When one model just isn't enough

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Key Points

- Catchment and water resource modelling are typically separate and rarely 'talk' to each other.
- These two platforms were combined for a project for the ACT Government.
- The benefits, such as improved flow calibration, far outweighed the limitations.
- Future applications could include land use change and climate change impacts.

Abstract

Catchment and water resource modelling are important tools for understanding current and future catchment processes, water requirements and assessing the effectiveness of management activities. Generally, however, the two platforms are developed separately and rarely 'talk' to each other. The requirements of the ACT Government to improve their understanding of water quality, land use change, water resources and basin plan requirements within key ACT sub catchments as well as the wider Upper Murrumbidgee, was best answered through a combination of catchment and water resource modelling (Source platform). The development of both models in conjunction with each other allowed for benefits of each modelling platform to be incorporated into the other. For example, flow routing calibrated in Source Rivers was applied to the Source catchments model to further improve flow calibration, and vice versa, the rainfall runoff parameters calibrated within Source catchments were used to infill gaps in the streamflow gauge record used as input into water resource model. This paper describes the benefits, limitations and potential future applications of combining catchment and water resource modelling.

Keywords

Catchment modelling, water resource modelling, eWater Source, integrated models, flow calibration

Introduction

Alluvium Consulting Australia was engaged by the ACT Government to build a water quality and water resources model of the ACT and wider Upper Murrumbidgee catchment in the eWater Source platform. The models were developed to support planning of water quality initiatives as part of the ACT Healthy Waterways strategy and to meet requirements of the Basin Plan. The two models combined were conceptualized to represent:

- The rainfall runoff and diffuse water quality of each ACT water management area and the wider upper Murrumbidgee catchment
- Extractions and transfers for ACT water supply by Icon Water
- Extractions by other licenced water users
- Returns to the river from the Lower Molonglo Water Quality Control Centre and the Queanbeyan Sewage Treatment Plant

The development of both the catchment and water resource model in conjunction with each other, allowed for benefits from each modelling platform to be incorporated into the other. Construction of a Source catchment model requires transforming the physical catchment information into a mathematical form that is used to convert rainfall to runoff and simulate hydrologic processes within a catchment. The outcome is a numerical representation of the physical features that represent the land-based framework, hydrological processes and pollutant load generation aspects of the catchment. Similarly, Source Rivers (water resource model) require transforming the operational processes of the water resources within and between catchments.

Benefits of combining catchment and water resource models

Combining aspects of the Source catchment and rivers platforms allowed for an integrated approach to representing the physical and operational processes occurring within a catchment. A standout benefit of developing the models together was in the flow calibration stage. Benefits over the project included:

- Flow routing (representing flow lag and attenuation) calibrated in the water resource model were applied to the catchment model to further improve the flow calibration
- Rainfall runoff calibrations from the catchment model were applied to water resource model and used to infill gaps and extend the observed streamflow gauge data (Figure 1)
- Integrated scenarios: the combined models were used to simulate pre-development, current and future development. If the landscape changed (i.e. no urban or agricultural land use in pre-development), the catchment inflows applied to the water resource model were able to be updated easily
- Consistency between models (including datasets – refer to Table 1)

Datasets required for the two modelling platforms are relatively consistent, however some differences do exist. Comparison of datasets used in the Upper Murrumbidgee model is provided in Table 1.

Table 1. Comparison of key datasets required in the ACT/Upper Murrumbidgee catchment and water resource models. * SRTM – Shuttle Radar Topography Mission. ** ALUM – Australian Land Use Mapping

