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: Marion Lake Geological Site **PLACE NO.:** 14417

KNOWN AS: Marion Lake Geological Site, Dhilba Guuranda-Innes National Park (designated place of geological significance)

ADDRESS: Narungga Country
Dhilba Guuranda-Innes National Park
Inneston
CR5769/587 H131500 S177
Hundred of Warrenben

CONFIRMED IN THE SOUTH AUSTRALIAN HERITAGE REGISTER:

8 July 1999

STATEMENT OF HERITAGE SIGNIFICANCE

Marion Lake Geological Site is one of only a few places in South Australia where modern stromatolites can be found and may provide insight into the underlying processes required for the formation of these structures. The stromatolites at Marion Lake are estimated to be between 3000 to 5000 years old, and in appearance differ little from ancient examples which were formed by cyanobacteria, one of the earliest forms of life on earth. Too young to be fossils, the Marion Lake structures are a rare example of subfossil stromatolites and with the other geological features associated with the saline lake, creates a natural landscape that is of outstanding scientific importance due to its potential to yield detailed information about the natural history of South Australia.

STATEMENT OF DESIGNATION

Designated Place of Geological Significance

Marion Lake Geological Site preserves rare modern stromatolites, uncommon geological formations, and fossilised evidence of past marine life. Rare and exceptional subfossil stromatolites found on the shores of the lake have a high likelihood to yield information about the natural development of the Yorke Peninsula coast. Remarkably fine laminations of aragonite and organic material preserve near-modern seasonal and climatic environmental changes.

The Lake's geological features demonstrate formation by the evaporation of water and deposition of minerals over thousands of years to form carbonate and gypsum deposits. Geological features such as boxwork limestone, springmounds, lunettes and tepees have all formed throughout the area and contribute to its geological significance. These, in tandem with similar structures at the nearby Deep and Inneston Lakes (SHP 16678) have the potential to yield detailed information on the natural evolution of South Australia.

Elements of Significance:

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

- Modern stromatolites,
- Geological features including but not limited to boxwork limestone, springmounds, lunettes and tepees,
- Remaining gypsum deposits as well as other mineral or evaporite deposits,
- Holocene-aged marine sands and seagrass,
- Calcreted, Pleistocene-aged dune,
- The environment of the lake and its surrounds.

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

- Built structures including buildings, signage and trails.

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

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

The Marion Lake Geological Site is home to an assemblage of finely layered stromatolites. The Marion Lake stromatolites are noted as outstanding examples for their induration (hardening), the fine laminations of the layers within, and preserved cyanobacteria inside.

Stromatolites are uncommon within South Australia. Formation requires highly specific conditions to be able 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 Marion Lake and the nearby Inneston Lake (SHP 16678), 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 Marion Lake are 'modern', being only 3000-5000 years old. The young age of the Marion 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 in the Flinders Ranges (SHP 14278, SHP 14797) with many stromatolites disappearing in the late Precambrian[3] (ending ~541Ma).

While examples of living stromatolites such as those found at Inneston and Deep Lakes (SHP 16678, Coorong Lagoon, and the South-East (SHP 26530)) are regarded as very rare, the subfossil stromatolites at Marion Lake are too young to be considered 'true' fossils. As such, they 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. The subfossils contain a mixture of organic material and rock material that allows for the visualisation of fossilisation in real-time. The Marion Lake Geological Site is therefore rare and highly scientifically significant.

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

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

Marion Lake is one of a few places in South Australia where modern stromatolites can be found and may provide insights into the underlying processes required in the formation of stromatolites, which are not well understood. The stromatolites at Marion Lake Geological Site display 'irregular' and very fine laminations, providing an understanding into their development. These can also 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 factors through ongoing research.[4] The layers can also provide information related to the seasonal variations to salinity and water levels of the lake.[5]

The Marion Lake stromatolite's young age and recent cessation of bacterial life presents an opportunity for research into a rare stage of stromatolite development. It is thought but not known that the past development of the Marion Lake stromatolites is reflected in the still living stromatolites at Deep and Inneston Lakes (SHP 16678). Additional research and comparison of stromatolites at these three places may result in a better understanding of the timeline of stromatolite growth and cessation[6] and could be correlated to ancient examples.

Well-preserved geological features, such as tepees, lunettes and spring mounds can potentially contribute insights 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 assist in tracing the history of the place when paired with the stromatolites.

Additionally, Marion Lake Geological Site has a high likelihood to provide insight into the geological development of the Yorke Peninsula's Southern coast during the Pleistocene-Holocene epochs. The preserved organisms, such as fossilised marine sea life can provide an understanding of the evolution and past living conditions of South Australia's native species. For example, in-situ fossilised specimens of a now endangered extant species of seagrass, *Posidonia australis*. The fossilisation processes and near-modern growth of the stromatolites could also demonstrate the evolution of marine life in South Australia.

