South Australian
HERITAGE COUNCIL

BETTER HERITAGE INFORMATION
SUMMARY OF STATE HERITAGE PLACE

COMMENTARY ON THE LISTING

Description and notes with respect to a place entered in the South Australian Heritage Register in accordance with either the *South Australian Heritage Act 1978* or the *Heritage Places Act 1993*.

The information contained in this document is provided in accordance with s14(6) and s21 of the *Heritage Places Act 1993*.

NAME: Inneston Lake and Deep Lake Geological Sites **PLACE NO.:** 16678

KNOWN AS: Inneston Lake and Deep Lake Geological Sites, Dhilba Guuranda-Innes National Park

ADDRESS: Narungga Country
Pondalowie Bay Road
Dhilba Guuranda-Innes National Park
Inneston
CR/6240/20 H131500 S131, CR/6240/20 H131500 S101
Hundred of Warrenben

CONFIRMED IN THE SOUTH AUSTRALIAN HERITAGE REGISTER:

8 July 1999

STATEMENT OF HERITAGE SIGNIFICANCE

Inneston Lake and Deep Lake are among a small number of places in South Australia where living stromatolites occur. Stromatolites (structures formed in rock by an ecosystem composed of several extremely ancient life forms, bacteria and cyanobacteria) have long been known in the fossil record and are among the earliest life forms known, existing 3,500 million years ago. They were believed to have become extinct about 100 million years ago, until the discovery of recent stromatolites in several lakes in South Australia and Western Australia.

Inneston and Deep Lakes are of outstanding scientific importance because of the occurrence of living stromatolites, and provide rare opportunities in which to study the morphology and environmental conditions for the formation of a modern occurrence of one of the earliest life forms on earth (*Yorke Peninsula Heritage Survey, 1997*)

(Validated 22 February 2000)

STATEMENT OF DESIGNATION

Designated Place of Geological Significance

The Inneston Lake and Deep Lake Geological Sites are the result of thousands of years of hydrological and geological change. There are abundant gypsum deposits at both Inneston Lake and Deep Lake, with those at Deep Lake remaining highly intact. The precipitated minerals in the base of the lakes illustrate recent sea level changes and sediment depositions that contributed to the geological fabric of the place as well as the formation of rare living stromatolites.

Groundwater movement fills Inneston Lake and Deep Lake through springmounds and fissures, while boxwork gypsum texture at Inneston Lake contributes to the ecosystem of the place. The many geological features associated with the carbonates at both lakes demonstrate the continuing development of the geological landscape and yield opportunities to research the geological history of the Yorke Peninsula coast.

Elements of Significance:

Elements of heritage significance include (but are not necessarily limited to):

- A highly intact natural environment supporting stromatolites (Deep Lake),
- Exceptional tepee structures (Deep Lake)
- Brecciated, cemented and chemically altered rock formations,
- Continually forming Gypsum deposits, quarried and natural,
- Spring mounds and fissures feeding groundwater into the lakes,
- Continually forming selenite domes and other remaining high-purity gypsum deposits,

Elements not considered to contribute to significance of place include (but are not necessarily limited to):

- Human-made structures, railways, fences, and paths

Designated Place of Palaeontological Significance

The Inneston Lake and Deep Lake Geological Sites are highly preserved habitats for assemblages of layered stromatolites formed from ancient microbial mats. Comprised of both fossilised and living stromatolites the structures are made from some of the earliest lifeforms on earth. Once abundant worldwide three billion years ago, the 'living fossils' at Inneston and Deep Lakes are very rare and provide a glimpse into the ancient development of microbial organisms and the evolution of life. Living microorganisms continue to grow and thrive as they layer upon decomposing and

lithified microorganisms and sediment. Climatic data is retained within the laminations making the structures highly likely to yield information that will contribute to an understanding of the evolution of the climate and landscapes within the State.

Elements of Significance:

Elements of heritage significance include (but are not necessarily limited to):

- Rare living stromatolites growing rapidly at two separate lakes, some untouched by mining activity,
- Hypersaline lake environments supporting growth of microbial organisms,
- Geological features that support the growth of microbial organisms, such as carbonate crusts, and boxwork limestones,

Elements not considered to contribute to significance of place include (but are not necessarily limited to):

- Human-made structures, railways, fences, and paths

RELEVANT CRITERIA (under section 16 of the *Heritage Places Act 1993*)

(b) it has rare, uncommon or endangered qualities that are of cultural significance

Stromatolites are layered sedimentary rock formations created mainly by photosynthetic microorganisms. Both fossilised and living stromatolites provide a record of climatic change over time. Fossilised stromatolites are uncommon and living stromatolites are rare in South Australia.

