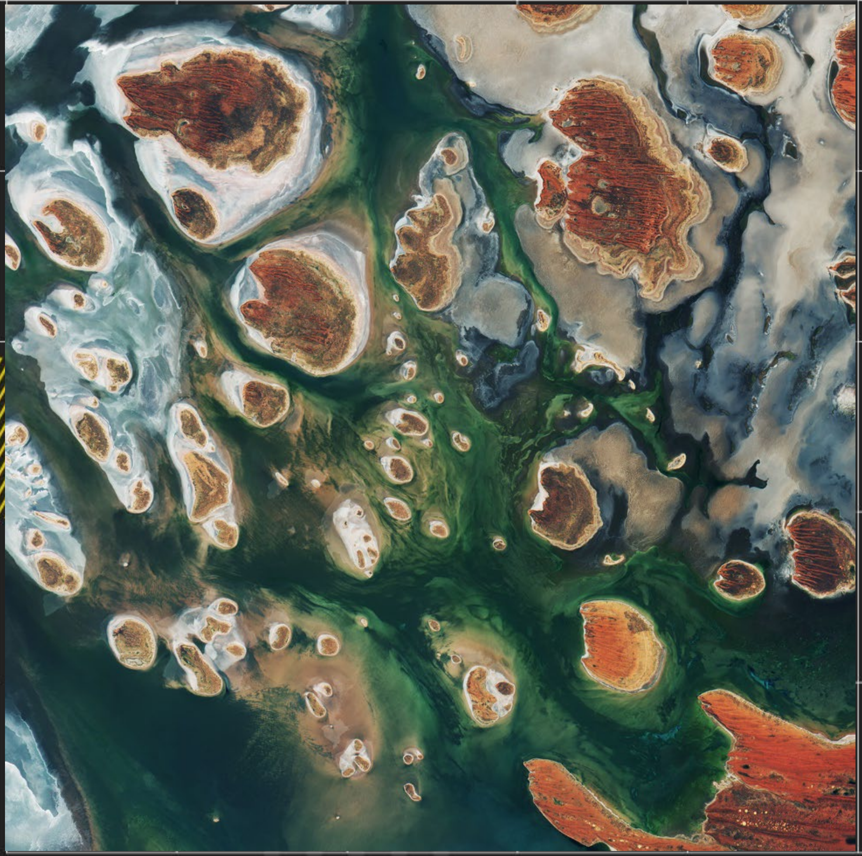
Stantec

LAKE MACKAY CASE STUDY



IMAGERY-BASED BEST PRACTICES FOR EPHEMERAL LAKE HYDROLOGY

Sumari Veal - Stantec

AWS 2025

Australian Water School

Acknowledgment Of Country

We acknowledge the traditional custodians of Whadjuk Nyoongar Boodja

Stantec's Reconciliation Journey
by Chern'ee Sutton.

Agenda

1. Introduction to Stantec
2. Acknowledgements and Contributions
3. Problem Statement
4. Lake Mackay Case Study
5. Lessons Learnt

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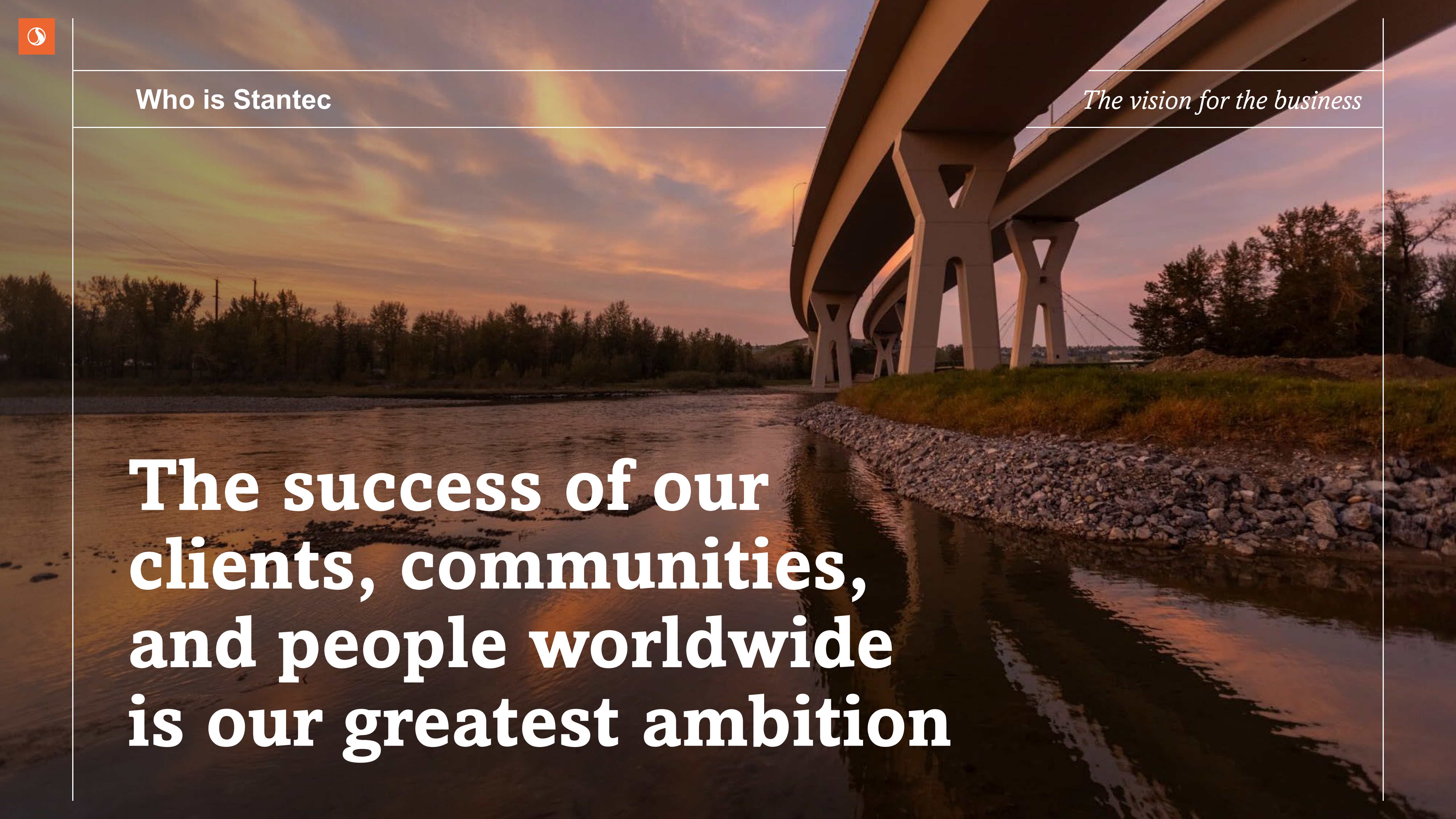
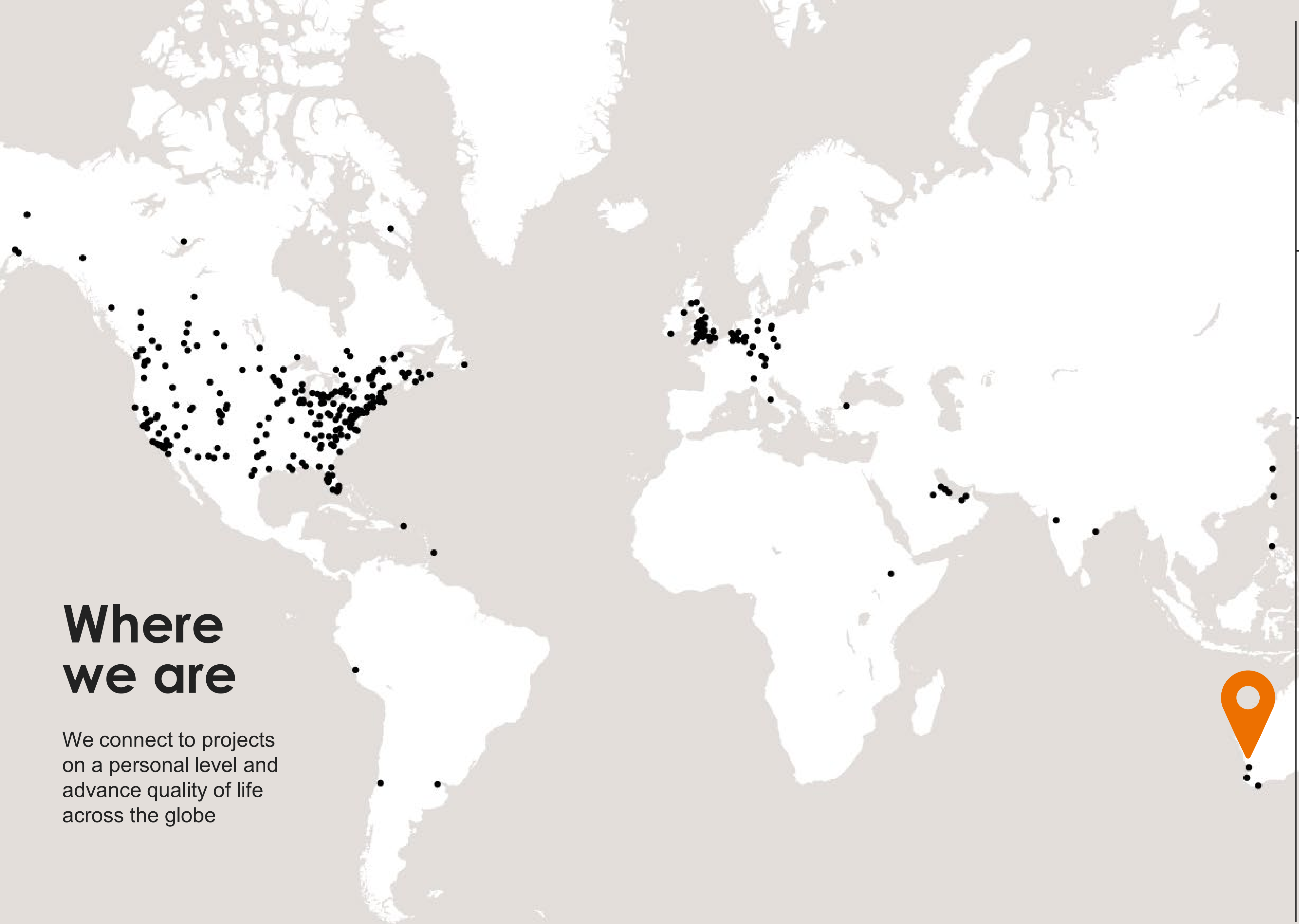
Who is Stantec?



The success of our clients, communities, and people worldwide is our greatest ambition

Where we are

We connect to projects on a personal level and advance quality of life across the globe



STN

Traded on NYSE & TSX

32,000

Employees Globally

450

Locations Worldwide

One team, the whole cycle

ABOUT STANTEC

Stantec is a team of designers, planners and engineers, deeply committed to delivering positive outcomes for the communities in which we live and work.

