Roads and Traffic Authority

Pacific Highway Upgrade - Oxley Highway to Kempsey

Aboriginal Heritage Working Paper

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GHD Pty Ltd
ABN 39 008 488 373

Level 3, GHD Tower
24 Honeysuckle Drive
NEWCASTLE NSW 2300

Phone: +61 2 4979 9999
Fax: +61 2 4979 9988
Email: ntlmail@ghd.com

Appendix G

Sub-surface investigation – discussion of results

1 Sub-surface investigations

The sub-surface investigations were undertaken within two separate areas, as per the proposed research design. The sub-surface investigation data is summarised in **Table 1**.

At the Hastings River test area, 30 units were excavated in total, on two perpendicular transects measuring 110 and 50 metres each. Several units along each transect could not be excavated due to stockpiles of timber (F15, G15 and G20), with unit G10 representing the intersection of the two transects (excavated and recorded as unit F25).

At the Wilson River test area, 29 units were excavated in total, on two perpendicular transects measuring 95 and 50 metres each. One unit could not be excavated due to stockpiles of timber (B30), with unit B25 representing the intersection of the two transects (excavated and recorded as unit A55).

In total, 59 test units, each measuring one square metre in area were excavated, resulting in a total excavation area of 59 metres squared. In total, 160 separate excavation unit spits (1 x 1 metre area by ten centimetre deep 'spit') were excavated. On average, 2.7 spits were excavated in each test unit with a maximum of five spits (up to 0.5 metres depth) required. However, the Wilson River units were generally shallower (mean of 2.34 spits per test unit) compared to the Hastings River units (mean of 3.07 spits per test unit).

A total volume of deposit of 20.195 metres cubed (20,195 litres) was excavated and wet-sieved. On average, about 342 litres of deposit was excavated from each unit, with a mean of 126 litres excavated from each unit spit.

A total of 1,193 stone artefacts were recovered during the sub-surface investigations, including 1,049 at the Wilson River location and 144 at the Hastings River location. Artefacts were present in 54 (91.5 per cent) of the test units, attesting to the widespread distribution of lithic items at each site. On average 20.2 artefacts were located in each test unit and 7.46 artefacts in each excavation unit spit. The maximum artefact count in a single square metre test unit was 372 (Wilson River unit A40). The maximum artefact count in a single excavation unit spit was 283 (Wilson River unit A40 spit 2).

The overall mean density of artefacts per cubic metre is 59.07 (13.57 at the Hastings River and 109.48 at the Wilson River). By volume, artefact density per individual excavation unit spit varied substantially, from nil to a peak of 1,401 artefacts per cubic metre in spit 2 of Wilson River unit A40.

Table 1 Summary of sub-surface investigation data

Test area	Number of units excavated	Plan area excavated (m^2)	Volume excavated (m^3)	Number of artefacts	Mean artefact density per conflated m^2	Peak count per test unit (1 m^2)	Peak artefact density per unit spit (per m^3)	Mean artefact density per m^3
Hastings River	30	30	10.61	144*	4.80	29	147	13.57
Wilson River	29	29	9.58	1049*	36.17	372	1401	109.48
	Total 59	Total 59	Total 20.19	Total 1193	Mean 20.22	Highest 372	Highest 1401	Mean 59.07

* Includes unprovenanced artefacts; 2 in Hastings River and 18 in Wilson River.

1.1 Hastings River test area

The Hastings River test area is located within survey areas OHK 46 (level-very gentle spur crest) and OHK 47 (gentle simple slope), which prior to the conduct of the sub-surface investigations did not have any identified heritage evidence. Therefore, the sub-surface investigations have resulted in the addition of two further site loci for consideration.

One square metre test units were excavated at five metre intervals along two perpendicular transects. Transect G comprised eight excavated units (**Figure 1**). Several units could not be excavated due to stockpiles of timber (G15 and G20) and unit G10 represented the intersection of the two transects (excavated and recorded as unit F25). All of the G-transect units occur on the level-very gentle crest, with an open aspect.

Transect F comprised 22 excavated units (**Figure 1**). One unit (F15) could not be excavated due to stockpiles of timber. As per the G-transect units, units F20 to F30 occur on the level-very gentle crest, with an open aspect. Units F0 to F10 occur on the northern verge of the crest, with a 1-1.5 degree slope to the north and a northerly aspect. These units still comprise part of the level-very gentle spur crest context.

Units F35 to F110 occur in a different context, a gentle simple slope (survey area OHK 47). The gradient is approximately 3° to the south and the aspect is also to the south.

The coastline at North Shore Beach is located nine kilometres to the east. The intervening coastal flats include the Maria River, which joins the Hastings River at Blackmans Point 3.5 kilometres east of the study area, and Limeburners Creek, which joins the Hastings River further to the east near the coastline.

This is a resource rich zone (ocean, beach, coastal rocks, river / estuaries, swamps / wetlands and forests on the low hills) but one that has largely formed in the Holocene period (last 10,000 years) after the sea rose to its present level. During the last glacial maximum (about 24,000 to 17,000 years ago) the climate was colder and drier than at present, and the sea level was lower and the shoreline many kilometres to the east of its present location. The Hastings River would still have been adjacent to the study area during this period, although the base level for the river valley channel would have been lower than at present and the location of the channel probably varied.

Minor sedimentary rock outcrops are present on the crest and the underlying geology comprises lithic sandstone, siltstone, tuff, shale and limestone of the Carboniferous Byabbara Beds. Apart from minor exposures around several remaining trees and a vehicle track, dense pasture grass limited surface visibility prior to the sub-surface investigations.

Soils in the Hastings River test units typically comprised a shallow silty clay loam or silty loam A unit overlying a clay B unit. The A unit was typically slightly acidic (pH 5.5 to 6.5) and 5Y 2.5/1 black or 5Y3/1 very dark grey in colour. Often the transition zone or clay base would be undulating and varied in depth, typically between 0.15 and 0.3 metres. The B unit light to medium clay was typically slightly acidic (pH 5.0 to 5.5) and 5Y 4/3 olive in colour. Gravel, particularly decomposed sandstone, was common in many spits excavated. Excavation ceased on top or marginally within the B unit clay.

1.2 Wilson River test area

The Wilson River test area is located within survey areas OHK 90 (level-very gentle ridge crest), OHK 91 (gentle ridge crest) and OHK 92 (gentle simple slope), which prior to the conduct of the sub-surface investigations hosted five sites of identified heritage evidence on the surface. Therefore, the sub-surface investigations have resulted in the addition of further evidence, representing extensions to several of these sites.

One square metre test units were excavated at five metre intervals along two perpendicular transects. Transect A comprised 20 excavated units (**Figure 2**). Units A0 to A80 occur on the broad level-very gentle ridge crest (survey area OHK 90), with a gradient of 1 degree to the east. Units A85 to A95 occur on the gentle ridge crest (survey area OHK 91), with views to the west limited by the rise of the crest. The gradient is 1.5-2 degree to the east-northeast.

Transect B comprised nine excavated units (**Figure 2)**. One unit could not be excavated due to stockpiles of timber (B30), with unit B25 representing the intersection of the two transects (excavated and recorded as unit A55). Units B0 to B20 occur in the same context as units A0 to A80 (broad level-very gentle ridge crest of survey area OHK 90), with a gradient of one degree to the south. The aspect is primarily to the south and east to the Wilson River and its floodplain. Units B35 to B50 occur on the gentle simple slope (survey area OHK 92), with a three degrees gradient to the north and a similar aspect, although constrained by vegetation. The dry ridgetop forest has been cleared around these units and grass established.

The coastline at North Shore Beach is located 13.5 kilometres to the east. The intervening coastal flats include Limeburners Creek and associated swamps / wetlands, and Cooperabung Creek which joins the Maria River which in turn joins the Wilson River about one kilometre east of the study area.

This is a resource rich zone (ocean, beach, coastal rocks, river/estuaries, swamps / wetlands and forests on the low hills) but one that has largely formed in the Holocene period (last 10,000 years) after the sea rose to its present level. During the last glacial maximum (about 24,000 to 17,000 years ago) the climate was colder and drier than at present, and the sea level was lower and the shoreline many kilometres to the east of its present location. The Wilson River would still have been close to the study area during this period, although the base level for the river valley channel would have been lower than at present and the channel location may have varied.

The underlying geology comprises lithic sandstone, siltstone, tuff, shale and limestone of the Carboniferous Byabbara Beds. Moderate to high levels of ground disturbance are evident in the locality of the test area, including from vegetation removal, vehicle tracks, refuse, log and material stockpiles, shed construction and erosion.

Soils in the Wilson River test units typically comprised a shallow silty clay loam A unit overlying a clay B unit. The A unit was typically slightly acidic (pH 5) and 5Y 2.5/1 black or 2.5Y 3/1 very dark grey in colour. The transition zone or clay base varied in depth, typically between 0.1 and 0.2 metres. The B unit medium to heavy clay was typically slightly acidic (pH 5.5) and 2.5Y 4/3 olive brown or 2.5Y 5/3 light olive brown in colour. Gravel, particularly decomposed sandstone, was present in many spits excavated. Excavation ceased on top or marginally within the B unit clay.

1.3 Revised site descriptions

Subsequent to completion of the sub-surface investigations, updated descriptions of the recorded Aboriginal heritage sites within the study area can be presented for those relevant sites (OHK 46, 47, 90, 91 and 92).

Site OHK 46/A

Site OHK 46/A was identified through the Hastings River sub-surface investigations and comprises artefact deposits located on the level-very gentle spur crest. It comprises 99 artefacts identified in test units G0 to G50 and F0 to F30. There is a high potential for further sub-surface deposits to occur across the crest, outside of the areas sampled.

Site OHK 47/A

Site OHK 47/A was identified through the Hastings River sub-surface investigations and comprises artefact deposits located on the gentle simple slope. It comprises 43 artefacts identified in test units F35 to F110. There is a high potential for further sub-surface deposits to occur across the slope, outside of the areas sampled.

Site OHK 90/A

Site OHK 90/A was recorded during the initial survey as an artefact scatter. Additional evidence representing an extension of this site was identified on the level-very gentle ridge crest through the Wilson River sub-surface investigations, within test units A0 to A80 and B0 to B20. This evidence comprised 867 artefacts.

Site OHK 91/A

Site OHK 91/A was recorded during the initial survey as an artefact scatter, one of two sites on the gentle ridge crest north of the Wilson River. Additional evidence representing an extension of this site was identified on the gentle ridge crest through the Wilson River sub-surface investigations, within test units A85 to A95. This evidence comprised 73 artefacts.

Site OHK 92/A

Site OHK 92/A was recorded during the initial survey as an artefact scatter, one of two sites on the gentle simple slope north of the Wilson River. Additional evidence representing an extension of this site was identified on the gentle simple slope through the Wilson River sub-surface investigations, within test units B35 to B50. This evidence comprised 91 artefacts.

