

Running a 2D Model

Cameron Ackerman, P.E., D.WRE

USACE, Institute for Water Resources, Hydrologic Engineering Center





Overview

- Performing Computations
 - 2D Preprocessor
- Computation Options
- Cell Size Considerations
 - Associating a Terrain Model
- Time Step Selection



Performing Computations

- Floodplain Mapping
 - Creates a stored map
 - Must set up map in RAS Mapper prior to run
- Mapping Output Interval
 - Time Series Data written to HDF file at Cross Sections, Storage Areas, and 2D Cells
 - XS
 - WSE, Flow, Velocity
 - Cells
 - WSE, Depth cell center
 - Velocity at cell faces

Unsteady Flow Analysis

File Options Help

Plan: Grid 400ft Short ID: Grid 400ft

Geometry File: Grid400ft

Unsteady Flow File: Flow Boundary Conditions

Programs to Run

- Geometry Preprocessor
- Unsteady Flow Simulation
- Sediment
- Post Processor
- Floodplain Mapping

Plan Description

Simulation time window

Starting Date: 02JAN1900 Starting Time: 0000

Ending Date: 02JAN1900 Ending Time: 2400

Computation Settings

Computation Interval: 10 Second

Mapping Output Interval: 5 Minute

Hydrograph Output Interval: 5 Minute

Detailed Output Interval: 1 Hour

Project DSS Filename: C:\Users\q0heccta\Documents\Projects_RASMapper\Mun...

1 Levee (Lateral Structure) with breach data. 1 set to breach.

Compute



Performing Computations

1. Writing 1D Geometry
 - Bank Lines, Edge Lines (1D)
 - Interpolation Surface (1D)
2. 2D Geometry Preprocessor
 - Process 2D Cells and Faces
3. 1D Geometry Preprocessor
 - Hydraulic Tables for Cross Sections
4. Unsteady Flow Simulation
5. Post Processor (1D only)

HEC-RAS Finished Computations

Write Geometry Information
Layer: Complete

Geometry Processor
River: MissRiver RS: 29569.19
Reach: Below_Grey_Cloud Node Type: Cross Section
IB Curve:

Unsteady Flow Simulation
Simulation:
Time: 384.0000 18FEB2099 00:00:00 Iteration (1D): 0 Iteration (2D): 0
Writing Profiles 500

Post Process
River: MissRiver RS: 151400
Reach: thru_St_Paul Node Type:
Profile: 17FEB2099 2400
Simulation: 66/66

Computation Messages

Plan: 'Fail Middle - 2D Run Modified' (StPaulIES.p03)
Simulation started at: 16Jul2014 01:10:38 PM
Using 64 Bit Computation Engines

Writing Geometry
Computing Bank Lines
Bank lines generated in 303 ms
Computing River Edge Lines
River Edge Lines generated in 302 ms
There are no stored interpolation surfaces
Interpolation Surfaces will be recomputed
Computing XS Interpolation Surfaces
XS Interpolation Surfaces generated in 374 ms
Geometry 'GeomWriter' association was set to the terrain layer (Terrain)
Computing 2D Flow Area '2DArea' tables
2D Flow Area '2DArea' tables complete 12.76 sec
Completed writing geometry

Geometric Preprocessor HEC-RAS 5.0.0 Beta June 2014
10 Internal Boundary curve(s) have been read in

Finished Processing Geometry

Writing event conditions
Event conditions complete

Performing Unsteady Flow Simulation HEC-RAS 5.0.0 Beta June 2014

Finished Unsteady Flow Simulation

Writing Results to DSS
Finished Writing Results to DSS

Reading Data for Post Process

Running Post Processor HEC-RAS 5.0.0 Beta June 2014

Finished Post Processing

Computations Summary

Computation Task	Time(hh:mm:ss)
Completing Geometry	15
Preprocessing Geometry(64)	1
Unsteady Flow Computations(64)	1:11
Writing to DSS(64)	7
Post-Processing(64)	30
Complete Process	2:06