The Inneston Lake and Deep Lake Geological Sites are home to assemblages of layered stromatolites. Formation requires highly specific conditions to support the growth of the 'microbial mats' (colonies of cyanobacteria and other microorganisms) that eventually form mineral and organic-rich layers through sedimentation. Examples of stromatolites in South Australia can be found at Inneston Lake, Deep Lake and the nearby Marion Lake (SHP 14417), the Coorong Lagoon, Sleaford Mere and at other places in the South-East[1] and Flinders Ranges.[2]

Most fossilised stromatolites are millions to billions of years old and are regarded as some of the earliest evidence of life, however the stromatolites at Inneston and Deep Lakes are 'modern', being only 3000-5000 years old and are also living stromatolites, undergoing an active formation process.

Living stromatolites are very rare and the young age of the Inneston and Deep Lake stromatolites adds an additional element of rarity to the State Heritage Place. Modern stromatolites are rarer than true, 'fossil' stromatolites such as those found, for example,

in the Flinders Ranges (SHP 14278, SHP 14797) with many stromatolites disappearing in the late Precambrian[3] (ending ~541Ma).

The Inneston and Deep Lake stromatolites demonstrate a stage between 'living' and true fossilised stromatolites providing an extremely rare insight into how stromatolites developed, grew and what could be the next stage of evolution for the still-living stromatolites. Inneston Lake and Deep Lake Geological Sites are rare and highly scientifically significant as the place allows for the visualisation of cementation and fossilisation of stromatolite layers in real time.

Additionally, the two lakes are the location of selenite deposition, a variety of gypsum crystal. Normally forming in layers of zigzags, Deep Lake is the only brine pond in South Australia that forms the selenite in flat laminae. Conditions at Inneston and Deep Lakes can be used to better understand formation of selenite in other hydrological settings and perhaps how they began to form ~6000 years ago.[4]

(c) it may yield information that will contribute to an understanding of the State's history, including its natural history

The Inneston and Deep Lake Geological Site can contribute to an understanding of South Australia's natural history due to the presence of modern stromatolites and uncommon geological and palaeontological features associated with the ancient saline lake.

The Inneston and Deep Lake Geological Site is one of the few places in South Australia where living stromatolites can be found and is recognised as South Australia's 'greatest potential for studies of primary productivity and microbiology.'[5] The stromatolites' algal communities grow in a restricted area with numerous variables coinciding to create an environment that the microbes can survive within. As a result of this it is likely that the site provides the opportunity to study numerous associated processes including carbon and sulphur cycling in hypersaline environments. [6]

Research thus far on the living stromatolites has identified '*Microcoleus, Phormidium, Spirulina* and possibly *Oscillatoria*' living in the microbial mats at Deep Lake. [7] It's believed that these algae may be the same as those that produced the Marion Lake (SHP 14417) subfossil stromatolites.[8] While much of the organic matter is removed or replaced in the Marion Lake stromatolites, the Inneston and Deep Lake living stromatolites provide an opportunity for identification and may yield a better understanding of the timeline of stromatolite growth, cessation and interaction with the South Australian environment through geological time.

Formation of these stromatolites and the processes involved are not well understood. Living stromatolites at the Inneston and Deep Lake Geological Site display

