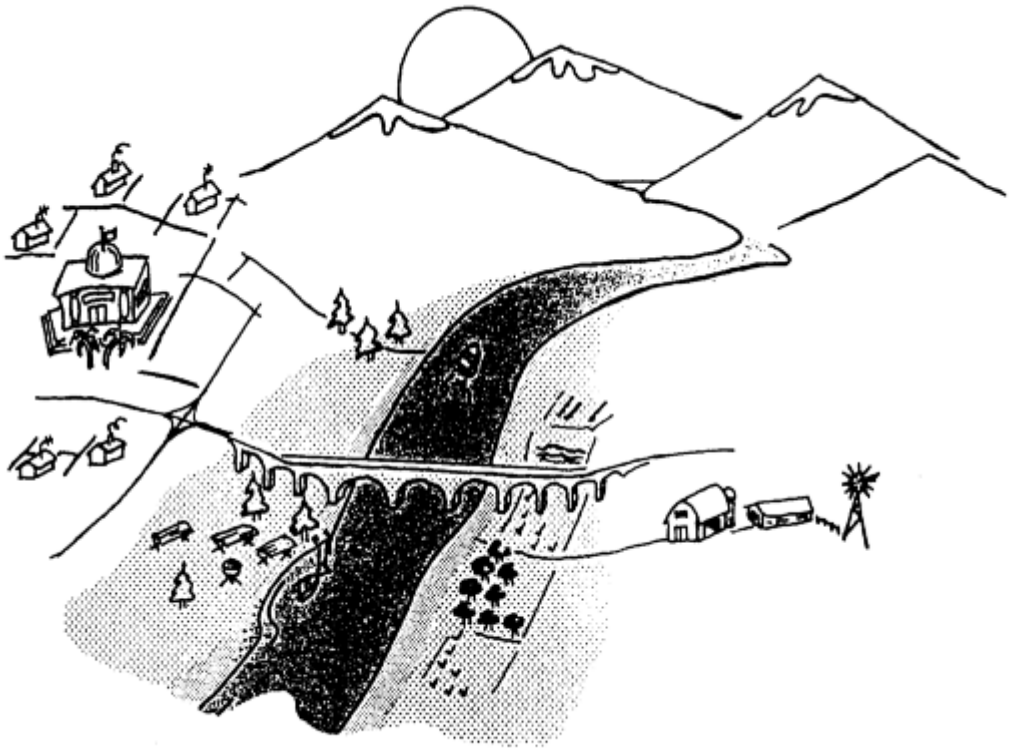
US Army Corps of Engineers®
Hydrologic Engineering Center

HEC-RAS

River Analysis System



HEC-RAS User's Manual

Version 6.3
Exported - January 2023

Approved for Public Release. Distribution Unlimited.

Table of Contents

1 FOREWORD 18

FOREWORD 18

2 INTRODUCTION TO HEC-RAS 20

GENERAL PHILOSOPHY OF THE MODELING SYSTEM 20

OVERVIEW OF PROGRAM CAPABILITIES 20

User Interface 20

River Analysis Components 21

Data Storage and Management 22

Graphics, Inundation Mapping, and Reporting 22

HEC-RAS Documentation 22

OVERVIEW OF THIS MANUAL 23

3 INSTALLING HEC-RAS 24

IMPORTANT 24

INSTALLATION PROCEDURE 24

To install the software onto your hard disk, do the following: 24

UNINSTALL PROCEDURE 25

4 WORKING WITH HEC-RAS 26

STARTING HEC-RAS 26

STEPS IN DEVELOPING A HYDRAULIC MODEL WITH HEC-RAS 28

Starting a New Project 29

Entering Geometric Data 29

Entering Flow Data and Boundary Conditions 32

Performing Hydraulic Computations 33

Viewing and Printing Results 34

GETTING AND USING HELP 38

5 WORKING WITH PROJECTS 39

UNDERSTANDING PROJECTS 39

ELEMENTS OF A PROJECT 40

Plan Files 40

Run Files 40
Output Files 40
Geometry Files 41
Steady Flow Data Files 41
Unsteady Flow Data Files 41
Quasi-Unsteady Flow Data Files 41
Sediment Data Files 42
Water Quality Data Files 42
Hydraulic Design Data Files 42
CREATING, OPENING, SAVING, RENAMING, AND DELETING PROJECTS 43
PROJECT OPTIONS 44
6 ENTERING AND EDITING GEOMETRIC DATA 45
DEVELOPING THE RIVER SYSTEM SCHEMATIC 46
Adding Tributaries into an Existing Reach 48
Editing the Schematic 48
Interacting with the Schematic 50
Background Map Layers 53
CROSS SECTION DATA 54
Entering Data 54
Editing Data 56
Options 57
Plotting 64
STREAM JUNCTIONS 64
Entering Junction Data 64
Selection a Modeling Approach 65
BRIDGES AND CULVERTS 66
Cross Section Locations 67
Contraction and Expansion Losses 69
Bridge Hydraulic Computations 70
Low Flow Computations 70
Pressure Flow Computations 71
Weir Flow Computations 71
Combination Flow 71

