Integrated catchment and receiving water modelling

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Overview

Today we'll cover

- Why undertake environmental modelling?
- What is integrated catchment and receiving water modelling?
- Some limitations of historical methods
  - What really matters!
- The TUFLOW Catch solution
- Application to Oxley Creek, Southeast Queensland

The why

Environmental modelling is fundamentally about:

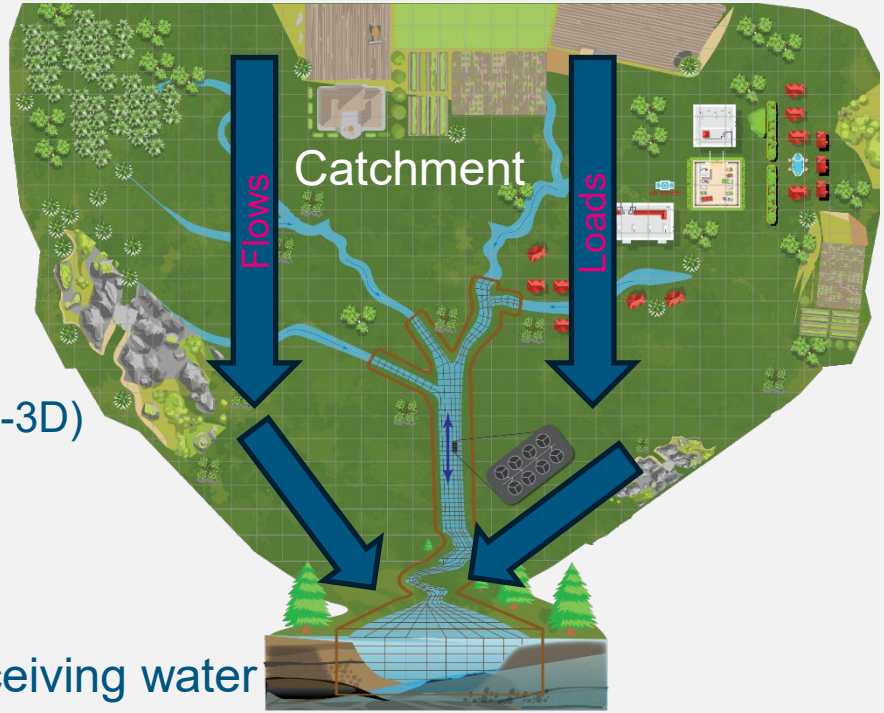
- Answering questions to support evidence-based decisions
- Example question:
  - “If a farmland area is revegetated or urban development built how does downstream water quality of a creek change?”
- The focus is often the quality of the receiving water – why?
  - Legislative imperatives in the receiving waters
  - It’s our professional responsibility

https://www.abc.net.au/listen/programs/backgroundbriefing/rivers-of-red-threaten-great-barrier-reefs-future/6723280

The what

Integrated catchment and receiving water modelling:

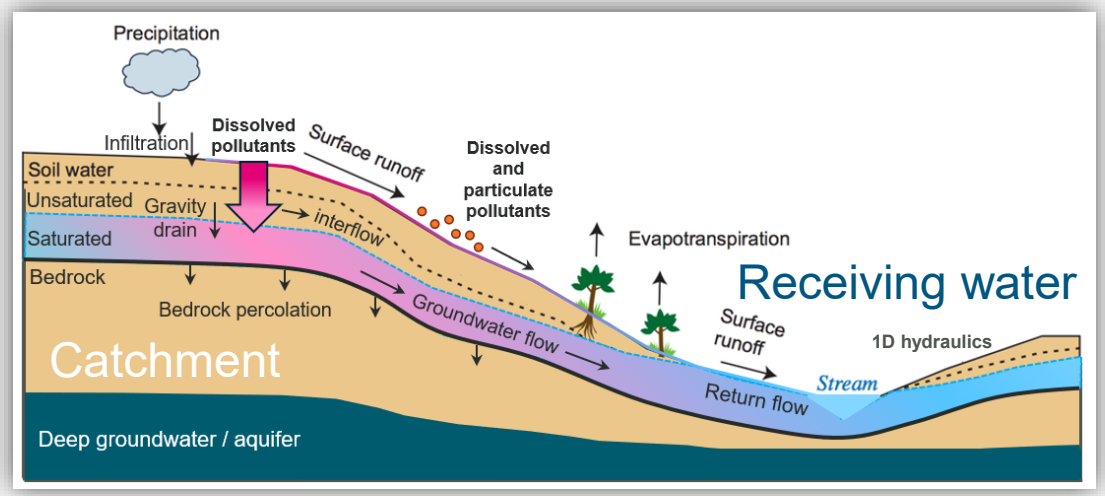
- Simulates surface and subsurface water and pollutant flow
- From catchment top (2D)
- To downstream receiving waterway exit (1D-3D)
- “Pollutants” include sediment, nutrients, pathogens, salt etc.



The what - catchment

Specifically we simulate the catchment:

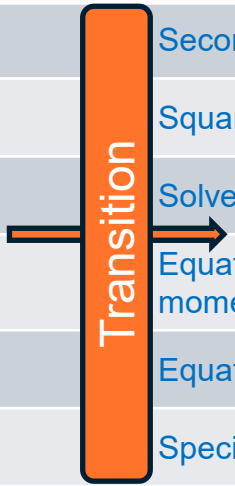
- Rainfall runoff, in some form - hydrology
- Pollutant export and transport
- Predictions are inflows and loads to downstream receiving water models



The how

Link catchment and receiving water models, but…

Feature	Catchment model	Receiving water model
Temporal resolution	Daily	Seconds
Spatial resolution	Square kilometres	Square/cubic metres
Water flow	Lumped 0 dimensional	Solves 1D/2D/3D equations of motion
	Nonphysical routing of volume	Equations solved for water level, velocity and momentum
Pollutants	Mean concentrations multiplied by flow	Equations solved for advection and transport
	Total SS, N and P	Speciated SS, N and P

