Managing Pollution Impacts In Tuggerah Lakes

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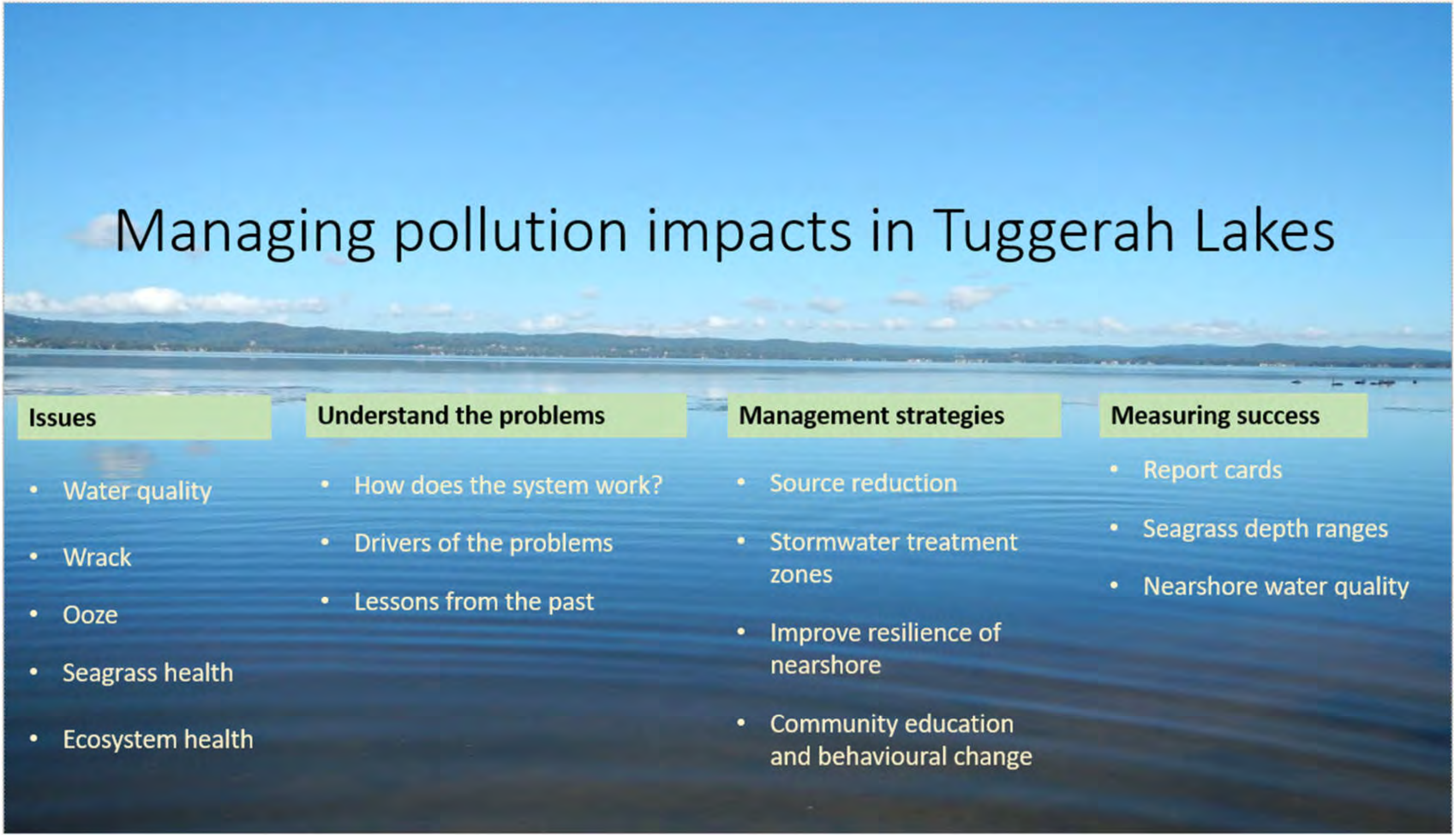
Managing pollution impacts in Tuggerah Lakes
Issues
Water quality
Wrack
Ooze
Seagrass health
Ecosystem health
Understand the problems
How does the system work?
Drivers of the problems
Lessons from the past
Management strategies
Source reduction
Stormwater treatment zones
Improve resilience of nearshore
Community education and behavioural change
Measuring success
Report cards
Seagrass depth ranges
Nearshore water quality

Over 10 years of scientific research supports this presentation…..

- Catchment, estuary and lake water quality monitoring
- Catchment models
- Hydrological model
  - Ocean-entrance exchange
  - Water-level variations
  - Stratification of water column
  - Salinity simulations
  - Catchment discharge
- Ecological response model
  - Biogeochemical model
  - Seagrass model
  - Resuspension model
  - Nearshore zone model
  - Wrack model

- Ecological Processes
  - Resuspension of benthic microalgae
  - Internal recycling of nutrients
  - Net ecosystem metabolism
  - Pelagic/benthic productivity ratios
  - Seagrass wrack decomposition rates on different substrata
  - Seagrass leaf production & biomass accumulation
  - Rate of epiphyte growth
  - Quantification of key morphological & physiological characteristics of *Zostera capricornii*
  - Seagrass growth characteristics
  - Carbon & nitrogen isotope ratios of dominant autotrophs & consumers in Tug. lakes
  - Sources of primary production contributing to the diet of consumers in Tuggerah Lakes
  - Benthic habitat assessment
  - Wrack and Ooze field surveys
  - Composition & Biogeochemistry of Ooze

Scientific Contributors Dr Peter Scanes, Dr Angus Ferguson, Renee Gruber, Dr Brian Sanderson, Kirsty Brennan, Dr Sonia Claus, Tony Weber, Joe Neilson, Jaimie Potts, Aaron Wright, Dr Rod Connolly, Dr David Welsh, Prof. Tarik Meziane, Dr Rebecca Swanson

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How does the Tuggerah Lakes system work?
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Estuaries & Catchments

Historical changes in Tuggerah Lakes

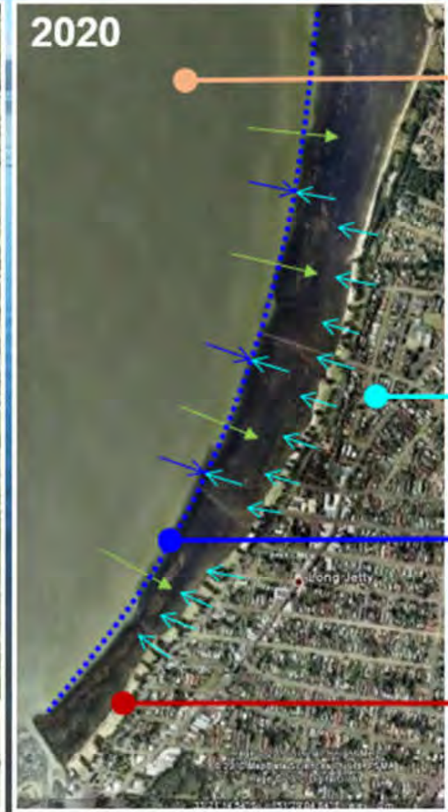
1890 – 1950 Growth of agriculture and forestry
- Increased sediment and nutrient loads

1960 – 1990 Urban development
- High sediment and nutrient loads to the nearshore
- Rapid increase in ecological impacts

Sandy shoals exposed to strong currents (sand ridges)

