Frequency curves & Hydraulics primer

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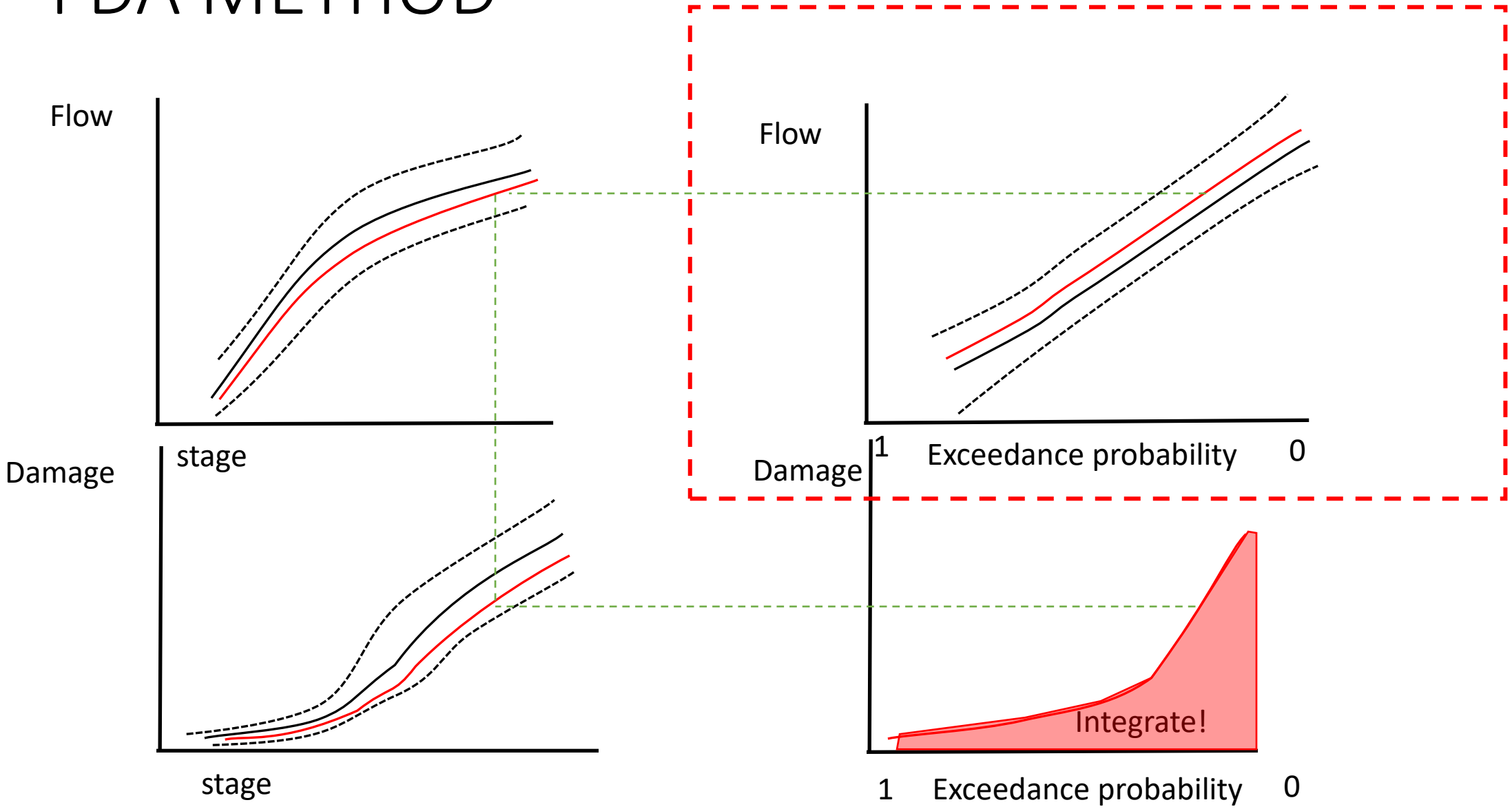
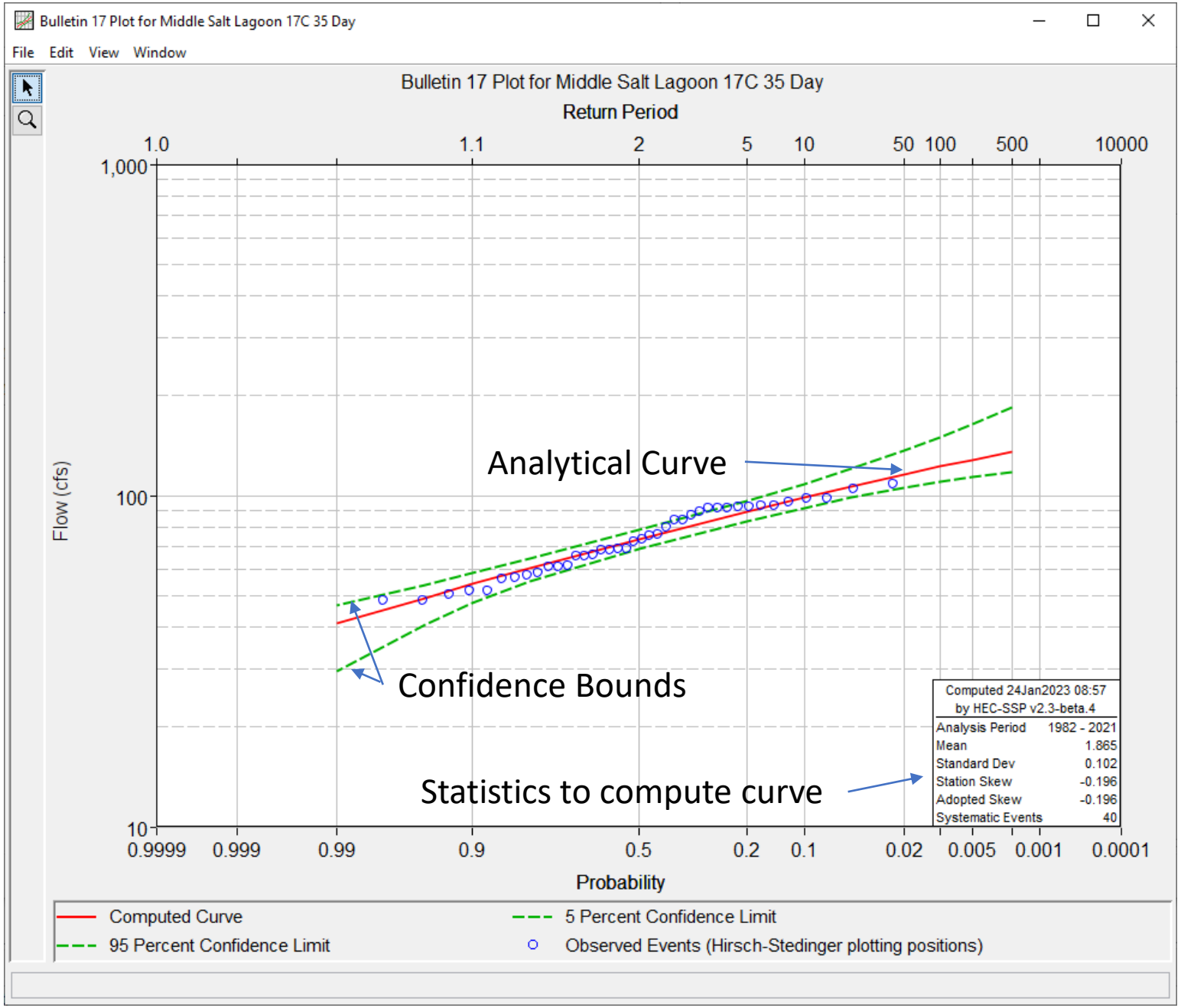
Slides from: Richard Nugent, PhD

