W GUMBLEY LTD.
ARCHAEOLOGISTS

Warren Gumbley
Principal/Director

PO Box 7108, Hamilton East, Hamilton 3247
cell s 9(2)(a) landlines 9(2)(a)
emails 9(2)(a)

Assessment of archaeological values for S15/573 at Pencarrow and Duncan Road, Tamahere.

For Waikato Thoroughbred Racing Ltd

By Dr Warren Gumbley

April 2026

Introduction

Waikato Thoroughbred Racing Ltd (WTRL) intend to develop of a suite of parcels bordered by Pencarrow Road, Hooker Road, and the Waikato Expressway (SH1), and Duncan Road (Section 49 SO 457609, Lot 1 DP 471383, Lot 2 DP 471383, Lot 2 DP 16925, Section 2 SO 547526) totalling approximately 164 ha.

The purpose of the Project is to create a unique, world-class greenfield racing hub designed for horse training, racing and other equine-related activities, while bringing the expertise and strength of the local racing fraternity together in a centralised location.

This enables the local racing industry to be more streamlined, competitive, sustainable and future-focused while bringing potential international investment and creating a 'destination' for horse racing in New Zealand, also increasing tourism opportunities for the wider region.

A key driver behind the proposed greenfield equine hub and racecourses is enabling the consolidation of four separate racecourse facilities (Te Rapa, Waipa and Cambridge thoroughbred courses, and the Cambridge harness track).

These facilities duplicate assets and resources and, given their current condition, require significant levels of upgrades and investment to provide fit-for-purpose facilities that meet the higher standards of the modern-day racecourse experience. The retirement of these areas also frees up significant tracts of land within existing urban areas for future development, increasing housing supply.

To support the development's financial viability and enhance the site's long-term vibrancy as a racing, entertainment, commercial and community precinct, the proposal includes a range of complementary activities on the remaining land. These include equine support services, rural residential housing, a retirement living community, a village centre and a bloodstock sales precinct

This report reviews the nature of the identified archaeological sites within the project area and assesses their values and the effects of the proposed development on those values. One archaeological site has been identified in the project area: S15/573, a series of four borrow pits and associated Māori-made soils created for the cultivation of kumara and possibly taro.

The Heritage New Zealand Pouhere Taonga Act (HNZPTA) provides protection for all archaeological sites that meet the Act's definition, whether or not they are recorded. The protection and management of sites are managed through the archaeological authority process, administered by HNZPT. It is illegal to destroy or modify archaeological sites without an Authority to do so from HNZPT.

The HNZPTA 2014 (s6) defines an archaeological site as:

> (a) Any place in New Zealand including any building or structure (or part of a building or structure) that:
>
> > (i) was associated with human activity that occurred before 1900 or is the site of the wreck of any vessel where that wreck occurred before 1900; and

(ii) provides, or may provide through investigation by archaeological methods, evidence relating to the history of New Zealand; and

(b) Includes a site for which a declaration is made under Section 43(1) of the Act[1].

Any person who intends to carry out work that may modify or destroy an archaeological site must first obtain an authority from HNZPT. The process applies to sites on land of all tenures, including private, public and designated land.

[1] Such declarations usually pertain to important post-1900 remains with archaeological values.

Background

Landform and soil survey data

The project area sits entirely on the Hinuera Formation, which forms a gently sloping plain from Cambridge to Taupiri. This formation represents the remains of a protracted alluvial process that succeeded the eruption of Taupo 26,0000 years ago and lasted for approximately 10,000 years. During that time, the sediments steadily filled the hill and valley systems of the Waikato to the extent that the Waikato River became a braided river system crisscrossing the developing surface of the formation. The result has been the Horotiu Plain stretching from the mouth of the Karapiro Gorge in the south to the Taupiri Gorge in the north. The surface of this plain is gently undulating (Figures 2 and 3), reflecting the remnant surface left by the ancient braided Waikato River system. The low ridges are remnant levees and have generally well-drained soils of the Horotiu Series, with less well-drained soils of the Bruntwood Series occupying the slopes of the ridges. In the low-lying areas, often remnant swales, the soils are generally poorly drained and belong to a range of soil series, particularly silt and clay loams such as Te Kowhai Series[2], or peat soils[3].

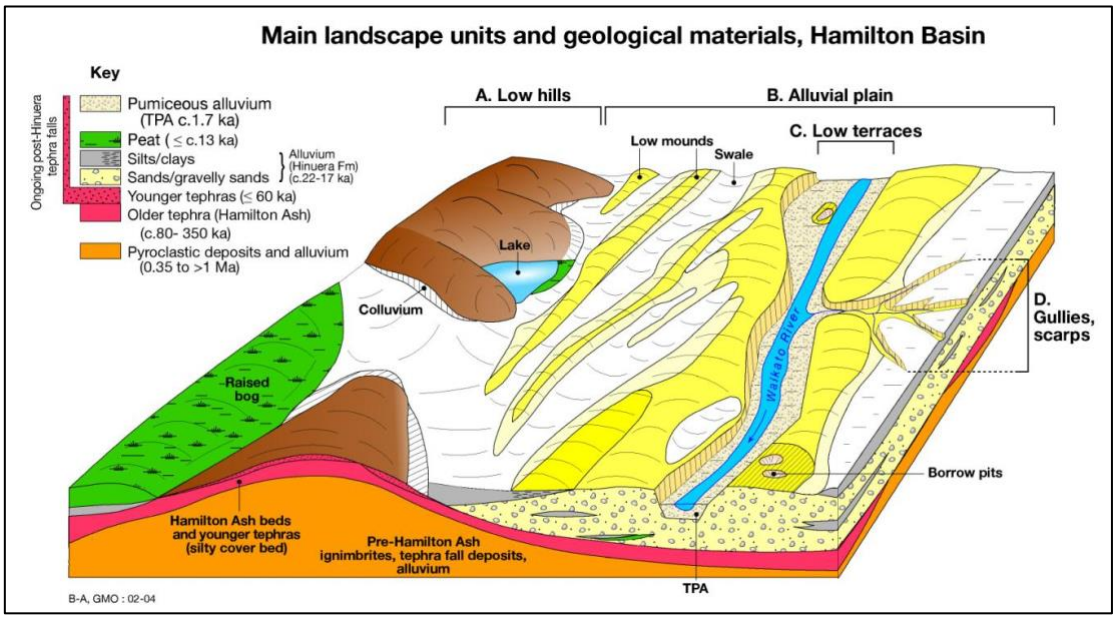


Figure 1. Block diagram showing the principal landform units of the Hamilton Basin (Lowe 2010:4).

[2] Also Puketaha and Eureka Series soils.

[3] Te Rapa, Kaipaki and Rukuhia Series peat soils.

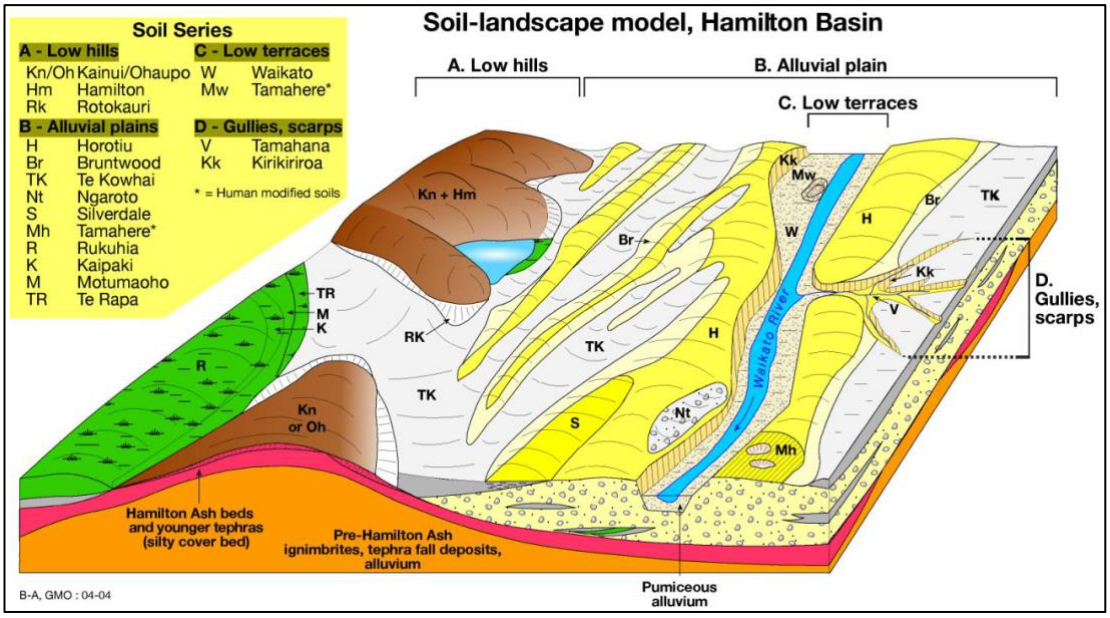


Figure 2. Block diagram showing the soils found in the Hamilton Basin and their relationship to the landform units (Lowe 2010:5). Note Mh refers to Tamahere loam (Māori-made soils).

From the 1950s until the early 1980s, the Soil Bureau of the DSIR conducted an inventory survey that characterised the soil on the plain, which was published in a 1984 bulletin (McLeod 1984) with an accompanying soil map. The soil survey data are generally accurate but relatively coarse, capturing the dominant soil in an area while ignoring fine-scale local variations. Positional data for individual soil units are not precise because they are derived from digitised large-scale maps compiled by the Soil Bureau in the early 1980s, based on data accumulated since the 1950s.

The soils recorded within the area of concern are typical of the soils found across the Horotiu Plain. The dominant soil classes are the Horotiu Series and Te Kowhai Series soils, with Bruntwood Series also present, along with a small area of the Kainui hill soil series. A fifth soil Series is also identified. This is an area of Tamahere Series soils. Tamahere soils are classified in the New Zealand Soil Classification schema as an Artifact Fill Anthropic Soil. In other words, Tamahere Series soils are anthropogenic, resulting from the addition of transported coarse alluvium to existing or parent soils. In most cases, on the Hinuera Formation, the parent soils are Horitiu soils, with Bruntwood soils sometimes modified in this way, and, in rare cases, also Te Kowhai soils. Tamahere soils are associated with the pre-European Māori practice of horticulture, focused principally on the cultivation of kūmara and secondarily taro. As such, they are markers of the presence of archaeological deposits.

