Fairy Bower Overtopping Monitoring and Decision Support System

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10:30 3 December 2022
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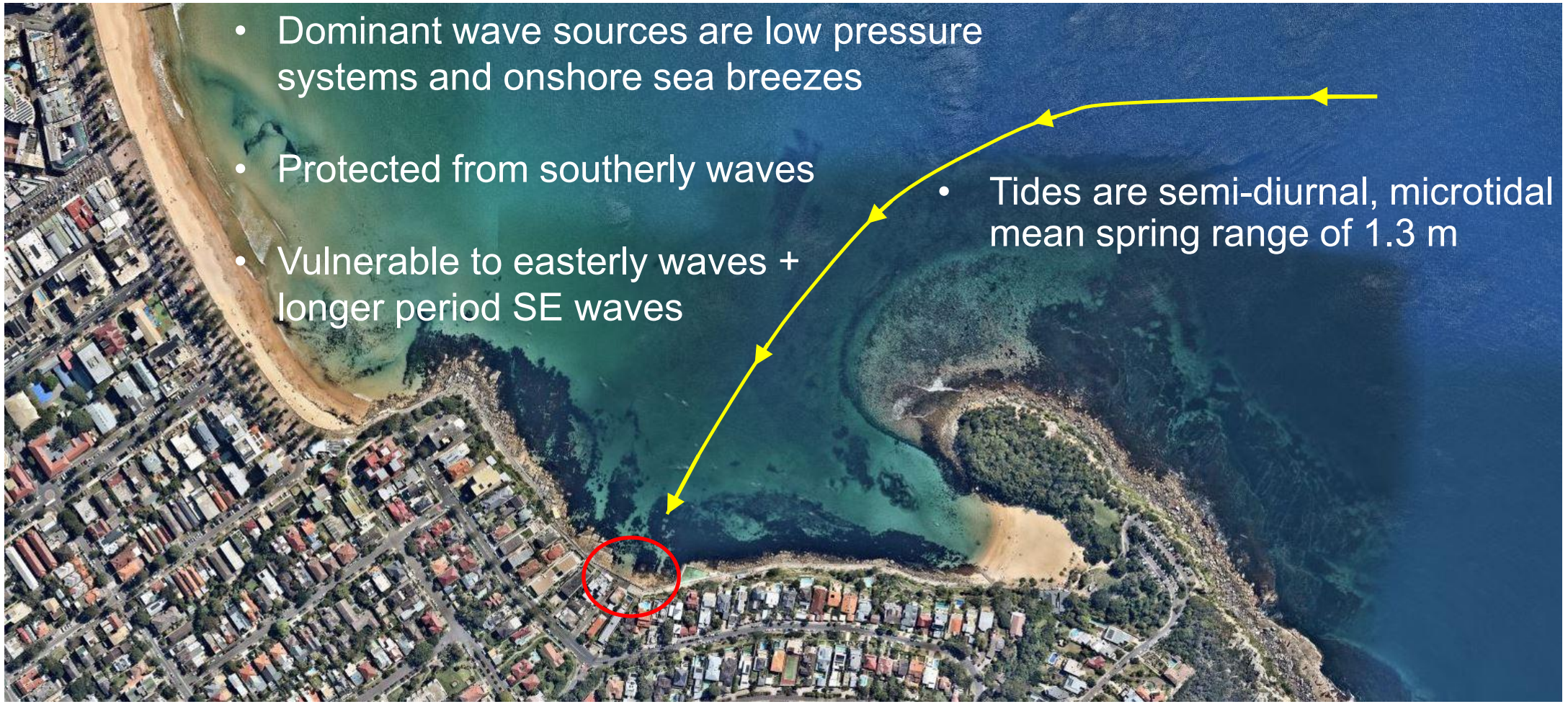
Introduction



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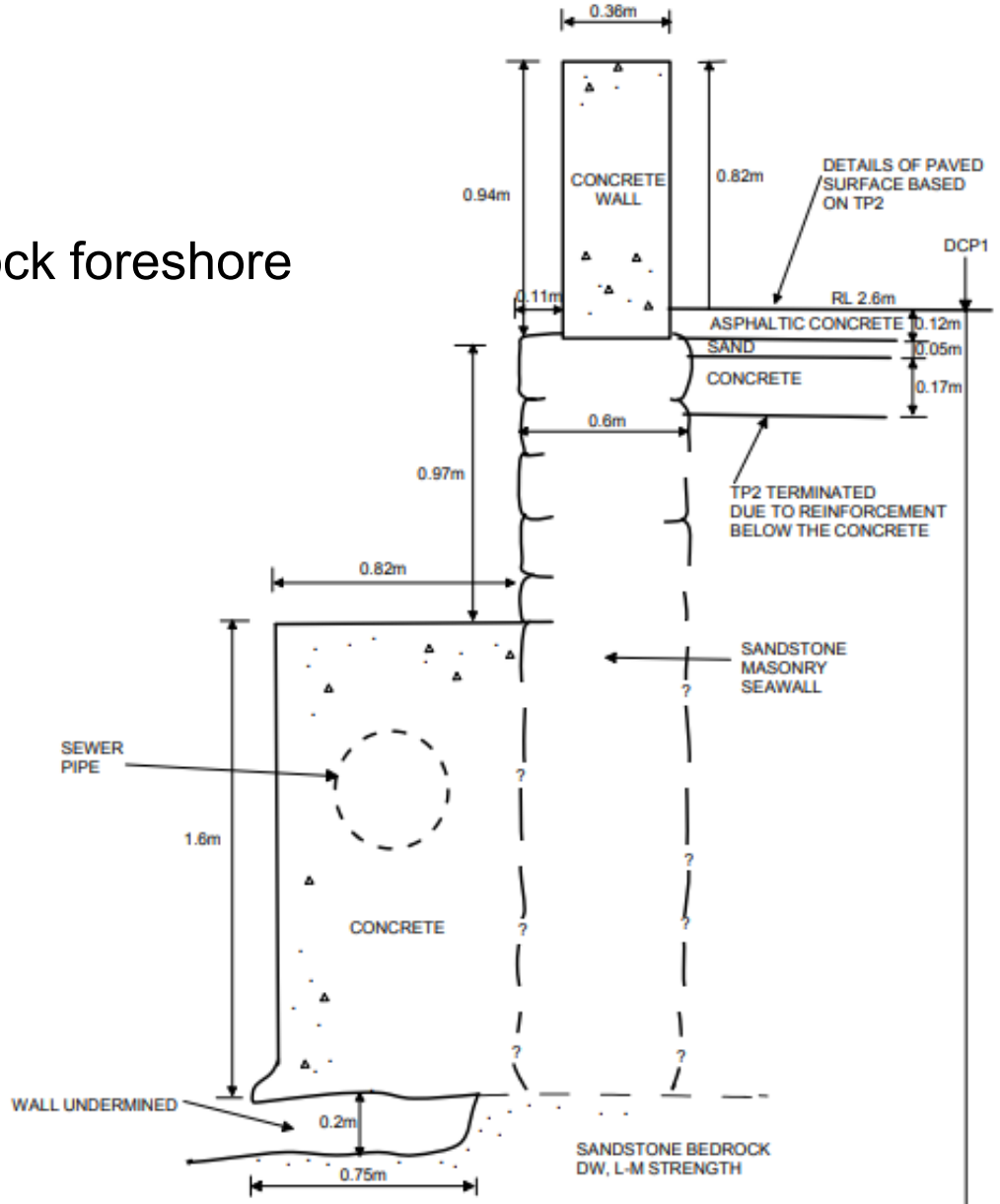
Fairy Bower Seawall
Manly
20:30 5th June 2016

20:30 5 June 2016

Background

- Considered as a vertical seawall:
  - Crest: +3.4 m MSL
  - Toe: -0.3 m MSL

- Bedrock foreshore



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Background

- Lower sandstone section below promenade was built in the late 1890s

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Background

- Lower sandstone section below promenade was built in the late 1890s
- Upper concrete parapet added after damage in June 1974 storm

