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Consolidating Flow-MER Modelling Tools and Metadata for National Environmental Reporting

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Abstract: We describe recent efforts to consolidate and standardise modelling tools used across the Flow-Monitoring, Evaluation and Research (Flow-MER) program to support basin-scale environmental water management. This work involves code harvesting, tagging, and metadata alignment across CSIRO contributions, with the goal of improving interoperability and discoverability. Our approach enables transparent reporting, integration of diverse models, and easier re-use across catchments and partner organisations. We report on technical strategies, challenges, and emerging benefits of this consolidation effort. The Flow-MER program brings together science and environmental water management to evaluate the outcomes of Commonwealth environmental watering in the Murray-Darling Basin. A key challenge is consolidating diverse modelling tools and outputs into a coherent reporting and operational framework. To address this, CSIRO is leading an initiative to create a consolidated repository of modelling assets enriched with metadata standards. As a case study, we describe the Water Actions Table (WAT) reporting workflow, which illustrates how heterogeneous data and reports can be transformed into consistent, reproducible outputs. Our architecture links data, models, and reports across programs and contributors, improving transparency, supporting reproducibility, and helping to ensure that modelling science is rapidly translated into policy-relevant insights.

Keywords: *Environmental flows, digital architecture, data architecture, workflow optimisation*

1. INTRODUCTION

Flow-MER is Australia's primary investment in long-term monitoring, evaluation, and research to support environmental water delivery (the managed delivery of water into rivers, wetlands, and floodplains to support ecological health) in the Murray-Darling Basin. It brings together multiple research institutions, each contributing models, data, and tools tailored to specific ecological *themes* such as waterbirds, hydrology, vegetation, and fish. These contributions provide the evidence base for adaptive management of Commonwealth environmental water, supporting both regional insights and Basin-scale synthesis (Cuddy et al., 2024).

Despite its breadth, Flow-MER faces challenges of fragmentation. Models, code and outputs are often developed in silos, making them difficult to share or reuse across catchments. Inconsistent documentation and metadata reduce transparency, reproducibility and opportunities for integration into broader assessments. Overcoming these barriers is crucial for building trust in modelling results and ensuring their value for decision-making.

To address this, CSIRO is leading a program-wide effort to consolidate code and metadata and minimise manual processes. The aim is to standardise how modelling tools are tagged, versioned, and integrated so that they can be reused across projects and incorporated into reporting frameworks such as the Water Actions Table (WAT) and Synthesis Reports. A core component of this program is the Flow-MER Data Portal, which provides a central point for sharing, accessing, and visualising program data across partners and stakeholders. This approach aligns with the FAIR data principles (Wilkinson et al., 2016) and strengthens the link from models through to reporting.

2. METHODOLOGY

Our methodology is structured around consolidating code and metadata from Flow-MER contributors into a standardised, reusable architecture (Figure 1). The process begins with code harvesting, where modelling tools relevant to Flow-MER are identified and extracted from internal and project GitHub repositories. To support discoverability and long-term maintenance, we developed tagging conventions and metadata standards in collaboration with program leads. These metadata fields include descriptors such as model type, ecological theme, spatial and temporal scale, required inputs, and generated outputs. By applying consistent tagging and versioning, models can be integrated across catchments while preserving attribution and provenance.

The second component involves integration with reporting workflows and the Flow-MER Data Portal. Tagged and standardised models are linked directly to program outputs, such as the WAT and Synthesis Reports. This is achieved through a combination of GitHub strategies (repository structure, issue tracking, release tagging),

automated scripts for metadata extraction, and APIs for connecting outputs to visual dashboards and to the Flow-MER Data Portal. The portal provides the access and delivery layer, enabling partners and stakeholders to explore, share, and reuse program outputs. To ensure accuracy and reusability, contributors collaborate in providing metadata and validating linkages. The result is a transparent, reproducible architecture that enables both automated reporting and traceable connections from models to decision-support products.

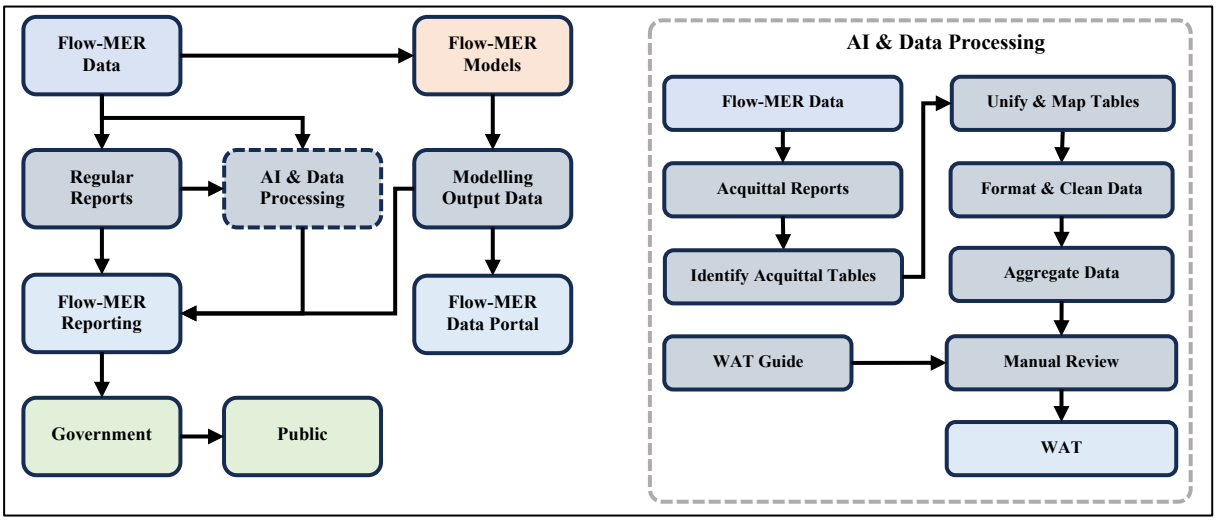

Figure 1 High-level architecture for Flow-MER (left), and the AI-assisted workflow for generating WAT (right). The architecture includes code management processes that feed into reporting pipelines and the Flow-MER Data Portal, which provides the access and delivery layer for sharing outputs with partners and stakeholders.

3. USE CASE: WAT

The Water Actions Table (WAT) provides a practical demonstration of how the consolidated architecture supports reporting. Flow-MER data and acquittal reports are ingested into the AI-assisted workflow (Figure 1, right). This process begins by extracting acquittal tables from heterogeneous report formats, which are then unified and mapped into a consistent schema. The mapped tables allow data to be extracted, aggregated, and validated against the WAT Guide to ensure alignment with program reporting requirements. Automated steps reduce manual handling of data, while a final manual review stage preserves quality assurance and enables expert interpretation of ambiguous cases. The resulting WAT reports deliver standardised, reproducible outputs that can be linked transparently back to underlying data and models. This workflow illustrates how the broader Flow-MER architecture can be operationalised to improve both efficiency and traceability in environmental reporting.

4. CONCLUSION

This work demonstrates how consolidating code, metadata, and reporting workflows within Flow-MER can reduce fragmentation and strengthen the link between modelling tools and decision-making. By applying consistent standards and integrating models with program outputs such as the WAT, we provide a reproducible pathway from code to reporting. Future work will expand this approach across additional reporting frameworks and develop more automated pipelines, further improving transparency, efficiency, and reusability of modelling assets at Basin scale.

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