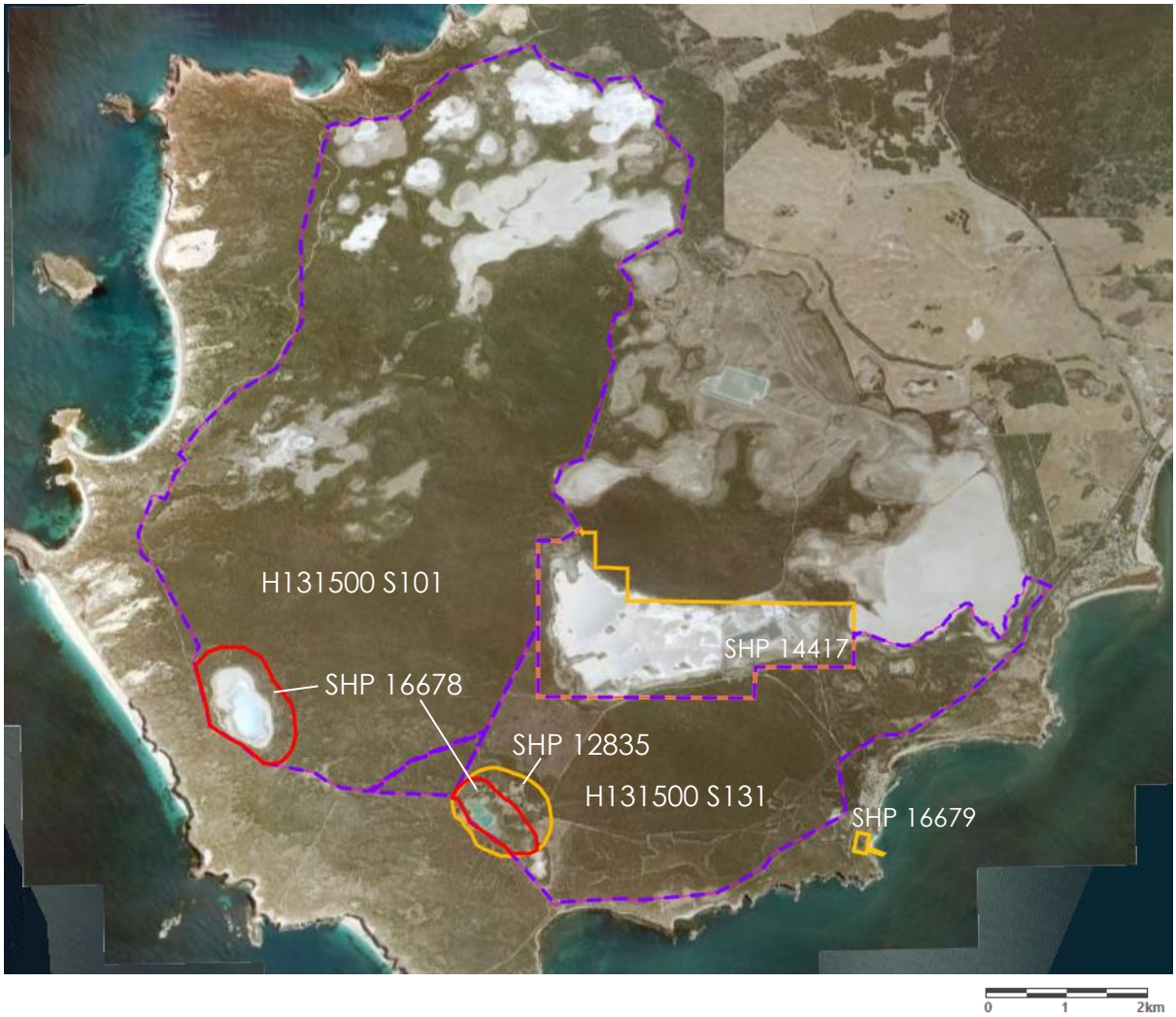
laminations, yielding opportunities for research to enable an insight into their development. These laminations can be used to identify the growth patterns of stromatolites, seasonal changes, storm frequency, changes to the species of bacteria forming the mat and many other aspects about the natural history of South Australia.[9] The layers can also demonstrate seasonally variable salinity and water levels of the lake.[10] In turn, this information can shed light on broader climate trends across time and into the future.

Well-preserved geological features, such as tepees and spring mounds can also yield insight into the geological history and formation of saline lake environments and their interaction with freshwater aquifers. Research thus far has identified sea-level rises as a main factor in the development of the local environment and are useful in tracing the history of the place when paired with the stromatolites.

SITE PLAN

Inneston Lake and Deep Lake Geological Sites **PLACE NO.: 16678**

Dhilba Guuranda-Innes National Park



Aerial view of Deep Lake (Left) and Inneston Lake (Right) with the Inneston Gypsum Mining Precinct (SHP 12835) surrounding Inneston Lake.