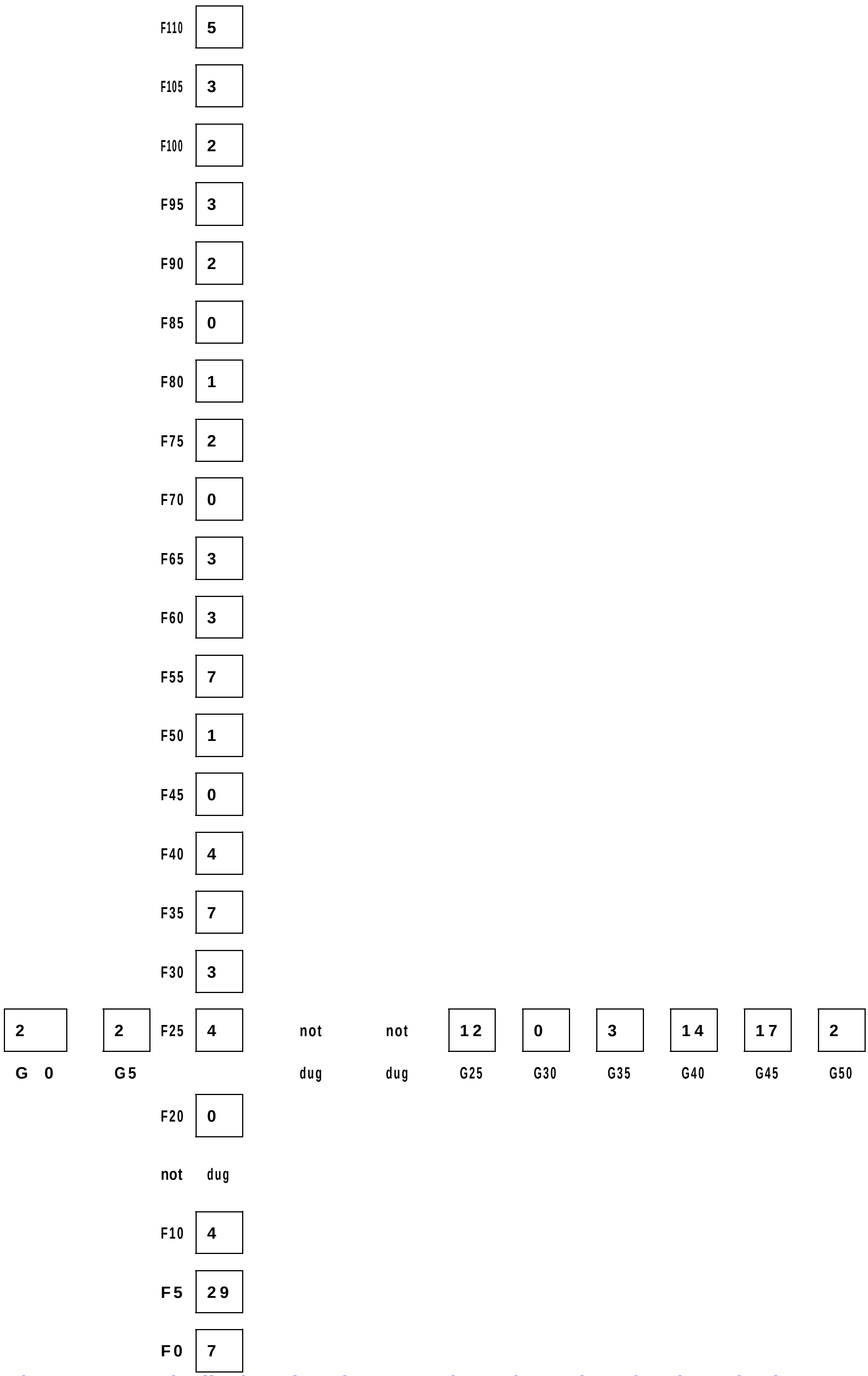

Figure 1 **Distribution of artefacts - Hastings River sub-surface investigations**

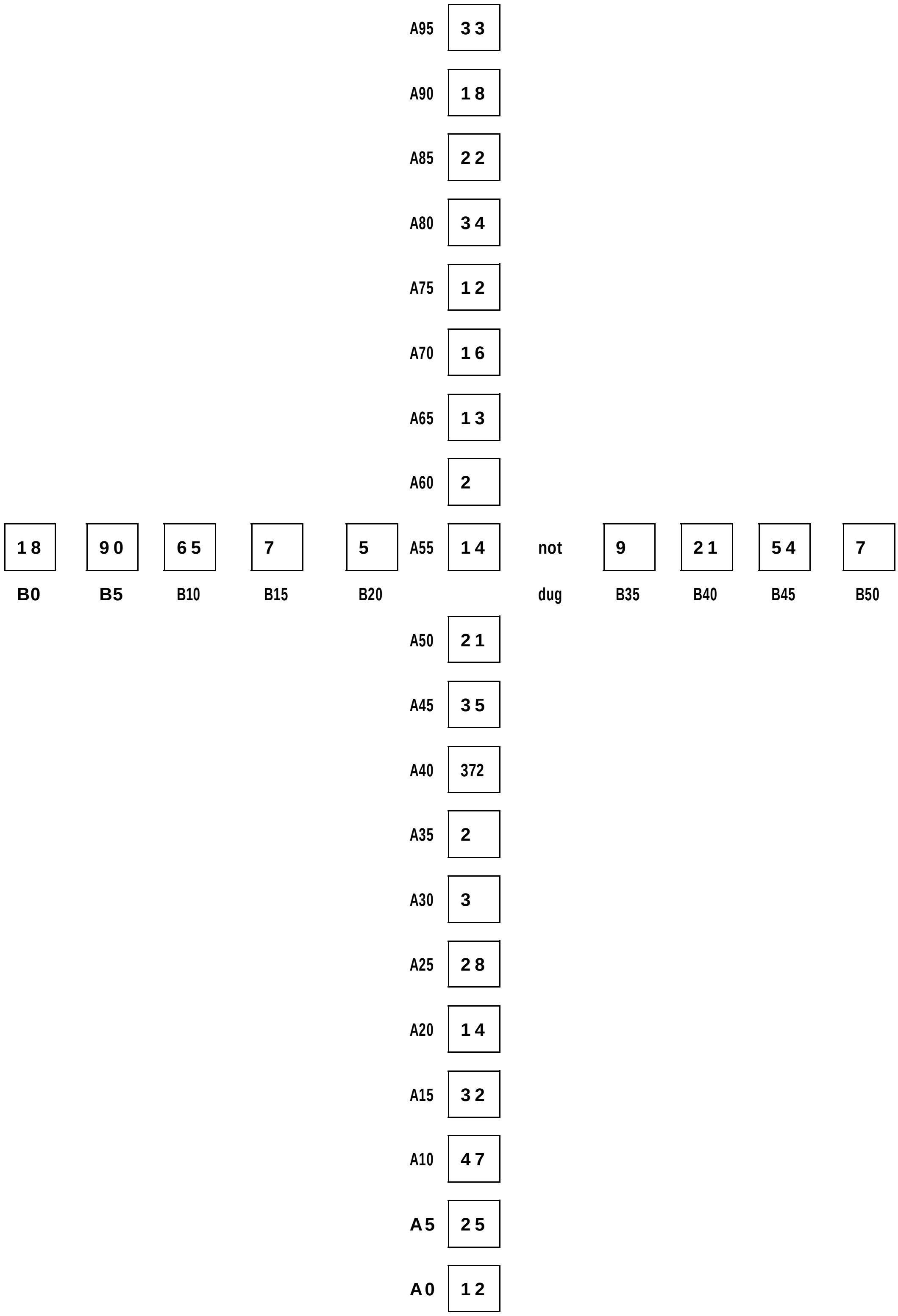

Figure 2 **Distribution of artefacts - Wilson River sub-surface investigations**

2 Discussion - Sub-surface investigation results

2.1 Integrity of Aboriginal sites

One objective of the study was to determine whether in situ deposits are present and the general integrity of the excavated sites. Assessing the effects of post-depositional impacts on spatial context and site contents is important in determining the types of scientific information that may be suitably examined and identifying issues relevant to the interpretation of the evidence.

The integrity of the evidence can be examined by various means, including:

- Land-use history and natural processes.
- Horizontal and vertical distributions of stone artefacts.
- Conjoins and inferred associations between individual stone artefacts.

Various forms of human activity and natural processes can disturb archaeological evidence after it is deposited. As Gollan (1992:44) observed, the archaeological resource is '*constantly in a state of flux, being made (exposed and discovered) and unmade (by impacts, random and non-random, cultural and natural), but generally trending towards loss of systematic informational content*'. It is important to identify the range of processes that may have affected a site, in order to account for possible effects to the horizontal and vertical spatial distribution of evidence.

During the survey assessment, conditions of ground disturbance were assessed as moderate to high within the excavation areas. Impacts to the study area from recent land use practices were noted, including vegetation removal, vehicle tracks, and stockpiling of timber and other materials. Notwithstanding these impacts, the sub-surface investigation results have demonstrated a moderate degree of integrity to the heritage evidence, particularly through associations and several conjoins between lithic artefacts.

The spatial configuration of stone artefact distribution patterns can be examined to assess the integrity of deposits. This is particularly useful for broad area excavations, where the evidence of entire activity events can be identified. However, smaller sub-surface investigations can also be useful, especially for assessing the vertical distribution of artefacts.

On-site stone knapping, repair of other artefacts and processing of food and materials is often evident from the spatial distribution of knapping debitage and discarded implements. This is particularly the case for discard patterns not complicated by subsequent discard of similar stone debris at the same location (superimpositioning). Activities during prehistoric times may result in disturbance of a pristine discard pattern. In particular, cores and other large items of stone may be translocated or reused in various activities. Microdebitage, which is least likely to have been affected by many subsequent prehistoric human activities, is particularly useful in identifying original activity areas. If individual clusters and concentrations of stone discard are identified, the degree of subsequent lateral and vertical disturbance by bioturbation and other post-depositional processes may be inferred in a broad area excavation. However, in relation to small test units, assessment of lateral movement may not be possible.

The use of conjoining as a technique of analysis has been undertaken primarily for major site salvages (*cf* Baker and Gorman 1992, Koettig 1992, 1994, Rich 1995). Conjoin analysis involves physically fitting back together objects broken in antiquity (Hiscock 1986:159). Objects which are fitted together are said to be conjoined, and a number conjoined together are termed a conjoin set (Hiscock 1986:159). In Australia, conjoin analysis has been used to examine site integrity (vertical or horizontal artefact displacement) and to reconstruct stone working technology. Limitations of the method include the substantial amount of time required to refit artefacts, the difficulty involved in refitting small artefacts, and the inability to concisely describe conjoined artefacts and their relationships other than by lengthy discussion, photos and / or drawings.

Conjoining of artefacts is highly labour intensive and is therefore a preferred method of analysis only when significant results are likely to be obtained. The potential for successful application of the conjoining method significantly decreases when artefacts are less than 20 millimetres in size (Schick 1986:34).

For the present study, potential conjoins between artefacts were identified during examination and recording of the items. Two sets of conjoined artefacts were noted, indicating minimal post-depositional lateral or vertical movement of stone for these items:

- Conjoins of grey-green chalcedony flake portions in Wilson River unit A50 spit 2 (item # 584 and 589).
- Conjoins of grey acidic volcanic flake portions in Hastings River unit G45 spit 1 (item # 1177 and 1178).

An alternative and sometimes complementary analytical method to conjoin analysis is that of 'artefact association'. This method is appropriate for lithic assemblages comprising a high proportion of microdebitage (*cf* Kuskie and Kamminga 2000). The fundamental difference between the two methods is that while a conjoin constitutes proof that an artefact derives from a particular knapping or heat treatment event, an 'association' of a lithic item is inferential in nature and is therefore less certain.

Inferences can be made about the 'association' of individual items based on a number of criteria such as spatial proximity, similarity of stone material and shared technological and typological attributes. The degree of confidence in inferring associations between lithic items varies. The associations inferred in individual test units on the basis of similar stone material type, particularly for the less common stone materials, include for example:

- 15 grey-green chert flake portions, lithic fragments and a backing flake and bondi point in Wilson River unit A5 spit 1.
- A yellow acidic volcanic flake and flake portion in Wilson River unit A10 spit 1.
- A grey-yellow acidic volcanic flake and lithic fragment in Wilson River unit A15 spit 1.
- A blue-grey chalcedony flake and flake portion in Wilson River unit A25 spit 1.
- A blue-grey chert flake, flake portion and lithic fragment in Wilson River unit A25 spit 1.
- 12 yellow-cream acidic volcanic flake portions, lithic fragments and flakes in Wilson River unit A40 spit 1.
- Two yellow acidic volcanic flake portions and a lithic fragment in Wilson River unit A40 spit 1.

- Two yellow-brown acidic volcanic lithic fragments and a flake in Wilson River unit A40 spit 1.
- Four cream acid volcanic flake portions and lithic fragments in Wilson River unit A40 spit 2.
- 11 yellow acidic volcanic flake portions, lithic fragments and a flake in Wilson River unit A40 spit 2.
- Seven yellow-brown acidic volcanic flake portions and lithic fragments in Wilson River unit A40 spit 2.
- A yellow-grey acidic volcanic flake and flake portion in Wilson River unit A45 spit 1.
- Two yellow-grey tuff flake portions in Wilson River unit A45 spit 1.
- Two grey-green chalcedony flake portions and a retouched flake in Wilson River unit A50 spit 2.
- A grey-red chalcedony flake, flake portion and a retouched flake in Wilson River unit B0 spit 1.
- 15 grey-blue acidic volcanic flake portions, flakes, lithic fragments, a utilised flake and a geometric microlith in Wilson River unit B5 spit 2.
- Seven yellow acidic volcanic flake portions and a flake in Wilson River unit B5 spit 2.
- Three cream-yellow acidic volcanic flakes and two flake portions in Wilson River unit B35 spit 1.
- Two orange acidic volcanic flake portions in Wilson River unit B45 spit 4.
- 22 grey acidic volcanic flake portions, utilised flake portions, flakes, lithic fragments and an utilised geometric microlith in Hastings River unit F5 spits 1-3.
- Four grey acidic volcanic flake portions in Hastings River unit F5 spit 2.