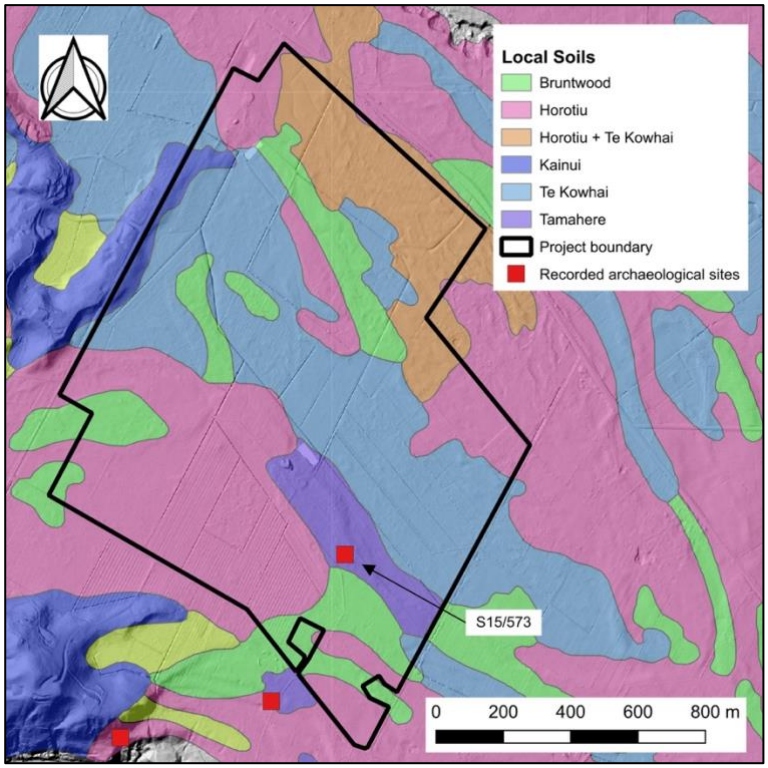


Figure 3. Map showing the Soil Bureau survey data for the project area.

Historic Survey Plans

The earliest survey plan that refers to the area of concern is SO 96, which was compiled to show the allocation of land parcels to members of the Waikato Militia. The copy available today is a copy made at some time after 1879[4]. The plan shows a number of lots annotated with the names of the soldiers to which each was allocated. Aside from the boundary or parcels, roads, the river, and the names of the beneficiaries, little information is present on the plan.

[4] It is likley the copy was made as part of the subdivision that is shown in DP 127,

Figure 4. A copy of one of the three maps forming SO 96. The area of concern is highlighted.

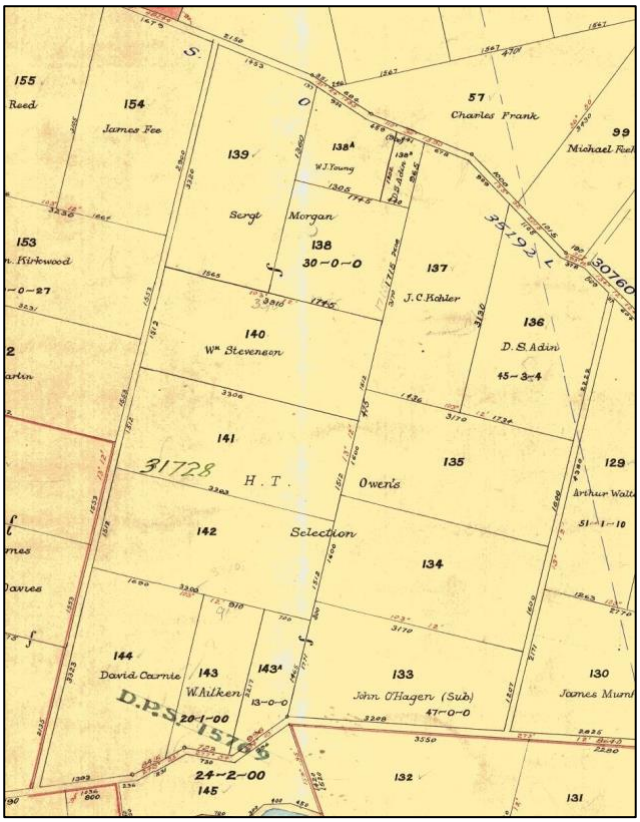


Figure 5. Part of SO 96 showing the area of concern.

The survey plan DP 127 is dated to 1880 and refers to the subdivision of sections 135, 137, 138, 138A, 138B, 139, 140, 141, 153, and 154. The plan shows that the subdivision spanned both sides of Pencarrow Road and was carried out for Mr Paton Esquire, the land owner. Details on the plan show an array of ditch and bank fences, as well as the extent of "Titree" and cleared areas. To the north of Pencarrow Road, the plan shows a tree plantation (possibly an orchard) and two buildings. No buildings are shown on the southern side of Pencarrow Road within the area of concern. It seems likely that the buildings shown within the subdivision, on the north side of the road, represent the dwelling and outbuildings of the Paton farm.

Based on evidence from recent aerial photography and LiDAR data, many of the ditches shown on DP 127 appear to remain.

No later survey plans contain any helpful information.

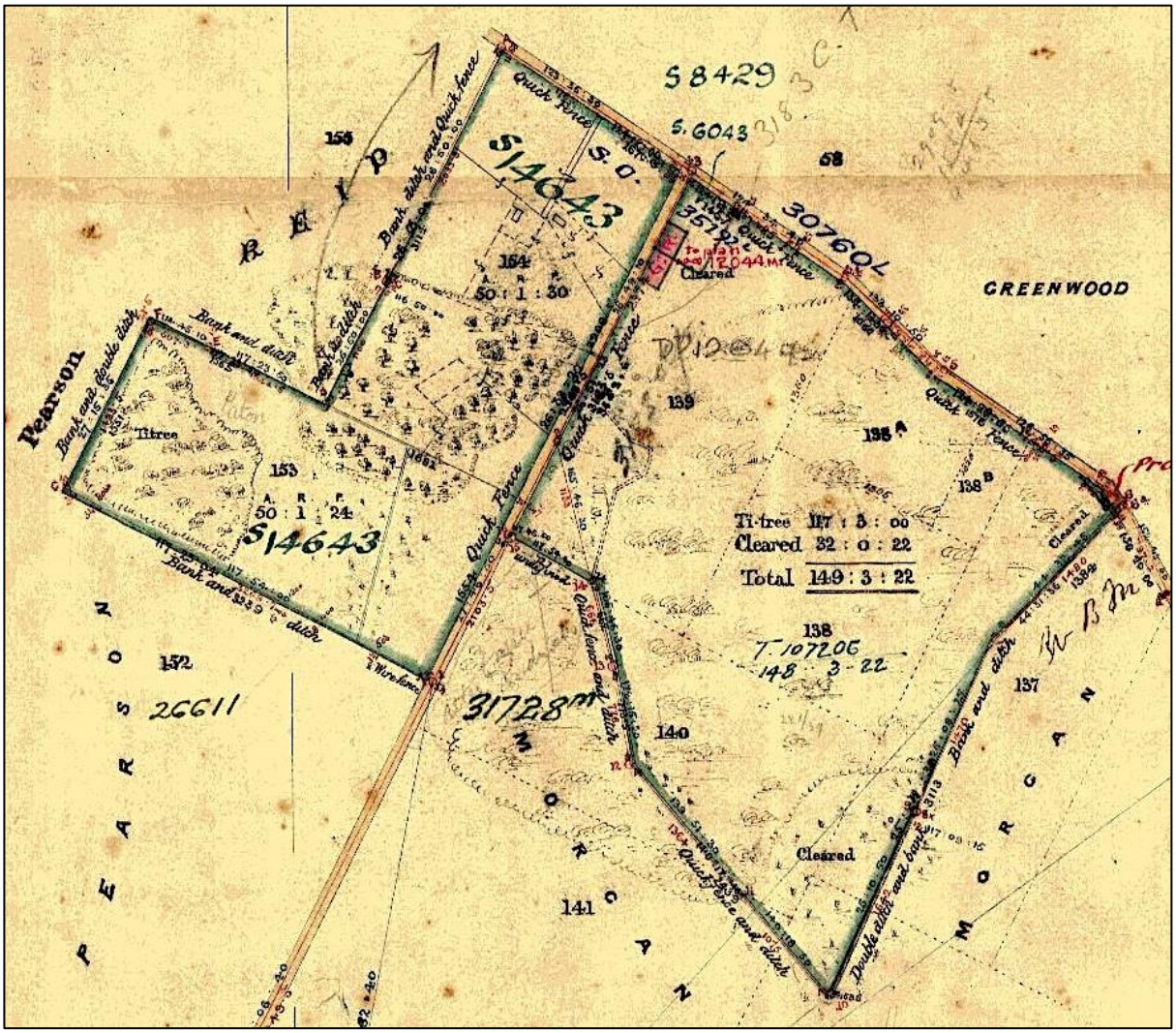


Figure 6. Part of the survey plan DP 127.

Recorded Archaeological Sites

One archaeological site is recorded in the national archaeological site recording database[5].

S15/573 was recorded in 2012 following a review of aerial photography from the 1940s in the area surrounding the Cambridge Section of the Waikato Expressway. The site has never been inspected.

The site description is brief:

> "4 borrow pits in an area of 130 x 40 m, visible on aerial photo SN266/834/56. Aerial photo dates from 1943. The site has not been visited, and its current condition has not been ascertained."

As the record indicates, no on-site archaeological survey had occurred in relation to this site, nor anywhere else within the area of concern.

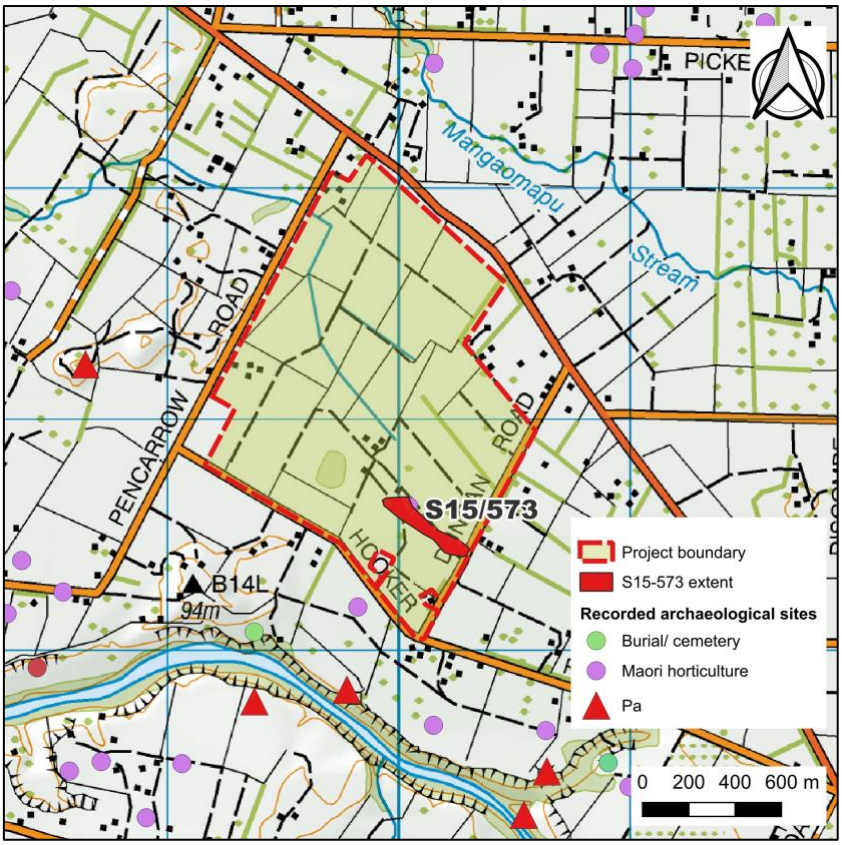


Figure 7. Map showing the location of S15/573, with surrounding recorded archaeological sites also shown.

[5] NZ Archaeological Site Recording Scheme.