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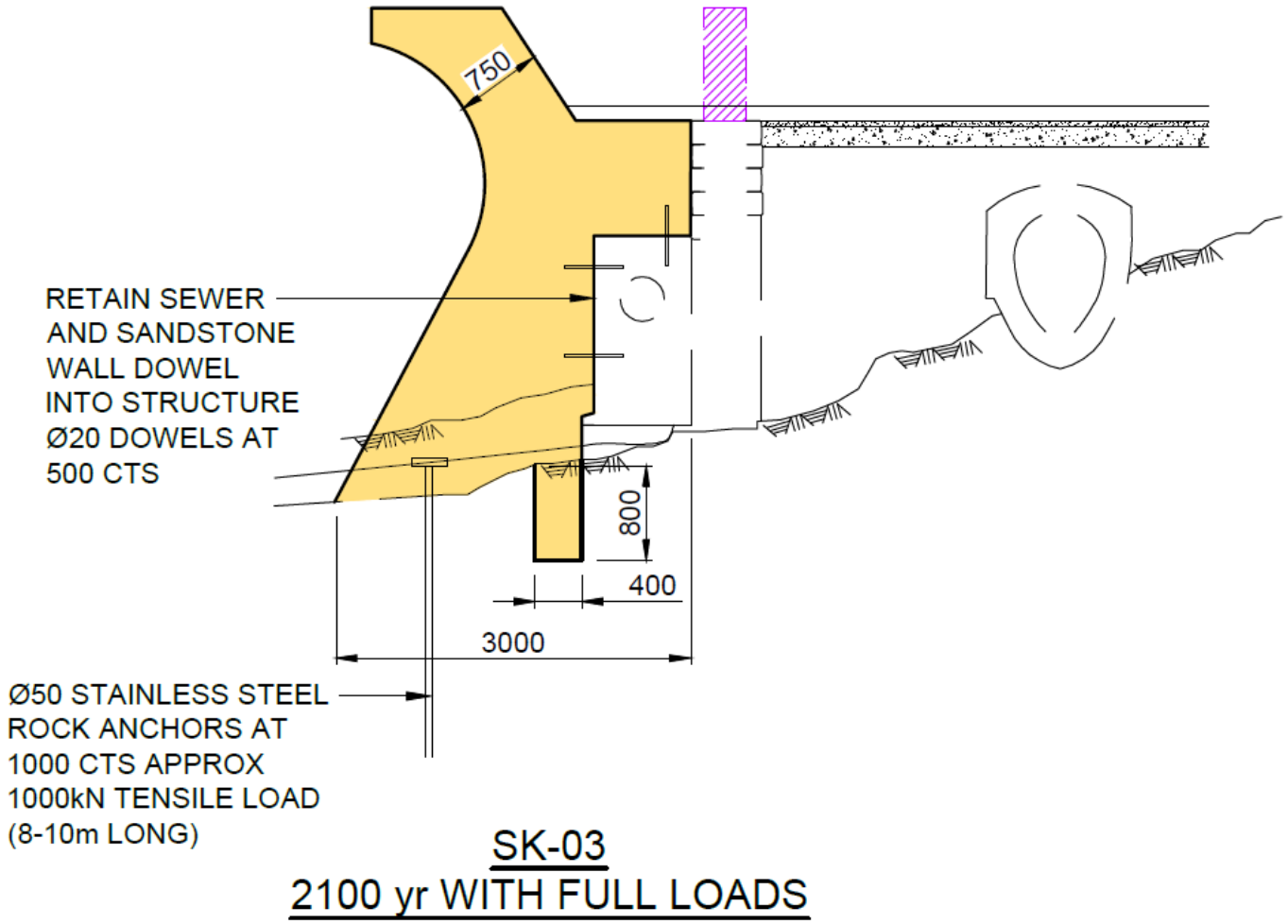
Hazard management

- Preliminary designs for a structural modification to reduce overtopping

- In the interim, during overtopping events the local council either:
  - deploys signs
  - posts staff to raise awareness, or
  - completely closes access



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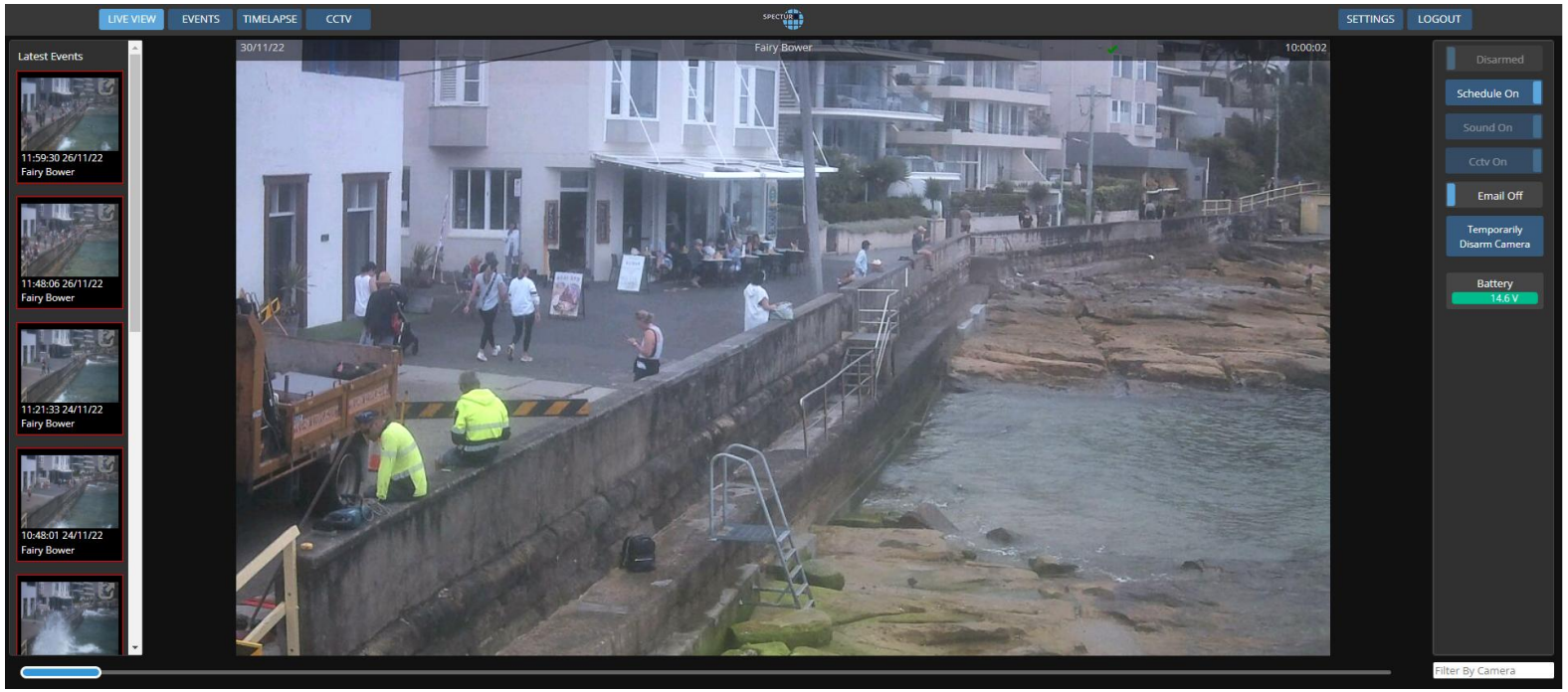
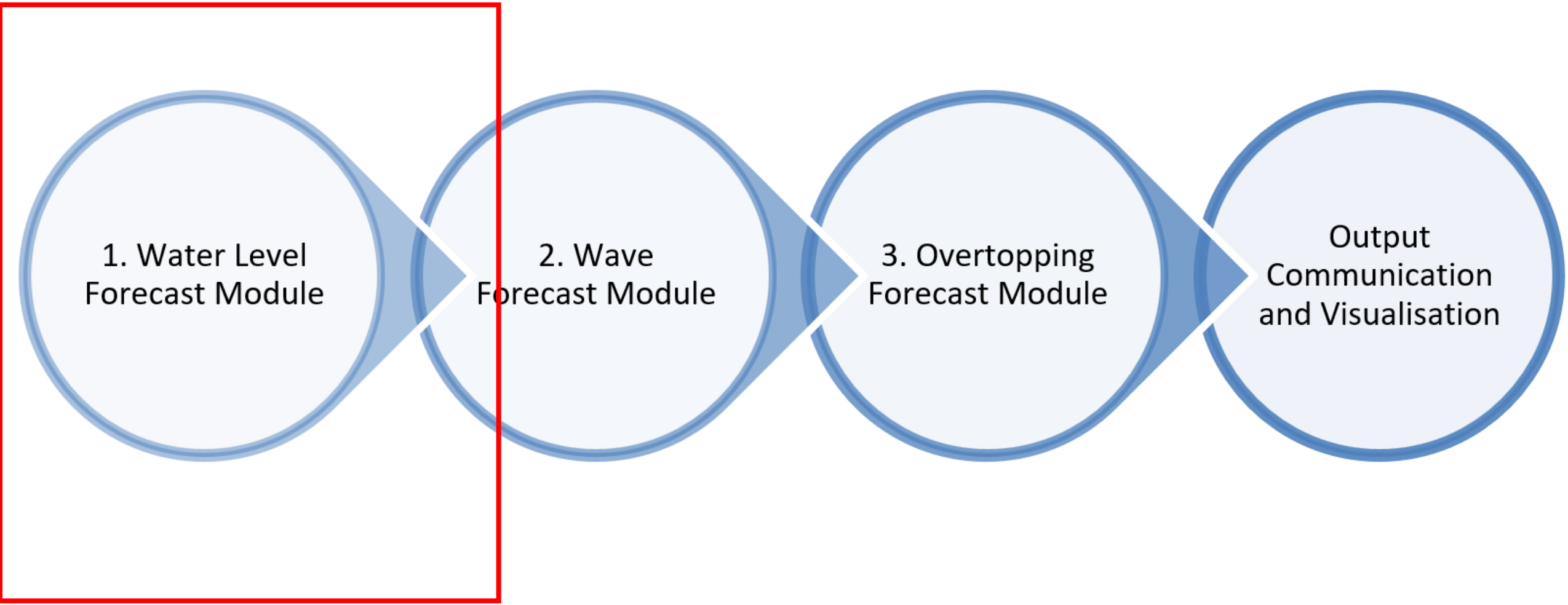
Monitoring system

