Review of how indigenous people managed for water in desert regions of Australia

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Abstract

Traditional knowledge, oral instruction and stylised mapping were all important to Australian Aborigines in defining the type of water supplies available in a particular region, and assisting in their location. Observations of birds, especially the more sedentary species such as the zebra finch (*Poephila guttata*), could be significant. Specific sources of water utilized by indigenous people included; flooded gnammas (rock-holes), soakage-wells in permeable sediments, clay dams, flooded claypans, riverine waterholes, mound springs, rain-water accumulated in tree hollows (especially in *Allocasuarina decaisneana*), water from excavated tree roots (especially from mallee eucalypts), dew, and water from the body of the water-holding frog (*Cyclorana platycephala*).

Introduction

The ability of Australian indigenous people to survive in the desert regions where rainfall is low (<200 mm pa), episodic and unreliable, and evaporation is exceptionally high (>3,000 mm pa), has long excited the popular imagination. Most of the early European explorers expressed awe and wonder at the extraordinary ability of Aborigines to survive in what they regarded as hostile if not "impossible" regions. So great was the respect of early explorers for the water-locating ability of Aborigines that several of them (*e.g.* Austin 1856; Calvert 1897; Carnegie 1898; Wells 1899) felt obliged to adopt the extreme and ethically-repugnant measure of depriving Aborigines of their liberty and forcing them to find water. After being deserted by some Aborigines in the Gibson Desert in 1897, Wells (1899) wrote "I then regretted not having chained one of the tribe [a practice adopted by him in December 1896], in spite of my promise to the contrary, for *without a [Black] guide in such country one is almost powerless*". Reading today about incidents such as this serves as a timely reminder that there has been a strong and unfortunate tendency not to give proper recognition to the key importance of Aboriginal knowledge in the exploration and development of Australia (*cf* Reynolds 1990).

One human physiological imperative is an adequate intake of water. Hence the adage "water is life" or, as Giles (1889, v1, p292) put it, "Life for water he [the explorer] will at any moment give, for water cannot be done without". Despite the often meagre nature of water resources, desert Aborigines were, as a rule, able to satisfy this physiological imperative. The purpose of this review is to bring together in convenient form some rather scattered literature (especially in a temporal sense - the references span 145 years!) on how and where Aborigines obtained water in desert regions. Few attempts have been made during the past few decades to review this topic comprehensively, and that of Reim (1962) is in a foreign language. Kavanagh (1984) provided a valuable compilation on "survival water", but his review included some sources (*e.g.* bores) and methods (distillation and those dependent on polyethylene sheets) that were foreign to traditional Aboriginal culture. The opportunity to make first-hand observations to add to the body of knowledge sketched in this review has now gone; the last of the small groups of Aborigines living a strictly traditional life in the desert probably disappeared in the late 1970's - at least there is good evidence that this was the case for the Gibson Desert (Peasley 1983).

General Aspects of Water Location

The role of culture and traditional knowledge

Of key importance to the survival of indigenous people in deserts was the role of oral instruction and stylised mapping of traditional knowledge regarding the type and location of water supplies. Gould (1969) pointed out that the sequence and location of water sources were memorized by Aborigines, and adults would instruct children as groups passed along a chain of waterholes. A knowledge of name sequence and the approximate location of water bodies would often extend beyond the regions that a person had actually visited. Kavanagh (1984, p2-23) also stressed that prior knowledge of the location of surface waters, and the approximate volume contained in them, was of paramount importance for the survival of traditional desert dwellers.

After a period of rainfall, which in Australian desert regions is irregular or episodic, Aborigines would move out to exploit the smaller bodies of water while they still existed. They would forage thoroughly around one of these before moving on to the next. Eventually they would be forced to retreat to the larger and more permanent sources of water. Depending on rainfall, Aborigines would sometimes visit a single reliable waterhole repeatedly within the same year or be compelled to migrate along a chain of water sources to a completely different region without returning to the original site for perhaps two or three years (Gould 1969).

Gould (1984) mentioned the use of smoke signals to indicate that water had been found and to call others to converge on that spot.

Thomson (1962), in a narrative of the Bindibu [=Pintupi] Expedition of 1957, described how he spent several weeks with Aborigines in what is probably the most formidable of all the Australian deserts - the Great Sandy Desert, Western Australia. Just before parting company with these people he was given a very generous gift; a tutorial about their desert waters and a priceless "map" to assist their location. It is worthwhile reproducing Thomson's account of this episode as follows:

> "Just before we left, the old men recited to me the names of more than fifty waters - wells, rockholes and claypans - including those that I have described in this narrative; this, in an area that the early explorers believed to be almost waterless, and where all but a few were, in 1957, still unknown to the white man. And on the eve of our going, Tjappanongo produced spear-throwers, on the backs of which were designs deeply incised, more or less geometric in form. Sometimes with a stick, or with his finger, he would point to each well or rock hole in turn and recite its name, waiting for me to repeat it after him. Each time, the group of old men listened intently and grunted in approval - "Eh!" - or repeated the name again and listened once more. This process continued with the name of each water until they were satisfied with my pronunciation, when they would pass on to the next. *I realized that here was the most important discovery of the expedition - that what Tjappanongo and the old men had shown me was really a map, highly conventionalized, like the works on a "message" or "letter" stick of the Aborigines, of the waters of the vast terrain over which the Bindibu huunted.*" [see Fig 1].