Seagrass, macroalgae growing in deeper waters

Low grade, sandy shorelines



Catchment erosion causes high turbidity in lake basin

Turbidity causes seagrass to migrate shorewards

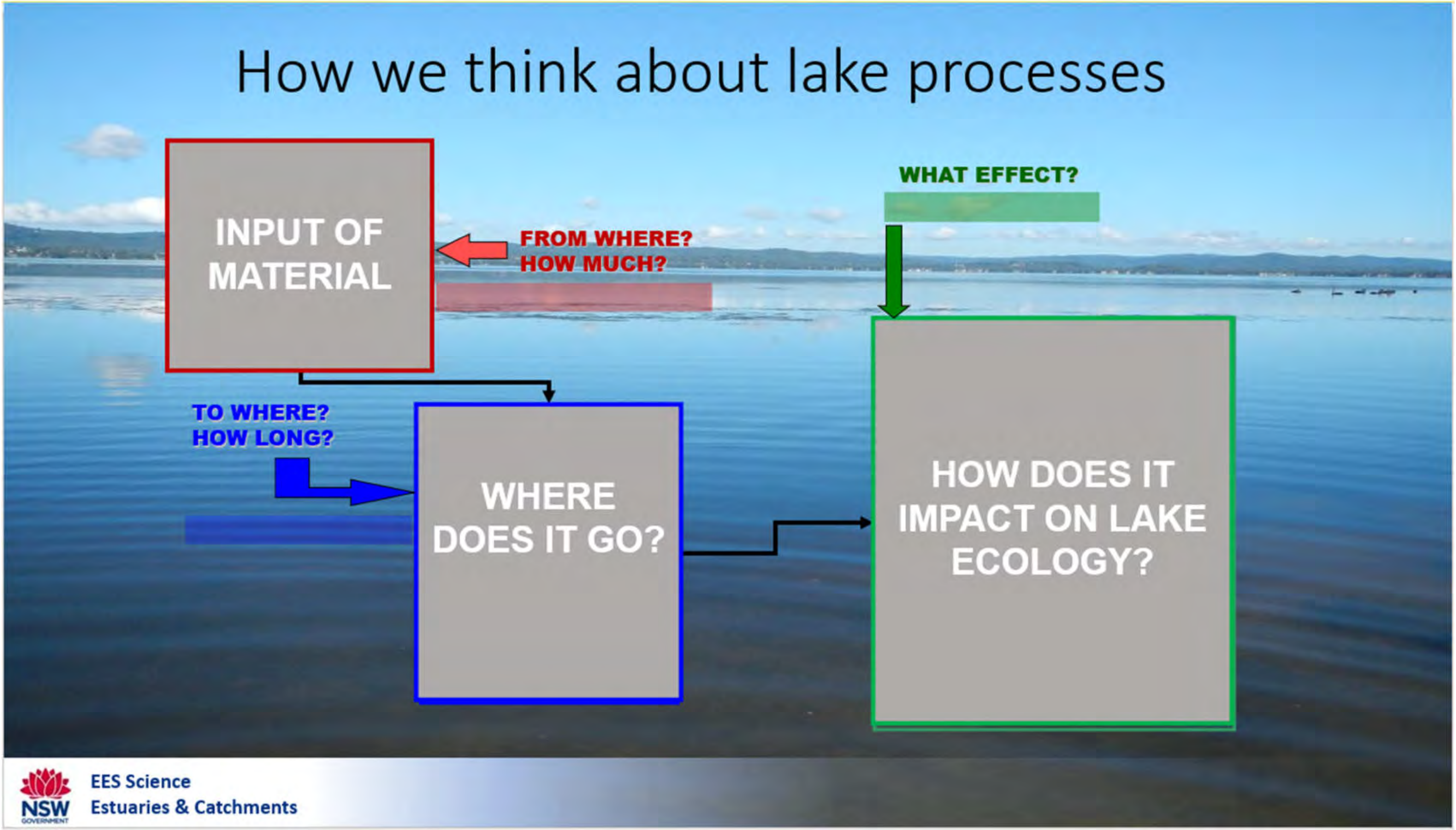
Increased urbanisation – nutrient inputs greatly increased to nearshore zone

Nearshore and lake basin ‘decoupled’ – Seagrass, macroalgae in nearshore zone trap runoff from urban fringe

Modified shoreline alters habitat and shoreline processes

Historical changes at Killarney Vale

Killarney Vale 1930s


How we think about lake processes
INPUT OF MATERIAL
FROM WHERE?
HOW MUCH?
WHAT EFFECT?
TO WHERE?
HOW LONG?
WHERE DOES IT GO?
HOW DOES IT IMPACT ON LAKE ECOLOGY?
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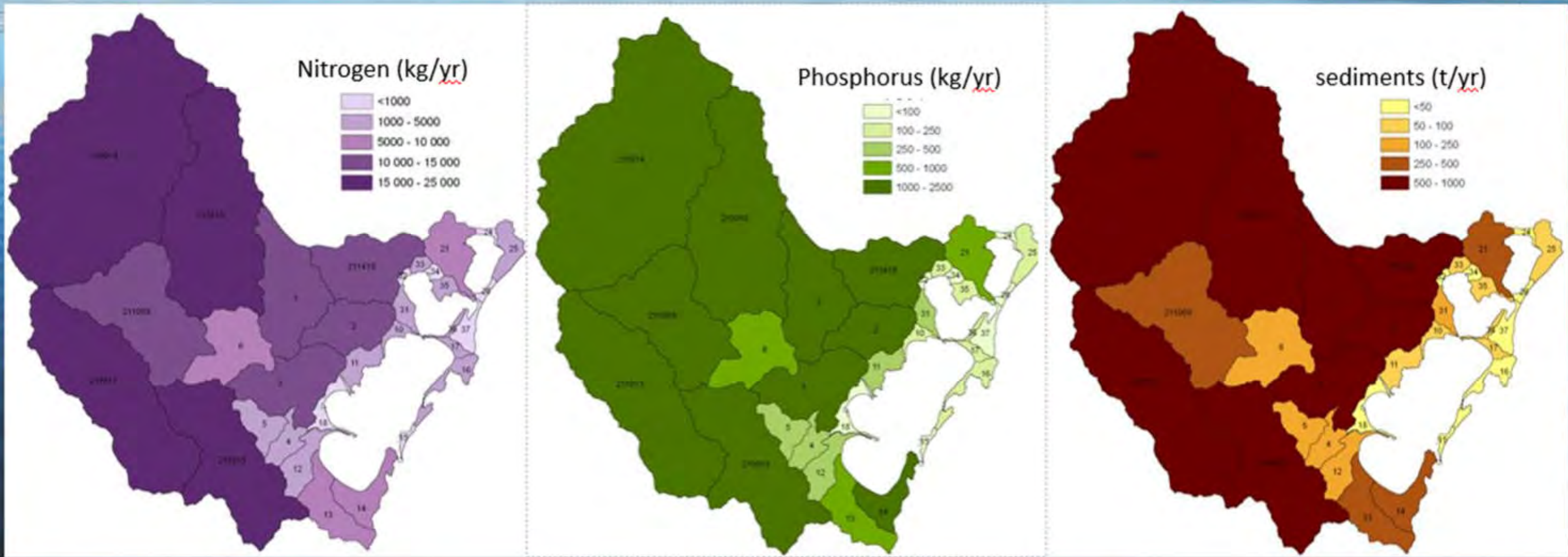
Where are the pollutants coming from?

