2

Environmental Context

This chapter outlines the physical context of the Upper Nepean. The location and boundaries are delineated, and the topography, geology and vegetation are defined. The broader geographic and environmental context, in which the study area is situated, is also described. The four catchments are discussed individually. They each have different overall characteristics, which would have presented a different suite of opportunities and constraints to human occupation. It is assumed that the area is likely to have been used by Aboriginal people since the late Pleistocene through to the historic era. Accordingly, consideration is given to climatic variation and corresponding changes to the physical environment over that time. The weathering and site formation processes, which created and continue to form rock shelters, are described. These processes have considerable relevance to the nature of human occupation of shelters and to their potential to preserve the rock art they host.

2.1 Introduction

The study area is located on the Woronora Plateau, situated between the Illawarra Escarpment and the watershed divide between the Nepean and Bargo rivers. The plateau is deeply dissected, and is drained by six major rivers: the Georges, Woronora, Cataract, Cordeaux, Avon and Nepean (Figure 2.1). The study area is defined on a catchment (the Upper Nepean) and land use basis (it is confined to the Metropolitan Special Area), and it occupies the southern extent of the Woronora Plateau. The Metropolitan Special Area measures c. 78,000 hectares and is managed jointly by the SCA and the NSW OEH. Public access has been restricted for a considerable time, and it is now a significant naturally vegetated and largely undeveloped area (Mills et al. 1985:5). A considerable part of the Nepean's upper catchment is outside the Metropolitan Special Area. This extraneous area is predominantly private property and is situated largely on Wianamatta group soils or the overlying Robertson Basalt. It has been extensively cleared (Mills et al. 1985:2).

The Upper Nepean catchment includes four main rivers: the Cataract, Cordeaux, Avon and the headwaters of the Nepean. The Cataract, Cordeaux and Avon join the Nepean at the north-west boundary of the study area. The Nepean River thereafter drains to the north where it becomes the Hawkesbury (near Windsor, north-west of Sydney), and finally flows eastward to meet with the sea at Broken Bay, north of Sydney. The drainage of the Upper Nepean system is unusual given its proximity to the eastern seaboard, in that the rivers flow in a north-westerly direction rather than flowing eastward to the sea.

The Woronora Plateau is located on the southern margins of the geological feature known as the Sydney Basin (cf. Branagan et al. 1979), and is comprised of Triassic and Permian strata (Sherwin et al. 1986). The surface geology of the plateau coincides with the surface of the Triassic formation, comprised of Hawkesbury Sandstone, which is dominant, and intermittent exposures of the underlying shales, claystones and sandstones of the Narrabeen Group (Sherwin et al. 1986). The sedimentary sequence of the Sydney Basin was deposited in a relatively stable tectonic period, and is, therefore, generally conformable and remains essentially horizontal (Young 1985). All the archaeological material examined in this research is located within or on the weathered features of the Hawkesbury Sandstone strata of this sequence.

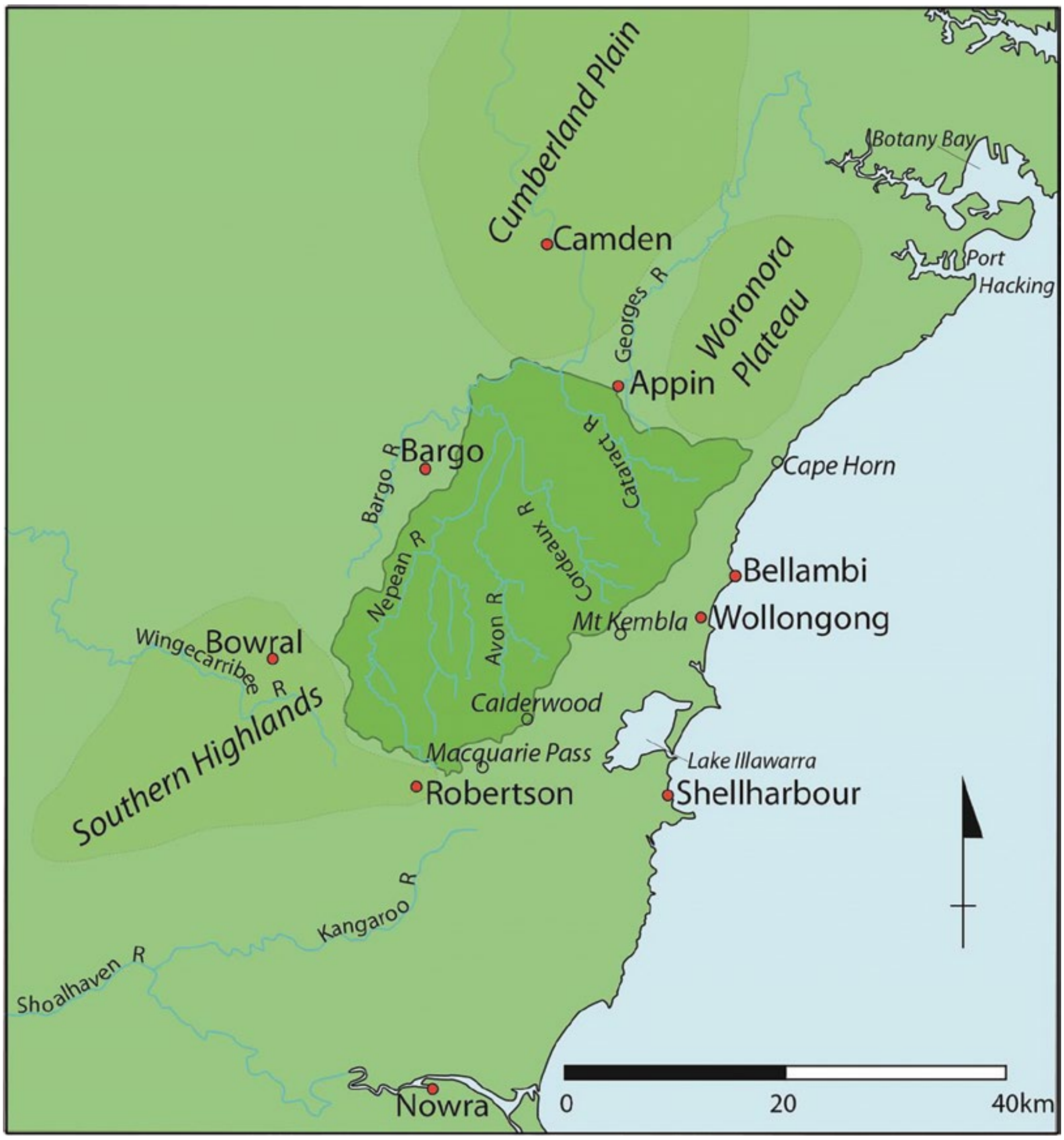

Figure 2.1 The Upper Nepean catchment in a regional context.
Source: Map reproduced from Dibden (2011).