Tindale (1974, p63, fig23) reproduced a comparable "map" of water resources prepared by Katabulka of the Ngatatjara [Ngaatjatjarra] tribe in the Warburton Ranges of Western Australia. This again used spirals to show the location of pools and soakage-wells. The importance of native water maps and associated names in the establishment of the Canning Stock Route was discussed by Tindale (1974, p148).

Seeking help from birds

Magarey (1899), in his review of Aboriginal use of desert waters, stated that, "As thoroughly reliable guides to water in very dry regions the birds have no rivals."

The zebra finch (*Poephlia guttata*), striated pardalote (*Pardalotus striatus*) and red-browed pardalote (*Pardalotus rubricatus*) excel as desert water-finders. The zebra finch is a very sedentary species (the longest movement recorded is only 24 kilometres; Blakers *et al.* 1984) which must have fresh water, so a sighting of it in the desert is very significant. Various pigeons, such as the crested pigeon (*Ocyphaps lophotes*), the forest bronzewing (*Phaps chalcoptera*), and the flock pigeon (*Phaps histrionica*), are also good water "diviners". In addition, Kavanagh (1984) lists both the diamond dove (*Geopelia cuneata*) and the budgerigar (*Melopsittacus undulatus*) for the Simpson and Western Deserts. Wells (1899) described how, in the Great Sandy Desert, his attention was attracted by the noisy flight of a "crested bronze-wing pigeon" which he decided to follow; he was soon rewarded by finding "a splendid native well of a permanent character in sand and soft sandstone".

Specific Sources of Water

Rock-holes (including gnammas); *water lying in hollows on hard, impermeable rock.*

Gnammas are rock-holes (Fig 2) commonly found in outcrops of hard rock, particularly granite, and especially on the top of domed inselbergs (Twidale & Corbin 1963). They are formed over long periods through the gradual enlargement by chemical weathering of what is initially a small cup-sized depression. The word "gnamma" is of Aboriginal origin and comes from the Western Desert languages which were spoken over a huge area of arid country mostly in Western Australia, but also extending into South Australia and Northern Territory. The Western Desert people use this word, or a close phonetic variant of it, to refer to a rock-hole (usually in granite) and especially one likely to contain water. In fact, Tindale (1974) defined a gnamma not as rock-hole, but as a "rockhole *of water*". The word is now firmly established, both in common parlance and in a technical (geological) sense.

One of the earliest written accounts of Australian gnammas (although that term was not used) was that of Austin (1856) who, like several nineteenth century explorers who followed, held an Aborigine captive for the purpose of finding water, during his exploration of the Murchison region of Western Australia. Austin described how his captive led his party to a water-hole in a region where they would never have thought of searching for one, and noted that his party "depended upon the precarious supply of rainwater accumulated *in the hollows of the rocks*".

Giles (1889, v1, p217) provided the following description of what was clearly a gnamma that he encountered in late October 1873:

> "Searching about [on a hill of bare rock] we found another of those extraordinary basins, holes or cups washed out of the solid rock . . . . . From this singular cup we obtained a sufficient supply of that fluid so terribly scarce in this region."

A little earlier, Giles had bestowed the name "The Cups" on a hill (close to Warburton, Western Australia) for its several gnammas. Giles' (1889, v1, p211) account read:

> "Searching about [on a bare rocky hill], I found several small holes or cups worn into the solid rock; and as they mostly contained water, the horses were unpacked, while a further search was made. This hill was always after called the Cups."

Lindsay's (1893) narrative of the Elder Scientific Exploring Expedition recorded that on 2 October 1891 he was directed to "a fine 'gnamer' rockhole" at Symon's Hill in the vicinity of Fraser Range in Western Australia. Subsequently, Calvert (1897) and Carnegie (1898) used the term "namma-hole." All three authors were referring

