2020

Recovering Pink Lake's lost Colour

Technical report communique

Cover Artwork: Tjaltjraak Mooraak, Walkabout at Kepa Kurl by Donna Beach (Ninnon) Donna Beach (Ninnon), artist and direct descendant of the Bullenbuk people of Esperance. Department of Biodiversity Conservation and Activities (DBCA) ©

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Prepared for the Shire of Esperance

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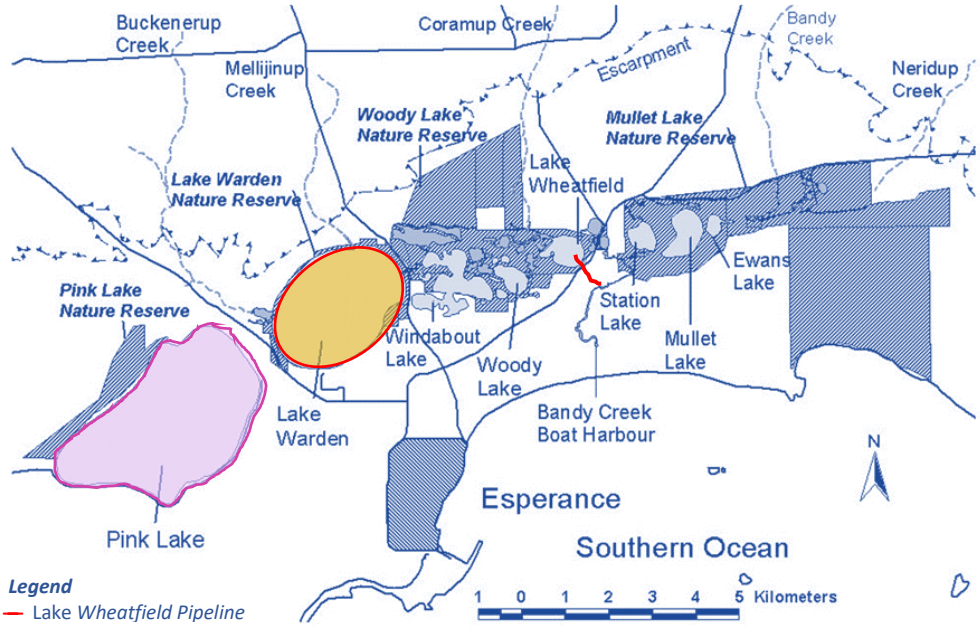
Shire of Esperance

We make it happen!

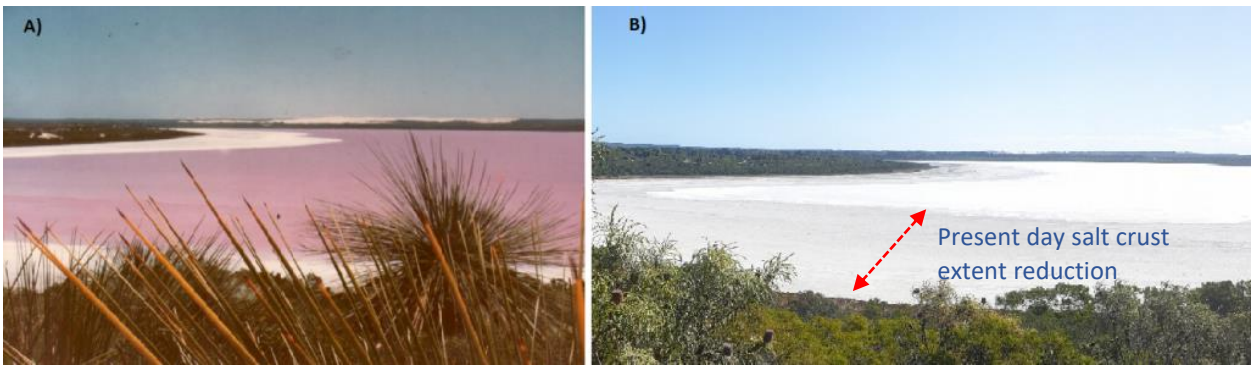
Can Pink Lake's lost colour be recovered?