Altitude in the study area ranges from 730 metres (Australian Height Datum [AHD]), at its southern boundary, to 449 metres (AHD) in the north. The major rivers follow this fall in land surface, which coincides with the surface and dip of the Hawkesbury Sandstone formation, and which falls to the north-west at an average slope of less than 1° over 15–20 kilometres (Young & Johnson 1977). The Woronora Plateau is dominated topographically by the river systems and the ridge/divides of the plateau from which they initiate. First- and second-order streams rapidly become narrower with increased gradient, eventually flowing through canyon-like gorges much of their length. These are narrow and deep, and their valley sides are nearly vertical (Young 1985). The crest landforms at plateau level vary between being either narrow or broad. At plateau level, dells (upland swamps) are located within the first- and second-order valleys of the Cataract, Cordeaux and Avon (Young 1982).

2.2 Climate

The context of climate change in Australia underpins much interpretation of observed changes in the archaeological record. Climate change, specifically relating to temperature and effective rainfall, is outlined in this section. The Illawarra region currently experiences a temperate climate. The average annual rainfall is 1,200 millimetres. The orographic effect of the Illawarra Escarpment is pronounced, with annual rainfall on the plateau in the vicinity of the escarpment being 1,700 millimetres on average. On the western boundary, average rainfall is about 900 millimetres per year (Mills et al. 1985:5).

During the time Aboriginal people have occupied south-east Australia, average temperatures and effective precipitation have been variable. During the Last Glacial Maximum between 24,000 and 17,000 years BP, the climate was much drier and colder than present, with periods of extreme coldness and aridity (Kershaw et al. 1991; Attenbrow 2004:204). Sea levels at this time were c. 135 metres lower, and the continent was approximately one-third larger than now (Black et al. 2008:438). While glacial or periglacial conditions prevailed at this time in regions with elevations above 1,000 metres, the east coast and foothills of the Great Dividing Range are likely to have experienced less extreme conditions due to oceanic influences (Attenbrow 2004:207). The late Pleistocene recovery from the glacial period, from c. 15,000 years BP onwards, saw a gradual increase in precipitation and vegetation growth rather than an abrupt change (Attenbrow 2004:207).

While generally warmer and wetter than the late Pleistocene, the Holocene has also witnessed climatic variability, particularly during its middle period (Dodson & Mooney 2002:456). In south-east Australia during the early Holocene, climate was relatively stable and this is perhaps related to reduced seasonality (Black et al. 2008:438). The significant environmental change during the early Holocene was the reduction in landmass resulting from rising sea levels. Based on the expansion in woody taxa, Kershaw et al. (1991) argue that recovery from glacial conditions is evident between 11,500 and 8,500 years BP. Maximum effective precipitation, and perhaps also warmth, occurred between 7,000 BP and 5,000 years BP (Black et al. 2008:438), and this is believed to have peaked between 6,000 and 4,000 years BP, when maximum warming was 1°C, and effective precipitation was about 30 per cent higher than the present (Dodson & Mooney 2002:456). At this time, an expansion of wet sclerophyll and rainforest species occurred in south-east Australia (Black et al. 2008:438). After this time, there was a return to a cooler and drier climate. A more variable climate has been experienced in south-east Australia in the last 5,000 years (Shulmeister 1999:83). At about 5,000 years BP, a sharp decline in effective precipitation occurred, resulting in falling lake levels, a reactivation of continental dunes and a decline in rainforest elements.

Additionally, the modern Eucalypt grasslands in the woodlands of south-east Australia replaced the Casuarina/Asteraceae associations (Kershaw et al. 1991). Between 4,000 BP and 2,000 years BP, effective precipitation was lower, and it was also possibly cooler (Black et al. 2008:438). This period saw an intensification of the El Niño–Southern Oscillation (ENSO) climatic pattern, which was causal of these changes, and productive of increased variability in seasonality and precipitation (Attenbrow 2004:207). During the last 1,500–1,000 years, temperature and precipitation increased until reaching the climate currently experienced today (Attenbrow 2004:206).

Attenbrow (2004:203) argues that environmental changes resulting from global climatic change were of sufficient magnitude to affect both the land and subsistence resources (relative abundance and/or spatial distribution of resources) in the Sydney region, and that this would have led people to modify land use and extractive methods, with ensuing changes in habitation patterns, tool kits and so on. Attenbrow (2004:203) is careful to stress that these responses to environmental change, which may be visible in the archaeological record, are indirect changes mediated by people's decisions and choices. In summary, over the course of Aboriginal occupation in south-eastern Australia, major climatic oscillations occurred resulting in changes to sea levels, landforms, temperature and precipitation, and vegetation structures. In Chapter 3, archaeological models relating to Aboriginal responses to these changes will be discussed further.

2.3 Geology

The Hawkesbury Sandstone is highly quartzose, being composed of medium-coarse, poorly sorted quartz grains with an argillaceous matrix of secondary quartz siderite (iron carbonate) cement (Standard 1964; Packham 1969). The average composition of Hawkesbury Sandstone includes 68 per cent quartz in a 20 per cent carbonate and clay rich matrix, which includes 2 per cent siderite (Packham 1969:408–412). The carbonate and clay-rich cement component makes the sandstone very susceptible to weathering processes. Both the chemical and physical weathering processes, which have created and continue to shape the rock shelters in the study area, represent complex formation processes and histories (Huntley et al. 2011).

Both the lithology and bed dimensions of the Hawkesbury Sandstone are variable (Conaghan & Jones 1975). The sandstone facies are up to 10 metres thick, while the mudstone facies are typically 0.3–5 metres thick. Coupled with the characteristics of the sandstone, as comprised of relatively discontinuous layers, its cross-bedded nature results in rock shelter formation, which is often highly irregular in morphology. Walls are commonly comprised of short, bedded sections located between bedding planes. Bedding planes, from which blocks of sandstone have previously fallen (roof-fall), often form shelter ceilings. Ceilings in shelters can be numerous and they are often low. Shelter floors, likewise, are frequently comprised of rock, either broad expanses, or as roof-fall boulders. As indicated in Chapter 1, considerable variability in shelter characteristics and morphology exists in the study area. For this research, the physical characteristics of shelters (shape, size and floor characteristics) are quantified, in order to explore whether or not they exercised any control in regard to their use as potential occupation sites and in the production of rock art (Plate 2.1).

