Catchment pollutant loads modelling methods



Great Barrier Reef

Report Card 2016

Reef Water Quality Protection Plan

Australian Government

Queensland Government

Methods for modelling catchment pollutant loads

This report summarises the data and methods used for reporting progress towards the Reef Water Quality Protection Plan 2013 (Reef Plan, Australian and Queensland governments 2013) targets for catchment pollutant loads in the Great Barrier Reef Report Card 2016.

The targets for catchment pollutant loads are as follows:

- At least a 50 percent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas by 2018.
- At least a 20 percent reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas by 2018.
- At least a 60 percent reduction in end-of-catchment pesticide loads in priority areas by 2018.

Catchment modelling

The Source Catchments modelling framework (eWater, 2010) is used to model pollutant loads for the 35 catchments affected by land management practices in the Great Barrier Reef region.

This catchment-scale water quantity and quality model uses a node link network to represent the stream (Figure 1). The model generates run-off and pollutant loads for each functional unit (land use) within a sub-catchment, and runoff and pollutants are transported from a sub-catchment through the stream network via nodes and links to the end of the catchment.

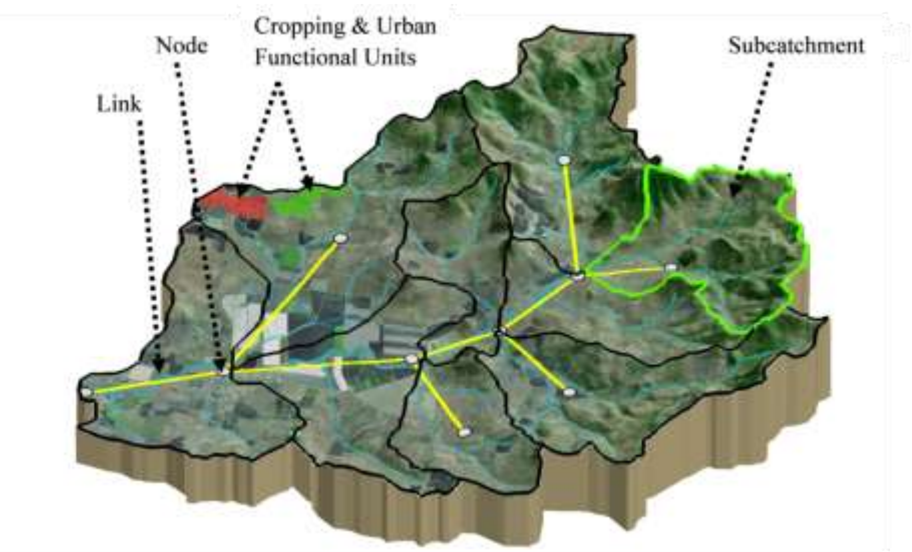

Figure 1: Example of a functional unit (FU) and node-link network generated in Source Catchments. These components represent the sub-catchment and stream network

The Source Catchment model runs at a daily time-step which allows for the exploration of the interactions of climate and management at a range of time-steps. However, for the Reef report card, average annual catchment loads are reported.

The model was run using a fixed climate period from 1986 to 2014 to remove the influence of climate on estimated load reductions. The latest land-use mapping (DSITIA, 2012) was used to describe the spatial extent of each agricultural land use for the baseline year.

The pollutants modelled were:

- fine and coarse sediment
- dissolved and particulate nutrients
- five photosystem II herbicides.

The Paddock to Reef Integrated Monitoring, Modelling and Reporting Program has developed water quality risk frameworks for each agricultural industry. These frameworks articulate best practice in relation to the Reef Plan adoption targets. These practices are described in terms of their relative water quality risk, from low to high. This is a departure from the ABCD management practice frameworks which were the basis for prioritising and reporting investments under Reef Plan 2009. See the Management Practice Methods report for more information about the risk frameworks.

To reflect the reported change in adoption of improved management practices, three scenarios are run:

- pre-development (prior to agricultural development)
- the baseline (i.e. representing land management practices in 2013)
- then each subsequent year with the proportion of land managed using defined practices adjusted each year.

The proportion of land managed using defined management practices is the only variable that changes between modelled scenarios. This allows for the relative load reductions attributed to the areas of improved land management to be reported.

For the baseline scenario, key land uses were modelled including grazing, sugarcane, cropping, horticulture and forestry.