We are more than 2,300 practitioners across Australia, innovating at the intersection of community, creativity, and client relationships to advance communities everywhere.

We put together teams to meet the needs of each project - whatever the challenge, our team can help you navigate and deliver.

Buildings

- Airports
- Civic & Cultural
- Commercial
- Defence
- Education
- Energy
- Health & Aged Care
- Industrial
- Mission Critical
- Science & Technology
- Workplace

Community Development

- Aged Care
- Brownfield Development
- Defence
- Education
- Health
- Industrial
- Land Development
- Masterplanned Communities
- Municipal Infrastructure
- Retail, Hospitality & Mixed-Use
- Sports & Recreation
- Urban Places

Energy & Resources

- Energy Transmission & Distribution
- Mine Decommissioning & Closure
- Mine Facilities
- Mine Project Development & Execution
- Mine Transport
- Mine Water & Treatment
- Net Zero Mining
- Process Engineering (Minerals & Metals)
- Renewable Energy & Storage
- Resource Beneficiation
- Tailings & Waste

Environment

- Climate Solutions
- Defence
- Energy & Energy Transition
- Mine Industry & Closure Mining, Minerals & Metals
- Rehabilitation & Restoration
- Resilience
- Tailings & Waste Transport
- Water

Transport

- Airports
- Bridges
- Ports & Maritime
- Rail & Public Transport
- Roads & Highways
- Smart(ER) Mobility
- Transport-Oriented Communities
- Urban Places

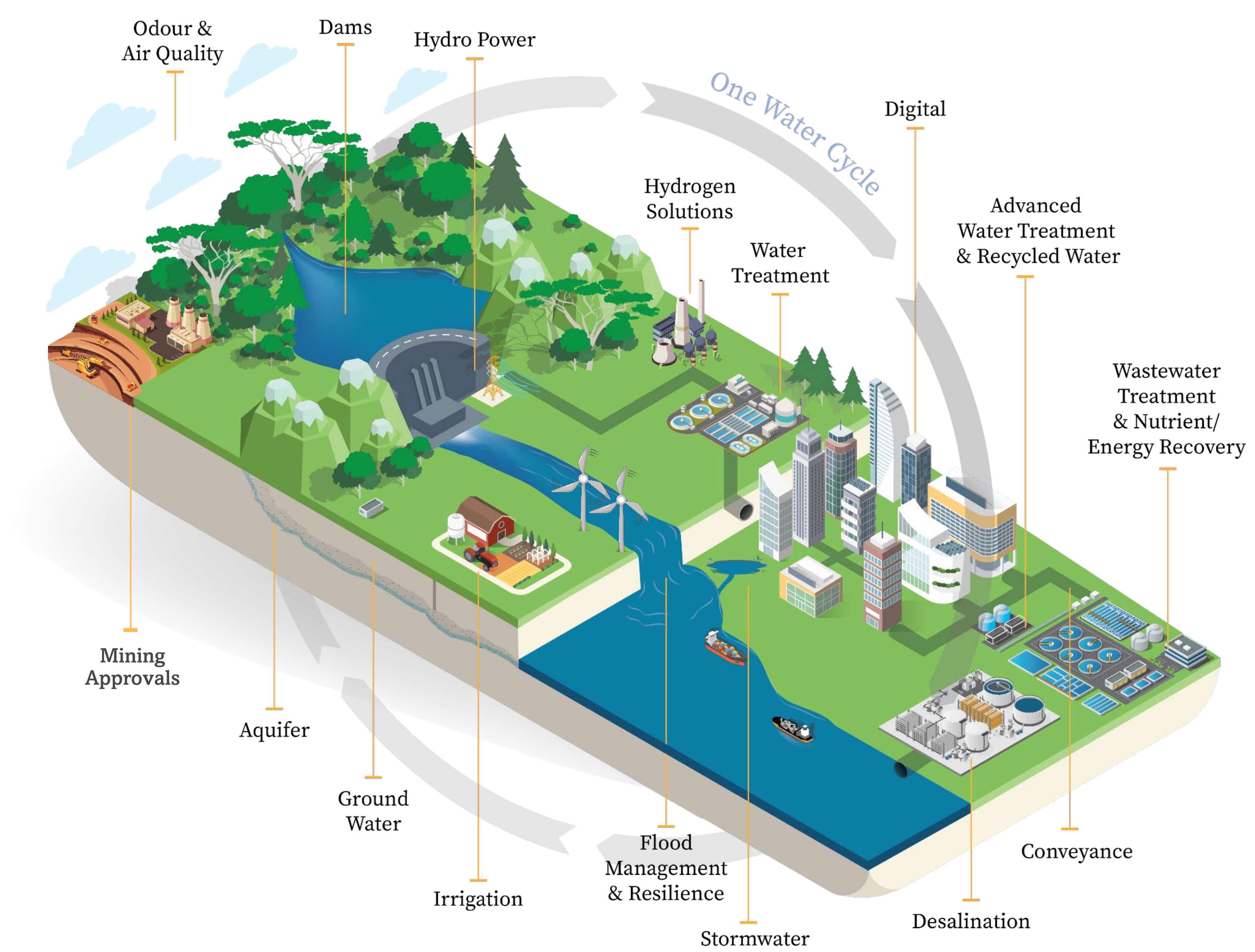
Water

- Advisory
- Asset Management
- Conveyance and Structures
- Dams and Hydropower
- Digital
- Planning and Modelling
- Wastewater Treatment
- Water Resources
- Water Treatment and Desalination

One Water
One Environment

By partnering with clients, we deliver sustainable solutions through our One Water, One Environment approach, which integrates the management of fresh water, wastewater, stormwater, and groundwater through the lens of environmental stewardship.

From mining, conveyance systems and dam improvements to cutting-edge water treatment and digital solutions, we tackle the complexities of water and environmental management with a commitment to excellence and resilience.



2 Acknowledgements

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Sumari Veal

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Environment Business Leader, WA/NT

Chris Urbanek

GIS Team Lead, WA

Dr Erin Thomas
Subterranean Ecology Team Lead, WA

Kai Krueger
Environmental Scientist, WA

Krey Price
Collaborator

3

Problem Statement

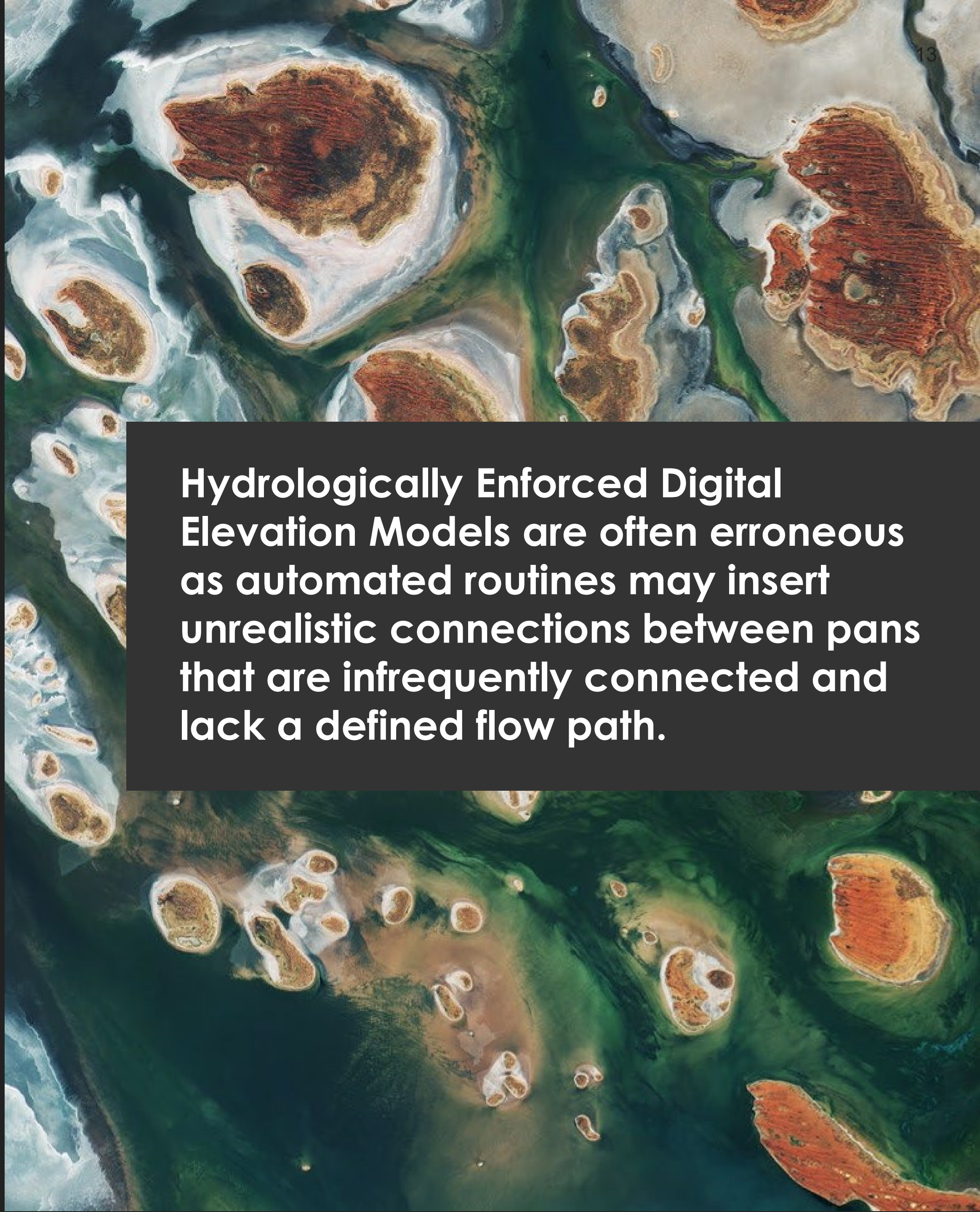
Endorheic Ephemeral Lake Systems

- Endorheic: *No topographic outlet*
- Ephemeral: *Hydrology that goes dry*

- Difficulties in understanding inundation patterns and pan connections over time (infrequent flooding)

- Indefensible traditional hydraulic modelling methodologies

- Implications for mine planning, infrastructure design and environmental management



Hydrologically Enforced Digital Elevation Models are often erroneous as automated routines may insert unrealistic connections between pans that are infrequently connected and lack a defined flow path.

