

# Load based approaches for modelling visual clarity in streams at regional scale

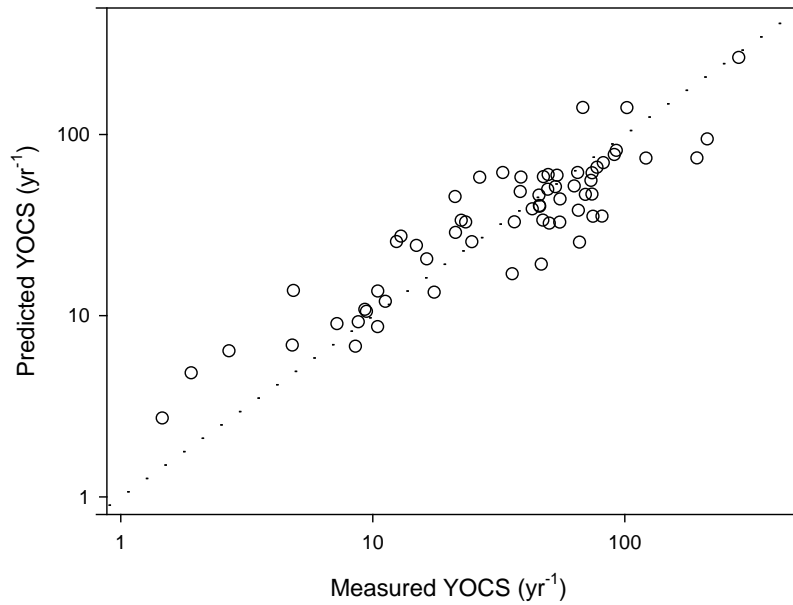
A.H. Elliott, R.J. Davies-Colley, A. Parshotam, D. Ballantine

National Institute of Water and Atmospheric Research, New Zealand

**Abstract:** Reduction of visual clarity in streams by diffuse sources of fine sediment is an important cause of water quality impairment in New Zealand and internationally. In this paper we introduce a concept of a load of optical cross section (LOCS), which serves as a basis for TMDL-based management of light-attenuating substances and can be used in water quality models based on mass accounting. In this approach, the beam attenuation coefficient (units of  $m^{-1}$ ) is estimated from the inverse of the visual clarity (units of m) measured with a black disc (Davies-Colley and Smith, 2001). This beam attenuation coefficient can also be considered as an optical cross-section (OCS) per volume of water, analogous to a concentration. The instantaneous 'flux' of cross section is obtained from the attenuation coefficient multiplied by the water discharge, and this can be accumulated over time to give an accumulated 'load' of cross section (LOCS). Moreover, OCS is a conservative quantity, in the sense that the OCS of two combined water volumes is the sum of the OCS of the individual water volumes (barring effects such as coagulation, settling, or sorption). The LOCS can be calculated for a water quality station using rating curve methods applied to measured time series of visual clarity and flow. This approach was applied to the sites in New Zealand's National Rivers Water Quality Network. Although the attenuation coefficient follows roughly a power relation with flow at some sites, loess rating curves are required at other sites. The hybrid mechanistic-statistical catchment model SPARROW (Schwarz et al. 2006), which is based on a mean annual mass balance, was then applied to the NRWQN dataset. Preliminary results from this model are presented (Table 1, Figure 1), highlighting the importance of factors related to erosion such as rainfall, slope and hardness of catchment rock types, and the influence of pastoral development, on the load of optical cross section.

**Table 1.** Key parameters from an exploratory SPARROW model. The  $R^2$  and RMSE values are calculated in natural log space.

Parameter	Estimate	Std Error	p
Pasture yield ( $yr^{-1}$ )	71.6	9.7	<0.001
Non-pasture yield ( $yr^{-1}$ )	7.2	2.3	0.0024
Rain power exponent (dimensionless)	1.40	0.25	<0.001
Slope power exponent (dimensionless)	1.54	0.27	<0.001
Induration exponential exponent (dimensionless)	-0.30	0.17	0.09
Lake effective settling velocity ( $m yr^{-1}$ )	175	45	0.0003
Observations	65		
Adjusted $R^2$ of LOCS	0.91		
RMSE of LOCS	0.52		
Adjusted $R^2$ of YOCS	0.85		
RMSE of YOCS	0.49		



**Figure 1.** Measured and predicted YOCS from the SPARROW model. The dashed line is for perfect agreement.. Further work will refine and extend this modelling by introducing a larger dataset and further explanatory variables.

## References

- Davies Colley, R. J., Smith, D. G, Ward, R. C., Bryers, G. G, McBride, G. B., Quinn, J. M. and Scarsbrook, M. R. (2011) Twenty Years of New Zealand's National Rivers Water Quality Network: Benefits of Careful Design and Consistent Operation, *Journal of the American Water*
- Schwarz, G.E., Hoos, A.B., Alexander, R.B. and Smith, R.A. (2006) The SPARROW Surface Water-Quality Model – Theory, Application, and User Documentation. USGS, Reston, Virginia.