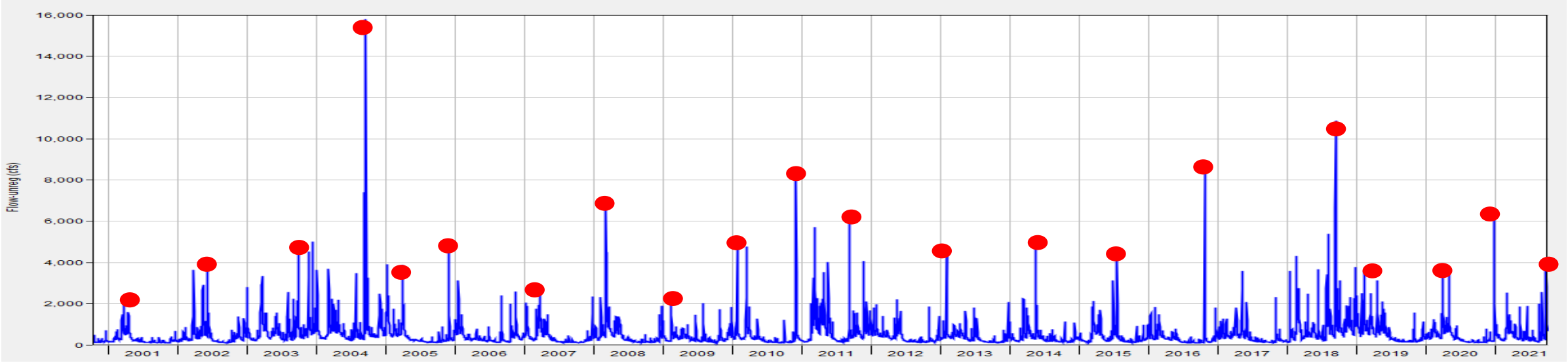
FDA METHOD


Flow
stage
Damage
stage
Flow
1
Exceedance probability
0
Damage
Integrate!
1
Exceedance probability
0