Historical Aerial Photography

Historical aerial photography often provides valuable information prior to post-World War II agricultural intensification and urban expansion. The earliest aerial photographs available that refer to the project area are the SN266 series flown in mid-1943. This is the series referred to in the archaeological site record S15/573. Two runs cover the project area 833 and 834. Of these, SN266/833/55 and SN266/834/56 cover the project area. In these three sets of buildings, each representing a farmstead with a house and outbuildings, can be distinguished.

Both images display the area of S15/573, with SN266/834/56 appearing clearer. Altogether, six depressions characteristic of borrow pits are visible in the photograph. These can be seen on a low ridge just southwest of one of the clusters of farm buildings. Five of the pits are distinctly visible, while the sixth is less clear.

Figure 8. Part of the georectified copy of SN266/834/56 showing the locations of the probable borrow pits (indicated by arrows). The red line indicates the project area boundary, with Hooker Road visible in the bottom left of the image and Duncan Road in the bottom right.

Measured from a georectified copy of SN266/834/56, these depressions have dimensions of approximately:

- 30 m x 15 m,
- 15 m x 15m,
- 10 m x 10 m,
- 10 x 10 m,
- 20 m x 15 m,
- 15 m x 10m.

These represent fairly typical sizes for borrow pits.

LiDAR data

Two LiDAR survey provide data referring to the project area. The earlier is from 2007, and the more recent is from 2021. The hillshade models produced from both sets of data show a number of features relating to modern agricultural practices, but apart from the borrow pits identified in S15/575, nothing that may be interpreted as archaeological is visible.

There is little difference between the two data sets except that the largest of the probable borrow pits is obscured in the 2021 data, which suggests it has either been filled or obscured by overgrown vegetation. The former is more likely. The hillshade models indicate there may be seven depressions rather than six.

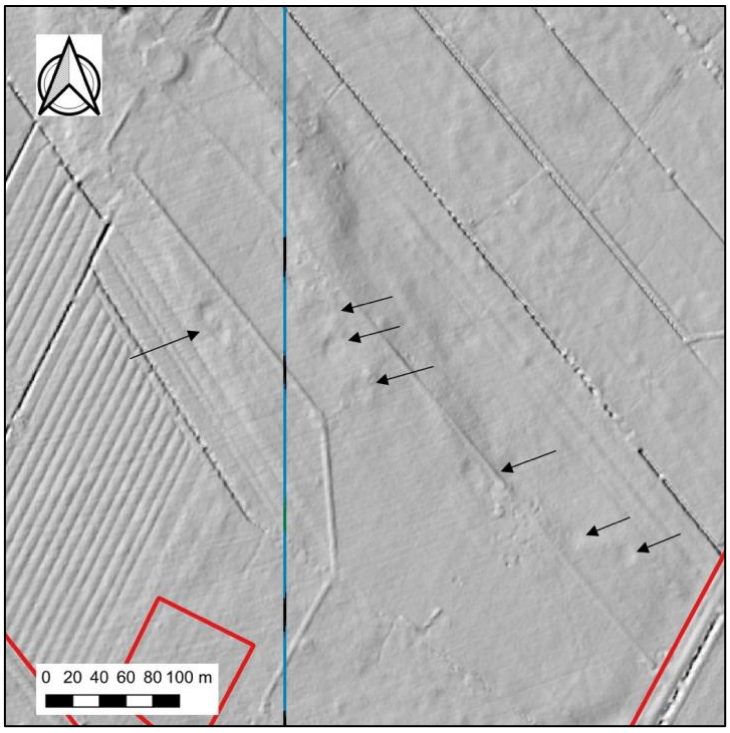


Figure 9. Hillshade model derived from 2007 LiDAR survey data showing the locations of probable borrow pits (indicated by arrows). The red line indicates the edge of the project area. The vertical line is an artefact of the processing of the LiDAR data.

Site Inspection

Two site visits were undertaken. The first occurred on 5 October 2025 and the second on 16 December 2025. The first site visit was part of a fact-finding phase to evaluate the potential for archaeology across the project area and to determine the validity of an archaeological site (S15/573) recorded there. The second site gathered data to better understand the extent and condition of S15/573.

Site visit 5 October 2025

This visit included both the Duncan (Section 49 SO 457609, Lot 1 DP 471383) and Montgomerie (Section 2 SO 547526) farms, comprising approximately 80% of the project area.

Apart from the recorded archaeological site S15/573 (located on the Montgomerie farm), no other archaeological evidence was found during my site inspections. In conversations with both Tim Montgomerie and Roger Duncan, neither was aware of any archaeological remains on their farms apart from S15/573.

Before the inspection of S15/573 began, Tim Montgomerie observed that his father had filled each of them to varying extents. This aligns with the images I reviewed, which show the pits becoming progressively less visible. All potential pits were inspected, though ground visibility varied as some paddocks had moderately long grass. Three pits could be identified as shallow circular depressions with signs of recent filling in each. Of the other four, two had been backfilled to be flush with the surrounding ground level. The two southernmost potential pits could not be recognised.

A series of soil auger samples identified Māori-made soils in some areas, indicating that they are present but discontinuous in the vicinity of the identified borrow pits. The evidence from the soil auger is that the Māori-made soils have been disturbed by modern cultivation.

Site visit 16 December 2025

During the second site visit, a further 51 soil auger samples were examined to better define the extent and state of the archaeological deposits. During this visit, it had been intended to excavate some spade-dug test pits to examine the soil profile, but the onset of heavy rain prevented this.

The combined data show that the parent soil is mostly Bruntwood loam, with smaller areas of Horotiu loam at the highest elevations. Soils modified for Māori horticulture were found on both soil types. The Bruntwood loams include relatively coarse sand, which made it difficult to be precise and confident in interpreting the auger samples in places.

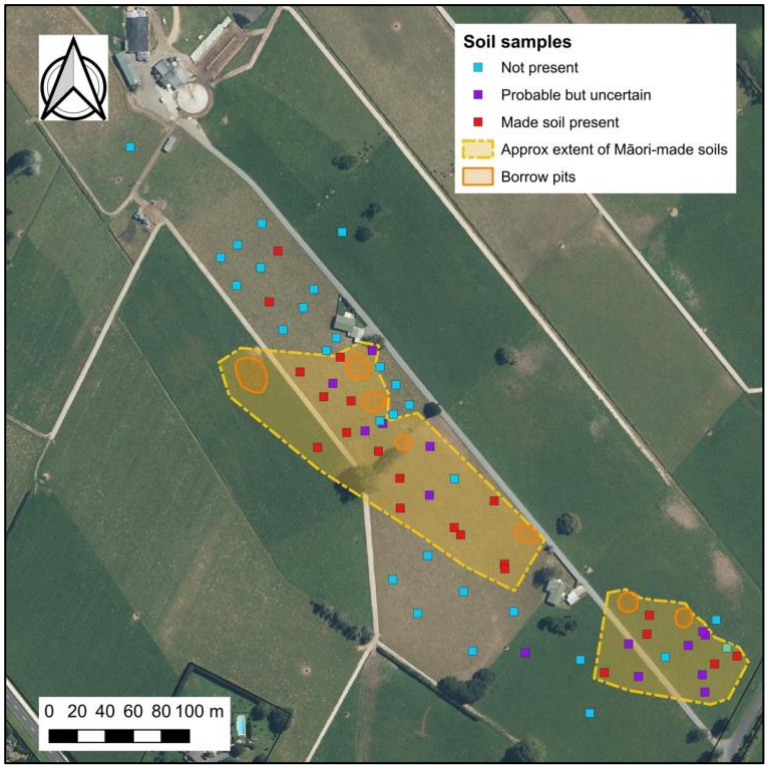


Figure 10. Map showing the locations of borrow pits and soil auger sample sites in relation to S15/573. The borrow pit extents are based on a 1942 aerial photograph (SN266/834/56) and 2021 LiDAR data.

Results and interpretation

Both desktop and on-site investigations indicate that S15/573 is the only archaeological site located within the project area.

S15/573 is a Māori horticultural site that belongs to the Waikato Horticultural Complex. A detailed description of this complex is provided in Appendix Two of this report.

The Waikato Horticultural Complex comprises a series of remnant sites where a distinct form of Māori horticulture has been practised since the 16th century. The horticultural system was a particular adaptation of the tropical horticultural system brought with Polynesians to New Zealand. The system emphasises the cultivation of kūmara and, secondarily, taro. The agronomy required the extraction of sand and gravel from the underlying alluvium to create growing environments that enhanced yield, facilitated harvesting, minimised tuber damage, and encouraged shorter, fatter tubers that stored well. Gardens were planted in areas where the forest had recently been cleared. The sand and gravel were recovered from pits dug into the ground surface, which varied in size but were typically 3-4 m deep. An average pit was approximately 650 m^2, and over 7300 borrow pits have been recorded, resulting in approximately 4,745,000 m^3 of sand and gravel used to make gardens in the Middle Waikato Basin. These gardens cover approximately 4500 to 5000 hectares in total.

The data indicate that there are seven borrow pits associated with two distinct tracts of Māori-made soil, separated by a house and curtilage, suggesting that the two were contiguous in the past. Altogether, and including the areas of the two farm houses that lie within the general

area of the site, the area of Māori-made soils covers approximately 2.3 ha. It is worth noting that the extent of the identified tracts is somewhat smaller than the area described as containing Tamahere loam in the soil bureau data. However, experience has shown that the soil mapping associated with the map "Soils of the Waikato Lowlands" (McLeod 1984) is less precise and more generalised than other survey data from the Waikato, and so inconsistencies such as this are not uncommon.

Two forms of agronomy have been identified within the Waikato Horticultural Complex that involve distinct uses for the quarried material and require differing levels of energy input and time. The soil auger surveys did not detect intact remains of the TAL agronomic system, which is readily identifiable with a soil auger when well preserved. Therefore, the results indicate that either the agronomy is of the bowl-shaped-hollow form of agronomy or that it was of the TAL form but has been damaged by modern cultivation. It should be noted that archaeological investigations at some sites find both agronomies present.

It is also important to note that gardens are associated with crop storage pits and seasonal kāinga (domestic occupation sites) located within or adjacent to the garden areas. Given the site's remoteness from the river and the nearest pā, it would be surprising if these features were absent.