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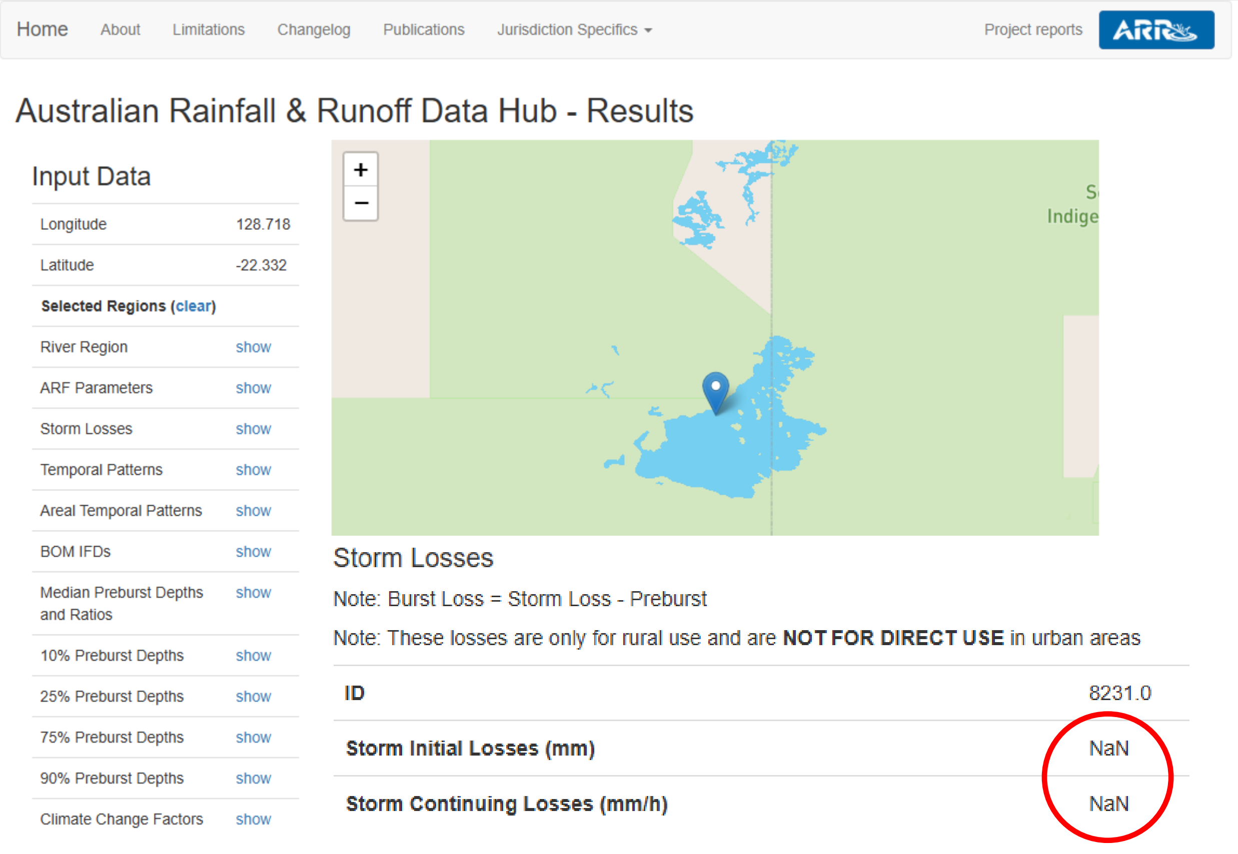
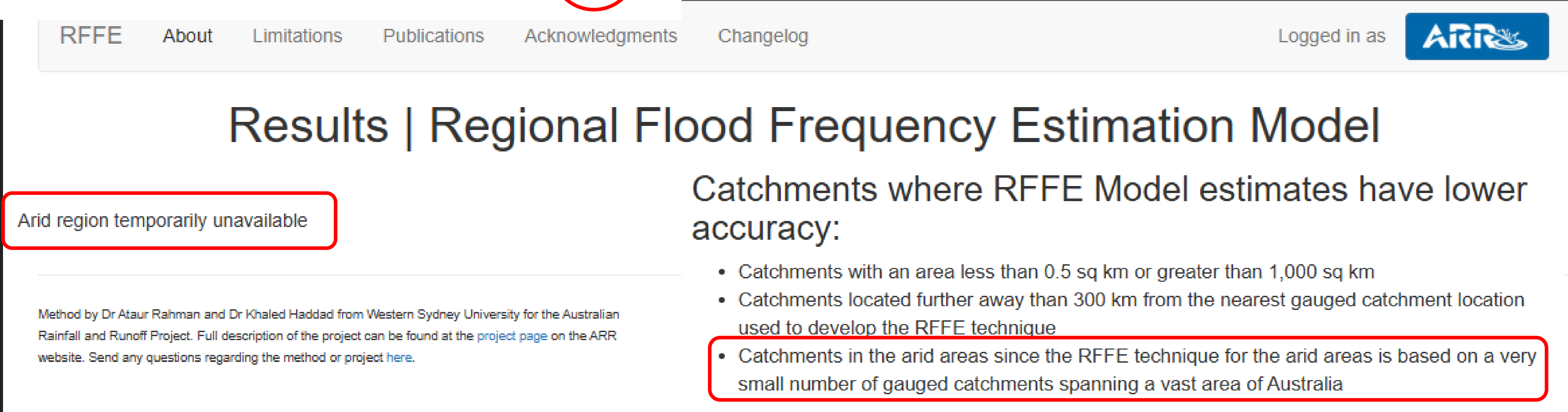
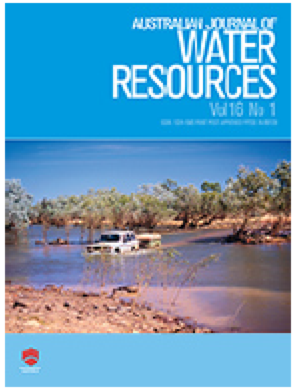
ARR Data Hub and RFFE Data Gaps

There are 798 gauged catchments in the data-rich areas and 55 gauged catchments in the data-poor (arid/semi-arid) areas. A simplified index type regional estimate is recommended (ARR Project 5).







Australasian Journal of Water Resources

ISSN: 1324-1583 (Print) 2204-227X (Online) Journal homepage: https://engineersaustralia.tandfonline.com/loi/twar20

Design flood estimation in Western Australia

D Flavell

1 gauge

Goldfields Region. The only gauging data available for the Goldfields was recorded by Western Mining personnel (the late Mr Bert Barnes) for the stream that flows through West Kambalda into the Newtown Dam. There are 13 years of record between 1968 and 1980.

9.2.4 Goldfields – Leinster area

A flood estimation procedure was developed using the very limited available streamflow data and on-site observation. The streamflow data comprised 13 years of record for the stream which flows through West Kambalda into the Newtown Dam.

In the Goldfields Region of Western Australia, Flavell's Regional Flood Frequency Procedure is based on a single gauge with only 13 years of record.

4 Case Study

Lake Mackay is the **largest salt lake in Western Australia**, and the 4^{th} largest in Australia with a surface area of over **3,000 square kilometres.**

Situated on the border of Northern Territory and Western Australia.

Lake Mackay Sulphate of Potash Project

As our communities grow, so does the demand for food. We can contribute to solving our food security challenge by using land resources more efficiently.

We completed a range of environmental surveys with targeted searches for conservation significant species and migratory waterbirds.

We also investigated and validated baseline and operational water balance scenarios in relation to the potential effects of climate change.

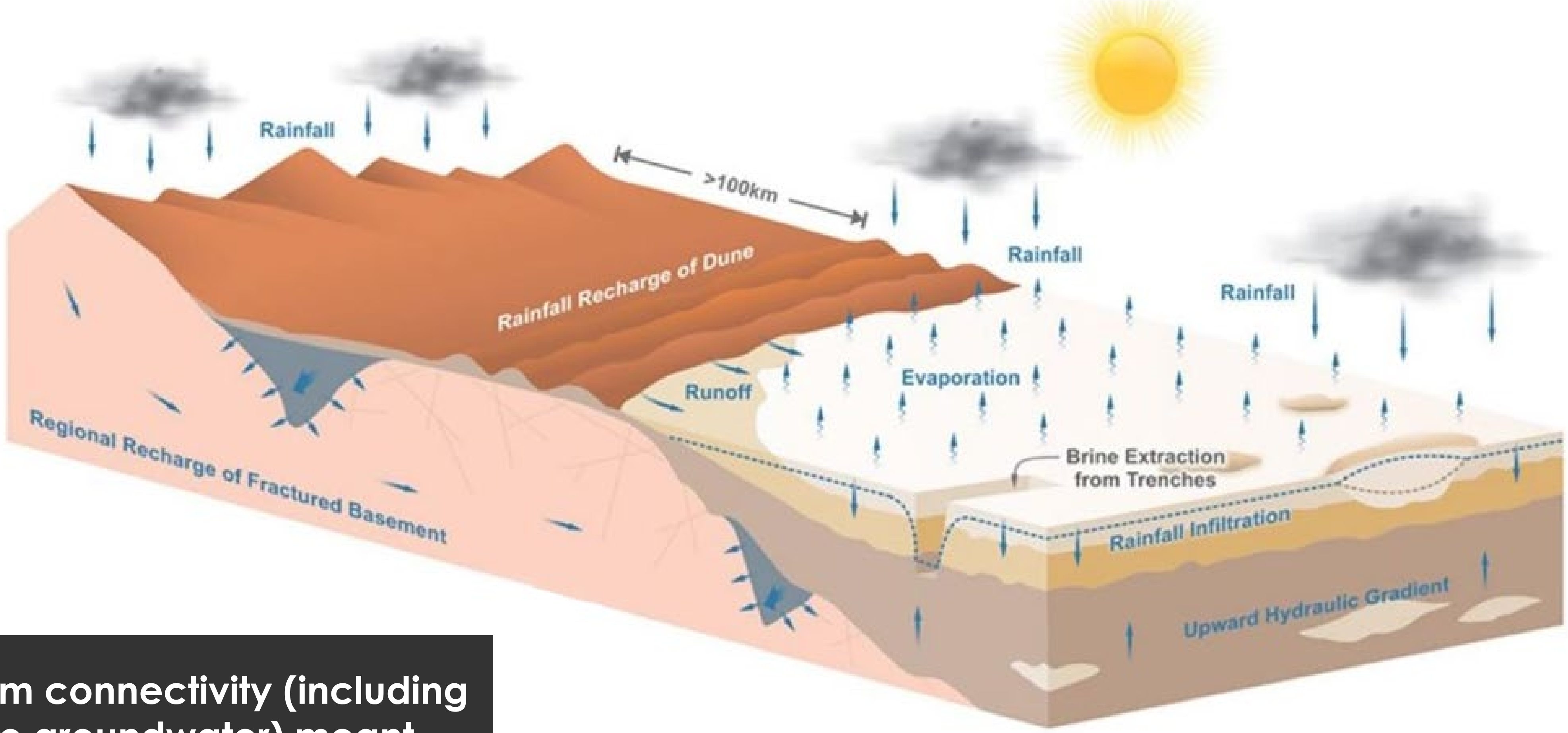
State environmental approval was granted early 2025.

WA, Australia
2018 to 2025

Lake is rarely inundated to 100% for long periods and dries rapidly following these peak events. Many areas of the lake contain water less than 5% of the time. During sporadic flooding events the lake transforms into an **important breeding ground** for waterbirds.