Flow-Frequency functions: analytical vs graphical

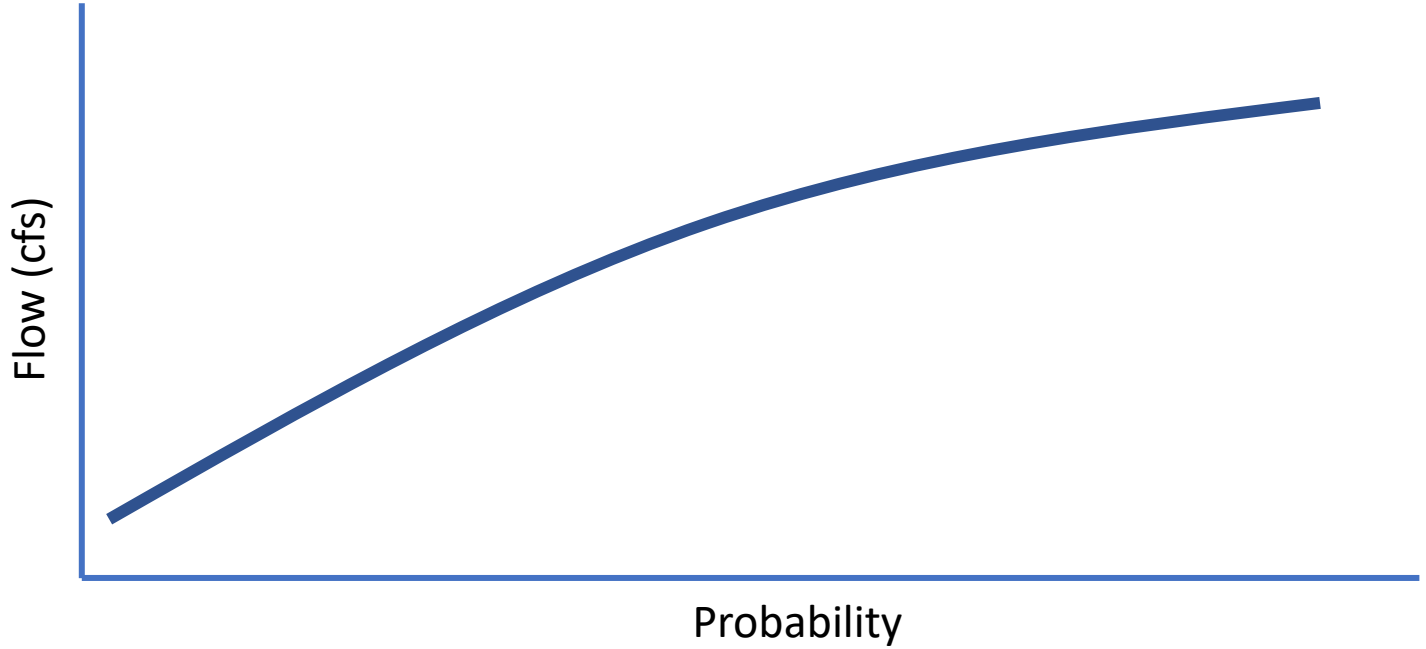


Analytical Frequency Curve (Parametric)