The above associations, of varying degrees of confidence, indicate that some vertical mixing of deposit, presumably through bioturbation, has occurred in a number of units. However, they also indicate a degree of horizontal integrity of the evidence.

It is concluded that within the sub-surface investigation areas, not withstanding the moderate-high level of recent human impacts as evident from surface inspection, relatively in situ heritage evidence is present and has potential to exist in the areas not directly sampled. However, a portion of the heritage evidence has been subject to post-depositional impacts resulting in horizontal or vertical displacement of items. Bioturbation and recent human impacts are assumed to be the main agents of disturbance and primarily have affected the vertical, rather than horizontal, integrity of the evidence. Importantly to note however, in terms of the research potential of the deposits, the impacts of post-depositional processes can be identified and controlled for (*cf* Koettig 1989, Kuskie and Kamminga 2000).

Stone materials recorded during sub-surface investigations

A total of 1,193 stone artefacts were recovered during the sub-surface investigations, including 1,049 at the Wilson River location and 144 at the Hastings River location. The counts and frequencies of stone material and artefact types are presented in Table 2 for the Hastings River assemblage and Table 3 for the Wilson River assemblage.

Fifteen different categories of stone material were identified in the combined excavation lithic item assemblage, including five sub-categories of acidic volcanic stone. These were subdivided on the basis of matrix and inclusion characteristics, but for the purposes of analysis can be recognised as a single category ("acidic volcanic"). Only single examples of breccia, quartzite and siltstone were identified.

Both the Hastings River assemblage (80.56 per cent) and Wilson River assemblage (82.36 per cent) are dominated by acidic volcanic stone, in similar proportions. The remainder of the Hastings River assemblage is comprised of lithic sandstone (8.33 per cent) and very low frequencies (less than three per cent) of quartz, crystal quartz, chalcedony, silcrete, quartzite, siltstone and tuff. The remainder of the Wilson River assemblage is comprised of quartz (4.86 per cent), lithic sandstone (3.15 per cent), tuff (3.15 per cent) and very low frequencies (less than three per cent) of chalcedony, chert, crystal quartz, silcrete and breccia.

Acidic volcanic

Acidic volcanic is a broad category of extrusive, fine-grained igneous stone, formed by rapid cooling. A number of sources of volcanic stone occur throughout the region (Hastings SH 56-14 1:250,000 geological map). A total of 27 or 3.1 per cent of acidic volcanic items at the Wilson River exhibit terrestrial cortex. Given the large size of several of these items, a terrestrial outcrop and probably a relatively local source can be inferred. However, most artefacts were reduced to the extent that cortex was not present. One acidic volcanic item at the Wilson River exhibits waterworn cortex, indicating an alluvial or colluvial gravel source.

A total of two or 1.7 per cent of acidic volcanic items at the Hastings River exhibit terrestrial cortex and four (3.5 per cent) waterworn cortex. One of the items with waterworn cortex (#1103) is a large primary flake portion, indicating a relatively local gravel source.

Quartz / crystal quartz

There are three main forms of massive quartz: veins, geodes and macro-crystals. For the purposes of flaking, these varieties are essentially similar, although vein or reef quartz is more likely to contain major pre-existing flaws. Quartz is composed of extremely small hexagonal crystals of silicon dioxide (SiO_2), which give it a glossy texture. When pure it is translucent, but minute traces of minerals may add colours such as smoky grey, pink or yellow. Most quartz has microscopic gas or liquid filled vacuoles that give it a milky appearance. While this does not affect the rock's strength, clay minerals in ground water, particularly iron compounds, may seep into the minute flaws and weaken the stone, leading to natural fracturing. It can also break with a conchoidal fracture.

Because quartz exhibits a small degree of cleavage and tends to have internal flaws, it ranges in flaking quality from very poor to acceptable. Internal cracking of quartz often occurs during flaking and its fracture path is usually much less predictable than stone which breaks with a strong conchoidal fracture. For these reasons quartz is generally a low-quality flaking material. However, because of its abundance and availability, in some regions it is the main stone type used for flaking. Its other advantage is that it provides small flakes with very sharp edges, which are suitable for light-duty work such as skinning, light butchering and cutting plant matter.

Quartz comprises 2.78 per cent of the Hastings River assemblage and 4.86 per cent of the Wilson River assemblage. Crystal quartz, the clear macro-crystal variety, comprises 2.78 per cent of the Hastings River assemblage and 1.05 per cent of the Wilson River assemblage. One small lithic fragment from the Wilson River exhibits terrestrial cortex. However, in general alluvial or terrestrial gravels (such as from decomposed conglomerate) could represent relatively local sources of this material.

Chalcedony

Chalcedony is a compact variety of silica, formed of quartz crystallites, often fibrous in form and with sub-microscopic pores that contain water (about one per cent of weight). Chalcedony can form veins or it can occur as pseudomorphs, resulting from solution infiltrating voids or cavities in rock, sometimes by gradually replacing decaying organic matter. Chalcedony, like fine quality chert, was a valued stone tool material.

Three items (2.08 per cent) of the Hastings River assemblage and 29 items (2.76 per cent) of the Wilson River assemblage are chalcedony. All were highly reduced (less than 30 millimetres in maximum dimension) and a number of the items are implements (for example, utilised flakes, bondi points and a thumbnail scraper). None of the items exhibit cortex.

Substantial areas of limestone occur in the underlying geology, both in the immediate locality north of the Wilson River to Mingaletta Road (Byabbara Beds) and elsewhere within the study area and region. Chalcedony is often associated with limestone and this may represent a relatively local source of the material. The highly reduced nature of the items within the test excavation areas may relate to the prized nature of this material and the purposes of reduction (such as the creation of small backed artefacts).

Chert

Chert is a highly siliceous sedimentary rock, with a chemical composition of silicon dioxide and major constituent minerals of chalcedony, quartz and opal. Chert is formed by a chemical process, from silica derived from the compaction and precipitation of single-celled organisms (such as diatoms – a small algae, and radiolarians). These organisms remove silica from water to make their shells. After dying, shells accumulate at the bottom of a water body, and if in sufficient quantity, form a silica-rich ooze. Following burial, the silica-rich ooze becomes cemented and hardened into rock (diatomite or radiolarite). As these rocks become strongly lithified, they recrystallise to a very fine-grained rock composed of microcrystalline quartz (chert). Chert is also commonly found as nodules in limestone. Chert was a favoured material for manufacturing artefacts, as it breaks by the process of conchoidal fracture and provides flakes that have sharp, durable edges.

Chert comprises 21 items (two per cent) of the Wilson River assemblage. All were highly reduced (less than 20 millimetres in maximum dimension) and several of the items are implements (bondi points and utilised geometric microlith). None of the items exhibit cortex.

As with chalcedony, chert is also associated with limestone and this may represent a relatively local source of the material. The highly reduced nature of the items within the test excavation areas may relate to the prized nature of this material and the purposes of reduction (such as the creation of small backed artefacts).

Table 2 Counts and frequencies of artefact types and stone types for the Hastings River assemblage

Lithic type	Stone material												Total	Frequency (%)
	Acidic volcanic 1	Acidic volcanic 2	Acidic volcanic 4	Acidic volcanic 5	Chalcedony	Crystal quartz	Lithic sandstone	Quartz	Quartzite	Silcrete	Siltstone	Tuff		
Flake	6	1	9			1	2						19	13.19%
Flake - distal	4	7	8			1	2						22	15.28%
Flake - longitudinal	4	3	7	1			2	3					20	13.89%
Flake - longitudinal - utilised		1	1										2	1.39%
Flake - medial	2	1	6			1	1						11	7.64%
Flake - medial - utilised	1		2										3	2.08%
Flake - proximal	8	5	5		1	1			1		1	1	23	15.97%
Flake - proximal - utilised		1											1	0.69%
Flake - utilised	1		1		1								3	2.08%
Geometric microlith - utilised			1										1	0.69%
Hammerstone	1												1	0.69%
Lithic fragment	3	8	10				1	1		2			25	17.36%
Non-descript core	1	1	3				4						9	6.25%
Retouched flake		1											1	0.69%
Retouched piece			1		1								2	1.39%
Utilised piece			1										1	0.69%

Lithic type	Stone material												Total	Frequency (%)
	Acidic volcanic 1	Acidic volcanic 2	Acidic volcanic 4	Acidic volcanic 5	Chalcedony	Crystal quartz	Lithic sandstone	Quartz	Quartzite	Silcrete	Siltstone	Tuff		
Total	31	29	55	1	3	4	12	4	1	2	1	1	144	100%
Frequency (%)	21.53	20.14	38.19	0.69	2.08	2.78	8.33	2.78	0.69	1.39	0.69	0.69	100%	

Table 3 Counts and frequencies of artefact types and stone types for the Wilson River assemblage

Lithic type	Stone material													Total	Frequency (%)
	Acidic volcanic 1	Acidic volcanic 2	Acidic volcanic 3	Acidic volcanic 4	Acidic volcanic 5	Breccia	Chalcedony	Chert	Crystal quartz	Lithic sandstone	Quartz	Silcrete	Tuff		
Bondi point		1					1	1						3	0.29%
Bondi point - tip		1					1							2	0.19%
Bondi point - utilised		2					2						1	5	0.48%
Bondi point -tip - utilised		1												1	0.10%
Flake	39	137	16	6	6		8	5	3	15	11	3	10	259	24.69%
Flake - backing		1						1						2	0.19%
Flake - distal	15	83	9	1	3		5	2	1	2	11		3	135	12.87%
Flake - distal - utilised		1					1							2	0.19%
Flake - longitudinal	12	42	6	1			2			1	3		3	70	6.67%
Flake - medial	7	52	2		1		2	1	2		9		2	78	7.44%
Flake - medial - utilised													1	1	0.10%
Flake - proximal	30	128	20	5	6		3	3	2	8	5		4	214	20.40%
Flake - proximal - utilised		4												4	0.38%
Flake - utilised		5			1	1							1	8	0.76%
Geometric microlith			1		1									2	0.19%
Geometric microlith - utilised		2	1					1					1	5	0.48%

Lithic type	Stone material													Total	Frequency (%)
	Acidic volcanic 1	Acidic volcanic 2	Acidic volcanic 3	Acidic volcanic 4	Acidic volcanic 5	Breccia	Chalcedony	Chert	Crystal quartz	Lithic sandstone	Quartz	Silcrete	Tuff		
Lithic fragment	10	136	17		4		1	7	3	3	12	1	6	200	19.07%
Microblade		1												1	0.10%
Non-descript core	6	14	3	5	2					4		2	1	37	3.53%
Non-descript core fragment	2			1	1									4	0.38%
Retouched flake		6					2							8	0.76%
Retouched piece		4			1									5	0.48%
Retouched utilised piece		1												1	0.10%
Thumbnail scraper							1							1	0.10%
Utilised piece			1											1	0.10%
Total	121	622	76	19	26	1	29	21	11	33	51	6	33	1049	100%
Frequency (%)	11.53	59.29	7.24	1.81	2.48	0.10	2.76	2.00	1.05	3.15	4.86	0.57	3.15	100%	

Lithic sandstone

Sandstone is a cemented or compacted sedimentary rock consisting of detrital grains, which range in size from 1/16 to two millimetres in diameter. Quartz typically comprises the majority of grains. The grains can be bound together by a cement of silica, carbonate or other minerals, or a matrix of clay minerals. The nature of the cement is denoted by terms such as argillaceous (clayey), calcareous, ferruginous and tuffaceous sandstone.

Twelve items (8.33 per cent) of the Hastings River assemblage and 33 items (3.15 per cent) of the Wilson River assemblage are sandstone. All are flakes, flake portions, cores or lithic fragments, with several of the cores relatively large in size (up to 160 millimetres in maximum dimension). Several items exhibit terrestrial cortex. The sandstone within the assemblages is typically very course grained, however has been well-compacted and lithified. Substantial areas of lithic sandstone occur in the underlying geology, both in the immediate locality of the sub-surface investigations north of the Wilson River and north of the Hastings River (Byabbara Beds) and elsewhere within the region. A relatively local source is inferred.

Tuff

Tuff is a fine grained, isotropic stone formed after a cloud of ash was ejected in an explosive volcanic eruption. The ash settled to the ground or through ponded water. After burial, some tuff beds became indurated, through a low-grade metamorphic process (probably involving pressure) in which the stone recrystallised to a more stable structure. Tuff samples examined from the Hunter Valley near Newcastle are rhyolitic in chemical composition (quartz and potassium-feldspar, occasionally with layer silicate or goethite) (Kuskie and Kamminga 2000). Tuff is often grey in colour (a function of grain size, not a reference to individual grains, which can be of a variety of colours). However, tuff is porous enough for the diffusion of iron bearing solution, with iron precipitating out to give a yellow, brown, red or orange colour. Variations to the surface colouration can also result from weathering processes.

