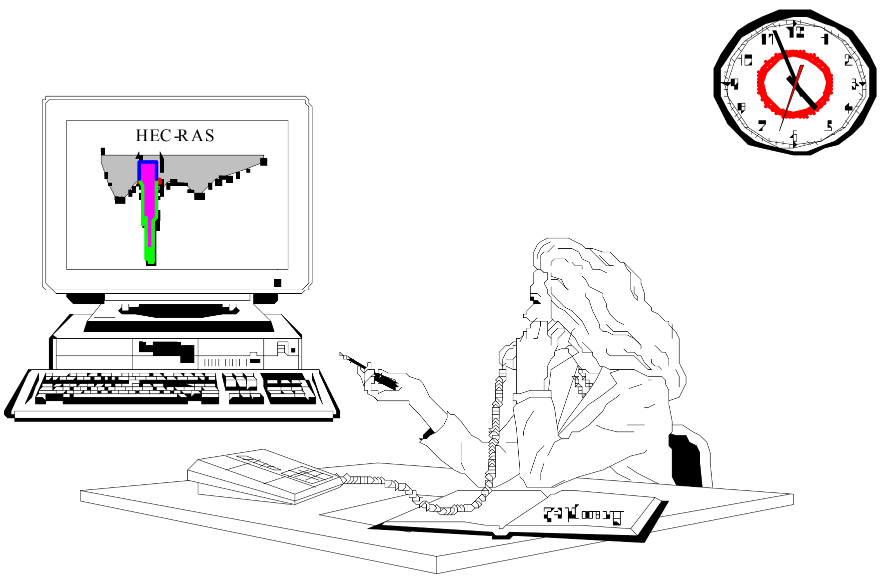
US Army Corps
of Engineers
Hydrologic Engineering Center

HEC-RAS



River Analysis System

Applications Guide

Version 3.1
November 2002

Approved for Public Release. Distribution Unlimited

CPD-70

REPORT DOCUMENTATION PAGE				*Form Approved* *OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the date needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** November 2002	**3. REPORT TYPE AND DATES COVERED** Computer Program Documentation		
4. TITLE AND SUBTITLE HEC-RAS, River Analysis System Applications Guide				**5. FUNDING NUMBERS**
6. AUTHOR(S) John C. Warner, Gary W. Brunner, Brent C. Wolfe, and Steven S. Piper				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US ARMY CORPS OF ENGINEERS HYDROLOGIC ENGINEERING CENTER (HEC) 609 Second Street Davis, CA 95616-4687				**8. PERFORMING ORGANIZATION REPORT NUMBER** CPD-70
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for Public Release. Distribution is unlimited.				**12b. DISTRIBUTION CODE**
14. SUBJECT TERMS water surface profiles, river hydraulics, steady and unsteady flow, computer program				**15. NUMBER OF PAGES** 344
				16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	**18. SECURITY CLASSIFICATION OF THIS PAGE** UNCLASSIFIED	**19. SECURITY CLASSIFICATION OF ABSTRACT** UNCLASSIFIED		**20. LIMITATION OF ABSTRACT** UNLIMITED

13. ABSTRACT *(Maximum 200 words)*

The U.S. Army Corps of Engineers' River Analysis System (HEC-RAS) is software that allows you to perform one-dimensional steady and unsteady flow river hydraulics calculations.

HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking, multi-user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities.

The HEC-RAS system will ultimately contain three one-dimensional hydraulic analysis components for: (1) steady flow water surface profile computations; (2) unsteady flow simulation; and (3) movable boundary sediment transport computations. A key element is that all three components will use a common geometric data representation and common geometric and hydraulic computation routines. In addition to the three hydraulic analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed.

The current version of HEC-RAS supports Steady and Unsteady flow water surface profile calculations. New features and additional capabilities will be added in future releases.

HEC-RAS

River Analysis System

Applications Guide

Version 3.1

November 2002

US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

Table of Contents

Foreword

The U.S. Army Corps of Engineers' River Analysis System (HEC-RAS) is software that allows you to perform one-dimensional steady and unsteady flow river hydraulics calculations. The HEC-RAS software supersedes the HEC-2 river hydraulics package, which was a one-dimensional, steady flow water surface profiles program. The HEC-RAS software is a significant advancement over HEC-2 in terms of both hydraulic engineering and computer science. This software is a product of the Corps' Civil Works Hydrologic Engineering Research and Development Program.