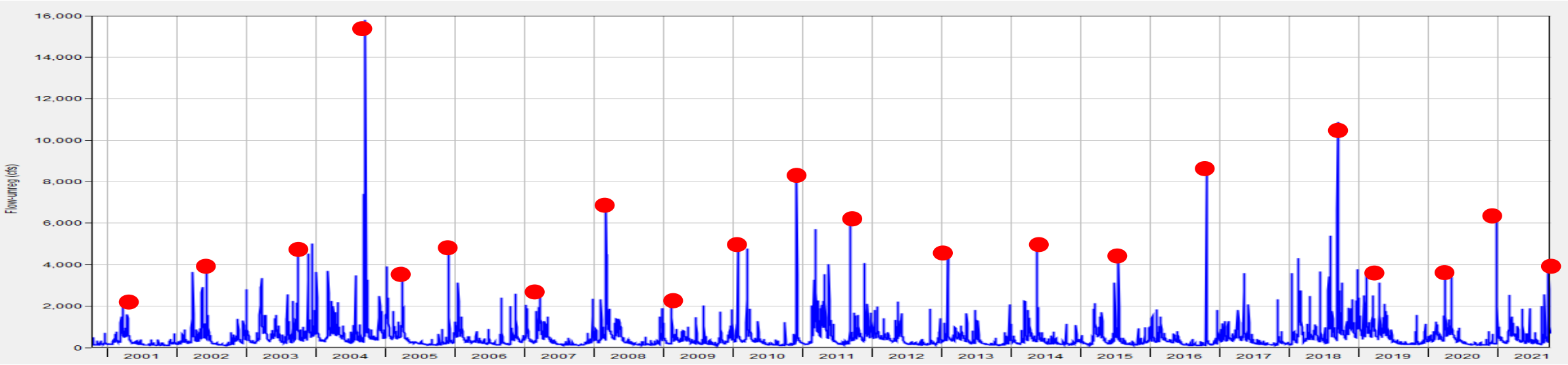


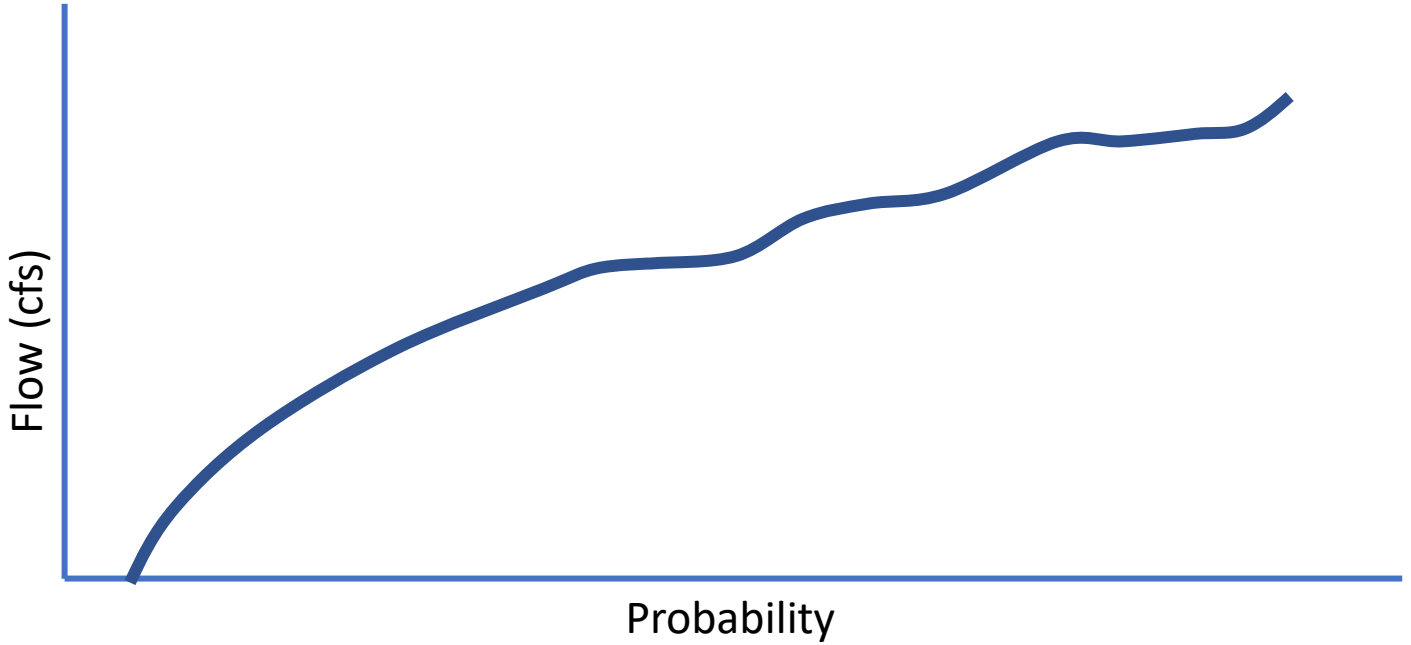
Bulletin 17C

- Log Pearson III
  - Mean
  - Standard Deviation
  - Skew



Graphical Frequency Curve (non-parametric)





Flow-frequency function options

- **Analytical:** Log Pearson Type III Distribution – a distribution identified by the mean, standard deviation, and skew of the time series of annual maximum flows.
  - Outputs – statistics (mean, std dev, skew), Equivalent Record Length

- **Graphical:** Flow or stage magnitude is ordered smallest to largest; plotted against exceedance probabilities, and line is drawn between the flows to develop the empirical distribution
  - Outputs – Quantiles, Equivalent Record Length

conditions => recommended function type

- **Analytical**
- **Unregulated streamflow data at the point of interest is available**
- LP3 moments can be derived using regional regression analysis or existing regional equations
- A streamflow record can be modeled using precipitation records

