2D Model Review

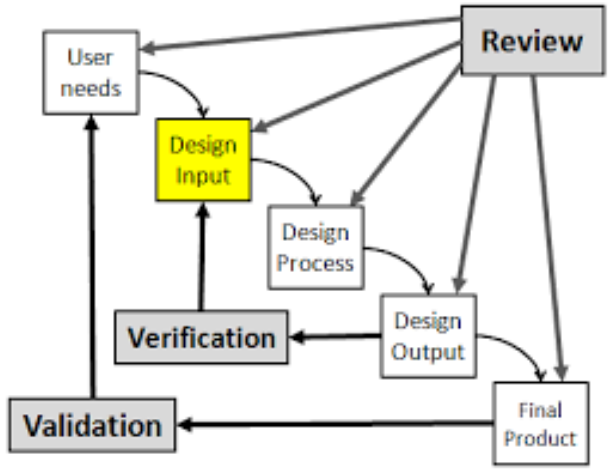
How to Review a 2D Hydraulic Model and
What to Submit to FEMA Workshop

By

Thomas Plummer

CIVIL ENGINEERING
SOLUTIONS, INC.

Why Review 2D Models?



How to Review a 2D Hydraulic Model and
What to Submit to FEMA Workshop

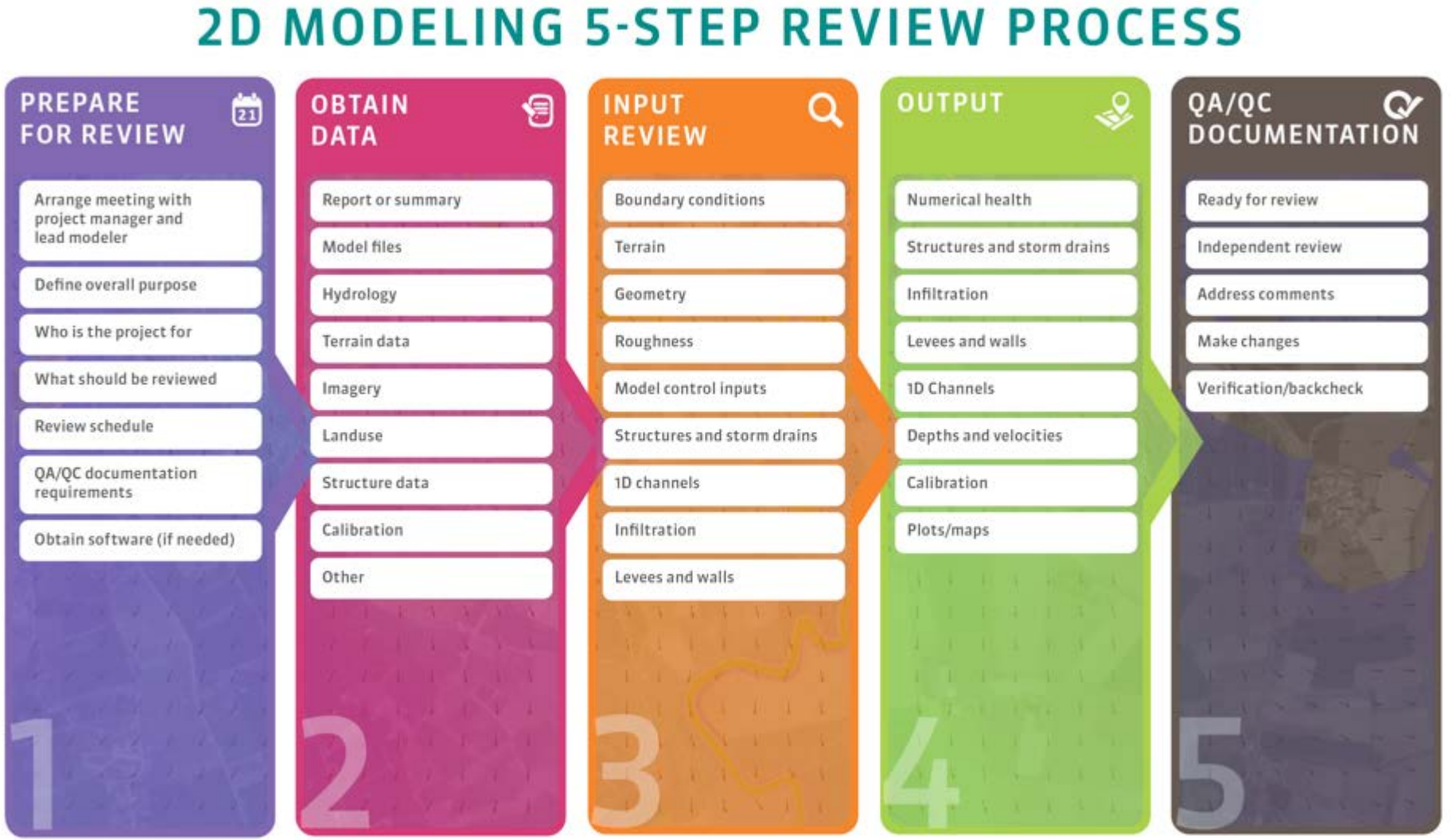
ACCURACY?