Pause Take Snapshot of Results Close



2D Pre-processor to compute cell information

Unsteady-flow Simulation

Writing Geometry
 Computing Bank Lines
 Bank lines generated in 303 ms
 Computing River Edge Lines
 River Edge Lines generated in 302 ms
 There are no stored interpolation surfaces
 Interpolation Surfaces will be recomputed
 Computing XS Interpolation Surfaces
 XS Interpolation Surfaces generated in 374 ms
 Geometry 'GeomWriter' association was set to the terrain layer (Terrain)
Computing 2D Flow Area '2DArea' tables
 2D Flow Area '2DArea' tables complete 12.76 sec
 Completed writing geometry

RAS Mapper – 2D Flow Areas

The screenshot shows the RAS Mapper interface with a layer list on the left and a context menu open over the '2D Flow Areas' layer. The layer list includes:

- Geometries
 - Bald Eagle Multi 2D Areas
 - 1D-2D Dam Break Model Refined Grid
 - Rivers
 - XS
 - Storage Areas
 - 2D Flow Areas
 - Bridges/
 - Inline Str
 - Lateral S
 - SA/2D C
 - Pump St
 - BC Lines
 - Manning
 - Infiltrat
 - Percent
 - Referen
 - Errors
 - U.S 2D - D.S
 - 2D to 2D Co
 - SA to 2D Co
 - Single 2D Ar
 - SA to 2D Flow Area
 - SA to 2D Flow Area - Detailed

The context menu for '2D Flow Areas' includes the following options:

- Layer Properties
- Open Attribute Table
- Edit Geometry
- Zoom to Layer
- Move Layer
- Export Layer
- Open Folder in File Explorer
- Compute 2D Flow Areas Hydraulic Tables** (highlighted)
- Plot Property Table
- Find



Computation Options

- Defaults
- Per 2D Flow Area

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | **Advanced Time Step Control** | 1D Mixed Flow Options

Use Coriolis Effects (not used with Diffusion Wave equation)

	Parameter	(Default)	BaldEagleCr
1	Theta (0.6-1.0)	1	1
2	Theta Warmup (0.6-1.0)	1	1
3	Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	Diffusion Wave
7	Initial Conditions Time (hrs)		4
8	Initial Conditions Ramp Up Fraction (0-1)	0.5	0.5
9	Number of Time Slices (Integer Value)	1	1
10	Turbulence Model	<i>Non-Conservative (original)</i>	<i>Non-Conservative (original)</i>
11	Longitudinal Mixing Coefficient		
12	Transverse Mixing Coefficient		
13	Smagorinsky Coefficient	0	0
14	Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	6 Cores	6 Cores
17	Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18	Convergence Tolerance		
19	Minimum Iterations		
20	Maximum Iterations		
21	Restart Iteration	10	10
22	Relaxation Factor	1.3	1.3
23	SOR Preconditioner Iterations	10	10

OK Cancel Defaults ...



Computation Options

- Theta
- Theta Warmup
- Water Surface Tol
- Volume Tolerance
- Max Iterations

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

Use Coriolis Effects (not used with Diffusion Wave equation)

Parameter	Default	Value
1 Theta (0.6-1.0)		1
2 Theta Warmup (0.6-1.0)		1
3 Water Surface Tolerance [max=0.2](ft)		0.01
4 Volume Tolerance (ft)		0.01
5 Maximum Iterations		20
6 Equation Set	Diffusion Wave	Diffusion Wave
7 Initial Conditions Time (hrs)		4
8 Initial Conditions Ramp Up Fraction (0-1)		0.5
9 Number of Time Slices (Integer Value)		1
10 Turbulence Model	Non-Conservative (original)	Non-Conservative (original)
11 Longitudinal Mixing Coefficient		
12 Transverse Mixing Coefficient		
13 Smagorinsky Coefficient		0
14 Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
15 Latitude for Coriolis (-90 to 90)		
16 Solver Cores	6 Cores	6 Cores
17 Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18 Convergence Tolerance		
19 Minimum Iterations		
20 Maximum Iterations		
21 Restart Iteration		10
22 Relaxation Factor		1.3
23 SOR Preconditioner Iterations		10

OK Cancel Defaults ...