1. Labbi-labbi
2. Tananga
3. Liuwiringa
4. Kunnamannera
5. Maiyada-maiyada
6. Wirra-wirra
7. Kirindji
8. Kanandibaroo
9. Markodarindja
10. Kampanbarro
11. Wirrkaldjarra
12. Pinna
13. Luwano
14. Kira
15. Tjul'tjun'waridji
16.Dandju
17. Tildi
18. Wakilbi
19. Kuna
20. Pintinba
21. Yinindi
22. Yalbirrimanno
23. Tanda
24. Kurandal
25. Palta
26. Kura
27. Binbiyan
28. Tjipallalla
29. Yirabanda
30. Dangalli
31. Yappadarra
32. Timbabiddi
33. Yuldumallo
34. Kunagarri
35. Mukubanda
36. Mari-mari
37. Karruwildji
38. Wallabarrarba
39. Kiribarro
40. Yanna
41. Wangadjarro
42. Wornba
43. Tjimarri
44. Kunnanno
45. Wirrarigulong
46. Danneriyono
47. Miltji-miltji
48. Papulba
49. Lola

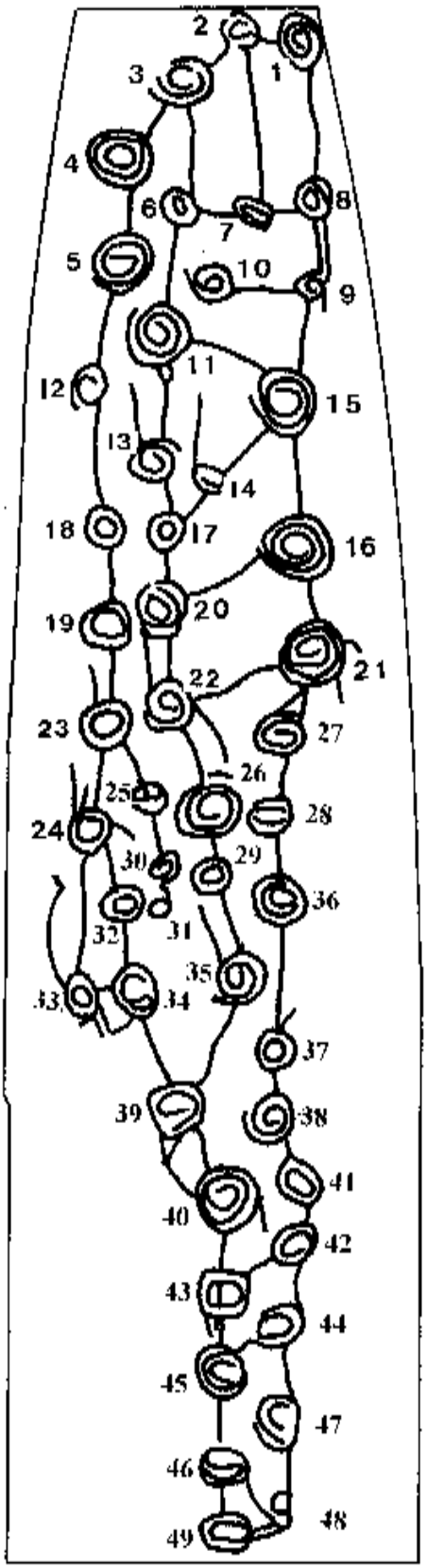

Figure 1. A highly conventionalized map of the Western Australian water resources of the Bindibu [=Pintupi], as carved into the back of a spear-thrower. Redrawn from a photograph of Thomson (1962). The soakage-well known as "Lola" (number 49) is described in a quotation contained in the text of this article.

Figure 2. A gnamma of the deep, pit-shaped variety on Pildappa Rock, a granite inselberg near Minnipa on the upper Eyre Peninsula, South Australia. This ovate gnamma measures 2.7 by 2.3 metres and has a depth of 70 centimetres.

to a rock depression capable of holding water. In fact, "gnamer rockhole" and "namma-hole" are both tautologies because the Aboriginal word "gnamma" by itself meant a rock-hole.

There can be no doubt that rock-holes (many of which were true gnammas in the sense of my initial definition) were of key importance to Aborigines dwelling in the arid regions of Australia for many thousands of years before white settlement. Indeed, Aboriginal tracks in many regions of Australia were largely governed by the occurrence and distribution of rock-holes. The Aboriginal tracks that radiated out in all directions from Ooldea Soak in South Australia (Johnston 1941; Berndt & Berndt 1942) provide a good example.

It is thought (*e.g.* Jutson 1934) that both animals and Aborigines played a significant role in the enlargement of some gnammas by scratching debris and weakened rock from the bottom and sides while tapping the last vestiges of water. Further, Tindale & Lindsay (1963, p65) pointed out that Aborigines sometimes diverted water into a gnamma by chipping grooves in the surrounding rocky slopes. There are several reports of Aborigines (and later European pioneers) covering gnammas with branches or flat slabs of rock to cut down on evaporation, and to keep out wild animals which not uncommonly fell in and drowned, and thus polluted a precious supply of water. Helms (1896), for example, noted that Aborigines filled rock-holes with loose sticks to prevent animals gaining access to the water. He also described how the Aborigines got very excited when one of his camels micturated on the rock and they quickly placed handfuls of earth in front of the flow of urine to prevent pollution of the water in a gnamma.