“

Accuracy is a product of sound engineering judgment and proper application of any model

Accuracy ~  X  !

Model Review Overview



1. PREPARE FOR REVIEW

The "Getting up to Speed Phase" you need to gain an understanding of:

•Understand the Purpos

•Who is the Analysis for

•What is the level of con purpose and Audience?

•Do you have the ability

•Am I a Disinterested In ver?

•What elements of the a

•Is the time allotted for r

•What is the intended pr

•DATA: What format is it

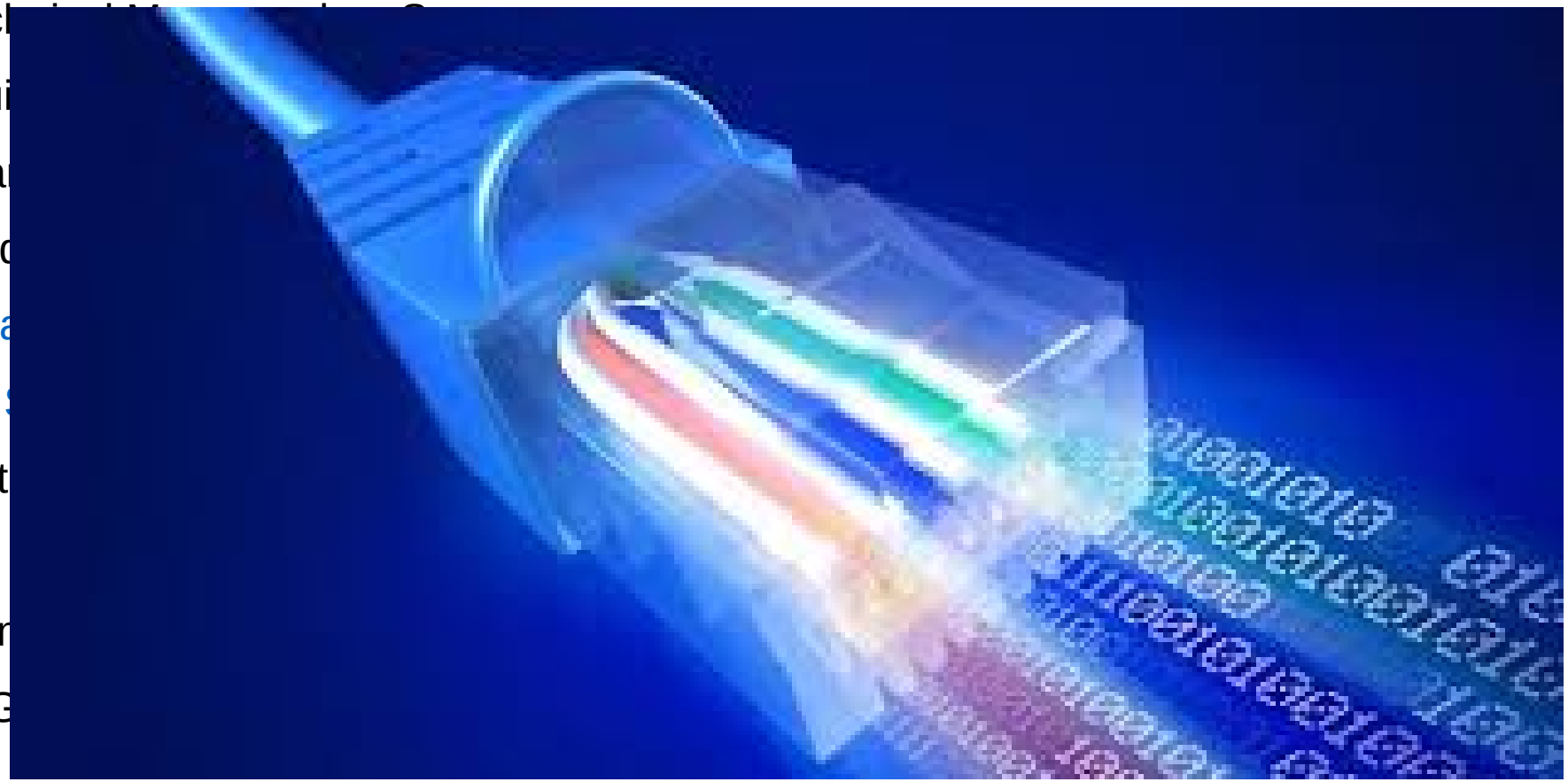
•What level of QA/QC in ith this in advance)