Sulphate of Potash (K_2SO_4) can be extracted from groundwater brine in lakebed sediments through a network of ~4m deep trenches and evaporation ponds to precipitate salts between bird breeding seasons. Salts to be wet harvested and pumped to an adjacent process plant.

Proposal includes 12 tenements of ~4,000 km^2 for a 20-year life of mine. By tapping into one of Australia's richest sources of SoP reserve, Agrimin can produce a high-quality fertiliser, helping farmers increase crop yields.



Complex system connectivity (including surface water to groundwater) meant baseline conditions and potential operational changes needed to be assessed. This included rainfall inundation extent modelling and a GoldSIM water balance.

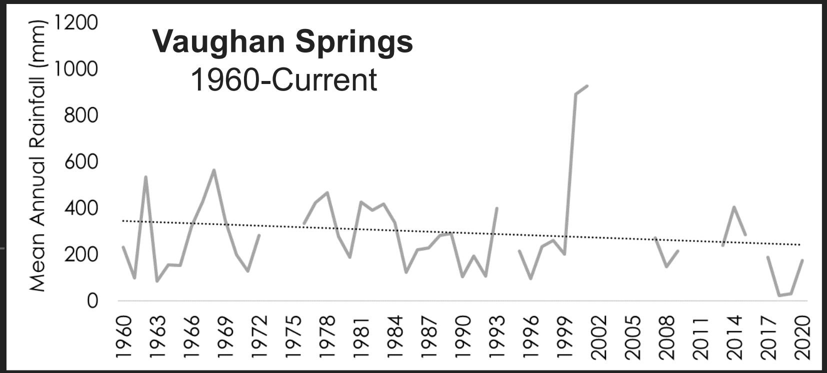
Methodology

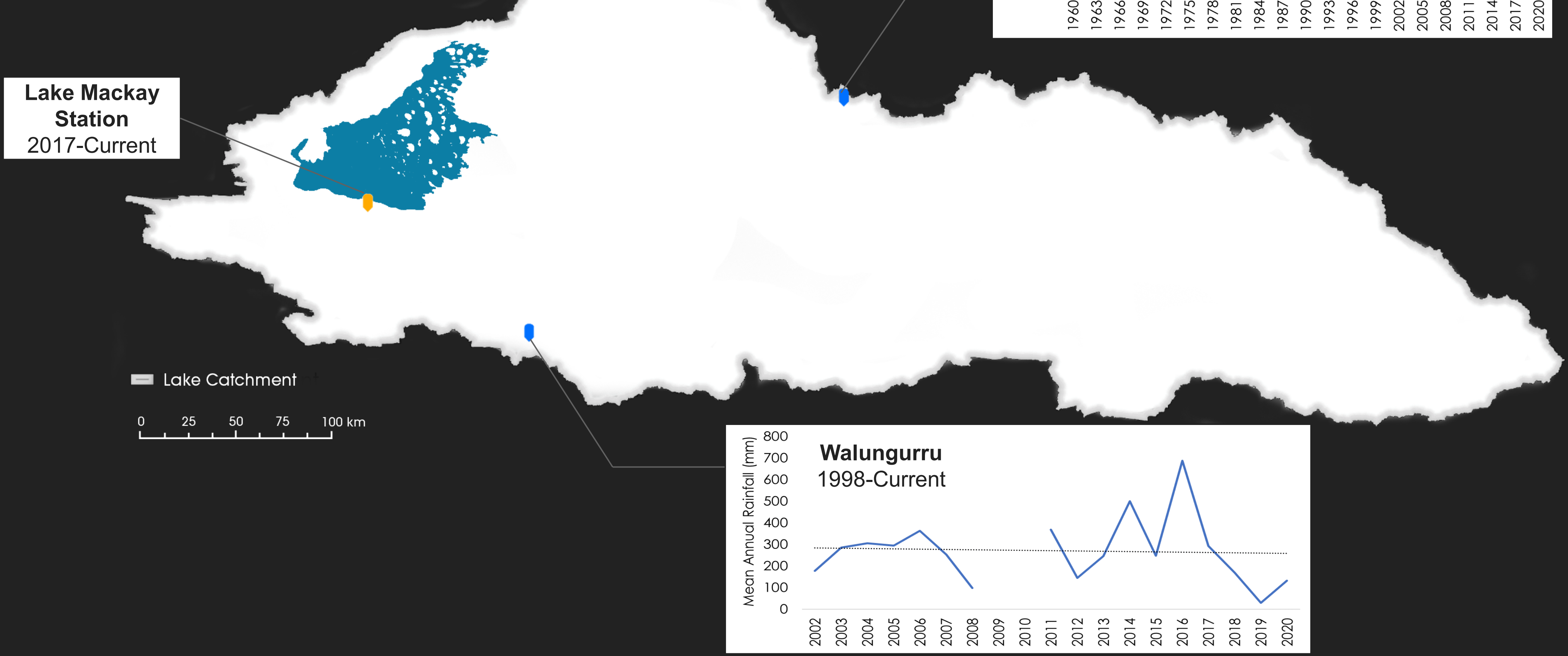
Data analyses and modelling aimed to address knowledge gaps in relation to:

1. Regional rainfall patterns and relationship to inundation of the lake.
2. Inundation frequency, surface water extent and duration of inundation on the lake.
3. Baseline and operational water balance scenarios for the lake.
4. Potential climate change impacts on the water balance of the lake during operations.

1. Rainfall Data Analysis

Scattered weather stations provide an incomplete picture of inundation on the lake. SILO data used to infill long-term sequences.





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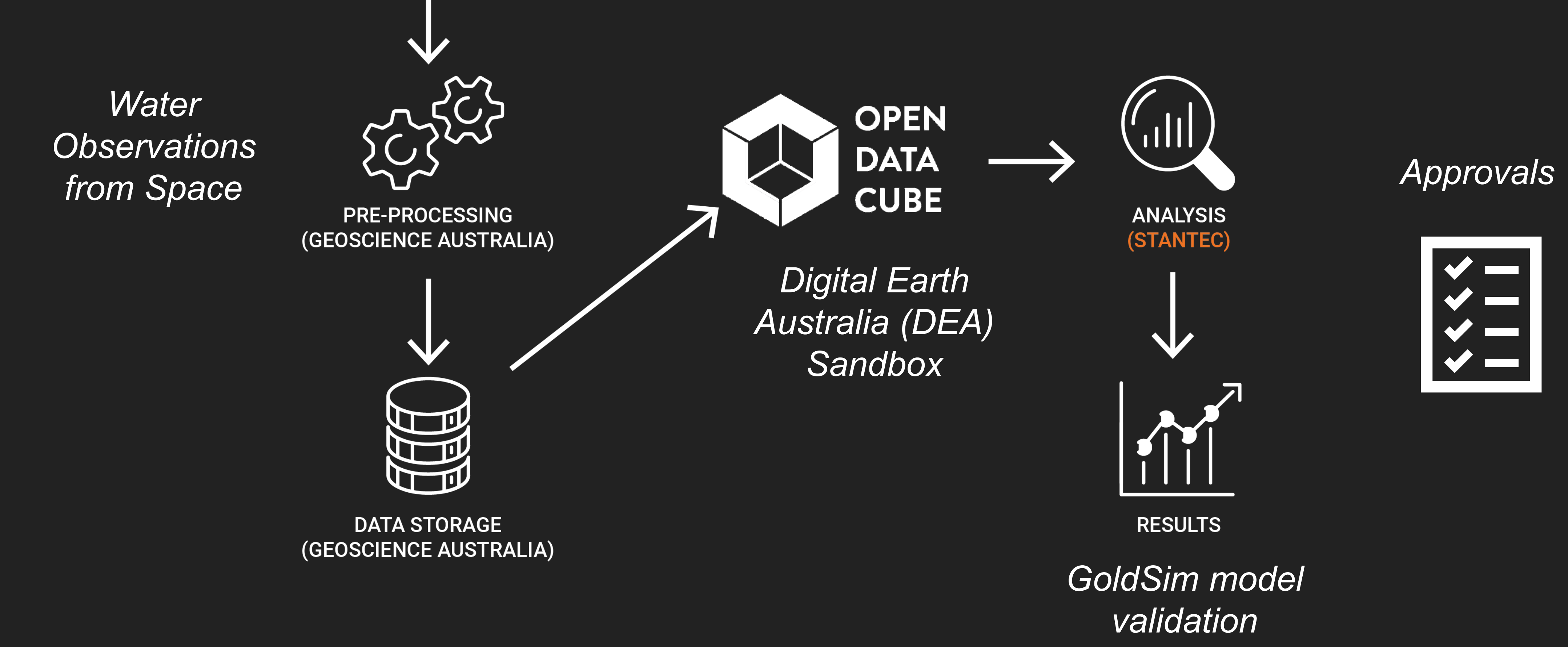
2. Satellite Imagery Analysis

We now have access to a multi-decadal archive of freely available satellite imagery that provides a direct measure of surface water. Over 1,000 images analysed in hours not weeks.

2. Satellite Imagery Analysis Overview

Using the Open Data Cube, we were able to process thousands of images in a matter of hours – a quantity of data that would normally take weeks to process.



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Data Sources

Water Observation from Space (WOfS) provides historical information about where surface water is found in Australia using passive (30 x 30m) *Landsat* 5 and 7 data.

Superior to traditional methods of water-detection such as the Normalised Difference Water Index (NDWI), as it uses a decision-tree algorithm to ground-truth the imagery from various sites for Australian landscape spectral characteristics.

https://www.ga.gov.au/news/water-observations-from-space-contribute-to-a-greater-unders...

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News

Water Observations from Space contribute to a greater understanding of flooding in Australia

Published: 26 April 2016

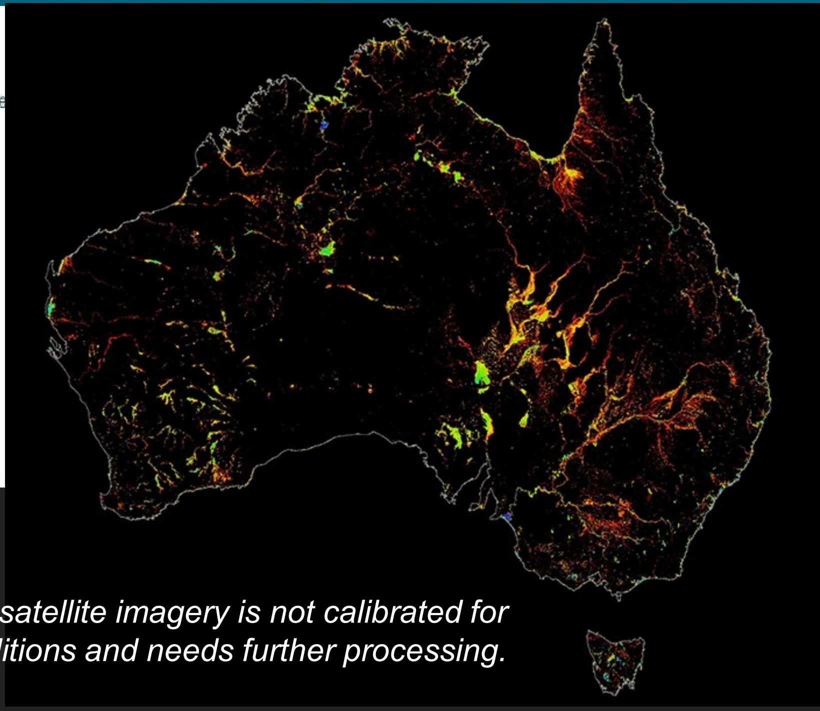
First released in 2014, Geoscience Australia's Water Observations from Space (WOfS) product provides historical information about where surface water is found in Australia.