Some rock-holes, including many found in sandstone, have been produced by fracturing or some agency other than the slow enlargement of a small concavity by chemical weathering and are therefore not gnammas (see Kavanagh 1984).

Soaks (native wells); *water that seeps into hollows dug in freely permeable sediments.*

Smyth (1878, v2, p245) quoted the explorers Grey and Eyre as praising the ability of Aborigines to dig wells through loose sediments. So called "native wells" or "native soakage-wells" were commonly holes dug into sand or soil lying next to the point where a sloping surface of hard, impermeable rock disappeared beneath a flat plain. The upraised rock surface serves as a rain-water catchment and the run-off soaks into the soft sediments surrounding it. Sometimes the wells were located in swales between sandridges and with no close proximity to rocky outcrops (Rowlands & Rowlands 1965). In such cases there may have been a widespread subsurface water table that was accessible only in the more depressed regions. Generally the depth of these wells did not exceed about 4 or 5 metres, but an average depth was only about 1.5 metres. In the case of deep wells, the sides were secured with pieces of timber and brushwood and cross-pieces were left to serve as a ladder (Basedow 1925, p96).

The word "springs", even when given the apparent authority of incorporation into proper nouns, seems often to have been misapplied to soakage-wells. Jack (1915), for example, noted with respect to the Indulkana Springs in South Australia that "[these] springs may be better described as holes in a saturated sponge of alluvial than as true springs." He also quoted Captain Hubbe's opinion regarding the Oowallinna Springs that, "I am fully convinced that this so-called spring is simply a strong soakage".

Helms (1896) noted that well-holes were often filled with sticks or sand to prevent evaporation and stop animals from drinking or fouling the water. Small soakages under rocks near the base of hills were, after use, always completely covered up again on departure.

Soaks and their importance to travellers were well described by Carnegie (1898) who, however, seemed to make the probably unnecessary assumption that some sort of underground rock basin is a necessary prerequisite for water to flow into an excavation into the soil surrounding a rocky outcrop. While a hidden rock basin or underground rock dam would create a favourable situation, it seems a safe assumption that localised water-tables may become established even where a bedrock surface slopes away continuously beneath the regolith. Wells (1899) reported that "from Mount Bates to the Fitzroy River no surface waters were found in the [Great Sandy] desert, and I am of the opinion that none except native wells are to be found. These are numerous; but *without the assistance of a [Black] guide, or except by running the tracks of natives, they are most difficult to discover."*

Basedow (1906), who participated in the South Australian Government North-west Expedition of 1903, described the occurrence of several native soakage-wells at the base of granitic hills in the Musgrave Ranges. The same author pointed out that natives sometimes exploited soakage-wells that were located in the sandy beds of superficially dry rivers. Likewise, Strehlow (1947, p60) mentioned that the Western Arrernte Aborigines dug soaks to obtain water anywhere along the bed of the Finke River from Japalpa to Running Waters.

Thomson (1962) made some interesting comments about the extraordinary capacity, based on traditional knowledge and long experience, of Bindibu Aborigines to locate soaks and wells in the desert; in effect they were

able to see these features clearly where Europeans would see nothing. Thomson's comments are as follows:

> "There was certainly a great deal more water in the desert than had been assumed by white man, but the location of the wells, soaks and springs on which the Bindibu depend was known only to these people. Most important of all, its behaviour under diverse conditions was familiar to them from life-long experience, backed by traditional information that was handed down from generation to generation by word of mouth. A few days after we went to Labbi-labbi, Hosmer and I went back to the stranded Jeep with some men. They led us to a small well that had a plentiful supply of good water, only a mile from the place where the Jeep was bogged. This was Lola [see Fig. 1], typical of the wells of the remote desert. Wells of this type are less impressive than clay pans and rock holes, certainly the least spectacular of all the desert waters. But in times of drought they are the most dependable. *The difficulty in this country is that there is no way in which the white man can find the wells and soaks, nor, as a rule, is there anything in the lie of the land to explain why the water is there when he does find it*. Lola was situated at the bottom of a depression among low hills and dunes and here, even at an advanced stage in the hot season - well into September - the water-table was only 3 feet from the surface. The well itself was about 14 inches in diameter and there was a step about 2 feet down on the shelving bank. The people had no drinking utensils and when they came to water, each one in turn knelt down and drank, like an animal. Of Lola, the Bindibu say 'nabba pala' - good water."