The iconic named Pink Lake is located near the Town of Esperance, approximately 600 km south east of Perth Western Australia. Pink Lake is about 1,040 hectares in area located approximately five kilometres west of the town of Esperance. It is a terminal, predominately rainfall and groundwater lake located on the Esperance coastal plain at the western end of the Lake Warden Wetland System.



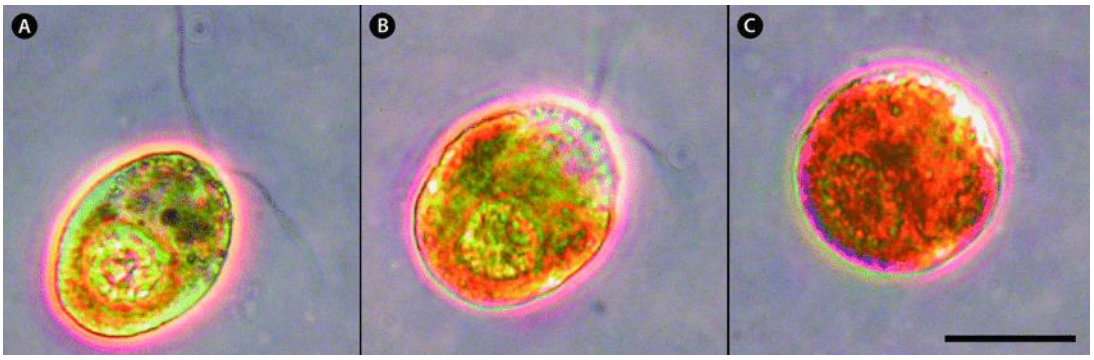
The Lake Warden Wetland System and Lake Wheatfield pipeline route in red

The Shire of Esperance (SoE) is concerned about Pink Lake's prolonged diminished 'pink colour' since the mid 1990's impacting on tourism and the local community. The SoE have commissioned a feasibility study to assess whether it could be part or fully recovered. The following is a summary of the study's findings.



Pink Lake bloom and salt crust formation near edge of Lake 1985 (Photo P. Birch), and March 2020 dry lake and decrease in salt crust area by hundreds of meters (Photo T. Massenbauer).

The cause of Pink Lake's historic pink colour is a result of an algae known as *Dunaliella salina (D. salina)*. The organism produces red carotenoid pigment at high concentrations when stressed as a survival response to outcompete other organisms for limited nutrients.



Dunaliella salina cells in different culture conditions. (A) Green cell from a non-stressed culture. (B) Stressed cell turning orange. (C) (Ramos et.al 2011)

The stress factors include salinities greater than 10 times seawater, warm water, extremely low phosphate nutrient and high light intensity. Under these optimum stress conditions, the red coloured *D. salina* stained water fades to pink when there is the presence of a salt crust at lake depth, and fine white to light grey suspended particles to diffuse light intensity. All these factors sustained for more than a four-week period likely result in a pink bloom.

