CASE STUDY 3:
HUNTER WATER – LAKE MACQUARIE EFFECTS-BASED STUDY MODELLING APPROACH

Hunter Water undertook an effects-based study of the impacts of sewage overflows and stormwater flows on Lake Macquarie. Ecological health risks of WWSO were modelled to be negligible compared to the impact of diffuse stormwater flows. Potential human health risks associated with WWSOs were modelled to be spatially and temporally complex. Further investigation is required to understand the source of pathogen loads.

Management approach
Effects-based

Receiving environment principles considered/met/achieved
Ecosystem, Community

Background
Hunter Water has traditionally adopted a containment strategy for the management of wet weather sewage overflows (WWSO) through a process of assessing sewage system performance followed by upgrades in areas where the largest and most frequent overflows occur. Starting in 2001, Hunter Water prepared Upgrade Management Plans (UMPs) for its sewerage systems that identified system upgrades to improve the performance of the sewerage systems in wet weather. The containment objective targets were based on perceived 'best value for money' by comparing the cost to reduce overflow frequency and volume of various modelled scenarios. Implementation of high priority elements of the UMPs has resulted in a reduction in overflow frequency and volume. However the direct benefits to the receiving environment, public health and amenity of these works have not been assessed and therefore it is uncertain if the most cost effective upgrades, for benefits gains, have been targeted.

Modelling approach
Hunter Water commenced a study of Lake Macquarie in 2012 to assess the impacts of WWSO on the receiving environment and public health risks. Initial strategic planning at the time was focused on adopting a risk-based study, whereby sewerage assets would be categorised based on the distance from sensitive receptors and the frequency and volume of overflows. Through discussions with stakeholders it was discovered that ecological modelling had already been completed of Lake Macquarie that would align with an effects-based study.
Hunter Water partnered with the NSW Department of Planning and Environment (DPE) to enhance a pre-existing ecological response model (ERM) of Lake Macquarie and develop a pathogen model. The pre-existing ERM treated all pollution sources as equal, with no consideration of the contribution of wastewater overflows versus diffuse stormwater pollution sources.

The key steps undertaken were:

- Data Collection – This involved the collation of existing data, models and a gap analysis. This led to an environmental monitoring and a WWSO event-based sampling program to collect data for the calibration of models and to ascertain the relative contribution of stormwater and sewage pollution loads to the receiving environment.
- Modelling – This consisted of developing multiple complex interconnected models as shown in Figure 1, which also shows the key data inputs required for each model.

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- Ecological Impact Assessment – The model outputs identified areas of ecological impact within the lake, with seagrass used as an indicator of ecological heath. It included quantification of the contribution of sub-catchment pollutant loads and a comparison of WWSO and stormwater contributions.
- Community Values – This identified recreational areas around the lake that have the greatest value. This was achieved through the utilisation of community surveys, mobile phone data and active recreational areas identified by Lake Macquarie City Council.
- Human health risk assessment – Mapped the results of community values in GIS and correlated it with the modelled enterococci throughout the lake to assess human health risks.

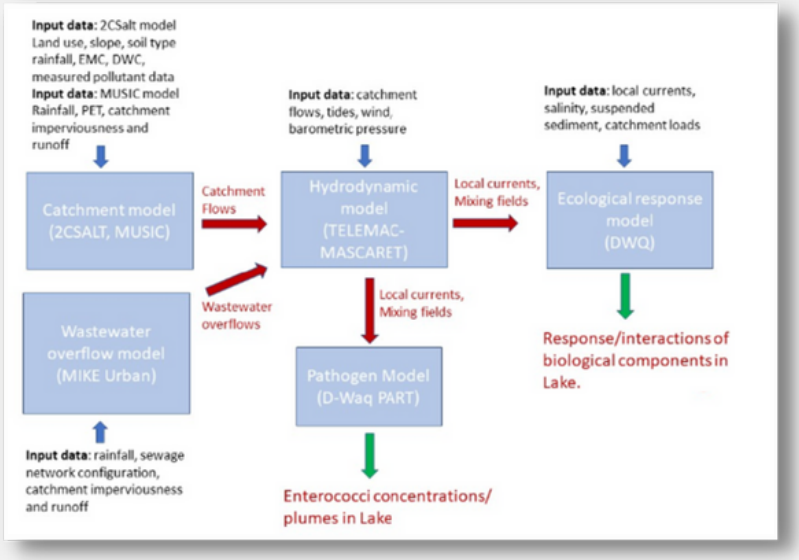
Stakeholder Involvement

This trial project was established with the support of the environmental regulator, the NSW Environment Protection Authority, as Hunter Water sought new science-based methods for understanding the impacts of WWSO.