Assessment of Archaeological Values and Effects on those values

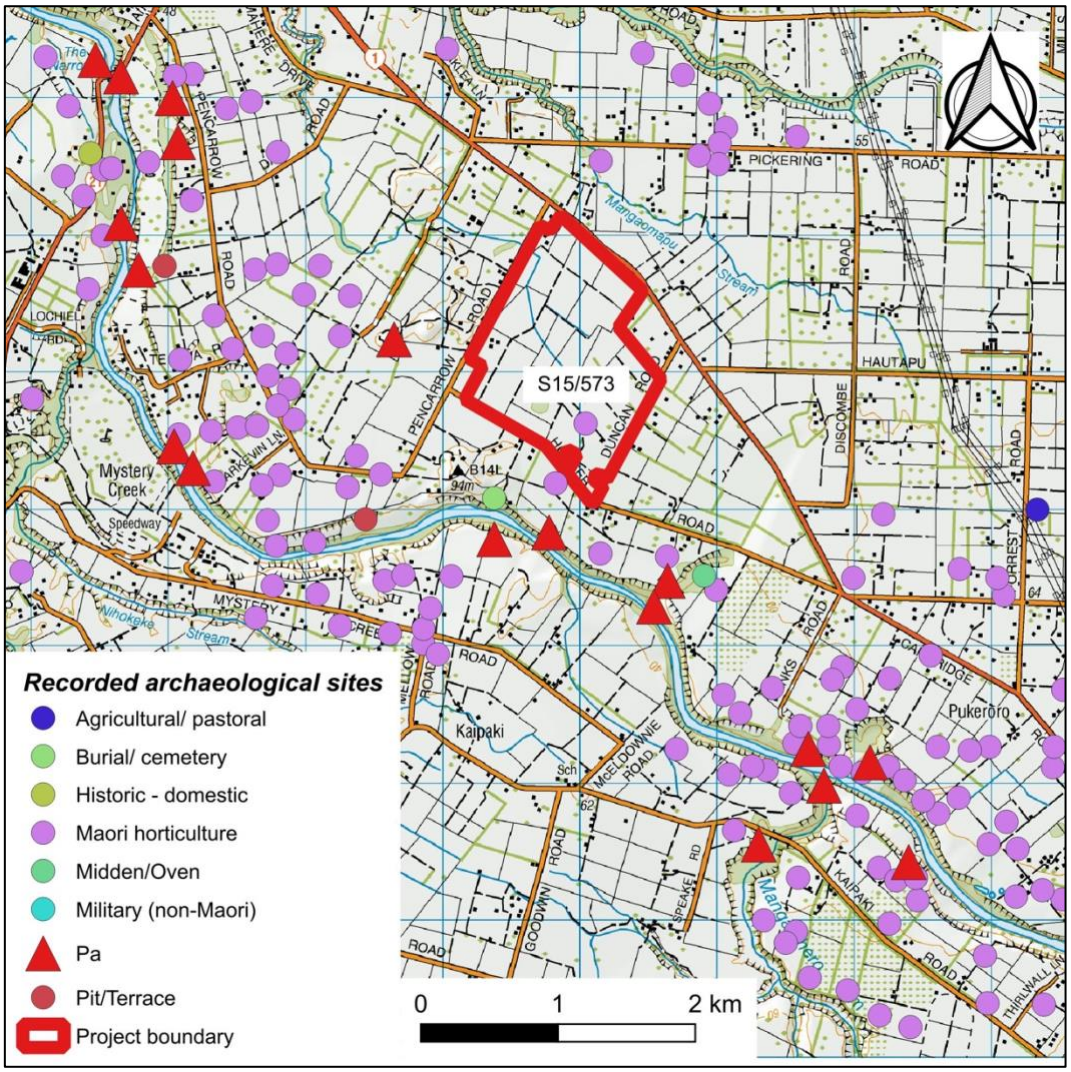


Figure 11. Map showing the distribution of recorded archaeological sites with S15/573 highlighted.

S15/573 is part of an extensive series of horticultural sites that are concentrated along the banks of the Waikato River and its tributaries. Approximately 50 % of these sites lie within 500 m of the river, and 80 % within 1 km of it (Gumbley & Hutchinson 2012). S15/573 is approximately 800 m from the river. Locally, the archaeological landscape is typical of the wider pattern where garden systems are clustered around pā distributed along the riverbank. The landscape within 4 km of the project is dominated by 16 recorded pā and 114 horticultural sites (gardens/māra), including 500-600 borrow pits.

The nearest pā (S15/25) is sited on the river scarp edge 850 m south of S15/573, with another four pā within 1.5 km of the site. Larger concentrations of borrow pits and associated Māori-made soil are concentrated on the plain surface between the top of the riverbank and Hooker Road. The largest part of the horticultural sites (S15/27) in the immediate vicinity is focused around the pā S15/25, and it appears likely that S15/573 is associated with pā S15/25 on the basis of proximity. Locally, S15/573 is conspicuously distant from the river compared to the other local garden sites, which are generally within 500 m of the riverbank.

Little archaeological data is available from the Tamahere area, despite the area's development over the past 30 years. The only radiocarbon-dated sites were those investigated in relation to the Waikato Expressway[6], 6.5 km to the north, with a single radiocarbon date from S15/574 (Trilford 2017), and three assays from S15/794, a pā 2.8 km SE on the riverbank (Simmons 2021). Two of the assays submitted by Simmons for the pā S15/794 suggest occupation on the river either around 1700 AD or after 1800 AD.

The site's preservation status is hard to determine from the available data. The evidence from the soil auger survey leaves this question unresolved. If the agronomic practices at the site followed the TAL form, it strongly suggests that the site has been disturbed and that the stratigraphy has been mixed through modern cultivation. Alternatively, if the bowl-shaped hollow (BSH) form of agronomy was used, it may be better preserved. However, given the site's position on relatively high ground in local terms, it is likely that the area has been ploughed in the past, which would have damaged the Māori-made soil component of the site. Nonetheless, deeper features are likely to have been preserved, including the borrow pits, which have been filled to varying degrees in recent times (Tim Montgomerie, pers. comm.). The relative remoteness of the garden from a pā suggests that one or more kāinga may be connected to the site, and crop storage, such as kumara storage pits, could be an important aspect.

The distribution and density of archaeological sites throughout Tamahere indicate that this area was the focus of substantial occupation, with a lot of the economy devoted to crop cultivation, especially on the eastern side of the river. As noted above, little is known about the area's archaeology. Given the dearth of archaeological information about Tamahere's landscape and its relatively poor preservation after 30-40 years of progressive subdivision and development, this site has the potential to make a useful contribution to addressing that shortfall, even if the Māori-made soil component has been damaged.

S15/573 is an example of a Māori horticultural site belonging to the Waikato Horticultural Complex. While this site type is common within the Middle Waikato Basin, this agricultural system, while sharing attributes with similar horticultural systems in other parts of New Zealand, nonetheless represents a distinct form of adaptation within the Polynesian horticultural tradition to New Zealand's temperate climate. As such, the Waikato Horticultural Complex represents the largest cultivation system in New Zealand and, therefore, the largest horticultural system in Polynesia, along with those on Hawai'i Island. Land development within the Middle Waikato Basin since WW2, especially in the last 40 years, has had a significant impact on the preservation of sites belonging to the Waikato Horticultural Complex, with approximately 66% becoming significantly damaged or destroyed since the 1940s.

[6] S15/248 and S15/487; see Keith 2022.

Effects on Archaeological Values

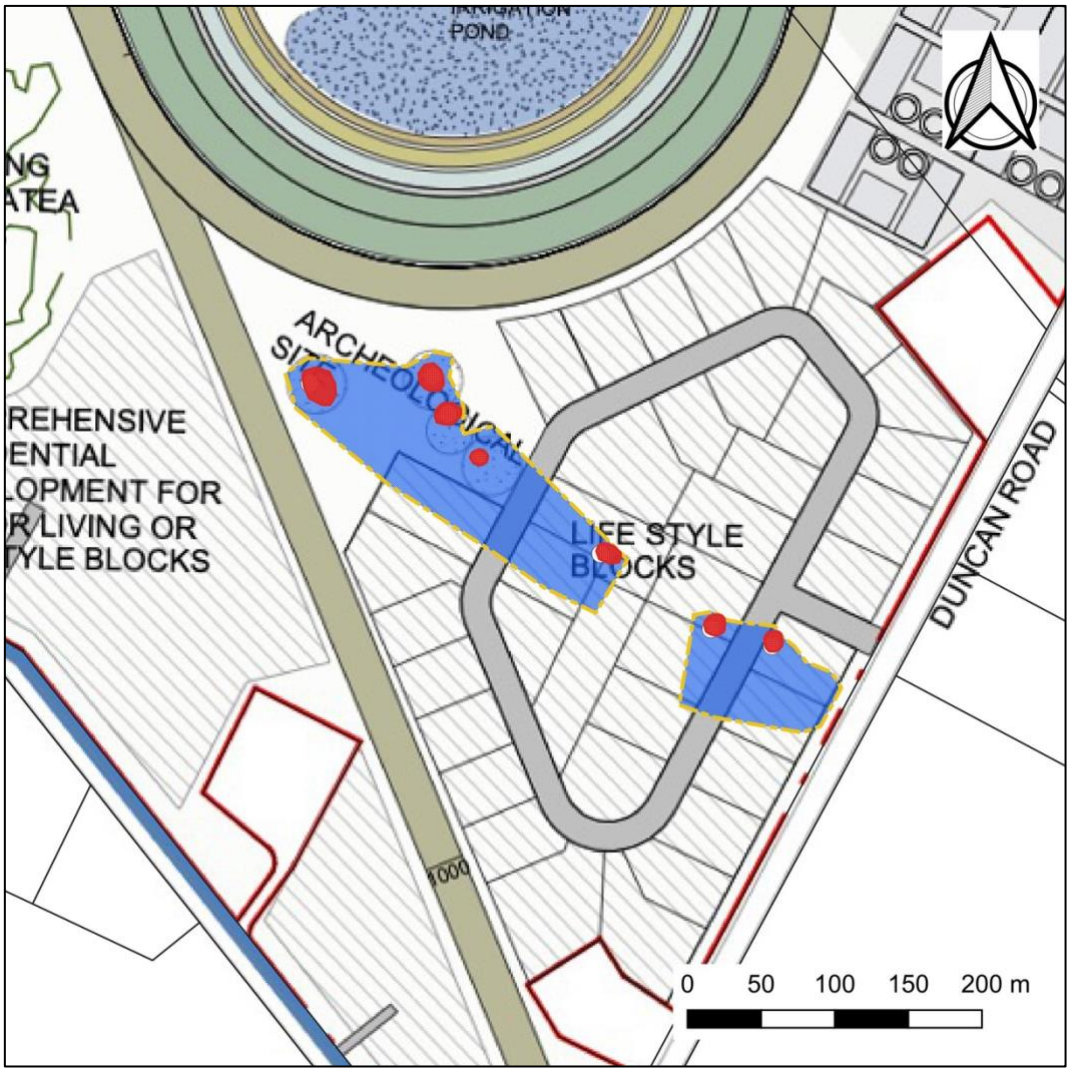


Figure 12. Overlay of the estimated extent of the S15/573 onto part of the Master Plan dated 24/2/2026. The Māori-made soil is shown as blue polygons, and the location of borrow pits is shown in red.

The current proposal will directly affect the southern part of the site. The estimated extent of the Māori-made soils is 2.2 ha (based on auger survey data), with 1.6 ha in the northern segment and 0.6 ha in the southern segment, and the possibility that the two areas were contiguous across the area of the farm-workers' house. The southern part of the site will be affected by the development of the lifestyle residential sections, along with 0.7 ha of the northern segment. While these sections are moderately large lots (less than 0.5 ha), they will have extensive effects on the archaeological deposits, cumulative over time. These cumulative effects will effectively result in the effective destruction of that part of the site from an archaeological perspective.

The northern part of S15/573 will be unaffected by the proposed development, and it is intended to protect that area (0.9 ha) through a covenant that will preserve its archaeological deposits.

Conclusions

S15/573 is a Māori horticultural site typical of the Waikato Horticultural Complex. Sites of this type are examples of the technical adaptation of a tropical horticultural system, including plants, to the temperate environment of New Zealand, specifically the Waikato Basin. S15/573 has suffered damage from farming practice over the years, such that the Māori-made soils have been disturbed and the borrow pits filled to varying degrees. While the site's archaeological deposits are not well preserved, it can furnish information on the agronomic practices employed as part of the Waikato Horticultural Complex, complementing and building on information from other similar sites in the Waikato. Sites of the Waikato Horticultural Complex are suffering attrition due to ongoing urban and rural development along the Waikato River between Karapiro and Taupiri. Preservation of part of S15/573 after development will provide an amenity space where the technical development these sites represent may be recognised and interpreted. Overall the effects of the proposal on S15/573 are acceptable.