•Do I have Adequate So c…)

2. OBTAINING DATA

Items to Obtain:

- Report or Tech
- Agency Requi
- Model Input a
- Horizontal and
- Structure Data
- Terrain Data: S
- Resource Dat
- Rainfall Data:
- QA/QC Docur
- Data Types: G



2. OBTAINING DATA

Structures, Levees, and other Significant Model Elements:

- Engineering Drawings, or As-Builts (Hardcopy or Digital)
- Survey Data
- GIS or Database of Elements (MH, Inlets, Outlets, Sizes and Inverts, etc…)
- Maintenance Records (Debris?)

Digital Image and Photo Files:

- Images: Geo-Refenced?
- Photos: Geo Located – Is there a drawing that shows where all photos were taken and what direction they were taken

2. OBTAINING DATA

Terrains: Information About the Data:

- Vertical Datum and Horizontal Projection for each data provided
- Accuracy of the data for each
- When/how was the data obtained
- Conditions at the time the data was obtained (water in channel)
- Metadata

Terrain Data – Basis of the Surface:

- RAW Data (direct survey data, LiDAR data point files)
- Final Terrain Basis
  - Description of the process used to develop this
    - Combination of sources,
    - What data was excluded and why?
  - Locations where adjustments were made

2. OBTAINING DATA

Sources of Runoff Data:

- Previously reviewed and Approved/Accepted Study and/or Model
- Locally accepted method or model
- Stream gage data?
- Stated Values? (assumed)

Hydrology Data Sets:

- Soils Data
- Land cover, land use, vegetation type
- Infiltration potential
- Rainfall: Elevation varied, spatially varied

Hydrology – Reality Check other Resources:

- Compare to FEMA FIS published rates?
- Compare to USGS regression equations
- Compare to NOAA Atlas
- Compare to historical known events or locally recorded information

3. INPUT REVIEW

Boundary Conditions Verification:

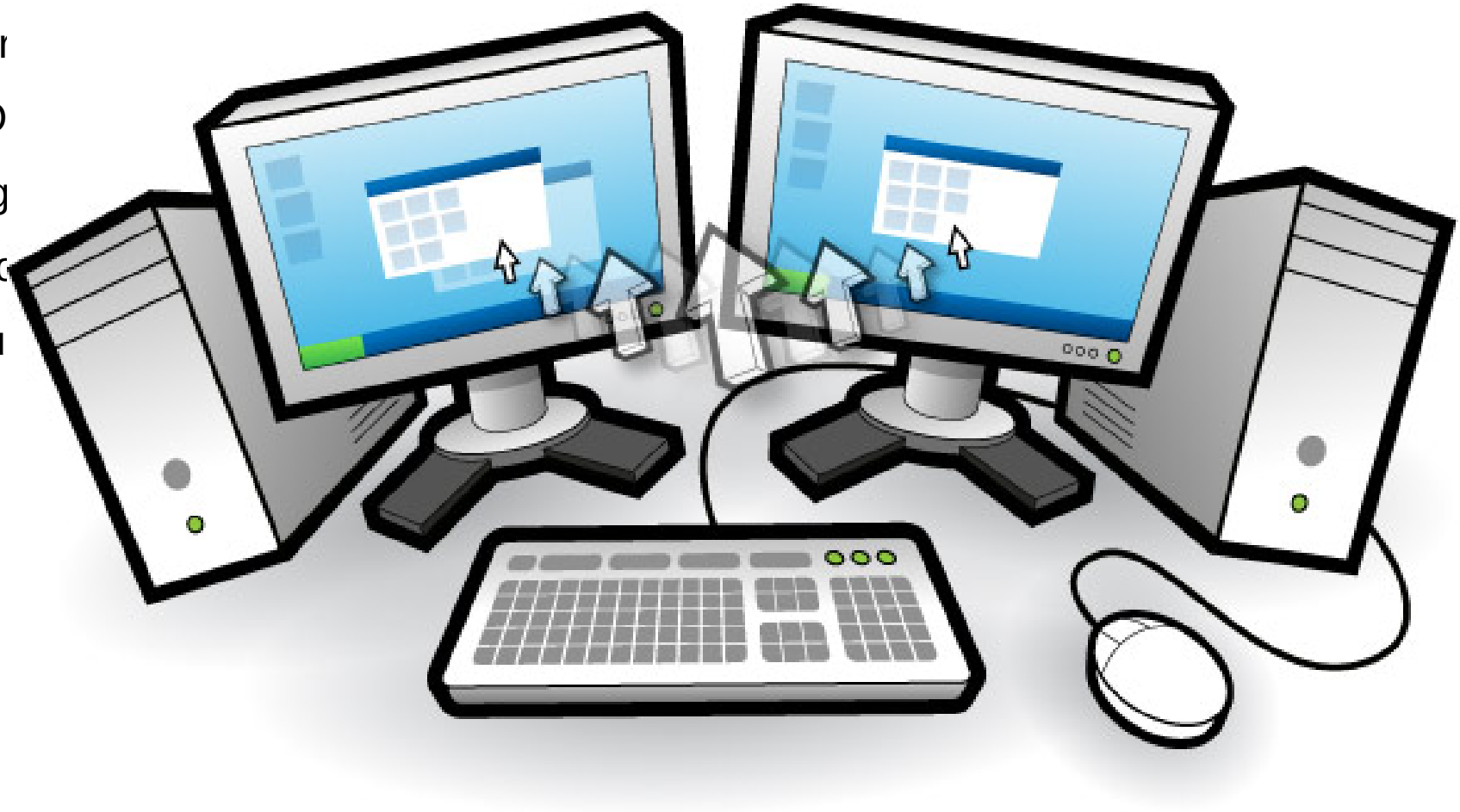
•Boundar

•Inflow/O

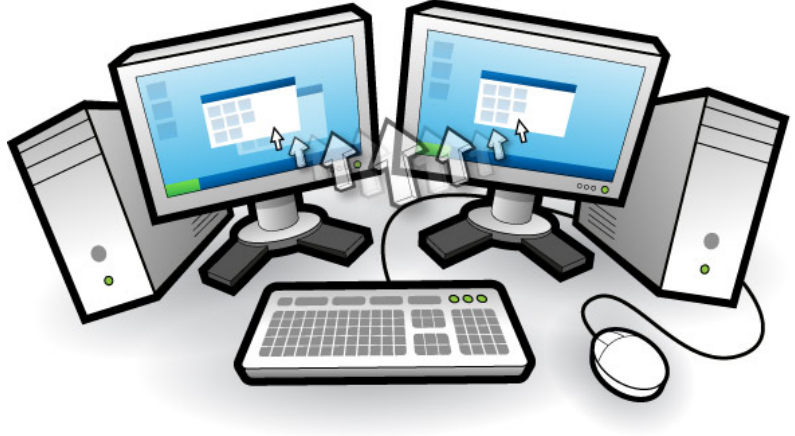
•Is timing

•Initial Co

•Are Bou



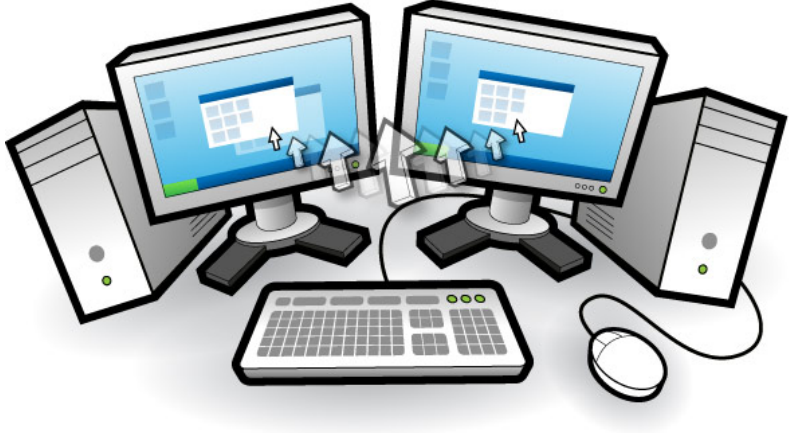
3. INPUT REVIEW



Terrain Review:

- Verify Horizontal Projection of all data sets
- Verify Vertical Datum of all data sets
- Verify accuracy of terrain
- Verify High/Low ground grade breaks were included
- Verify inverts of channels are ground not water or obstructed/interpolated
- Verify Seams of combined data do not include vertical changes
- Check final Terrain, vs. Raw data.
- Verify intended Terrain Modifications were incorporated into final model.