WOfS is the world's first continent-scale map of the presence of surface water derived from *Landsat* satellite imagery. It covers the entire Australian continent, showing the presence of water over a 27year period. By using *Landsat* data, WOfS is useful at `paddock scale', providing a quantitative indication of how often surface water has been seen anywhere in Australia.

Available online in map form through the Australian Flood Risk Information Portal, WOfS provides information on where water is usually seen, such as in lakes and rivers, and where it is unusual, such as during flooding events.

Historical challenge - floods in Australia

With many areas having high vulnerability to flooding, Australia's management of this hazard is a key challenge for communities, governments, insurers, and industries. In financial terms, floods are one of the most damaging forms of natural hazard faced by Australia.

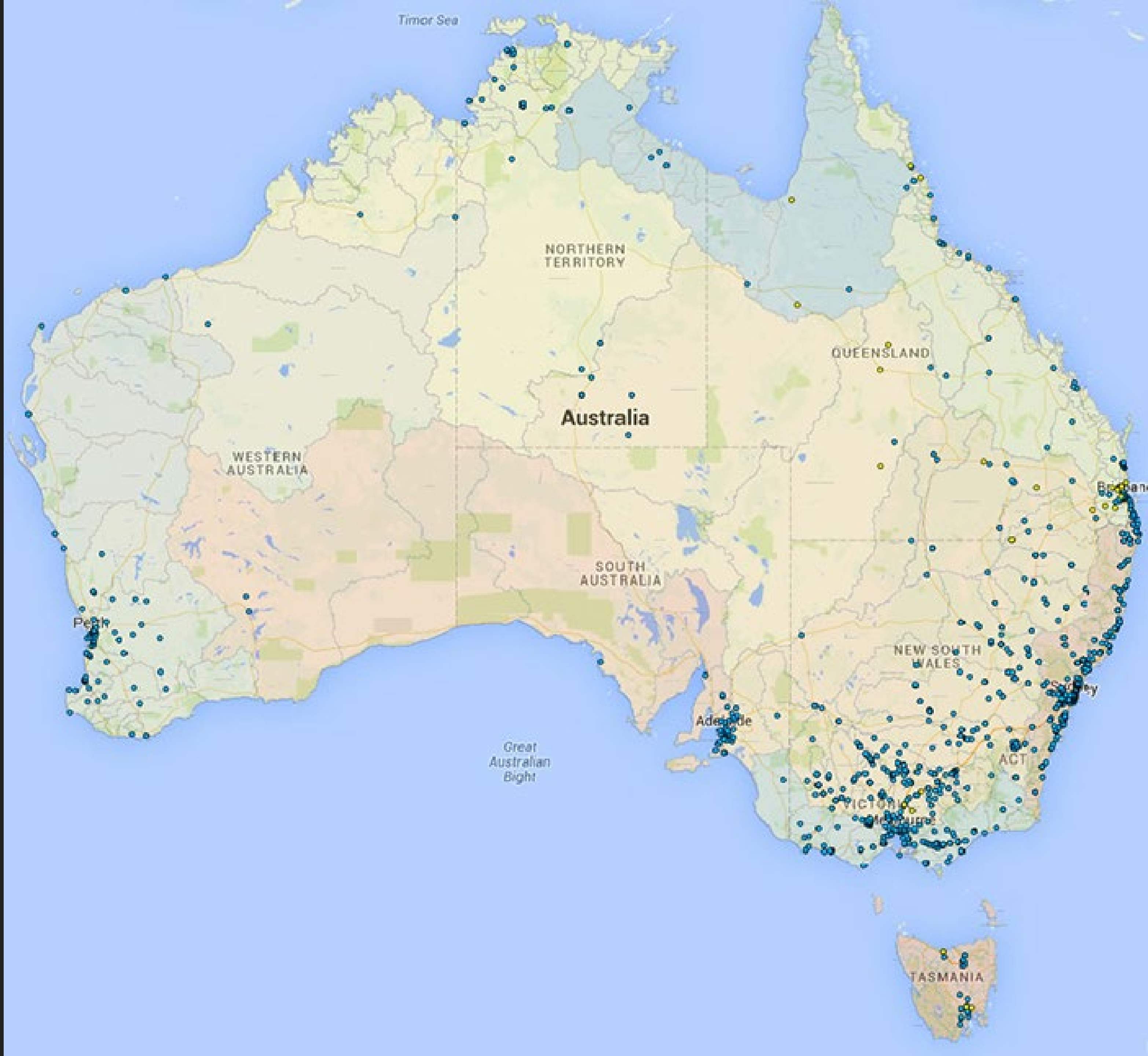


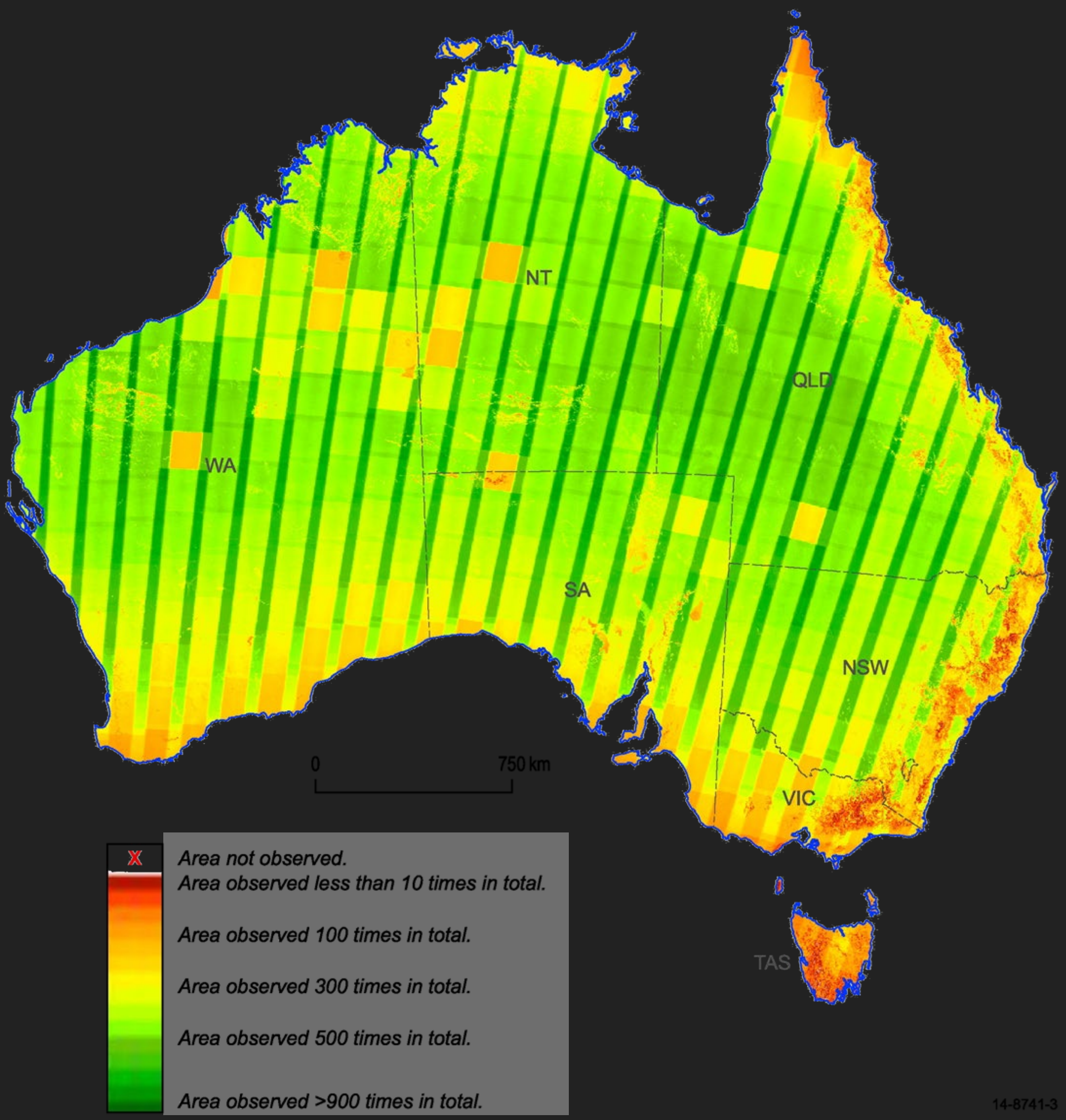
Note United States Geological Survey (USGS) satellite imagery is not calibrated for Australian conditions and needs further processing.