Borrow pits represent the most visible element of sites belonging to the Waikato Horticultural Complex, and where sites such as these are preserved, they form an important visual link for interpreting the place. The borrow pits at this site have all been filled, so they are now visually indistinct or no longer visible. Consideration should be given to partially re-excavating the recent fill to enhance the visibility of the pits. However, care should be taken to preserve the underlying archaeological layers.

Recommendations

1. Site S15/573 is an archaeological site; therefore, an Authority under The Heritage New Zealand Pouhere Taonga Act 2014 is required before any development affecting S15/573 can begin.
2. The unaffected part of S15/573 should be safeguarded by a covenant that includes the surveyed extent of the area to be protected and management clauses to ensure the site's preservation in perpetuity. Covenants are a common mechanism to protect archaeological sites.
3. It is important to determine the extent of Māori-made soils and related archaeological deposits in the area to be covenanted for effective management. Therefore, adequate investigation must be undertaken to determine this. This information should be documented on a survey plan and filed with the NZ Archaeological Association site file S15/573.
4. An archaeological management plan should be implemented to oversee the archaeological site during development (Archaeological Management Plan: S15/573 Duncan Road, Pukeroro, Waikato, March 2026). The archaeological management plan may be revised as necessary with the consent of Heritage New Zealand Pouhere Taonga. Compliance with the archaeological management plan, including the

incidental finds protocol, will ensure that archaeological features will be recognised and preserved where identified for preservation.

5. An archaeological investigation of the section of S15/573 affected by residential development must be conducted to recover archaeological information that would otherwise be lost.
6. Archaeological investigation shall be directed by an Archaeological Research Strategy (Archaeological Research and Mitigation Strategy: S15/573, Duncan Road, Pukeroro, Waikato, March 2026). The research strategy plan may be revised as needed with the consent of Heritage New Zealand Pouhere Taonga.

References

Gumbley, W. 2021. The Waikato Horticultural Complex: An archaeological reconstruction of a Polynesian horticultural system. Volumes 1 and 2, PhD thesis, The Australian National University.

Gumbley, W., Hutchinson, M. 2013. *Pre-European Maori Garden Sites in Waipa District: An assessment of the state of the resource.* Unpublished report to N.Z. Historic Places Trust.

Simmons, A. 2021. *Final archaeological report Cambridge Cycleway River Ride; Sites 15/762, S15/763, S15/764, Whakanui Stud Farm*. Unpublished report to Heritage New Zealand Pouhere Taonga.

Trilford, T. 2017. *4 Armistead Lane, Tamahere: Archaeological investigations of site S15/574 (HNZPTA authority 2017/45).* Unpublished report to Heritage New Zealand Pouhere Taonga.

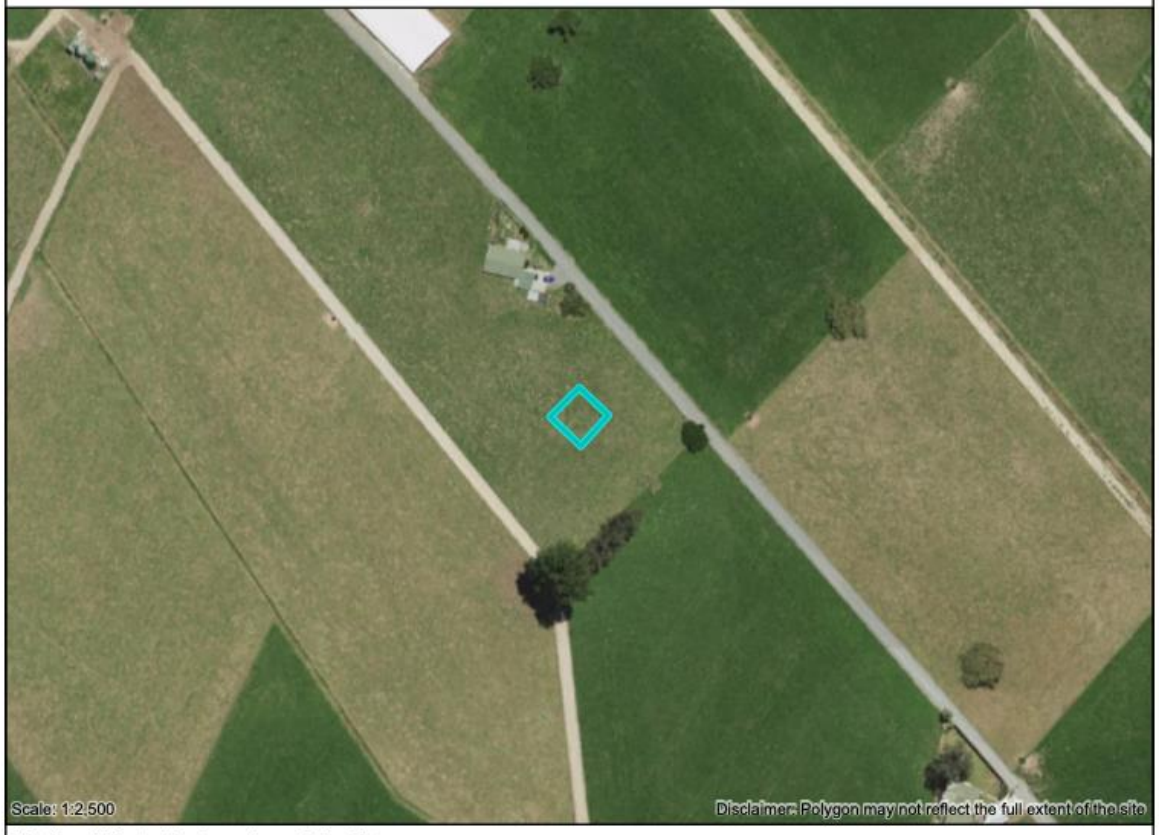
Appendix One: NZAA Site Record S15/573.

NEW ZEALAND ARCHEOLOGICAL ASSOCIATION INCORPORATED

Site Record Form

ARCHSITE archaeological site recording scheme

NZAA Site Number:	S15/573	**Site Coordinates (NZTM)**	
Imperial Site Number:		**Easting:**	1810039
Site Type:	Maori horticulture	**Northing:**	5806626
Site Name(s):		**Source:**	On Screen



Finding Aids to the Location of the Site:

Brief Description:
4 borrow pits in an area of 130 x 40 m, visible on aerial photo SN266/834/56.

Condition of Site when last visited:
No Recent Info

Printed by: WGLT_WarrenGumbley_ArchSite

Date Report Created: 23/09/2025

NEW ZEALAND ARCHEOLOGICAL ASSOCIATION INCORPORATED

Site Periods:

Indigenous pre-1769

Ethnicity:

Maori

Site Features:

Borrow pit

Associated Sites:

Description:

Updated: 26/04/2012 - NZTM E1810039 / N5806626 (On Screen). 4 borrow pits in an area of 130 x 40 m, visible on aerial photo SN266/834/56. Aerial photo dates from 1943. The site has not been visited and its current condition has not been ascertained. Updated by: Campbell, Matthew.

Condition Notes:

Date Report Created: 23/09/2025

Appendix Two: The Waikato Horticultural Complex: Pre-European Māori horticulture sites on the Waikato plains

By Dr Warren Gumbley **2025**

Introduction

In the Waikato, pre-European Māori garden sites are identified by two defining features: the presence of borrow pits and soils heavily modified by the addition of sand and gravel. These two features make these garden sites so visible compared to pre-European Māori gardens in most of the rest of New Zealand. Here, the archaeological evidence is principally found in both the middle and the lower Waikato basins (Selby & Lowe 1992).

Borrow pits are oval or circular depressions, usually between 1 and 6 metres deep (archaeological investigations indicate they were typically 3–5 metres deep originally) and often 100-300 m^2 (Figure 1). However, on the lower river terrace formed on the Taupō Pumice Alluvium, they are usually approximately 2-2.5 m deep.

Figure 1. Borrow pit (one of 34) at site S14/27 located at Tamahere. (photo: D Lowe).

In the Middle Waikato Basin, pre-European Māori garden complexes are concentrated along the Waikato River from Arapuni to Taupiri, in areas on the Horotiu Plain and in some places along the margins of the Waipā River and its tributaries. In the Lower Waikato Basin, this

class of sites remains poorly understood, but it is known to exist on raised levees along the banks of the Waikato River in the area of Huntly-Rangiriri and possibly in some places lower down the river (Grange et al. 1939; Taylor 1958; Clarke 1977; Law 1968).

The total original area of these sites in the Middle Waikato Basin is unknown, but Taylor (1958) proposed an estimate of 5000 acres (2000 hectares) based on the soil survey data available in 1958. My analysis of the available archaeological and soil survey data[7] using GIS, indicates that an estimated area of 4000 or more hectares is probably more accurate (Gumbley 2021). The locations of the gardens are strictly associated with a particular series of soils. I have recorded over 7000 borrow pits in the Waikato with an average volume of approximately 600 cubic metres. Altogether, I estimate that approximately 4.2 million cubic metres of sand and gravel have been applied to gardens in the Middle Waikato Basin.

In the Middle Waikato Basin, these 'made' or 'modified' soils are classified by soil scientists into the Tamahere series, with the two named soil types being 'Tamahere gravelly sand (on Horotiu soils) (TH)[8]' or 'Tamahere gravelly sand (on Waikato soils) (THw)' (Bruce 1979; McLeod 1984). In the New Zealand Soil Classification (NZSC) (Hewitt 1998) the modified garden soils in the Waikato belong to the Artifact Fill Anthropic Soils class.

In addition to modifying the well-drained Waikato series soils (found on low river terraces) and Horotiu loams, the less well-drained Bruntwood silt loams (found on upper river terraces and the Horotiu Plain) were also modified. Uncommonly, the poorly-drained Te Kowhai silt loams are found to have been modified for gardening. This appears to have happened more commonly downriver from Hamilton in areas where gardens were expanded onto adjacent, poorer soils.

The Horotiu and Bruntwood loams (as well as the Te Kowhai soil) have formed on 18,000–20,000-year-old volcanogenic alluvium called the Hinuera Formation. Since the Hinuera alluvium finished accumulating approximately 10,000 years ago, the deposits of this formation have been overlain by a cover (500-700 millimetres) of thin multiple tephra-fall deposits (Figure 2).

The Waikato series soils formed on 1800-year-old course pumiceous alluvium (Taupō Pumice Alluvium), which formed low terraces near the Waikato River (Grange et al., 1939; Taylor, 1958; Lowe, 1988; Singleton, 1988; McCraw, 2002).

Specifically, it was the sand and gravel alluvium substrate from the Hinuera and Taupō Pumice Formations that was quarried from the borrow pits and applied to the upper soil horizon (Figure 2).

[7] It must be noted that the soil survey data is incomplete and does not include areas where borrow pits have been identified south of Cambridge and along the banks of the Waikato River above Cambridge.

[8] Also sometimes annotated as Mh and Mw respectively.