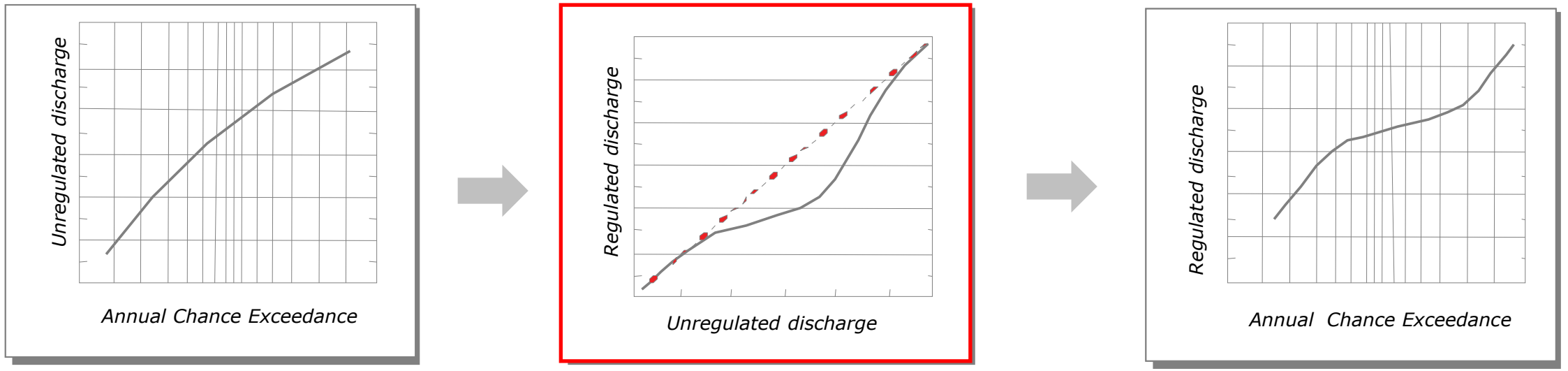
- **Graphical**
- **Streamflow is regulated**
- **Analytical curve does not fit data well**
- Flow quantiles are derived from regional regression analysis or existing regional equations
- Discharge is predicted using rainfall-routing-runoff modeling

Use analytical curves if possible

- Repeatable
- Better reflection of uncertainty
- Extrapolation
- Incorporate historic information