One item of the Hastings River assemblage and 33 items (3.15 per cent) of the Wilson River assemblage are tuff. Almost all were highly reduced (less than 30 millimetres in maximum dimension) and a number of the items are implements (for example, utilised bondi point, utilised geometric microlith and utilised flakes). None of the items exhibit cortex.

Tuff occurs in the underlying geology, both in the immediate locality of the sub-surface investigations north of the Wilson River and north of the Hastings River (Byabbara Beds) and elsewhere within the region. A relatively local source is inferred. As with the other homogenous, fine-grained stone materials chalcedony and chert, the highly reduced nature of the tuff items within the test excavation areas may relate to the relatively valued nature of this material in this region and the purposes of reduction (for example, the creation of small backed artefacts).

Silcrete

Silcrete is a brittle, intensely indurate rock composed mainly of quartz clasts cemented by a matrix which may be well-crystallised quartz, cryptocrystalline quartz or amorphous (opaline) silica (Langford-Smith 1978:3). The texture of silcrete reflects that of the host rock (for example, sandstone) and clasts may range in size from very fine grains to boulders.

Silcrete is produced by an absolute accumulation of silica, which can be precipitated from solution by evaporation, cooling, the neutralisation of strongly alkaline solutions, reaction with cations, adsorption by solids and the life-processes of organisms (Summerfield 1983:76). In weathered profiles, downward percolation of silica released through bedrock weathering and clay mineral authigenesis, together with water-table fluctuations, are suitable conditions for formation (Summerfield 1983:80).

Mineral composition of silcrete is highly variable and silcrete cannot be precisely characterised by its bulk chemical composition, other than a minimum silica content of 85 per cent weight as an arbitrary lower limit. In addition to silicon, minor traces of aluminium, iron or titanium may be present. Iron occurs both within the matrix and as a late-stage precipitate on weathering surfaces and in voids. Trace element abundance tends to be related to the composition of the host material.

Silcrete is normally grey in colour, but can be whitish/cream, red, brown or yellow. It shatters readily into sharp, angular pieces with a conchoidal fracture and newly broken rocks have a semi-vitreous sheen (Langford-Smith 1978:4). It was an attractive material to Aboriginal people because of its flaking properties and availability. Flakes have reasonably sharp, durable edges, and therefore the stone was used for a variety of tasks, including heavy-duty woodworking and for small spear barbs.

Two items of the Hastings River assemblage and six items of the Wilson River assemblage are silcrete. Two of the Wilson River items exhibit terrestrial cortex. The source of these items is uncertain.

Heat effects

Heat effects typically arising from unintentional heating were observed on 17 items within the combined assemblage. Mostly the heat effects were observed on acidic volcanics, but also on a single silcrete and two tuff items. The heat effects include convoluted or rugose fracture surfaces, potlid fractures or cracking (crazing) and geometric or planar fracturing. It is inferred that these effects have been caused by unintentional heating (for example, bush fires and camp fires).

Deliberate heat treatment, or thermal alteration, of stone is known to have commonly occurred in eastern Australia, but typically for silcrete, a material for which the flaking properties could be significantly improved. No evidence of intentional thermal alteration exists for the few silcrete items identified in the sub-surface assemblage.

Lithic item types recorded during sub-surface investigations

The Hastings River sub-surface assemblage is overwhelmingly dominated by complete flakes (13.2 per cent), flake portions (52.8 per cent) (including proximal, distal, medial and longitudinal portions) and lithic fragments (17.4 per cent). Cores comprise 6.2 per cent of the assemblage, with very low frequencies of other items such as utilised flakes (2.1 per cent), utilised flake portions (4.2 per cent) and retouched pieces (two), along with a single utilised geometric microlith, utilised piece, hammerstone and retouched flake (**Table 2**).

The larger Wilson River sub-surface assemblage is overwhelmingly dominated by complete flakes (24.7 per cent), flake portions (47.4 per cent) (including proximal, distal, medial and longitudinal portions) and lithic fragments (19.1 per cent). Low frequencies of other items occur, including non-descript cores (3.5 per cent), retouched flakes (0.76 per cent), utilised flakes (0.76 per cent), retouched pieces (0.5 per cent), utilised geometric microliths (0.5 per cent) and utilised bondi points (0.5 per cent), along with seven utilised flake portions, four core fragments, three bondi points, two bondi point tips, two geometric microliths, two backing flakes and a single utilised bondi point tip, retouched utilised piece, utilised piece, microblade and thumbnail scraper (**Table 3**).

Many of the categories in the sub-surface investigation assemblage, specifically the higher frequency ones such as flakes and flake portions and lithic fragments, represent debris from stone knapping. The knapping events can be non-specific (with complete flakes the outcome) or in some cases may relate to the production of microliths. Formal tool types are evidenced within several of the artefact categories (for example, bondi point and geometric microlith). These can provide relatively more information for interpretation, as they allow for greater assessment of on-site activities and traditional Aboriginal culture. The occurrence of each lithic item type is discussed below.

Lithic fragments

A total of 200 lithic fragments were identified in the Wilson River test area, representing 19.07 per cent of that assemblage (**Table 3**). A total of 25 lithic fragments were identified in the Hastings River test area, representing 17.36 per cent of that assemblage (**Table 2**). These are flaked pieces of stone which lack sufficient morphological attributes to identify them as a flake (a positive scar) or a core (only negative flake scars), but which are inferred to derive from knapping. Only three (1.3 per cent) of the lithic fragments display evidence of non-intentional thermal alteration, such as geometric shattering, potlidding or convoluted or rugose surfaces, indicating that overall most probably derive from human processes (ie knapping).

Lithic fragments occur predominantly in acidic volcanics in both assemblages (83.5 per cent of the Wilson River and 84 per cent of the Hastings River). The interpretive value of lithic fragments is primarily confined to the circumstantial evidence they provide regarding intensity of site use.

Flakes

A total of 259 complete flakes were identified in the Wilson River assemblage (excluding other typological categories such as utilised flakes and backing flakes), representing 24.7 per cent of the assemblage (**Table 3**). Nineteen complete flakes (13.2 per cent) occur in the Hastings River assemblage (**Table 2**). Flakes are defined here as complete flakes which have technologically diagnostic features and a ventral (sometimes termed positive) surface, usually with evidence of hard indenter initiation, or occasionally bending initiation, as well as a termination. This class of artefacts may represent:

- The fragmented debris of on-site knapping of primary flakes and microblades.
- Possibly backing retouch of implements.
- A small proportion of sundry, other on-site fracture of siliceous stone, such as accidental breakage of implements.

As per the overall Wilson River assemblage, flakes occur in virtually every stone material but predominantly acidic volcanics (78.8 per cent). Flakes range in size from class one to nine (ie up to 90 millimetres in maximum dimension), consistent with the overall small size of items in the artefact assemblage (**Table 4**). 83.4 per cent of flakes are less than 30 millimetres in maximum dimension.

In the smaller Hastings River assemblage, flakes predominantly occur on acidic volcanics (84.2 per cent). Flakes range in size from class one to seven (ie up to 70 millimetres in maximum dimension) (**Table 5**). 63 per cent of flakes are less than 30 millimetres in maximum dimension.

In addition to these recorded flakes, eight complete flakes at the Wilson River and three at the Hastings River display evidence, both microscopic and macroscopic, of utilisation. Therefore, while the flakes present within the assemblages predominantly represent debitage, items have also been manufactured or selected for specific use. An additional item at the Wilson River was recorded as a microblade, an elongated thin flake with a ridge in cross-section, that is inferred to have been a stage in the process of manufacturing backed artefacts (for example, bondi points). Two backing flakes were also identified at the Wilson River. These small flakes were presumably detached during the backing retouch of artefacts and are an important indicator of on-site microlith manufacture.

The nature of flake initiation and termination can reveal information regarding the potential strategies employed by Aboriginal people for both manufacturing particular kinds of artefacts as well as strategies for managing particular stone materials.

Five main types of flake platform were identified on the flakes from the combined assemblage:

- *Cortical initiation surface* – an initiation surface on a pebble or cobble.
- *Focused initiation surface* – an initiation surface area defined by a complete or partial Hertzian cone, sometimes with lateral extensions forming a narrow platform which less than twice the area of the ring crack.
- *Multiple scars fracture initiation surface* – an initiation surface which comprises more than one flake scar, including fracture surfaces that are faceted.
- *Plain fracture initiation surface* – an initiation surface which comprises a single flake scar or continuous cortex surface.
- *Crushed or uncertain initiation surface* – an initiation surface which has been largely obliterated during the reduction/knapping process, or which does not fall into another category.

Table 4 Maximum size class (10 millimetre increments) of artefacts by type for the Wilson River assemblage

Lithic type	Size class													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
bondi point		2	1											3
bondi point - tip		1	1											2
bondi point - utilised		4	1											5
bondi point -tip - utilised		1												1
flake	44	109	63	27	11	2	2		1					259
flake - backing	2													2
flake - distal	42	62	27	4										135
flake - distal - utilised	1	1												2
flake - longitudinal	10	20	25	11	3	1								70
flake - medial	21	45	11	1										78
flake - medial - utilised		1												1
flake - proximal	34	101	54	19	2	3				1				214
flake - proximal - utilised			1	3										4
flake - utilised		1	1	5	1									8
geometric microlith		1	1											2
geometric microlith - utilised		2	2	1										5
lithic fragment	65	103	26	6										200
microblade		1												1

Lithic type	Size class													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
non-descript core		5	5	5	6	3	4	6			2		1	37
non-descript core fragment		1	1	1		1								4
retouched flake		5		2		1								8
retouched piece		4	1											5
retouched utilised piece		1												1
thumbnail scraper	1													1
utilised piece			1											1
Total	**220**	**471**	**222**	**85**	**23**	**11**	**6**	**6**	**1**	**1**	**2**	**0**	**1**	**1049**

Table 5 Maximum size class (10 millimetre increments) of artefacts by type for the Hastings River assemblage

Lithic type	Size class													Total
	1	2	3	4	5	6	7	8	9	10	11	15	16	
flake	2	2	8	4		2	1							19
flake - distal		11	7	2		1		1						22
flake - longitudinal		7	5	4	3		1							20
flake - longitudinal - utilised			1		1									2
flake - medial	1	6	1	3										11
flake - medial - utilised		2					1							3
flake - proximal	1	6	9	3	1	2		1						23
flake - proximal - utilised				1										1
flake - utilised			2	1										3
geometric microlith - utilised			1											1
hammerstone										1				1
lithic fragment	5	8	7	4	1									25
non-descript core					3	1			1	1	1	1	1	9
retouched flake				1										1
retouched piece		1		1										2
utilised piece			1											1
Total	**9**	**43**	**42**	**24**	**9**	**6**	**3**	**2**	**1**	**2**	**1**	**1**	**1**	**144**

Plain fracture initiation surfaces are the most common, comprising 70.9 per cent of flakes retaining a platform in the Wilson River assemblage and 77.8 per cent in the Hastings River assemblage. Lower frequencies of crushed or uncertain (14 per cent at Wilson River, 16.7 per cent at Hastings River), focused (seven per cent at Wilson River, 5.6 per cent at Hastings River), multiple scar (6.6 per cent at Wilson River) and cortical (1.2 per cent at Wilson River) platforms occur.

Two forms of fracture or flake initiation, the point or area defining the beginning of a flake-forming fracture, were identified: Hertzian and bending. Hertzian initiation is predominant (96.5 per cent of flakes retaining a platform at the Wilson River and 100 per cent at the Hastings River), which arises from percussion and leads to the formation of a conchoidal flake. Bending initiation (commonly associated with soft hammer percussion and pressure flaking) was identified on only two items at the Wilson River (0.8 per cent).

Four main types of terminations were identified on the flakes from the sub-surface investigations:

- *Feather termination* – a normal ending to a flake, in which the fracture turns slightly to meet the fresh surface of the core at a very low angle, as in the ending of a feather.
- *Hinge termination* – when the end of the flake or fracture continuously turns at ninety degrees to the surface of the core or outside surface of the flake.
- *Outrepassé termination* – (also 'plunging') a flake with a thick ending caused by the flake-forming fracture turning inwards within the core. This occurs when the fracture front approaches the bottom of a core.
- *Step termination* – when the end of the flake turns sharply at ninety degrees to the surface of the core or outside surface of the flake.