Māori-made soils

Traditionally, soil scientists believed, from the 1920s, that the sand and gravel were applied as mulch or were well-mixed into the topsoil. This, along with a longer-standing narrative that the addition of sand and gravel was added to improve the drainage of "heavy' soils, appears to have led to a series of misunderstandings about the nature of this phenomenon. To date, two variants have been found, each representing a different but related agronomic process. The archaeological remains of these are called Bowl-Shaped Hollows (BSHs) and Transported Alluvium Layer (TAL).

Bowl-shaped hollows

In the late 1990s, during an archaeological investigation in Hamilton (Figure 3), we identified a series of previously unknown archaeological features: bowl-shaped depressions (BSDs) filled with coarse material, each representing a single kūmara plant (Gumbley & Higham 2000; Gumbley et al. 2004). These conformed closely to historical references, which describe orderly gardens where kumara was grown in mounds organised in this fashion (Best 1925; Colenso 1880).

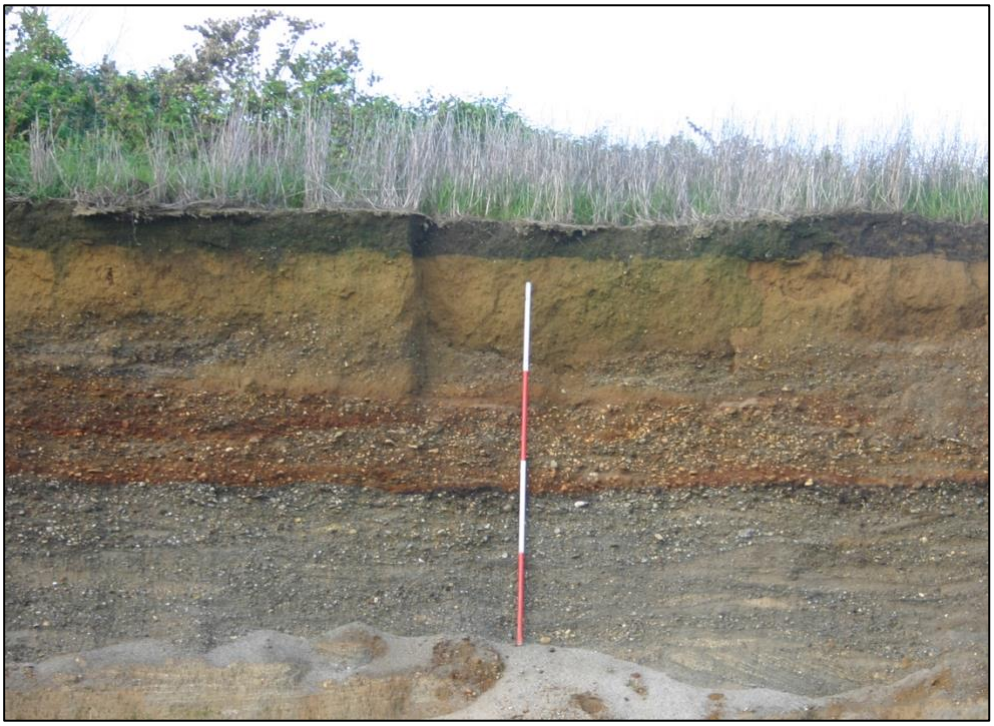


Figure 2. A photograph showing the upper horizons of Horotiu sandy loam. The upper 700-800 mm of yellowish-brown material is the accumulated volcanic tephra that overlies the Hinuera Formation alluvium. It is this alluvium that was quarried and added to the gardens. (Scale is 2 m.) (photo: W. Gumbley)

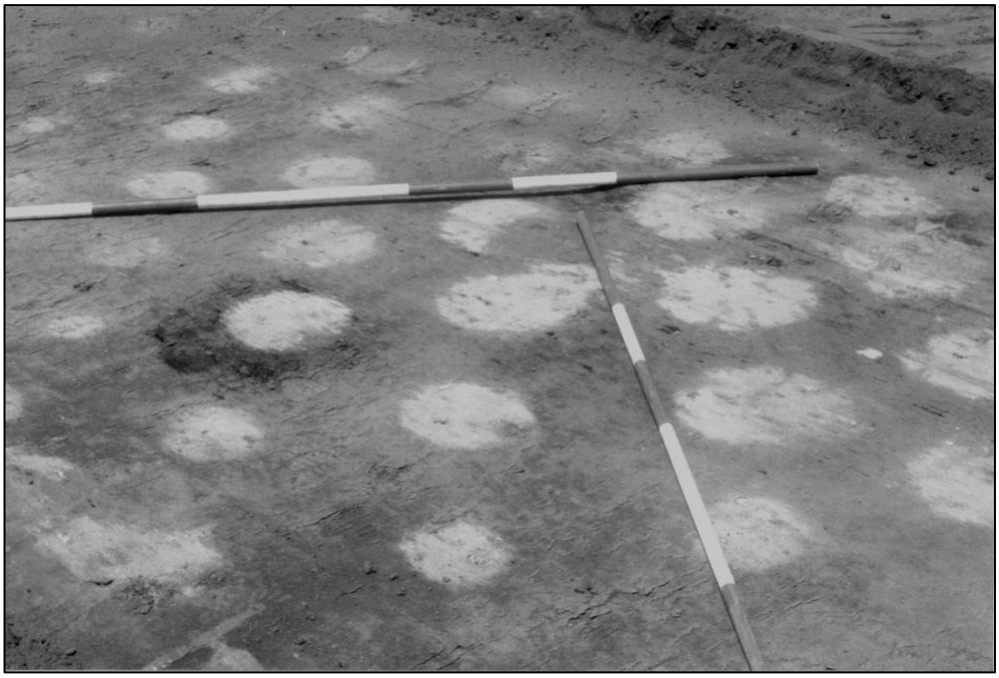


Figure 3. Photograph from S14/201 (Chartwell, Hamilton) showing the sand-filled bases of bowl-shaped hollows (BSHs) dug into the subsoil. (Scale intervals: 0.5 and 0.25 m.) (photo: Gumbley).

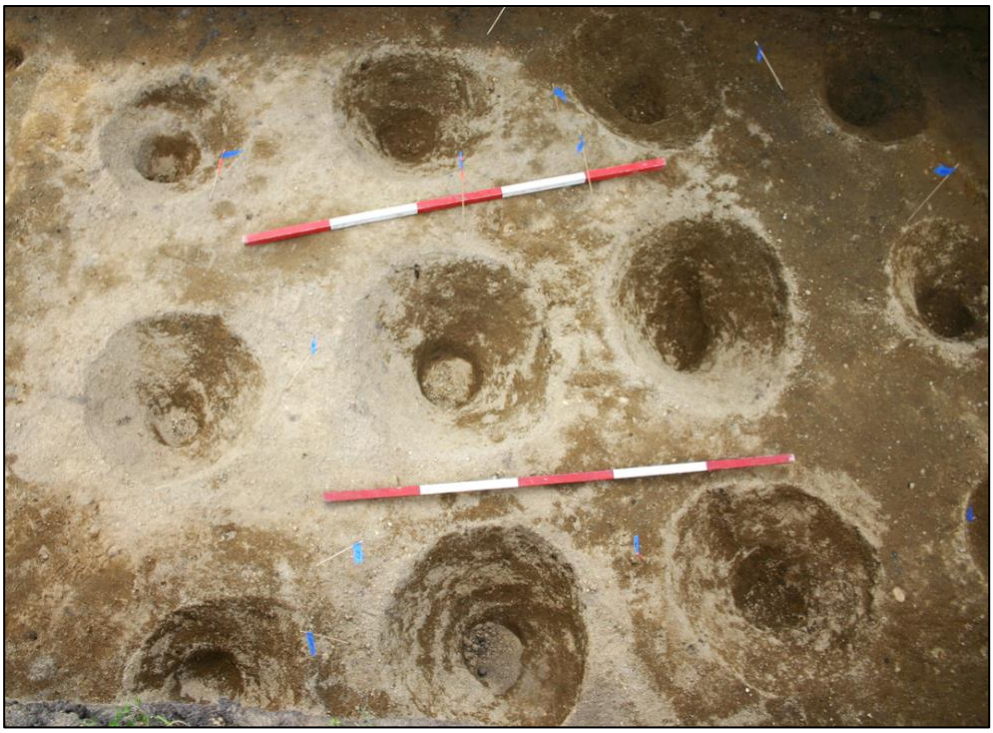


Figure 4. Photograph from S14/195 (Horotiu) showing bowl-shaped hollows (forming bases for growing mounds) with the sand and gravel removed (Scales are 1 m.) (photo: Gumbley).

Since 1999, these sand-filled bowls, arranged similarly, have also been found at several sites, ranging from Leamington/Cambridge to Taupiri (Figure 4).

The term ‘bowl-shaped hollow’ reflects the in-ground morphology of these features. The hollows are typically 25–40 centimetres in diameter and 20–30 centimetres deep. They are

characteristically filled with sand and gravel alluvium quarried from the Hinuera Formation alluvium (C horizon). Occasionally, the remains of digging stick (kō) marks can be found at their base, evident as a 'dimple' (Figure 4).

BSHs are usually found in groups and regularly laid out in parallel rows, in either a grid or quincunx pattern. While the spacing varies, it averages 60 cm between each. BSHs represent the remains of structures for the growing of individual plants. It is inferred that a mound was raised above, and the plants were grown in it, but the mounds have not been preserved. They would have been destroyed to harvest each plant.

Transported Alluvium Layer (TAL)

The TAL tracts are extensive layers of sand and gravel that are usually 15-25 cm centimetres thick when they have not been significantly modified by modern cultivation. This phenomenon presents as a discrete topsoil unit formed from transported sand and gravel quarried from borrow pits. Generally, these soils overlie a darkened Ab horizon (buried topsoil) that sits on the principal sediments of the B-horizon (subsoil). This Ab horizon has been interpreted as buried topsoil by soil scientists (Grange et al. 1939; Bruce 1978 & 1979), and my experience supports that. Charcoal is often found in the Ab horizon, sometimes as obvious remains of charred root systems. This charcoal represents the remains of the forest cleared for the gardens, and forest species can be identified following the analysis of bulk samples.

When the sand and gravel layer is well-preserved, the topsoil divides into three elements (Figure 5):

1. the turf layer ~15 centimetres thick with a dark, well-sorted medium sand and finer material relatively rich in organic matter;
2. a very dark greyish brown to black layer of coarse material (sand and gravel), ~15 centimetres thick;
3. a pale brown layer of coarse material (sand and gravel), ~ 15 centimetres thick.

The uppermost element (1) is a recent soil horizon developed under pasture turf, with bioturbation accounting for the well-sorted nature of the sediments. Units 2 and 3 are the cultural deposits. Soil micromorphological analysis of these two units demonstrated that apart from the colour difference, they are identical and result from the same rapid depositional process. Neither units 2 or 3 have significant amounts of charcoal. Instead, the colour difference results from staining by humic acid type A, which results from bracken fern colonisation after the gardens were abandoned and which has only affected the upper part of the layer. When this layer is removed, the interface with the subsoil is dimpled and undulating (Figure 6), and these are the remnants of tool marks and sometimes tuber moulds.

Soil micromorphological analysis has also demonstrated that the TAL layer was not cultivated and did not function as a mulch. Instead, this material is the remains of growing mounds that were collapsed during the harvest of the kūmara. This is consistent with the results of experimental gardening I have also undertaken.