The bulk of pollutants enter the lake from rural sub-catchments during flood events



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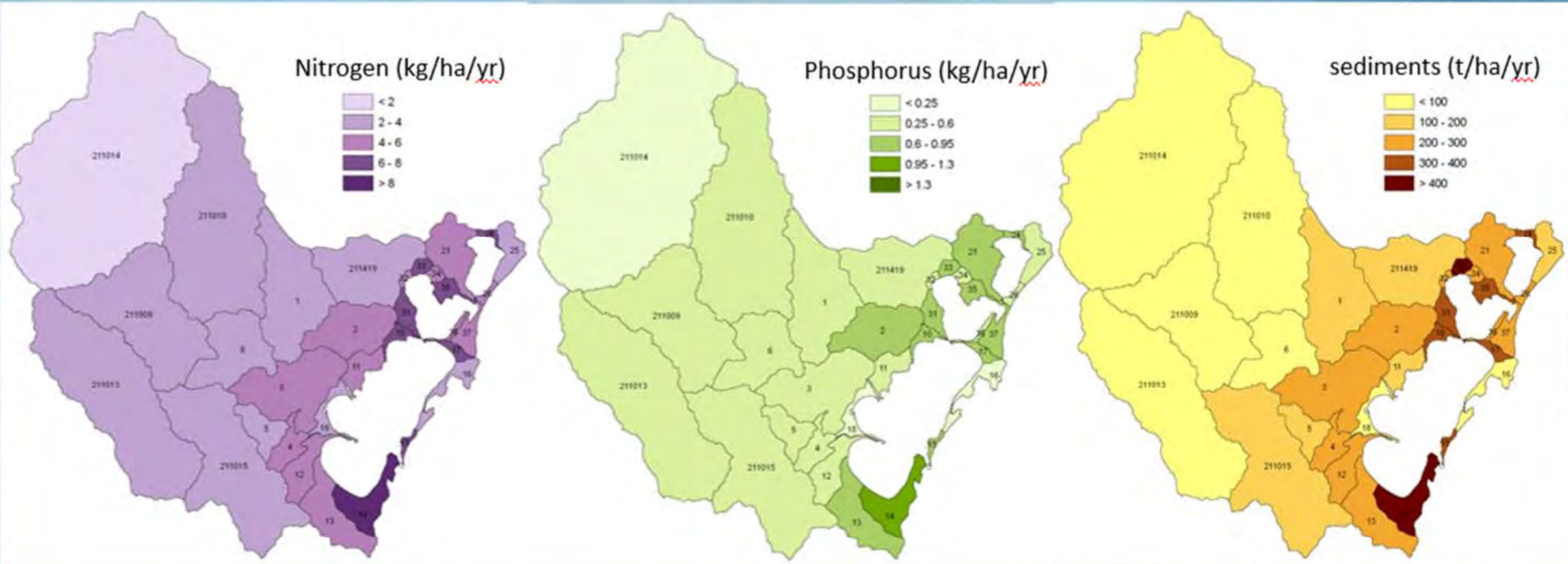
Where are the pollutants coming from?

However, urban sub-catchments generate more reactive pollutants per unit area and have greater impacts on the nearshore zone throughout the year

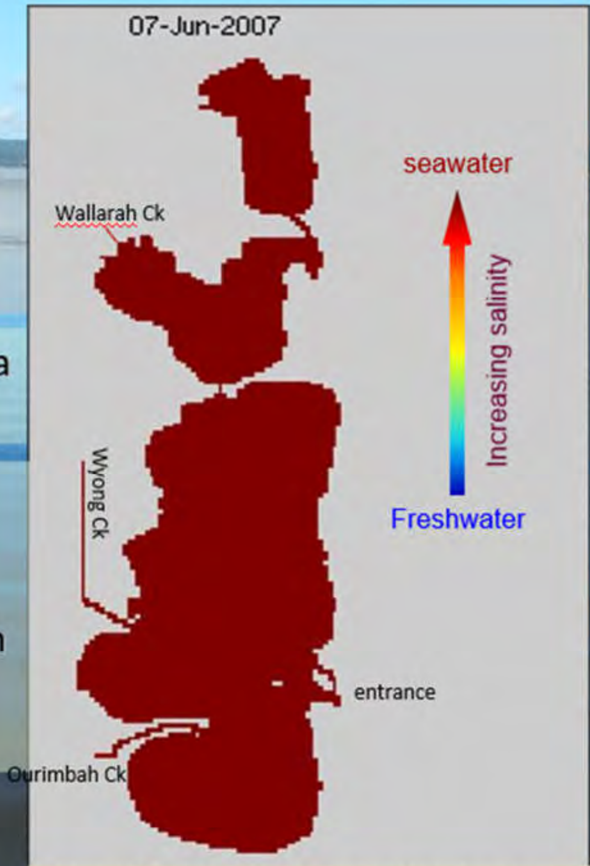


Where do pollutants go?

Understanding the mixing of catchment inputs

This animation shows how a freshwater in a flood event mixes with lake water

- Wind-driven currents are the main mixing mechanism
- Freshwater is trapped along the western shores of Tuggerah Lake due to circulation patterns.



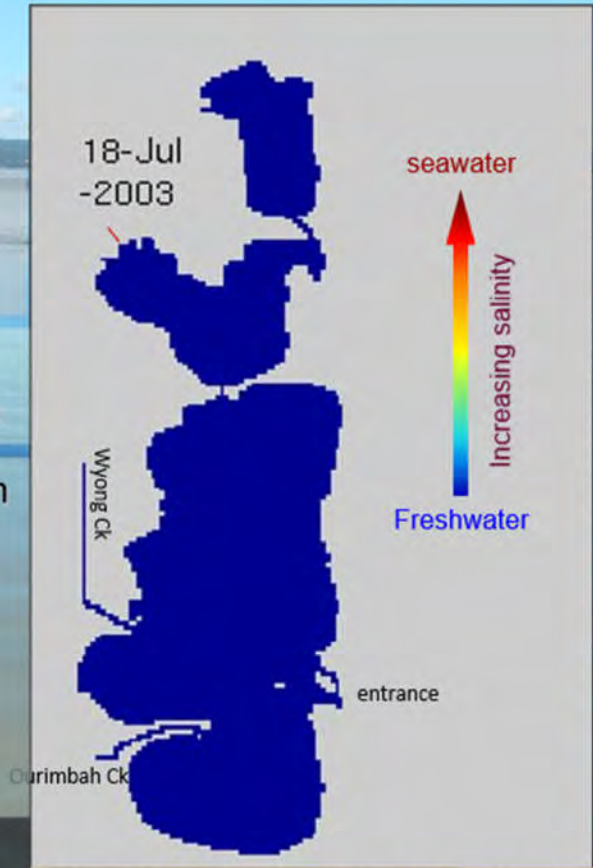
Note: model does not include barrier effects due to seagrass along the nearshore

How much is flushed to the ocean?