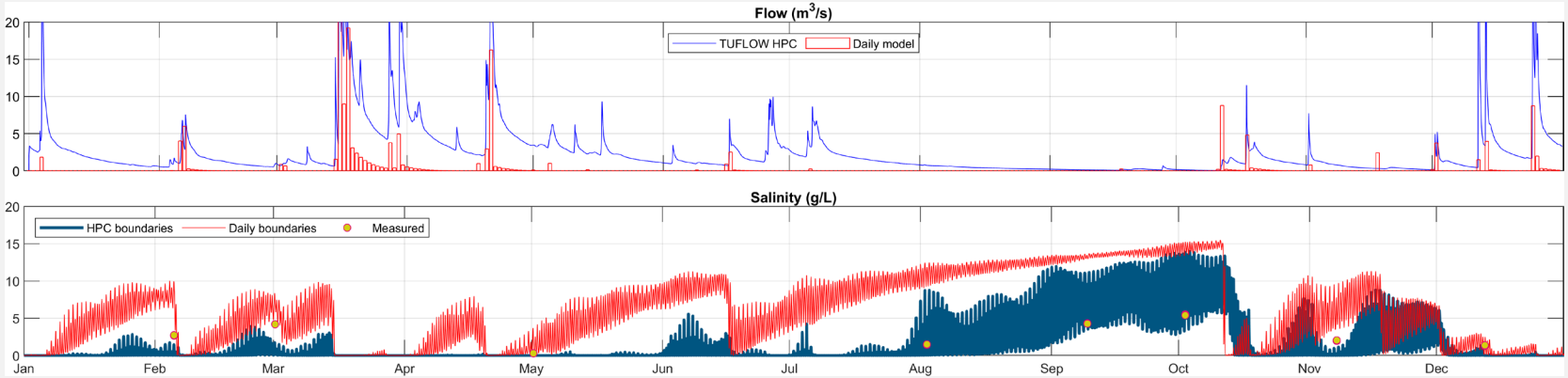


The why (do we care)

Link catchment and receiving water models, but…

The rigour of catchment model predictions can directly influence the predictive power of receiving water models and it depends on the questions being asked

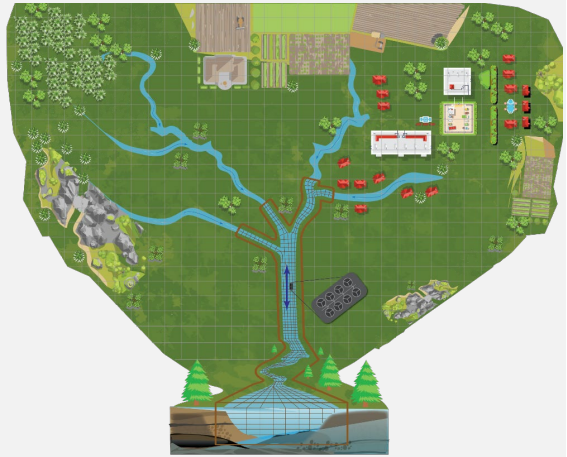
Does a misalignment really matter? Yes, it can.



TUFLOW Catch

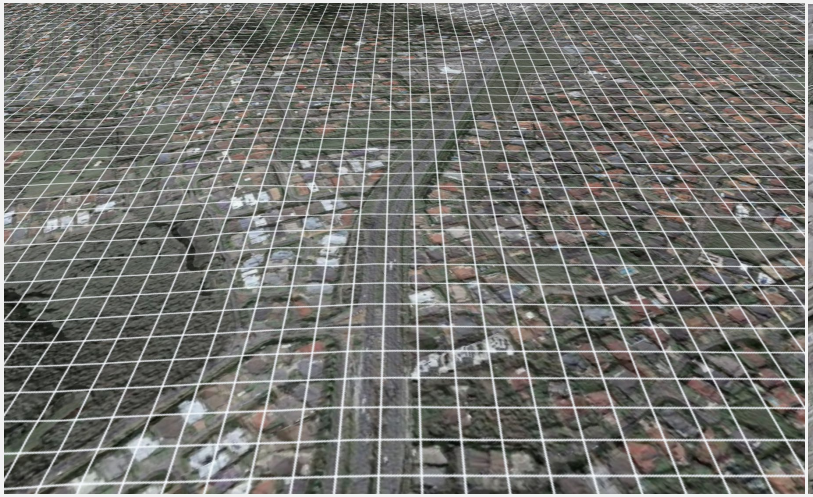
TUFLOW Catch provides this realignment (pilot stage)

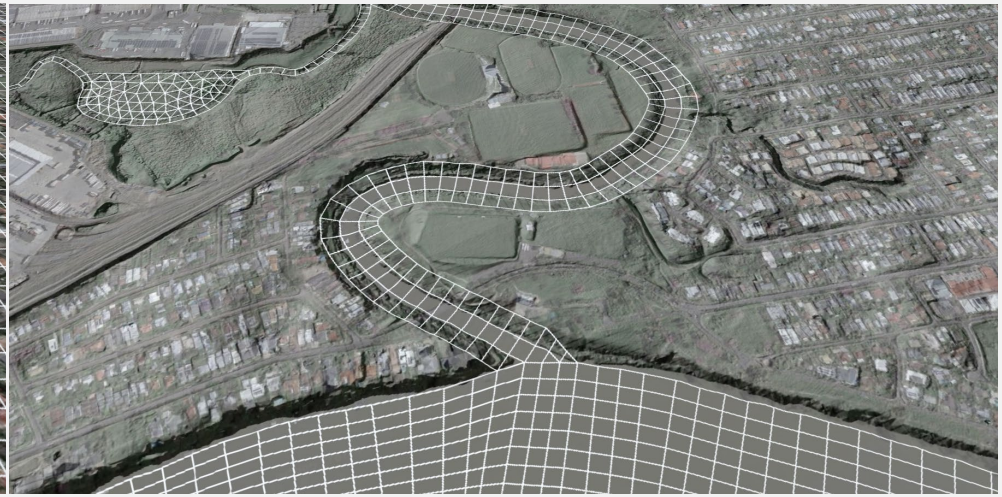
- Two existing products upgraded, enhanced and linked as one
  - TUFLOW HPC (catchment) and TUFLOW FV (receiving water)
- Development collaboration
  - Alluvium Consulting and Griffith University
- Development supported by TUFLOW and
  - Queensland Water Modelling Network (Queensland Government)
  - Healthy Land and Water



What is “TUFLOW”?