Unregulated-regulated transform functions

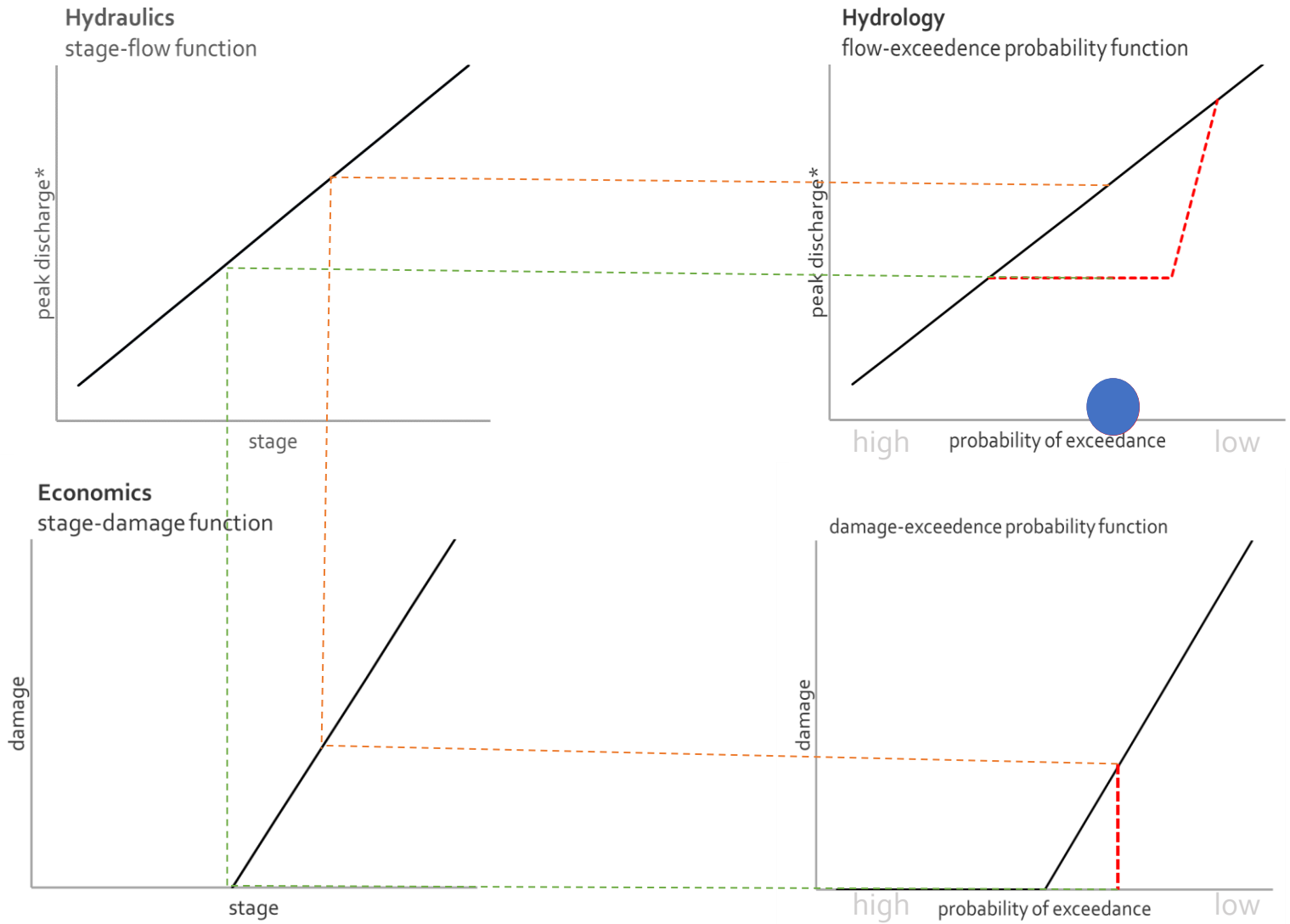
Unregulated-regulated Function Basics



Unregulated-regulated in action

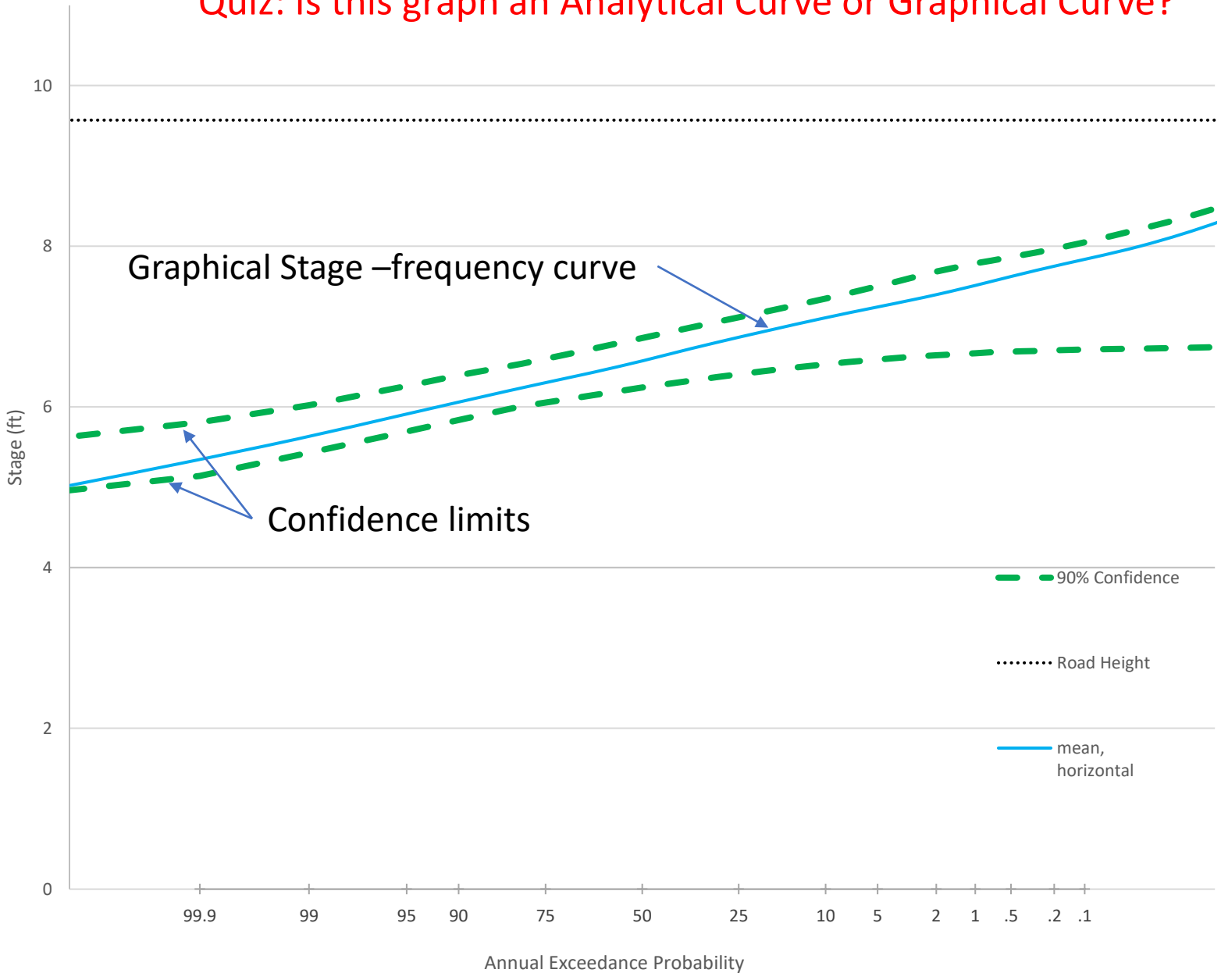