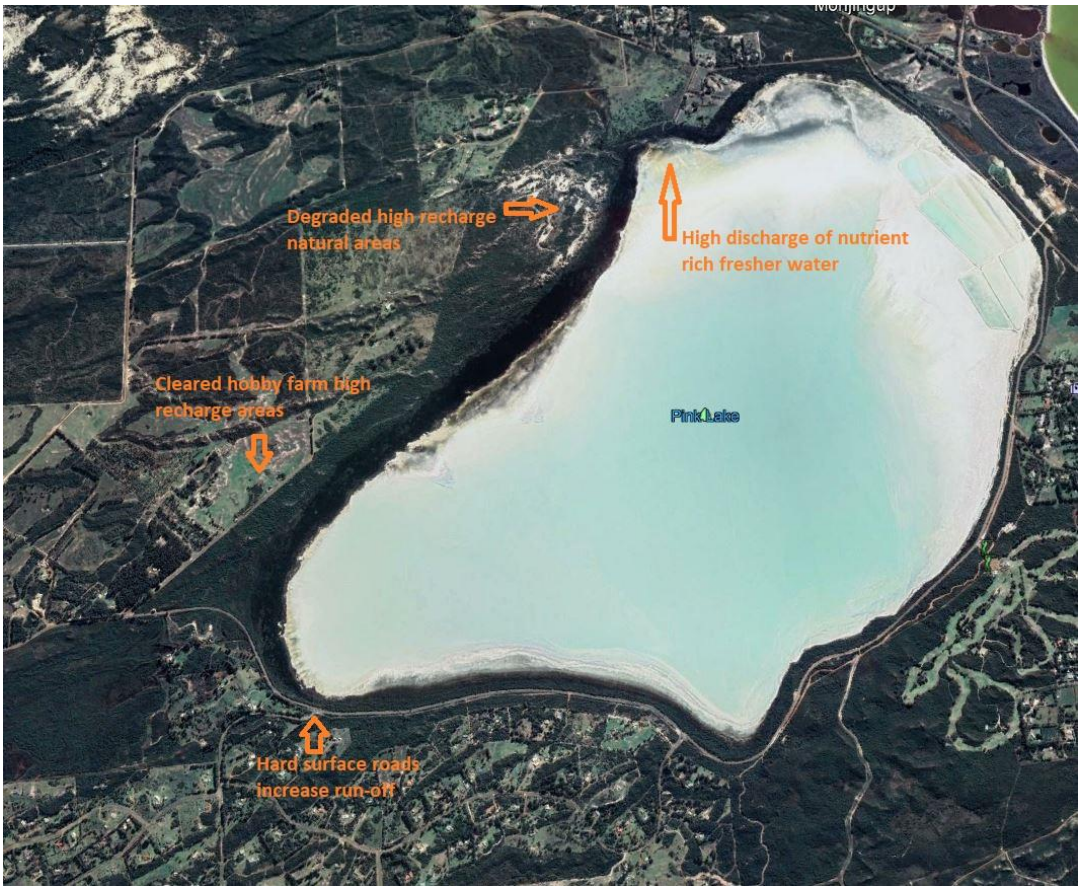
Pink Lake is likely no longer pink due to the removal of too much salt based on annual salt harvest quotas being set by incorrect hydrological investigations undertaken in 1986. Of the estimated 923,500 tonnes of salt present in Pink Lake as of 1900, about 50 per cent had been harvested up until 2007. The removal of salt has resulted in *D. salina* bloom salinity thresholds not being sustained for periods longer than four weeks and diminished salt crust formation at very shallow depths when the lake dries out before *D. salina* can bloom.

Premier Scaddan at Pink Lake salt pile 1915 and Pink Lake Salt pile 1939, crust extracted by shovel (SLWA)

Bagging salt on Pink Lake around 1900 (SLWA 0000658d)

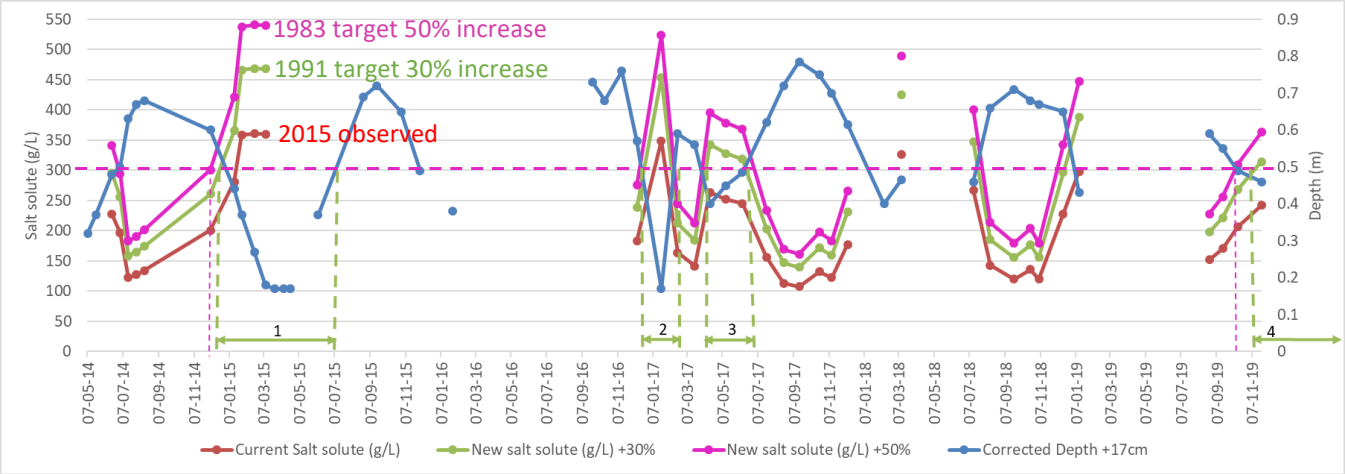
Pink Lake 2008, Pink salt evaporation ponds after salt harvesting permanently closed (Photo by Daryl Jones)