Modelled load estimates were validated against field data collected at 25 monitoring sites across the Great Barrier Reef catchments. For further information on the model validation processes, refer to Waters et al. (2014).

The catchment loads modelling program undergoes an external peer review every three years. The program was reviewed in 2012 and again in 2015. Prior to the release of each Reef report card, modelled load estimates are reviewed both internally and externally.

Management practice change

The Reef Plan's management practice adoption frameworks describe and categorise farming practices according to recognised water quality improvements at the paddock scale. Improvements in water quality as a result of adopting improved management practices were determined by linking paddock model time-series outputs to catchment models.

Management practice change has been modelled for the sugarcane, grains, horticulture, banana and grazing areas of the Great Barrier Reef catchments. For details on how management practice changes are represented in the modelling, refer to the modelling technical reports listed under 'Further reading' at the end of this report.

Improvements in grazing management (in particular, vegetation cover management) through riparian and streambank fencing were also modelled. Spatial data on the length of stream and gully fencing were supplied by regional natural resource management (NRM) bodies.

Modelling assumptions

- Loads reported for each Reef report card reflect the relative change in modelled average annual loads for the specified model run period (1986 to 2014).

- Land-use areas in the model are static over the model run period and are based on the latest available Queensland Land use Mapping Program data (DSITIA, 2012).
- Paddock model runs that were used to populate the catchment models represent ‘typical’ management practices for a given management class and do not reflect the actual array of management practices that occur year-to-year across the Great Barrier Reef catchments.
- Application rates of pesticides and fertilisers that were used to populate the paddock models were derived through consultation with relevant industry groups and regional NRM bodies.
- Practice adoption areas represented in the model were applied at the spatial scale of the data supplied by regional NRM bodies.
- The water quality benefits from adopting a management practice change were assigned in the year that on ground works were implemented
- It is important to note that these modelled load reductions are based on improved land management adoption data supplied by industry and regional NRM bodies. Results are, therefore, indicative of the likely long-term water quality response due to adoption of improved land management practices for a given scenario, rather than a measured reduction in load.

Linking paddock and catchment models

The publicly available version of the eWater Source Catchments model (www.ewater.org.au) was modified to incorporate hillslope constituent generation from the most appropriate paddock models for cropping and sugarcane areas, and the Revised Universal Soil Loss Equation (RUSLE) for grazing. In addition, gully and streambank erosion and floodplain, channel and reservoir deposition processes were based on the SedNet/ANNEX approach (Wilkinson et al., 2014). A detailed description can be found in Ellis and Searle (2013) and Ellis (2017). The spatial and temporal representation of gully, streambank and in stream erosion processes were incorporated to better represent the erosion processes observed in the summer-dominant rainfall areas of northern Australia’s reef catchments.

Two approaches were used to represent improved land management practices in the Source Catchments model depending on the land use of interest.

In the first approach, for sugarcane, bananas and cropping the constituent time-series (e.g. load per day per unit area) for the given land use was supplied from an output time-series from a paddock model. Unique combinations of climate, soil type and defined management practices within each land use were identified and represented spatially in the paddock model simulations used to inform the catchment models. For cropping (grain cereal crops) and bananas, the HowLeaky model was used (Rattray et al., 2004). For sugarcane modelling, the Agricultural Production Systems sIMulator (APSIM) (Holzworth et al., 2014) was used. For load reduction representation, the defined management practice for a particular land-use segment was altered between scenarios.

In the second approach, the RUSLE model was written into the Source Catchments model to model hillslope soil erosion in grazing lands. The cover term (C-factor) in the model is generated from remotely sensed groundcover satellite imagery seasonally (four scenes per year). The paddock-scale model GRASP (McKeon et al., 1990) was used to provide scaling algorithms for each scenario to account for changes in management in each identified land type; for example, shifting areas from moderate risk to moderate–low risk. These scaling algorithms were applied at the pixel scale to each ground cover satellite image for the modelling period. This is applied according to a spatial representation of areas of defined management practices as provided annually by regional NRM bodies. Calculations were performed pixel by pixel, with results accumulated to a single land-use representation in each sub-catchment. All loads generated for each land use represented within a sub-catchment were then aggregated at the sub-catchment scale and routed through the stream network.

Total load

The total baseline load is the load modelled within each Great Barrier Reef catchment using the 2012–13 land management. A pre-development land-use map was also developed and modelled. The model was then run for a 28-year period to establish an average annual load for this period. The anthropogenic load was calculated as the total baseline load less the pre-development load.