During the weathering of exposed sandstone, the siderite is hydrated to iron oxide plus water, and mobilised to the surface of the outcrop where it is oxidised and may hydrate to form a crust on the surface. These surfaces are rich in iron minerals such as goethite, hematite and/or limonite, and the predominance of one or the other depends on local, site specific weathering conditions (Watchman, pers. comm., in Sefton 1988). The iron oxide deposits intermix with the quartz and clay, at or near the surface. Chemical weathering of the sandstone occurs behind crusts whereby the siderite and silica are mobilised by water action to the surface of the stone. As these surfaces form from within the stone, they produce an impermeable crust. Behind the crust the sandstone continues to weather, disintegrating and changing chemically. Siderite cement can oxidise to form goethite or hematite beneath the silica skin. The skin then begins to detach, which results in the disintegrating sandstone spilling to the floor. The chemical processes both create case-hardened surfaces upon which rock art was produced, and, at the same time, act to facilitate their eventual disintegration and the removal of imagery. It has also been determined that some of the coloured pigment, which is likely to have been utilised for rock art production on the Woronora Plateau, may have been sourced locally from within shelters, as minerals are released during these weathering events (Huntley et al. 2011).

Plate 2.1 Typical rock shelter floor comprised of roof-fall boulders (rock shelter EC36).
Source: Photograph by Julie Dibden, 2011.

The formation processes in shelters are likely to have contributed significantly to the preservation or otherwise of rock art (cf. Hughes 1976). The majority of the sheltered rock art in the study area is highly weathered, and is now indeterminate in regard to its original form. This phenomenon is not new or recent. In the late nineteenth century, Mathews (1895:272) commented that rock art located in a shelter in the northern Woronora Plateau was highly weathered owing to the 'natural decay of the rock'. Weathering processes, in which imagery is removed and/or covered with silica skins, can be highly active (Plate 2.2). For example, graffiti (names and dates) has been observed to be almost entirely obscured by mineralisation (pers. observ.). In another example, a comparison of pigments and rock surfaces photographed at an interval of two years, between 2001 and 2003, reveals significant loss of both pigment and the crust on which it rests (pers. observ. of photographic records of J. Dibden & J. Huntley). The hostile nature of the physical and chemical processes that occur in the Hawkesbury Sandstone has significant impact upon the art surfaces and the imagery itself, and this is recognised generally for the Sydney Basin, with the implication that much of the extant rock art is unlikely to be old.

Hughes (1976) conducted a study of three sandstone shelters located to the south of the Woronora Plateau, to measure the rates of rock weathering and roof-fall. His study has established a strong relationship between rates of weathering and site usage—specifically, that the more a site was occupied, the greater the rate of roof-fall. The implication of this finding is that rock art present at the time shelters were occupied is likely to have been removed due to accelerated weathering and roof-fall (Hughes 1976:52). Hughes (1976:53) argues that where rock art has survived in shelters known to have been used as habitation sites, it is likely to have been produced late in their occupational histories. He suggests also that the reduced weathering occurring in the absence of human (Aboriginal or European) usage is a likely contributor to the preservation of rock art.

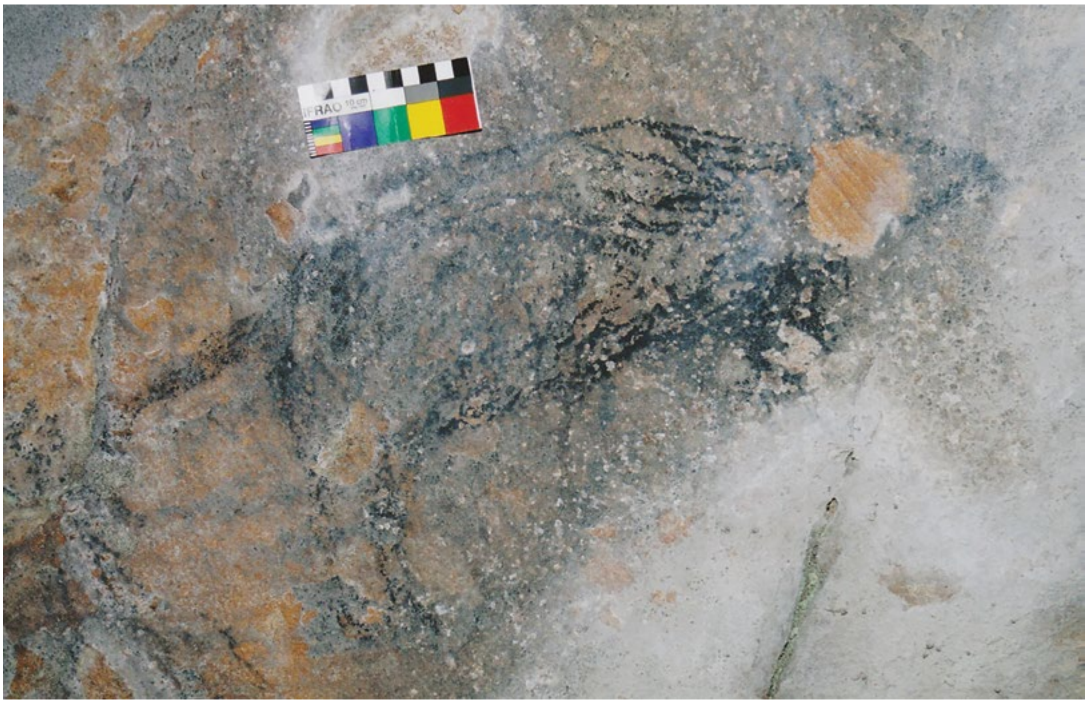

Plate 2.2 Example of weathering processes on rock art.

Note the mineral skin and exfoliation of rock surface. Each process is, respectively, covering and removing parts of the image (rock shelter DCC30).

Source: Photograph by Julie Dibden, 2011.

In regard to rock art located on open sandstone platforms, weathering rates are significant to the point that engraved images of sailing ships (which can only be c. 200 years old) in the Sydney Basin have been reported to be virtually invisible (Edwards 1971:361). However, it is noted that, according to Jo McDonald (pers. comm., Feb. 2011), contact engravings are apparently thinly incised into rock, and this may have a causal relationship with their swift deterioration. Maynard (1979:93) refers generally to the outline engravings 'on the soft Sydney sandstone in the Sydney–Hawkesbury area, which suffer erosion to the point of obliteration'. Edwards (1971:361) suggests that a combination of soft sandstone, salt-laden air and exposure to high levels of rainfall combine to accelerate weathering of engravings in open sites. Hughes (1976:52) also indicates that rock art located on open rock exposures is likely to undergo ongoing deterioration from exposure to rain and running water. These aspects of site formation processes, which operate in the Sydney Basin, have obvious implications in regard to the antiquity of extant rock art.