Gould (1970) described a native soakage-well located at Pulykara, near Mt. Madley, in the centre of the Gibson Desert. This well, which was one of the most dependable sources of water in the region, had been dug down to a depth of about 4.5 metres to reach the water table lying beneath the superficially dry bed of a lake. Likewise, in the western Gibson Desert, the well known as Ngarinarri sustained the aborigines, Warri and Yatungka, the so-called "last of the nomads", during a prolonged drought in the 1970's (Peasley 1983, p87). This well, which was dug through a claypan, was 3.5 metres deep.

Impoundments; *dams constructed from clay with wooden shovels*

Dams of native construction were unusual. However Giles (1889, v2, pp92-3) came across a substantial crescent-shaped clay dam which had been built by Aborigines at Pylebung in western South Australia. The clay had been dug out of a muddy hole with wood shovels to form a dam 18 metres long, 1.5 m thick at the base, 0.6 m across the top and 1.5 m high. Later (Giles 1889, v2, pp170 & 184) this expedition came across a second smaller native clay-dam and found that Aborigines had dug out a "tank" or hollow for water storage purposes at Boundary Dam (named for its location near the border between South Australia and Western Australia).

Murray (1902) described two native dams at Paraminna to the north of Fowler's Bay in South Australia. Here the excavated clay had been reinforced with twigs and branches and formed into a U-shaped dam with a basal width of about 1 metre and a height of about 60 centimetres. Serventy (1961) briefly mentioned Kalgarbin, a dam built by Aborigines in the Great Victoria Desert. Hercus (1990) referred to first-hand accounts of Aborigines in the Simpson Desert prolonging their water supply by building dams across the deeper claypans. When these supplies were exhausted they reverted to soakage-wells.

Claypans; *water lying in a depression in soft sediments with low permeability*

Giles (1889, v1, p39) described a claypan as follows:

> "A clay pan is a small area of ground, whose top soil has been washed or blown away, leaving the hard clay exposed; and upon this surface, one, two, three, or (scarcely) more inches of rain water may remain for some days after rain: the longer it remains the thicker it gets, until at last it dries in cakes which shine like tiles; these at length crumble away, and the clay pan is swept by winds clean and ready for the next shower. In the course of time it becomes enlarged and deepened."

The two salient and rather obvious features of claypans are their ephemerality and high turbidity. They range in size from tens to hundreds of metres across. The shininess of a dried pan referred to by Giles is caused by the extreme fineness of the particles deposited at the final stage of drying (Basedow 1906). The occurrence and Aboriginal use of claypans or "warla" in the Great Sandy Desert was discussed by Lowe & Pike (1990) who pointed out that when they held water they were favoured camping places because they attracted game.

Although sometimes put into a separate category, it is convenient to include with claypans those basins that are called by the Aboriginal word "gilgai". These are small sub-circular depressions 1.5 - 7.5 metres in diameter (Ollier 1966) which, like claypans, have a floor of clay and provided a strictly ephemeral source of water.

Riverine waterholes; *water in holes scoured out of river beds by water movement*

In the low lying regions of central Australia, water-courses scour out coarse bed material during rare floods, and quite large holes may be formed, especially where

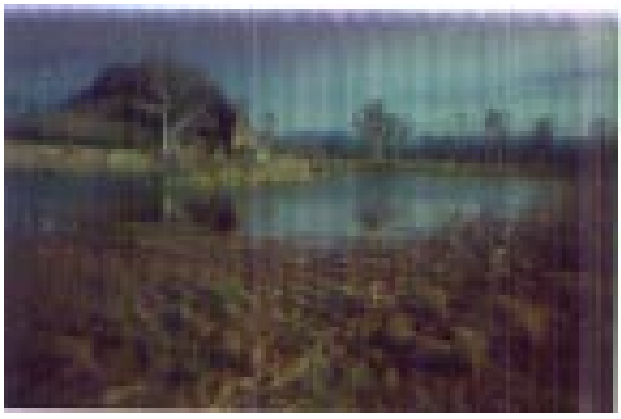

Figure 3. A semi-permanent waterhole located in the bed of the Finke River, near its source, 3 km upstream from Glen Helen Gorge, Northern Territory.

bends occur. After an episodic filling, many of these waterholes suffer rapid losses through evaporation and seepage, and quickly disappear. However, some quasi-permanent waterholes of this kind may occur. Strehlow (1947, p60) mentioned five important "permanent" waterholes frequented by the Western Arrernte Aborigines along the upper reaches of the Finke River (Fig 3), while Mabbutt (1971) pointed to 15 such water bodies along this same river to the south of the James Range. Similar waterholes also form along the Alberga, Lander and Palmer rivers in central Australia (Peterson 1978). Large waterholes are a feature of several rivers in the Channel Country, such as Cooper Creek, the Diamantina and the Georgina, where they occur even along straight stretches (Mabbutt 1971).