N ↑

LEGEND

- Outline of Elements of Significance for State Heritage Place
- Parcel boundaries
- Existing State Heritage Place(s)

Confirmed in the South Australian Heritage Register on 8 July 1999
Designated as a Place of Geological and Palaeontological significance on 8 July 1999
The South Australian Heritage Council endorsed the content of this BHI - SSHP on 19 October 2023
Amendment endorsed 7 December 2023

SITE PLAN - DETAIL

Inneston Lake and Deep Lake Geological Sites **PLACE NO.: 16678**

Dhilba Guuranda-Innes National Park

Aerial view of Inneston Lake with a portion of the Inneston Township to the North. The SHP is located within the Inneston Gypsum Complex (SHP 12835)

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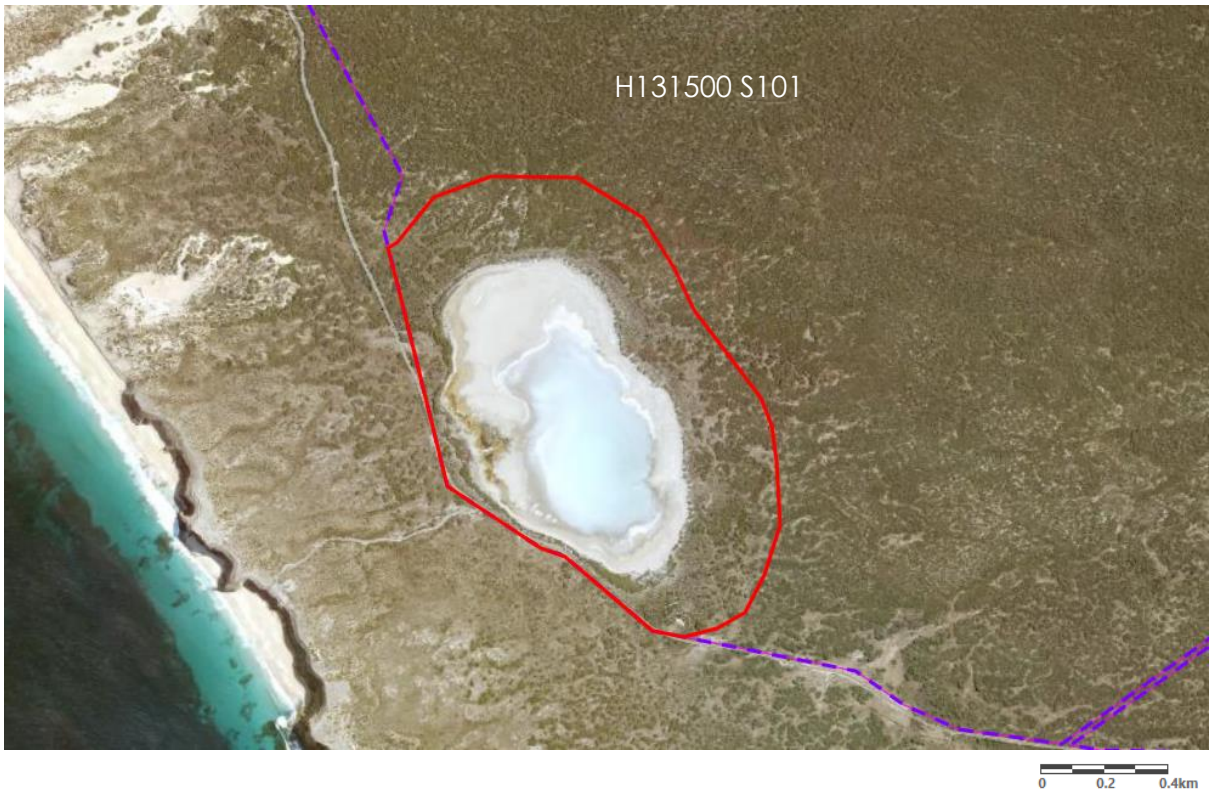

Aerial view of Deep Lake

N ↑

LEGEND

Outline of Elements of Significance for State Heritage Place

Parcel boundaries

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PHYSICAL DESCRIPTION

Inneston Lake

Inneston Lake is a salina (salt lake) located within Dhilba Guuranda-Innes National Park, approximately 9km southwest of Marion Bay.

Inneston Lake is a naturally occurring depression artificially deepened by mining activity. The State Heritage Place is approximately 850m long and 220m wide and the remaining 440m from the north-western end of the lake, approximately one-third of the State Heritage Place at the south-eastern end remains dry. Perennial water fills the north-western part of the lake, which fluctuates in depth seasonally and is replenished by groundwater. The boundaries of the SHP are offset from the original lake shoreline, including the part which is currently dry.

