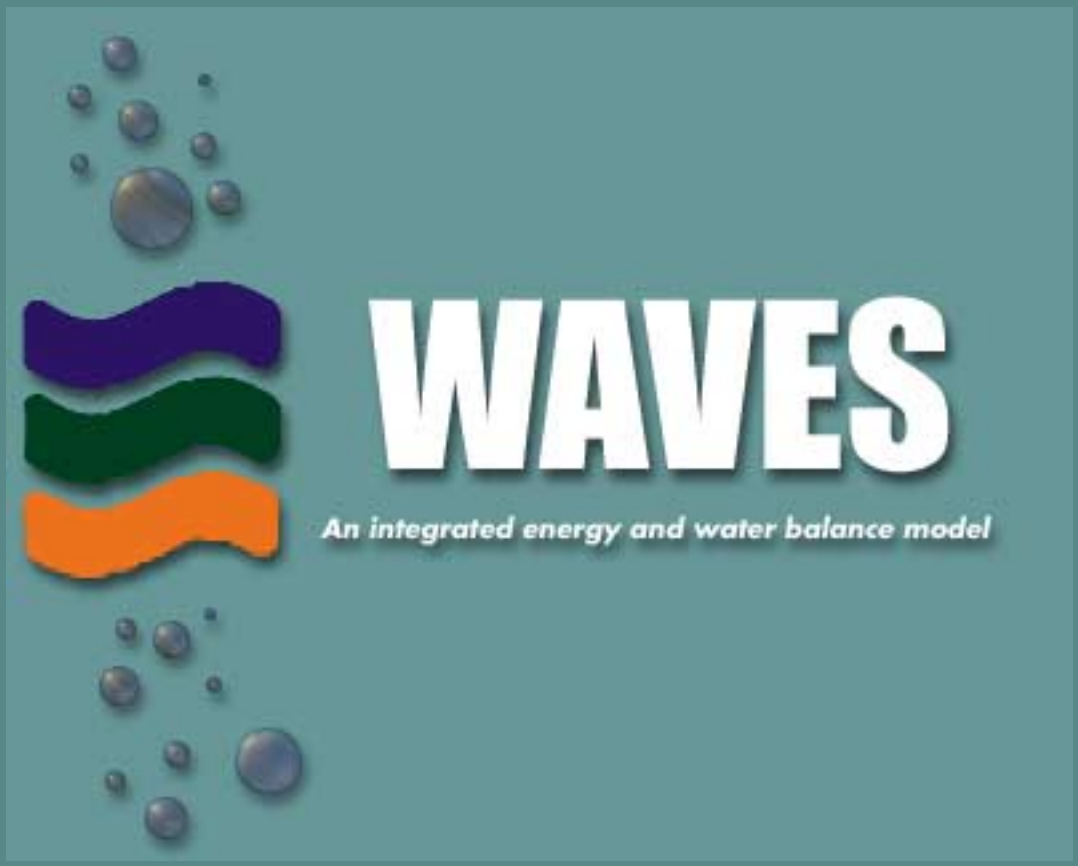

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WAVES

An integrated energy and water balance model

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PREFACE

The interactions between climate, vegetation and soil are all around us. They provide the driving forces and fluxes for the atmosphere above the ground, and the large groundwater systems below it. Understanding and quantifying these interactions has therefore long been of great interest to researchers.

In the Australian context, the main questions are: what is the current water balance, how has it changed from historical levels, and what is the optimum land management regime to satisfy a range of competing needs? Dryland salinity is a good example of a disturbed water balance with land management implications. Historically, groundwater levels were well below the soil surface, and were kept there by deep-rooted perennial native vegetation. Widespread clearing of this vegetation, and replacement with more shallow-rooted annual cropping and grazing systems, has led to an increase in groundwater recharge. This has caused groundwater levels to rise, mobilise the stored salt in the soil profile, and bring it close to the surface where evaporative concentration has resulted in dryland salinity. The question being addressed in this field is whether rising water-level trends can be halted or reversed using only vegetation management, or in combination with engineering options.

WAVES is a one-dimensional, daily time-step model that simulates the fluxes of mass and energy between the atmosphere, vegetation, and soil systems; it has been under development since 1993. It is a process-based model that couples these systems by modelling the interactions and feed-backs between them. WAVES attempts to model each sub-system with a consistent level of detail, so that no area is over emphasized or requires too many parameters, and similarly no area is treated in a trivial manner. More than this, WAVES tries to strike a balance between the complexity of the model as a whole, the usefulness of the model and its ease of use, and the accuracy of the model outputs. If these balances have been struck, then WAVES should be easy enough to use, but accurate enough to believe.

The material in this work is broken into five chapters, with the level of detail varied through each, so that everyone should be able to get the information they require. Chapter 1 is an Executive Summary that provides a broad-brush view of the WAVES model, highlighting strengths and weaknesses, to allow readers to gauge whether WAVES could be applied to any particular problem. Chapter 2 contains the conceptual model for each of the sub-systems of WAVES. This provides more detail on the assumptions used to scale processes to a daily-time-step, and some of the specific process formulations used in WAVES. Chapter 3 is a very detailed description of the equations that are solved in running WAVES and, where required, provides the solution method

for nonlinear equations and matrix solution schemes. A skilled scientist should be able to essentially reproduce the functions of WAVES from this chapter. Chapter 4 provides a sensitivity analysis of the major parameters in WAVES, and testing of the quality of the mass and energy balances as simulated for test cases. It also provides an extensive treatise on use of Richards' equation for solving soil-water dynamics; without a robust solution method for this sub-system, WAVES would not be possible. Chapter 5 is a compilation of case studies that have used WAVES, showing the range of application of WAVES as well as the excellent results that can be obtained with it. These studies test the full capabilities of WAVES in many varied environments; it is not an exhaustive list of all the applications that have been made and published by all workers using WAVES. At the end are two appendices. Appendix A details some of the mathematics that underpin the longwave radiation equations used in WAVES. Appendix B details the equations and solution of the analytic model used to test the Richards' equation with a particular soil hydraulic model.

The material presented represents a working document for WAVES v3.5. It is anticipated that further changes will be made to WAVES in the future, as new processes call to be modelled, and new techniques and physical descriptions are developed.

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