Mound springs; *systems fed by carbonated water under hydrostatic pressure*

Water, taken in near the Great Dividing Range in Queensland, passes underground and rises under hydrostatic pressure through cracks in the overlying rock near the south-western edge of the Great Artesian Basin. These waters are high in calcium and bicarbonate and, as they reach the surface, half-bound carbon dioxide is lost, and calcium carbonate in the form of tufa or travertine is deposited (Bayly & Williams 1973). Over a long period, these deposits form substantial mounds around the springs.

The mound springs in north-eastern South Australia were semi-permanent oases in the desert and there is abundant archaeological evidence that they were of great importance to Aboriginal people (Boyd 1990). Only one of eight mound springs examined north of William Creek failed to provide evidence of large Aboriginal camp sites, and at Dalhousie Springs archaeological remains associated with one camp site extend for almost three kilometres. The Dalhousie Springs were an important water resource for the Lower Southern Arrernte people and the Wangkangurru people of the Simpson Desert (Potezny 1989).

Tree trunk hollows; *water accumulated in pockets of decay in trees above ground level.*

Lindsay (1893, p129) and Helms (1896), apparently in reference to the same incident observed during the Elder Scientific Exploring Expedition, described how an Aboriginal woman located and extracted water from a tree hollow. First she noticed a line of ants going up and down a tree, entering and emerging from a small knot-hole about shoulder-height from the ground. She then made a tube by removing the bark from a straight twig, using her teeth. Three or four of these tubes were then joined end to end and the long composite pipe was pushed through the hole in the knot and used as a drinking-straw to suck up the water trapped in the tree hollow. Where the opening to the water chamber was somewhat larger, an alternative procedure, described by Cairns (1859) and Smyth (1878, v2, p253), could be used; the Aborigine tied a bunch of grass to the end of a spear and dipped this into the water before pulling it out and squeezing the water out of the grass into a coolamon.

Magarey (1899) noted that the tree species most exploited by Aborigines for tree-hollow water was the desert oak (*Allocasuarina decaisneana*) and that such trees were as well known to the Aborigines of a region as were rock-holes (gnammas) and native soakage-wells. Bloodwood (*Eucalyptus terminalis*) may also have reservoirs in its trunk (Tietkens 1891). Kavanagh (1984, p6-5) found that the Ngatatjara [Ngaatjatjarra] People in the Warburton Ranges, used water stored in the trunks of old specimens of the cork tree (*Hakea macrocarpa*).

Tree roots; *water that flows from cut tree roots after excavation*

Magarey (1899) related the story of the noted explorer Tietkens expressing astonishment to an Aborigine that one of his kin could be generating a column of smoke away in the distance, in country that Tietkens had repeatedly visited and knew (or thought he knew!) to be absolutely waterless. The Aborigine at Tietkens's side responded, "He is all right. He got tree-water."

One of the earliest descriptions of Aborigines securing water from the roots of trees was that of Eyre (1845, v1, p350) who observed the procedure during his epic trek across the Great Australian Bight. Cairns (1859) provided a similar account of water recovery from the roots of mallee eucalypts in north-western Victoria. In brief, mallee roots when excavated, broken off and held vertically, dripped a clear, watery and highly potable fluid. In the desert regions of central Australia, the red mallee, *Eucalyptus socialis*, was the favoured species. However, either side of the Nullarbor Plain it was a different red mallee, *Eucalyptus oleosa*, that was exploited by natives for water (Cleland 1957).

Magarey (1899) pointed out that Europeans "have laid down under a 'water-tree' and died of thirst, whilst the water they so terribly needed lay only two or three inches under the scorching sand, and beneath their outstretched finger-tips. The aboriginal knows better." However, the apparently simple Aboriginal technique was not as easily imitable by Europeans as Magarey seemed to suppose. Helms (1896) noted that his own attempts to imitate the technique were often unsuccessful and Giles (1889, v1, p45) expressed similar reservations as follows:

> "A white man would die of thirst while digging and fooling around trying to get the water he might know was preserved by the tree, but not for him; while an aboriginal, upon the other hand, coming to a mallee-tree, after perhaps travelling miles through them without noticing [selecting] one, will suddenly make an exclamation, look at a tree, go perhaps ten or twelve feet away, and begin to dig. .....A very long root such as I have mentioned might give nearly a bucketful of water; but woe to the white man who fancies he can get water out of mallee."

The roots of water-mallees run out from the trunks for 10-20 metres and lie only 5-25 centimetres beneath ground level. An Aborigine would try the ground at about 2-3 metres from the trunks, or near a bulge or crack in the earth, and excavate the root with a wood shovel or spear-point. The root would be pulled up and broken off near the trunk, then pulled up towards its extremity, and broken into lengths of 50-100 cm. These lengths were then stood on end against the trunk to drain into a coolamon or marsupial-skin bag. If an Aborigine were

very thirsty he or she would suck immediately on the cleaned end of a vertical root-stick. Roots about as thick as a person's wrist were said to be best. One water-mallee usually has from four to eight side roots running close to the surface, and one mallee root of average length would provide enough water for the immediate needs of two or three thirsty natives (Magarey 1899).

