

MINERosion 4: A user-friendly catchment/landscape erosion prediction model for post mining sites in Central Queensland



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Thesis Abstract

Soil erosion from post mining landscapes subjected to significant rainstorm events is believed to have adverse effects on the surrounding environment, as well as the mining processes. The research project reported in this thesis was encouraged by the fact that, to the best of the author's knowledge, there is a lack of catchment/landscape scale erosion/deposition model, to deal with the special conditions of post-mining rehabilitation sites.

Previous research has produced the hillslope erosion model MINEROSION 3.01 which was useful to determine the parameters (slope gradient, length and vegetation cover) required to design postmining landscapes that meets the criteria of acceptable erosion rates. However, MINEROSION 3.01 was not suitable to determine the erosion rates from whole catchments or 'whole of mine' landscapes and a model is needed to provide the environmental officers with a tool to allow them to manage the whole of mine landscape, specifically in relation to offsite and onsite discharges of water and sediment. MINEROSION 3.01 was found to be suitable for upscaling to produce a new user-friendly catchment scale model named MINEROSION 4. As an initial stage, MINEROSION 3.01 was revised to fix some of its errors and add some new features and a new version MINEROSION 3.1 was developed and validated against plot data from a previous project (Postmining Landscape Parameters for Erosion and Water Quality Control, 1992-1998). The agreement between predicted (Y_1) and measured (X_1) annual average soil loss is good with a regression equation of $Y_1 = 0.8 X_1 + 0.005$ and an $R^2 = 0.70$; while predicted (Y_2) and measured (X_2) rainstorm erosion events have a regression of $Y_2 = 0.867 X_2$ with an R^2 of 0.68.

As the new model should be a spatial distribution model, the variability of media properties of Central Queensland coal mines need to be determined. Ninety three soil and spoil samples were collected from six selected coalmines. They were analyzed and represented in both MINEROSION 4 model database and as a standalone database file for Central Queensland coalmines media properties. These

properties were used to derive the rill and interrill erodibilities of soil and spoil. These values are generally in agreement with the values in the embedded MINErosion 3.1 database as determined by Sheridan (2001). This work shows large variability in soil and spoil erodibilities which should result in large variability in erosion rates across a minesite. A knowledge of the hotspots in advance will assist the mine to manage and allocate suitable resources across the postmining landscape.

The fundamental theory, and framework of the new MINErosion 4.1 model is as follows. The model integrates the hillslope scale model of MINErosion 3.1 with the ESRI ArcGIS® 9 which was employed to generate the required hydrological parameters for each raster from the Digital Elevation Model (DEM) of the minesite. MINErosion 3.1 was then applied to each raster and a depositional sub-routine was added and used to determine whether sediment will be deposited (if sediment load > transport capacity) or transported to the next raster (if sediment load < transport capacity). In this way, the model can represent the erosion/deposition pattern for the whole catchment for a single event erosion as well as the annual erosion rate. The results are represented as a set of raster layers and printed maps. The model was validated against 10 years of measured data from Curragh mine site's rehabilitation project. The validation results are excellent and the agreement between predicted (Y) and measured (X) soil losses are good with regression equations of $Y = 0.919 X$ ($R^2 = 0.81$) for individual rainstorms, and $Y = 1.473 X$ ($R^2 = 0.726$) for average annual soil loss. The latter shows an overestimation of 47 % and is probably associated with an underestimation of the annual transport capacity by the Van Rompaey et al., (2005) equation adopted in this work.

MINErosion 4.1 is user-friendly and requires only few laboratory measured input parameters. To the authors knowledge this is probably the first time that a catchment/landscape scale erosion is successfully predicted from laboratory based input parameters. Prediction is likely to be most reliable when erodibilities are measured using a flume-rainfall simulation as described by Sheridan (2001). However, when such measurements are not available, they can also be estimated

from several soil physical and chemical parameters which are commonly available from routine soil analysis.

MINEROSION 4.1 is a versatile model and can be applied to landscapes with multiple catchments. The scale of landscape and the resolution of the model prediction is limited by the computing power available. The more rasters is involved, the longer it takes for the computation to be completed. It is also limited by the detail of spatial landscape information available to the operator. The more information available, the greater the spatial variation that can be represented in the output. Examples of some application to Curragh mine is presented in the thesis.

Finally, it is suggested that with some future minor modifications, the model could be applicable for agriculture catchments. Another potential future development is to add other suitable sub- routines towards developing this model as a general landscape evolution model.