The first version of HEC-RAS (version 1.0) was released in July of 1995. Since that time there have been several releases of this software package, including versions: 1.1; 1.2; 2.0; 2.1; 2.2; 2.21; 3.0 and now version 3.1 in September of 2002.

The HEC-RAS software was developed at the Hydrologic Engineering Center (HEC), which is a division of the Institute for Water Resources (IWR), U.S. Army Corps of Engineers. The software was designed by Mr. Gary W. Brunner, leader of the HEC-RAS development team. The user interface and graphics were programmed by Mr. Mark R. Jensen. The steady flow water surface profiles module and a large portion of the unsteady flow computations modules was programmed by Mr. Steven S. Piper. The unsteady flow equation solver was developed by Dr. Robert L. Barkau. The Stable Channel Design Routines were programmed by Mr. Chris R. Goodell. The routines that import HEC-2 and UNET data were developed by Ms. Joan Klipsch. The routines for modeling ice cover and wide river ice jams were developed by Mr. Steven F. Daly of the Cold Regions Research and Engineering Laboratory (CRREL).

Many of the HEC staff made contributions in the development of this software, including: Vern R. Bonner, Richard Hayes, John Peters, Al Montalvo, and Michael Gee. Mr. Darryl Davis was the director during the development of this software.

This manual was written by John C. Warner, Gary W. Brunner, Brent C. Wolfe, and Steven S. Piper.

Introduction

Welcome to the Hydrologic Engineering Center's River Analysis System (HEC-RAS). This software allows you to perform one-dimensional steady flow, unsteady flow, and sediment transport calculations (The current version of HEC-RAS can only perform steady flow calculations. Unsteady flow and sediment transport will be added in future versions).

The HEC-RAS modeling system was developed as a part of the Hydrologic Engineering Center's "Next Generation" (NexGen) of hydrologic engineering software. The NexGen project encompasses several aspects of hydrologic engineering, including: rainfall-runoff analysis; river hydraulics; reservoir system simulation; flood damage analysis; and real-time river forecasting for reservoir operations.

This introduction discusses the documentation for HEC-RAS and provides an overview of this manual.

Contents

- HEC-RAS Documentation
- Overview of this Manual

HEC-RAS Documentation

The HEC-RAS package includes several documents. Each document is designed to help the user learn to use a particular aspect of the modeling system. The documentation is arranged in the following three categories:

Documentation	Description
User's Manual	This manual is a guide to using HEC-RAS. The manual provides an introduction and overview of the modeling system, installation instructions, how to get started, simple examples, detailed descriptions of each of the major modeling components, and how to view graphical and tabular output.
Hydraulic Reference Manual	This manual describes the theory and data requirements for the hydraulic calculations performed by HEC-RAS. Equations are presented along with the assumptions used in their derivation. Discussions are provided on how to estimate model parameters, as well as guidelines on various modeling approaches.
Applications Guide	This document contains examples that demonstrate various aspects of HEC-RAS. Each example consists of a problem statement, data requirements, general outline of solution steps, displays of key input and output screens, and discussions of important modeling aspects.

Overview of this Manual

This **Applications Guide** contains written descriptions of 17 examples that demonstrate the main features of the HEC-RAS program. The project data files for the examples are contained on the HEC-RAS program distribution diskettes, and will be written to the HEC\RAS\STEADY and HEC\RAS\UNSTEADY directories when the program is installed. The discussions in this manual contain detailed descriptions for the data input and analysis of the output for each example. The examples display and describe the input and output screens used to enter the data and view the output. The user can activate the projects within the HEC-RAS program when reviewing the descriptions for the examples in this manual. All of the projects have been computed, and the user can review the input and output screens that are discussed as they appear in this manual. The user can use the zoom features and options selections (plans, profiles, variables, reaches, etc.) to obtain clearer views of the graphics, as well as viewing additional data screens that may be referenced to in the discussions. The examples are intended as a guide for performing similar analyses. This manual is organized as follows:

- **Example 1, Critical Creek**, demonstrates the procedure to perform a basic flow analysis on a single river reach. This river reach is situated on a steep slope, and the analysis was performed in a mixed flow regime to obtain solutions in both subcritical and supercritical flows. Additionally, the example describes the procedure for cross section interpolation.