Computation Options

- Equation Set
- Diffusion Wave
- Shallow Water Eqn (faster)
- Shallow Water Eqn (conservative)

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

Use Coriolis Effects (not used with Diffusion Wave equation)

Parameter	(Default)	BaldEagleCr
1 Theta (0.6-1.0)	1	1
2 Theta Warmup (0.6-1.0)	1	1
3 Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4 Volume Tolerance (ft)	0.01	0.01
5 Minimum Iterations	10	10
6 Equation Set	Diffusion Wave	Diffusion Wave
7 Initial Conditions Time (s)		
8 Initial Conditions Ramp Up Fraction (0-1)	0.5	Diffusion Wave SWE-ELM (original/faster) SWE-EM (stricter momentum)
9 Number of Time Slices (Integer Value)	1	
10 Turbulence Model	Non-Conservative (original)	Non-Conservative (original)
11 Longitudinal Mixing Coefficient		
12 Transverse Mixing Coefficient		
13 Smagorinsky Coefficient	0	0
14 Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
15 Latitude for Coriolis (-90 to 90)		
16 Solver Cores	6 Cores	6 Cores
17 Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18 Convergence Tolerance		
19 Minimum Iterations		
20 Maximum Iterations		
21 Restart Iteration	10	10
22 Relaxation Factor	1.3	1.3
23 SOR Preconditioner Iterations	10	10

OK Cancel Defaults ...



Computation Options

Initial Conditions

- Time
- Ramp Up Fraction

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

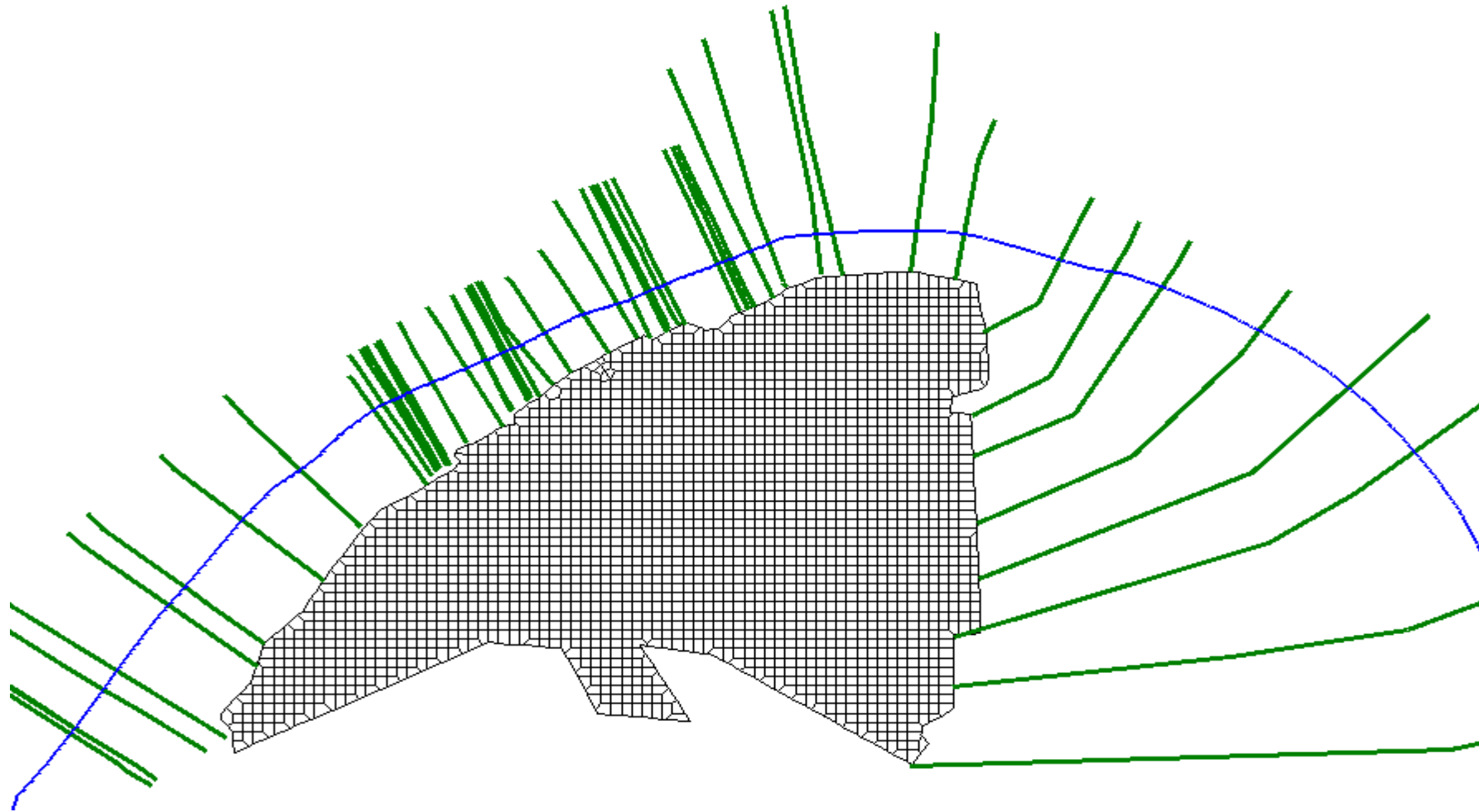
Use Coriolis Effects (not used with Diffusion Wave equation)