- Security camera
- Solar panel (power) + battery
- Transfer by mobile SIM card
- Image every 2 seconds
- Live web view or app view + archive



Early warning system



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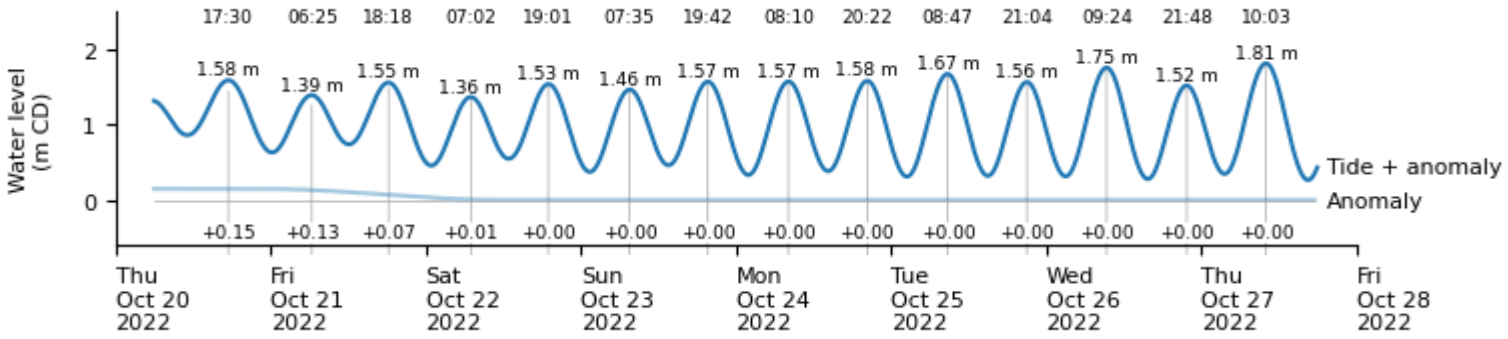
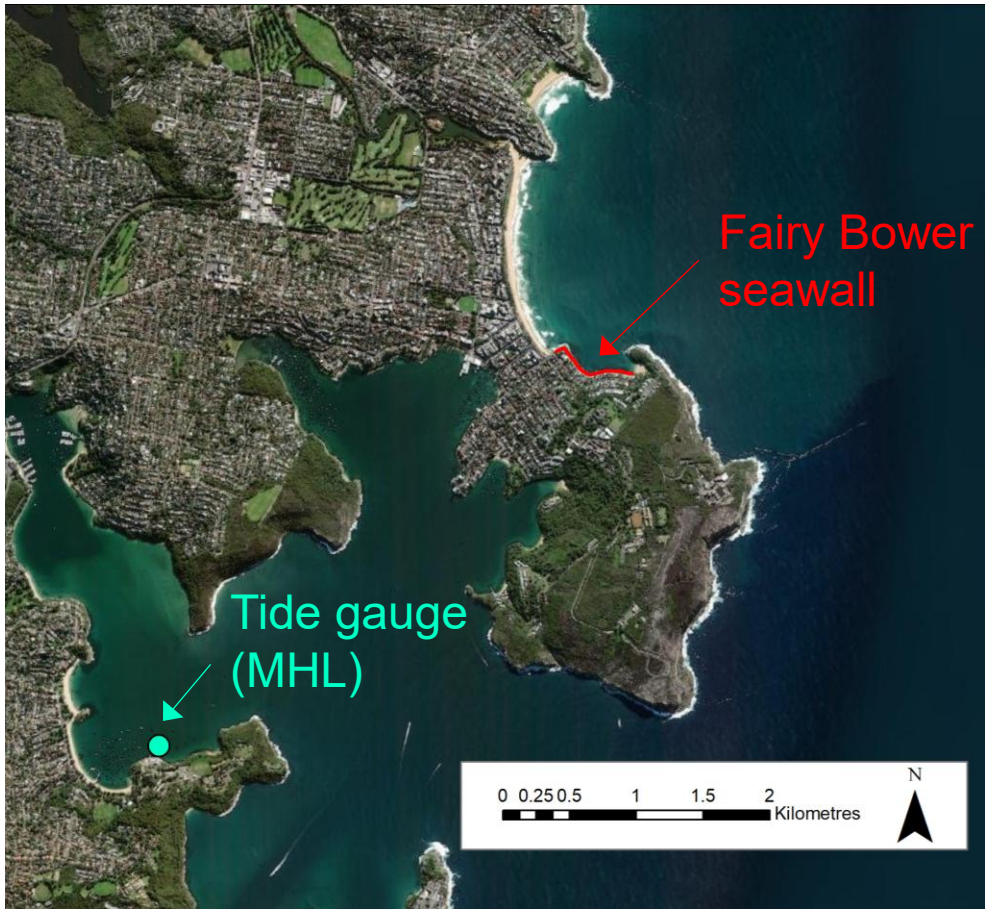
Water level forecast module

- Predicted astronomical tides combined with measured anomaly to account for:
  - inverse barometer effect
  - wind setup
  - coastally trapped waves, etc

- Since anomalies are a slow moving phenomena, tide gauge reading is applied as constant for 24 hours then tapers back to zero at 0.1 m per day





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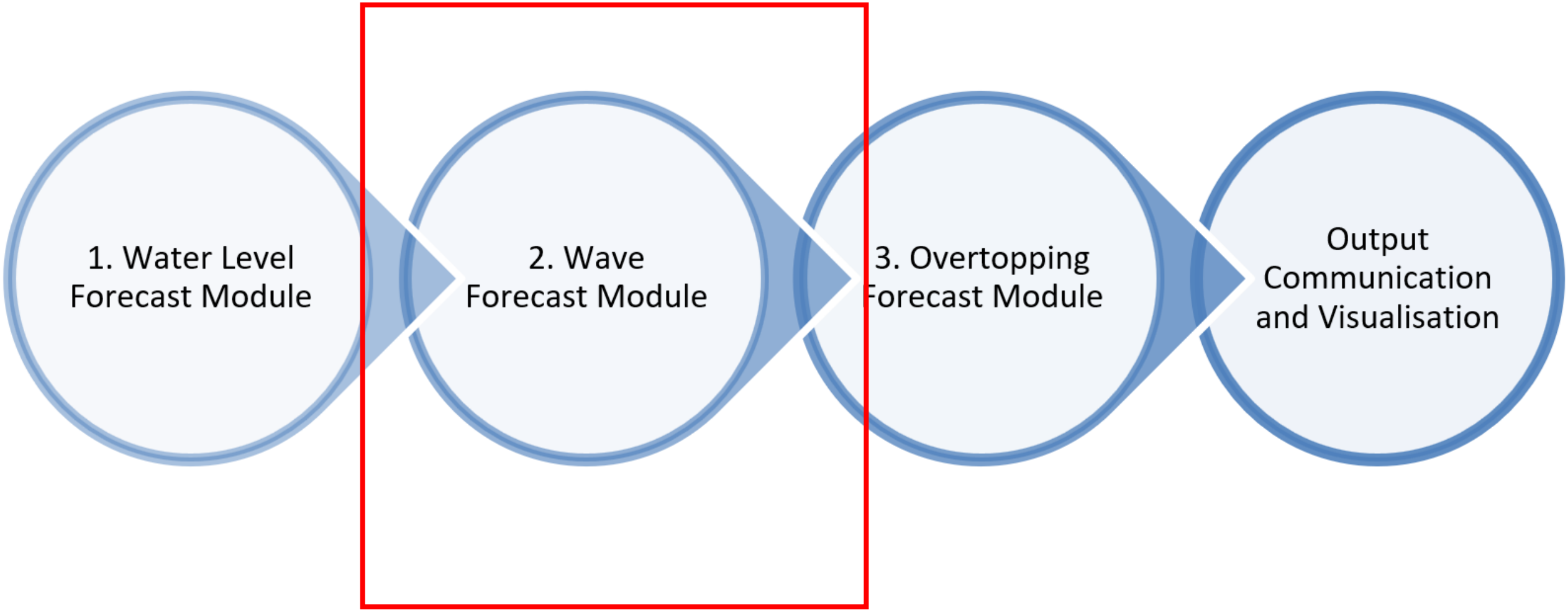