2.4 Soils and Geomorphology

Two major soil landscapes have been defined for the Upper Nepean catchment: the Hawkesbury Sandstone Soil Landscape, which is a colluvial landscape; and the Lucas Heights Soil Landscape, which is residual. The Hawkesbury Sandstone Soil Landscape is confined to the major rivers and larger tributaries. It is characterised by rugged sandstone escarpment and ridges, with moderate to steep slopes and narrow, deeply incised valleys. Sandstone outcrops are common, occurring as boulders, benches and large blocks. They often form scarps of up to 10 metres in height. The soils in this landscape are subject to mass movement as the principal geomorphological process; they are shallow, discontinuous and generally sandy (Hazelton & Tille 1990). The Lucas Heights Soil Landscape is confined to ridge tops and gentle slopes. It is comprised of gently undulating crests, ridges and plateau surfaces, with low local relief and slopes of less than 10 per cent. Soils in this landscape are generally yellowed to lateritic podzolic, and are generally shallow (Hazelton & Tille 1990). Soils in the study area are infertile; one reason why the sandstone country was avoided by early settlers (Mills et al. 1985:5).

The rivers and streams have dissected the Woronora Plateau to varying degrees. Creeks flow from major ridges and divides in narrow, steep-sided gullies joining the major rivers in wider valleys. As the rivers proceed northwards, these valleys narrow and become sheer, cliff-lined gorges. Dells are present in the Cataract, Cordeaux and Avon catchments. Dells are swampy sediment traps containing sedge-heath vegetation communities, located in headwater valleys at plateau level. Most dells are located in first- and second-order valleys, generally on valley floors, but sometimes on benches or steep valley sides (Young 1982:16). They occur on the east side of the plateau where elevation is greatest, and precipitation substantially exceeds evaporation. Dells consist of deep deposits of sediment provided by downslope movement from adjacent higher slopes. Their initiation is largely a factor of geomorphic processes (Young 1982:49). Deep, permanent pools are present in the larger dells, thus providing an important source of water, particularly in droughts (Young 1985). Elsewhere in dells, water is stored in long furrows running parallel to land contours (Young 1985). The sediments in dells have been dated to c. 17,000 BP. Dells are relatively stable, their boundaries do not change over time, and they do not encroach on neighbouring forested areas.

The Cataract catchment has gentle slopes, generally with 88 per cent having less than a 10° gradient, whereas the Cordeaux and the Avon have fewer gentle slopes. Local relief is far greater in the latter two catchments, which are deeply dissected and average local relief exceeds 100 metres, while in the Cataract local relief is 65 metres (Young 1982:13). The Hawkesbury Sandstone has been considerably breached in the Cordeaux, and the correspondingly low dell numbers, in part, reflect this feature (Young 1982:12). The largest dells are located in the Cataract catchment; the largest is located at Sublime Point and Maddens Plains. It measures 2.5 kilometres in width (at its widest) with several arms measuring 2–3 kilometres long by 300–500 metres wide (Young 1982:11). The dells on Lizard Creek in the Cataract, are 5 kilometres long. However, most dells measure less than 1 kilometre in length and approximately 200 metres in width [<13 hectares] (Young 1982:11). Dells contain acidic, swampy soils, and accordingly support almost treeless vegetation dominated by sedges, restiads and water-tolerant shrubs (Young 1985). While potable water is also available at plateau level away from dells, they are important occupational determinants in that they are likely to have provided Aboriginal people with a reliable, if not abundant, source of fresh water on the ridge crests. Given the late Pleistocene age of dells, this scenario is likely to have some considerable antiquity.

The Woronora Plateau contains patches of Ferricrete (laterite) preserved (and believed to be still forming) on undissected, relatively flat ridge crests. This Ferricrete is hard, orange-brown nodular material believed to form via iron migration through the Hawkesbury Sandstone (Young 1985). It is possibly a raw material that was used for the production of red pigment for use in rock art and other decorative purposes. To date, this notion has not yet been confirmed.

2.5 Regional Context

The Upper Nepean catchment area is bounded in the east by the Illawarra Escarpment. This natural physiographic boundary is the easterly divide between the rivers of the study area and the shorter streams of the coastal plain. The escarpment is a visual and physical barrier to human movement between the coast and the plateau, although not one that is insurmountable. The northern boundary of the study area is the east–west-oriented divide that separates the Cataract

River catchment from the rivers and streams that flow in a northerly direction, emptying into either Botany Bay (Georges River, Woronora River) or Port Hacking (Hacking River). The land to the north of the study area is the north section of the Woronora Plateau and is of the same geology and comparable topography with that of the study area. The southern boundary of the study area coincides with the headwaters of the Nepean's tributaries and the Avon River. This area is also marked by a localised topographic and geological boundary, comprised of Wianamatta Shale, and is associated with a marked and subdued topographic physiography. The area is also comprised of pockets of remnant volcanic geology (Mills et al. 1985).

For the purposes of providing a wider geographic and environmental context to the study area, each of these areas adjacent to the study area is described in more detail below. As Officer (1984:7) remarks, the landscape of the Hawkesbury Sandstone provides a dramatic contrast between open and fertile plains and the 'rugged, poorer and inaccessible highland'. Officer (1984:7) also draws attention to the possibility that this division in the landscape may have determined human access and communication. In this regard, Officer identifies various routes between the plateau and the coast. The one relevant to the current study is the divide between the Georges and Woronora rivers and the Cataract River on the northern boundary of the study area.

2.5.1 The Illawarra

This narrow band of undulating land is located between the base of the Illawarra Escarpment and the littoral zone of the Pacific Ocean. The northern part of the coastal land is situated at a point located 1 kilometre to the east of the north-east boundary of the study area. This area is coincident with Cape Horn, and is where the cliffs of the Illawarra Escarpment meet with the sea cliffs that line the coast along the north-eastern margin of the Woronora Plateau. Southwards from Cape Horn, the coastal margin increases gradually in width to measure approximately 16 kilometres (as measured from the base of the escarpment at Macquarie Pass to Shellharbour on the coast) adjacent to the south-east boundary of the study area.

The Illawarra Escarpment rises dramatically from the coastal plain. It comprises an upper near-vertical cliff line measuring up to 50 metres high, below which very steep slopes fall to the coastal plain. The escarpment in many areas is a barrier to human movement and, accordingly, access from the coast to the plateau is possible only in few places so that movement into the study area is highly constrained and channelled. The western part of the coastal margin comprises the foothills of the escarpment, drained to the east by short first- to third-order streams. The moderate to steep slopes of the foothills extend variously to within a few hundred metres or less of the littoral zone in the north, to 2 kilometres at Bellambi, and approximately 3 kilometres at Wollongong and the western margins of Lake Illawarra. The streams drain into beaches located between bedrock headlands. Beaches vary from a few hundred metres to several kilometres in length. Lake Illawarra dominates the topography in the southern part of the coastal plain. Early commentators described the vegetation of the Illawarra as luxuriant tree-cover, including rainforest and wet sclerophyll forest communities (R. L. Jones 1990:37–38). During the late Holocene, the Illawarra was covered continuously with Eucalypt forest (which may have been wet sclerophyll) and probably patches of rainforest (R. L. Jones 1990:43).