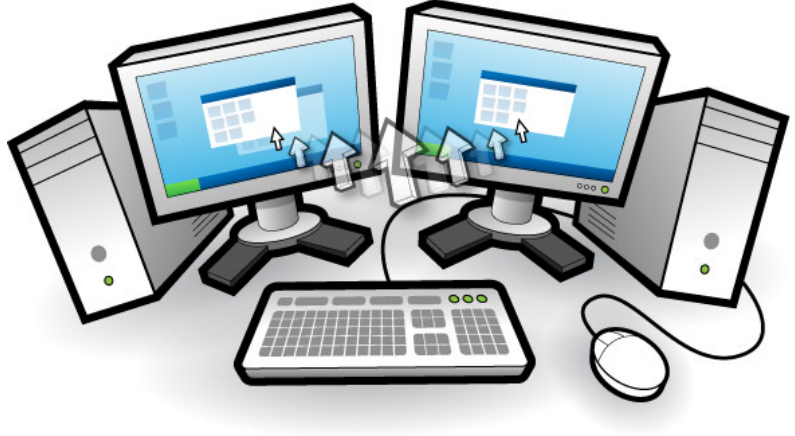
3. INPUT REVIEW



Model Geometry Decision Review :

- Does the model Geometry represent the Terrain well?
  - Are **elements** of appropriate size, shape & alignment to adequately describe the **terrain** and **water slope surface**? Is timing appropriate, and combined appropriately
  - Does the Geometry account for features like levees and embankments?
  - Does the Geometry account for flow restrictions such as walls or structures (if not accounted for by other means such as roughness)?
  - If variable element sizes are used, does the transition from small to large cells occur gradually?
- Was a sensitivity analysis for Element size performed?
  - Does making the element sizes smaller produce significantly different results?

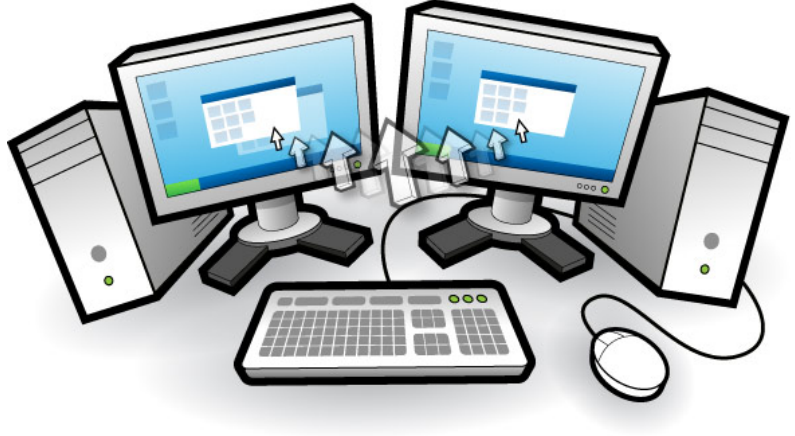
3. INPUT REVIEW



Roughness Review:

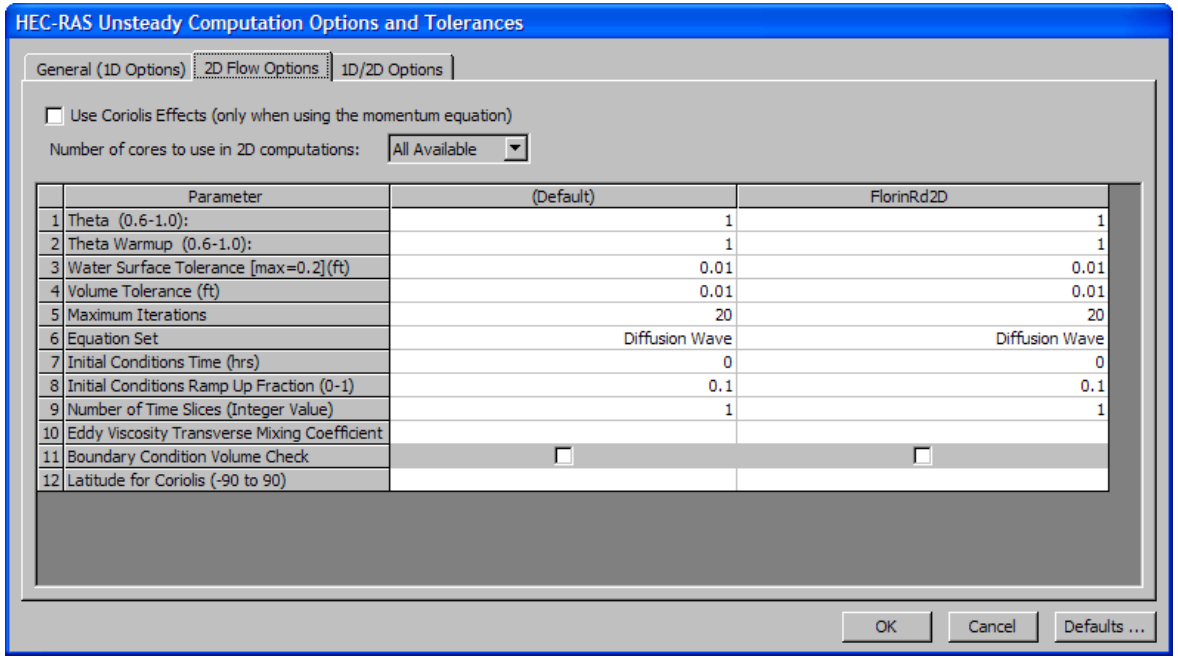
- Details of how roughness is accounted for in the model
- References available: agency guidelines, other standard references
- Are Values Reasonable for the “Purpose”, and within the range of published values
- If roughness is variable, check to see how model is adjusting those values during the run.
- Does Roughness account for impediments (not accounted for in terrain)?