Because of the low salinities in Pink Lake under current conditions, adding more *D. salina* to the lake will not result in a bloom. Land development, road infrastructure adjacent Pink Lake and climate change flood events add to the current dilution problem but could be a benefit during a drying climate.



Pink Lake increased freshwater from stream fed springs, land clearing and road infrastructure (Image from Google Earth 2020)

A 30 and 50 per cent increase in salinity would likely return Pink Lake's salinity to 1991 and 1983 concentrations respectively and associated historic pink blooms. Adding 164,000 tonnes of salt would result in 1991 salinities and 273,000 tonnes of salt would result in 1983 salinities. Adding 466,000 tonnes of salt would recover Pink Lake to pre-1900 salt levels. The groundwater under Pink Lake is not suitable to meet Pink Lake's salt needs. A do-nothing scenario would take about 787 years to naturally accumulate enough salt to meet the 1991 target and 1,319 years to meet the 1983 target.



Pink Lake modelled 50 % and 30% salinity increase scenario to observed data at depth over time. Pink dashed line is salinity threshold for D. salina bloom, green arrow lines are optimum bloom periods (Raw Data Source DBCA)

Adjacent to Pink Lake is Lake Warden which has a salt accumulation problem resulting from catchment salinity with an estimated stored excess of 530,000 tonnes of salt.

Lake Warden, March 2020 (Photo Dan Paris). Depth 0.28m salinity 540g/L

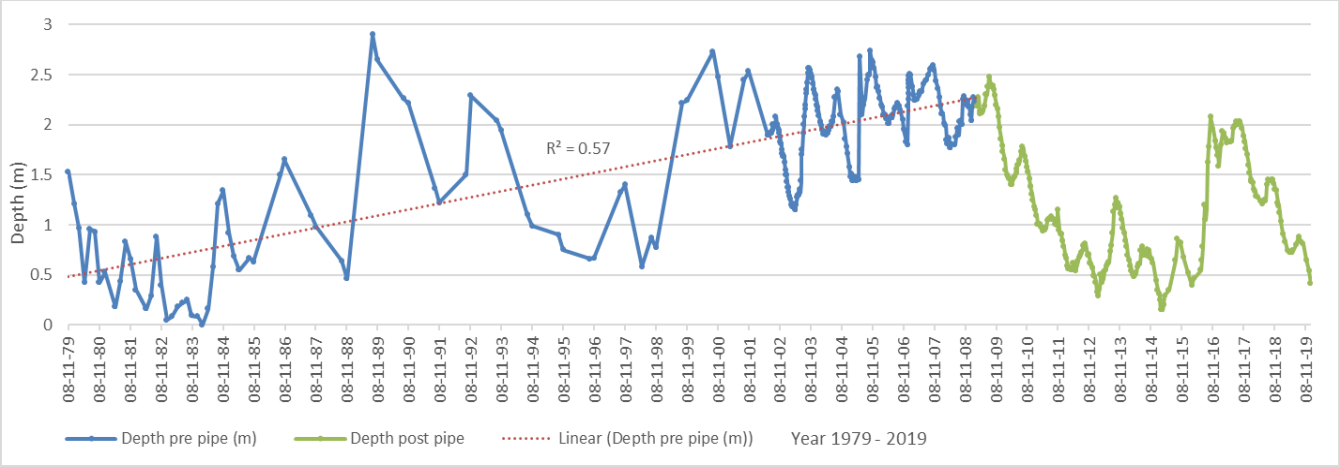
Catchment saline areas feeding Lake Warden (Photo Tilo Massenbauer)