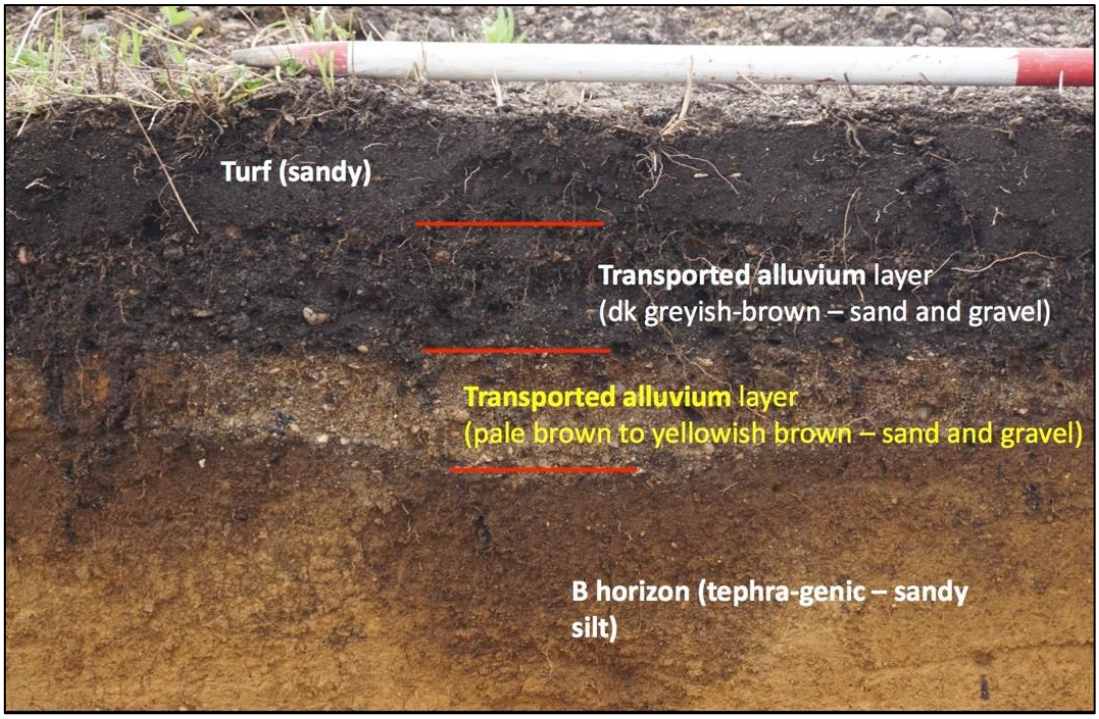


Figure 5. An example of an unmodified transported alluvium layer (TAL) agronomic system.

Figure 6. Example of the dimpled interface found at S15/374 at Ngaruawahia, garden site located on Waikato series soil (Gumbley & Gainsford 2018).

Borrow pits

Borrow pits are large and readily identifiable features in the landscape. The larger borrow pits can be up to 40 metres across, and they are generally 3–4 metres deep. However, the larger ones can be over 5 metres deep, with the deepest known example 6.5 m deep. They were quarries used to access the alluvial sands and gravels in the underlying substrate that were utilised to construct the growing environments (BSH and TAL) described above.

Medium to large borrow pits are actually aggregations of multiple 'shafts'. This process is also illustrated by the identification of small borrow pits (~ 2 metres wide by ~ 2 metres deep) as individual isolated features. These, presumably, were borrow pits in their 'youth'. Examples of quarries dug into river banks and into the toes of escarpments have also been found. Notably, the excavation of the sand and gravel substrate was accompanied by the immediate back-filling of the quarry shafts with a mixture of the unwanted tephritic subsoil material (re-worked B-horizon) and the sand and gravel substrate. This measure seems to have been employed to stabilise the pits, preventing collapse and also demonstrates clearly that the 'fertile' tephritic material was unwanted.

The average volume of borrow pits is approximately 650 m^3, and with over 7000 borrow pits in the Waikato recorded from historical aerial photographs and modern remote sensing data (LiDAR), this indicates that over 4 million cubic metres of material has been quarried and used to form gardens.

Fireplaces and domestic activities

Cooking and other domestic activities are associated with horticultural sites and are found both within and on the periphery of the gardens. Functionally, these equate to seasonal kāinga, where hapū members relocated to undertake a range of activities centred on horticulture. These activities may include forest clearance and garden preparation (including quarrying sand and gravel from borrow pits), crop planting and maintenance, and harvesting, including the construction of crop storage pits.

Morphologically, these places vary in size and include numerous fireplaces, including well-formed umu (hāngi). Postholes represent structures of various sorts, ranging from small whare to simple shelters, fences, or windbreaks. Crop storage pits are also clustered with these collections of fireplaces.

These domestic clusters have been documented at a number of sites and are a standard aspect of the Waikato Horticultural Complex.

Drains

Features relating to garden drainage have been identified at three sites in the inland Waikato. They are rare. They have been found around the peripheries of all otherwise dry horticultural sites where the bulk of the horticulture took place on adjacent, slightly higher, and well-drained soils, in particular, Horotiu loam. In each case, the drainage features were situated on poorly drained Te Kowhai silt loam. At each site, the drains have been relatively shallow, narrow and generally dendritic in pattern, with smaller 'limb' channels feeding a 'trunk' unit

carrying the collected water away to a nearby gully or waterway. Altogether, the patterns suggest *ad-hoc* solutions to episodic problems rather than a planned element of the original garden design.

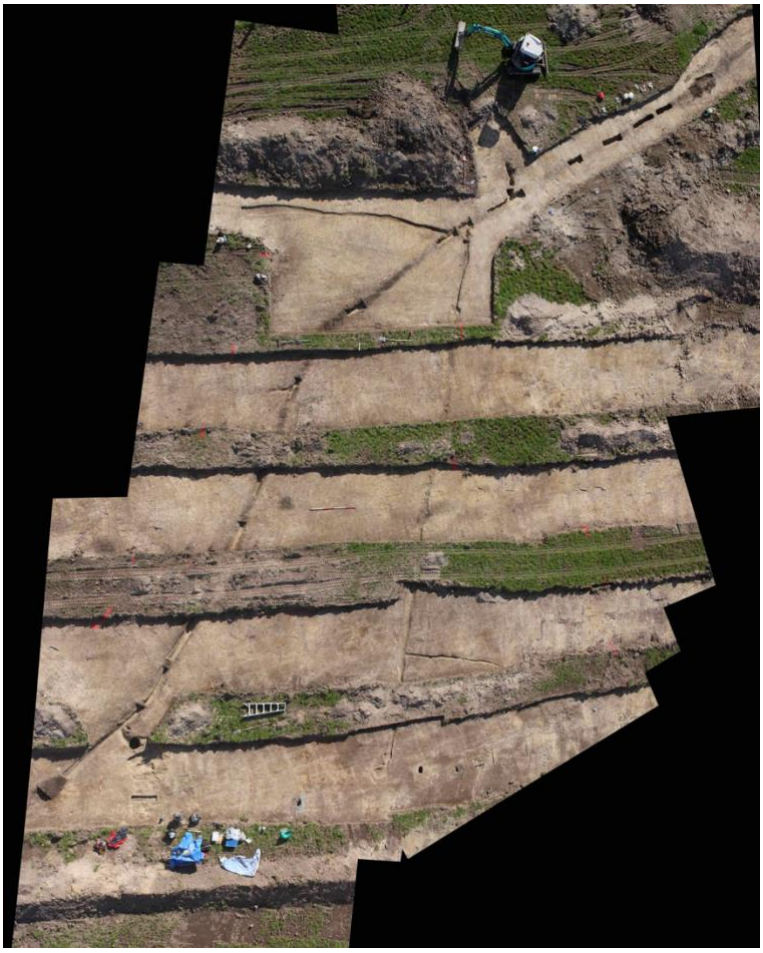


Figure 7: Drainage system identified at S14/250 (Taupiri) (Gumbley & Gainsford 2020c)

Vegetation clearance remains

Charcoal patches and charred root systems

As noted above, charcoal deposits are often found in association with the horticultural activity, trapped in the under-lying buried topsoil and are the remnants of initial forest clearance and vegetation management. These can take the explicit form of charred root systems, but they are also found as concentrations of charcoal in the surface of the buried topsoil (Ab horizon) under the 'made soil'. The charcoal deposits provide unique and important data about the environment before, during and after gardening has occurred. This information not only tells about the past environment but also provides vital information that allows effective radiocarbon dating (see below).

Basin-shaped Depressions (BSDs)

BSDs are a less common phenomenon that appears to be common at some sites and absent at others. Initially, these were thought to be another growing system, but their irregular form, size range, and the nature of the fill indicate they were remnants of forest clearance, where the root systems of small trees or shrubs were dug up and removed. They are generally oval but vary widely in size, from 1.5 m long to 3-4 m. A thick layer of forest charcoal mixed with topsoil is often present in the base, and, sometimes, there is also clear evidence of in situ burning in the base. Sand and gravel fill the bulk of each depression.

Plant microfossil evidence

Analysis of plant microfossils[9] found in association with the BSHs and TAL units has found abundant kumara starch grains and, more rarely, taro remains. Tropical yam/uwhi, a tropical cultivar that has very rarely been identified in New Zealand, has been found at one site. This shows that this plant was grown in the Waikato despite its sensitivity to a temperate climate.

Timing and Radiocarbon dating

The scale and extent of the Waikato horticultural system begs the question of the timing of the development of this intensified approach to swidden horticulture and whether there is any pattern in its spread through the Waikato.

The settlement of the inland Waikato was principally accomplished by descendants of the Tainui Waka[10]. Arrival traditions indicate that the Tainui Waka, along with the Arawa Waka, were among the last colonising waka to reach New Zealand, with the Tainui Waka ultimately settling on the west coast of North Island around Kāwhia and Aotea Harbours (Kelly 2002). Jones (Jones and Biggs 1995) and Kelly (2002) place this event in the mid-fourteenth century, and both propose migration inland occurred in the second half of the sixteenth century.

The archaeology of New Zealand offers particular challenges because of the short chronology of the settlement by Polynesians, which is inferred to have begun in the middle to late thirteenth century. This is based both on the proliferation of settlement through Aotearoa/New Zealand by the end of the fourteenth century (Anderson 2016; Anderson et al. 2015; Smith 2019; Wilmshurst et al. 2008) but also on a recent Bayesian analysis of 1558 radiocarbon dates (Bunbury et al. 2022). Because radiocarbon dates commonly manifest margins of error that result in calibrated date ranges of close to a century (at 95 %) (Hogg et al. 2017). For our short chronology, this places considerable stress on the capacity of the technique to produce a level of precision permitting the discernment of events or processes in cultural change before European settlement. This is further exacerbated by the frequency of wiggles in the southern hemisphere atmospheric calibration curve, particularly during the period after 1500 AD (Hogg et al. 2017). Altogether, this makes it difficult to date specific

[9] Microfossils are the microscopic remains of plants. Pollen, phytoliths and remains of vegetation such as starch grains and xylem cells are what is analysed.