3. INPUT REVIEW



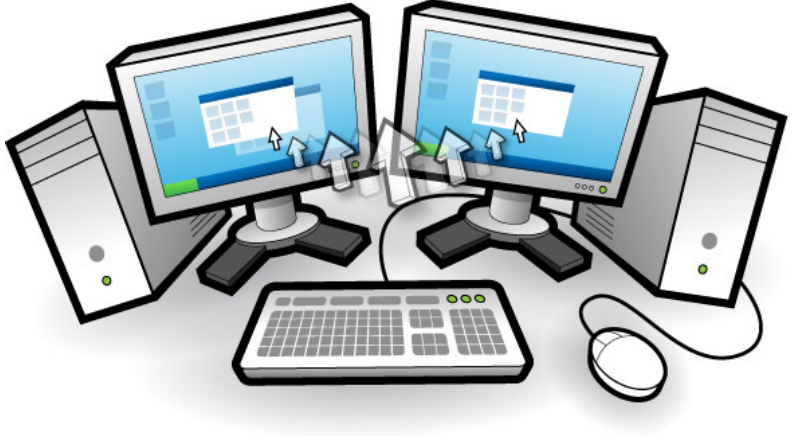
Model Control Variable Inputs Review:

- Different for each model environment, verify if appropriate values were used
  - Time Steps (if applicable)
  - Simulation duration cover the entire event
  - Output Interval
  - Depth for water movement (if rain on grid, should be smaller)
  - Vertical Tolerances, Flow rate Tolerances
  - Courant, etc (per software recommendations)
- Was sensitivity analysis performed for the Control Variables, and are inputs consistent with those findings?



	Parameter	(Default)	FlorinRd2D
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)	0	0
8	Initial Conditions Ramp Up Fraction (0-1)	0.1	0.1
9	Number of Time Slices (Integer Value)	1	1
10	Eddy Viscosity Transverse Mixing Coefficient		
11	Boundary Condition Volume Check	☐	☐
12	Latitude for Coriolis (-90 to 90)		

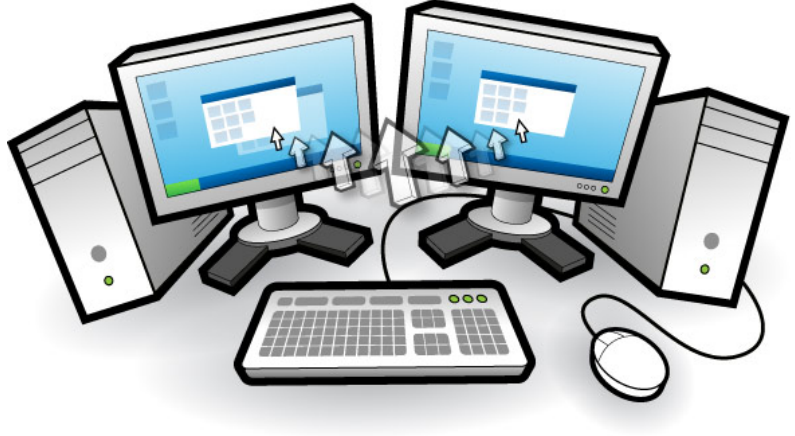
3. INPUT REVIEW



Structures, Special Facilities and other embedded 1D Elements Input Review:

- Compare input values to data source (as-builts, GIS)
  - Inverts, Slope, Rims, Size
  - Location is correct spatially
  - If Rating curves were used, verify they were translated correctly
  - Modification data was included
- 1D Channels
  - Cross Section Spacing is appropriate
  - Roughness, reach lengths
  - Trimmed and linked to 2D correctly
- Check that all structures were included, and no undocumented structures were added.