The pre-existing water quality / ERM developed by DPE predicts the impacts of catchment inputs on water quality and flow-on effects on aquatic plants within the Lake, where seagrass is an indicator of ecological health. Utilisation of this model, originally developed on behalf of Lake Macquarie City Council (LMCC) to aid stormwater management decision making for new development, saved Hunter Water from undertaking several years of data gathering and modelling.

Hunter Water provided assistance to DPE when undertaking WWSO event-based sampling as multiple teams were required at various locations of the wastewater network. Significant collaboration went into planning the sampling program, which included a pilot study to better define the sampling effort and logistics of the final sampling campaign. The sampling program was dependent on sufficiently large rain events to trigger overflows and mobilise DPIE and Hunter Water staff. However the program occurred over a period of below average rainfall which proved problematic when sampling over a narrow timeframe and only resulted in 2 of the 3 planned sampling events taking place.

FIGURE 1
Schematic diagram of effects-based modelling (DPIE, 2021)



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Outcomes

The model outputs indicate that the ecological health risks of WWSO are negligible compared to the overwhelming impact of diffuse (stormwater) flows and their constituent nutrient and sediment loads. This can be largely attributed to the small volume of WWSO relative to the stormwater runoff volume that enters Lake Macquarie. The study also indicated that there are some potential human health risks due to wastewater overflows however these are spatially and temporally complex, requiring nuanced qualification.

- Sampling data indicates that enterococci densities provide a robust indicator of human faecal contamination in sewage and diffuse flows.
- Comparisons of Beachwatch data and model outputs suggest that enterococci densities in the lake for most of the year cannot be predicted by WWSO alone which implicates significant impacts due to a large background of pathogen loads in diffuse catchment runoff.
- Further investigation is required to determine the temporal and spatial dynamics of the pathogen profiles, and sources, of these diffuse loads in order to better assess human health risk in the lake.

Work is ongoing to relate the results of modelling to WWSO sources and prioritise a reduction in WWSO in accordance with Hunter Water's strategic objectives and risk appetite.

Costs/benefits

The traditional containment strategy approach involves undertaking sewer flow gauging and hydraulic model calibration to understand sewerage system performance. There are 4 catchments around Lake Macquarie and the cost to undertake flow gauging and build 4 calibrated models would be in excess of $1.5m.

An effects-based approach requires the addition of developing catchment, hydrodynamic, ecological response and pathogen models. The update of existing models and the development of a new pathogen model cost in the order of $600k, which is on the top of the cost of developing the original ERM. The overall financial benefits to the water authority, or the overall economic benefits to the community, through an effects-based approach have not been quantified.

Project Timing

The modelling project took 5 years to complete, which was in addition to the development of the sewer hydraulic models and the original ERM developed for LMCC. The original ERM would have taken several years to build, suggesting that the effects-based approach takes considerably more time to develop when compared to a containment approach.

A repeat of this study with no prior data or models could potentially be undertaken in 4 years if it was highly focused with parallel model development and favourable event-based data collection. In comparison sewer hydraulic models used for a containment approach can be built within 18 months, at considerably less cost and less onerous requirements for event-based data collection.

References

- NSW DPIE, 2021; Effects-based assessment of wastewater overflows in the Lake Macquarie catchment
- NSW OEH, 2016; Conceptual Model of the Lake Macquarie Ecosystem
- NSW OEH, 2016; Lake Macquarie Effects Based Assessment – Modelling Approach Report
- Rutledge F, Silk J, Ferguson A, Floyd J, Wright A, Adams M, 2018; Effects based assessment framework for management of wet weather sewer overflows.