Groundwater Hydrology
Conceptual and Computational Models

K.R. Rushton
Emeritus Professor of Civil Engineering
University of Birmingham, UK
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Appendix: Computer Program for Two-zone Model

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It was more than twenty years ago when visiting India that I was asked the question, ‘How should a groundwater investigation be planned?’ At that time I had difficulty in giving a convincing answer, but in the intervening years, with involvement in many challenging practical groundwater studies, the important issues have become clearer. The key is understanding before analysis; this is reflected by the use of the words conceptual and computational models in the title of this book.

The number of groundwater investigations throughout the world continues to increase. The objectives of these investigations are varied, including meeting regulatory requirements, exploring the consequences of groundwater development and rectifying the results of over-exploitation of groundwater resources. Although hydrogeologists and water resource engineers working on these projects may not carry out the analytical and numerical analysis themselves, it is vital that they understand how to develop comprehensive quantified conceptual models and also appreciate the basis of analytical solutions or numerical methods of modelling groundwater flow. The presentation of the results of groundwater investigations in a form that can be understood by decision makers is another important task. This book is designed to address these issues. The first task in every investigation is to develop conceptual models to explain how water enters, passes through and leaves the aquifer system. These conceptual models are based on the interpretation of field data and other information. Second, techniques and methodologies are required to analyse the variety of flow processes identified during the conceptual model development. A considerable number of computational models are available.

Developments of both conceptual and computational models for groundwater hydrology have continued from early in the twentieth century to the present day. Initially, computational models relied on analytical methods but there is now a greater use of numerical models. Computational models for analysing groundwater problems are the subject of many articles in the literature. However, conceptual models are not discussed as widely. Real groundwater problems are frequently so complex that they can only be analysed when simplifying assumptions are introduced. Imagination and experience are required to identify the key processes which must be included in conceptual and computational models. Furthermore, the selection of appropriate aquifer parameters is not straightforward. A computational model does not need to be complex, despite the availability of model codes which include both saturated and unsaturated flow conditions with the option of a large number of three-dimensional mesh subdivisions and numerous time steps. Simpler, more flexible analytical or numerical models are often suitable for the early stages of modelling; more complex models can be introduced when there is confidence that the important features of the aquifer system have been recognised. In an attempt to indicate how the key processes are identified and aquifer parameters are selected, more than fifty major case studies are included in this book.

Case studies illustrate how crucial insights are gained which lead to a breakthrough in identifying the important flow processes which must be incorporated in the conceptual models. Comparing and contrasting an aquifer system with other field problems has proved to be of immense benefit. A further advantage of case studies is that they can indicate appropriate aquifer parameter values. For example, selecting suitable values for the effective vertical hydraulic conductivities of low permeability strata is notoriously difficult. However, experience gained from other investigations in similar situations often provides suitable first estimates. Due to differences in climate, geology and the way in which groundwater is utilised, the reader may find it difficult to appreciate the significance of some of the case studies. Yet much can be learnt from groundwater studies in other countries. Although the reader may never be involved in studying losses from lined canals or irrigated ricefields, insights gained from these investigations can be transferred to other projects involving