Entering and Editing Bridge Data 71
Bridge Design Editor 84
Culvert Hydraulic Computations 86
Entering and Editing Culvert Data 87
Bridge and Culvert Options 91
Bridge and Culvert View Features 93
MULTIPLE BRIDGE/CULVERT OPENINGS 94
Entering Multiple Opening Data 94
Defining the Openings 96
Multiple Opening Calculations 98
INLINE STRUCTURES (DAMS, WEIRS AND GATED SPILLWAYS) 98
Entering and Editing Inline Structure Data 98
Weir/Embankment Editor 100
Gated Spillway Editor 102
Geometric Properties of the Gates 104
Gate Flow Coefficients 104
Coefficients for Weir Flow over the Gate Sill 105
User Defined Gate Curves 106
Culverts 108
Outlet Rating Curves 108
Outlet Time Series 108
LATERAL STRUCTURES (WEIRS, GATED SPILLWAYS, CULVERTS, AND DIVERSION RATING CURVES) 109
Entering and Editing Lateral Structure Data 109
Weir/Embankment Editor 114
Gated Spillway Editor 117
Culvert Editor 118
Diversion Rating Curve Editor 119
Outlet Time Series 120
Linear Routing Option 120
STORAGE AREAS 121
2D FLOW AREAS 124
Draw a Polygon Boundary for the 2D Flow Area 124

Adding Break Lines inside of the 2D Flow Area 125
Creating the 2D Flow Area Computational Mesh 126
Break Lines 131
Hand Based Mesh Editing Tools 131
STORAGE AREA AND 2D FLOW AREA CONNECTIONS 133
Weir Embankment Editor 135
Culvert Data Editor 135
Gate Data Editor 138
Diversion Rating Curve 139
Outlet Time Series 140
Linear Routing Option 140
2D FLOW AREA AND STORAGE AREA EXTERNAL BOUNDARY CONDITIONS 141
PUMP STATIONS 141
CROSS SECTION INTERPOLATION 148
RIVER ICE 155
Entering and Editing Ice Data 155
Entering Ice Data at a Cross Section 155
Entering Ice Data Through a Table 157
Entering Ice Data at Bridges 158
Setting Tolerances for Ice Jam Calculations 159
VIEWING AND EDITING DATA THROUGH TABLES 160
Manning's n or k values 160
Reach Lengths 161
Contraction and Expansion Coefficients (Steady Flow) 162
Contraction and Expansion Coefficients (Unsteady Flow) 163
Minor Losses 164
Bank Stations 164
Levees 165
Ice Cover 165
Names 165
River and Reach Names 165
River Stationing 165
Node Names 166

Node Descriptions 167
Junctions 167
Storage Areas 167
Storage Area Connections 167
Pump Stations 168
Picture File Associations 168
Ineffective Flow Area Elevations 168
Bridge Width Table 168
Weir and Gate Coefficient Table 169
HTAB Internal Boundaries Table 170
Linear Routing Coefficients 171
Preissmann Slots on Lidded XS's 172
Manning's n by Land Classification 173
IMPORTING GEOMETRIC DATA 174
Supported File Formats 175
GIS Format 175
USACE Survey Data Format 175
HEC-2 Data Format 175
HEC-RAS Format 175
UNET Geometric Data Format 175
MIKE11 Cross-Section Data 176
CSV (Comma Separate Value) Format 176
Geometric Data Importer 176
River Reach Stream Lines 177
Cross Section and IB Nodes 179
Match River Stations to Existing Geometry 180
Round Selected River Stations 180
Create River Stations 180
Storage Areas and Connections 181
GEOMETRIC DATA TOOLS 181
Graphical Cross Section Editor 182
Bank Station Tools 183
Persistent Scale 184
Compare Geometry Files 184
Merge Cross Sections 185