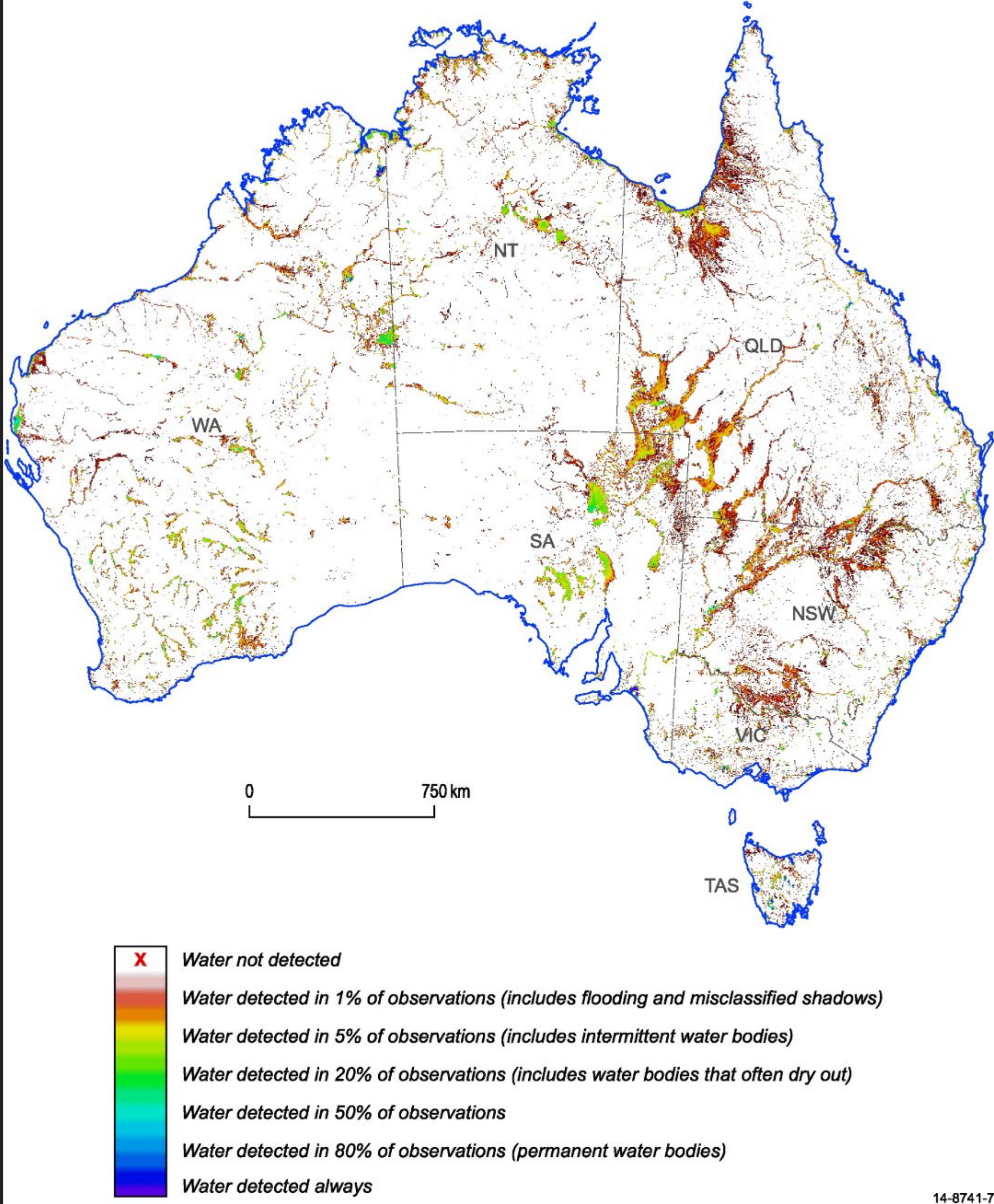
Data Sources

Limited flood studies across majority of Australia, including most mining areas. WOfS is playing a key role in filling data gaps by mapping the presence of water using the classification algorithm described by Mueller et al. (2016) on a per-pixel basis to create a % water presence for every pixel.

Complements flood studies by providing a historical summary of how frequently surface water has been observed in Australia between 1987 and present day.







[Water Observations from Space]

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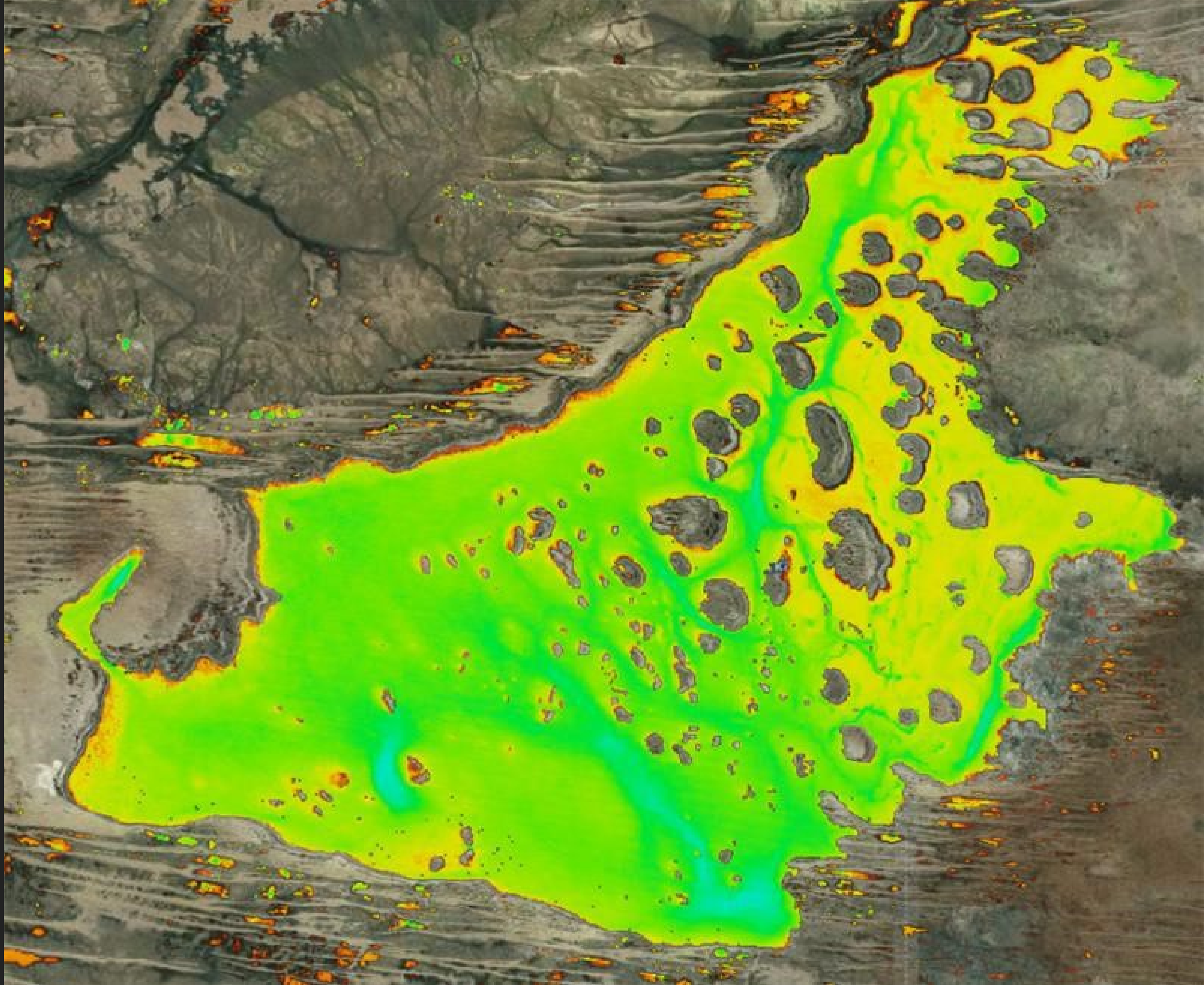
The lighter blue hues indicate areas where water is retained for the **longest time following inundation** events



Lake Mackay as displayed in WOfS summary layer.

opendatacube.org

OPEN DATA CUBE

Overview | Get Started | Community | About

Empowering Global Insights:
Open Source Earth Observation at Scale

The Open Data Cube (ODC) is a free, open-source software package that simplifies the management and analysis of large amounts of satellite imagery and other Earth observation data. It allows users to easily access, process, and analyze decades of geographical data to track changes on Earth's surface over time. ODC is designed to help scientists, researchers, and government agencies make better-informed decisions in areas such as environmental issues, land use, and resource management.

Get Started | Learn More

ODC ECOSYSTEM

→

ODC CORE

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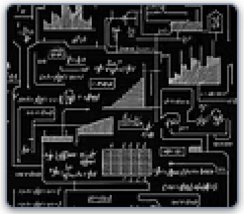


ODC ALGORITHMS

+

ODC APPS

→

Geospatial Data:

- *Satellite Imagery*
- *UAS Imagery*
- *Ground Based Weather Stations*

FLEXIBLE DEPLOYMENT

Depending on your application, the Open Data Cube can be deployed on HPC, Cloud, and local installations. Typical installations run in Linux based environments.

Informed Decisions:

- *Deforestation*
- *Water Quality*
- *Illegal Mining*

Key Features

The Open Data Cube is a powerful platform for managing and analyzing Earth Observation (EO) data at scale. It offers efficient cataloging and organization of vast EO datasets, along with robust metadata management and data provenance tracking. Its Python-based API enables high-performance querying and custom analysis development. The platform supports multi-sensor data integration, flexible data access, and scalable processing capabilities, including cloud deployment and parallel processing for everything from checking out your back yard to continental-scale analyses.