3. INPUT REVIEW



Infiltration:

- Verified if allowed for project “purpose” and per Agency requirements
- Review if method used, is being applied appropriately
- Verify inputs match the source data

Levees and Walls:

- Review Agency guidelines and requirements
- Verify locations are appropriate
  - Verify continuity, ending and starting points
  - Verify top elevations against source data

4. OUTPUT REVIEW

“M d
s e

4. OUTPUT REVIEW

WHAT CAN BE/NEEDS TO BE REVIEWED IS VERY DEPENDANT ON WHICH SOFTWARE IS BEING USED:

It is important in ALL CASES to review:

- Primary Variable Results
  - Water Surface
  - Velocity (x and y)
- Secondary Variable Results
  - Depth
  - Flow
  - Depth-Velocity Relationships
  - Fr – Froude Number

Tertiary Variable Results:

- Output relating to the numerical health of the model (Cumulative and Incremental)
  - Mass/Volume Conservation
  - Time step variation or incrementing
  - Warnings/Errors noted

4. OUTPUT REVIEW

NUMERICAL HEALTH:

- **Mass/Volume Balance Errors:**
  - (< 1% industry standard**)**
- High velocities
- Perched water surface elevations
- Oscillations
- Time Step Variations
  - May be a particular area of the model is causing this
- Fr – Froude Number
- Control variables approaching or exceeding range limits

4. OUTPUT REVIEW

SPECIAL FEATURES:

- 1D Elements Pipes, Ditches, etc…:
  - Do they carry any water? – Review hydrograph
  - Are there oscillations?
  - Depths and Velocities realistic?
  - Do results make sense (hand calc)
- Levees and Walls
  - Do they leak?
  - Does water surface near them rise or fall suddenly?
  - If overtopped, does overflow make sense for the available head and overtopping length?
  - Are they safe for the head differential being modeled?

4. OUTPUT REVIEW

SPECIAL FEATURES (Cont):

- 1D Channels:
  - Do they carry any water? – Review hydrograph
  - Are there oscillations?
  - Depths and Velocities realistic?
  - Do results make sense (hand calc)

4. OUTPUT REVIEW

2D Areas:

- Flooding Extents:
  - Does it make sense? High areas wet? Low areas dry?
  - Unexplained sudden rise or lowering of water surface?
- Depths and Velocities:
  - Are Velocities Reasonable?
    - Anything >12fps should be examined
  - Are Velocity directions reasonable?
- Calibration:
  - Verify results against the data
  - Do you agree that the results verify the model for the calibration event?

TOTAL MODEL:

- DOCUMENTATION, PLOTS and EXHBIITS:
  - Do they match the final model results

RE-EXECUTE THE MODEL:

- Do your results match the results provided?

5. QA/QC DOCUMENTATION OF THE REVIEW

WHO?

•Document who performed which elements of the review

Use a SYSTEM of Review and DOCUMENT every step of the review:

•As each step of the review occurs, the review should be documented so that each subsequent reviewer does not have to repeat a review of a previously reviewed element:

- •Reviewers could highlight in yellow items that were verified, in red things they found in error
- •Comments need to be documented or summarized when returned
- •Provide a means for the Project Team to respond to comments in an orderly way:
  - •How about a checklist? “accept, reject, will be addressed in future” and provide them some room to respond if necessary
- •Provide a means to chronology additional back checks and responses