Channel Bank Stations 186
Reverse Stationing Data 186
Cross Section Points Filter 187
Fixed Sediment Elevations 189
Pilot Channels 191
Ineffective Areas - Set to Permanent Mode 193
Ineffective Areas – Fix Overlapping 194
Ineffective Areas – Convert Multiple Blocks to Single “Normal” Ineffective 194
Manning’s n Set Channel to Single Value 194
Vertical Datum Adjustment 194
Reach Connectivity 194
Reach Order for Computations 194
Reach Order – Find Loops 195
Flow Roughness Factors 195
GEOMETRIC DATA OPTIONS 197
Main Channel Manning's n Value Compositing 198
Hydrologic Unsteady Routing 198
GEOREFERENCING AN HEC-RAS MODEL 200
GIS Tools in HEC-RAS 201
Tables 201
GIS Cut Lines 204
Scale Cut Lines to Reach Lines 205
GIS Coordinate Operations 205
Plot GIS Profile Reach Bounds 206
EXAMPLE OF GEOREFERENCING AN HEC-RAS MODEL 207
Creating the River Network using HEC-GeoRAS 207
Creating the River Network using HEC-RAS 210
Importing the Stream Centerline 211
Storage Areas and Connections 214
Cross Sections 216
ATTACHING AND VIEWING PICTURES 221
SAVING THE GEOMETRIC DATA 223
7 PERFORMING A STEADY FLOW ANALYSIS 224

ENTERING AND EDITING STEADY FLOW DATA 224
Entering Steady Flow Data 224
Steady Flow Data Options 225
Saving the Steady Flow Data 230
Importing Data from the HEC Data Storage System (HEC-DSS) 230
Importing Flows from an Existing Output Profile 232
PERFORMING STEADY FLOW CALCULATIONS 233
Simulation Options 233
8 PERFORMING A 1D UNSTEADY FLOW ANALYSIS 239
ENTERING AND EDITING UNSTEADY FLOW DATA 239
Unsteady Flow Data 239
Boundary Conditions 240
Flow Hydrograph 241
Stage Hydrograph 243
Stage and Flow Hydrograph 243
Rating Curve 243
Normal Depth 244
Lateral Inflow Hydrograph 245
Uniform Lateral Inflow Hydrograph 245
Groundwater Interflow 245
Time Series of Gate Openings 245
Elevation Controlled Gate 246
Navigation Dam 247
Internal Boundary Stage and/or Flow Hydrograph 247
"Rules" Editor 249
Precipitation 249
Initial Conditions 249
Meteorological Data 251
Unsteady Flow Data Options 252
Observed Data 252
Observed Stage and Flow Time Series Data 252
High Water Marks 256
Observed Rating Curves 256
Saving the Unsteady Flow Data 257

PERFORMING UNSTEADY FLOW CALCULATIONS 257
Defining a Plan 258
Selecting Programs to Run 259
Geometric Preprocessor 259
Cross Section Property Tables 259
Hydraulic Structure Property Tables 260
Viewing the Preprocessor Hydraulic Properties Tables 261
Unsteady Flow Simulation 262
Post-Processor 263
Simulation Time Window 264
Unsteady Flow Computation Settings 264
Unsteady Flow Simulation Options 266
Saving the Plan Information 289
Starting the Computations 289
CALIBRATION OF UNSTEADY FLOW MODELS 290
Observed Hydrologic Data 291
River and Floodplain Geometry 293
Roughness Coefficients 294
River and Floodplain Storage 298
Hydraulic Structure Coefficients 300
Tools Available in HEC-RAS to aid in Model Calibration 300
Steps To Follow in the Calibration Process 301
General Trends When Adjusting Model Parameters 301
Calibration Suggestions and Warnings 302
MODEL ACCURACY, STABILITY, AND SENSITIVITY 303
Model Accuracy 303
Model Stability 303
Model Sensitivity 319
FINDING AND FIXING MODEL STABILITY PROBLEMS 320
Utilizing the Profile Plot. 322
Computational Level Output for Debugging 322
Detailed Log Output for Debugging 323
PERFORMING A DAM OR LEVEE BREACH ANALYSIS WITH HEC-RAS 327

User Enter Breach Data 328
Simplified Physical Breaching 331
DL Breach 334
DLBreach Data and Parameterization in HEC-RAS 335
Transport Parameters 344
DL Breach Acknowledgements and References 354
USING HEC-RAS TO COMPUTE UNGAGED LATERAL INFLOWS 355
Observed Stage and Flow Data 355
Lateral Inflow Computations 357
Computations and Output 360
9 VIEWING RESULTS 362
CROSS SECTIONS, PROFILES, AND RATING CURVES 362
Viewing Graphics on the Screen 362
Graphical Plot Options 365
Plotting Velocity Distribution Output 367
Plotting Other Variables in Profile 368
Plotting One Variable versus Another 369
Sending Graphics to the Printer or Plotter 370
Sending Graphics to the Windows Clipboard 370
3D PERSPECTIVE PLOTS 371
Pre-processing Results for 3D Viewing 373
3D Viewer 373
Menu and Options 374
Controls 375
Particle Tracing 377
Toolbar 378
Min map 379
Speed/Position Information 381
How To Use the 3D Viewer 381
Movement 381
Changing View/Rotation 382
Changing Elevation 382
Mouse Lock/Unlock 382
Flight Plans/Paths 382