Understanding the efficiency of ocean exchange

This animation illustrates the limited influx and exchange of oceanic water during each high tide

- Tidal flushing has little influence on lake basin water quality
- Tidal flushing has no impact on nearshore water quality
- Almost all pollutants are retained in the lake



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Environmental issues in the Tuggerah Lakes system
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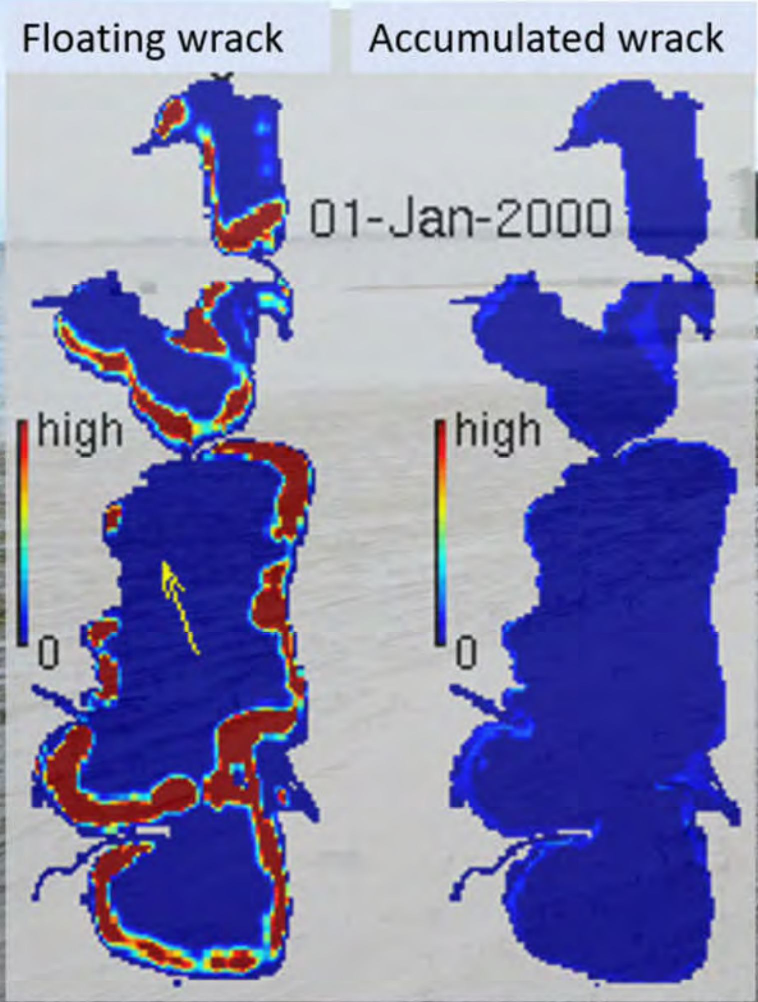
Issue #1 Seagrass Wrack



- Wrack is a naturally occurring and valuable part of the lake ecosystem
- Wrack is produced when seagrasses seasonally shed leaves
- Wrack is transported by wind-driven currents and waves

High energy, low grade shore

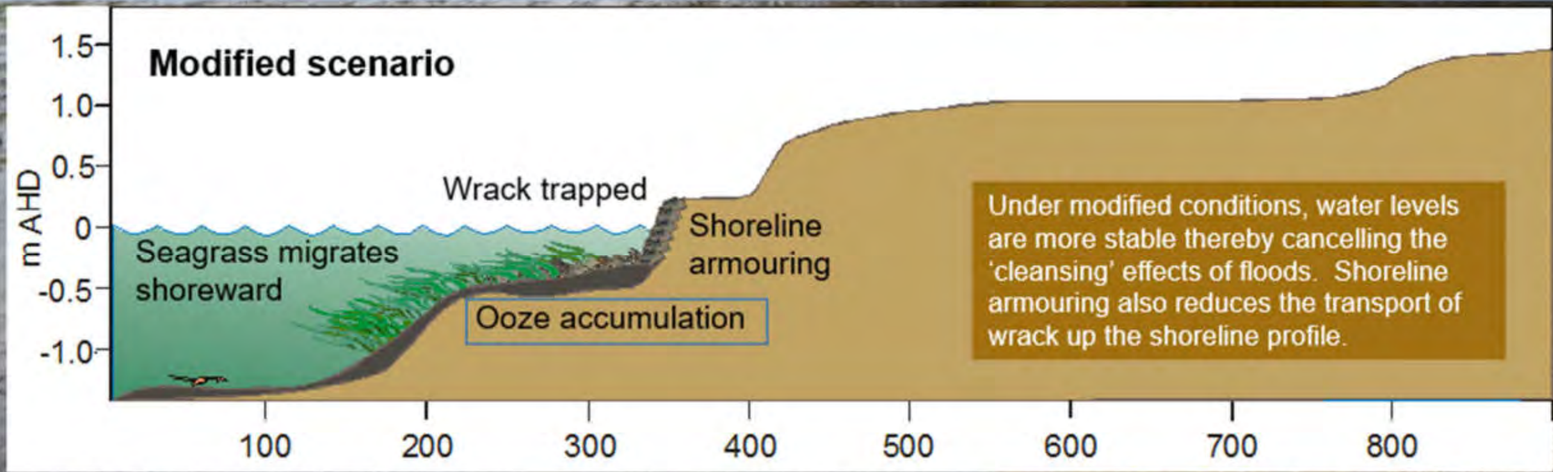
Low energy, modified shore

Accumulation of wrack

The ultimate fate of wrack depends on wind, water levels, and the grade of the shoreline on which is accumulates.



Entrance management & modified shorelines = more wrack trapped in nearshore



Strategic wrack harvesting

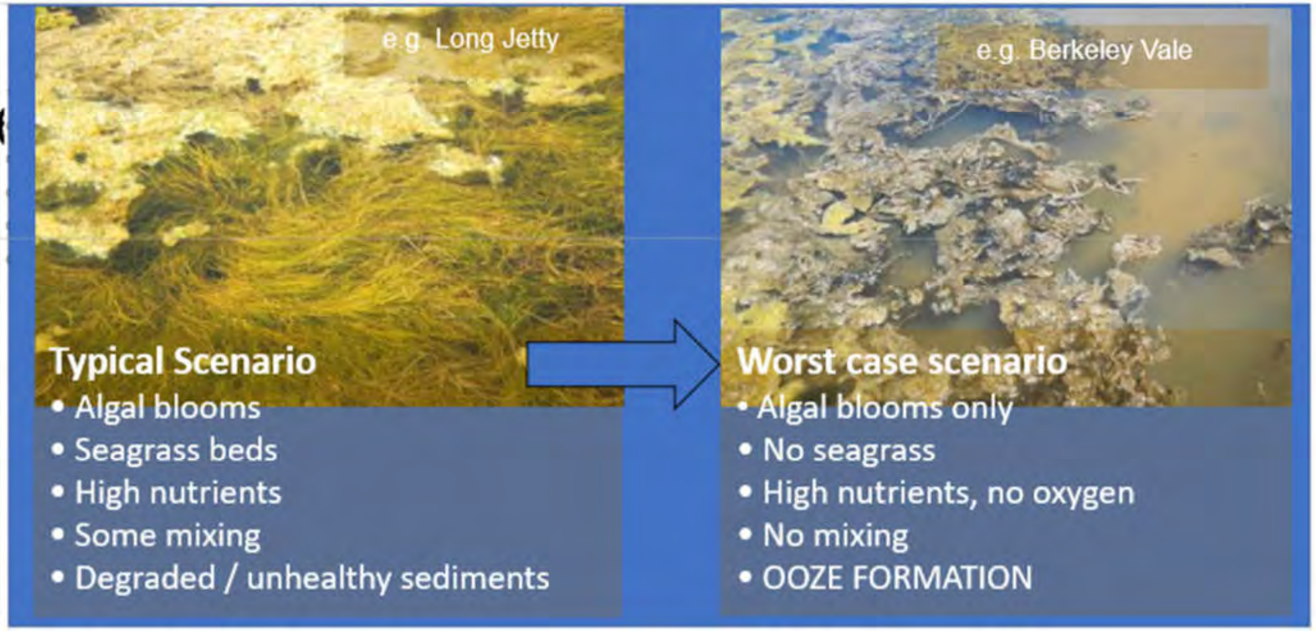
Based on research and modelling results a strategic wrack harvesting strategy has been developed