- TUFLOW HPC
  - **2D fixed grid and 1D pipe network** modelling
  - Catchment runoff, flood inundation, urban drainage, advection dispersion
- TUFLOW FV
  - **Flexible mesh** 1D, 2D, **3D** modelling
  - Hydrodynamics, heat (atmospheric exchange), advection dispersion
  - Sediment transport, particle tracking, water quality

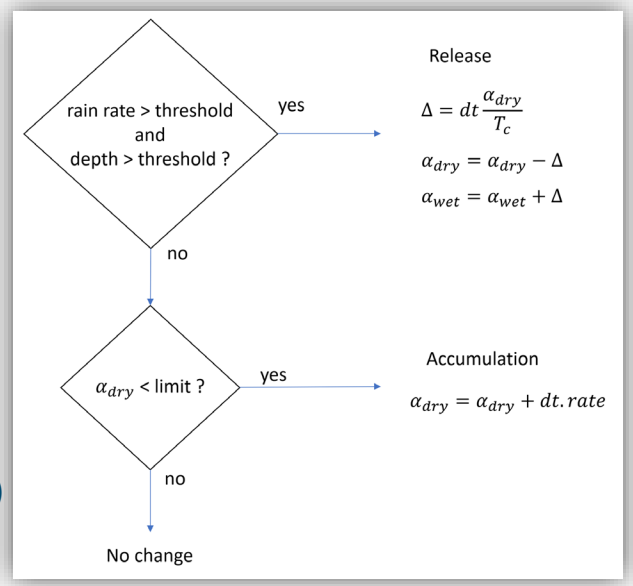




TUFLOW Catch

TUFLOW HPC upgrade and enhancements

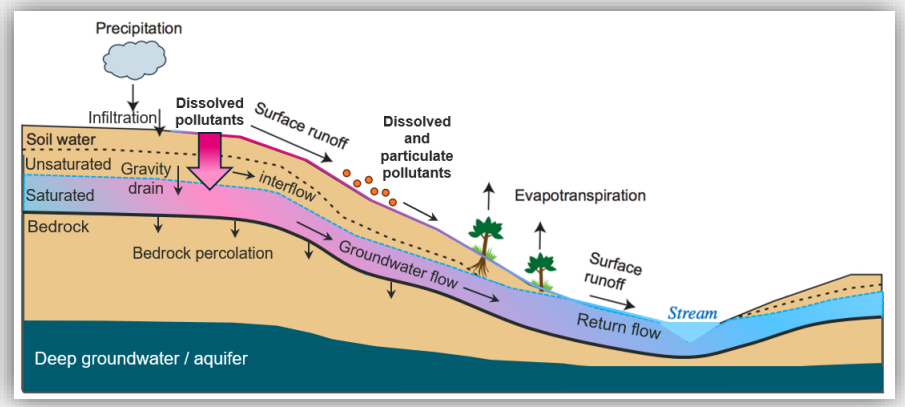
- On a cell by cell basis, TUFLOW HPC now offers:
  - Pollutant dry store accumulation
  - Pollutant wet export (release)
  - Surface and subsurface transport of released pollutants
  - Optional infiltration of pollutants (e.g. not for sediment)
  - Timeseries or constant can be provided (e.g. temperature)



TUFLOW Catch

TUFLOW HPC upgrade and enhancements

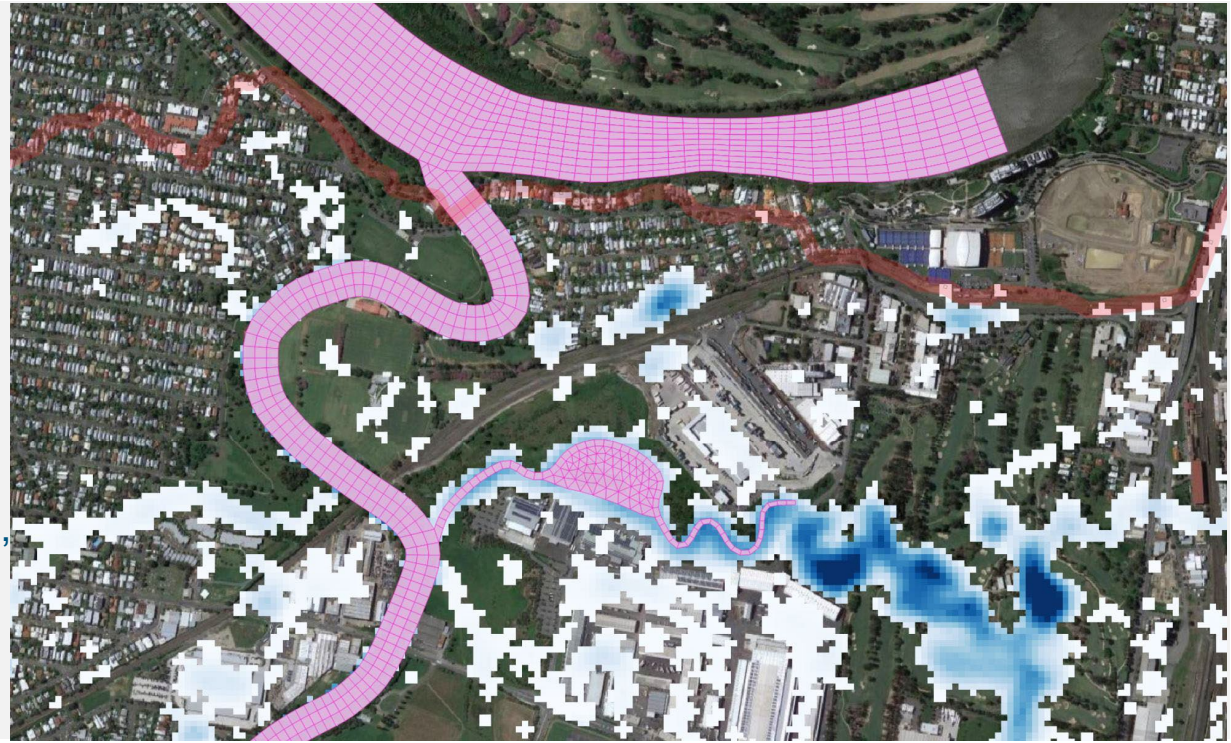
- Automated linkage between catchment and receiving waterway (critical issue)
  - Nodestrings (momentum)
  - Lateral inflows (no momentum)
  - Geospatially determined
  - TUFLOW FV boundary input files written
  - All constituents required by TUFLOW FV and WQ