- **Example 2, Beaver Creek - Single Bridge**, illustrates an analysis of a single river reach that contains a bridge crossing. The data entry for the bridge and determination for the placement of the cross sections are shown in detail. The hydraulic calculations are performed with both the energy and pressure/weir flow methods for the high flow events. Additionally, the model is calibrated with observed high flow data.

- **Example 3, Single Culvert (Multiple Identical Barrels)**, describes the data entry and review of output for a single culvert with two identical barrels. Additionally, a review for the locations of the cross sections in relation to the culvert is presented.

- **Example 4, Multiple Culverts**, is a continuation of Example 3, with the addition of a second culvert at the same cross section. The second culvert also contains two identical barrels, and this example describes the review of the output for multiple culverts.

- **Example 5, Multiple Openings**, presents the analysis of a river reach that contains a culvert opening (single culvert with multiple identical barrels), a main bridge opening, and a relief bridge opening all occurring at the same cross section. The user should be familiar with individual bridge and culvert analyses before reviewing this example.

- **Example 6, Floodway Determination**, illustrates several of the methods for floodplain encroachment analysis. An example procedure for the floodplain encroachment analysis is performed. The user should be aware of the site specific guidelines for a floodplain encroachment analysis to determine which methods and the appropriate procedures to perform.

- **Example 7, Multiple Plans**, describes the file management system used by the HEC-RAS program. The concepts of working with projects and plans to organize geometry, flow, and other files are described. Then, an application is performed to show a typical procedure for organizing a project that contains multiple plans.

- **Example 8, Looped Network**, demonstrates the analysis of a river system that contains a loop. The loop is a split in the main channel that forms two streams which join back together. The example focuses on the procedure for balancing of the flows around the loop.

- **Example 9, Mixed Flow Analysis**, describes the use of a mixed flow regime to analyze a river reach containing a bridge crossing. The bridge crossing constricts the main channel supercritical flow, creating a subcritical backwater effect, requiring the use of the mixed flow regime for the analysis. Results by subcritical and supercritical flow regime analyses are presented to show inconsistencies that developed, and to provide guidance when to perform a mixed flow analysis.

- **Example 10, Stream Junction**, demonstrates the analysis of a river system that contains a junction. This example illustrates a flow combining of two subcritical streams, and both the energy and momentum methods are used for two separate analyses.

- **Example 11, Bridge Scour**, presents the determination of a bridge scour analysis. The user should be familiar with the procedures for modeling bridges before reviewing this example. The scour equations and procedures are based upon the methods outlined in Hydraulic Engineering Circular No. 18 (FHWA 1995).

- **Example 12, Inline Weir and Gated Spillway**, demonstrates the analysis of a river reach that contains an inline weir and a gated spillway. Procedures for entering the data to provide flexibility for the flow analysis are provided.

- **Example 13, Bogue Chitto - Single Bridge (WSPRO)**, performs an analysis of a river reach that contains a bridge crossing. The example is similar to Example 2, however, all of the water surface profiles are low flow and are computed using the WSPRO (FHWA, 1990) routines that have been adapted to the HEC-RAS methodology of cross section locations around and through a bridge.

- **Example 14, Ice-Covered River**, is an example of how to model an ice covered river as well as a river ice-jam.

- **Example 15, Split Flow Junction With Lateral Weir and Spillway**, is an example of how to perform a split flow optimization with the steady flow analysis portion of the software. This example has a split of flow at a junction, as well as a lateral weir.

- **Example 16, Channel Modification**. This example demonstrates how to use the channel modification feature within the HEC-RAS Geometric Data Editor. Channel modifications are performed, and existing and modified conditions geometry and output are compared.

- **Example 17, Unsteady Flow Application.** This example demonstrates how to perform an unsteady flow analysis with HEC-RAS. Discussions include: entering storage area information; hydraulic connections; unsteady flow data (boundary conditions and initial conditions); performing the computations; and reviewing the unsteady flow results.

- **Appendix A** contains a list of references.