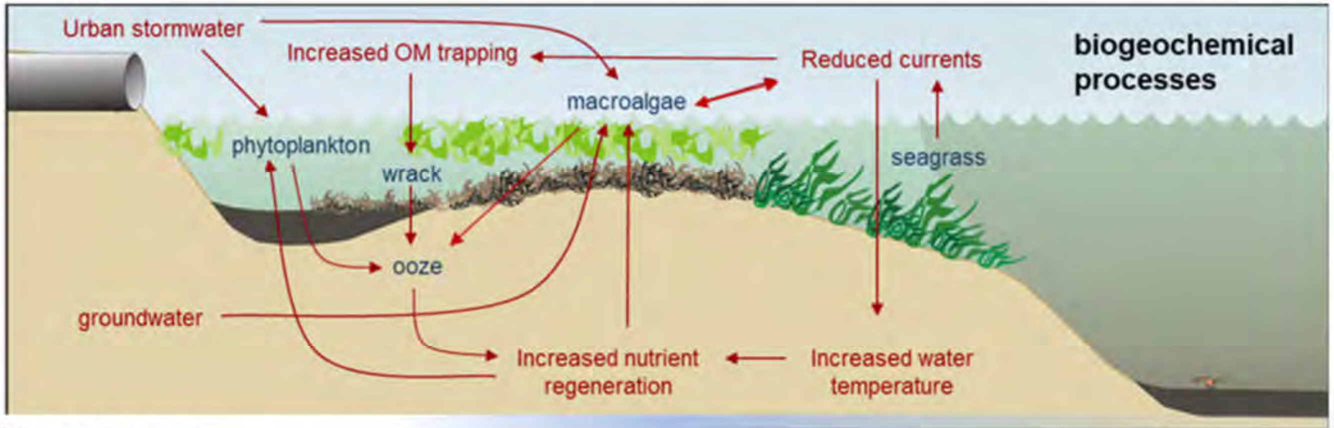
Objectives for strategic harvesting:

- Minimise wrack that reduces water circulation and public amenity
- Focus on areas where nearshore circulation will improve after collection
- Collect it before it can move somewhere else
- Move wrack to where existing harvester or land-based actions can collect
- Avoid any disturbance of sediments or living seagrass
- Allow wrack to remain in places where it doesn't cause problems

- Sensitive harvesting from nearshore will prevent further degradation
- Strategic harvesting will maximise "bang for your buck"

Issue #2 Poor water quality in the nearshore zone



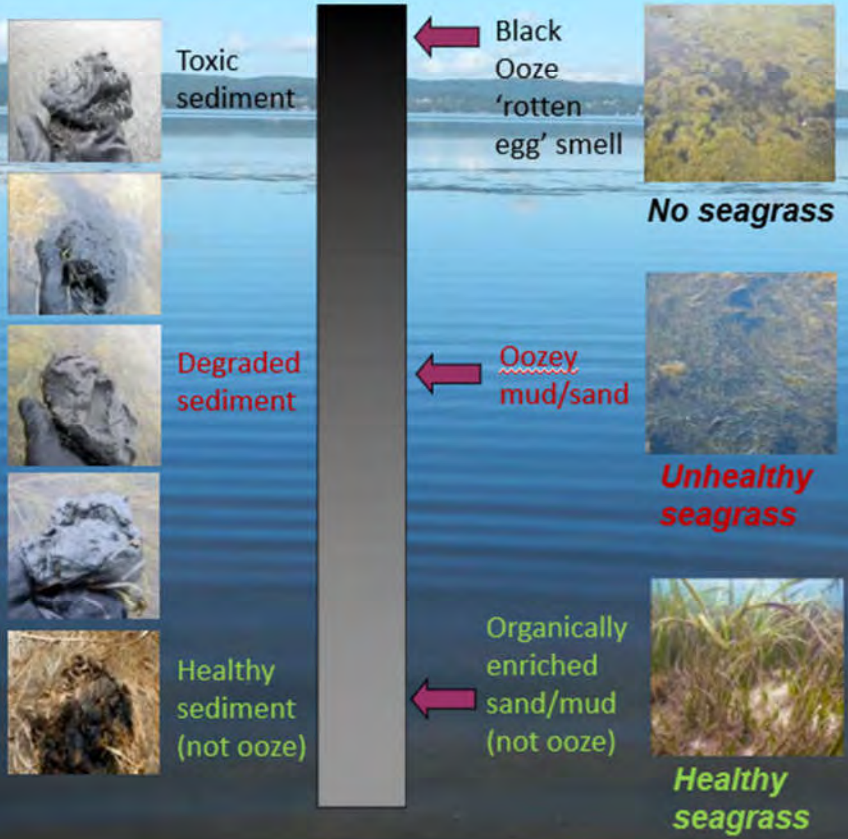


Poor water quality in the nearshore zone arises due to interactions between:

- Poor flushing
- Chronic inputs of nutrient-rich stormwater and groundwater
- Recycling of nutrients due to bacterial breakdown of organic matter

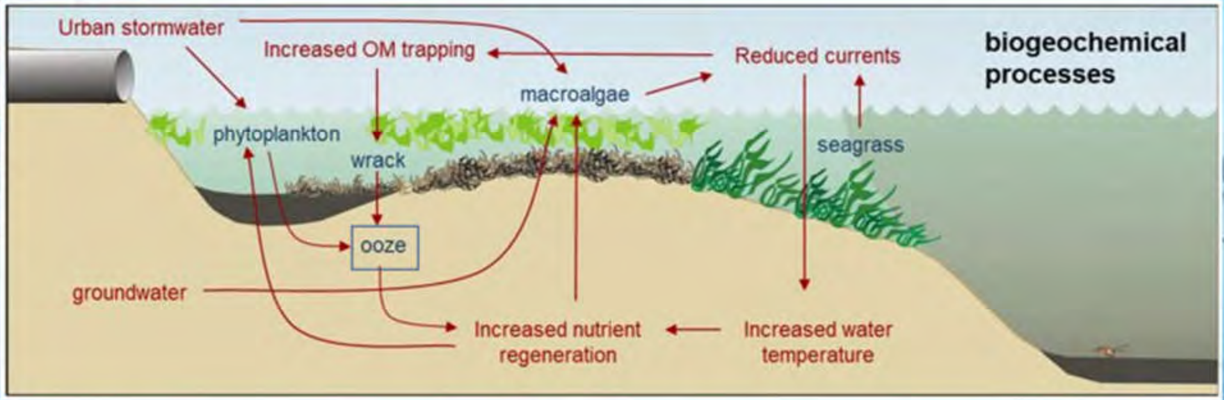
Issue #3 Ooze

Not all muddy sediments qualify as ‘ooze’. Organic-rich muds are a normal part of estuarine ecosystems.