Data type	Catchment model requirements	Water resource model requirements	Dataset used	Application for Upper Murrumbidgee
Climate	Gridded or point data - timeseries		SILO gridded (0.05° daily rainfall and MWET) Point data from BoM Water Data Online, ACT and NSW government	Catchment model – 1980 to 2017 Water Resource model – 1890 to 2017 Gridded dataset used to calculate average rainfall and evaporation across sub-catchments, point data for specific storages and lakes
Streamflow	Gauged flow data - timeseries		ACT and NSW streamflow gauges	Consistent across models
Topography	Digital elevation model and stream networks to delineate catchments		Combination of 1-10m LiDAR provided by ACT/NSW Government and SRTM* (30m) in gaps	Catchment model – 440 sub-catchments Water Resource model - 42 sub-catchments (Water resource model aggregated the delineated catchments from the catchment model to major gauging locations consistent with existing Water Management Area, and previous IQQM and REALM water resource models)
Land Use (existing and future development)	Spatial land use data (ALUM** classification preferred)	Not specifically required	ACT and NSW Government land use mapping (ALUM classification)	Catchment model – land use mapped to 16 functional units including vegetation, agriculture, rural residential and urban sub classes. 4 functional units developed for future urban areas.
Water storage and lakes	Location, surface area and volume, full supply level, discharge rating curve, observed discharge volume/rate and observed water quality	Location, surface area and volume, full supply level, discharge rating curve, observed discharge volume/rate	Spatial, discharge and water quality data provided by ACT/NSW governments and ICON water	Combination of observed discharge and modelled discharges (provided by ICON water) incorporated into Catchment and Water Resource model
Water Quality	In stream continuous (time series) or point (i.e. monthly) sampling	Not specifically required	ACT/NSW Government water quality programs	Catchment model – combination of observed WQ and literature recommended concentrations applied to land use in model. In stream water quality monitoring used for model validation.
Sewage Treatment Plants (STP)	Timeseries of discharge and water quality	Timeseries of discharge	Provided by ACT Government	Combination of observed discharges and modelled (developed in project) applied to catchment and water resource models across scenarios (pre-development, existing and future development.
Operation rules	Not specifically required but can be included (not included in this project)	Operation rules of water transfers	Provided by ICON water	Only applied in water resource model
Gross take and diversion	Not specifically required but can be included (not included in this project)	All gross take and diversion	Provided by ICON water	Only applied in water resource model

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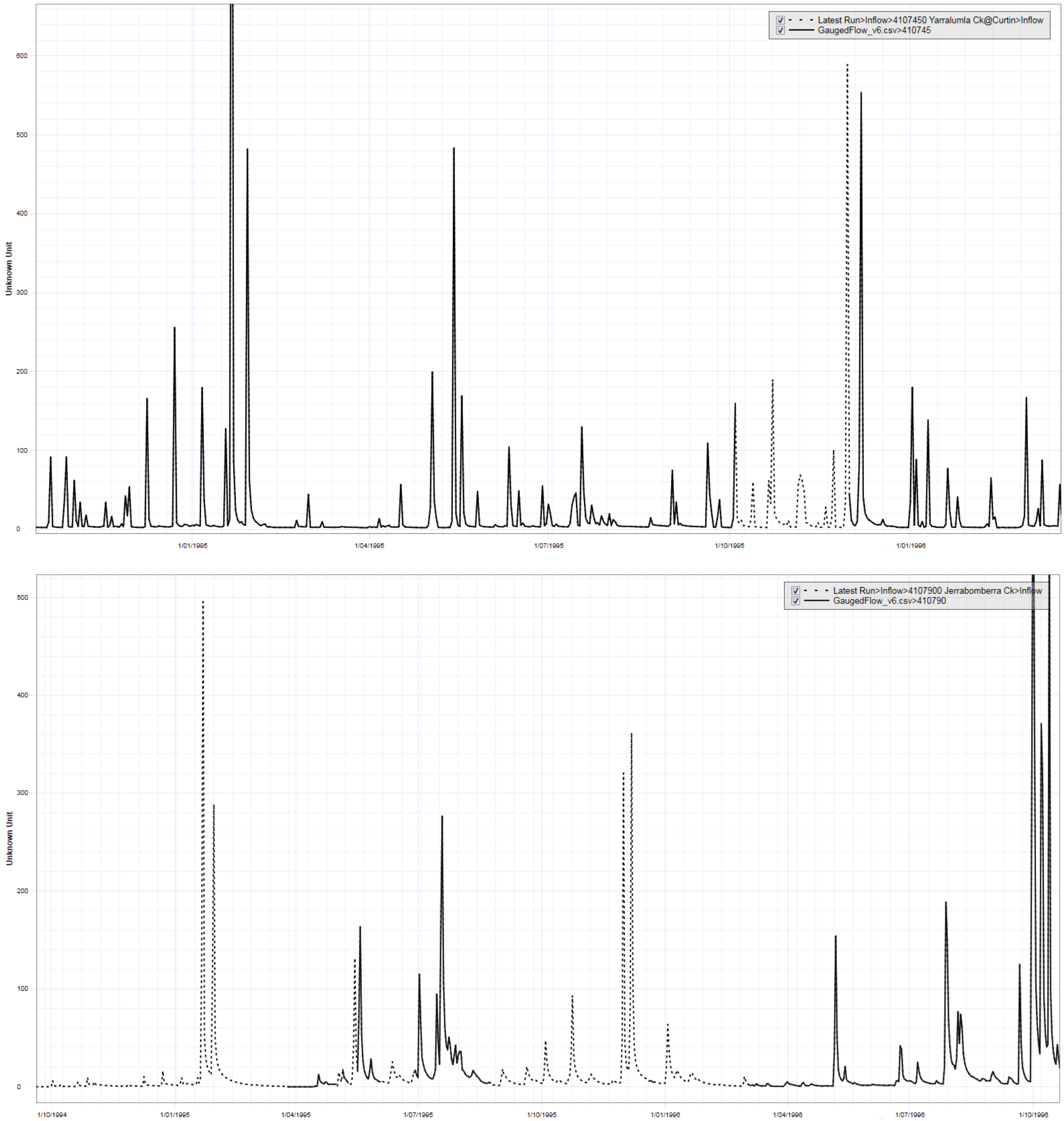