SITE PLAN

Marion Lake Geological Site **PLACE NO.: 14417**

Dhilba Guuranda-Innes National Park

Aerial view of the Yorke Peninsula.

N ↑

LEGEND

Existing State Heritage Place(s)

Outline of Elements of Significance for State Heritage Place

Parcel boundaries (indicating extent of listing)

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

SITE PLAN - DETAIL

Marion Lake Geological Site **PLACE NO.: 14417**

Dhilba Guuranda-Innes National Park

Aerial view of the Marion Lake Geological Site.

N ↑

LEGEND

Existing State Heritage Place(s)

Outline of Elements of Significance for State Heritage Place

Parcel boundaries (indicating extent of listing)

PHYSICAL DESCRIPTION

Marion Lake Geological Site is a large inland saltwater lake approximately 4km southwest of Marion Bay. The lake is approximately 2.7km in area and is located within the Dhilba Guuranda-Innes National Park. There is evidence of extensive mining, however, geological features of interest remain intact.

Most fossils in the State Heritage Place are modern stromatolites. These stromatolites are approximately 3000-5000[7] years old and are comprised of layered deposits of cyanobacteria and sediment that form a rock-like structure over time.

Stromatolites are uncommon in the fossil record and modern stromatolites are regarded as rare.[8] The Marion Lake stromatolites are found surrounding the shores of the lake in shallow water. The chemical composition of stromatolite structures varies, however the formations at Marion Lake are composed predominantly of aragonite and calcite to form a framework of micrite substrate within which relict bacterial remains can be found. Stromatolites associated with micrite formations are small, dome-like formations approximately 1-2cm in diameter.[9]

Further from the current shoreline, in association with boxwork limestone formed ~5740 years ago, are larger stromatolite forms approximately 3.8 thousand years (ka) old. The stromatolite caps are ~10cm thick but may have up to 40cm relief due to the boxwork limestone on which they are formed. The physical and chemical conditions within Marion Lake indicate that the algal portion of the stromatolites has been largely stripped away through decay and replaced with aragonite,[10] though some organic matter does remain.[11]

Pleistocene fossiliferous limestone (2.5 Million years ago (Ma) -11 thousand years ago (ka)) is also present, with a maximum thickness of 1 metre. Also present in the lake are fossilised fibres of a species of Holocene (5.8ka) seagrass, *Posidonia australis*.[12] *Posidonia australis* is an extant and currently endangered seagrass species.

Geological features of interest at Marion Lake Geological Site, 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. In South Australia, the best examples of these successions are found at Marion Lake and Streaky Bay.[13]

- 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 – these structures occur around the margin of Marion Lake. They are also 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. Deep Lake (SHP 16678), located ~3.7 kilometres to the west, is also well known for these structures.[14] Groundwater flows preferentially through the hollows created by these structures[15] 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.[16] The springmounds at Marion Lake (and also those discovered more recently at Sleaford Mere on the Eyre Peninsula) are interesting in that they pass into a sheet of finestral limestone (known as a veneer boundstone), which overlays the porous boxwork limestone. In some areas they also pass into thin laminated stromatolites as well as algal mats and tufas.
- Lunettes – layers of sand and silt or clay formed by wind and water movement, forming large mounds of sediment. These can be in the form of small, fixed sand dunes to large structures protruding from the landscape, though they are relatively small at Marion Lake.

Elements of Significance:

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

- modern stromatolite structures,
- Holocene fossilised seagrass,
- Pleistocene fossiliferous limestones,
- boxwork limestones,
- highly laminated gypsum precipitations,
- tepee structures,
- spring mounds formed by underground aquifers,
- lunette and dune structures.

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

- human-made structures, roads and fences, tramways and walls.

HISTORY OF THE PLACE

Fossil stromatolites first appeared in the geological record around 3.5 billion years ago and many are around 540 million years old. The stromatolites at Marion Lake Geological Site are very young, approximately 3000-5000 years old and are therefore classified as 'subfossil' stromatolites[17] and are also known as 'modern stromatolites' for their young age.