	Parameter	(Default)	BaldEagleCr
1	Theta (0.6-1.0)	1	1
2	Theta Warmup (0.6-1.0)	1	1
3	Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	Diffusion Wave
7	Initial Conditions Time (hrs)		4
8	Initial Conditions Ramp Up Fraction (0-1)	0.5	0.5
9	Number of Time Slices (Integer value)	1	1
10	Turbulence Model	Non-Conservative (original)	Non-Conservative (original)
11	Longitudinal Mixing Coefficient		
12	Transverse Mixing Coefficient		
13	Smagorinsky Coefficient	0	0
14	Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	6 Cores	6 Cores
17	Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18	Convergence Tolerance		
19	Minimum Iterations		
20	Maximum Iterations		
21	Restart Iteration	10	10
22	Relaxation Factor	1.3	1.3
23	SOR Preconditioner Iterations	10	10

OK Cancel Defaults ...



1D/2D Model and Computational Time Step





Computation Options

- Time Slices

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

Use Coriolis Effects (not used with Diffusion Wave equation)

	Parameter	(Default)	BaldEagleCr
1	Theta (0.6-1.0)	1	1
2	Theta Warmup (0.6-1.0)	1	1
3	Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	Diffusion Wave
7	Initial Conditions Time (hrs)		4
8	Initial Conditions Ramp Up Equation (0-1)	0.5	0.5
9	Number of Time Slices (Integer Value)	1	1
10	Turbulence Model	Non-Conservative (original)	Non-Conservative (original)
11	Longitudinal Mixing Coefficient		
12	Transverse Mixing Coefficient		
13	Smagorinsky Coefficient	0	0
14	Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	6 Cores	6 Cores
17	Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18	Convergence Tolerance		
19	Minimum Iterations		
20	Maximum Iterations		
21	Restart Iteration	10	10
22	Relaxation Factor	1.5	1.5
23	SOR Preconditioner Iterations	10	10

OK Cancel Defaults ...



Computation Options

- Boundary Condition Volume Check

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

Use Coriolis Effects (not used with Diffusion Wave equation)

Parameter	(Default)	BaldEagleCr
1 Theta (0.6-1.0)	1	1
2 Theta Warmup (0.6-1.0)	1	1
3 Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4 Volume Tolerance (ft)	0.01	0.01
5 Maximum Iterations	20	20
6 Equation Set	Diffusion Wave	Diffusion Wave
7 Initial Conditions Time (hrs)		4
8 Initial Conditions Ramp Up Fraction (0-1)	0.5	0.5
9 Number of Time Slices (Integer Value)	1	1
10 Turbulence Model	<i>Non-Conservative (original)</i>	<i>Non-Conservative (original)</i>
11 Longitudinal Mixing Coefficient		
12 Transverse Mixing Coefficient		
13 Smagorinsky Coefficient		
14 Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
15 Latitude for Coriolis (-90 to 90)		
16 Solver Cores	6 Cores	6 Cores
17 Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18 Convergence Tolerance		
19 Minimum Iterations		
20 Maximum Iterations		
21 Restart Iteration	10	10
22 Relaxation Factor	1.3	1.3
23 SOR Preconditioner Iterations	10	10

OK Cancel Defaults ...



