minister of Public Works, the Hon J.G. Coates (*Ohinemuri Gazette* 14/6/1920). At this time the stopbanks were constructed to save flooding in Paeroa, but allowed farmland to be inundated. In 1920 he also agreed to pay $^{1}/_{3}$ of the costs for roading to his farm, and advertised that he had 20 acres he wished to be ploughed (*Ohinemuri Gazette* 31/3/1920, 12/7/1920). He transferred ownership of most of his farm blocks to the Crown in the late 1920s, but may have continued farming until the late 1930s when he and his wife sold the remaining parcels to the Rasmussen family, at which point he may have changed occupation as his cemetery record states he was a building contractor.

Rudolf Rasmussen and family

Rudolf Rasmussen, of Danish descent, had a dairy farm on the south side of Mill Road with Jakob Bertlesea from 1898, but they did not fare very well, as the flood of 1907 inundated the land with a bed of silt and they had to sell up. In 1907 they had a clearance sale,[1] at which they said they were going to be giving up dairying and wanted to sell the whole of their live and dead stock, plus wagons and other farm machinery (*Ohinemuri Gazette* 9/9/1907). In the Supreme Court in Hamilton, they claimed £1550 damages against G. Cooper owner of the property, who they claimed had interfered with the sluice gate on a drain, which allowed the silt to be deposited on the land up to two feet deep in places (*Ohinemuri Gazette* 16/9/1910). The jury later awarded them £656 (*Ohinemuri Gazette*

1 The list of equipment and stock gives a good idea of what was on an average farm at the time.

26/9/1910). Cooper took the matter to Appeal, and the majority on the bench held that there was no obligation on Cooper to have kept the flood-gate in repair, and therefore he was not liable for damages (*Ohinemuri Gazette* 28/7/1911).

Bertlesea was again before the court for assaulting Robert Thorp, apparently over a disagreement about whiskey tampering. At this time Bertlesea and Rasmussen were dismantling a flax mill along Mill Road, which is where the incident took place (*Ohinemuri Gazette* 2/10/1914). The pair again came before the court in relation to liquor offences in 1914 (*Ohinemuri Gazette* 20/5/1914).

Later Rasmussen and Bertlesea operated the Central Boardinghouse in Paeroa, and came to the attention of the police in 1916 when they were caught selling whiskey without a licence (*Ohinemuri Gazette* 26/1/1916). In this year Rasmussen married Elizabeth Lilian Wood.

Rasmussen bought land at Tairarata in 1920 and over the next two decades purchased most of the land in the vicinity of Opita. In 1921, he applied for a building permit (*Ohinemuri Gazette* 15/8/1921). It is not certain if this was for a farmhouse, but by this time he and Lilian had two sons: Alexander and Rudolf (Vulgar 2002). Later, Alex married Karen, also of Danish descent, and they had three children, Karl, Paul and Helen. Alex died in 1986 and Karl and Paul took over the running of the farm. Rudolf jnr. married Doreen, and had one son Rudolf and three daughters.

Robert and Winifred Gerrand

The road to the land where the Opita sites are located is called Gerrand Road after this family who moved there in 1916. The description as described by Grey Vulgar (2002) of the environment in the early farming period shows how difficult life must have been for all the farmers in the area.

> Access to the farm from Mill Road was not possible during the winter months as Gerrand Road, at this time, was a dirt track" [one of the first actions of David Keys was to pay for roading to his farm]. "The only access to the farm was by boat across the Waihou River" [it is notable that the Tairarata Block has a narrow access to the river]. All house and farm supplies were brought in by boat. The children crossed the river to go to school but this also meant that they had to walk through rough, sodden paddocks to get to the river, a distance of at least a mile. Their home was built one point five metres above the ground to avoid flooding. The house was unlined inside. They milked fifty cows in a dirt floor cow shed. They made fascines using cabbage trees so that the cows were at least out of the mud whilst they were milked" (Vulgar 2002).

References

PapersPast. http://paperspast.natlib.govt.nz/cgi-bin/paperspast

BDM Online. Birth, Death and Marriage Historical Records. Department of Internal Affairs. https://bdmhistoricalrecords.dia.govt.nz/Home

Vulgar, G., 2002. Mill Road, Paeroa, Revisited. Ohinemuri Regional History, Journal 46, Sept 2002. http://www.ohinemuri.org.nz/journal/journal_index.htm

Titles

SAPR 68/30, SAPR 180/22, SAPR 674/266, SA 366/175, SAPR 322/270, SAPR 303/55, SAPR 306/218, SA 182/133, SA 704/184, SAPR 364/201, SAPR 139/16, SA 811/12, SA 5C/1413, SA 20C/741, SAPR 30D/20, GN H803602, DI 3D/601, SAPR 183/57, SA 704/79
from originals held in Land Information New Zealand, Hamilton Office.

SA 323/282, SA 42C/411, 453587, SA 300/286, SA 683/200, SA 42C/409, SA 50A/368, SA 704/79, SA 572/97 current titles QuickMap database.

Rasmussen

Ohinemuri Gazette, 1907. Sale by Auction. Volume XVII, Issue 2250, 9/9/1907, page 3.
Ohinemuri Gazette, 1910. Claim for Damages. Volume XXI, Issue 2693, 16/9/1910, page 3.
Ohinemuri Gazette, 1910. Heavy Damages. Volume XXI, Issue 2697, 26/9/1910, page 2.
Ohinemuri Gazette, 1911. Ohinemuri River Silt. Volume XXII, Issue 2822, 28/7/1911, page 2.
Ohinemuri Gazette, 1914. No-License in Paeroa. Volume XXV, Issue 3242, 20/5/1914, page 2.
Ohinemuri Gazette, 1914. Charge of Assault. Volume XXV, Issue 3301, 2/10/1914, page 3.
Ohinemuri Gazette, 1916. A Liquor Case. Volume XXVI, Issue 3484, 26/1/1916, page 2.
Ohinemuri Gazette, 1921. The Brick Area. Volume XXXII, Issue 4304, 15/8/1921, page 2.

Bush

Ohinemuri Gazette, 1917. Borough Council. Volume XXVIII, Issue 3724, 26/1/1917, page 2.
Ohinemuri Gazette, 1917. Hauraki A and P Show. Volume XXVIII, Issue 3736, 26/2/1917, page 2.
Ohinemuri Gazette, 1918. Paeroa Tennis Club. Volume XXIX, Issue 3970, 13/9/1918, page 2.
Ohinemuri Gazette, 1918. The Epidemic. Volume XXIX, Issue 3996. 20/11/1918, page 2.
Ohinemuri Gazette, 1918. Welcome and Farewell. Volume XXIX, Issue 4005, 11/12/1918, page 2.
Ohinemuri Gazette, 1919. Voice of the People. Volume XXX, Issue 4054, 11/4/1919, page 2.

Keys

Auckland Council, 1911. Waikumete Cemetery. www.waitakere.govet.nz/cnlser/cemeterysearch/default.aspx
Ohinemuri Gazette, 1916. Men for the Front. Volume XXVII, Issue 3693, 8/11/1916, page 2.
Ohinemuri Gazette, 1920. Ohinemuri County Council. Volume XXXI, Issue 4099, 31/3/1920, page 3.
Ohinemuri Gazette, 1920. Public Works. Volume XXXI, Issue 4130, 14/6/1920, page 2.
Ohinemuri Gazette, 1920. Advertisements, column 1. Volume XXXI, Issue 4142, 12/7/1920, page 3.