During the Pleistocene (2.6Ma-11.7ka) and Holocene (11.7ka-present), marine transgressions inundated the area with sea water,[18] resulting in Marion Lake being a shallow open embayment, allowing for seawater to move through a passage in and out of the area.[19] The sedimentation of Pleistocene dunes that formed approximately 2.5Ma and Holocene banks (~11ka)[20] are likely to have contributed to the eventual closure of the area to the sea and development of numerous shallow lakes. [21]

Restricted lakes such as Marion Lake continued to support plant life into the early Holocene (5.8ka)[22] where evidence of a species of seagrass, *Posidonia australis*,[23] can be found fossilised. As water movement into the lake decreased, a highly saline lake was created that allowed the deposition of pure gypsum.[24] Fed by aquifers, the Lake formed depositions of gypsum through continuous evaporation, ranging from 2-3 metres deep in the centre of the lake and alternating with seasonal deposits of aragonite ($CaCO_3$) and gypsum ($CaSO_4 \cdot 2H_2O$) towards the edges.[25] It was in these shallower edges of Marion Lake, on hardened micrite, that the stromatolites began to form approximately 5000-3000 years ago. After a change in environmental conditions, micrite was deposited on top of the stromatolites, demonstrating that this was likely the time that the 'living rocks' ceased formation.[26]

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.[27]

Yorke Peninsula's dense vegetation and apparent lack of water delayed the arrival of pastoralism until 1846.[28] Following this, agricultural settlement on Yorke Peninsula began during the 1860s.

Extensive commercial mining has occurred in and around the lake since the 1870's. However, despite agriculture and mining over an extended period of time, numerous geological and palaeontological features remain. In the 1930s, mining operations were consolidated by Waratah Gypsum Pty Ltd who held mining leases on Marion Lake until they were surrendered in 2002 and 2015.[29] The Innes National Park

Management Plan, 2003 notes that between 1905 and 1973, 6 million tonnes of gypsum were mined from the area including Marion Lake and Inneston (SHP 16678).[30]

The Waratah Gypsum Pty. Ltd. avoided mining in areas where stromatolites were present and as a result, many remain well-preserved. The gazettal of the National Park in 1970 and later surrender of the mining tenements has afforded the structures with additional protection.

In 1984, Marion Lake was recognised as a Geological Monument and on 8 July 1999, Marion Lake was confirmed as a State Heritage Place in the South Australian Heritage Register and designated as a place of geological significance.

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

CHRONOLOGY

Year	Event
3.5Ga	Earliest recorded stromatolites (not at Marion Lake Geological Site).
Pleistocene (~2.6Ma-12ka)	Fossiliferous limestone dunes at Marion Lake Geological Site are formed.
Earliest Holocene (~12ka)	Marion Lake is an open-marine embayment (a small bay open to the ocean).[31]
Holocene	Marion Lake embayment blocked by the formation of a beach-dune barrier.
~6 ka	The Marion Lake depression is understood to have been filled and dried multiple times over many years either through sea-level changes and/or through the presence of an aquifer.[32] Date of earliest possible formation of stromatolites. Various evaporitic carbonates and salts begin to fill the lakes, allowing for the deposition of the gypsum that Marion Lake is known for.
5-3ka	Most likely age of stromatolites present at Marion Lake Geological Site.
1846	Emergence of European pastoralism on Yorke Peninsula and subsequent agricultural settlement.
1889	Gypsum mining commences at Marion Lake.
1930	Waratah Gypsum Pty Ltd consolidates mining activities at Marion 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. Marion Lake recognised as a Geological Monument by the SA Division of the Geological Society of Australia.
1993	Dhilba Guuranda-Innes National park expanded a third time.
1997	Yorke Peninsula Heritage Survey recommends Marion Lake Geological Site as a State Heritage Place that is designated for geological significance.[33]
1999	Marion Lake Geological Site confirmed as a State Heritage Place and designated as a place of geological significance.
2002	Waratah Gypsum Pty Ltd surrendered ML 623, ML 174, ML 137, ML 981 and ML 980.
2003	Dhilba Guuranda-Innes National Park Management Plan adopted.
2004	Dhilba Guuranda-Innes National Park Management Plan amended.
2011	Historical Archaeological Survey undertaken by Dr Cameron Hartnell and Ms Susan Arthure identifying archaeological significance.
2015	Waratah Gypsum Pty Ltd surrendered ML 904, ML 979. There has been no further mining since at Marion Lake Geological Site.
2020	Dhilba Guuranda-Innes National Park Management Plan updated. 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.[34]