Computation Option

- Number of Cores

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

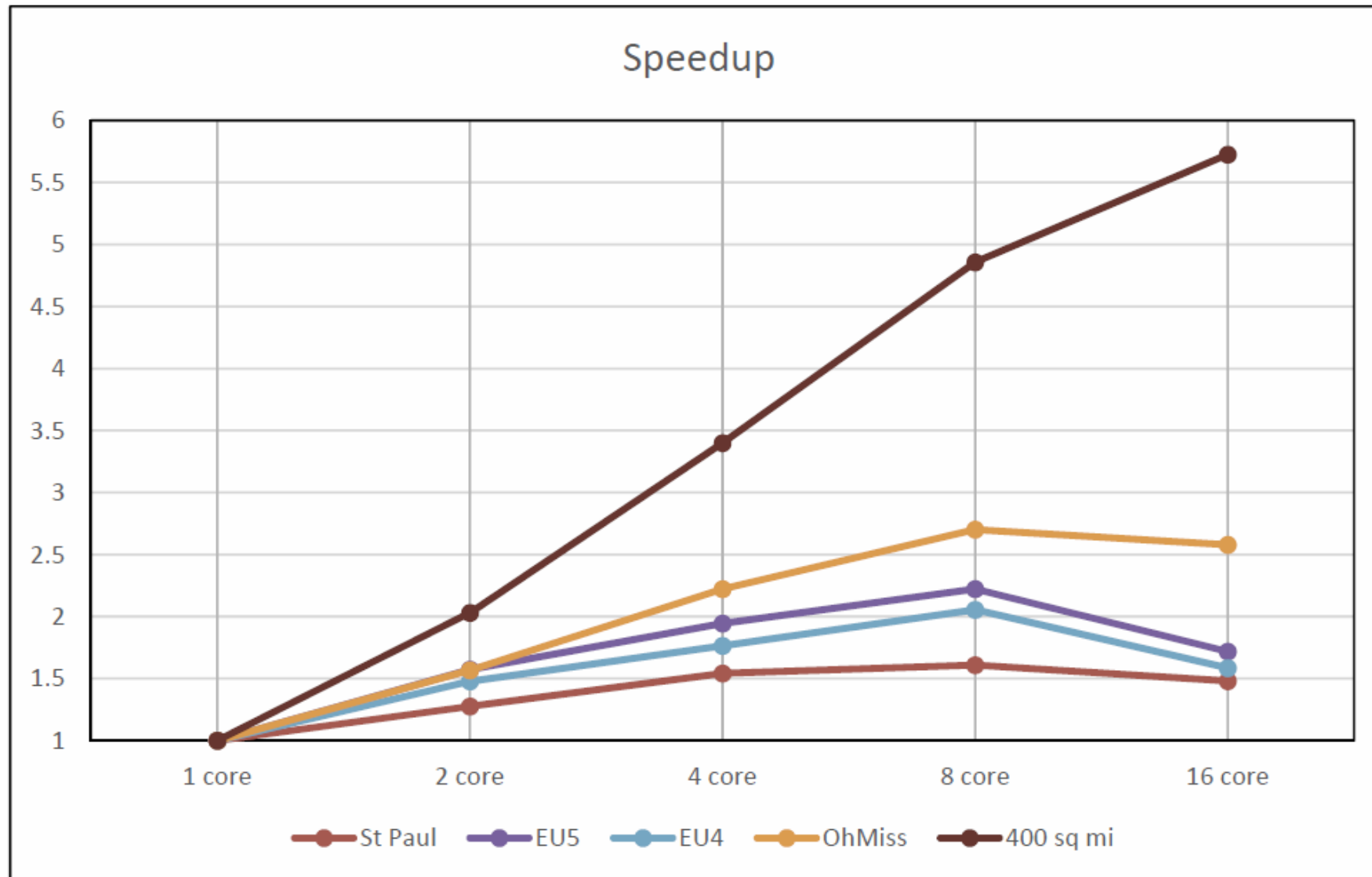
Use Coriolis Effects (not used with Diffusion Wave equation)