The most readily distinguished feature of the fracture path in the formation of a flake is the manner in which it terminates. The fracture path itself is governed by two components of force – compression and bending. Because siliceous stone is extremely stiff, the bending component decays rapidly as the fracture forming the flake grows, especially after it forms the bulb of force. This leaves the compressive component of the force as the predominant control on the fracture path and is the reason why long, thin flakes can be detached from siliceous stone (Kuskie and Kamminga 2000).

When the fracture profile is without discontinuities in its slope, there are two basic terminations: feather and hinge. Feather is the most common and normally desirable termination. Feather terminations were recorded on 84 per cent of flakes at the Wilson River, and 94.4 per cent of flakes at the Hastings River, which retained a termination.

Hinge terminations are more likely to occur when the line of force responsible for the fracture has a larger bending component (Cotterell and Kamminga 1979:104-105, 1987, 2000). Hinge terminations were recorded on 8.2 per cent of flakes at the Wilson River, and 5.5 per cent at the Hastings River, which retained a termination.

A flake (or flake scar) which terminates abruptly in a break that essentially is at right angles to the previous fracture path is termed a step flake (or fracture). Two varieties can be recognised. One occurs in microblade knapping, when the pressure is insufficient to cause a complete flake to be removed from the core. To form this type of termination, the fracture must come to rest and be reinitiated, although the duration of the rest may be as short as a millisecond. Another possible cause for this kind of halt is the fracture encountering a flaw in the stone. The second type occurs if the flake is thin and bends or buckles under the flaking force, which results in the flake snapping in half by a second, transverse fracture (Kuskie and Kamminga 2000). Step terminations were recorded on 6.2 per cent of flakes which retained a termination at the Wilson River.

An outrepassé (or plunging) termination on a flake results from the abrupt turning inwards within the nucleus of a flake-forming crack. This termination may occur when the fracture front approaches the base of the nucleus and must turn because of imbalance in stresses on either side of the fracture front (Cotterell *et al* 1985:207). Such a flake takes off part of the base of the nucleus. If the fracture front turns sharply in the other direction the flake will terminate in a hinge. Outrepassé terminations are occasionally evident on microblades (and the negative scar on microblade cores), both in Australia and overseas. These fractures are caused by striking the core too far from its edge (Cotterell and Kamminga 1979:106, 1987, 2000). An outrepassé termination was recorded on one flake at the Wilson River.

Flake portions

A total of 497 flake portions were identified (excluding utilised portions) in the Wilson River assemblage (47.4 per cent) and 76 (52.8 per cent) in the Hastings River assemblage (**Table 2** and **Table 3**). Flake portions include:

- *Distal* – the end of a flake (the opposite to that of the point of fracture origin on the ventral [or inside] surface).
- *Longitudinal* – a flake longitudinally fractured from its proximal to its distal end. The breakage may be slightly tangential but are mostly axial in orientation. Such breakages tend to occur during knapping (such as longitudinal cone splits) rather than through post-depositional processes.
- *Medial* – a mid portion of a flake, exhibiting more than one breakage and no platform or termination.
- *Proximal* – the portion of a flake comprising the point of fracture origin on the ventral [or inside] surface.

As for flakes, these artefacts predominantly represent the fragmented debris of on-site knapping of primary flakes and microblades (debitage), although portions with use-wear clearly relate to the use of tools (refer below). As per the overall assemblage, flake portions predominantly occur in acidic volcanic stone (85 per cent of the Wilson River assemblage and 80% of the Hastings River assemblage).

Cores and core fragments

A total of 37 non-descript cores were identified at the Wilson River (3.5 per cent of the assemblage), along with four core fragments (**Table 3**). The cores include the largest items of that assemblage, within size classes 11 and 13 (**Table 4**). Consistent with the overall assemblage, 81 per cent of the cores are acidic volcanic, with four of lithic sandstone, two of silcrete and one of tuff. Seven of the cores are multi-directional, 15 are bi-directional and 15 are uni-directional. A maximum of 19 flake removal scars was recorded.

Nine non-descript cores were identified at the Hastings River (6.2 per cent) (**Table 2**). Four of these are lithic sandstone and five are acidic volcanics. These items are the largest of the assemblage, with five ranging in size class between nine and 16 (**Table 5**). Five of the cores are multi-directional, two are bi-directional and two are uni-directional. A maximum of nine flake removal scars was recorded. Seven cores exhibit terrestrial cortex and one waterworn cortex, but many had been reduced sufficiently that no cortex was recorded.

Cores generally comprise only a small fraction of an excavated stone artefact assemblage (often less than five per cent). Due to the sampling methodology (one square metre units), the entire suite of artefacts discarded in a reduction/knapping event is not necessarily retrieved (in contrast to broader area excavations) and a higher number of cores would be expected in proportion to debitage present in the assemblage. It is possible also that some cores may have been retained after initial on-site reduction and transported elsewhere (off-site) for additional use / reduction.

Retouched flakes and retouched pieces

Eight retouched flakes and five retouched pieces were identified in the Wilson River assemblage, with one retouched flake and two retouched pieces in the Hastings River assemblage (**Table 2** and **Table 3**). Apart from three chalcedony items, the remainder are acidic volcanics. All but one of the items is less than 40 millimetres in maximum dimension. A number of other retouched artefacts have been recorded in separate categories (for example, bondi points). It is assumed that many of these items were retouched for the purpose of creating tools, such as backed artefacts.

Utilised flakes, flake portions and pieces

In the Wilson River assemblage, use-wear was identified on eight flakes, seven flake portions, one retouched piece and one unretouched piece (in addition to that noted on specific implements such as bondi points). These items comprise 1.6 per cent of the Wilson River assemblage. Thirteen (76.5 per cent) of these items are acidic volcanic, two are tuff, one is breccia and one is chalcedony.

In the Hastings River assemblage, use-wear was identified on three flakes, six flake portions and one unretouched piece (in addition to that noted on specific implements). These items comprise a relatively high 6.9 per cent of the Hastings River assemblage. All but one of these items is acidic volcanic.

The cause of the use-wear is not known but may relate to light-duty cutting or scraping of wood or animal tissue or other plant material.

Bondi points

Eight complete bondi points, including five with use-wear, along with three bondi point tips (including one with use-wear) were identified in the Wilson River assemblage. No bondi points were identified in the Hastings River assemblage. Five of these items (45 per cent) are acidic volcanic, but a relatively high proportion are chalcedony (four), chert (one) and tuff (one). Discussion of the potential preferential use of stone materials for certain implements is presented below.

The presence of discarded utilised bondi points, bondi points without evidence of utilisation, and backing flakes, indicates that backed artefact manufacture occurred on-site and re-tooling/refitting also occurred, with utilised points discarded. This issue is discussed further below.

Bondi points are a form of microlith often found in artefact scatter sites dating to the mid-late Holocene. While the function of these finely fashioned implements is not known with certainty, most archaeologists consider that they were used in armatures of hunting and fighting spears (Mulvaney and Kamminga 1999:235-36). Microliths may have served as barbs, or else as lacerators intended to disable an enemy or prey by causing haemorrhage. It is possible that different microlith types were designed to serve these different functions. Alternative uses have been proposed for bondi points, including their use as cutting implements (*cf* Sokoloff 1977). Most recently, Fullagar (*et al* 1994) has inferred from residues on a small sample of bondi points from the Hunter Valley that they served as multi-functional tools. However, the evidence for use in spear armatures is persuasive and it could easily account for the range of residues observed.

Summarising the evidence for spear armatures (Kuskie and Kamminga 2000):

- The microliths are very small and often have very delicate shapes that are unsuitable for most tool-use activities.
- A use-wear study (Kamminga 1980) has suggested that most specimens in museum collections have not been used, but were lost during and after manufacture of batches of them, and that the occasional use-wear observed was at least consistent with spear armature use and inconsistent with a number of other possible activities.
- Traces of resin have been detected on excavated bondi points from the New England and Pilbara regions and the Hunter Valley (*cf*. Fullagar in Koettig 1994:48, McBryde 1985, Mulvaney and Kamminga 1999:236), suggesting that normally they were cemented onto a wooden shaft or handle.
- Specimens and associated manufacturing debris are commonly found in large quantities at archaeological sites (and in landscape units) across southern Australia, indicating that large numbers were required, more so than any other formally shaped implement type, which is consistent with an interpretation of spear armatures.
- The closest ethnographic analogue postulated for microliths is the barbing of the 'death spear' or 'dread spear', which was commonly used along the southern coasts of Australia for hunting and / or fighting (Mulvaney and Kamminga 1999:292-93). Small jagged fragments of stone (usually quartz) were embedded in series into a layer of resin (sometimes referred to as gum) smeared on the head of a single piece wooden shaft. In some cases, grooves were carved into the wooden shaft to accommodate the stone barbs, but this was not a universal practice. It is not known if the sharp flakes cemented onto these spears were 'backed' by careful knapping, but such a practice would have allowed them to be fixed in a groove incised into the spear shaft, or maximised adhesion of the resinous cement. The barbed point of death spears was about 15 to 30 centimetres long, with up to about seven to 14 sharp stone flakes or fragments for single-sided armature and about 14 to 28 fragments for double-sided armature. For a spear armed with bondi points, the ranges may have varied from these figures.
- Australian microliths are potentially comparable to microliths fixed onto spears and arrows preserved in Stone Age and Metal Age sites in Europe and Africa.

Geometric microliths

Geometric microliths are a type of microlith that was probably also used as a spear barb (refer above). One utilised acidic volcanic geometric microlith was identified at the Hastings River, along with five utilised and two other geometric microliths at the Wilson River. Five of these at the Wilson River are acidic volcanic, one chert and one tuff.

Thumbnail scraper

A single chalcedony thumbnail scraper was identified at the Wilson River. Thumbnail scrapers are tiny retouched tools, made from flakes struck from microblade cores. Generally, thumbnail scrapers are uncommon implements in any assemblage. It is unlikely they were commonly used to scrape wood or other resistant materials, since they seldom exhibit abrasive smoothing and use-rounding wear on their retouched edges, and few are repeatedly resharpened to an exhausted 'slug' form, which is common for flake scrapers and adzes (Kuskie and Kamminga 2000). Mulvaney and Kamminga (1999:236-37) suggest that a proportion of those identified in microlithic assemblages may have been components of a spear armature ensemble.

Hammerstone

A single acidic volcanic hammerstone was identified at the Hastings River. With a maximum dimension of 100 millimetres it is one of the larger items in the assemblage. Hammerstones were used as percussive instruments to flake pieces of stone ('cores') or in applying controlled pressure to retouch a tool's edge.

Retouch / use-wear

For each excavation assemblage, a comparison is made in **Table 6** and **Table 7**of the frequency of retouched and/or utilised artefacts, for each stone material type. The results clearly demonstrate the preferential use of the highly siliceous, homogenous stone materials chalcedony, chert and tuff, with good conchoidal fracture properties, for backing and/or use as small tools.

At the Wilson River, although chalcedony forms just 2.1 per cent of non-retouched and/or utilised items (or just 2.76 per cent of the overall assemblage), the frequency of artefacts with retouch and/or use-wear that are made of chalcedony is substantially higher (16.3 per cent). Similarly, chert only forms 1.9 per cent of non-retouched and/or utilised items (or just 2.0 per cent of the overall assemblage), whereas the frequency of chert artefacts with retouch and / or use-wear is higher (4.1 per cent). Tuff displays a similar trend, comprising 2.9 per cent of non-retouched and / or utilised items (or just 3.15 per cent of the overall assemblage), whereas the frequency of artefacts with retouch and/or use-wear that are made of tuff is substantially higher (8.2 per cent).

Although a smaller assemblage is present at the Hastings River, a similar trend in the preferential use of chalcedony is evident. Although chalcedony forms just 0.8% of non-retouched and/or utilised items (or just 2.08 per cent of the overall assemblage), the frequency of artefacts with retouch and/or use-wear that are made of chalcedony is substantially higher (14.3 per cent).