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SITE DETAILS

Marion Lake Geological Site **PLACE NO.: 14417**

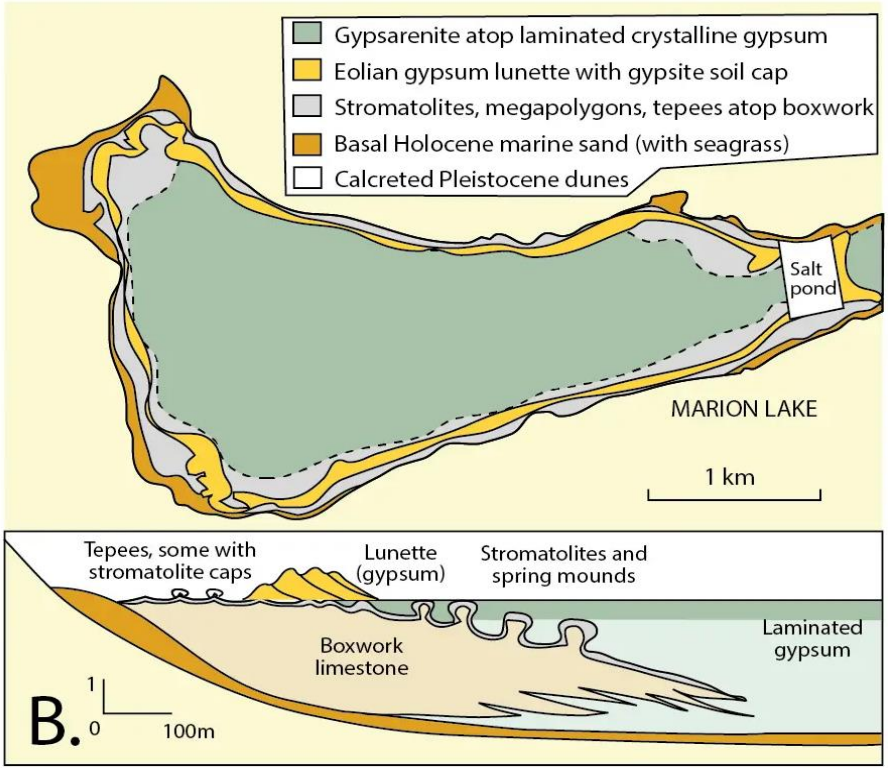
Dhilba Guuranda-Innes National Park

DESCRIPTION OF PLACE:	Gypsum Lake, approximately five square kilometres in area.	
REGISTER STATUS:	Confirmed 8 July 1999	
	Designated 8 July 1999	
CURRENT USE:	Dhilba Guuranda-Innes National Park	
	Unallotted Crown Land - Minister for Environment and Water	
LOCAL GOVERNMENT AREA:	Yorke Peninsula	
LOCATION:	**Street No.:**	NA
	Street Name:	Dhilba Guuranda-Innes National Park
	Town/Suburb:	Inneston
	Post Code:	5577
LAND DESCRIPTION:	**Title Reference:**	CR5769/587
	Plan No.:	H131500 S177
	Hundred:	Hundred of Warrenben

PHOTOS

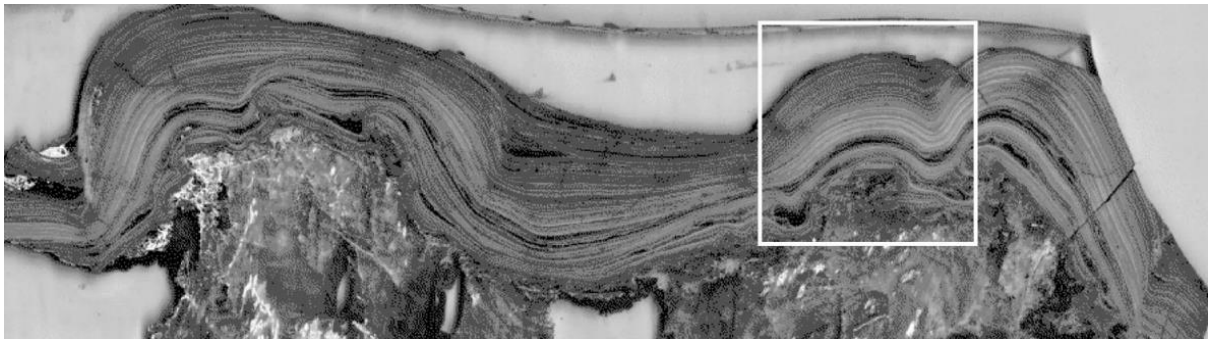
Marion Lake Geological Site **PLACE NO.: 14417**

Dhilba Guuranda-Innes National Park



A map of Marion Lake noting geological features, interpreted from Warren JK (1982).

Source: Saltwork Consultants Pty Ltd (2016-2023)



Marion Lake stromatolite laminae (laminated layers).

Source: Batchelor MT , Burne RV,Henry BI, Watt SD (2000)

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PHOTOS

Marion Lake Geological Site **PLACE NO.: 14417**

Dhilba Guuranda-Innes National Park

Tepee disrupting the fenestral carbonate crust on Marion Lake.

Source: Belperio AP et al. (1995)

Marion Lake - Gypsum Loading Dragline.

Source: Willington CM (1958)

Marion Lake - Moody's Gypsum Quarry.

Source: Willington CM (1958)

Holocene stromatolites on Marion Lake.

Source: Belperio AP et al. (1995)

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[15] Warren, JK (1982), 'The Hydrological Significance of Holocene Tepees, Stromatolites, and Boxwork Limestones in Coastal Salinas in South Australia'.

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