Without project = Black line

With project = Red Dash line

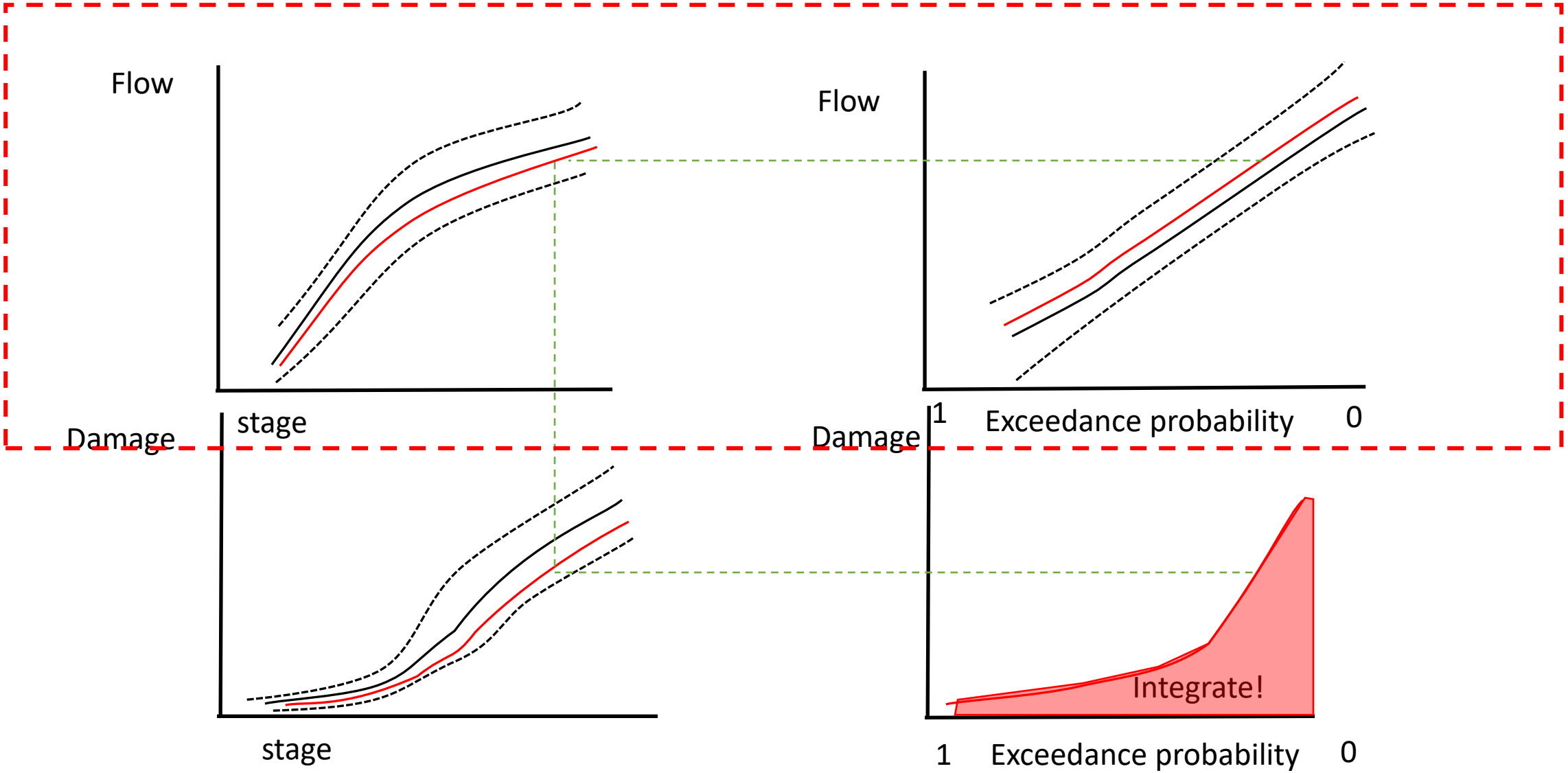


Frequency functions: Flow vs stage

Quiz: Is this graph an Analytical Curve or Graphical Curve?