How smelly ooze forms

Muddy sediment + organic matter + quiescent waters = OOZE

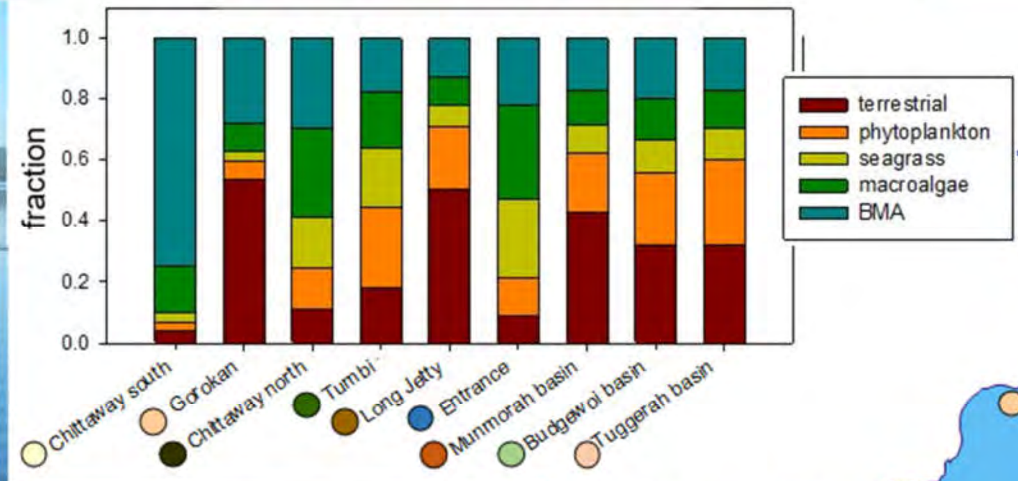


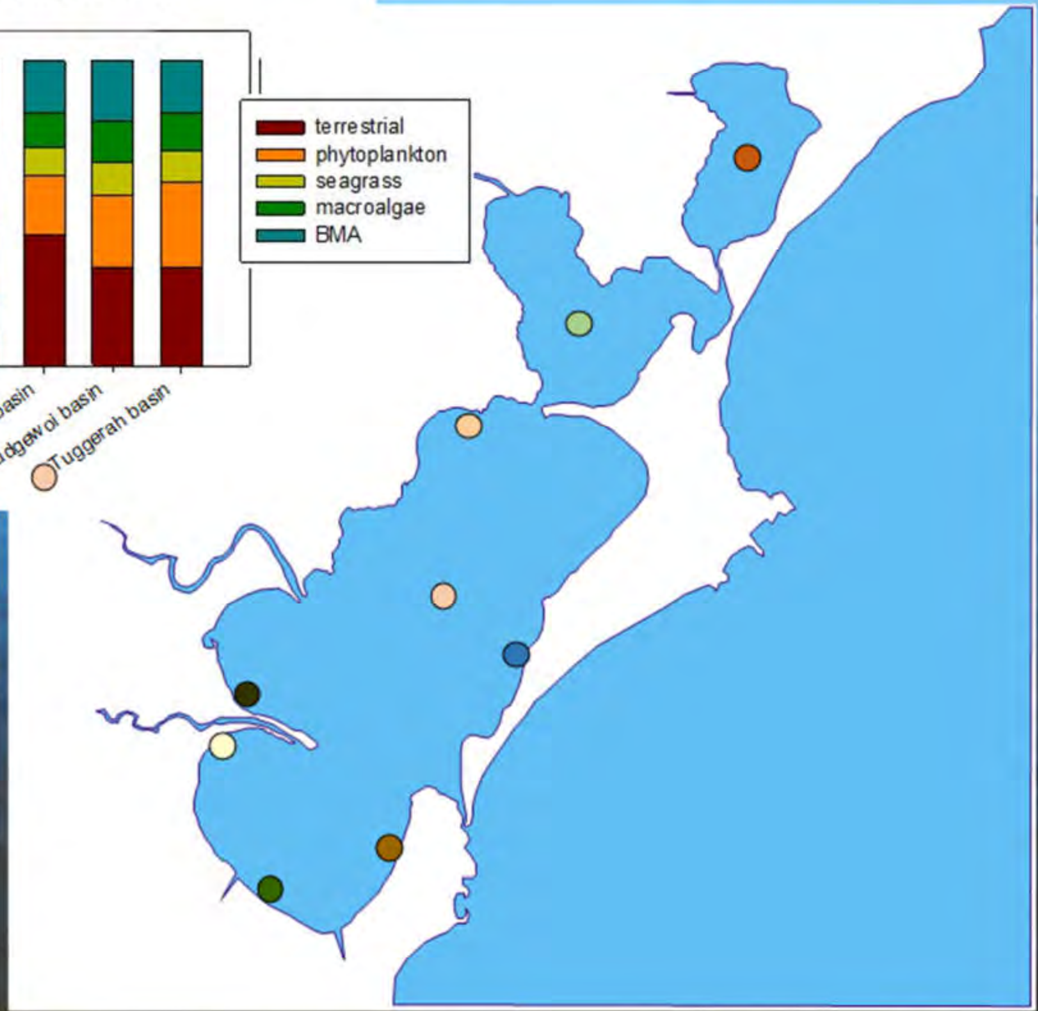
Ooze is made from
- mud, sand
- other solids (wrack)
- 'labile' organic matter
  - Algae
  - Leaves, grass
  - Animal waste

Ooze only forms where there are:
- high inputs of 'labile' organic matter (e.g. algae)
- low water flow

Poor water quality and reduced flushing in the nearshore zone promotes algal blooms and the formation of ooze

Ooze – organic matter sources





Seagrass wrack comprises on average 15% of the total organic matter in ooze. Wrack is not reactive and therefore not responsible for producing 'rotten egg' smells

The main reactive components of ooze are macro- and micro-algae which bloom in the nutrient-rich waters.

Wrack and macroalgae provide an important feedback by trapping particulate organic matter .

Dealing with Ooze

The primary focus of ooze management is to influence the factors associated with it's formation. Mechanical removal of ooze is short-term and highly problematic solution that will lead to various adverse environmental impacts.

Improve flushing of nearshore zones by strategic wrack harvesting and reducing macroalgae blooms

Improve shoreline processes by regrading shorelines to provide a low grade that allows wrack to deposit above the water level

Reduce nutrient inputs from stormwater and groundwater to limit the growth of algae in the nearshore zone

Reduce fine sediment inputs to improve sediment porosity


Management strategies for the future
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Tuggerah Lakes 'Restoration Project'

The Tuggerah Lakes Restoration project involved the large scale removal of ooze and macrophytes from the nearshore zone of the lakes. Despite considerable effort and cost, the effects of the project lasted only a one to two years before macrophytes and ooze re-established, highlighting the need to identify and treat the causes of ooze accumulation.

Management strategies

Ongoing management planning and implementation must be based on best available science and in accordance with the process underpinning the NSW Coastal Management Program

Source reduction strategies

- Streambank rehab
- Eliminate gravel verges on roads
- Identification of local pollutant generation hotspots in urban areas to allow development of targeted programs aimed at improving the quality and reducing the quantity of stormwater entering the nearshore (Berkeley Vale study)

Stormwater treatment strategies

- Redesign the stormwater treatment zones to enhance their effectiveness and aesthetic appeal (e.g. recent works near Long Jetty)

Improve resilience of nearshore

- Improve the function of shoreline processes and increase flushing of nearshore waters with the lake to reduce localised impacts of stormwater inputs (wrack management strategy)