The desert kurrajong (*Brachychiton gregorii*) is another especially good water-tree, its roots being very porous and yielding water very freely. Needle-bush (*Hakea leucoptera*) and the desert oak (*Allocasuarina decaisneana*) were further useful providers (Magarey 1899). To these should be added water bush, *Grevillea nematophylla* (Kavanagh 1984).

Dew; *water collected from vegetation in the form of dew droplets*

Magarey (1899) described how Aborigines would go out before sunrise and collect dew-drops with a sweep of the arm or movement of a stick. A more efficient method was to form a ball of grass and use this as a sponge to gather the dew lying on grass. The water would then be squeezed out of the ball into a coolamon or pitchi (Tindale & Lindsay 1963, p64). Another method was to hold a water container under the dew-drenched twigs of a shrub or tree which was tapped or shaken. The leaves of the sandalwood tree (*Santalum spicatum*) were said to be particularly useful for gathering early morning dew. Aborigines in central Australia collected dew from the desert heath myrtle, *Thryptomene maisonneuvii*, to make a sweet drink.

Frogs; *water contained within the body of frogs*

Carnegie (1898, p.17) recorded the following yarn told to him by a friend at a bush camp:

> "He [Carnegie's friend] was perishing from thirst, and, at the last gasp, he came to a clay-pan which, to his despair, was quite dry and baked hard by the sun. He gave up all hope; not so his black-boy, who, after examining the surface of the hard clay, started to dig vigorously, shouting, 'No more tumble down, plenty water here!' Struggling to the side of his boy, he found that he had unearthed a large frog blown out with water, with which they relieved their thirst. Subsequent digging disclosed more frogs, from all of which so great a supply of water was squeezed that not only he and his boy, but the horses also were saved from a terrible death!"

Although laughed off at the time by most of Carnegie's companions, the essentials of the story were, as Carnegie himself realized, factually based.

Spencer & Gillen (1912, v1, pp58-62) provided a good account of the behaviour and ecology of the water-holding frog (*Cyclorana platycephala*), which has the ability to take up a large amount of water (stored in the bladder) before burrowing beneath the surface of a claypan where they may aestivate for more than a year. They described how their native guide had the uncanny ability to appreciate the significance of some indistinct marks on the surface and how they cut into the rock-hard clay with a hatchet to recover one of these frogs at a depth of about 30 centimetres. It was a common practice for Aborigines to squeeze the body water out of this frog and drink it. In the words of Waite (1929), "water may be obtained by squeezing the body of the frog, and the Australian native will win through where unattended white men would perish of thirst". A graphic account was given by Basedow (1935, pp86-7) as follows:

> "My amazement reached a climax when he [an Aboriginal escort] seized the frog, placed the head-end in his mouth and squeezed its body. And while he squeezed he drank! It was not a mere sip, either; I should say the fluid he swallowed would have been sufficient to fill a teacup. As he drank, the old fellow looked at me out of the sides of his eyes in a very quizzical way; and when he had drained this most remarkable goblet to its last drop he smacked his lips afresh and exclaimed 'Bullya Marra' ['Good! Good!']."

The yield of fluid claimed in this quotation (*ca* 200 ml?) is probably exaggerated, since Tyler (1982) quoted a volume of only 10-25 ml. However, Kavanagh (1984) pointed out that the water-holding capacity constantly changes and that volumes range from one teaspoon to half a teacup [say 5-100 ml]. A yield of 100 ml is beyond the capacity of *C. platycephala* and may refer to *C. australis*. Not only was the body water drunk but the remainder of the frog was then eaten!

Apart from the observation of marks on the surface of a claypan, Aborigines could also detect the hidden chambers of aestivating *Cyclorana platycephala* by tapping on the hard surface with the butt of a spear (Basedow 1935; Goodhart 1939; Charnley 1954). A further method, useful after a long period of drought, was to stamp on the ground and listen for the faint croaking of the frogs (Tindale & Lindsay 1963; Cleland 1966).

Discussion

The first six of the above listed specific sources of water (gnammas, soaks, impoundments, claypans, riverine waterholes, mound springs) may all be grouped as surface water resources. The longevity of these range from the highly ephemeral small claypans (Gilgai) and larger claypans, through to the more reliable and often quasi-permanent soakage-wells. It was these mainly small-scale surface waters on which desert Aborigines principally relied. Other conceivable water sources, such as lakes, rivers and creeks, have been deliberately omitted from this review on the grounds that they were rarely significant in the context of Australian deserts. Although maps of these regions show them dotted with lakes and playas, and crossed by rivers, most of these are either dry or saline most of the time. With respect to survival waters in Australian deserts the general rule is that big is not beautiful! Water resources other than surface water, such as those from tree trunks and roots, dew and frogs, were very important to certain tribes such as the Ngalea (Tindale 1974, p215) and to people in transit (Cleland 1966).