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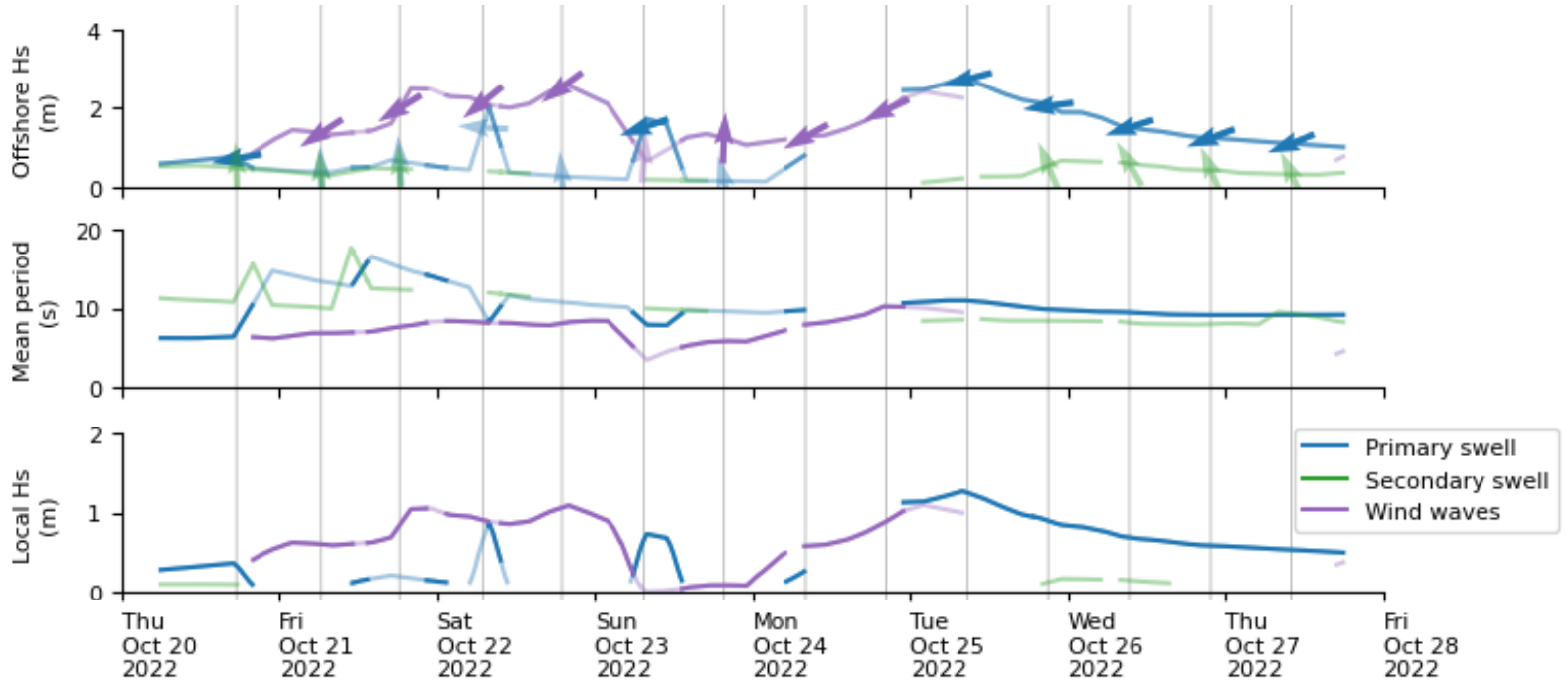
Wave forecast module

- Forecasts for offshore wave conditions obtained from the NOAA Wavewatch III global wave model
  - Primary swell
  - Secondary swell
  - Wind waves

- Wave transformation coefficients to evaluate each wave component → dominant condition at Fairy Bower



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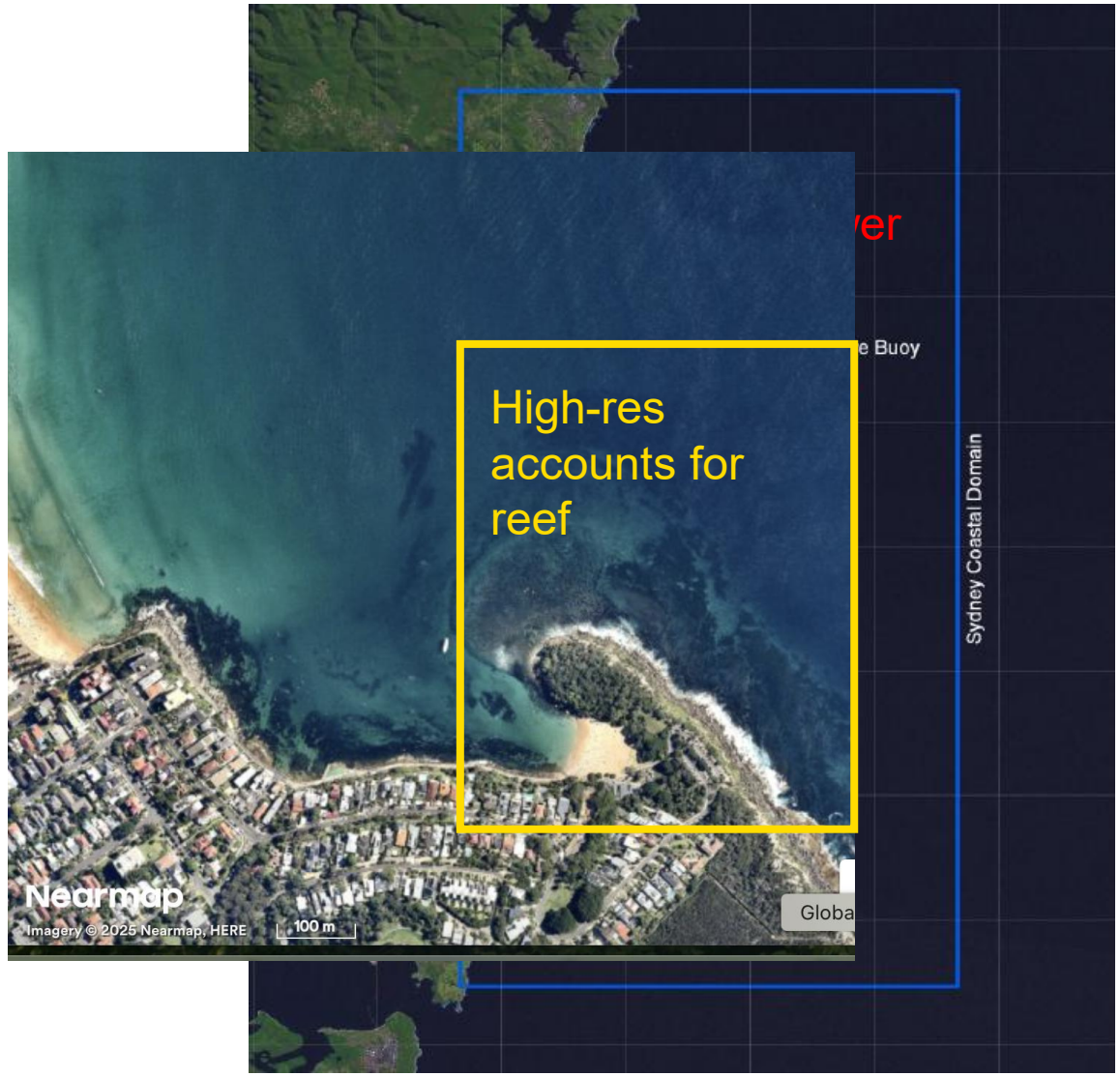
Wave forecast module

- SWAN wave model run for lookup tables between offshore wave conditions and Fairy Bower foreshore

- Original Nested grid (structured SWAN Mesh)
  - Coarse grid (100 m)
  - Nested grid (25 m)