Large deposits of gypsum exist at the bottom of the lake, including selenite (crystallised gypsum) domes, some as large as 2m high, undergoing active formation. The shores of the lake remain unmined and layered with domes of gypsum below the halocline (a layer of water where the salinity changes rapidly), as well as limestone and tepee structures. The southern margin of the lake contains the largest remaining gypsum mounds.[11]

The shores of Inneston Lake are also home to living stromatolites that are subaqueous[12] (occurring under water) and which can be found in 15-30cm of seasonal water on the lake floor. Living stromatolites at Inneston Lake range from 10-40cm in diameter and some are hollow.[13] The stromatolites are comprised of '*Phormidium, Spirulina*, possibly cyanophytes or green algae, moderately abundant diatoms, and other algae.'[14]

Salinity within Inneston Lake is extreme (>100,000 parts per million (ppm), where ocean water is 35,000 ppm). The brine shrimp *Paratemia* lives within the lake[15] and using boxwork structured limestones as a habitat.[16]

Deep Lake

Deep Lake is a naturally occurring saline drainage basin found within Dhilba Guuranda-Innes National Park, approximately 2km northwest of Inneston Lake. Deep lake is 1km long and 500m wide.

The natural, unmined lake floor is comprised of naturally precipitated gypsum deposits. During summer, the water level retreats to a small brine pond in the centre

of the depression with depths of less than 10cm. The lake water is hypersaline (100,000ppm) but is believed to be slightly less saline at the margins. The lake is replenished by salt water from spring mounds.[17]

Deep Lake is home to flat or domal living stromatolites which are covered seasonally by a layer of aragonite (fine carbonate) mud.[18] The stromatolites demonstrate coarser laminations than Marion Lake's sub-fossil stromatolites.[19]

Other features of the lake include the presence of tepee structures, some with 40cm relief above ground level; breccia; cements; diagenetic rocks; unmined gypsum; and aragonite.

Geological features of interest found at Inneston and Deep Lakes which are commonly found associated with stromatolites, include:

- Boxwork limestone – hardened (indurated), fossiliferous (finestral) limestones filled with cavities. Inside, they often form honeycomb-like patterns and are associated with cave formations. Boxwork limestone comprises most of the geological substrate of the lake and is associated with a succession of chemical changes between the limestone, aragonite and gypsum minerals.
- Laminated Gypsum – gypsum formed in thin organised layers from precipitation, where differences in the thicknesses between layers typically represents seasonal changes in the environment.
- Tepees – Deep Lake (SHP 16678), located ~3.7 kilometres to the west, is also well known for these structures[20]. They are formed through seasonal changes, most often from groundwater and initialise with overthrusting. Overthrusting is a process where rocks are pushed upwards. On a large scale, this process forms mountain ranges. The tepees are triangular structures that appear to erupt from the ground. Groundwater flows preferentially through the hollows created by these structures[21] and contributes to the area's landscape.
- Springmounds – small, lake-like structures formed around artesian springs that are connected to large underground freshwater aquifers. These springs push water up and onto the surface through fractures in the rock.[22]

Elements of Significance:

Elements of heritage significance include (but are not necessarily limited to):

- Rare living stromatolites growing rapidly at two separate lakes, some untouched by mining activity,
- Hypersaline lake environments supporting growth of microbial organisms,
- Geological features that support the growth of microbial organisms, namely carbonate crusts[23] and boxwork limestones

- A highly intact natural environment supporting stromatolites,
- Tepee structures (Deep Lake),
- Brecciated, cemented and chemically altered rock formations,[24]
- Continually forming Gypsum deposits, mined and natural,
- Spring mounds and fissures feeding groundwater into the lakes,
- Continually forming selenite domes and remaining high-purity gypsum deposits.

Elements not considered to contribute to significance of place include (but are not necessarily limited to):

- Human-made structures, railways, fences, and paths.

HISTORY OF THE PLACE

Stromatolites first appeared in the geological record around 3.5 billion years ago and many are around 540 million years old. The stromatolites at Inneston and Deep Lake Geological Sites are very young, believed to be approximately 3000-5000 years old,[25] of a similar age to those at Marion Lake (SHP 14417). However, unlike the stromatolites at Marion Lake, the stromatolites at Inneston and Deep Lakes are still growing. It is believed that Inneston Lake stromatolites are currently undergoing growth and development processes that previously occurred to stromatolites at Marion Lake[26] such as the initial formation of the mounds and continued lamination in conjunction with the surrounding environment.

