Improving Rehabilitation Practices for the Outer Batter Slopes of Bauxite Residue Disposal Areas at Worsley Refinery, Collie, Western Australia.

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Thesis Declaration

I declare that this thesis is my own account of my research and contains as its main content work that has not previously been submitted for a degree at any tertiary education institution.

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Abstract

Control of water erosion of soil at mine sites requires an ability to predict the effects of different management practices on soil loss. Using soil loss models such as the Revised Universal Soil Loss Equation (RUSLE) requires calibration of the model for materials and situations that are not defined in the model's handbook or software. The outer slopes of bauxite residue disposal areas are potentially highly erodible surfaces, and a recent evaluation of previous rehabilitation practices at Worsley Alumina, Collie, Western Australia, identified areas on the bauxite residue disposal areas where vegetation establishment and management of long term soil loss could be improved. Field experiments commencing in April 2000 at Worsley Alumina's bauxite refinery, Collie, and laboratory tilting flume experiments run at the University of Queensland, were designed to quantify the effectiveness of different surface treatments on reducing short-term soil loss, and to model long-term erosion risks. Crushed ferricrete caprock – rock-pitch – and different types of mulches, seed mixes and fertiliser rates were applied to the compacted clay batter slopes used to contain bauxite residue, with runoff, soil loss and vegetation establishment monitored periodically over 27 months. Laboratory tilting flume results were related to the field data using the soil erosion models MINErosion, the Modified Universal Soil Loss Equation (MUSLE) and RUSLE to predict event-based and annual soil loss for different treatments. Turbo-mulch, a blocky, coarse pine bark, was the most effective surface treatment for promoting vegetation establishment, reducing rill formation and reducing soil loss, a result supported in both the field and laboratory results. Turbo-mulch and vegetation did not reduce runoff, but resulted in decreased soil loss. This shows the importance of protecting soil from raindrop impact and of the soil holding capacity of vegetation. Increased seed and fertiliser rates did not significantly affect native plant numbers or foliage cover on topsoil without turbo-mulch. Rock-pitch was found to be resistant to erosion and mass movement along a rock-pitch/compacted clay interface. Field erosion measurements ranged from 0.87 t/ha/yr for turbo-mulched treatments to 7.41 t/ha/yr for a treatment with a different seed mix, lacking turbo-mulch and lacking underlying rock-pitch. RUSLE soil loss predictions based on soil properties and soil loss estimates from the MINErosion model ranged from 0.27 to 60.0 t/ha/yr. RUSLE predictions based on tilting flume data ranged from 0.14 to 81.1 t/ha/yr. RUSLE overpredicted soil loss for treatments without turbo-mulch, and underestimated soil loss for turbo-mulched treatments, necessitating calibration based on the unique materials trialed in this study. The relative soil loss measured in the field was best represented by RUSLE predictions based on tilting flume data rather than the MINErosion model. MINErosion did not adequately describe the effect of bulk density and infiltration on soil loss of compacted/consolidated materials. MUSLE and RUSLE are adequate models for the Western Australian conditions of this study, but further research is required to calibrate the C factor for turbo-mulched surfaces and calibrate the P factor for rock-pitch.

Keywords: soil erosion, tilting flume, turbo-mulch, rock-pitch, modelling.

CONTENTS

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Chapter 1 Introduction