Flight Plan Toolbar 385
BREACH HYDROGRAPH PLOT 385
STAGE AND FLOW HYDROGRAPHS 387
TABULAR OUTPUT 388
Detailed Output Tables 388
Detailed Output Table Options 392
Profile Summary Tables 393
User Defined Output Tables 395
Sending Tables to the Printer 396
Sending Tables to the Windows Clipboard 397
VIEWING RESULTS FROM THE RIVER SYSTEM SCHEMATIC 397
VIEWING COMPUTATIONAL LEVEL OUTPUT FOR UNSTEADY FLOW 398
VIEWING ICE INFORMATION 400
Graphical Ice Information 400
Tabular Ice Information 402
VIEWING DATA CONTAINED IN AN HEC-DSS FILE 403
EXPORTING RESULTS TO HEC-DSS 405
INUNDATION MAPPING WITH HEC-RAS MAPPER 408
10 PERFORMING A FLOODPLAIN ENCROACHMENT ANALYSIS 410
OVERVIEW 410
ENTERING FLOODPLAIN ENCROACHMENT DATA 411
PERFORMING THE FLOODPLAIN ENCROACHMENT ANALYSIS 414
VIEWING THE FLOODPLAIN ENCROACHMENT RESULTS 414
FLOODWAY ENCROACHMENTS WITH UNSTEADY FLOW 419
11 HYDRAULIC DESIGN (HD) CALCULATORS 421
COMPUTING SCOUR AT BRIDGES 422
General Modeling Guidelines 422
Entering Bridge Scour Data 423
Entering Contraction Scour Data 424
Entering Pier Scour Data 427
Entering Abutment Scour Data 430
Computing Total Bridge Scour 432
RIPRAP AND SCOUR CALCULATOR 434

Introduction and Conceptual Approach 435
Riprap Calculator: Sizing Rock Gradation 435
Scour Calculator: Computing Launchable Volume 435
Introduction and Conceptual Approach 435
Riprap Calculator: Sizing Rock Gradation 437
Step 1: Calculate Hydraulics and Select Profile 440
Step 2: Identify Design and Upstream Reference XSs 445
Step 3a: Define Manual Input Variables 449
Step 3b: Select Riprap Coefficient Parameters 454
Step 4: Compute the d30 of the Stable Rock Size 456
Step 5: Select Gradation to Compute Thickness 460
Rock Size and Weight Specifications 470
Limitation: Why Doesn't the Riprap and Scour Calculator use 2D Results? 471
Maricopa Method 471
Scour Calculator: Computing Launchable Volume 481
Step 1: Compute Hydraulics 482
Step 2: Identify Design and Reference Cross Sections 483
Step 3: Define Manual Input Variables 485
Step 4: Select the Appropriate Equations 486
Step 5: Compute Ensemble Scour Results 490
Step 6: Visualizing Scour Results 491
Step 7: Select a Reasonable Scour Depth Based on Calculations, Regional Geology, and Engineering Judgement 494
Ongoing Work and Wish List 494
Acknowledgement 495
Scour References 495
Appendix A: Example Calculations 496
Riprap Examples 496
Scour Examples 499
UNIFORM FLOW COMPUTATIONS 501
Solving for Slope, Discharge, or W/S Elevation 502
Solving for Bottom Width 503
Applying Uniform Flow Data to the Geometry File 505
Saving Uniform Flow Data 506
STABLE CHANNEL DESIGN FUNCTIONS 506

General Modeling Guidelines 506
General Command Buttons 506
Stable Channel Design 507
Copeland Method 508
Regime Method 512
Tractive Force Method 513
SEDIMENT TRANSPORT CAPACITY 514
SEDIMENT RATING CURVE ANALYSIS TOOL 520
Sediment Rating Curve Challenges and Best Practices 521
Opening the Sediment Rating Curve Analysis Tool 523
Funding and Support 523
Importing Sediment Data 523
Downloading Data From USGS 524
Converting Between Flow and Concertation 528
Clipboard Import 528
Importing Data Files 529
Bias Correction 533
Where Does The Bias Come From? 533
Bias Correction Functions 535
Bias Correction Results 535
References 537
Piecewise Linear Regression 537
Piecewise Regression Approach 538
Constraining the Inflection Point Range 539
Stationarity 543
The Stationarity Slide Bar 543
Temporal Averaging and Autocorrelation 546
Temporal Averaging 548
Setting the Temporal Averaging Threshold 549
Plotting Original and Averaged Points 550
Hysteresis Visualization 551
Analytical and Tabular Rating Curve Results 553
Regression Results (Analytical Results) 554
Generating a Tabular Rating Curve (Tabular Results) 556
Gradation Trend Analysis 559