While at the nearby Marion Lake (SHP 14417), which was an open embayment for part of its history[27] (receiving water flow directly from the ocean),[28] Inneston and Deep Lakes, likely only ever received water through precipitation and groundwater. Nevertheless, seasonal variations in water levels within the lakes allowed for the precipitation of laminated gypsum sequences over 6000 years.

The Narungga people are the traditional owners of Yorke Peninsula. Prior to and for some time after the arrival of Europeans, the Narungga people modified their environment, burning selected areas to create lightly forested expanses, suitable for hunting, within a broader landscape of thick mallee scrub.[29]

Yorke Peninsula's dense vegetation and apparent lack of water delayed the arrival of pastoralism until 1846.[30] Agricultural settlement on Yorke Peninsula began during the 1860s, while the first mining lease in the area was issued in 1874. In 1889 a mine at Marion Lake opened by the Australian Gypsum and Whiting Company. The Melbourne-based Permasite Company commenced gypsum mining at Inneston Lake from 1913. The Permasite Company developed a township named Inneston on the

coast at nearby Stenhouse Bay and infrastructure including a jetty and a railway connecting the lake to the coast.

In c.1930[31] the mining operations at both Marion and Inneston Lakes were acquired by the Waratah Gypsum Company Pty Ltd and mining operations were consolidated with Marion Lake, which proved more profitable than Inneston Lake.[32] Between 1905 and 1973, 6 million tonnes of gypsum were mined from the area including Marion Lake and Inneston (SHP 16678).[33] At Inneston Lake, intensive gypsum mining gradually deepened the lake floor.

Innes National Park, now Dhilba Guuranda-Innes National Park, was proclaimed in 1970, incorporating Deep and Inneston Lakes. Inneston Lake was recognised as a geological monument by the South Australian Division of the Geological Society of Australia in 1984. Inneston and Deep Lakes were confirmed in the South Australian Heritage Register in 1999.

Following the cessation of mining at Inneston Lake, natural replenishment of saline water into the lake has caused the natural process of gypsum precipitation to resume. Stromatolites at Inneston Lake have also grown considerably since mining ended.[34] Deep Lake, on the other hand, was never quarried for gypsum and remains highly intact.[35]

In 2020, co-management between the Narungga Nation Aboriginal Corporation and the Department for Environment and Water was established and a Management Plan implemented in 2023.

CHRONOLOGY

Year	Event
3.5Ga	Earliest recorded stromatolites in the fossil record (not at Deep and Inneston Lakes)
Pleistocene - Holocene (2.6Ma-Present)	Marion Lake and surrounds open to the ocean through an open embayment. Inneston and Deep Lakes remain landlocked.
6ka	Saline groundwater seepage begins the formation of gypsum within Inneston and Deep Lakes.
3ka	Likely earliest formation of stromatolites at Inneston and Deep Lakes.
1874	First mining lease in the area issued[36]
1889	Mining undertaken at the nearby Marion Lake (SHP 14417) by the Australian Gypsum and Whiting Company

1913	Permasite Company of Melbourne (Owned by G. Bell, A. Stenhouse and W. Innes) acquires mining leases over Inneston Lake.
1913-1930	Gypsum mining occurs at Inneston Lake, with a township built on the edge of the lake[37] (outside boundaries of SHP).
1920	Mining operations passed to Peninsula Plaster Company Limited.[38]
1927	Inneston officially recognised as a town.
1930	Consolidation of mining activities by Waratah Gypsum Company Pty Ltd and cessation of mining at Inneston Lake.
1970	Dhilba Guuranda-Innes National Park proclaimed.
1977	Dhilba Guuranda-Innes National Park expanded.
1984	Dhilba Guuranda-Innes National Park expanded a second time.
1986	A portion of the area around Inneston area is listed in the South Australian Heritage Register as the Inneston Gypsum Complex (SHP 12835).
1998	Inneston Lake and Deep Lake Geological Sites provisionally entered in the South Australian Heritage Register.
1999	Inneston Lake and Deep Lake Geological Sites confirmed as a State Heritage Place.
2003	Dhilba Guuranda-Innes National Park Management Plan adopted.
2004	Dhilba Guuranda-Innes National Park Management Plan amended.
2020	Dhilba Guuranda-Innes National Park Management Plan amended a second time. Co-management between the Narungga Nation Aboriginal Corporation and the Department for Environment and Water is established.
2023	A 2023 Dhilba Guuranda-Innes National Park and Yorke Peninsula Parks Management Plan is implemented[39]
Present	Stromatolites and gypsum deposits within Deep and Inneston Lakes continue to form.