Parameter	(Default)	BaldEagleCr
1 Theta (0.6-1.0)	1	1
2 Theta Warmup (0.6-1.0)	1	1
3 Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4 Volume Tolerance (ft)	0.01	0.01
5 Maximum Iterations	20	20
6 Equation Set	Diffusion Wave	Diffusion Wave
7 Initial Conditions Time (hrs)		4
8 Initial Conditions Ramp Up Fraction (0-1)	0.5	0.5
9 Number of Time Slices (Integer Value)	1	1
10 Turbulence Model	<i>Non-Conservative (original)</i>	<i>Non-Conservative (original)</i>
11 Longitudinal Mixing Coefficient		
12 Transverse Mixing Coefficient		
13 Smagorinsky Coefficient	0	0
14 Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
15 Latitude for Coriolis (90 to 00)		
16 Solver Cores	6 Cores	6 Cores
17 Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18 Convergence Tolerance		
19 Minimum Iterations		
20 Maximum Iterations		
21 Restart Iteration	10	10
22 Relaxation Factor	1.5	1.5
23 SOR Preconditioner Iterations	10	10

OK Cancel Defaults ...



Processing Time vs Number of Cores





Cell Size

- Cell size determination is based on
 - Land surface features of the Terrain
 - Faces control water movement
 - Water Surface Slope
 - Capturing localized effects in model requires smaller cell sizes (analogous to cross section spacing for rapidly varied flow).
- Start with a “large” cell size and refine the model through iteration.
- You always test different cell sizes to see what affect they have on water surfaces and velocities.



Time Step

- Time Step selection will be based on the size of the grid cells and velocity of water in the cells.
- Dependent on Equation Set selected
 - Diffusion Wave approximation
 - Full Shallow Water Equations

$$S_f = S_o - \frac{\partial y}{\partial x} - \frac{V}{g} \frac{\partial V}{\partial x} - \frac{1}{g} \frac{\partial V}{\partial t}$$



Time Step

- Full Shallow Water Equations
 - Experience shows, max C = 3.0

$$C = \frac{V * \Delta T}{\Delta X} \leq 1.0$$

- Diffusion Wave Approximation
 - Experience shows, max C = 5.0

$$C = \frac{V * \Delta T}{\Delta X} \leq 2.0$$

- C = Courant Number
- V = Velocity of the Flood Wave (ft/s)
- ΔT = Computational Time Step (seconds)
- ΔX = The average Cell size (ft)



Variable Time Step

- Reduce time step to improve accuracy
- Increase time step to reduce computation times

HEC-RAS Finished Computations

Write Geometry Information
Layer: COMPLETE

Geometry Processor
River: RS:
Reach: Node Type: Storage Area
IB Curve:

Unsteady Flow Simulation
Simulation:
Time: 0.5000 01OCT2013 00:30:00 Iteration (1D):
Unsteady Flow Computations

Computation Messages

Performing Unsteady Flow Simulation HEC-RAS 5.0.4.1 May 2018

Custom Read/Flags

2D_X_WSEL

Maximum adaptive timestep = 04.0 Minimum adaptive timestep = 00.5
Initial adaptive timestep = 01.0

01OCT2013 00:00:05	timestep =	2	(sec)
01OCT2013 00:00:15	timestep =	1	(sec)
01OCT2013 00:00:16	timestep =	0.5	(sec)
01OCT2013 00:01:08	timestep =	1	(sec)
01OCT2013 00:01:57	timestep =	2	(sec)
01OCT2013 00:07:31	timestep =	4	(sec)

Writing Results to DSS



Time Step Options

- Fixed Time Step (default)
- Adjust Time Step Based on
 - Courant Number
 - Date/Time and a Time step divisor

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | **Advanced Time Step Control** | 2D M

Fixed Time Step (Basic method) 20 Second

Adjust Time Step Based on Courant

Maximum Courant: 4

Minimum Courant: 1.95

Number of steps below Minimum before doubling: 5

Maximum number of doubling base time step: 2 80.00 sec

Maximum number of halving base time step: 1 10.00 sec

Courant Methodology

Velocity/Length (face velocity * dt / cell to cell distance)