- New higher resolution DEM and unstructured MESH



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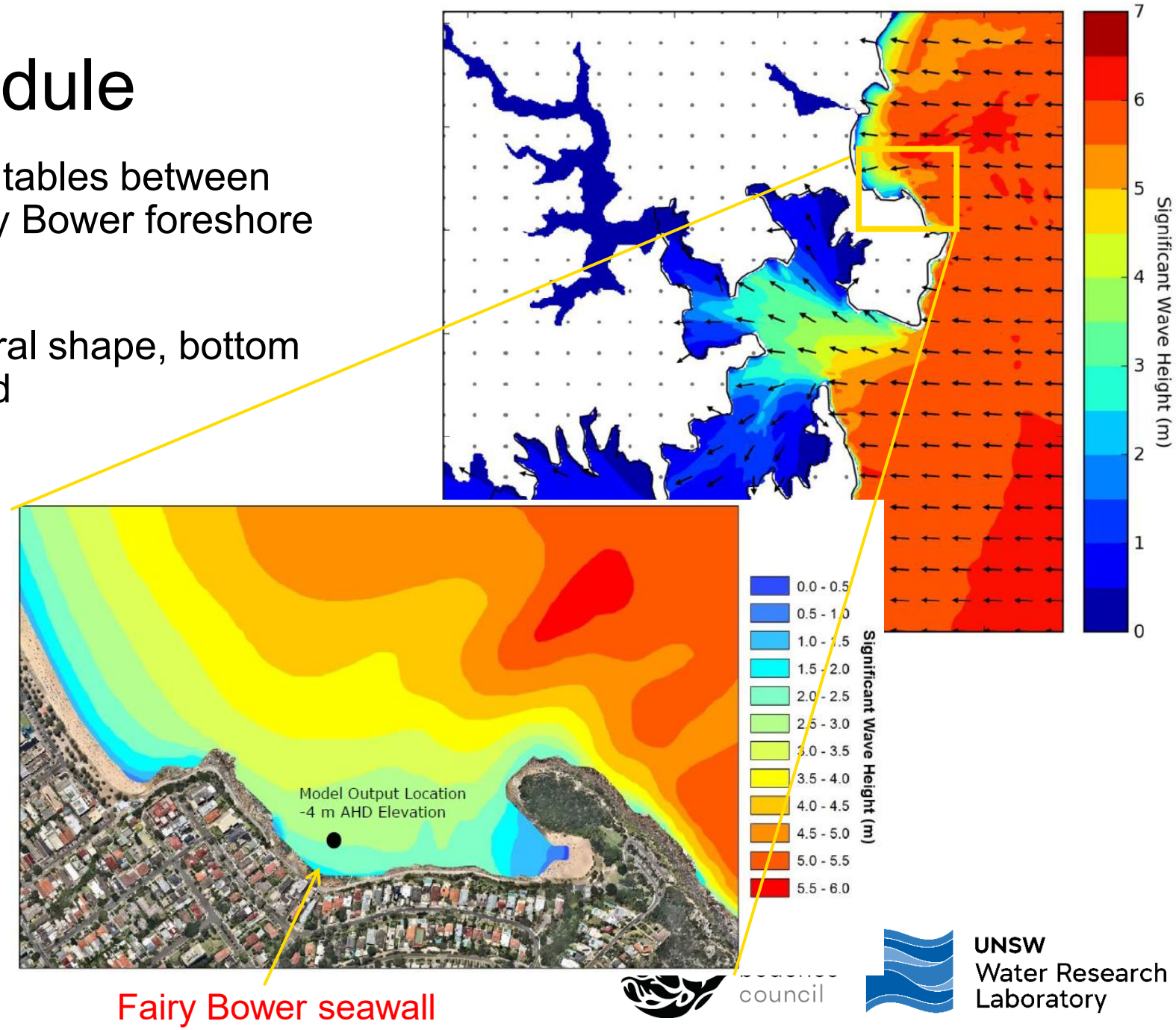
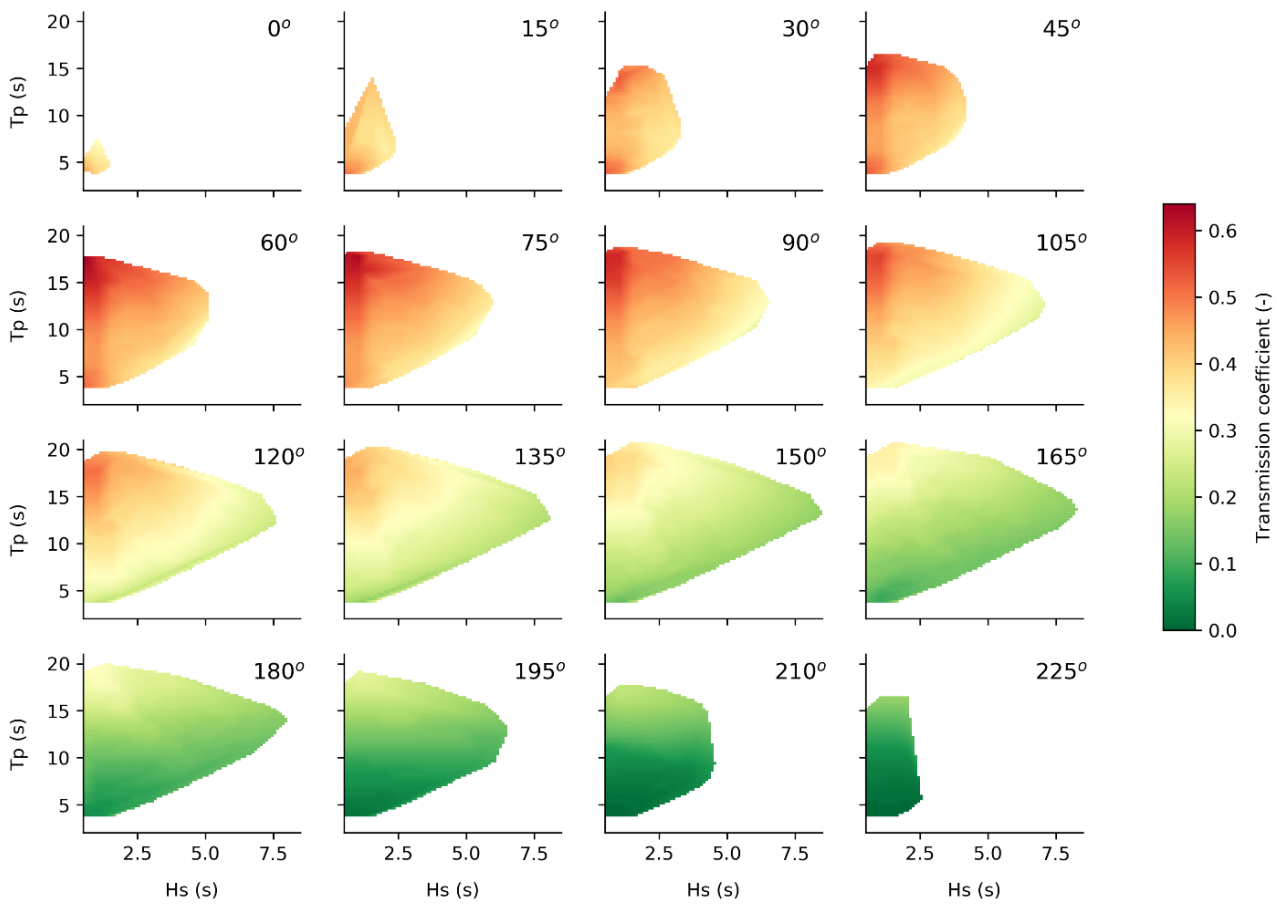
Wave forecast module

- SWAN wave model run for lookup tables between offshore wave conditions and Fairy Bower foreshore
- Water level: 0 m MSL
- Default JONSWAP settings: spectral shape, bottom friction no diffraction, H_{MAX} = 0.73 d



Wave forecast module

- SWAN model run with all unique wave height-period-direction combinations measured at Sydney buoy (1992-2017)
  - 17 Hs bins (0.5 m - 8.5 m @ 0.5 m)
  - 23 Tp bins (3.6 s - 20.7 s @ log spacing)
  - 16 direction bins (0 to 225°TN @ 15°)
- Obtained **1,753** wave transformation coefficients between Sydney wave buoy and Fairy Bower foreshore



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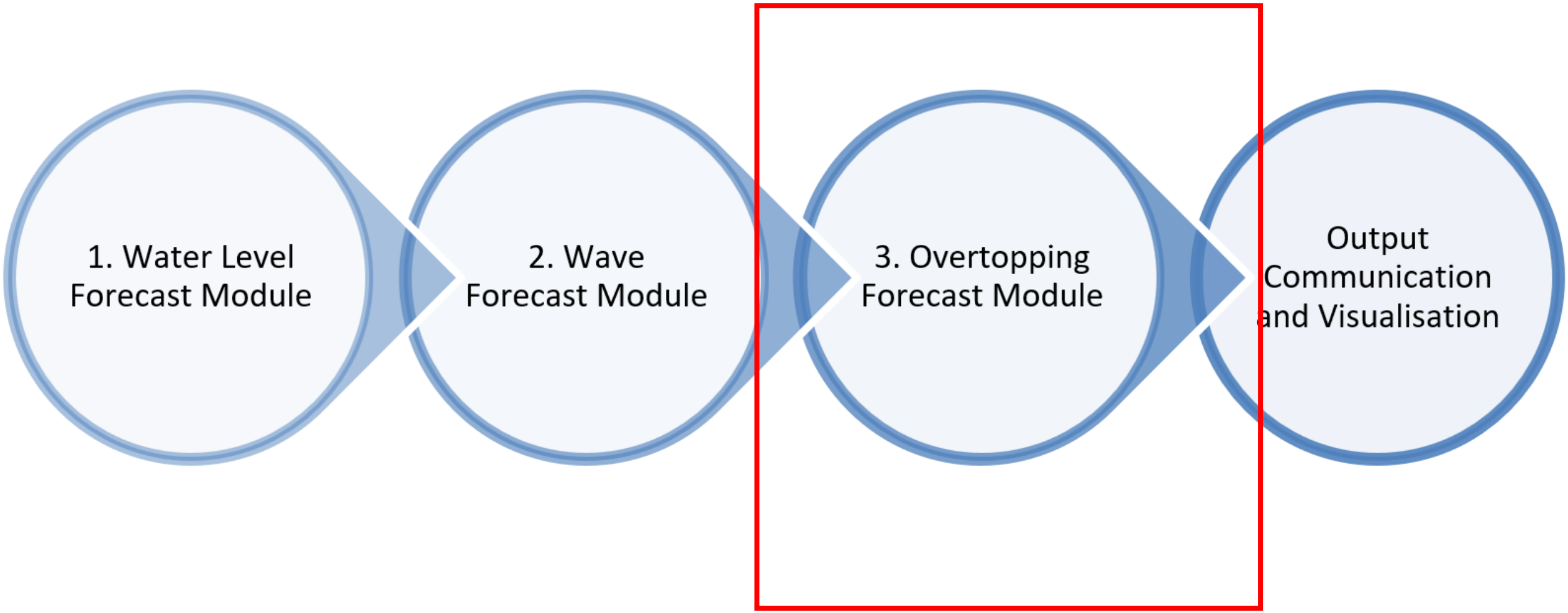
Early warning system