TUFLOW Catch

Pilot model

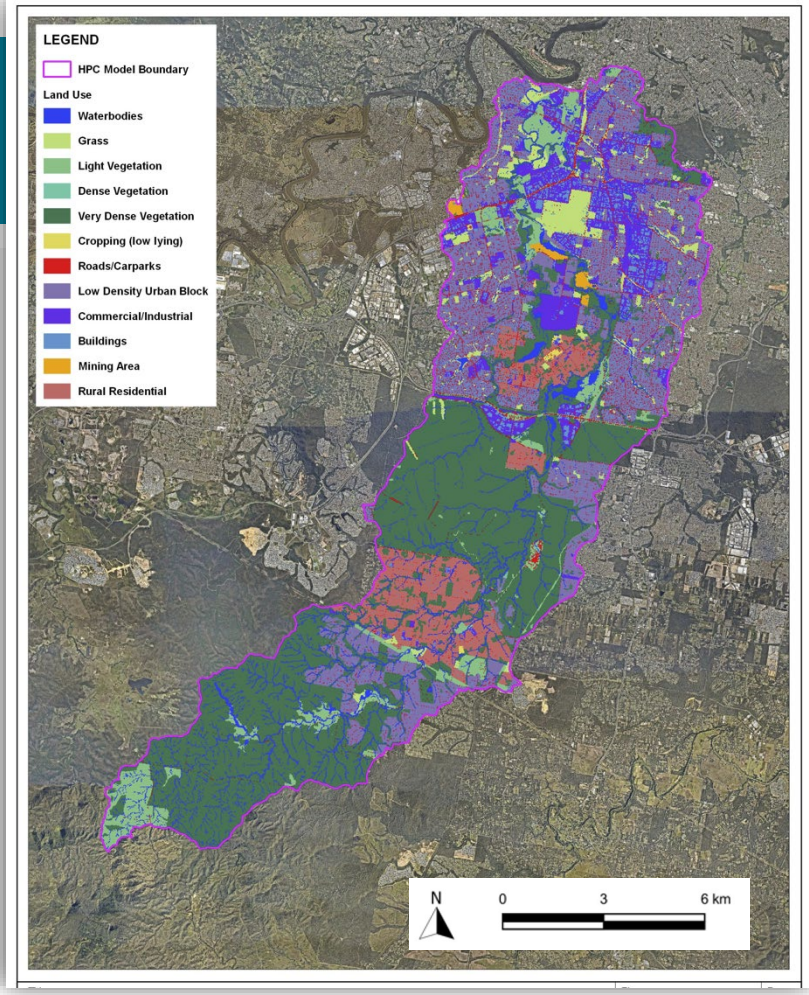
- Oxley Creek, Queensland
  - Drains to the Brisbane River
  - 260 km^2 catchment
  - Up to 300m above MSL
  - Mix of natural, agriculture, urban and industrial land uses



TUFLOW Catch

Pilot model

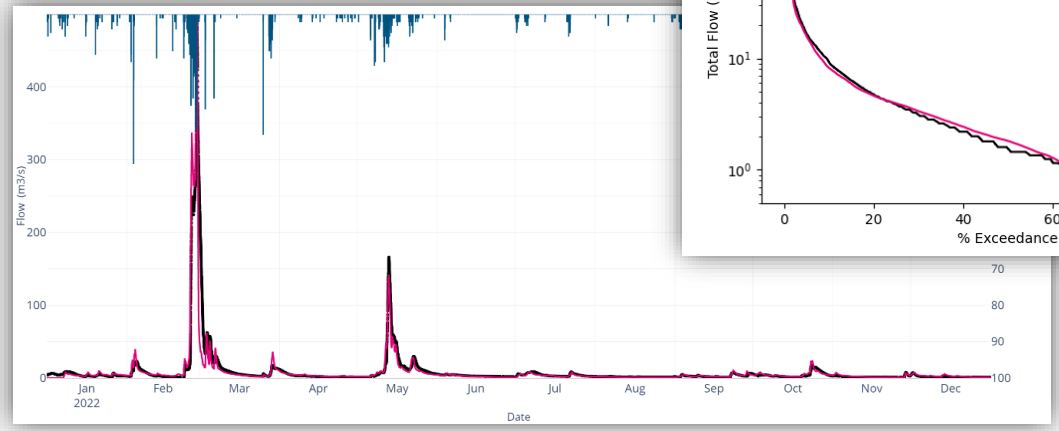
- TUFLOW HPC
  - Direct rainfall, seconds timestep
  - Run for two years – 3 hours per year
  - Spatially variable roughness and pollutant accumulation / export
  - Surface and subsurface flows
  - Surface flows calibrated to gauge data
  - Standard parameters