Along the coastal plain and behind estuaries, extensive wetland development occurred during the past 5,000 or so years, after the post-glacial sea level rise and stabilisation (R. L. Jones 1990). The marine influence in these wetlands has changed during the late Holocene. At Terragong Swamp in the Minnamurra Valley, for example, sediments dated to between 4,300 and 2,500 BP were deposited in an inter-tidal environment. Pollen and spore data indicate that wetland species at this time were saline plant vegetation. After c. 2,500 BP, however, a significant change in wetland plants occurred, with freshwater aquatic species appearing, reflecting a change to a freshwater wetland environment. Significantly, the plant species that became abundant in the swamp at this time were those that are known to have been important Aboriginal plant foods, such as Typha and Blechnum (R. L. Jones 1990:45; cf. Gott 1999). The coastal zone, including the ocean and its rock platforms and estuaries, would have provided Aboriginal land users with an abundance and diversity of plant and faunal resources likely to have exceeded that which exists in the study area today.

2.5.2 The Southern Highlands

The area to the west of the study area is a north–south-oriented divide between the Nepean catchment and the Bargo River. This divide is a major north–south passage between the Cumberland Plain of the Central Sydney Basin and the Southern Highlands. The underlying geology is Hawkesbury Sandstone, and the landforms are dissected similar to the Woronora Plateau. The landscape of the Southern Highlands proper, which is situated to the south and south-west of the study area, is of subdued relief. The geology is comprised of Wianamatta Shales and Narrabeen Sediments with pockets of volcanics (Herbert 1980). The land drains westward to the Wingecarribee River, and it too eventually joins the Nepean River much further to the north after skirting west of the Bargo and other rivers. Immediately to the south-east of the study area, the Kangaroo River begins its south-westerly passage to eventually join the Shoalhaven. The latter proceeds easterly to its confluence with the sea at Nowra.

The contrast between the Southern Highlands and the Upper Nepean area of the Woronora Plateau is dramatic. The former is gently undulating and of subdued relief; the country between Berrima and Moss Vale was described by Wilson in 1798 as 'a most beautiful country, being nothing but fine meadows with ponds of water in them; fine green hills, but very thin timber' (cited in Andrews 1998:12). While it is considered possible that these contrasting environments provided some influence over Aboriginal land use, it is unequivocal that European settlement has been strongly defined by these background conditions (Mills et al. 1985:5).

2.6 European Land Use

Until the 1880s, the majority of the Upper Nepean catchment was unalienated crown land. Given the nature of the topography, and its poor soils and forest cover, it was largely unsuited to agriculture (Mills et al. 1985:5). Accordingly, and unlike the Cumberland Plain, Illawarra and Southern Highlands, the Upper Nepean was not taken up by European settlers except for small areas of land at the headwaters of the Cataract and Cordeaux rivers where local relief is more subdued and soils deeper (these lands were resumed by the crown in the 1910s).

The Upper Nepean water catchment was gazetted in 1880 as a water reserve for Sydney and its suburbs. The area measured 924 square kilometres and encompassed the Cataract, Cordeaux, Avon rivers and the headwaters of the Nepean River (i.e. the study area). This was followed in 1888 by the commencement of works on the Upper Nepean Water Scheme. A program of dam construction on all four rivers occurred between 1907 and 1935 (Mills et al. 1985). Impacts relating to these works, while including denudation of the main valleys, all otherwise occurred within the immediate vicinity of the dam wall construction sites. Other European impacts in the area are generally confined to linear features including two public east–west-orientated roads (the Appin and Picton roads), numerous fire trails, an unfinished railway and several power transmission lines. Minor surface impacts occur in the vicinity of above ground facilities associated with underground longwall coal-mining operations. Public access to this country has been restricted for many years (Mills et al. 1985:5), but there is an ongoing incidence of unlawful entry. Recreational fishermen have for years camped, and in some instances continue to camp, in rock shelters situated along some of the lake edges, and this activity has resulted in significant impact on archaeological deposit and rock art.

Table 2.1 shows the area covered by dam water in each of the four catchments. The land of the study area totals 866.6 square kilometres, 30.05 square kilometres of which is flooded by dam water. This figure represents 3.5 per cent of the study area in total, and presents a bias in the study in terms of any analysis relating to site location and distribution. Generally, it is the sections of the valleys of each catchment that are wide and shallow that are dammed. Any archaeological sites in the valley bottoms of these locations are now destroyed.

Table 2.1 Summary of catchment areas, dam areas and percentage of each catchment denuded by flooding.

Statistics	Cataract	Cordeaux	Avon	Nepean	Total
Area dammed (ha)	850	780	1,015	360	3005
Total catchment (ha)	20,557	16,656	17,447	32,000	86,660
% of catchment dammed	4.1	4.7	5.8	1.1	3.5 (av.)

Source: After Mills et al. (1985).

2.7 Vegetation

In January 2001, during the period of fieldwork undertaken for this research, a wildfire swept through much of the Cataract, Cordeaux and Avon catchments. The consequence of this on the vegetation was, as would be expected, dramatic, and particularly so in its effect as to make movement across the area considerably easier. Prior to the fire, the thick understorey often acted to impede movement significantly. The modern vegetation structure and composition of the study area may now be different from what it was when the land was occupied by Aboriginal people. Information regarding Aboriginal fire regimes in south-east Australia is scant, although it is known that elsewhere fire was used to clear vegetation and to propagate new plant growth (Gott 1999) and encourage animal activity. Certainly, it is likely that Aboriginal people used fire for land management within the study area, and this is likely to have kept the woodland relatively open. Studies of Holocene changes in vegetation and fire are discussed below in order to give consideration to the pre-European environment.

Studies of sediments conducted in the Sydney Basin reveal the presence of charcoal in deposits that occur in variable densities throughout the late Pleistocene and Holocene. However, distinguishing between natural and cultural agencies, which may account for this variability, is problematic (cf. R. L. Jones 1990:43; Dodson & Thom 1991; Black et al. 2008). In the Illawarra, R. L. Jones (1990:43) found that burning of vegetation occurred throughout the late Holocene, but not on a large scale. He observed a sharp peak in charcoal in sediment from the Terragong Swamp at c. 2,500 BP. In the Mill Creek catchment, situated 70 kilometres north-west of Sydney, Dodson and Thom (1991) found that, during the entire Holocene, frequent fire, which may have been influenced by human activity, had acted to restrict the abundance of rainforest, and that Eucalyptus-Casuarinaceae forest and heath had dominated the landscape for the past 9,000 years. More recently, Black et al. (2008:445) argue that a climatic solution explains all periods of change in the fire history of the landscape at Goochs Swamp in the Blue Mountains, but that peaks in charcoal that coincide with ENSO-like climatic variability may reflect anthropogenic fires, which may have been a response to climate variability. This interpretation is somewhat at odds with previous ideas that Aboriginal people in Australia strongly controlled prehistoric fire activity (Black et al. 2008:437).