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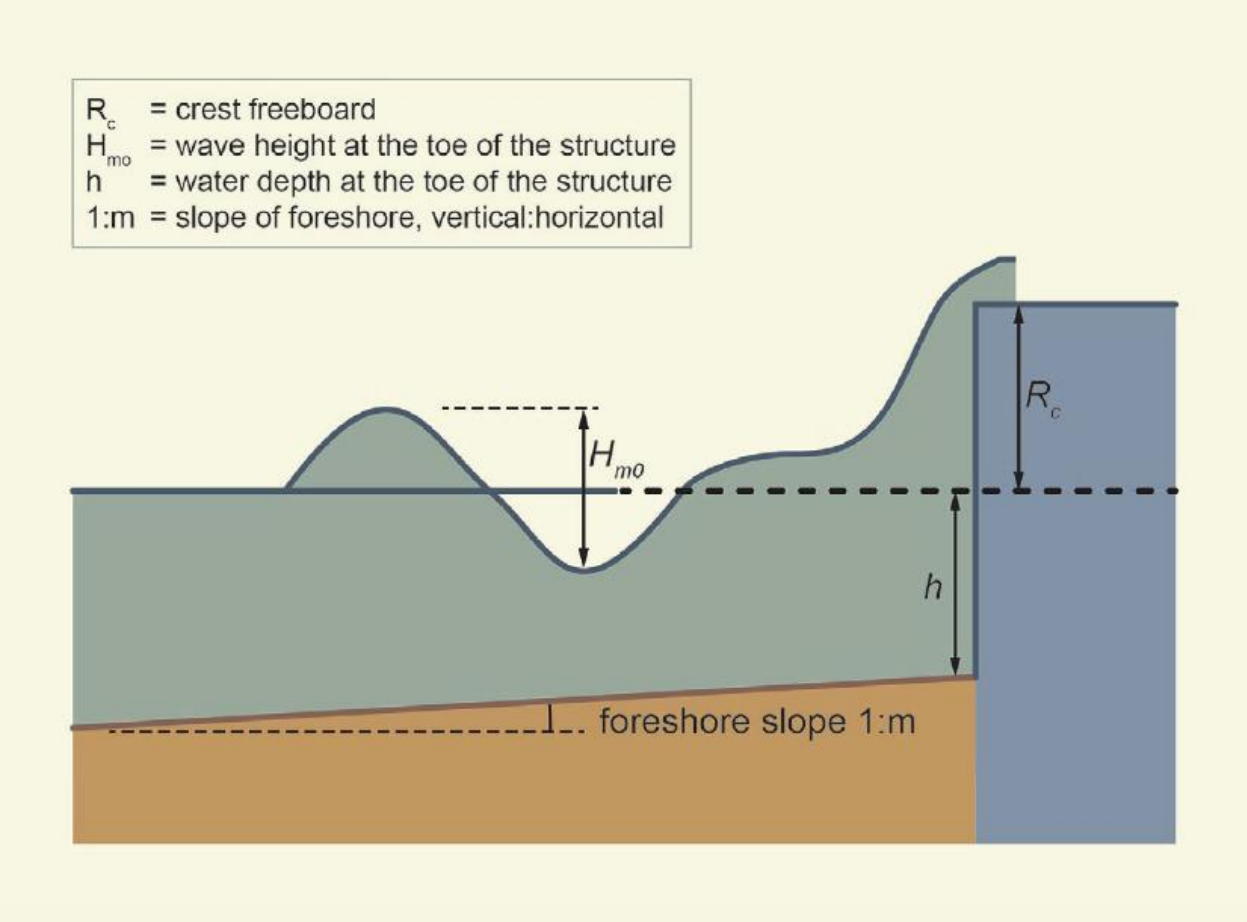
Overtopping forecast module

- Uses outputs from the water level and wave forecast modules
- Output checked to see if depth limited conditions prevail at the seawall toe
- EurOtop “mean value” formulae for plain vertical seawalls used to predict impulsive and non-impulsive wave overtopping (Eqs. 7.5, 7.7, 7.8)



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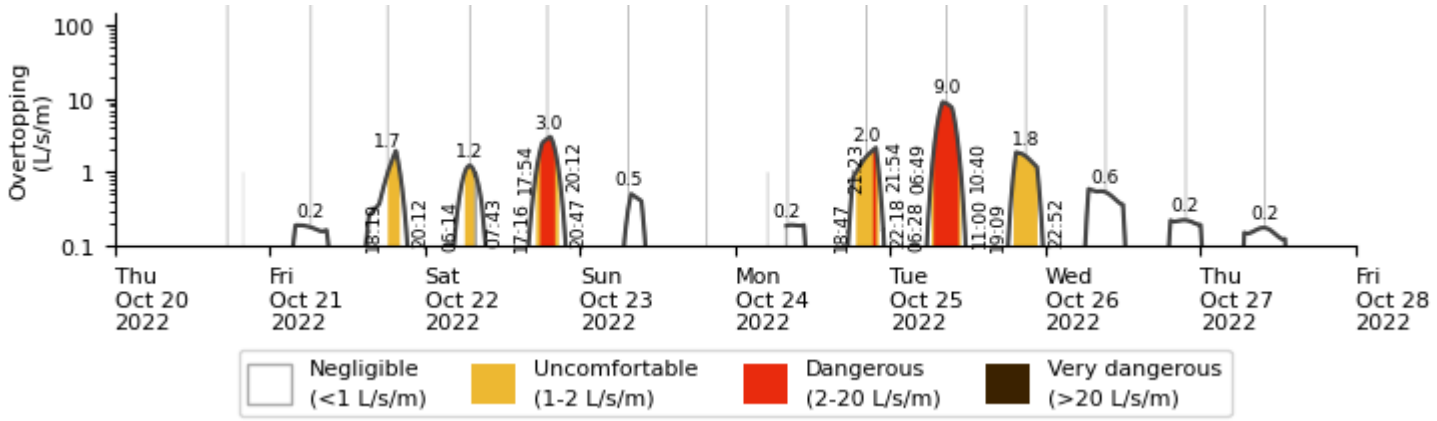
Overtopping forecast module

- The overtopping risk to pedestrians is classified by thresholds based on:
  - forecasts
  - monitoring
  - feedback from the local council

Overtopping Rate (L/s/m)	Warning code	Qualitative description of overtopping hazard
q < 1	Nil	Nil to occasional spray/splash
1 < q < 2	Yellow	Uncomfortable
2 < q <20	Red	Dangerous
q > 20	Black	Very dangerous



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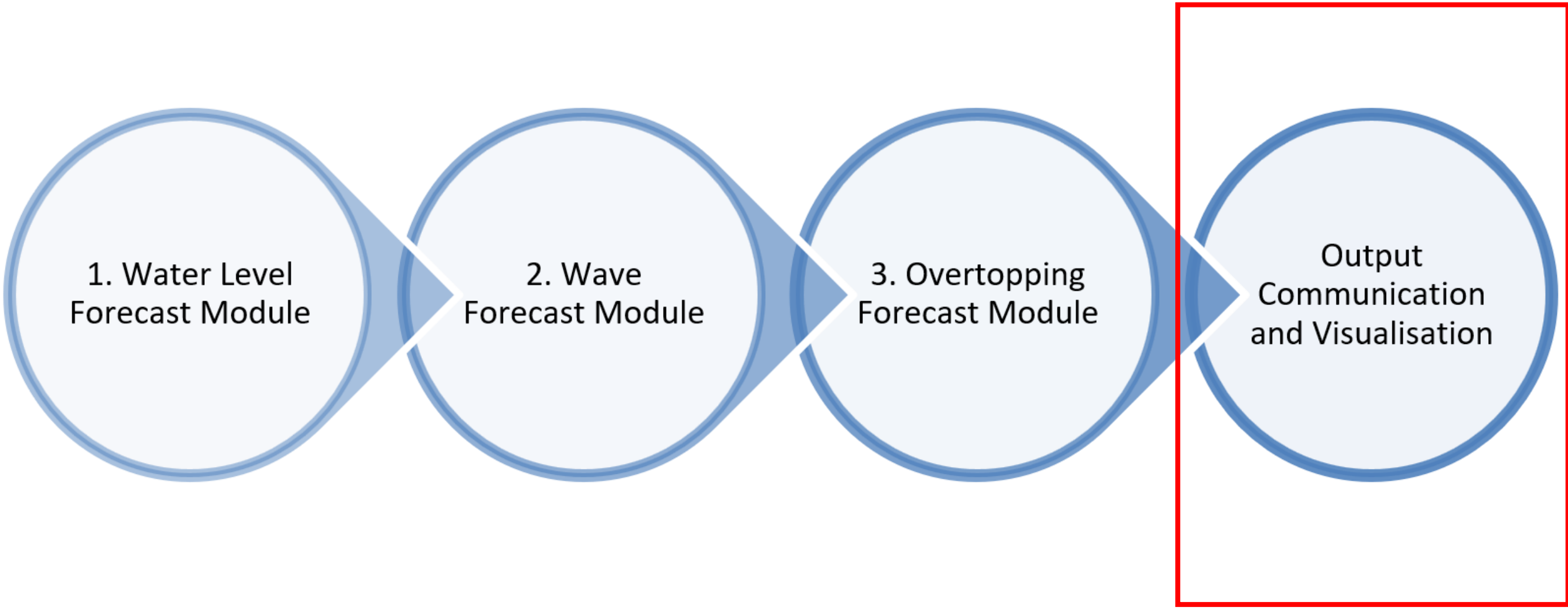
Early warning system