Gould (1991) discussed two alternative means whereby Ngatatjara [Ngaatjatjarra] Aborigines in the Western Desert survived when stressed by drought. The first strategy, "drought escape", was adopted in response to long periods of absolute drought, and involved the

abandonment of home areas and migration over long distances to join relatives already living in areas with an adequate water supply. Although Gould did not directly observe this pattern of behaviour during his 5-year study, he gathered indirect evidence from the Warburton Ranges Mission and various groups of Ngatatjara people that earlier severe droughts had resulted in the temporary evacuation of drought-stricken regions. The second strategy, "drought evasion", involved the continuous occupancy of the home area and reliance on the more reliable water supplies such as soakage-wells. Use of this strategy by the Ngatatjara was widely observed by Gould (1991) during 1969 and 1970. In regions with reliable water supplies, Aborigines may have relied exclusively on drought evasion. This is thought to have been the case for those living in or near the Everard Ranges (Tindale 1974; Gould 1991).

Despite their extraordinary water-locating skills, desert Aborigines had no absolute guarantee of survival. Cane (1990) noted, with respect to the Western Desert, that, "Almost every Aboriginal person I have spoken to can recall times when they were close to death - or members of their immediate family had died in attempts to find water during the critical phase of a prolonged dry season". In the late 1940's a group of Aborigines were trapped at a disappearing waterhole west of Lake Mackay. These people knew of two waterholes that may still have had water; one was to the north, the other to the south. Accordingly the party split into two; those going north survived, but the southern group found their waterhole dry and perished (Cane 1990). A further example was provided by Gould (1969) who described a region between the Warburton Ranges and the South Australian border with few reliable water sources and in which Aboriginal deaths occurred during seasons of marginal rainfall.

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Indigenous Australians are people with familial heritage to groups that lived in Australia before British colonisation. They include the Aboriginal and Torres Strait Islander peoples of Australia. The term Aboriginal and Torres Strait Islander people, or the person's specific cultural group (their mob), is often preferred, though the terms First Nations of Australia, First Peoples of Australia and First Australians are also increasingly common. â€œThe indigenous peoples of the Amazon have proven to be the best guardians of their traditional territories,â€ Swing adds. â€œThe fact that the Amazon ecosystems are as rich as they are today is proof of how successful these cultures have been, in living in balance with their environment.â€ About 200 SÃ¡para live in Ecuador, with approximately the same number across the border in Peru.Â These latter areas would include indigenous-managed territories, such as the SÃ¡para lands in Ecuador. However, experts warn that recognizing the contributions of indigenous peoples is not as simple as drawing polygons on maps. It means going beyond traditional â€œfortress conservation,â€ of walling people away from nature. The Tirari Desert, located in South Australiaâ€™s Far North regionâ€™s eastern part, encompasses an area of 15,250 square km. Part of the desert lies within the Kati Thanda-Lake Eyre National Park. A large number of salt lakes and sand dunes running from north to south are important features of the desert landscape.Â The desert is a part of Australia that houses the most populous and healthy population of Indigenous Australians belonging to groups like Pitjantjatjara, Mirning, and the Kogara. Large parts of the Great Victoria Desert, however, remain uninhabited as the climate and terrain are unsuitable for human settlement. Large, pristine areas of the desert are protected areas like the Mamungari Conservation Park. The holy grail of water in the desert is a step closer after scientists employed by the ruler of Abu Dhabi claim to have generated a series of downpours.Â They have a natural tendency to attach to tiny specks of dust which are ever-present in the atmosphere in the desert-regions. These are then carried up from the emitters by convection - upward currents of air generated by the heat release from sunlight as it hits the ground. Once the dust particles reach the right height for cloud formation, the charges will attract water molecules floating in the air which then start to condense around them. If there is sufficient moisture in the air, it induces billions of droplets to form which finally means cloud and rain. Australia's indigenous Aboriginal people lived right across the country for possibly 50,000 years or more. However Central Australia, not surprisingly, is a harsh environment that could only sustain a very low population density. Sustainability matters, then and now.Â And Australia's deserts are typically massive, eroded regions of ancient salty sea bed topped by thin soil with a crust on top, a crust that when broken releases red powdery dust into the air, to be dropped haphazardly thousands of kilometres away, most likely in the far distant sea. Australia's arid heart is not Nile River farmland just waiting to be watered.Â Forget the desert. The top third of Australia gets plenty of rainfall and in many places is great for agriculture. And practically empty. Why don't we?