Community education and behavioural change

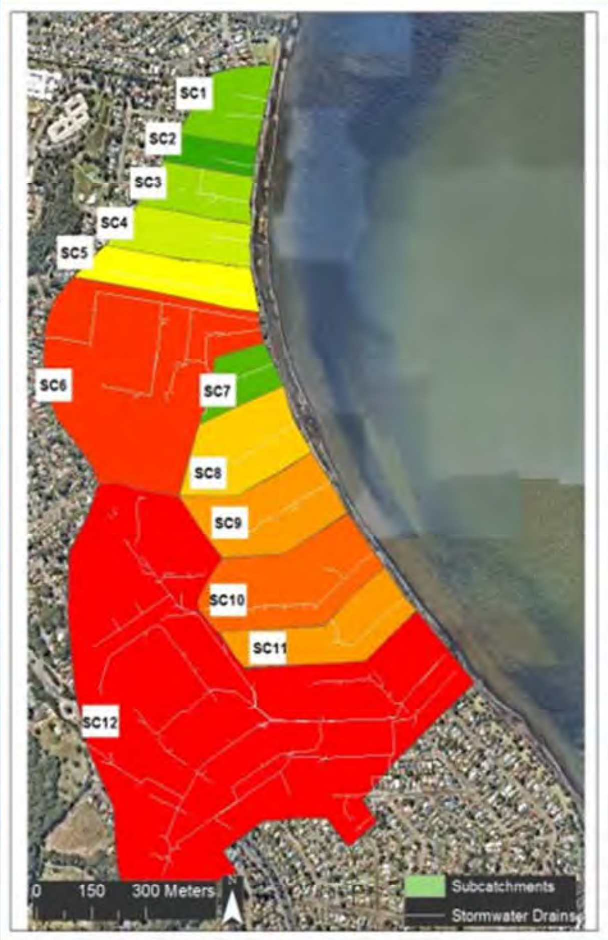
- Bring all stakeholders on board in understanding the problems and their roles in potential solutions (council website)

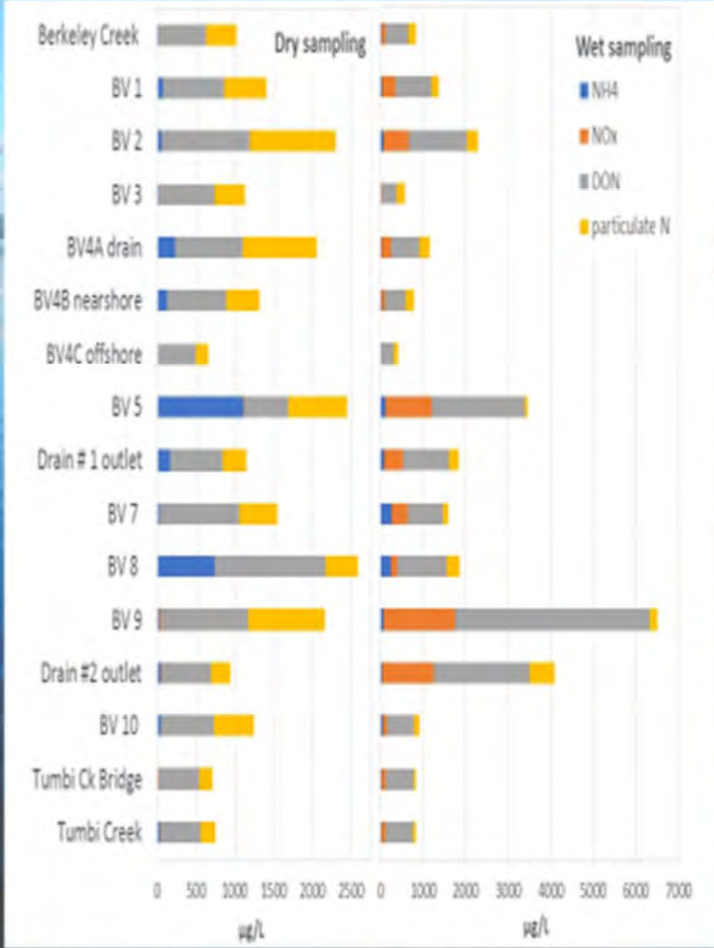
Effects-based assessment of management options

Management actions are prioritised according to an effects-based assessment approach to maximise cost-effective environmental outcomes

Berkeley Vale study

- Detailed catchment modelling to identify pollutant source hotspots
- Groundwater assessment to identify nutrient sources
- Hydrodynamic modelling of nearshore to assess different options to improve flushing





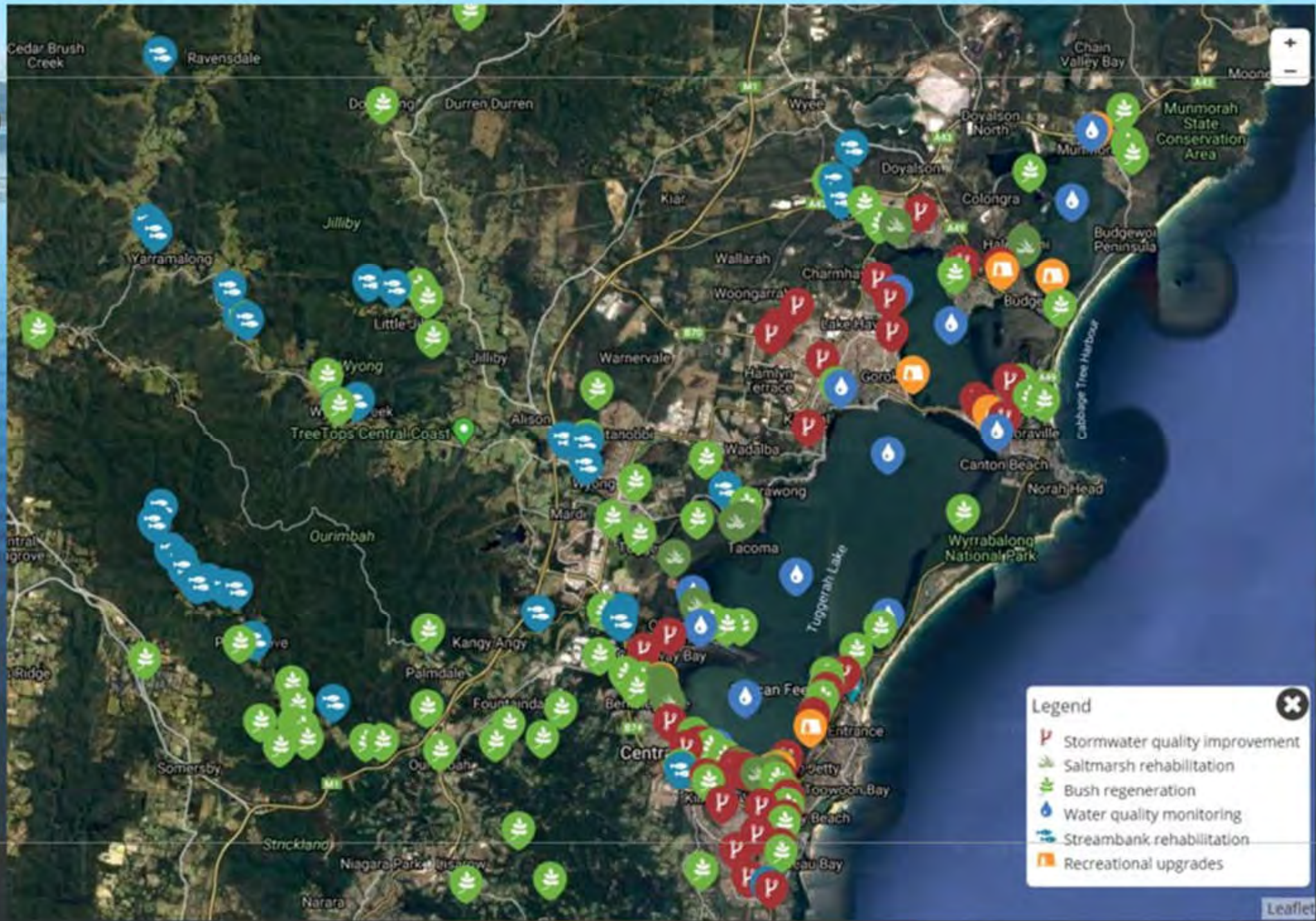
Improving shoreline processes – Long Jetty