Suspended Load Gradation Trends 560
Viewing Suspended Load Gradations 561
12 TROUBLESHOOTING WITH HEC-RAS.....563
BUILT IN DATA CHECKING..... 563
Checking the Data as it is Entered..... 563
Data Checking before Computations are Performed..... 564
ERRORS, WARNINGS, AND NOTES..... 564
STEADY FLOW LOG OUTPUT..... 566
UNSTEADY FLOW LOG OUTPUT..... 567
VIEWING THE LOG FILE 568
REVIEWING AND DEBUGGING THE NORMAL OUTPUT..... 568
Viewing Graphics..... 568
Viewing Tabular Output..... 569
The Occurrence of Critical Depth 569
COMPUTATIONS DO NOT RUN TO COMPLETION 569
13 PERFORMING CHANNEL DESIGN/MODIFICATIONS 571
GENERAL MODELING GUIDELINES 571
THE CHANNEL MODIFICATION (ORIGINAL) OPTIONS..... 571
Entering Channel Modification Data 572
Performing the Channel Modifications 575
THE CHANNEL DESIGN/MODIFICATION TOOL OPTIONS..... 576
Entering Channel Modification Data 576
Alternatives 577
Template Design 579
Modify a Range of XS..... 582
Performing the Channel Modifications 584
COMPARING EXISTING AND MODIFIED CONDITIONS 587
14 ADVANCED FEATURES FOR UNSTEADY FLOW ROUTING 590
MIXED FLOW REGIME..... 590
DAM BREAK ANALYSIS..... 594
Entering Dam Break Data 596
User Enter Breach Data..... 598
Simplified Physical Breaching..... 602

Breach Growth Shape 605
Estimating Dam Break Parameters 606
Breach Parameter Calculator 607
HEC-RAS Output for Dam Break Analyses 608
LEVEE OVERTOPPING AND BREACHING 610
MODELING PUMP STATIONS 617
NAVIGATION DAMS 623
Pool Only Control 625
Hinge Point Only Control 627
Hinge Point and Minimum Pool Operations 629
Hinge Point and Minimum and Maximum Pool Control 631
MODELING PRESSURIZED PIPE FLOW 633
USER DEFINED RULES FOR HYDRAULIC STRUCTURES AND PUMPS 636
Entering Rule Operations 638
Rule Sets 639
Operation Rules 639
Operation Types 640
Comment 640
New Variable 641
Get Simulation Value 643
Set Operational Parameter (for hydraulic structures) 647
Set Operational Parameter (for pumping stations) 651
Branch (If/Else): 654
AUTOMATED CALIBRATION OF MANNING'S N VALUES FOR UNSTEADY FLOW 678
Using the Automated Calibration Feature 681
Calibration Parameters 685
15 REFERENCES 689
16 HEC-RAS DATA EXCHANGE 694
SPATIAL DATA FORMAT 694
Records 694
Keywords 695
Values 695
Data Groups 695

Comments 695
SPATIAL DATA FORMAT 696
RAS GIS IMPORT FILE (RASIMPORT.SDF) 696
Header 696
River Network 697
Cross Sections0 698
Additional Cross Section Properties 699
Bridge_Culverts 700
Inline Structures 701
Lateral Structures 702
Storage Areas0 703
Storage Area Connections 704
RAS GIS EXPORT FILE (RASEXPORT.SDF) 704
Water Surface Bounding Polygon 706
IMPORT/EXPORT GUIDELINES 707
Defining the River Network 707
Defining Cross Sections 707
Water Surface Export Data Rules 707
SAMPLE RAS GIS IMPORT FILE 707
SAMPLE RAS GIS EXPORT FILE 713
17 HEC-RAS OUTPUT VARIABLES 719
HYDRAULIC OUTPUT VARIABLES 719
SEDIMENT TRANSPORT OUTPUT VARIABLES 724
18 IMPORTING HEC-2 DATA 727
WHAT YOU SHOULD KNOW FIRST 727
STEPS FOR IMPORTING HEC-2 DATA 728
REPRODUCING HEC-2 RESULTS 729
19 TERMS AND CONDITIONS OF USE 731

Welcome to the River Analysis System