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SITE DETAILS

Inneston Lake and Deep Lake Geological Sites **PLACE NO.: 16678**

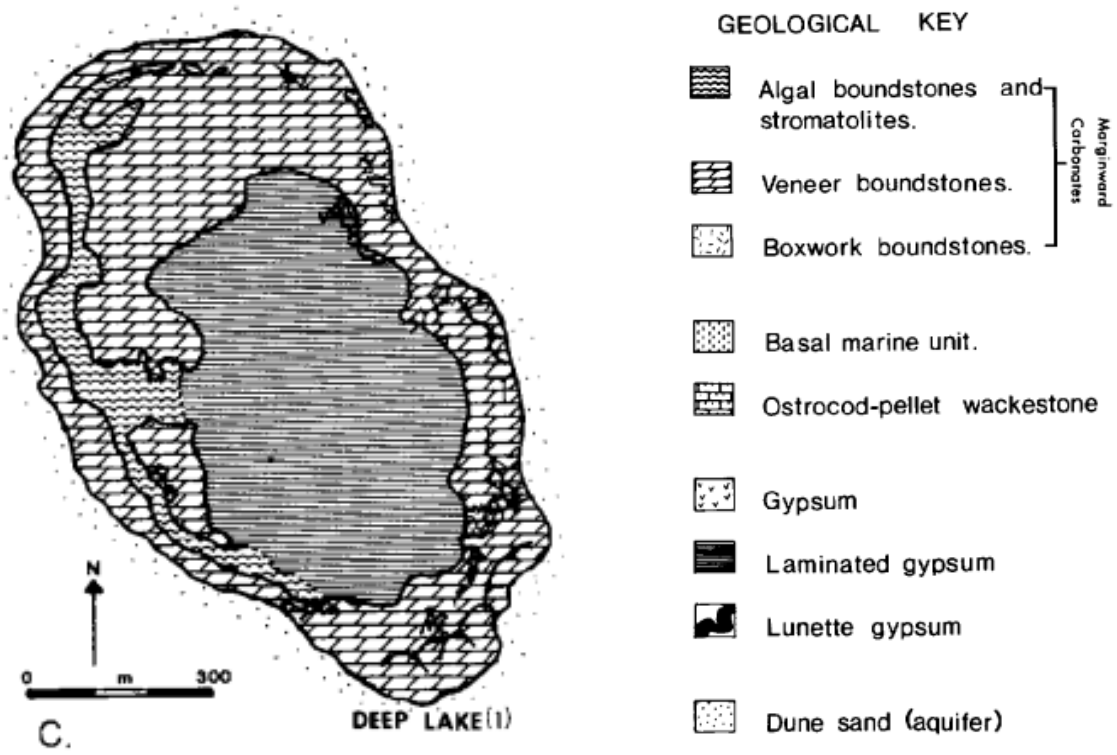
Dhilba Guuranda-Innes National Park

DESCRIPTION OF PLACE:	Two saline coastal lakes with living microbial colonies actively forming stromatolites	
DATE OF CONSTRUCTION:	NA	
REGISTER STATUS:	Identified to Heritage Policy Unit: 25 June 1998 Provisionally entered as a State Heritage Place in the SA Heritage Register: 8 October 1998 Confirmed: 8 July 1999 Designated: 8 July 1999	
CURRENT USE:	Dhilba Guuranda-Innes National Park Minister Environment and Conservation Land	
LOCAL GOVERNMENT AREA:	Yorke Peninsula	
LOCATION:	**Street No.:**	NA
	Street Name:	NA
	Town/Suburb:	Inneston
	Post Code:	5577
LAND DESCRIPTION:	**Title Reference:**	CR/6240/20
	Plan No.:	H131500 S131, H131500 S101
	Hundred:	Hundred of Warrenben

PHOTOS

Inneston Lake and Deep Lake Geological Sites **PLACE NO.: 16678**

Dhilba Guuranda-Innes National Park



Geological map of Deep Lake.