[10] Ngāti Kahupungapunga, a hapū understood to be descended from the Arawa Waka, were already settled in the region of the Puniu River (Jones & Biggs 1995).

sites closely and makes for a particularly knotty problem in determining the comparative ages of sites with others. While there are techniques to address the precision problem (e.g. wiggle-match dating), they are dependent on uncommon situations (e.g. the presence of entire water-logged posts) not found in dryland horticultural environments. Without canvassing taphonomic issues relating to radiocarbon dating, I will note that techniques may be applied that allow dating to discriminate to the level of considering forest clearance and site abandonment. This, together with the application of Bayesian statistical analysis, allows problems of accuracy and precision of radiocarbon dating in the Waikato context to be addressed. However, few of the radiocarbon dates available have been sampled with this understanding in mind. Generally, too few radiocarbon dates are gathered on a site-by-site basis for Bayesian analysis to be applied usefully.

At the time of my thesis completion (Gumbley 2021), 161 charcoal samples, identified to species, from Waikato horticultural sites had been radiocarbon-dated. A number of dates have been added in the last three years, but these do not change the overall pattern. I will attempt to summarise the radiocarbon and chronological data in the following paragraphs.

The radiocarbon samples come from 34 sites, extending from Taupiri at the northern end of the basin to Cambridge at the southern end. Twelve of these sites have only 1 or 2 radiocarbon dates and should be considered unreliable as accurate ages for individual sites. Nonetheless, they remain useful when the broader data set for the horticultural system is examined.

At Taupiri, radiocarbon dates indicate horticulture commenced in the late 16th century AD. The pattern is similar in the Ngaruawahia/Horotiu area and the Tamahere area. In the Cambridge area, the pattern is distinct and informative about the probable significance of this area in the development of the horticultural system.

On the Cambridge side of the Waikato River, 33 radiocarbon dates were available from sites in Cambridge North (approximately 2-3 km from the river) at the time my thesis was completed. A number have been added since then, and they reinforce the apparent pattern. In this area, horticulture commenced in the late 17th century but was mostly practised through the 18th century and into the early 19th century. Radiocarbon dates are available from two sites close to the river (S15/68 and S15/699[11]). Both of these sites are adjacent to or within the C3 zone. These dates indicate horticulture commenced here a century earlier than in Cambridge North, probably around the late 16th century.

On the Leamington side of the Waikato River, 28 samples were available from 6 sites. Dates from sites remote (inland) from the river, again approximately 2-3 km from the river, indicate horticulture commenced there in the mid-to-late 17th century and continued over the next century or more. In contrast, dates from sites adjacent to the river indicate horticulture was practised in the mid-to-late 16th century; a century earlier.

The patterning between the north and south of the Waikato River is consistent. Early horticulture was adjacent to the river and progressed further inland over time. In addition, the oldest dates we have associated with horticulture in the inland Waikato come from sites

[11] See Gumbley and Hutchinson 2014. N.B., these dates are also significant in the site damage context.

adjacent to the Waikato River in Cambridge. This suggests that the genesis of this agronomy was in the Cambridge/Leamington area.

A brief summary of site distribution in the inland Waikato and comments on signficance.

This summary largely draws from data compiled for a "state of the resource" review undertaken for NZ Historic Places Trust in 2013 considering horticultural sites in the Waipā District (Gumbley & Hutchinson 2013). Experience has shown that this pattern can be reasonably generalised to the rest of the Middle Waikato Basin. This study used the distribution of borrow pit observation in historic aerial photographs (1940s) and recent LiDAR data as a proxy for the distribution of horticultural sites. Our conclusions were:

> "There is a strong correlation between the location of borrow pits and distance from the banks of the Waikato River with 78 % of the borrow pits within 1 km of the river and 51 % within 500 m of the river. In the study area a few sites cluster to the Mangawhero and Mangaone Streams but these represent only a very small part of the resource. The principal exception to the otherwise strong clustering to the Waikato River is in the area of Cambridge North and Leamington where borrow pits are found up to 3.5 and 3 km from the river, respectively." (Gumbley & Hutchinson, 2013: 19)

This patterning emphasises the significance of the Waikato River in the settlement of the Middle Waikato Basin. Equally important in the current context is that it identifies the Cambridge area as distinct from the rest of the Basin. Here, horticulture was distributed exceptionally densely and remotely from the Waikato River (up to 2-3 km) compared to other areas.

This is still an evolving area of study, but it has revolutionised our understanding of how the tropical Polynesian horticultural system adapts to the temperate climate of New Zealand. It has long been proposed that the systematisation of kūmara horticulture was fundamental to the development of Māori culture and that this process was intimately linked with the development of pā. New research into the development of pā, which I am involved in, strongly indicates that the development of the Waikato Horticultural Complex is consistent with the development of pā in the Waikato. However, we know little about the genesis of this horticultural system, which appears to have its earliest manifestation in the Cambridge area, probably at sites adjacent to the riverbank.

References

Barber, I.G. 2004. Crops on the border: The growth of archaeological knowledge of Polynesian cultivation in New Zealand. In *Change through time: 50 years of New Zealand archaeology* (eds L. Furey and S. Holdaway). *New Zealand Archaeological Association Monograph 26, pp. 169-192.*

Best, E. 1925. *Maori Agriculture.* New Zealand Dominion Museum Bulletin 9, Government Printer, Wellington (reprinted 1976).

Bruce, J. G. 1978. Soils of Part Raglan County, South Auckland, New Zealand. *New Zealand Soil Bureau Bulletin 41*. New Zealand Soil Bureau, Department of Scientific and Industrial Research, Wellington.

Bruce, J.G. 1979. Soils of Hamilton City, North Island, New Zealand. *New Zealand Soil Survey Report* 31.

Bunbury, M. Petchey, F., Bickler, S. 2022. A new chronology for Māori settlement of Aotearoa (NZ) and the potential role of climate change in demographic developments. In *PNAS* 119(46), e2207609119.

Campbell, M., Harris, J. 2011. *The Taupiri Link, S14/158 and S14/198*. Unpublished report to N.Z. Historic Places Trust.

Challis, A.J. 1976. Physical and chemical analysis of a Maori gravel soil near Motueka, New Zealand. *New Zealand Journal of Science,* 19: 249-54.

Clarke A. 1977. Maori modified soils of the upper Waikato. *New Zealand Archaeological Association Newsletter* 20: 204-222.

Colenso, W. 1880. On the vegetable food of the ancient New Zealanders before Cook's visit. *Transactions of the New Zealand Institute* 13: 3-38.

Grange L. I., Taylor, N. H., Sutherland, C. F., Dixon, J. K., Hodgson L., Seelye, F. T., Kidson E., Cranwell, L. M., Smallfield, P. W. 1939. Soils and agriculture of part of Waipa County. New Zealand Department of Scientific and Industrial Research Bulletin 76.

Gumbley, W. 2021. *The Waikato Horticultural Complex: An archaeological reconstruction of a Polynesian horticultural system*. PhD Thesis, The Australian National University.

Gumbley, W. 2021. *The Waikato Horticultural Complex: An archaeological reconstruction of a Polynesian horticultural system*. PhD Thesis, The Australian National University.

Gumbley, W., Laumea, M., Gainsford, M. 2018. Archaeological investigation report: S15/421, S15/422, S15/427, 95 Swayne Road, Cambridge, New Zealand. Unpublished report to Heritage New Zealand.

Gumbley, W., Laumea, M., Gainsford, M. 2021. S15/424, Cambridge North: Report on archaeological investigations. Unpublished report to Heritage New Zealand.

Gumbley, W. and Gainsford, M. 2020a. S14/198 – Pre-European Māori horticultural site: Archaeological investigation report. Unpublished report to Heritage New Zealand and New Zealand Transport Agency.

Gumbley, W. and Gainsford, M. 2020b. S14/249 – Pre-European Māori horticultural site: Archaeological investigation report. Unpublished report to Heritage New Zealand and New Zealand Transport Agency.

Gumbley, W., Gainsford, M. 2020c. S14/250 – Pre-European Māori horticultural site: Archaeological investigation report. Unpublished report to NZTA and Heritage New Zealand Pouhere Taonga.

Gumbley, W., Gainsford, M. 2020d. S14/251 – Pre-European Māori occupation site: Archaeological investigation report. Unpublished report to NZTA and Heritage New Zealand Pouhere Taonga.

Gumbley, W. and Higham, T.F.G. 2000. Archaeological investigation of prehistoric garden complexes affected by R1 & N1 arterial routes, Chartwell, Hamilton. Unpublished report.

Gumbley, W., Higham, T.F.G., Lowe D.J. 2004. Prehistoric horticultural adaptation of soils in the Middle Waikato Basin: Review and evidence from S14/201 and S14/185, Hamilton. *N.Z. Journal of Archaeology,* 25: 5-30.

Gumbley, W., Hoffmann, A. 2013. *The Archaeology of pre-European Maori horticulture at Horotiu: The investigations of S14/194 and S14/195.* Unpublished report to N.Z. Historic Places Trust.

Gumbley, W., Laumea, M. 2017. *Burns Block - Hinuera Natural Stone Limited: Archaeological report for sites S15/639, S15/641 and S15/757. Lot 3 DPS 90315*. Unpublished report to Heritage New Zealand.

Gumbley, W., Laumea, M. 2019. *Archaeological investigation report: Pre-European Māori horticultural site S15/465.* Unpublished report to Heritage New Zealand.

Gumbley, W., Laumea, M., Gainsford M. 2018. *Archaeological Investigation Report: Pre-European Maaori Horticultural site S14/470.* Unpublished report to Heritage New Zealand.

Hoffmann, A. 2011. *Archaeological Investigation of S14/222 (modified soils), Horotiu, Waikato: final report.* Unpublished report to N.Z. Historic Places Trust.

Hoffmann, A. 2013. *Archaeological investigation of S14/221 (modified soils), Horotiu, Waikato: final report.* Unpublished report to N.Z. Historic Places Trust.

Jones, K.L. 2012. Rural block subdivision proposal: North-western Mahia Peninsula. Unpublished report to NZ Historic Places Trust and Mahia Titan Ltd.

Law, R. G. 1968. Maori soils in the Lower Waikato. *New Zealand Archaeological Association Newsletter* 11: 67-75.

Lowe, D.J. 1988. Stratigraphy, age, composition, and correlation of late Quaternary tephras interbedded with organic sediments in Waikato lakes, North Island, New Zealand. *New Zealand Journal of Geology and Geophysics* 31: 125-165.

McCraw, J.D. 2002. Physical environment. *In* Clarkson, B.; Merrett, M; Downs, T. (eds) *Botany of the Waikato*, pp. 13-22. Waikato Botanical Society, Hamilton.

McLeod, M. 1984. Soils of the Waikato Lowlands. *New Zealand Soil Bureau District Office Report* HN11.

Potts, K. 2019. *Final report for archaeological authority 2016/424: Landon Park subdivision*. Unpublished report to Heritage New Zealand.

Selby, M.J. and Lowe, D.J. 1992. The middle Waikato Basin and hills. *In* Soons, J.M.; Selby, M.J. (eds) *Landforms of New Zealand* (2nd ed), pp. 233-255. Longman Paul, Auckland.

Simmons, A. 2008. *Archaeological Monitoring of Earthworks at Riverton Estate*. Unpublished report to N.Z. Historic Places Trust.

Singleton, P.L. 1988. Cultivation and soil modification by the early Maori in the Waikato. *New Zealand Soil News* 36: 49-57.

Taylor N.H. 1958. Soil science and prehistory. *New Zealand Science Review*16: 71-79.