Water Resources Systems Analysis through Case Studies

DATA AND MODELS FOR DECISION MAKING

EDITED BY
David W. Watkins Jr., Ph.D.

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WATER RESOURCES SYSTEMS ANALYSIS THROUGH CASE STUDIES

DATA AND MODELS FOR DECISION MAKING

PREPARED BY
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Supplemental Material for Classroom Use

Several of the classroom exercises in this book require supplemental software, instructions and directions, and data sets. These are provided as free downloads from the ASCE Library at http://dx.doi.org/10.1061/9780784412879.fm. Each download is a zipped file with the materials necessary for a particular chapter:

Chapter 2—MACRO 2004 software and data

Chapter 3—Iowa Flood Damage data spreadsheet

Chapter 5—Bacteria Loading Estimator Spreadsheet Tool (BLEST v. 2.5) and TMDL solution in dry weather

Chapter 6—HEC-ResPRM Prescriptive Reservoir Model and Lake Superior Data

Chapter 7—Oasis with OCL software manual and access

Chapter 8—Storm Water Investment Strategy Evaluation (StormWISE) calculation sheet

Chapter 9—WeberOgden WEAP Lab and Weber Reservoir data spreadsheet

End-User License Agreement for Water Resources Systems Analysis through Case Studies

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Preface

The motivation for compiling case studies of systems analysis applications in environmental and water resources engineering comes mainly from my personal experience in teaching a course on this topic to graduate and upper level undergraduate students. Because my course notes—based closely on related courses I had as a student—and the textbooks I've used tend to focus heavily on methods and algorithms, interspersed with simple examples, students have often wondered why they needed to know so much "theory", and whether or not these techniques were actually used in the "real world." Then, as I searched for examples of real world applications, I found very few for which sufficient information was readily available and accessible to students (at least enough to "convince" them of the usefulness of systems analysis). As my next tack, I then set off to develop some case studies on my own, but again my progress stalled as I realized how difficult and time-consuming it can be to develop good case studies.

I soon learned that instructors at other universities faced similar challenges. Many felt their courses could be improved with more focus on applications. Some had a few case studies that they used in teaching, but they wished they had more. All agreed they lacked the time to develop a good selection of new case studies. Hence, it seemed logical to combine our efforts and compile a set of case studies that we all could draw from. We joined forces with several engineering practitioners, each with an interest in improving engineering education and a desire to pass on the results of their studies before the reports "disintegrated on the shelf." Although it did not happen overnight, as few really worthwhile things do, this collaborative effort resulted in the set of course-ready case studies compiled herein, ranging from "classic" applications such as reservoir operations to more recent applications such as watershed management for total maximum daily loads.

Most of the software and data sets required to complete the case studies are freely available for download from: http://dx.doi.org/10.1061/9780784412879.fm. The case study in Chapter 4 is completed using an on-line program, and software described in Chapter 7 may also be run remotely, following instructions in those chapters and the appendix, "Notes for Instructors." The software for the case study in Chapter 9 may be downloaded free of charge, following instructions in that chapter.

The contributors to this book still want students to understand the theory behind the software and analysis tools, but we hope that case studies will foster critical thinking skills and provide some extra motivation along the way. In addition, we will all be counting on today's students to help solve difficult socioeconomic and environmental problems such as these in the future.

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1. Introduction

David W. Watkins, Jr.[1]

What is Systems Analysis?

In a broad sense, systems analysis is the systematic analysis of design or decision alternatives to solve a problem. To formalize this approach, it is necessary to describe the problem in terms of decisions, objectives, and constraints. In engineering education, we often seek to simplify the problem so that the decisions, objectives, and constraints can be formulated in mathematical terms. Often, but not always, there are a large number of alternatives, and the evaluation of objectives and constraints involves analysis of a complex system, or set of interrelated components, preventing easy solution through intuition or quick analysis of all alternatives. When the search for the best alternative is automated through a mathematical algorithm (almost always on a computer), systems analysis is often called optimization or mathematical programming. Fields specializing in the techniques of optimization/math programming include Operations Research, Management Science, and Industrial Engineering. Others have referred to systems analysis as the "science of design" (Simon, 1969), or the "theory of problem solving" (Liebman, 1989).

Another way to define systems analysis is to describe what it is that "systems thinkers" or "systems modelers"[2] are able to do. In a nutshell, we expect students who have completed a systems analysis course to have developed the synthesis and analysis skills to do the following:

- Describe a water resources/environmental engineering design problem in terms of decisions, objectives, and constraints.
- Simplify the problem, if necessary, and formulate the decisions, objectives, and constraints in mathematical terms.
- Select an appropriate mathematical programming tool, or computer software, to solve the problem.
- Understand the solution procedure.
- Interpret the solution and analyze the uncertainties associated with it.
- Explain the solution, solution sensitivity, and limitations of the approach to someone unfamiliar with optimization or mathematical programming.

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[2] Systems analysis researchers and practitioners should not be confused with systems administrators, who maintain computer networks, or with many systems engineers who design physical process systems but are not applying the mathematical formulation and solution procedures referred to here.