Johnson (2000) has carried out a fine-grained palaeoecological study of sediments from the Mill Creek Valley. The study sought to examine land system responses to Aboriginal and European land management over the past 820 years. The results can be extrapolated with caution to the study area given its proximity and the comparability of land system, geology and vegetation structure. Johnson reached a number of conclusions, and those that may be salient to an understanding of the pre-European environment of the study area are listed below:

- Prior to European settlement, the environment is likely to have been well vegetated. The vegetation community comprised a stable sclerophyll association on valley sides and a significant wetland community on the valley floor. While the vegetation structures are currently undergoing successionary processes that are returning to those that occurred earlier, the current terrestrial vegetation types compare well with those that were present prior to European occupation.
- Prior to European settlement, charcoal input was relatively low (R. L. Jones [1990] obtained a similar result in the Illawarra) and is not linked to vegetation abundance. Johnson (2000) suggests that this result may distance Aboriginal burning practices from vegetation dynamics.
- A notable change in fire regime corresponds with the lower limit of pollen from introduced species. The present charcoal supply pattern appears to be similar to that which existed prior to European settlement.
- Prior to European settlement, sedimentation rates were significantly lower (Johnson 2000:221, 223, 229).

Providing that these results are, as suggested, relevant to the study area, they support a view that the current vegetation is both structurally and compositionally comparable with that during Aboriginal occupation, at least during the late Holocene. However, a recent study has found that long-term changes in understorey vegetation occur in the absence of fire in dry sclerophyll forests of south-east Australia, and that species richness declines significantly in the absence of frequent fire. This decline was also found to be associated with significant changes in species composition (Penman et al. 2009:535). In this study it was found that of 51 species, predominantly shrubs and herbs, declined over time in the absence of fire. This is relevant because those species that decline in the absence of regular burning all occur in the study area and are known to have been Aboriginal food plants (cf. Penman et al. 2009:537). The biodiversity values of vegetation communities in the study area, which existed at the time of Aboriginal occupation, therefore, should be considered to be somewhat uncertain.

The vegetation of the Woronora Plateau is now comprised mostly of sandstone plant communities—woodlands or open woodlands (Mills et al. 1985:6). These communities are dominated by Eucalypt species and possess a species-rich understorey of heath or shrubland. They are relatively homogenous across the study area. The understoreys present on the Narrabeen Group, however, are generally dominated by grasses and are less species rich. In the larger gullies, open forests occur, and some support simple rainforest communities. In the east, the sedgeland/heathland communities of the dells are extensive (see below). Where isolated pockets of other geologies are present, such as to the south where small areas of Robertson Basalt occur, tall Eucalypt forests grow. A small area in the Upper Cordeaux catchment is covered with a subtropical rainforest, which has developed on the Cordeaux Crinanite.

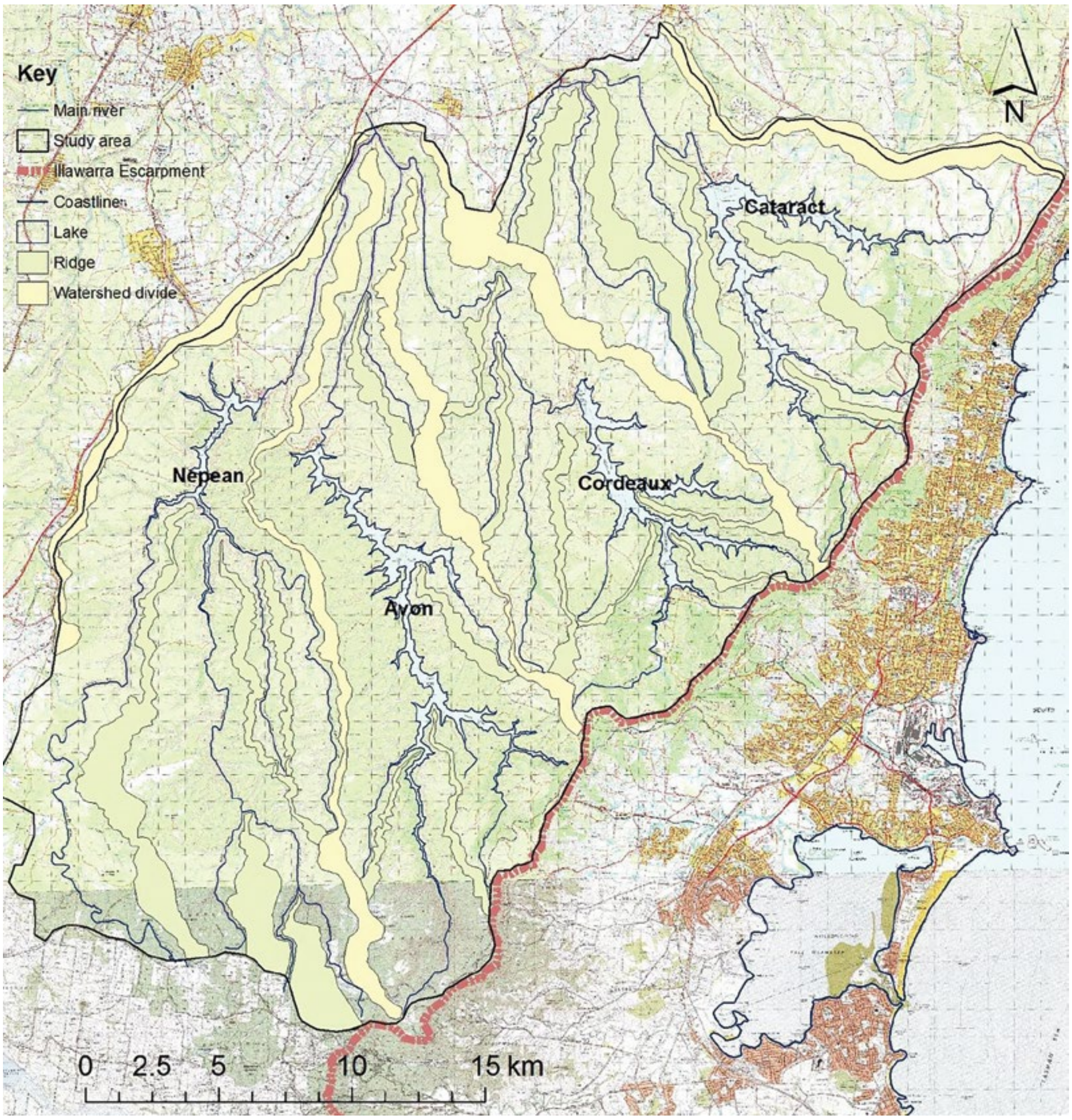

Figure 2.2 The Upper Nepean catchment in a local context.