01. Data Management and Organization

02. Multi-sensor Data Integration

03. Flexible Data Access

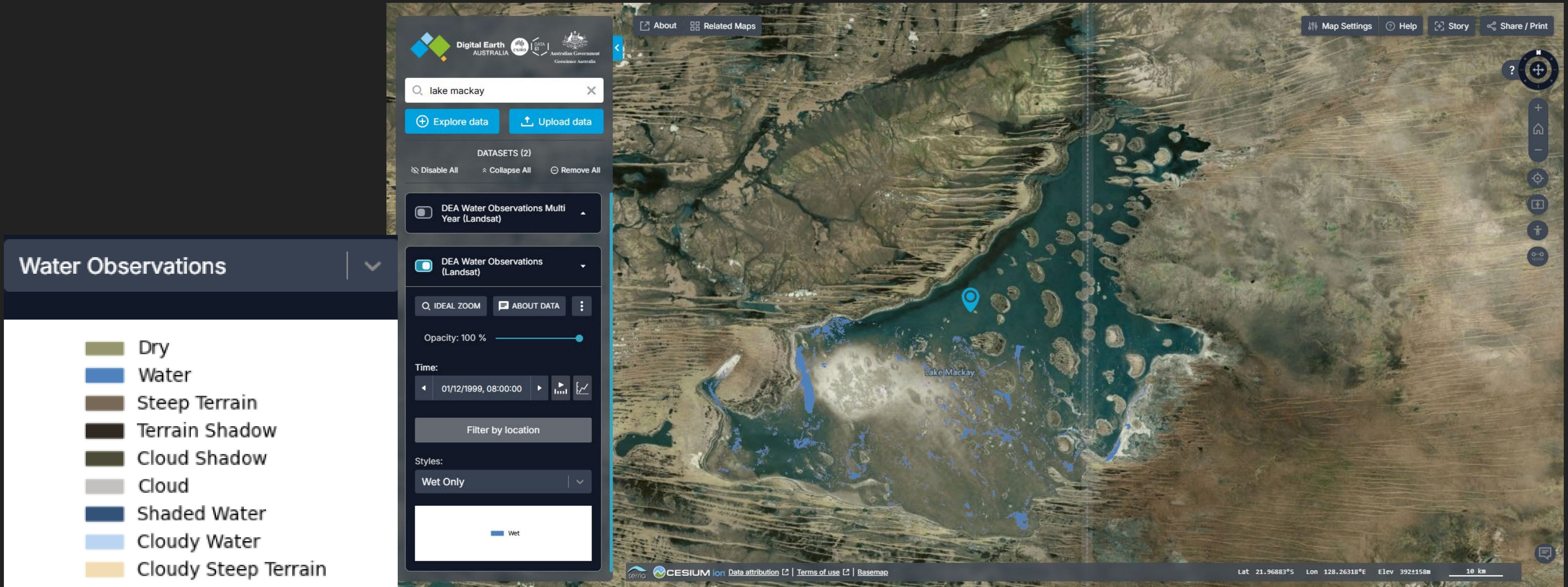
04. Scalable Processing

05. Interoperability

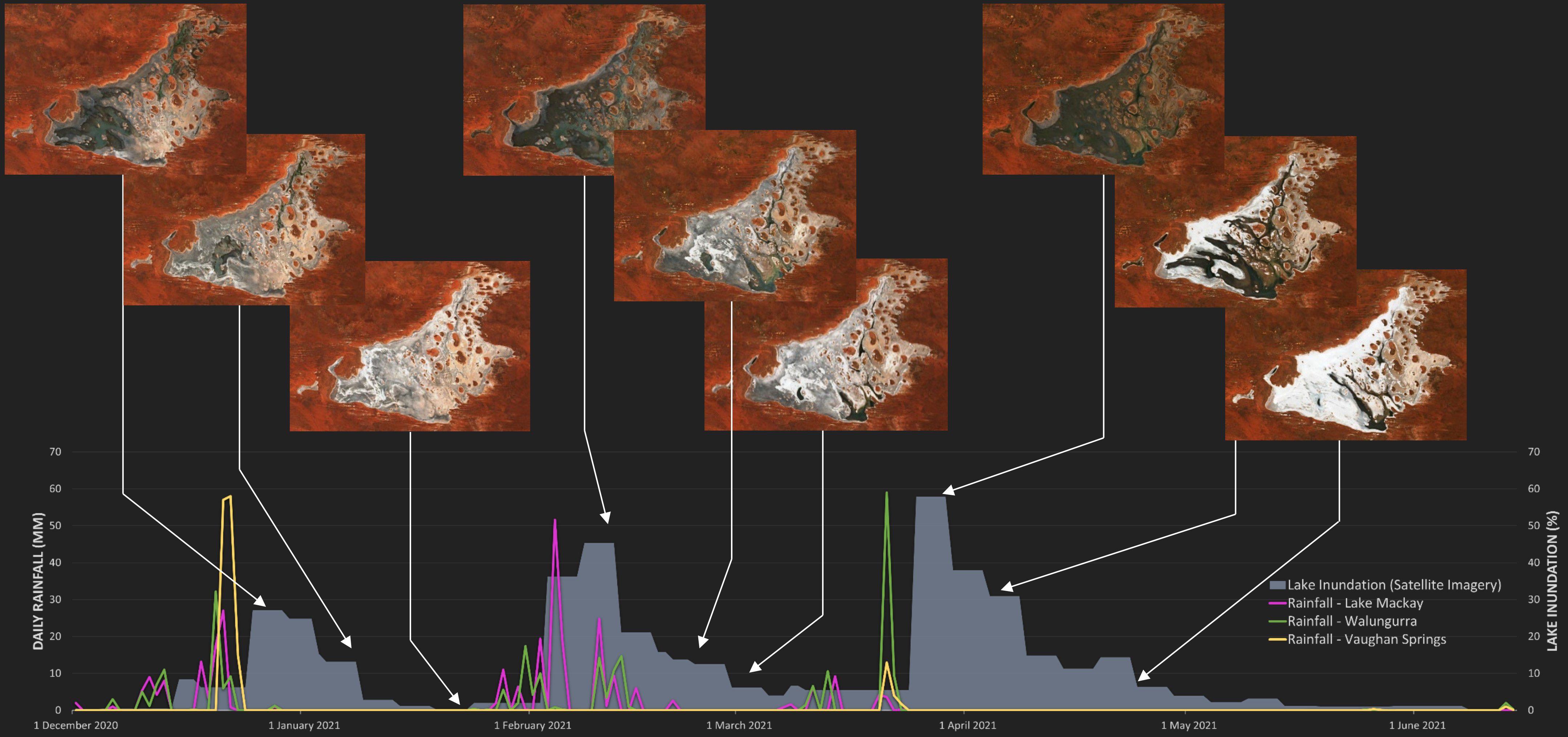
DEA Sandbox Processing

Spectral indices are used to classify land cover types. A customised DEA sandbox Jupyter Lab python script was used to alter pixel coverage, mask uncertain pixels, change "wet area" thresholds and resolve conflicting salt crust and cloud observations.

Products used in this analysis were the WOfS Summary Layer, Water Observation Feature Layers (WOFLs), and Sentinel-2 Analysis-Ready Data (ARD).



We constructed a timeline of estimated inundation extent of the lake for every available timestep and mapped this against rainfall distributions, giving us a more complete temporal and spatial picture of flooding events to validate hydrological modelling. This led to more informed environmental outcomes and regulator confidence.



Timelapse Generation

Topography Inputs

Topography is a major data input for these type of assessments.

Study area dependant for two main approaches:

01

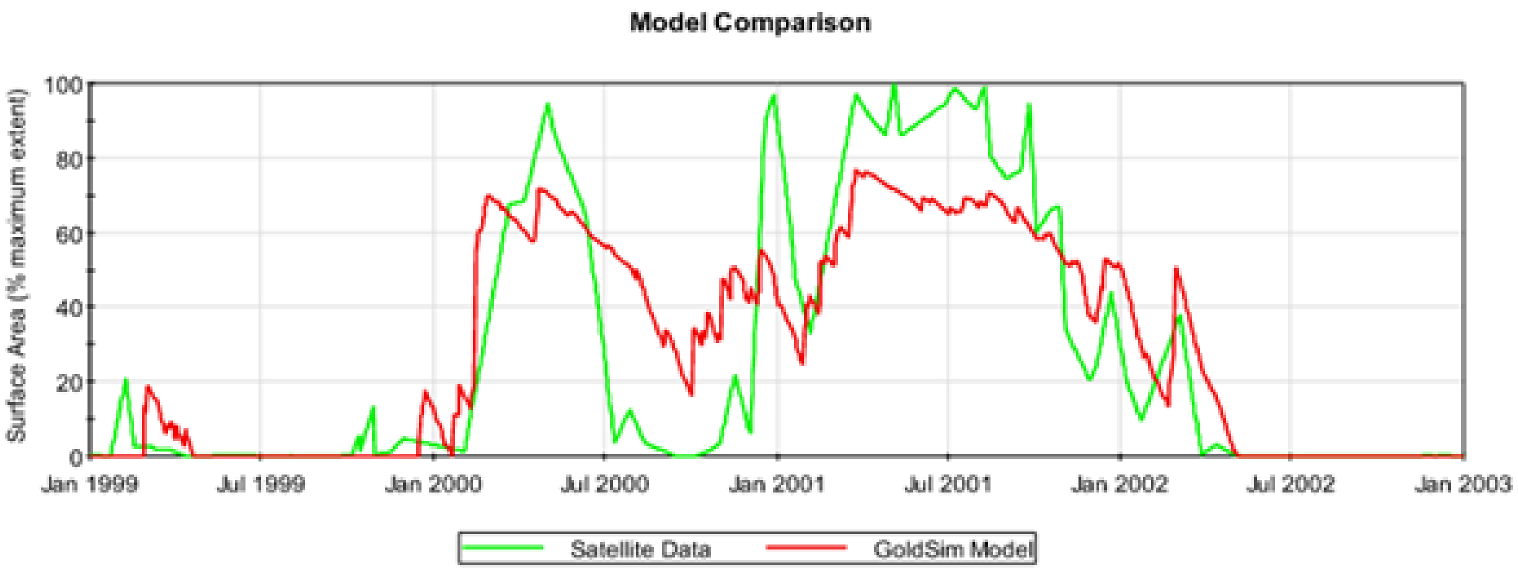
Bathymetry Mapping to determine lake depths if inundated

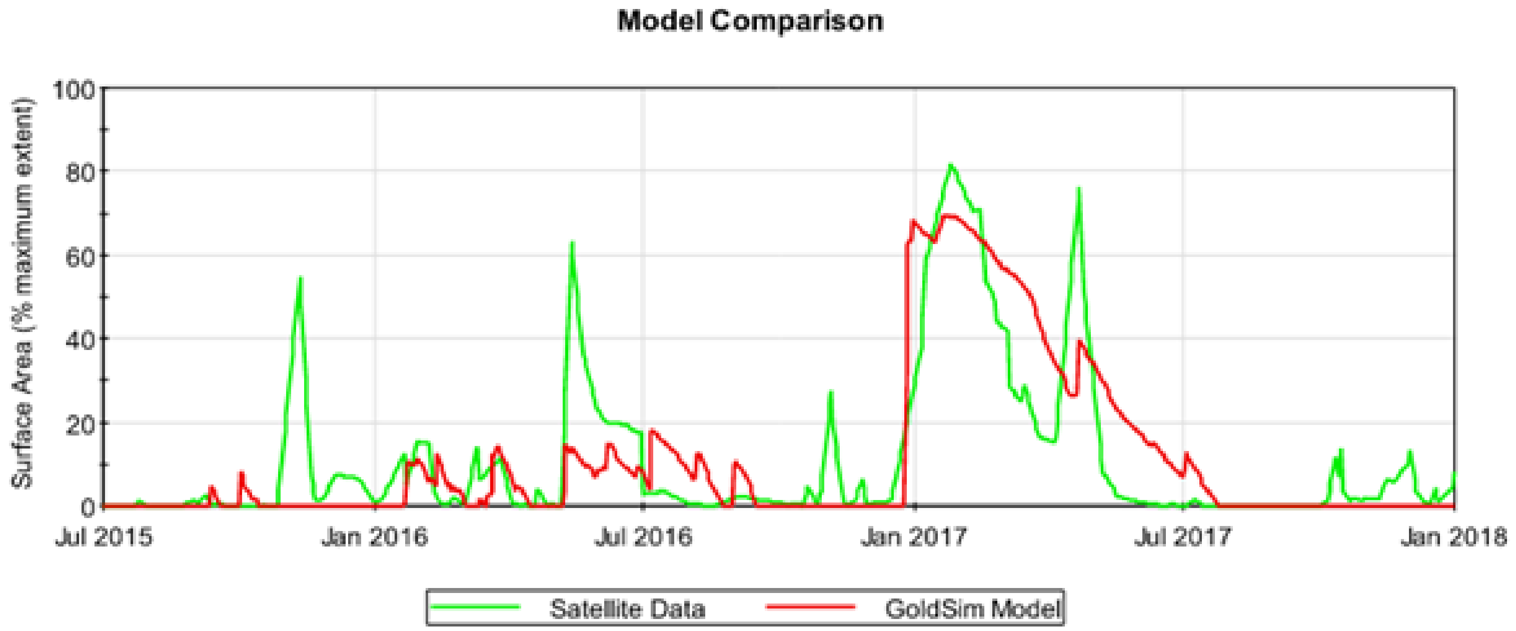
(surface ROVs)

02

LiDAR Surveys efficient when not inundated

(fixed-wing plane/drone flown sensors)





Modelling

Used to assess pre-mining vs. predicted impacts (SW and GW) during operations.

Satellite data analysis was pivotal to modeling validation.

It was shown that climate change has impacted the results. Post 2000, the lake floods partially every year, whereas prior to 2000 only rare flooding was recorded.