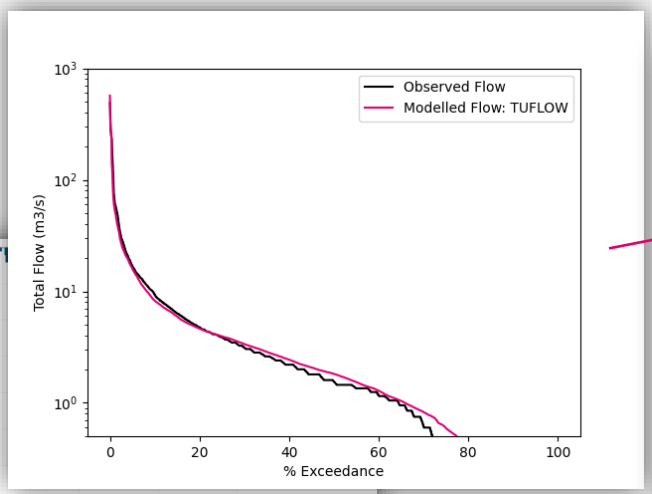


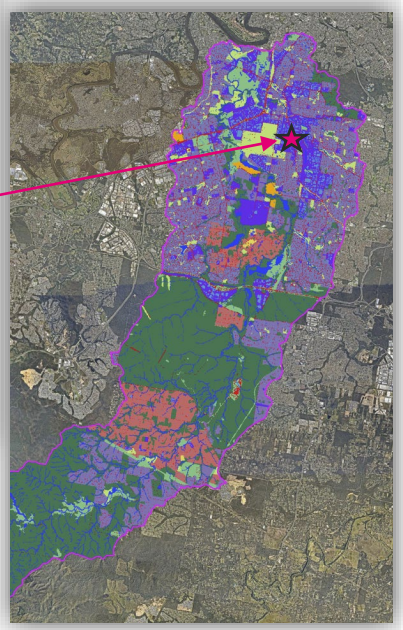
TUFLOW Catch

Pilot model

- TUFLOW HPC calibration example
  - Hourly NSE >0.8, PB <6%







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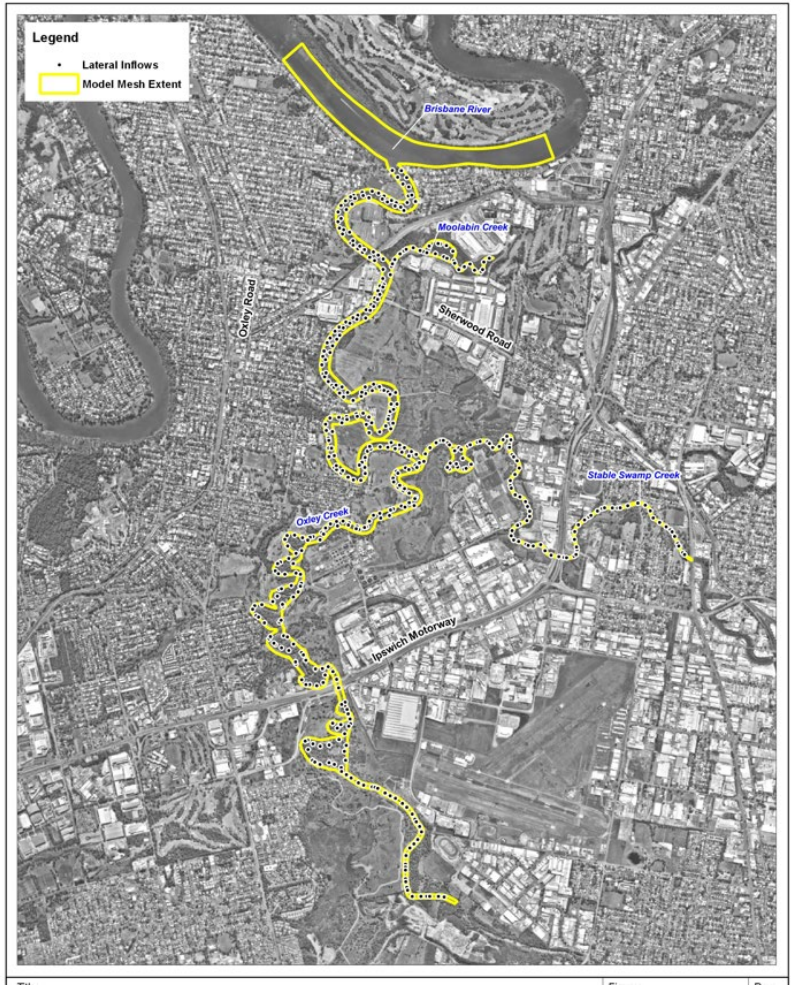
TUFLOW Catch

Pilot model

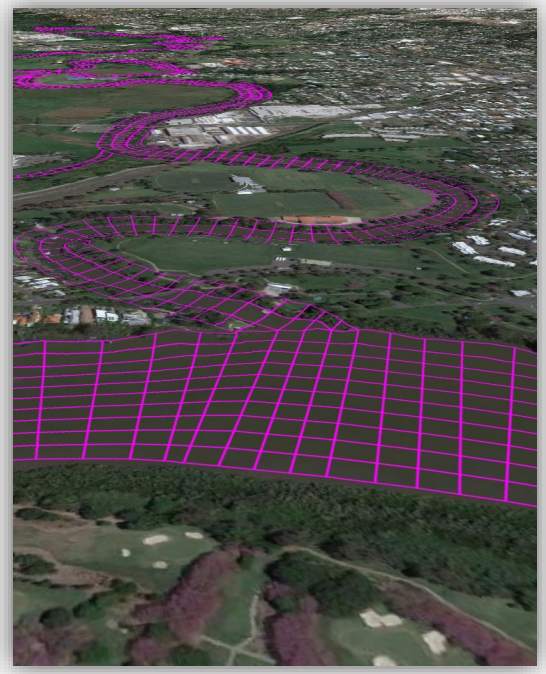
- TUFLOW HPC
  - Automatic linkage (critical issue)
  - 3 nodestrings (15 minute timestep)
  - 928 lateral inflows (3 hourly timestep)