Load reductions

To reflect investment in improved management practices since 2012–13, the model was then re-run in each year for the same climate period using the proportions of lowest risk to high risk management practice areas in that year. The relative change in pollutant loads from the anthropogenic baseline after investment reflects the load reduction due to changes in management practices (Figure 2).

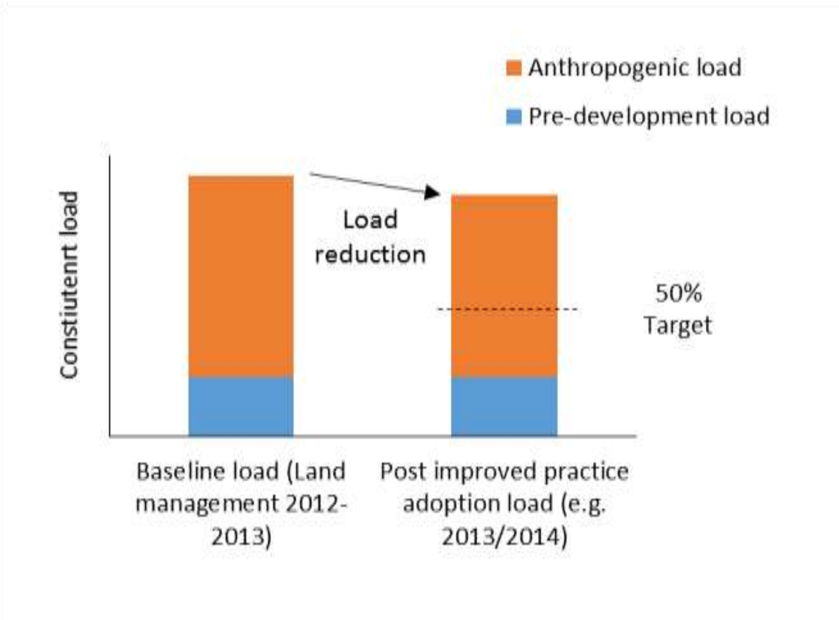

Figure 2: Example of modelled pre-development and anthropogenic pollutant loads, and the load reduction following investment in improved practices.

Modelling improvements

As part of the continuous program improvement, updated model input layers are incorporated into the model when they become available. Paddock to Reef program phase 2 improvements already implemented include: seasonal ground cover, improved soils layer, extended modelling climate period and hydrology parameter updates, finer resolution topographic data, and expanded water quality monitoring data sets. Improvements to the paddock modelling include more detailed modelling of bananas and grains, as well as representation of water-recycling pits in the lower Burdekin region.

A desktop gully-mapping program is continuing to improve the spatial representation of gullies in the models. When updated gully maps become available, these have been incorporated (areas included to date are the Normanby, Burdekin and Fitzroy catchments).

In sugarcane, loss of dissolved inorganic nitrogen (DIN) below the root zone can be a major loss pathway for nitrogen. This process was not represented previously in the model but functionality has now been added to enable a proportion of sugarcane DIN lost below the root zone to be returned to the stream. Loads now better reflect monitored data and this addition allows improved nitrogen management to be reflected in drainage run-off.

How the information is reported

Progress towards the targets is estimated by determining how much the modelled pollutant load has reduced from the average annual modelled anthropogenic baseline (total load less the pre-development load). This is calculated as a percentage reduction in average annual modelled load.

The average annual percentage reduction in load is calculated as:

$$\text{Reduction in load (\%)} = \frac{(\text{anthropogenic baseline load} - \text{anthropogenic change}) \times 100}{\text{Anthropogenic baseline load}}$$

Modelled total suspended sediment, nitrogen, phosphorus and pesticide loads at the end of the catchment are reported for the total Great Barrier Reef and for the six regions that make up the Great Barrier Reef catchment.

The program now also reports on overall toxic loads for pesticides. A pesticide toxic equivalent load is the calculated load of a pesticide multiplied by the relative toxicity of the pesticide compared to diuron.

Qualitative confidence ranking

A multi-criteria analysis was used to qualitatively score the confidence in each indicator used in the report card, from low to high. The approach combined expert opinion and direct measures of error for program components where available. Catchment loads modelling received a three-bar confidence ranking.

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