Source: Map reproduced from Dibden (2011).

On ridge tops, woodland and open forest communities grow to a maximum height of 15 metres. These communities are comprised of a range of Eucalypt species (Silvertop Ash and Scribbly Gum) and Red Bloodwood, with a small tree layer of Old Man Banksia and Paperbark Ti-tree. Numerous species occupy the shrub and ground layers of which *Gahnia sieberi* and *Persoonia levis*, respectively, provided seeds for flour and the other fruit. Gully forest occupies slopes and gullies. This dry forest community is dominated by Red Bloodwood and Sydney Peppermint, growing to a height of 25 metres. A species-rich understorey contains numerous Acacia species. The tubers of orchids (*Acianthus* spp. and *Dendrobium speciosum*) and fruits of *Persoonia* spp. and *Dianella caerulea* in these communities are potential foods.

Warm temperate rainforest is present in restricted areas of the catchment and is mostly confined to the east where it occurs in gullies on south- and east-facing slopes. A closed canopy of Coachwood and Sassafras grows to a height of up to 30 metres, shading a range of small trees including Blackwood, of which the seeds were processed for flour, and Lillypilly, the fruit of which was eaten. Cabbage Tree Palms, of which the tip of the palm is edible, also grow in this community. Seeds and rhizomes from commonly occurring plants such as *Gahnia sieberi*, *Acacia rubida*, *Lomandra longifolia* and *Pteridium esculentum* were processed for food. Plants across the plateau also provided a range of other resources including medicines, bark, fibres and wood.

The vegetation communities in dells are low heaths and sedgelands, ranging in height from 0.5 to 3 metres. They are dominated by coarse sedges (Cyperaceae family) and rushes (Restionaceae family), usually growing into tussocks up to 1.5 metres high. Additionally, low shrubs (Proteaceae and Myrtaeae families) grow along drainage lines and some hillslopes, but are mostly scattered. The occasional, generally isolated Eucalyptus (usually *E. heamtastosa*) is present (Young 1982:74–75). A variety of aquatic and terrestrial faunal species, many of which are represented in the rock art, were available for food, and also for tool-making. Given the high diversity of habitats, most native species occurring in the region are present (Mills et al. 1985:19). It is concluded that the study area is likely to have presented Aboriginal land users with a relatively abundant and spatially continuous distribution of natural resources.

2.8 The Individual Catchments

Each of the four catchments is described separately in this section. The intention is to summarise the main structural features of each area, and to describe their general character. These physical variables will then be considered as boundary conditions relating to Aboriginal land usage and human movement in each catchment (Figure 2.2).

2.8.1 Cataract River

The Cataract catchment extends from the escarpment in a north-westerly alignment between its northerly watershed with the Georges/Woronora rivers, and its southerly watershed/divide with the Cordeaux. The landforms of both watersheds are relatively broad and gently undulating. Today, the Appin and Picton roads traverse them, and are major local thoroughfares between the coast and interior. These routes are likely to have been utilised similarly by Aboriginal people. The divide between the Cataract and the Georges/Woronora rivers is recognised to have been an Aboriginal travel route between the Cumberland Plain and the coast. The explorer Throsby was shown this particular thoroughfare by two Aboriginal men in the early 1800s (McDonald 1966:27).

The Cataract River is comprised of two main arms, the Loddon and Cataract, both of which commence their drainage at the Illawarra Escarpment. The Loddon drains from Maddens Plains in the north-east of the study area, at c. 1.5 kilometres from the coast, and flows westward for 9 kilometres. The Cataract rises on the escarpment at c. 5 kilometres from the coast and flows north-west for a distance of c. 11 kilometres to the confluence of the two arms. This point is near to where the Cataract becomes a gorge (now coincident with the Cataract Dam wall). The Loddon and Cataract flowed through relatively wide valleys prior to the construction of the dam. Given the nature of these valleys, before they reach the gorge, they are likely to have been utilised for travel from the coast into the interior of the catchment. Likewise, the large ridge separating these two arms, being wide and gently undulating, is also likely to have been a thoroughfare into the catchment. To the west, three major creeks (Lizard, Wallandoola and Cascade) flow northward from the Cordeaux/Cataract divide, to where they each join the Cataract at various points along the gorge. In terms of human movement, the northerly extent of the landforms between these creeks, given that they join the Cataract where it is cliff-lined, are effectively dead ends. However, the Cataract catchment generally presents relatively little constraint to human activity and movement. Local relief and slope gradients are low. Ridge crests and valley bottoms (at least in the mid and upper reaches) are likely to have been used for access and as thoroughfares.

2.8.2 Cordeaux River

The Cordeaux catchment extends from the escarpment in a north-westerly alignment between its northerly watershed/divide with the Cataract and its southerly watershed with the Avon. The slopes falling to the Cordeaux River from the Cordeaux/Cataract divide are generally of moderate gradient only, and this contrasts with the remainder of the Cordeaux catchment, which is commonly steep. Similar to the Cataract/Cordeaux divide, the ridge between the Cordeaux and Avon is relatively broad and gently undulating, and is likely to have been a major thoroughfare between the coast and the interior of the Upper Nepean. At their confluence, the Cordeaux and Avon become unpassable cliff-lined gorges. However, from midway along the Cordeaux/Avon divide, human movement is possible to the north across the Cordeaux, and to the west across the Avon and Nepean rivers.

The Cordeaux River rises at a point on the Illawarra Escarpment immediately to the north of the Avon drainage system. Access between the escarpment and the coast is possible at this southern section of the catchment via the hillslopes of Mt Kembla. The Cordeaux drains to the north-west, and its upper reaches flow through a relatively wide valley that is likely to have been used as a thoroughfare into the catchment. However, from near to where the Cordeaux dam wall is now, and further to the north-west, the river is narrow, and it is highly unlikely that people would have used that section of the river as a thoroughfare. At c. 6 kilometres short of its confluence with the Avon, the river valley becomes very steep and cliff-lined. Several tributary creeks flow northward from the Cordeaux/Avon divide including Sandy, Wongawilli and Donald Castle creeks. All three flow through steep slopes and are often flanked by cliffs and rocky scarps. The creeks themselves were unlikely to have been habitually used for travel, but the minor divides between these were. The Cordeaux catchment contrasts with the Cataract primarily in terms of its greater local relief, steeper slope gradients and frequent occurrence of high, long cliff lines extending along valley slopes. The terrain in the Cordeaux is such that it is likely to have exerted constraints to human movement. It is considered most probable that people would have utilised the ridges of watershed divides and crests of minor divides between creeks to travel through the catchment.