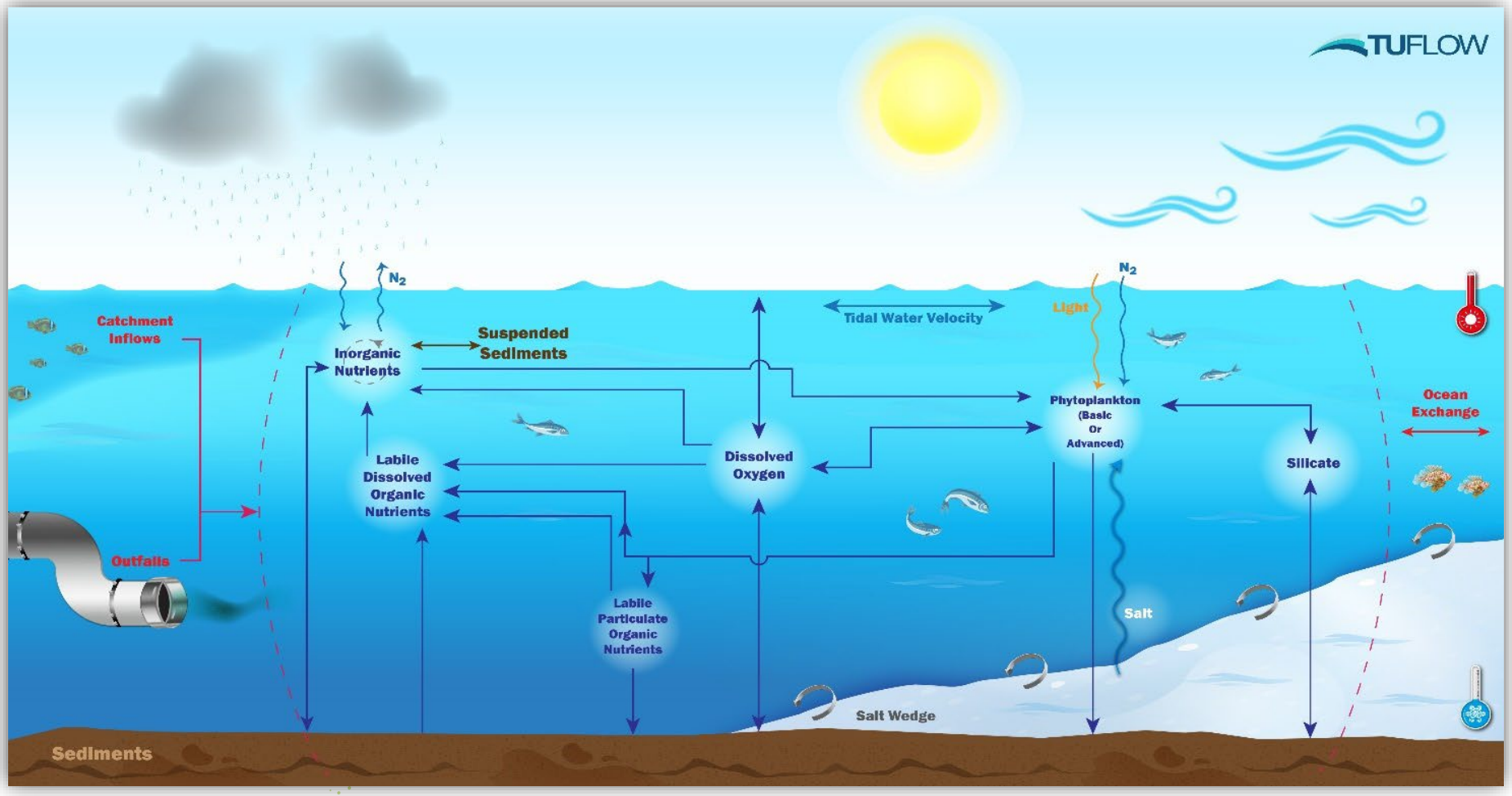


TUFLOW Catch

Pilot model

- TUFLOW FV - no new enhancements, but Oxley Creek:
  - 3D HD (12 layers), with AD, ST, WQ modules
  - Standard parameters – 10 hours for a year
  - Salinity, temperature, one sediment fraction
  - Dissolved oxygen, silicate, inorganic nutrients organic nutrients, one phytoplankton group
  - Used CFSR (via TUFLOW FV's free Get Atmos Python tool)
  - Ran for 2019