Table 6 Retouched and utilised artefacts by stone types for Wilson River test assemblage

Retouch / use-wear	Lithic type	Acidic volcanic	Breccia	Chalcedony	chert	Tuff	Other stone types	Total	Frequency (%) of total assemblage
Retouched	Bondi point	1		1	1			3	0.29%
	Bondi point - tip	1		1				2	0.19%
	Geometric microlith	2						2	0.19%
	Retouched flake	6		2				8	0.76%
	Retouched piece	5						5	0.48%
	Thumbnail scraper			1				1	0.10%
	Total retouched (#)	15	0	5	1	0	0	21	2.00%
	Total retouched (%[1])	71.4%	0%	23.8%	4.8%	0%	0%	100%	
Utilised	Flake portion - utilised	5		1		1		7	0.67%
	Flake - utilised	6	1			1		8	0.76%
	Utilised piece	1						1	0.10%
	Total utilised (#)	12	1	1	0	2	0	16	1.52%
	Total utilised (%[1])	75.0%	6.2%	6.2%	0%	12.5%	0%	100%	
Retouched/ utilised	Bondi point - utilised	2		2		1		5	0.48%
	Bondi point -tip - utilised	1						1	0.10%
	Geometric microlith - utilised	3			1	1		5	0.48%

Retouch / use-wear	Lithic type	Acidic volcanic	Breccia	Chalcedony	chert	Tuff	Other stone types	Total	Frequency (%) of total assemblage
	Retouched utilised piece	1						1	0.10%
	Total retouched / utilised (#)	7	0	2	1	2	0	12	1.14%
	Total retouched / utilised (%[1])	58.3%	0%	16.7%	8.3%	16.7%	0%	100%	
	Grand total	34	1	8	2	4	0	49	4.67%
	Overall frequency (%[1])	69.4%	2.0%	16.3%	4.1%	8.2%	0%	100%	
Not retouched/ utilised	**Total Not Retouched/Utilised (#)**	830	0	21	19	29	101	1000	95.33%
	Total Not Retouched/Utilised (%)	83.0%	0%	2.1%	1.9%	2.9%	10.1%	100%	

[1]Frequency of retouched and/or utilised items per stone type.

Table 7 Retouched and utilised artefacts by stone types for Hastings River test assemblage

Retouch / use-wear	Lithic type	Acidic volcanic	Chalcedony	Other stone types	Total	Frequency (%) of total assemblage
Retouched	Retouched flake	1			1	0.69%
	Retouched piece	1	1		2	1.39%
	Total retouched (#)	2	1	0	3	2.08%
	Total retouched (%[1])	66.7%	33.3%	0%	100%	
Utilised	Flake portion - utilised	6			6	4.17%
	Flake - utilised	2	1		3	2.08%
	uUtilised piece	1			1	0.69%
	Total utilised (#)	9	1	0	10	6.94%
	Total utilised (%[1])	90.0%	10.0%	0%	100%	
Retouched/ utilised	Geometric microlith - utilised	1			1	0.69%
	Total retouched / utilised (#)	1	0	0	1	0.69%
	Total retouched / utilised (%[1])	100%	0%	0%	100%	
	Grand total	12	2	0	14	9.72%
	Overall frequency (%[1])	85.7%	14.3%	0%	100%	
Not retouched/ utilised	**Total not retouched/ utilised (#)**	104	1	25	130	90.27%
	Total not retouched/ utilised (%)	80.0%	0.8%	19.2%	100%	

[1]Frequency of retouched and/or utilised items per stone type.

Activity types and activity areas

Identification and assessment of variations in spatial patterning of human occupation can assist greatly with interpretation of the evidence and provide meaningful information about the human behaviour that created this evidence.

In order to assess the research questions relating to both internal and comparative site structure, an analysis is utilised that Kuskie and Kamminga (2000) developed and used with success at the Black Hill/Woods Gully salvage. Primarily this analysis is conducted by examining the distribution of certain artefact and stone material types to determine notional activity types and areas. These activity areas are hypothetical frameworks which were developed to potentially reflect the way that people may have organised their use of space in relation to other activities and other factors (Boismier 1991:19, Kuskie and Kamminga 2000:449).

In this way an 'activity' refers to specific behaviour which results in the discard of a certain item. It should be noted that many Aboriginal activities will be ephemeral or invisible within the archaeological record and cannot be strictly verified through archaeological means. It is also noted that application of this technique is more suitable to large-scale broad area hand excavations, rather than smaller, spatially separate test units.

An 'activity area' refers to a single location in which one or more activity events have resulted in the discard of items that constitute archaeological evidence. Activity events are synonymous with discard events, that is, the discard of lithic item(s) resulting from a single action performed during an activity. Activity areas represent concentrations of artefacts produced by activities carried out by people following some form of organisational strategy during a particular occupation (Boismier 1991:19). These activities include tool manufacture and repair, cooking, food processing and the disposal of refuse (Kuskie and Kamminga 2000:449-452). The lithic item indicators of specific human activities relevant to the test assemblages are listed in **Table 8**.

One of the fundamental ways of identifying specific prehistoric activity areas is through analysis of the composition and patterning of lithic assemblages. Optimum results are obtained when the artefacts represent a single episode of activity or occupation and the patterns are not obscured by repeated cultural discard during subsequent use of the site (superimpositioning). Even when there are long intervals between reoccupation, the artefacts from different periods may become mixed because of low rates of sedimentation and processes of bioturbation. However, while such mixed assemblages pose considerable problems in interpretation, as several studies have demonstrated, meaningful interpretations may still be derived from activity analyses (Kuskie and Kamminga 2000:449-452, Kuskie and Clarke 2004).

Various taphonomic processes can affect open sites. The nature of post-depositional disturbance to the test excavation evidence has been outlined above. It is inferred that some relatively in situ evidence is present, while a portion of the evidence has been subject to post-depositional impacts resulting in horizontal or more commonly vertical displacement of items.

The sorts of problems and issues that arise with interpretation of activity areas *(cf* Boismier 1991, Binford 1991, Schick 1986) include the:

- Effects of post-depositional processes.
- Effects of chronological variations (time of occupation when discard occurred).
- Effects of multiple occupations on the form and content of sites and activity areas.
- Effects of extended-length occupations on the form and content of sites and activity areas.
- The extent to which artefact class distributions represent patterning of occupation.
- The extent to which qualitative and quantitative differences represent different functions.
- Import of items on-site and removal of items off-site.
- Effects of human behaviour such as 'tossing' or 'dumping' artefacts (Kuskie and Kamminga 2000:449-452).

Boismier (1991:19) suggests that to address these problems, temporally diagnostic classes, technological classes and morphological and functional classes are needed. We have attempted to control for these issues to the extent possible in this analysis and interpretation, following Kuskie and Kamminga (2000).

Binford (1978:356) has suggested that spatial patterning of discard material does not necessarily mirror the distribution of activities, since dispersal patterns arising from 'tossing' or 'dumping' may produce distributions that are inversely related to the patterns of use activity. However, while artefacts may have been moved around a camp and away from the location where they were knapped or used, or even off-site, small flakes and lithic fragments (flaked pieces) from implement production and tool-use tends to be incorporated rapidly into the sediment, and in the main are not significantly translocated by human agency during occupation. Elements of these small artefacts are therefore the essential markers of activity areas and foci. The process of linking larger artefacts to this associated micro-debitage by criteria such as specific spatial context and attributes of technology can assist in overcoming Binford's (1978) concerns (Kuskie and Kamminga 2000:449-452).

Five basic categories of activities were defined for the analysis and individual artefacts were assigned to each (**Table 6**). In general, these categories express the range of activities evident from the identifiable artefacts in the lithic assemblages:

- Non-specific stone flaking: general or non-specific knapping activity (artefacts do not identify a more specific activity; includes debitage from primary knapping events and from flake manufacture).
- Microblade production: a method of making small microlithic implements (for example, for backed artefacts) from regular elongated parallel sided flakes struck from a small core.
- Microlith production: backing retouch of microliths.
- Loss or intentional discard of microliths (complete and broken): the discard of backed artefacts either during manufacture, after use or unintentionally.
- Loss or intentional discard of non-microlith tools (including portions of tools): intentional discard after use or caching for future use of implements other than microliths.

In relation to the activity classes, it is important to note that different activities result in the production of different quantities of evidence. For example, microblade or microlith tool production can result in hundreds of artefacts from a single reduction event. Non-specific stone flaking can involve anything from a single to tens or even hundreds of discarded items. Different stone materials can also result in different quantities of discarded artefacts due to the mechanical and fracture properties of the stone. The techniques of reduction (for example, the way blows are applied) can also result in substantially different numbers of artefacts.

In contrast with the categories of non-specific stone flaking and microblade production, the categories of loss or intentional discard of microliths and discard of non-microlith tools generally involve very low numbers of discarded artefacts, which may correspond more closely with the number of activity events performed at a particular area.

Table 8 Lithic item indicators and counts and frequencies of activity types for each test area

Activity	Lithic type	Hastings River	Wilson River
Non-specific flaking	Flake	19	259
	Flake - distal	22	135
	Flake - longitudinal	20	70
	Flake - medial	11	78
	Flake - proximal	23	214
	Non-descript core	9	37
	Non-descript core fragment	0	4
	Lithic fragment	25	200
	Retouched flake	1	8
	Retouched piece	2	5
	Total non-specific flaking	**132**	**1010**
	Frequency non-specific flaking	**91.7%**	**96.3%**
Microblade production	Microblade	0	1
	Total microblade production	**0**	**1**
	Frequency microblade production	**0%**	**0.1%**
Microlith production	Flake - backing	0	2
	Total microlith production	**0**	**2**
	Frequency microlith production	**0%**	**0.2%**
Loss or intentional discard of microliths	Geometric microlith	0	2
	Geometric microlith - utilised	1	5
	Bondi point	0	3
	Bondi point - utilised	0	5
	Bondi point - tip	0	2
	Bondi point - tip - utilised	0	1
	Total loss of microliths	**1**	**18**
	Frequency loss of microliths	**0.7%**	**1.7%**

Activity	Lithic type	Hastings River	Wilson River
Loss or intentional discard of non-microlith tools	Flake - distal - utilised	0	2
	Flake - longitudinal - utilised	2	0
	Flake - medial - utilised	3	1
	Flake - proximal - utilised	1	4
	Flake - utilised	3	8
	Hammerstone	1	0
	Retouched utilised piece	0	1
	Thumbnail scraper	0	1
	Utilised piece	1	1
	Total loss of non-microliths	**11**	**18**
	Frequency loss of non-microliths	**7.6%**	**1.7%**
Total		**144**	**1049**

As is consistent with the artefact types, the test excavation assemblages are overwhelmingly dominated by items representing non-specific stone flaking, for which the specific activities cannot be reliably inferred (**Table 8**). These items represent 91.7 per cent of the Hastings River assemblage and 96.3 per cent of the Wilson River assemblage. A proportion of this evidence may relate to the production of microliths and formal tools.

Specific activities are represented in the sub-surface assemblages in very low frequencies. Microblade and microlith production was identified only at the Wilson River, but with a very low frequency of specific indicators (0.1 per cent and 0.2 per cent respectively). The frequency of discard of microlithic tools was higher, being 0.7 per cent at the Hastings River and 1.7 per cent at the Wilson River. A low frequency of non-microlith tools was identified at the Wilson River (1.7 per cent) but an unusually high frequency was identified at the Hastings River (7.6 per cent). These results provide an indication of the potentially different use of these two areas by Aboriginal people.

Reconstruction of individual activity areas within the sub-surface investigations is limited by the small and spatially separate nature of the units. Typically a single square metre test unit only intersects a small portion of an activity area (where present and as distinct from background discard) and broad area hand excavation is generally required to effectively identify and delineate discrete activity areas. However, from examination of the distribution of artefacts and their nature (**Figure 1** and **Figure 2**) a number of activity areas can be inferred, including:

- Wilson River unit A5: Grey-green chert non-specific flaking, microlith production and discard of microliths (probable backed artefact production).
- Wilson River unit A10: Acidic volcanic non-specific flaking and discard of microliths.
- Wilson River unit A20: Yellow tuff discard of non-microlith tools.

- Wilson River unit A25: Grey-blue chalcedony discard of non-microlith tools.
- Wilson River unit A40: Yellow-cream, yellow and yellow-brown acidic volcanic non-specific flaking, microlith production, and discard of tuff and acidic volcanic non-microlith tools and microlith tools (probable backed artefact production and retooling of spears).
- Wilson River unit A45: Discard of tuff microlith tools.
- Wilson River unit A50: Grey-green chalcedony non-specific flaking and discard of non-microlith tools.
- Wilson River unit A65: Discard of chalcedony and acidic volcanic microlith tools.
- Wilson River unit A80: Acidic volcanic non-specific flaking and discard of microlith and non-microlith tools.
- Wilson River unit A95: Acidic volcanic non-specific flaking, microblade production and discard of non-microlith tools, along with discard of chert microliths (probable backed artefact production and retooling).
- Wilson River unit B0: Grey-red chalcedony non-specific flaking and discard of acidic volcanic microliths and non-microlith tools.
- Wilson River unit B5: Grey-blue and yellow acidic volcanic non-specific flaking, discard of acidic volcanic microliths and discard of acidic volcanic and breccia non-microlith tools.
- Wilson River unit B10: Acidic volcanic non-specific flaking and discard of microliths.
- Wilson River unit B15: Discard of chalcedony microlith.
- Wilson River unit B35: Cream-yellow acidic volcanic non-specific flaking.
- Wilson River unit B40: Discard of acidic volcanic microlith.
- Wilson River unit B45: Acidic volcanic non-specific flaking and discard of microliths.
- Hastings River unit F5: Grey acidic volcanic non-specific flaking, discard of microliths and discard of non-microlith tools.
- Hastings River unit F30: Grey-pink acidic volcanic discard of non-microlith tools.
- Hastings River unit F75: Grey acidic volcanic discard of non-microlith tools.
- Hastings River unit F110: Grey acidic volcanic discard of non-microlith tools.
- Hastings River unit G40: Acidic volcanic discard of non-microlith tool (hammerstone) and non-specific flaking.
- Hastings River unit G45: Lithic sandstone non-specific flaking.
- Hastings River unit G50: Grey acidic volcanic discard of non-microlith tool.