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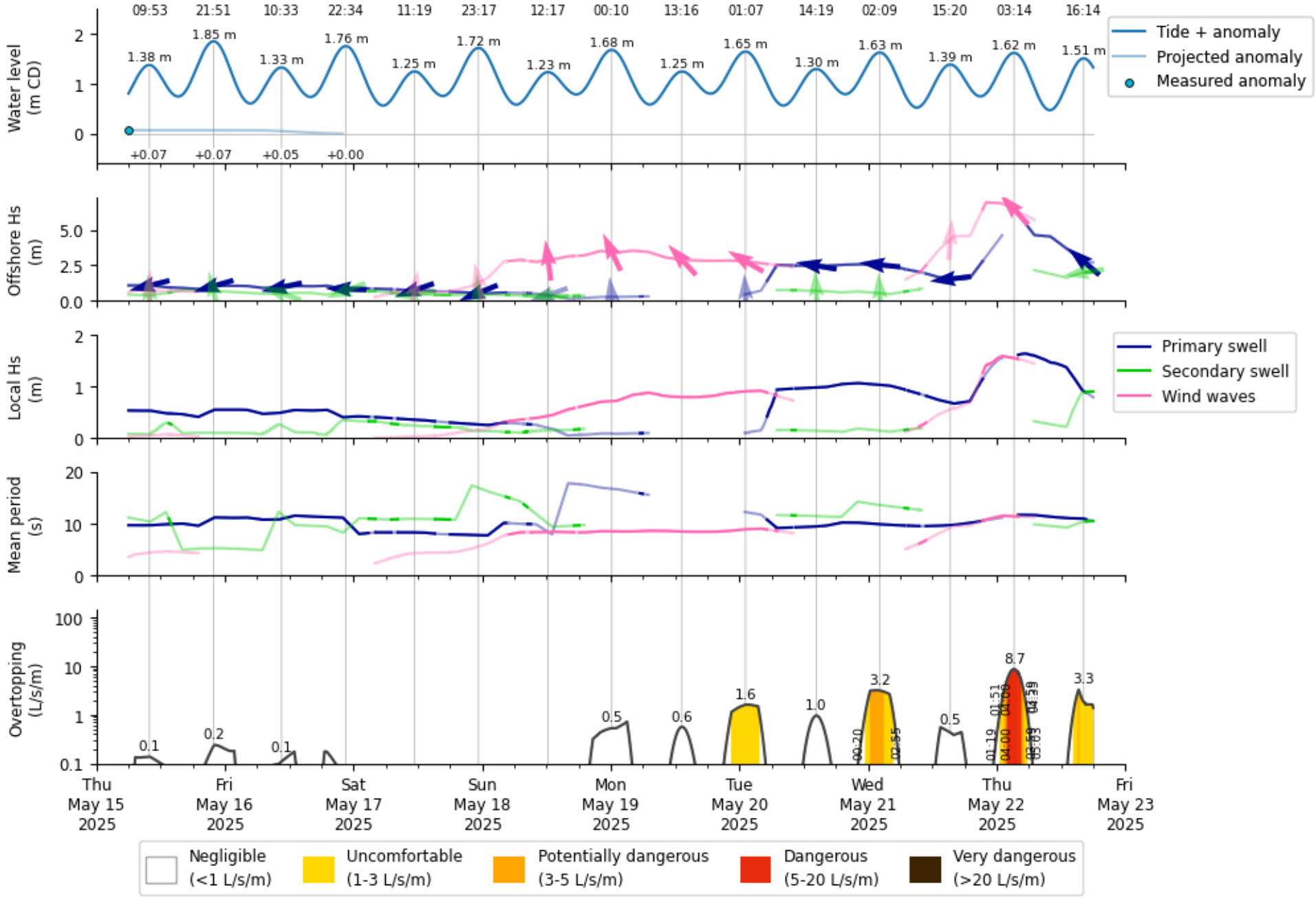
Output

- The overtopping risk to pedestrians is classified by thresholds based on:
  - forecasts
  - monitoring
  - feedback from the local council

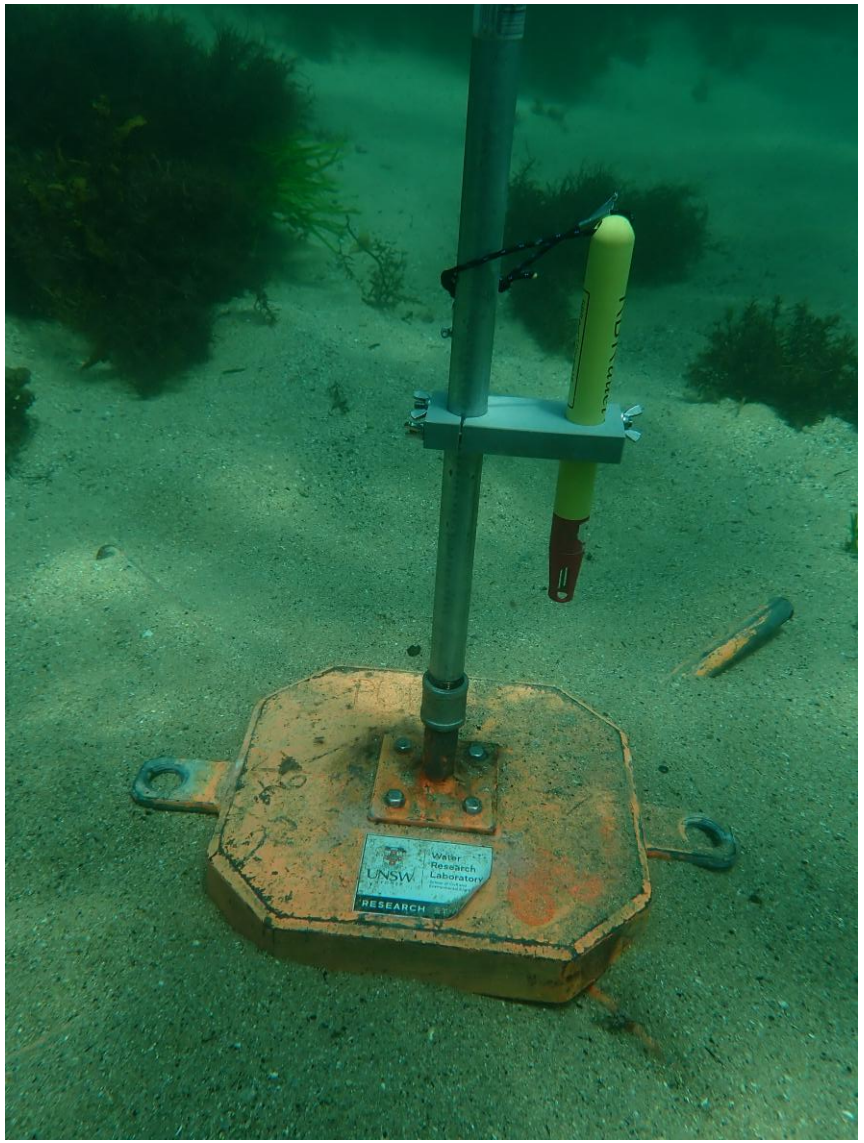
- Daily e-mail at 6 AM when overtopping is forecast within the next 7 days



Water level anomaly data is owned by the Environment and Heritage Group, NSW Department of Climate Change, Energy, the Environment, and Water, with collection and provision by Manly Hydraulics Laboratory.