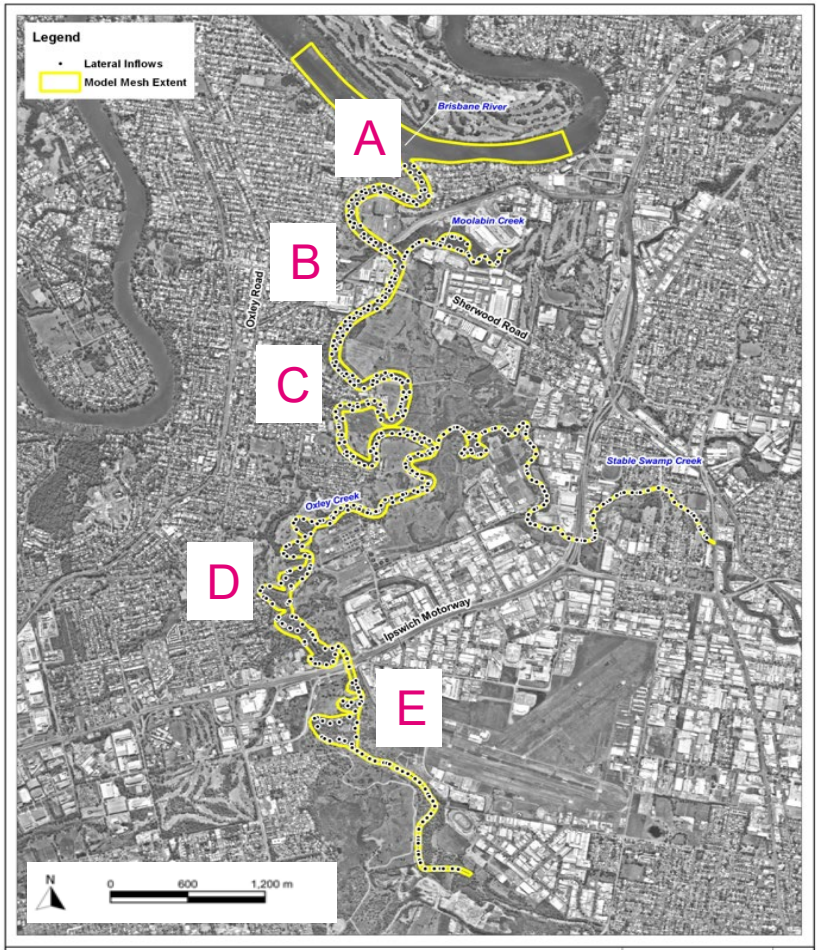


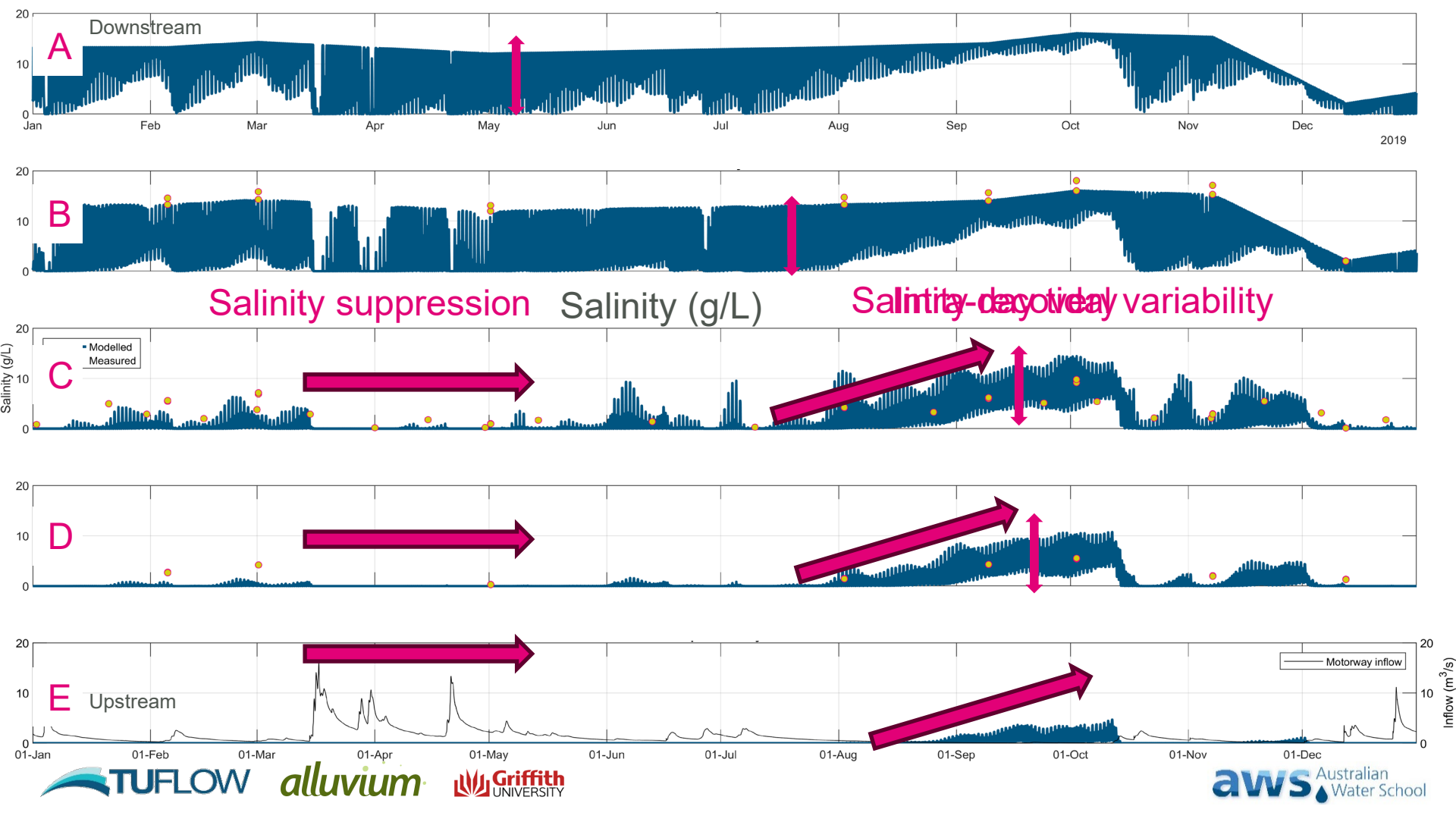

TUFLOW
N_2
Catchment Inflows
Inorganic Nutrients
Suspended Sediments
Tidal Water Velocity
Light
N_2
Ocean Exchange
Phytoplankton (Basic Or Advanced)
Dissolved Oxygen
Labile Dissolved Organic Nutrients
Silicate
Outfalls
Labile Particulate Organic Nutrients
Salt
Salt Wedge
Sediments

TUFLOW Catch

Pilot model

- TUFLOW FV
  - Calibration (2019)
  - Salinity (reflects hydrology)
  - Sediment (reflects pollutant export)
  - Surface measurements at snapshot in time within a day, on the incoming tide
  - Intra-day variability is not evident in measurements but is captured by the model





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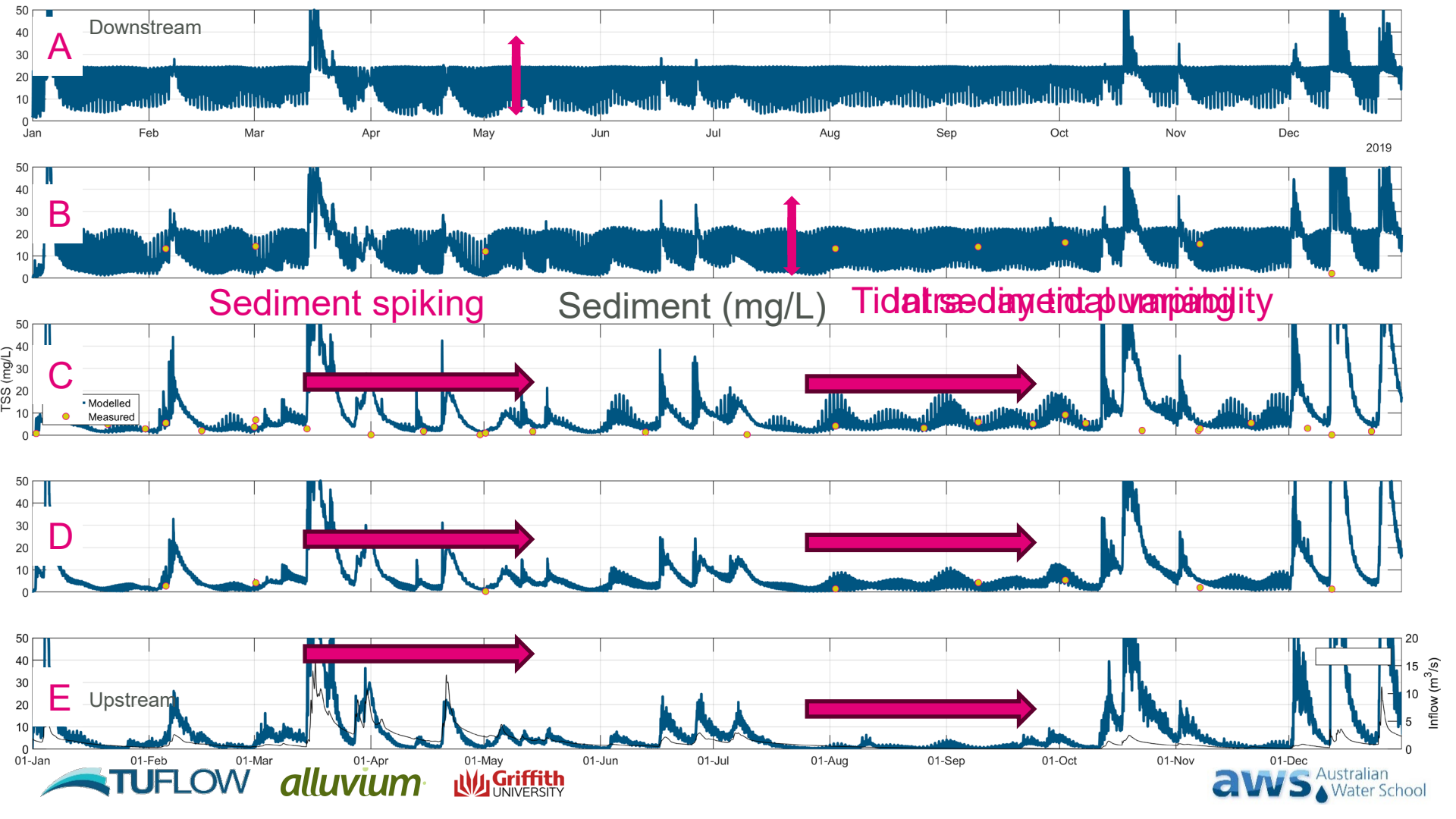