Spatial distribution of evidence

The spatial distribution of evidence within the test areas can be examined to determine whether there are focal points of activity or particular relationships between Aboriginal behaviour and aspects of the locality's environment. Several factors are analysed, including class of slope, landform unit and environmental context. However, it is emphasised that the nature of the sample (in terms of area / volume excavated and/or quantity of artefacts retrieved) is relatively small and limited in variability, and therefore caution must be applied in making inferences from such data.

Table 9 Summary of sub-surface investigation area artefact density for environmental variables

Test area	Site	Units	Class of slope	Landform unit	Number of artefacts	Mean artefact density per conflated m^2	Total excavated (m^3)	Mean artefact density per m^3
Hastings River	OHK 46	G0-5, G25-50, F0-10, F20-30	level-very gentle	spur crest	99	7.1	5.40	18.3
Hastings River	OHK 47	F35-F110	gentle	simple slope	43	2.7	5.21	8.2
					142* (total)	**4.7* (mean)**	**10.61**	**13.4* (mean)**
Wilson River	OHK 90	A0-80, B0-20	level-very gentle	ridge crest	867	39.4	7.28	119.1
Wilson River	OHK 91	A85-95	gentle	ridge crest	73	24.3	0.94	77.6
Wilson River	OHK 92	B35-50	gentle	simple slope	91	22.8	1.36	66.9
					1031* (total)	**35.5* (mean)**	**9.58**	**107.6* (mean)**

* Excludes unprovenanced artefacts; 2 in Hastings River and 18 in Wilson River.

Class of slope

Two classes of slope or gradient, as defined after McDonald *et al* (1984), were excavated (**Table 1**):

- Level to very gently inclined slopes < three per cent (1°45´).
- Gently inclined slopes > three per cent (1°45´) and <10 per cent (5°45´).

Artefact density averages 76.18 per metre cubed (26.83 artefacts/conflated metre squared) on the level-very gentle slope, compared with 27.56 per metre cubed (9.00 artefacts/conflated metre squared) on the gentle slope (**Table 9** and **Table 10**). The results indicate a trend for higher density (and presumably more Aboriginal activity) on areas of lower gradient, consistent with the results of excavations elsewhere in southeastern Australia. There is typically a strong correlation between higher artefact density and lower gradient, reflecting a greater focus of Aboriginal activity on more level ground (*cf* Kuskie 2000).

Table 10 Summary of artefact density for class of slope for the sub-surface investigation assemblage

Slope class	Area excavated (m^2)	Volume excavated (m^3)	Number of artefacts	Mean artefact density per conflated m^2	Mean artefact density per m^3
level-very gentle	36	12.68	966	26.83	76.18
gentle	23	7.51	207	9.00	27.56
Total/Mean	**59**	**20.19**	**1173**	**19.88**	**58.10**

Table 11 Frequency of artefact types per class of slope

Lithic type	Slope class	
	level-very gentle	gentle
bondi point	0.31%	
bondi point - tip	0.21%	
bondi point - utilised	0.41%	0.48%
bondi point - tip - utilised		0.48%
flake	24.43%	18.84%
flake - backing	0.21%	
flake - distal	12.53%	16.43%
flake - distal - utilised	0.21%	
flake - longitudinal	6.94%	9.18%
flake - longitudinal - utilised	0.21%	
flake - medial	6.83%	9.18%
flake - medial - utilised	0.31%	0.48%

Lithic type	Slope class	
	level-very gentle	gentle
flake - proximal	19.25%	23.19%
flake - proximal - utilised	0.41%	0.48%
flake - utilised	1.04%	0.48%
geometric microlith	0.21%	
geometric microlith - utilised	0.41%	0.48%
hammerstone	0.10%	
lithic fragment	19.77%	14.98%
microblade		0.48%
non-descript core	4.14%	2.90%
non-descript core fragment	0.41%	
retouched flake	0.83%	0.48%
retouched piece	0.41%	1.45%
retouched utilised piece	0.10%	
thumbnail scraper	0.10%	
utilised piece	0.21%	
Total	**100%**	**100%**

To further address this issue however, examination can be made of the site contents (for example, artefact, stone and activity types) between the different classes of slope (**Table 11**, **Table 12** and **Table 13**). The general numbers of different artefact types and stone material types within the different classes of slope are consistent with the size of each sample. There tends to be a strong correlation between the size of a sample and the range of different artefact and stone types (ie the larger the sample, the greater the range or diversity: Kuskie and Kamminga 2000, Kuskie and Clarke 2004). This assemblage is no different, with the level-very gently inclined terrain class bearing both the highest artefact numbers and greater diversity of types and stone materials.

Similarly, the frequency of artefact types, stone material types and activity types also varies depending on the size of the sample, but is generally similar between the two classes of slope (**Table 11**, **Table 12** and **Table 13**). Microlith production is absent from the gentle slope and microblade production is absent from the level-very gentle slope, but these anomalies are likely to reflect the small sample sizes. The results generally indicate that similar activities occurred on both classes of slope and in relatively similar proportions.

Table 12 Frequency of stone types per class of slope

Stone material	Slope class	
	level-very gentle	gentle
acid volcanic	82.3%	79.71%
breccia	0.10%	
chalcedony	3.00%	1.45%
chert	2.07%	0.48%
crystal quartz	0.83%	3.38%
lithic sandstone	3.73%	4.35%
quartz	3.62%	9.66%
quartzite	0.10%	
silcrete	0.72%	0.48%
siltstone	0.10%	
tuff	3.42%	0.48%
Total	100%	100%

Table 13 Count and frequency of activity types per class of slope

Activity type	Slope (count)		Slope (frequency)	
	level-very gentle	gentle	level-very gentle	gentle
non-specific flaking	923	200	95.55%	96.62%
microblade production		1		0.48%
microlith production	2		0.21%	
loss or discard of microliths	15	3	1.55%	1.45%
loss or discard of non-microlith tools	26	3	2.69%	1.45%
Total	966	207	100%	100%

Landform unit

Following the definitions of McDonald *et al* (1984) the sub-surface investigation areas can be subdivided into specific types of topographical features referred to as landform elements or landform units. The areas tested comprise three landform units, simple slope, spur crest and ridge crest.

Artefact density averages 114.36 per metre cubed (37.6 artefacts/conflated metre squared) on the ridge crest, compared with 20.4 per metre cubed (6.7 artefacts/conflated metre squared) on the simple slope and 18.33 per metre cubed (7.07 per metre squared) on the spur crest (**Table 14**). Hence, the results indicate a trend for increased Aboriginal activity (resulting in artefact discard) on the ridge crest unit, compared with the simple slope and spur crest units. To assess this variable further, examination can be made of the site contents (artefact, stone and activity types) between the different landform units (**Table 15**, **Table 16** and **Table 17**).

The ridge crest hosts the highest artefact count of the three landform units and also the greatest diversity of artefact types. This may relate to the sample size (ie the larger the sample, the greater the range or diversity). In terms of the frequency of specific artefact types (**Table 15**), no discernible trends are evident and the main types occur in relatively similar proportions.

The frequency of activity types is also generally similar (**Table 17**), with the exception of a higher frequency of loss or discard of non-microlith tools on the spur crest, along with the presence of microblade and microlith production only on the ridge crest. One possible explanation is that Aboriginal use of the spur crest (Hastings River) differed somewhat from the ridge crest (Wilson River), with proportionately less knapping activity and a higher use or discard of tools that may have been used for working plant or animal material on the Hastings River spur crest, whereas backed artefact production occurred on the Wilson River ridge crest. Alternatively, the absence of evidence of microblade and microlith production on the spur crest and simple slope, and the relatively higher frequency of non-microlith tool discard on the spur crest, could also be a factor of the relatively smaller sample sizes in these contexts. This issue is explored further below.

In regards to stone type, despite the differences in sample sizes, nine types occur on both the ridge and spur crests, with seven on the simple slopes (**Table 16**). Nevertheless, acidic volcanics are dominant in all contexts, but lithic sandstone is proportionately more common on the spur crest and quartz on the simple slope. This contrast may be a result of sampling factors, or possibly reflect the differential use of stone materials within the landscape.

Table 14 Summary of artefact density for landform unit for the sub-surface investigation assemblage

Landform unit	Area excavated (m^2)	Volume excavated (m^3)	Number of artefacts	Mean artefact density per conflated m^2	Mean artefact density per m^3
simple slope	20	6.57	134	6.70	20.40
spur crest	14	5.40	99	7.07	18.33
ridge crest	25	8.22	940	37.60	114.36
Total/Mean	59	20.19	1173	19.88	58.10

Table 15 Frequency of artefact types per landform unit

Lithic type	Landform unit		
	simple slope	spur crest	ridge crest
bondi point			0.32%
bondi point - tip			0.21%

Lithic type	Landform unit		
	simple slope	spur crest	ridge crest
bondi point - utilised	0.75%		0.43%
bondi point - tip - utilised	0.75%		
flake	14.93%	11.11%	25.96%
flake - backing			0.21%
flake - distal	18.66%	12.12%	12.55%
flake - distal - utilised			0.21%
flake - longitudinal	9.70%	16.16%	6.06%
flake - longitudinal - utilised		2.02%	
flake - medial	11.94%	7.07%	6.60%
flake - medial - utilised	0.75%	2.02%	0.11%
flake - proximal	20.15%	16.16%	20.32%
flake - proximal - utilised	0.75%		0.43%
flake - utilised		3.03%	0.85%
geometric microlith			0.21%
geometric microlith - utilised		1.01%	0.43%
hammerstone		1.01%	
lithic fragment	14.93%	18.18%	19.57%
microblade			0.11%
non-descript core	3.73%	7.07%	3.62%
non-descript core fragment			0.43%
retouched flake	0.75%		0.85%
retouched piece	2.24%	2.02%	0.21%
retouched utilised piece			0.11%
thumbnail scraper			0.11%
utilised piece		1.01%	0.11%
Total	**100%**	**100%**	**100%**

Table 16 Frequency of stone types per landform unit

Stone material	Landform unit		
	simple slope	spur crest	ridge crest
acid volcanic	77.62%	77.77%	82.87%
breccia			0.11%

Stone material	Landform unit		
	simple slope	spur crest	ridge crest
chalcedony	0.75%	3.03%	2.98%
chert			2.23%
crystal quartz	5.22%	3.03%	0.53%
lithic sandstone	1.49%	10.10%	3.51%
quartz	13.43%	2.02%	3.72%
quartzite		1.01%	
silcrete	0.75%	1.01%	0.64%
siltstone		1.01%	
tuff	0.75%	1.01%	3.40%
Total	**100%**	**100%**	**100%**

Table 17 Count and frequency of activity types per landform unit

Activity type	Landform unit (count)			Landform unit (frequency)		
	simple slope	spur crest	ridge crest	simple slope	spur crest	ridge crest
non-specific flaking	130	89	904	97.01%	89.90%	96.17%
microblade production			1			0.11%
microlith production			2			0.21%
loss or discard of microliths	2	1	15	1.49%	1.01%	1.60%
loss or discard of non-microlith tools	2	9	18	1.49%	9.09%	1.91%
Total	134	99	940	100%	100%	100%

Environmental / cultural contexts

The landscape of the study area can be subdivided into discrete, recurring areas of land for which it is assumed that the Aboriginal land use and resultant heritage evidence in one location may be extrapolated to other similar locations. These 'environmental contexts' or 'archaeological terrain units' are defined on the basis of two environmental variables:

- Firstly, *landform element* (following the definitions of McDonald *et al* 1984).
- Secondly, *class of slope* (following McDonald *et al* 1984).

The sub-surface investigations have included samples of four environmental contexts (level-very gentle spur crest, gentle simple slope, level-very gentle ridge crest and gentle ridge crest) (**Table 9**). Gentle simple slopes occupy 31.7 per cent of the overall undisturbed study area, gentle spur crests 6.6 per cent, level-very gentle ridge crests 0.63 per cent and gentle ridge crests 0.11 per cent.