2.8.3 Avon River

At its southern margin, the Avon catchment is bounded to the east by the Illawarra Escarpment and to the west by the divide between the Avon and the Nepean rivers. The southernmost area drains from a point where the escarpment at Calderwood changes its orientation from north–south to east–west. Calderwood is also the most southerly access point between the coastal plain and plateau. The Avon catchment extends from the escarpment in a predominantly northerly alignment between the Cordeaux and Nepean rivers. The watershed between the Avon and Nepean is relatively broad and gently undulating, and is likely to have been a major thoroughfare between the coast and the interior of the catchment. At their confluence, both rivers are impassable cliff-lined gorges.

For a distance of approximately six kilometres from the escarpment, the Avon River is located within a narrow steep gully and is fed by short tributary streams. It is bounded to the east by the escarpment. Two third-order creeks (Gallahers and Native Dog) flow from the escarpment, forming short ridges jutting into the catchment. As the Avon proceeds northwards, the catchment width is restricted to about 6 kilometres. Generally, only first- and second-order tributary creeks flow into the Avon. The majority of the Avon catchment is steep and deeply dissected. Cliffs line the river valley and tributary creeks along the majority of the length of their course. The terrain of the Avon catchment is likely to have strongly influenced the manner in which it was occupied. It is most probable that people would have utilised the crests of watershed and minor divides to travel through the catchment.

2.8.4 Nepean River

The Nepean River rises in a spring near Robertson, immediately to the south of the study area. The southernmost area of the catchment is at a point located c. 4 kilometres west of the Illawarra Escarpment. Macquarie Pass on the escarpment is an access point between the coastal plain and the plateau, and is situated some 3.5 kilometres to the south-west of the Calderwood access point. A number of tributaries flow from the Southern Highlands and join the Nepean.

The upper reaches of the Nepean traverse relatively large expanses of flat and swampy country before the tributaries and the Nepean itself begin to incise the sandstone. Three major tributaries—Little Burke River, Explorers Creek and Burke River, which are each oriented north–south—are situated to the east of the Nepean. The creeks and rivers form steep-sided and narrow gullies that are generally impassable south of the dam. These gorges have high continuous cliffs at the valley bottom and ridge-top levels (Sefton 2000; Sefton 2003a). The ridge crests would have presented the only viable thoroughfare passages in the catchment. All four rivers join within 2 kilometres of each other at the southern margin of the dam water. While the valley sides are narrow in the area of the dammed water, passage along the valley of the Nepean from this point northwards is probably possible. At the dam wall the catchment area is c. 4.5 kilometres wide. From the dam wall the river proceeds northwards through a steep-sided gorge located c. 2 kilometres to the west of the similarly formed Lower Avon gorge. The Nepean is relatively easily crossed at the point where it meets with the waters of the Cordeaux and the Avon.

2.9 Summary

The environmental context of the study area is significant in regard to a number of factors relevant to this research. The country of the Upper Nepean catchment is physically very different to its surrounds in the east (the coastal plain) and to the south (the Southern Highlands). The Upper Nepean has deeply dissected and rugged terrain, which contrasts with the more gentle and muted topography of the coast and Southern Highlands. Human movement between the coast and Upper Nepean entails breaching the cliffs of the escarpment, which can only be achieved in a few places. Except for the Cataract catchment, where the main river valleys are generally trafficable, human movement in the Upper Nepean is significantly constrained by the presence of steep, rocky valley slopes or narrow, cliff-lined gorges that occupy the majority of the valleys.

It is proposed that, given the nature of the topography, the landforms that people are most likely to have used, for access into and movement within the Upper Nepean catchment, are the watershed divides and ridge crests, which are gently undulating and relatively easy to move along, in comparison with the valley slopes and gorges. The watershed divides and ridge crests possess reliable and, in some places, abundant fresh water (Plate 1.3), which is available year round and in all years, including during periods of drought. Therefore, it is proposed that these divide and ridge landforms in the Upper Nepean are likely to have been the focus of domestic habitation and hence the location of base camps (discussed further in Chapters 3 and 5). The exception to this is the Cataract catchment where the valleys are also likely to have been utilised for habitation, given their accessibility due to the low local relief, generally low valley slope gradients, and their favourable amenity. The variability between different landforms, particularly crests versus valley slopes, is likely to have presented different constraints and opportunities in regard to human movement and occupation. Accordingly, landform categories are utilised in this research as independent variables in analyses of site distribution relating to sociocultural contexts of occupation and land use.

The study area can be considered to have possessed a wide variety of faunal, floral and other resources, and these are generally spatially continuous in distribution. Similarly, potable water is available across all landforms, including watershed and ridge crests (Plate 1.3). It is, however, possible that the Upper Nepean catchment may have been peripheral to the coastal margin where resource abundance is arguably higher, given the presence of marine and estuarine environments, in addition to that provided by the terrestrial context (cf. Attenbrow 2004:111). However, in contrast to both the coast and the majority of the Southern Highlands, the Upper Nepean possesses something locally distinguishing—that is, sandstone rock surfaces. While these may have presented people with constraints and challenges in regard to access and movement through country, significantly, they provided a number of locally unique opportunities such as shelter, abrasive surfaces for the manufacture and sharpening of tools, and sheltered surfaces, which have the potential to be marked with rock art.

The rock shelters in the Upper Nepean catchment are, however, not all equivalent in size, morphology and floor characteristics. Accordingly, their ability to satisfy people's needs as shelter, or for the fulfilment of other goals, is considered to be variable. The physical properties of rock shelters are used in this research as independent variables, against which to assess the social context of rock art production and use.

Climatic variability and corresponding environmental change, from the late Pleistocene and through the Holocene, has been described in this chapter. The country of the Upper Nepean catchment is unlikely to have experienced significant structural and landform change during this time, compared with the coastal region. Certainly, geomorphological processes are likely to have been generally unchanged within the time frame of Aboriginal occupation. However, climatic variability and its impacts relating to effective precipitation and temperature are likely to have been significant in the region, requiring a human response and the development of accommodating strategies in economic, technological and social spheres (cf. Attenbrow 2004:203).

Early European settlers did not occupy the Upper Nepean sandstone country as it was comprised of rugged terrain, forest cover and poor soils. This contrasts with all surrounding areas (the Cumberland Plain, Illawarra and Southern Highlands), which were occupied by the 1820s, thus significantly marginalising Aboriginal access and use of country in the local region. It is proposed that the Upper Nepean may well have remained in use by Aboriginal people during the period of the colonial encounter. Furthermore, it is considered possible that rock art was produced during that period for the pursuit of social strategies relating to the mediation between Aboriginal people and Europeans at that time.

This text is taken from *Drawing in the Land: Rock Art in the Upper Nepean, Sydney Basin, New South Wales*, by Julie Dibden, published 2019 by ANU Press, The Australian National University, Canberra, Australia.