Innovative remodelling of the lake shoreline has many potential benefits:

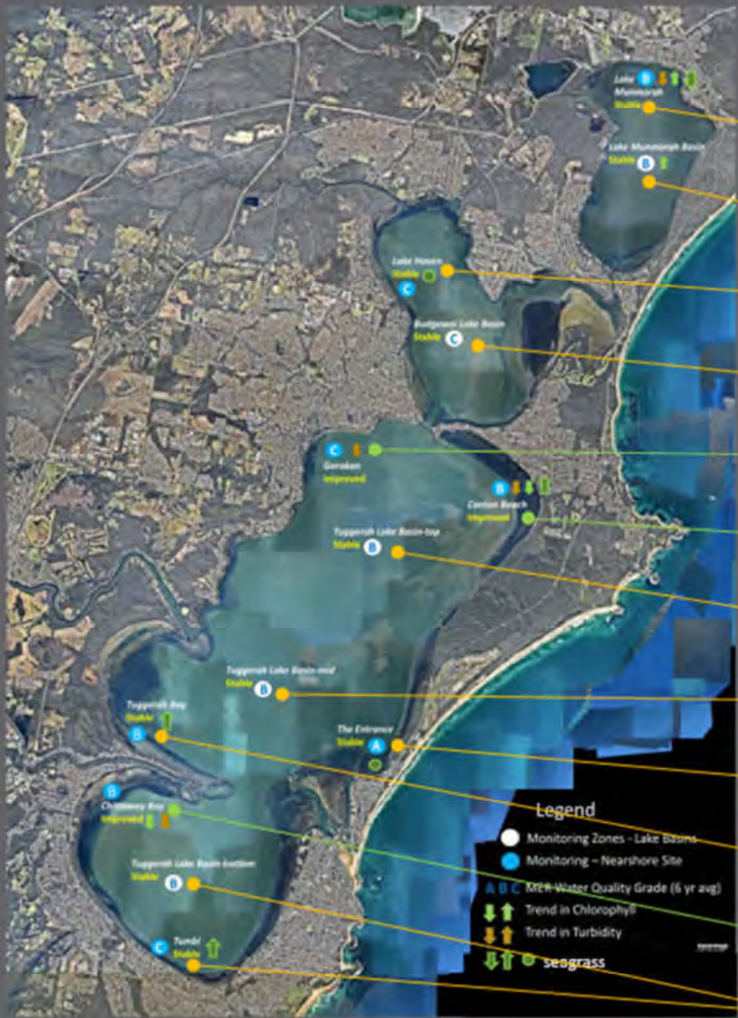
- Improve stormwater treatment
- Improve nearshore processes
- recreate intertidal and supratidal habitat
- Improve amenity
- Community education

It’s a huge problem! But don’t give up

- Click to

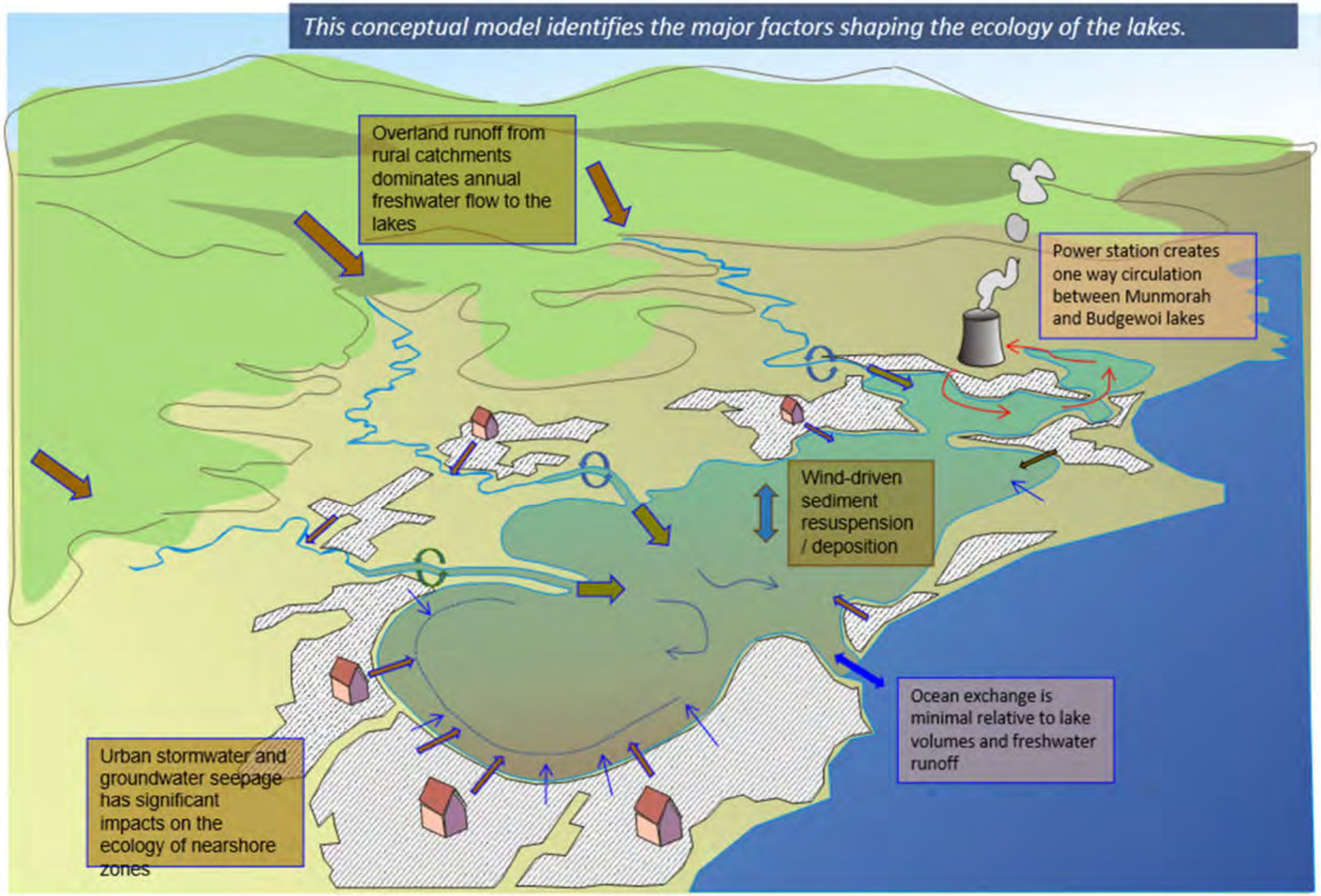


Tuggerah Lakes Water Quality Analysis 2012 - 2018



Report Card
how are we doing?

Water quality	Seagrass	grade
Stable	decline	B
Stable		B
Stable	Stable	C
Stable		C
improve		C
improve	improve	B
Stable		B
Stable		B
Stable	Stable	A
Stable	improve	B
improve		B
Stable	improve	B



This conceptual model identifies the major factors shaping the ecology of the lakes.
Overland runoff from rural catchments dominates annual freshwater flow to the lakes
Power station creates one way circulation between Munmorah and Budgewoi lakes
Wind-driven sediment resuspension / deposition
Ocean exchange is minimal relative to lake volumes and freshwater runoff
Urban stormwater and groundwater seepage has significant impacts on the ecology of nearshore zones