However, evidence within a single archaeological terrain unit or environmental context can also vary, in relation to different usage of the area by Aboriginal people. For example, a particular spur crest may lead from a ridgeline used for transitory movement to a camp site bordering a food resource, whereas another spur crest may lead to a stone material source. Individual survey areas on these spur crests may host different types and proportions of evidence, reflecting different ways in which these landforms were utilised. Hence, a series of cultural sub-contexts can also be identified in an attempt to encompass the potential range of variation in heritage evidence within each environmental context. These units are termed *environmental/cultural contexts* (after Kuskie 2000).

In relation to the Hastings River and Wilson River test excavation areas, there is no obvious further subdivision beyond the environmental context level, given that both are situated similar distances from the rivers and coastal environments and multiple resource zones, and have a similar underlying geology. Both areas represent the margins of the coastal hills where they meet the coastal plain, albeit that the hills in the Wilson River area tend to be more steeply inclined and of a higher elevation than the hills in the Hastings River area. Further subdivision is only necessary if comparing these ridges with others (for example, greater than one kilometre from a major river), on which basis proximity to major water source / subsistence resource zone could be expected to be a factor in the nature and distribution of evidence within the same environmental contexts.

Table 18 Summary of sub-surface investigation area artefact density for environmental contexts

Environmental context	Plan area excavated (m^2)	Volume excavated (m^3)	Number of artefacts	Mean artefact density per conflated m^2	Mean artefact density per m^3
level- very gentle spur crest	14	5.40	99	7.1	18.3
level- very gentle ridge crest	22	7.28	867	39.4	119.1
gentle ridge crest	3	0.94	73	24.3	77.6
gentle simple slope	20	6.57	134	6.7	20.4
Total	**59**	**20.19**	**1173***	**19.9* (mean)**	**58.1* (mean)**

* Excludes unprovenanced artefacts; 2 in Hastings River and 18 in Wilson River.

The mean artefact densities between each environmental context are compared in **Table 18**. In terms of environmental context (combination of landform unit and class of slope), there are markedly higher artefact densities in the level-very gentle ridge crest and to a lesser extent the gentle ridge crest contexts, than on the gentle simple slope or level-very gentle spur crest contexts. This reflects the differences between the Wilson River and Hastings River excavation results, with the ridge crest at the Wilson River containing markedly higher densities than the spur crest at the Hastings River. A comparison between the samples of gentle simple slope excavated at each location confirms this result (**Table 9**), with the mean density significantly higher at the Wilson River (66.9 per metre cubed compared with 8.2 per metre cubed).

Intra-Site Distribution

The sub-surface investigations of the locations at the Wilson River and Hastings River reveal variations in the internal distribution of evidence within each site. Variations have been identified above in relation to environmental factors, however within the same environmental contexts there is also spatial patterning of evidence, typical of open artefact sites.

At the Hastings River, a generally low density of artefacts is present, consistent with background discard (manuport and artefact material which is insufficient either in number or in association with other material to suggest focused activity in a particular location; *cf*. Rich 1993, Kuskie and Kamminga 2000), interspersed by several discrete clusters of artefacts, representing activity areas (refer to **Figure 1**). One cluster occurs in unit F5 and represents an activity area involving non-specific flaking, discard of microliths and discard of non-microlith tools. Other clusters occur in units G40 (non-specific flaking and discard of non-microlith tool {hammerstone}) and G45 (non-specific flaking). All three activity areas occur on the level-very gentle spur crest, whereas other units in this context have evidence consistent with background discard.

At the Wilson River, a number of artefact clusters are present (for example, units A10, A15, A40, A45, A80, A95, B5, B10 and B45, refer to **Figure 2**), including several of very high density (for example,. unit A40, with 372 artefacts per meter squared or 1075 artefacts per metre cubed). A number of these clusters contain evidence of discrete activity areas, including backed artefact production at units A5, A40 and A95. However, at other clusters, the nature of discrete activities could not be inferred, and there may be mix of different stone materials. In these cases, the higher artefact counts have either arisen through discrete knapping activities that could not be identified (for example, due to the sample only intersecting the margin of the activity area, or an insufficient portion of the activity area having been excavated to confidently identify it), or through superimpositioning of evidence over time. In the latter case, repeated visits to a site and discard of material can cause unrelated artefacts to accumulate in a location, giving the appearance of a cluster, but not having formed through a single occupation activity.

Therefore, the Wilson River location can be characterised as an area with a moderate number of discrete activity areas, along with a generally moderate density of artefacts that may represent background discard (accumulated over time through superimpositioning of evidence) or are in fact additional activity areas (that could not be clearly identified through the sample).

Conclusion

The sub-surface investigations of the locations at the Wilson River and Hastings River have demonstrated some distinct patterning of evidence, both in relation to environmental variables and internal site structure. The primary conclusions are that:

- There is a significant difference in the quantity and density of evidence, and by inference the intensity of site use, between the Wilson River and Hastings River locations. Substantially more evidence was located at the Wilson River.
- There is a trend for higher artefact density, and by inference intensity of Aboriginal occupation, on level-very gentle slopes rather than gentle slopes.
- There is a trend for higher artefact density, and by inference intensity of Aboriginal occupation, on ridge crests rather than spur crests and simple slopes. This was also identified through analysis of the survey results.

- There is a trend for higher artefact density, and by inference intensity of Aboriginal occupation, within the level-very gentle ridge crest and to a lesser extent the gentle ridge crest contexts, than on the gentle simple slope or level-very gentle spur crest contexts. The survey results also identified a trend for higher artefact density on gentle ridge crests and to a lesser extent level-very gentle ridge crests, than in other contexts.
- Backed artefact production was only conclusively identified on the ridge crest at the Wilson River, while a higher frequency of loss or discard of non-microlith tools occurred on the spur crest at the Hastings River. While this could be a result of sampling issues, a possible explanation is different Aboriginal use of these areas.
- The Hastings River excavation area is characterised by a generally low density of artefacts, consistent with background discard, interspersed by a low number of discrete clusters of artefacts which represent activity areas.
- The Wilson River excavation area is characterised by a moderate number of discrete activity areas, along with a generally moderate density of artefacts that may represent background discard (accumulated over time through superimpositioning of evidence) or in fact represent additional activity areas (that could not be clearly identified through the sample).
- At the Wilson River, at least one artefact cluster/activity area is of a relatively high density by southeastern Australian standards (unit A40, with 372 artefacts per metre squared or 1075 artefacts per metre cubed).

Given the similar broader environmental context of the two excavation areas (similar distances from major rivers, coastal environments and multiple resource zones, and similar landform pattern and underlying geology), further comparison of environmental variables is not feasible. Cultural choice may have played a role in the differential use of the Wilson and Hastings river areas. The excavation data remains available for comparison should similar excavations be undertaken within different environmental contexts in the region (such as closer to or further distant from major rivers / multiple resource zones, or in different landform patterns, landform units or classes of slope).

Potential resource

A predictive assessment based on the test excavation results can be made of the potential quantity of artefacts present in the survey areas subject to test excavation. Based on the mean artefact density from each environmental context within each test area, and extrapolation of this data to the total area of each specific survey area represented by that environmental context, a potential resource of around one million artefacts can be inferred at the Wilson River and 100,000 at the Hastings River (**Table 19**). Of course, these extrapolations are based on relatively small samples and may be inaccurate (higher or lower) by a substantial margin. They do highlight the potential quantities of stone artefact evidence that may be present within these narrow portions of the study area, and also give a glimpse of the substantial body of evidence that must exist in similar contexts outside of the study area.

Table 19 Potential quantity of stone artefacts in survey areas subject to sub-surface investigation based on extrapolations from the mean density of artefacts in the excavations

Survey area	Environmental context	Number of artefacts retrieved by sub-surface investigation in context	Mean artefact density per conflated m^2	Approximate total area of survey area (m^2)	Estimated total number of artefacts
OHK 46	level-very gentle spur crest	99	7.1	9,485	67,344
OHK 47	gentle simple slope	43	2.7	12,972	35,024
OHK 90	level-very gentle ridge crest	867	39.4	7,713	303,892
OHK 91	gentle ridge crest	73	24.3	5,187	126,044
OHK 92	gentle simple slope	91	22.8	27,622	629,781
		1173 (total)	**19.9 (mean)**	**62,979 (total)**	**1,162,085 (total)**

Chronology

The potential age of the excavation evidence can be assessed in relation to two criteria: artefact typology and geomorphology. In terms of direct dating, no charcoal from an identifiable cultural context (such as hearths or shell middens) was obtained during the sub-surface investigations. A very small quantity of shell fragments was retrieved from the Hastings River test area. This comprised single fragments of possibly mud oyster shell (weight <0.1 grams) in unit G25 spit 1 and unit G30 spit 2. While it is possible that this shell represents the decayed remnants of shellfish brought to the site for human consumption, firm conclusions are not possible from such tiny fragments. These samples were not suitable for radiocarbon or AMS (Accelerator Mass Spectroscopy) dating.

The soil deposits on the elevated land are assumed to have formed from polygenetic processes and the soils reflect the influence of both pedological and sedimentary depositional phenomena. The A unit soils are in a constant state of formation and transformation, through *in situ* weathering processes of underlying bedrock and subsequent downslope movement through bioturbation / erosion processes. However, the extent to which these soils extend back in age is uncertain. Such soils are generally assumed to form relatively quickly (*cf* Dean-Jones and Mitchell 1993). Earlier A horizon deposits are being reworked and progressively moved downslope by the same processes. Hence at any given time in the past say 50,000 years, the A horizon soils may have been essentially the same as those occurring today. There may be no surviving stratigraphic signature of these earlier events. Locally, the A horizons from time to time may have been partially or entirely stripped by extreme erosion events, to be replaced by new materials transported from upslope or formed in situ by bioturbation (Hughes 2000).

Unless the A horizons are thick (at least 0.3 metres) and incorporate in situ older, dateable deposits in their basal levels, it will not be possible stratigraphically to distinguish older artefact assemblages from mid to late Holocene assemblages. Such is the case with the Hastings and Wilson River sub-surface investigation areas. Of course, the possibility that artefacts survive in the modern A horizon soil which are older than the sedimentological age of the unit itself cannot be discounted, although would be very difficult to determine archaeologically (*cf* Hughes 2000).

Hence in relation to the sub-surface investigations, the artefact evidence, rather than geomorphologic evidence, may provide the most useful information about the chronology of Aboriginal occupation.

Spear points fashioned by finely executed pressure flaking heralded the beginning of the 'Australian Small Tool Phase'. The best estimate for the common appearance of these points is 6000-5000 years BP (where present menas the year 1950 AD), which is the age range for specimens excavated from Nauwalabila rock shelter in Kakadu National Park, Northern Territory. The common appearances of the other implement types are spread over the succeeding millennia, and some even appear to be less than 1000 years old (Mulvaney and Kamminga 1999).

While there are claims of 6000 years BP or earlier for microblade technology and delicately retouched microliths, their more certain common occurrence in different regions dates to about 4000 years BP. In the thousand years that followed, microlithic technology proliferated across southern Australia, and became well established in southeastern Australia, where microliths and knapping debris occur extensively in the uppermost sediments of Aboriginal camping localities. Microblade technology and microliths disappear at many archaeological sites in Australia between about 1000-2000 years BP, but in some regions of the east coast they may have continued until only a few hundred years ago (for example, Merimbula, Kuskie 2004). However, in the southeast generally, microliths disappeared about a thousand years ago (Mulvaney and Kamminga 1999).

Evidence of microliths (bondi points and geometric microliths) was located at both the Hastings River and Wilson River test areas, and therefore at least these items, if not also the associated deposits, are inferred to date to within the last 4000 years or so BP. These items occur at the Hastings River in unit F5, and widely at the Wilson River, in units A5, A10, A20, A25, A40, A45, A65, A80, A95, B0, B5, B10, B15, B40 and B45.

No artefacts that are heavily worn or otherwise of greater age in appearance were identified. The potential for evidence of Aboriginal occupation older than the Holocene period is inferred to be very low. Apart from taphonomic issues affecting the potential survival of any evidence, the locality of the study area was not as conducive to Aboriginal occupation prior to about the early to mid-Holocene period, than it was later in the Holocene. Prior to the early to mid-Holocene, the sea level was lower and the shoreline and important subsistence zones many kilometres to the east of their present location. The climate was colder and drier than at present. Although the Wilson River and Hastings River would still have been nearby, the base level for the river valley channels would have been lower than at present and the locations of the channels probably varied.