The salt chemistry is similar to Pink Lake. Sustainably harvesting salt from Lake Warden for Pink Lake would likely benefit both wetlands. Pumping salt brine and harvesting salt crust from Lake Warden can meet Pink Lake's 1991, 1983 and 1900 salinity targets.

Pink Lake 1991, 1983, 1900 salt target engineering scenario feasibility estimate summary

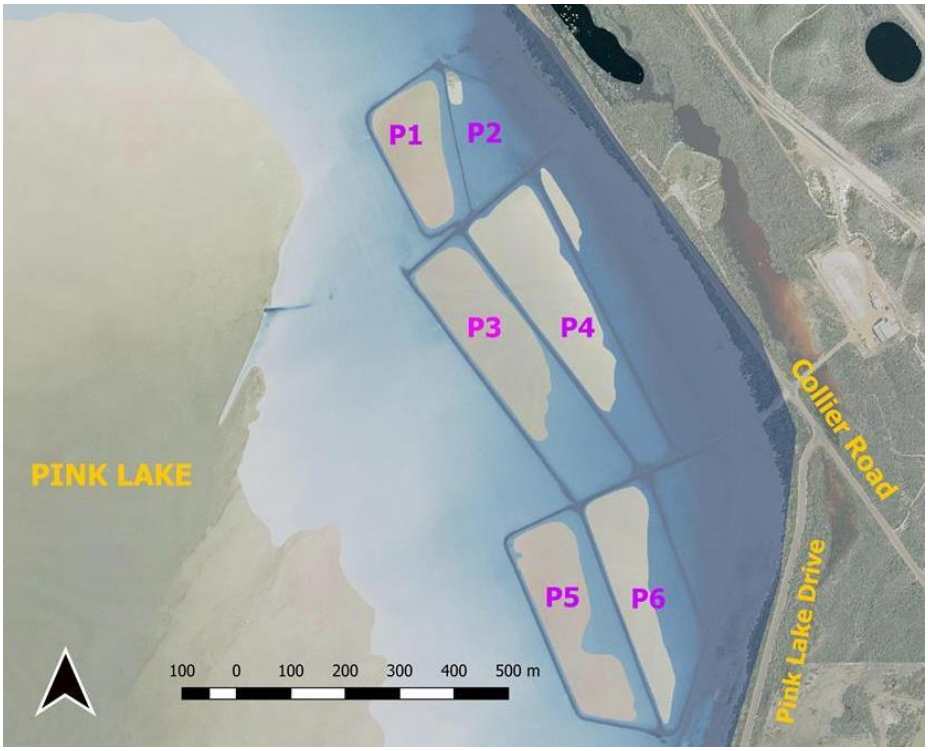
Lake Warden harvest method scenario	a) Pink Lake proportion of 1991 Target met (%)	b) Pink Lake proportion of 1983 Target met (%)	c) Pink Lake proportion of 1900 Target met (%)	Time period (Years)
Brine Pump 100,000 L/hr	100%	100%	82%	a) 1991 = 2 yrs, b) 1983 = 3 yrs
Brine Pump 20,000 L/hr	46%	38%	16%	8
Salt crust harvesting	100%	64%	44%	8
Salt crust and brine 20,000L/hr	100%	91%	62%	8
Salt crust and brine 100,000L/hr	100%	100%	100%	a) and b) = 2 yrs c) = 8 yrs

The strategies meet modelled annual pink bloom thresholds for longer periods under all scenario salinity targets using observed data from 2014 to 2020. To access target quantities of salt at Lake Warden, the Lake Wheatfield pipeline is integral to maintaining Lake Warden's depths at levels optimal for salt crust and/or brine harvesting.