Source: Warren, JK (1982)

PHOTOS

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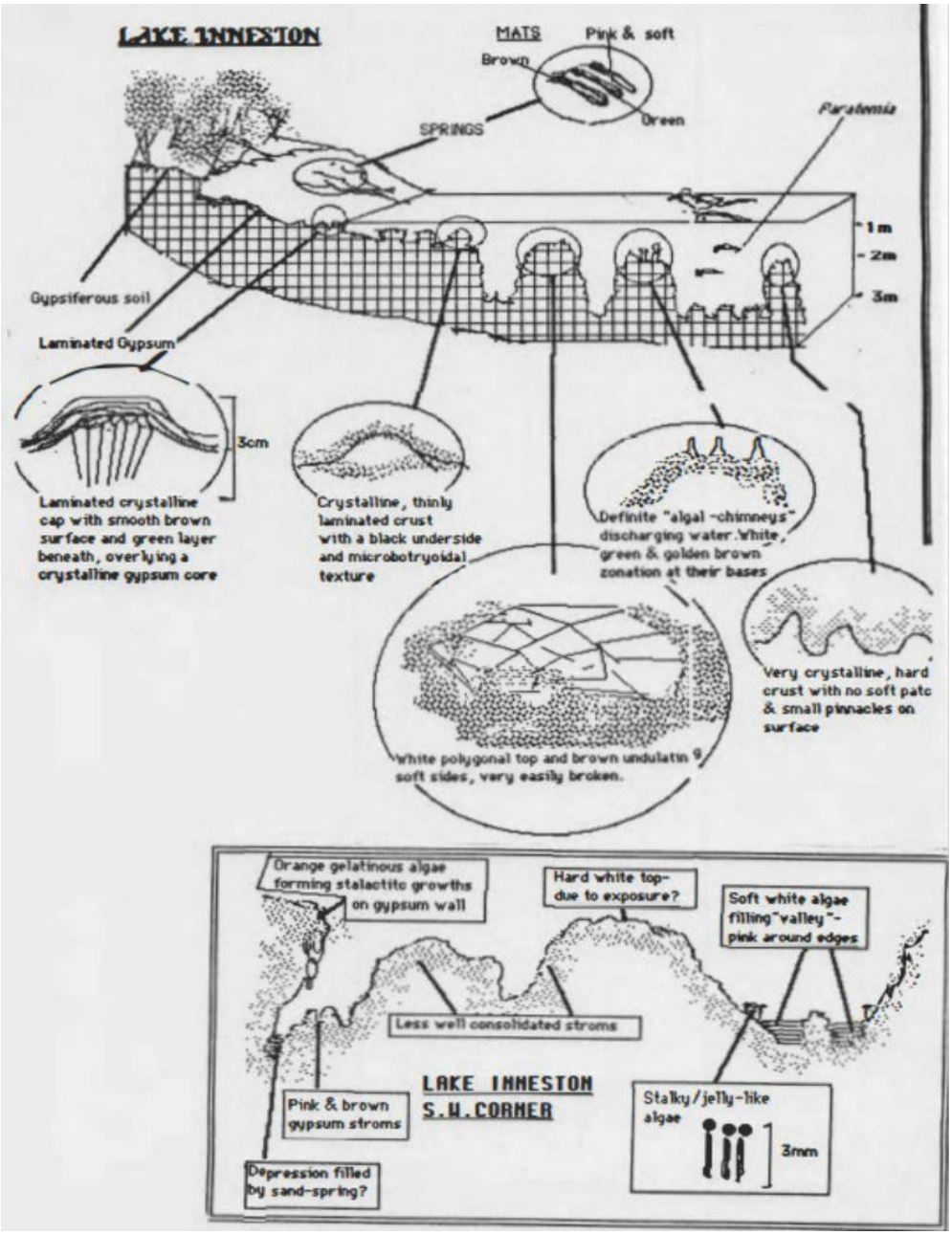

Diagrams of geological formations and algal structures at Inneston Lake

Source: Lock, DE, and Burne, RV (1986)

[1] Thurgate ME (1996), 'The stromatolites of the Cenote Lakes of the Lower South East of South Australia', *Helictite*, Vol. 34, pp. 17-25.

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[8] Von Der Borch, CC, Bolton, B and Warren JK (1997), 'Environmental setting and microstructure of subfossil lithified stromatolites associated with evaporites, Marion Lake, South Australia'.

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