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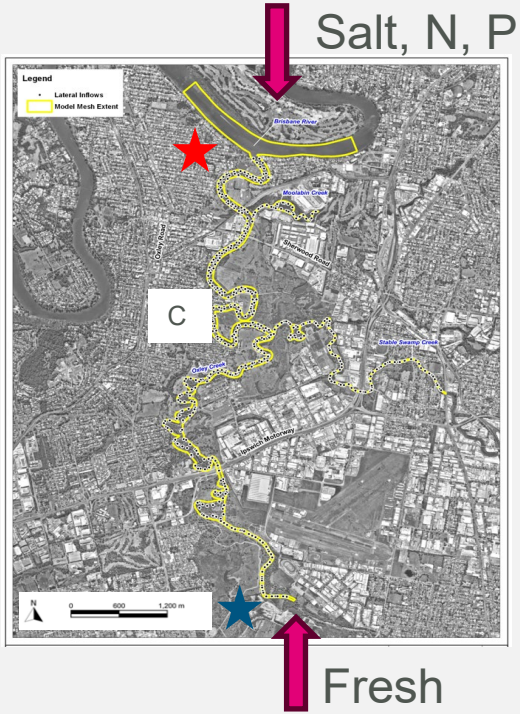
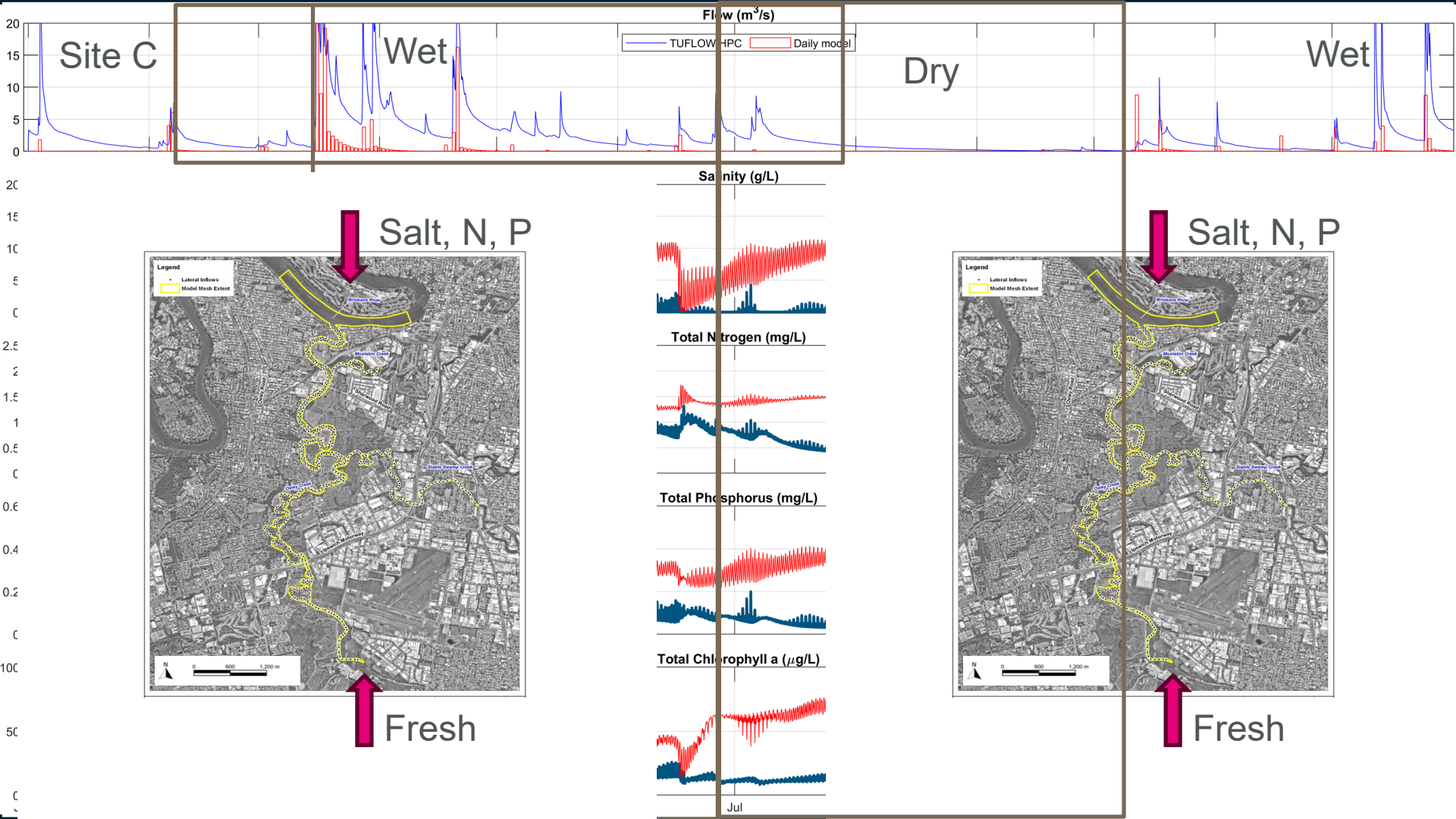
Why!

Comparison with existing catchment model

- Daily lumped hydrology model
  - Currently in use, albeit with broader use intent
- Salinity, sediments
- Location C




Site C
Wet
Dry
Wet
Flow (m³/s)
TUFLOW HPC
Daily model
Salinity (g/L)
Total Nitrogen (mg/L)
Total Phosphorus (mg/L)
Total Chlorophyll a (μg/L)
Jul
Salt, N, P
Fresh
Salt, N, P
Fresh
Legend
Lateral Inflows
Model Mesh Extent
Brisbane River
Moolabin Creek
Stable Swamp Creek
Burbank Motorway

Summary

Integrated catchment and receiving water modelling

- Tools have been often historically disparate
- Key issue is that receiving water modelling is heavily reliant on predictions from upstream hydrology models
  - The predictions of upstream hydrology matter to receiving water modelling!
- Benefits of high spatial and temporal resolution forcing downstream receiving water modelling to hydrology is clear for Oxley Creek – what questions are being asked?

Questions?