EWS Validation

- To check the wave transformation coefficients, a wave gauge was deployed in December 2021



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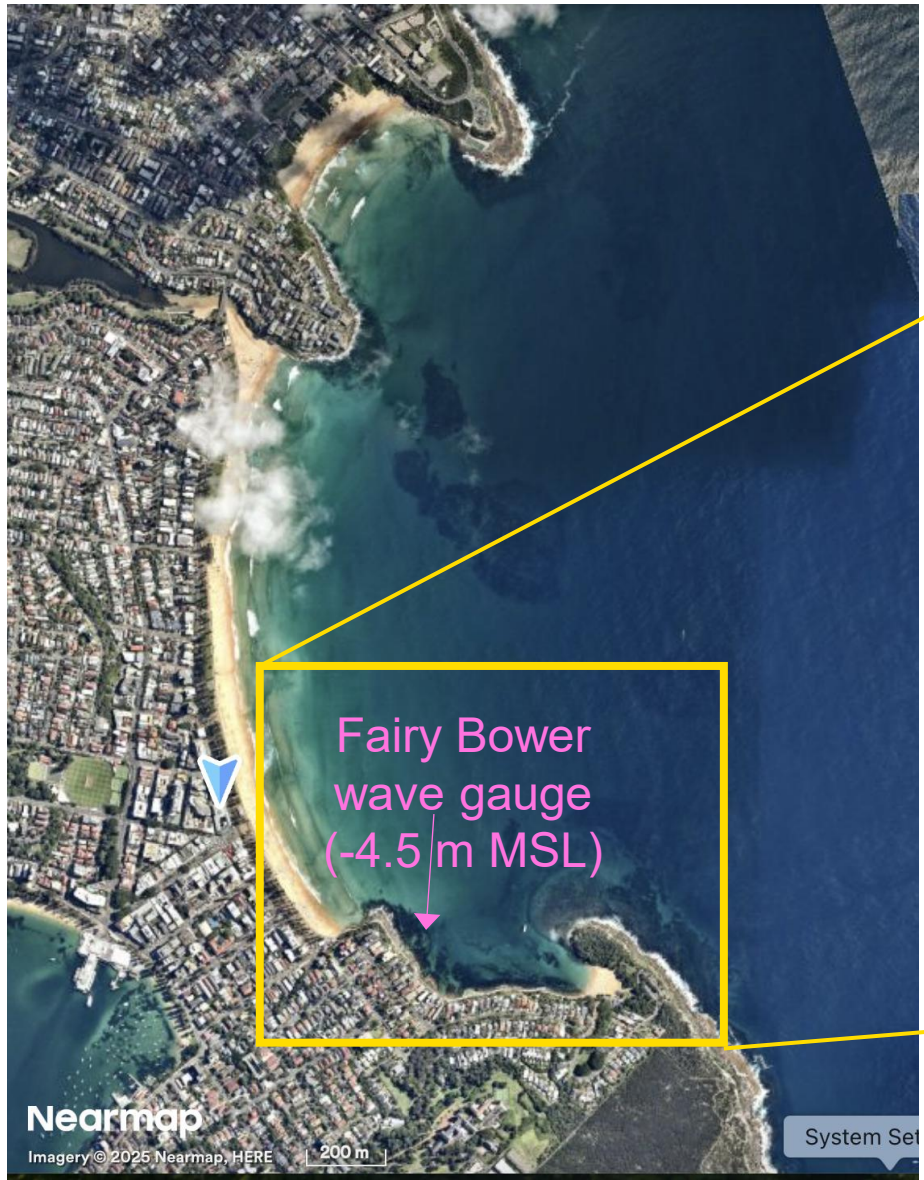
Wave measurements



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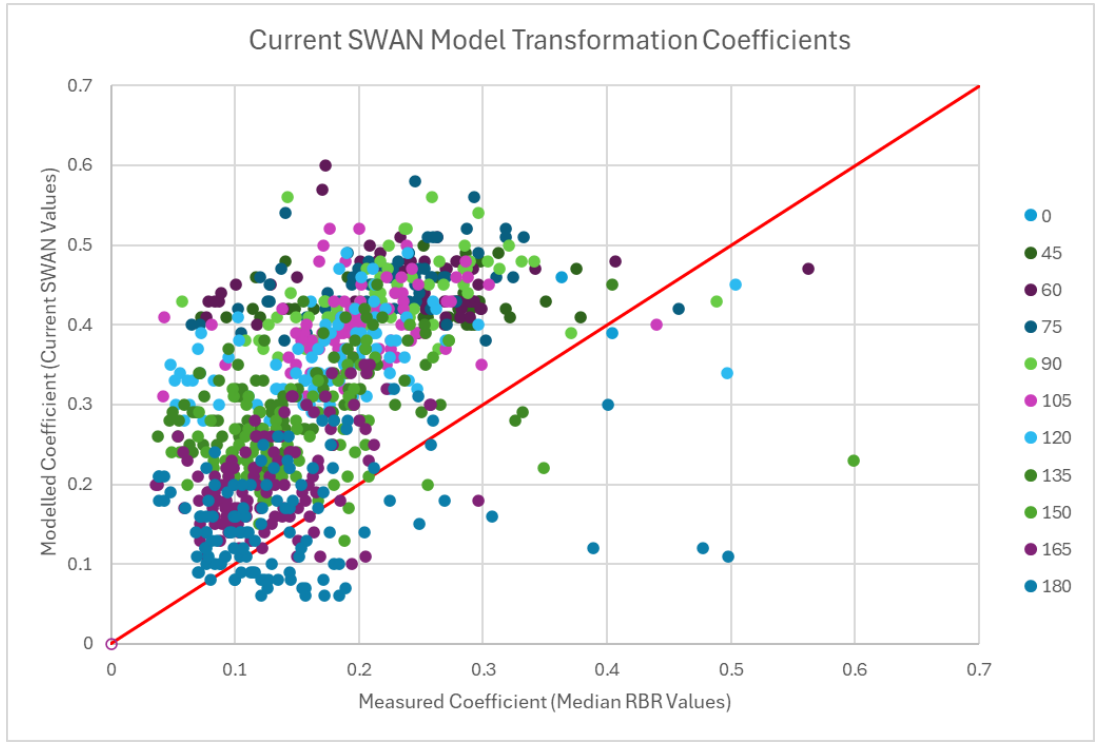
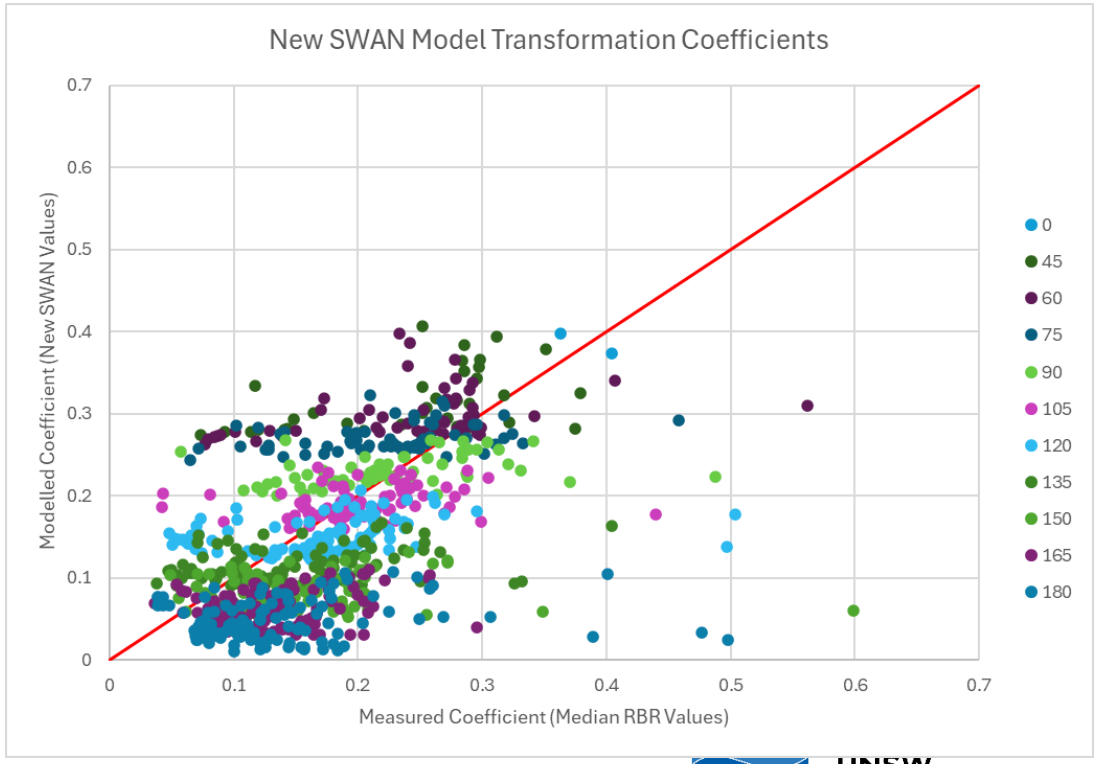
Comparison of Wave Transformation coefficients

Existing system:
Lower resolution Structured SWAN model



New research (Katie Matheson UG Thesis):
High resolution Unstructured SWAN model



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Summary and Next steps

- System has assisted the local council to manage the risk to pedestrians for ~5 years
- On-going improvements to revise wave transformation coefficients and improve over-topping estimates.
  - Account for bi-directional wave climate
  - Diffraction effects
  - Hywathy approach (Manuel Zornoza-Agueda,et al.) https://doi.org/10.1016/j.coastaleng.2025.104837

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Coastal Engineering

Volume 202, 15 December 2025, 104837

HyWaThy: Hybrid modeling of nearshore Waves with different baThymetric states

Manuel Zornoza-Aguado, Beatriz Pérez-Díaz, Laura Cagigal, Sonia Castanedo, Fernando J. Méndez

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