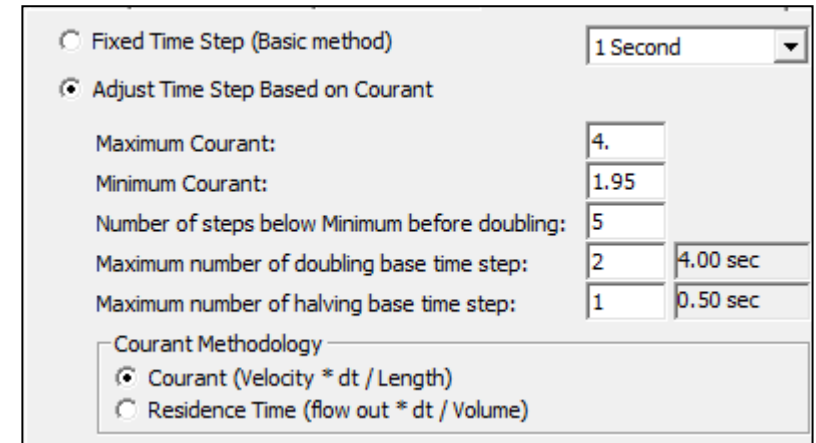
Residence Time (cell outflow * dt / cell volume)

Adjust Time Step Based on Time Series of Divisors Verify Dates ...

Time Step	Date(ddMMMyyyy hhmm)	Divisor
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Variable Time Step

- Maximum Courant before halving time step
- Minimum Courant before doubling time step
 - **Min < ½ Max !**
- Number of steps before doubling
- Maximum number of doubling
- Maximum number of halving
- Courant (default) or Residence Time



Fixed Time Step (Basic method) 1 Second
 Adjust Time Step Based on Courant

Maximum Courant:
 Minimum Courant:
 Number of steps below Minimum before doubling:
 Maximum number of doubling base time step: 4.00 sec
 Maximum number of halving base time step: 0.50 sec

Courant Methodology
 Courant (Velocity * dt / Length)
 Residence Time (flow out * dt / Volume)



Mapping Output Interval

- Adaptive time step is always integer interval of Mapping Output Interval, so Unsteady may need to adjust base Computation Interval

The screenshot displays the HEC-RAS software interface. On the left, the 'Computation Settings' panel shows 'Computation Interval' set to '2 Second' and 'Mapping Output Interval' set to '10 Second'. The 'Simulation Time Window' shows 'Starting Date' and 'Ending Date' both as '01OCT2013'. The 'DSS Output Filename' is 'C:\Users\q0hecssp\Doc'. A note states 'Time Step is controlled by courant condition.' On the right, the output log shows 'Maximum adaptive timestep = 10.0' and 'Minimum adaptive timestep = 00.625'. The 'Initial adaptive timestep = 01.25' is highlighted in red. The log lists several timesteps: 01OCT2013 00:00:06 (2.5 sec), 01OCT2013 00:00:16 (1.25 sec), 01OCT2013 00:00:17 (0.625 sec), 01OCT2013 00:01:22 (1.25 sec), 01OCT2013 00:03:25 (2.5 sec), and 01OCT2013 00:11:20 (5 sec). The log also indicates 'Writing Results to DSS' and 'Finished Unsteady Flow Simulation'. At the bottom, there are buttons for 'Comp', 'Pause', and 'Take Snapshot of Results'.

Time	timestep =	(sec)
01OCT2013 00:00:06	2.5	(sec)
01OCT2013 00:00:16	1.25	(sec)
01OCT2013 00:00:17	0.625	(sec)
01OCT2013 00:01:22	1.25	(sec)
01OCT2013 00:03:25	2.5	(sec)
01OCT2013 00:11:20	5	(sec)



Time Series of Divisors

- Control time step length by date
- Enter integer halving divisor to reduce time step

Simulation Time Window

Starting Date: 01JAN1999 Starting Time: 1200

Ending Date: 05JAN1999 Ending Time: 1300

Computation Settings

Computation Interval: 2 Minute Hydrograph Output Interval: 1 Hour

Mapping Output Interval: 1 Hour

Adjust Time Step Based on Time Series of Divisors Verify Dates ...

	Time Step	Date(ddMMMyyyy hhmm)	Divisor
1	60.00 sec	01JAN19991200	2
2	120.00 sec	02JAN19991200	1
3	60.00 sec	02JAN19991530	2
4	20.00 sec	03JAN19990200	6
5	40.00 sec	03JAN19990730	3

Questions?