Outcomes

- Increased understanding of flooding event areal extent and duration.
- Detection of minor flooding events not measured by rainfall stations.
- Stage-duration trend information that is design storm independent.
- More informed environmental outcomes for key species to classify individual inundation events under different ecological thresholds and evaluate suitability for foraging and breeding events or distance to water for habitat suitability and water availability for a given taxa.

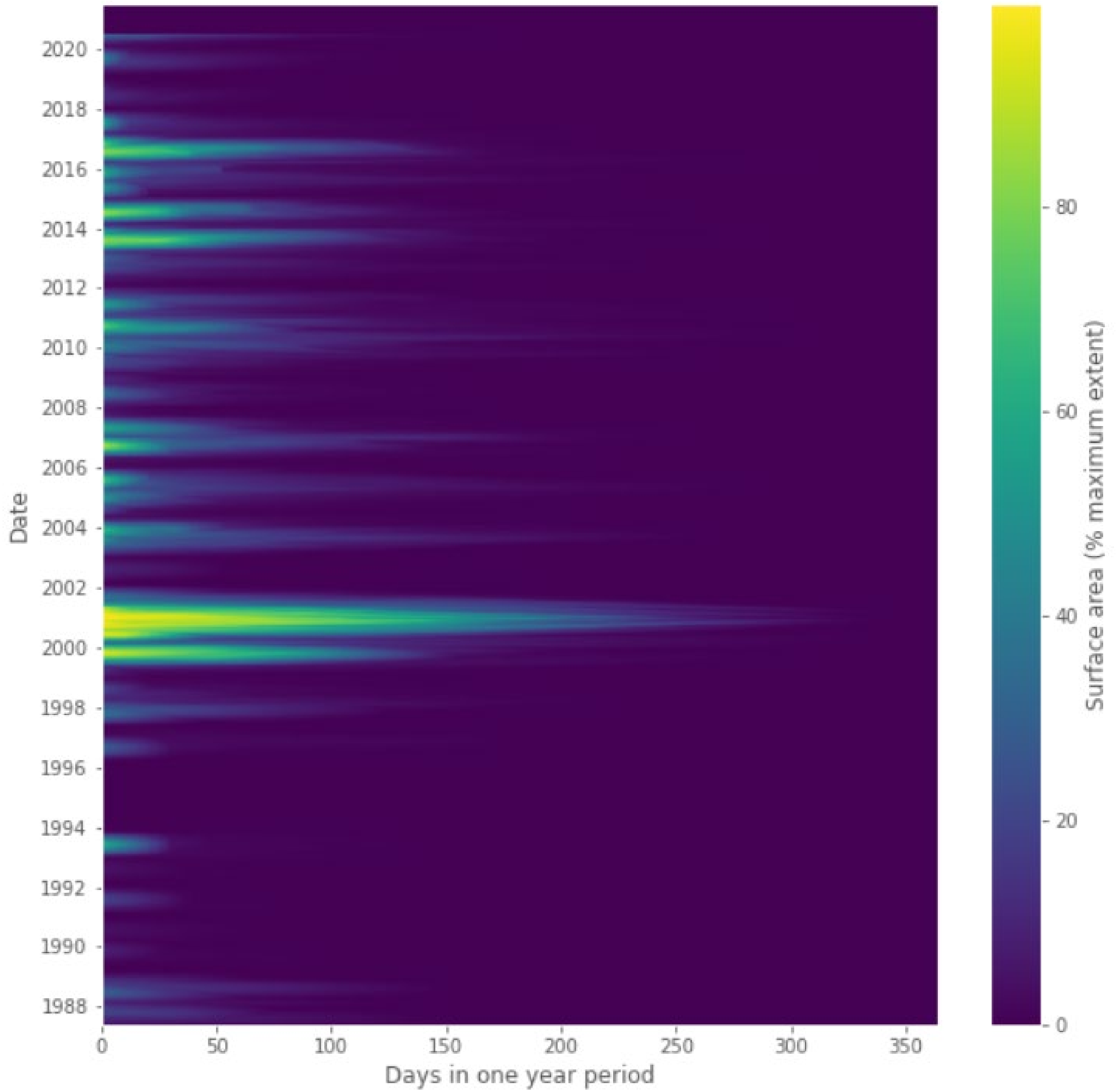
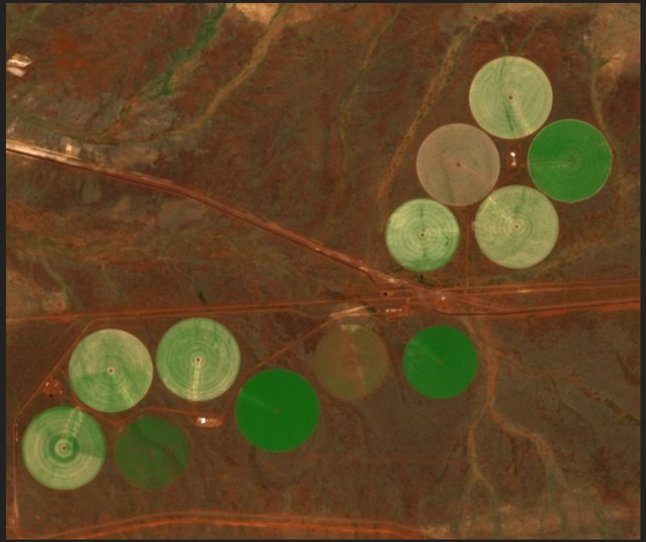


Figure 18. Short-time surface area duration (STSAD) plot for Lake Mackay (yellow is increased % surface area inundation).

Detect changes, map trends, and quantify differences.

This improved understanding benefits all stakeholders in the Lake Mackay Sulphate of Potash Project and has the potential to set a precedent for studies of ephemeral lake systems in Australia, as well as other hydrologically data-poor areas.

Natural resource management



Land use change

Climate monitoring

5

Lessons Learnt

"With these assessments, Agrimin was better equipped to meet regulatory needs and improve our approaches to solving food security challenges."

Lessons Learnt

- The derived timeline of water cover for WOfs DEA waterbodies is based on observations where at least 80% of the waterbody is covered by ‘good’ pixels (where reliable point data is available).

- This is problematic for large areas such as Lake Mackay as the full extent of the lake is not always covered by the imaging swath of the satellite, and the scan-line corrector issue on Landsat 7 greatly reduces the available coverage.

- A large number of WOfS excluded from the available default DEA models, reducing temporal resolution.

- The repeat cycle of the Landsat satellites is either 8 or 16 days - some minor inundation events may have been missed if duration was shorter than the rotation period of the satellite. The start and end dates, and maximum inundation levels of some events were missed.

- DEA does not provide a Sentinel-2 WOfS data product, but it is possible to custom fit this calculation using Sentinel-2 ARD and the WOfS algorithm by DEA in the ODC environment.

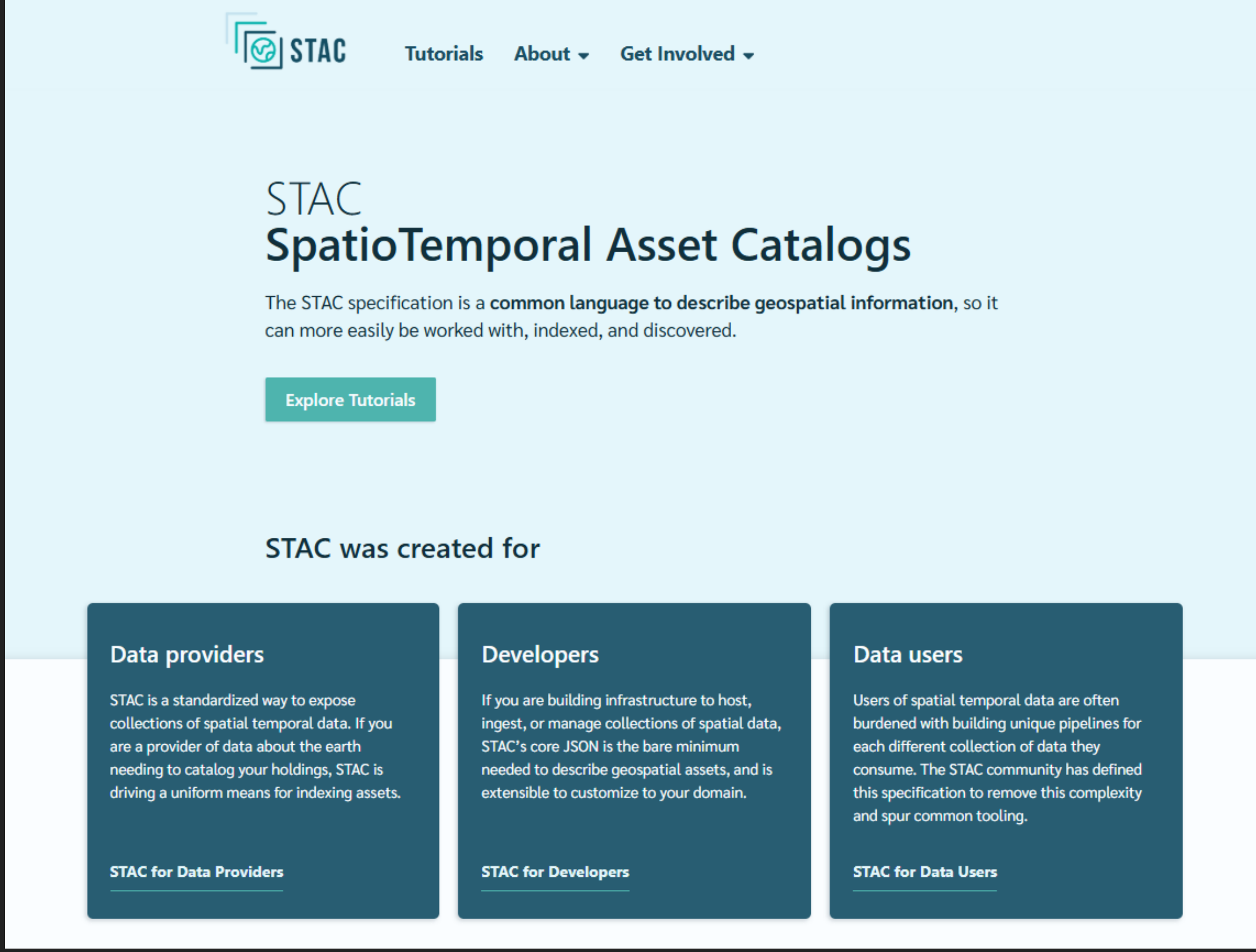
- Custom processing gave 1135 valid observations comprising 880 *Landsat*, 162 *Sentinel-2a* and 93 *Sentinel-2b* observations compared to the 164 valid observations provided by the DEA Waterbodies dataset.

Alternatives to Open Data Cube and Passive Imagery

Spatial Temporal Asset Catalogue (STAC) API – hosted by other platforms (cloud-based storage)

Standardised framework to bulk-analyse large satellite (or other temporal) datasets

Index band hotspot analysis of Active remote sensing Synthetic Aperture Radar (SAR) data



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Questions?