Figure 1. Rainfall runoff from catchment calibration used to infill gaps (dashed line) in the observed streamflow gauges (solid line) in water resource model. The top chart shows result for Yarralumla Creek and bottom chart shows result for Jerrabomberra Creek.

Limitations

Initially it was hoped to include both models as a single integrated model, however the necessity to develop a water resource model that strictly adhered to the requirements of the Murray Darling Basin Authority meant that two separate, but integrated models were developed. The key hurdles were related to workflow and included:

- Water balance assessments
- Operation of storages and extractions
- Representation of land use and water quality

Catchment models are generally calibrated in a way that limits the use of 'hard wired' observed data in running the model. Aspects of the model, including rainfall runoff from different land use/slope (known as functional units), storages, and sewage treatment plants outflow and water quality are calibrated and parameterized so that future scenarios can be simulated without using the observed data. This is important for allowing the model to be relatively independent of the observations and captures the catchment processes rather than exact replication of observed. While the catchment model was well calibrated, it did not reflect the transfers of water resources as accurately as the water resource model which used observed streamflow gauge data within the simulations. Also, the calibration periods were unable to be consistent across the two models due to the computational time that would be required to calibrate the catchment model (~440 catchments with 16 functional units) over the longer time period (1890-present) required for the water resource model.

Conclusions

The benefits of integrating the catchment and water resource models far outweighed the limitations. Future applications of integrated models could include:

- Incorporating land use change in water resource models. An example could include incorporating change in flow and water quality downstream of a new development from catchment model with expected change in demand in the water resource model.
- Climate change impact on catchment processes and water resources. An example could include incorporating projected rainfall and evaporation (i.e. based on Australian Rainfall Runoff 2016 guidelines or best available research) in catchment model to represent potential change in runoff coefficient across land uses (i.e. drier catchments with increased rainfall intensity). The results could then be applied to the water resource model to determine impacts to water demand in the system.

If suitable to the project, developing either a single integrated model or two separate but linked models (as in this project) should be considered.

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