Lake Warden depth records pre and post Lake Wheatfield engineering (Raw Data Source DBCA)

Brine pumping from Lake Warden would cause higher nutrient loads deposited into Pink Lake which would likely be naturally assimilated over time, with the pink lake colour returning. The brine nutrient issue, salt quantities and methods can be trialed using the existing evaporation ponds on Pink Lake. If the salt pond trials are successful and the recovery of Pink Lakes colour is deemed economically feasible, a more detailed environmental impact assessment would be required.



Layout of disused Pink Lake evaporation ponds to be used for future trials

The internationally recognised Ramsar listed Lake Warden site's water bird values would greatly benefit from a large reduction in salinity resulting in more foraging biomass availability due to better water quality at optimal wading habitat depths. Based on the findings of this study, recovering Pink Lake's pink colour to benefit the Esperance, State, National and International community is environmentally and technically feasible.

Report References

Massenbauer, T (2020), Esperance Pink Lake Feasibility Study – Technical report of major findings, Prepared for the Shire of Esperance, internal report

Lizamore J. L, (2020), Water quality review of Pink Lake and Associated Lakes - technical support document for the Esperance Pink Lake Feasibility Study, internal report for the Shire of Esperance

Marimuthu, S (2020), Water balance for Pink Lake and Lake Warden Esperance – technical support document for the Esperance Pink Lake Feasibility Study internal report for the Shire of Esperance

Summary of findings

The following points summarise major findings from the Pink Lake salt modelling and extrapolated calculations using historic information:

- The 1900 total surface salt, including crust and brine, is estimated at 923,500 tonnes
- The 1980 total salt crust and solute loads are estimated at 767,500 tonnes
- Between 1897 to 2007, an estimate 465,800 tonnes salt was harvested from Pink Lake.
- Up until 1977, 111,000 tonnes of salt crust were harvested from the lake by hand shovel.
- Between 1977 – 2007, 353,800 tonnes of brine salt were removed by pumping lake water to evaporation ponds
- The Hurle (1986) salt modelling and harvest quotas of 14,000 tonnes overestimate salt inputs and surface salt availability for Pink Lake.
- The late springtime average lake salinity estimates up to the early 1990's was about 300 g/L at a depth of about 0.4-0.5 m
- Current springtime lake depth salinity observations range from 120 g/L at 0.5 m and 240 g/L at 0.45 m.
- As the lake has become more diluted in salinity, the salt crust precipitation cycle is now shorter in period, over a smaller lake area, forms at shallower Lake depths later in the year, and salinity saturation occurs just before the lake dries out resulting in no longer sustaining *D. salina* pink bloom events.
- Pink Lakes current salt storage estimate is about 450,000 tonnes of salt
- Salt naturally accumulates in Pink Lake via rainfall and surficial aquifer discharge at estimated rates of about 207 tonnes per year.
- Adding the estimated total salt harvested from Pink Lake (465,800) to the current estimated salt total (450,000) equals 915,800 tonnes of salt, which can be tested against the 1900 salt estimate. This is 7,700 tonnes less than the 1900 estimate of 923,500 tonnes, with one percent variation between the two estimate methods.
- Increasing Pink Lakes salinity by 30 per cent would require an additional 164,000 tonnes of salt. The additional salt would return the lake to approximately 1991 salinities and have resulted in likely *D. salina* pink blooms over a minimum eight-week period for every year from 2014 to 2020.
- Increasing Pink Lakes salinity by 50 per cent would require an additional 273,000 tonnes of salt. The additional salt would return the lake to approximately 1983 salinities and have resulted in likely *D. salina* pink blooms over a minimum eleven-week period for every year from 2014 to 2020, at an increased bloom depth of 0.5 to 0.6 m.
- Accessing salt from groundwater under the lake to meet the current short fall is not feasible due to salinity, hydraulic head and transmissivity being too low in the Pallinup aquifer. Another alternate salt source is required such as Lake Warden.

Further Enquires

Please contact the Shire of Esperance (08) 90710 666 or https://www.esperance.wa.gov.au/