•SEE APPENDIX A FOR EXAMPLES

5. QA/QC DOCUMENTATION OF THE REVIEW

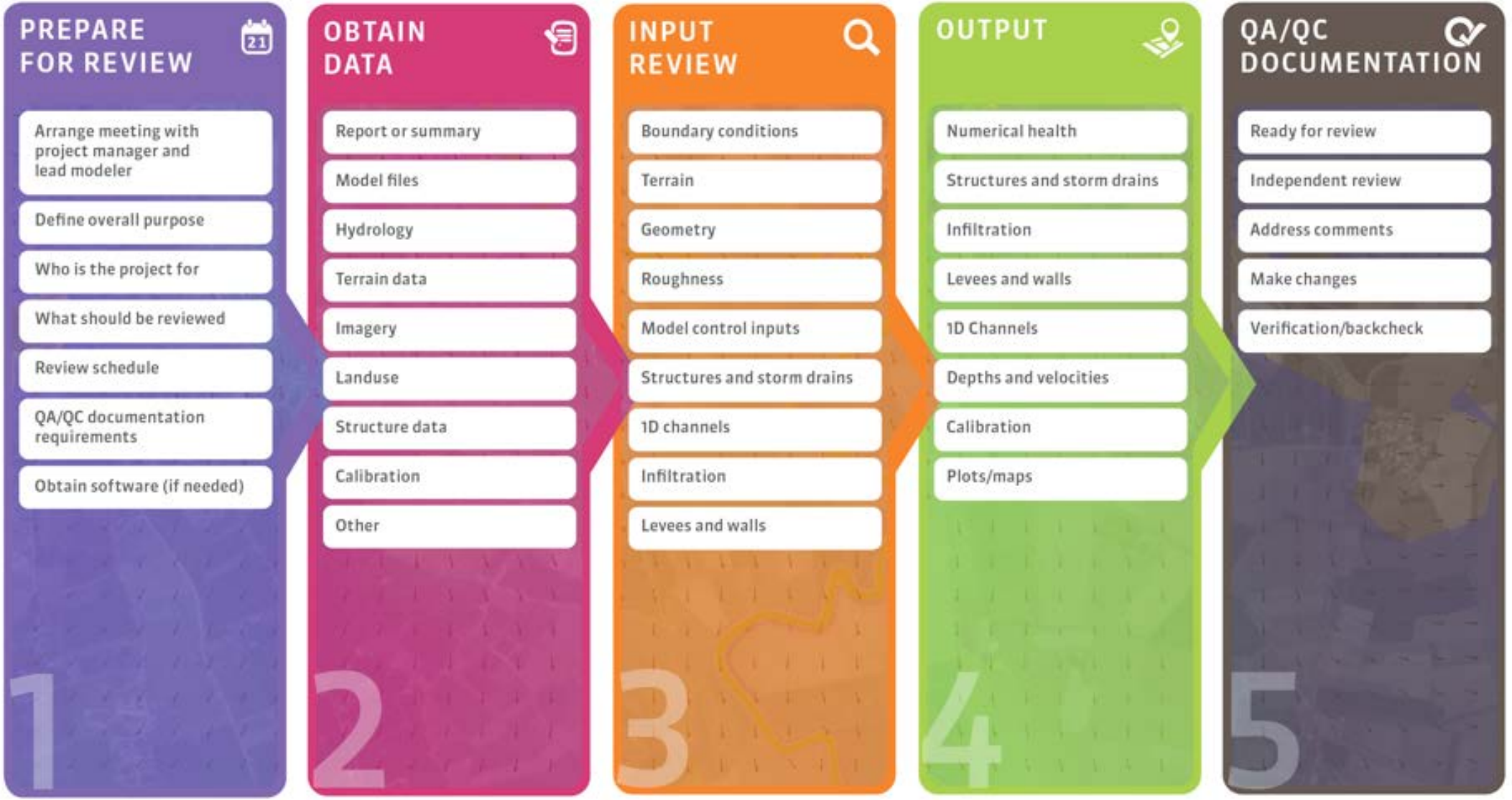
ATKINS NORTH AMERICA

QA/QC - FLO-2D REVIEW CHECKLIST

	Project Title:						
	Project No.:		Project Task:		Date Submitted for Review:	Date of Review:	
	Preparer Name:			Reviewer Name:			
	Preparer Company:			Reviewer Company:			

Item No.	Hydraulic Model Review Item	Comments	Status	Response to Comments
	1. Data Requirements			
1.1	FLO-2D model version documented?			
1.2	Vertical and horizontal datum of project provided?			
1.3	Topographic information provided (vertical and horizontal datum, what kind)? If multiple data sets are used, are the extents for each one known?			
1.4	Soil data information used documented and provided?			
1.5	Land use information documented and provided?			
1.6	Documentation on techniques and procedures provided?			
	2. SUMMARY.OUT			
2.1	Check total rainfall volume.			
2.2	Check total inflow volume.			
2.3	Check percent infiltration. In general, should be 20-40% for heavily urbanized, 25-50% for urbanized, and 40-70% for natural of total rainfall.			
2.4	Verify that volume conservation errors are minimal.			
2.5	Verify that the file was written to completion.			
	3. CONT.DAT			
3.1	Check the limiting Froude number setting (typically 0.9-0.95 unless in steep areas).			
3.2	Check that the Shallow n value is reasonable (typically 0.1-0.2, but it may be turned off for some projects).			
3.3	Verify that model run time is adequate (i.e., all TIMETOPEAK.OUT values < run time).			

What are the Data needs to make this Happen?



Questions?
How to Review The Model

How to Review a 2D Hydraulic Model and What to Submit to FEMA Workshop

Thomas S. Plummer P.E. CFM
Civil Engineering Solutions, Inc.
thomas@civilsolutions.com 916 645 5700