FDA METHOD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Damage
stage
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Exceedance probability
0
Damage
Integrate!
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0

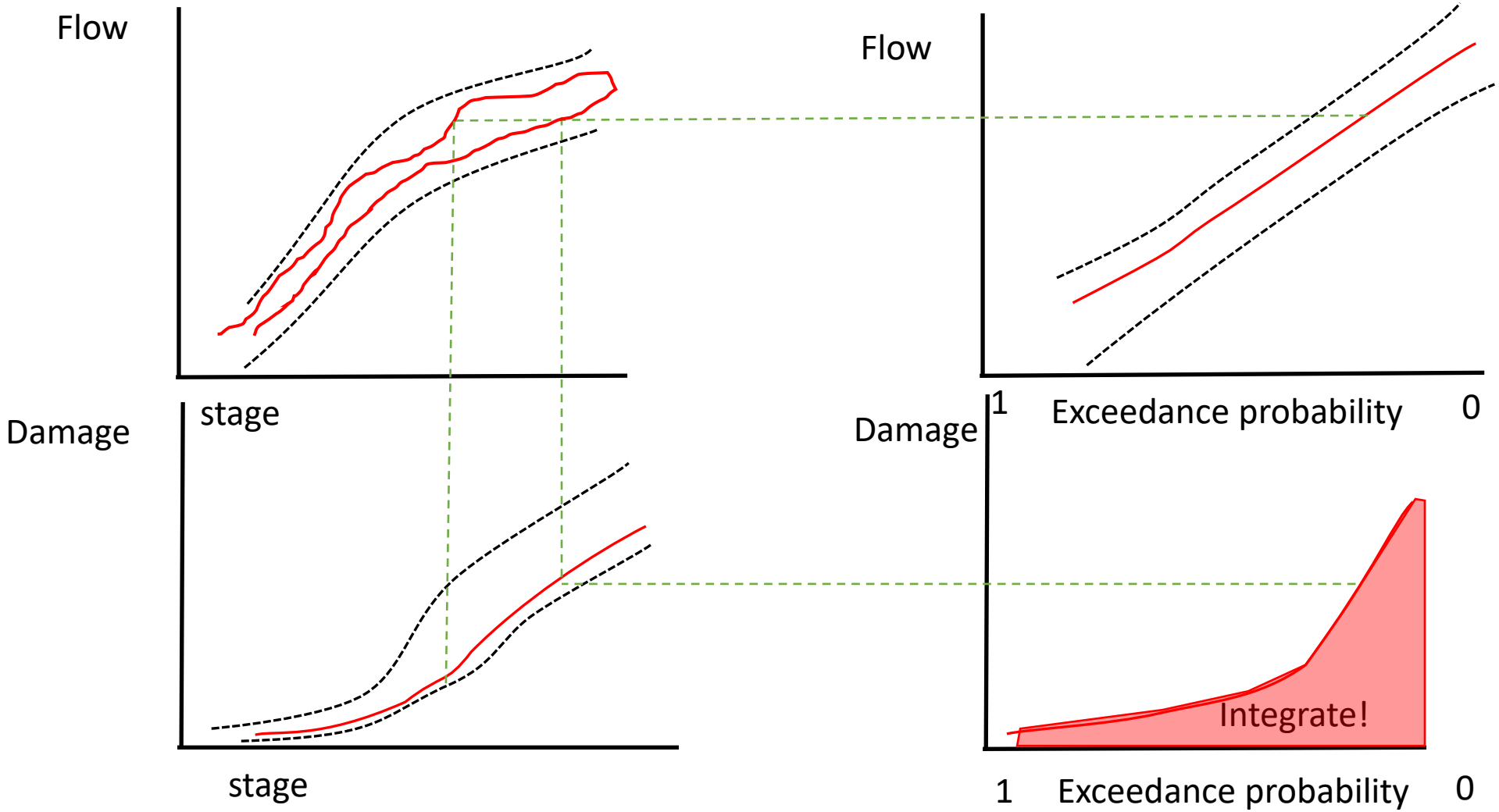
When is stage-frequency justified?

- **Use stage-frequency when:**

1. **When stage to flow is not one-to-one.**
2. **When stage is the only available gauge data.**

- **When is stage to flow not one-to-one? Examples include:**
- **Backwater**
- **Tidal conditions**
- **Ice jam floods**

FDA METHOD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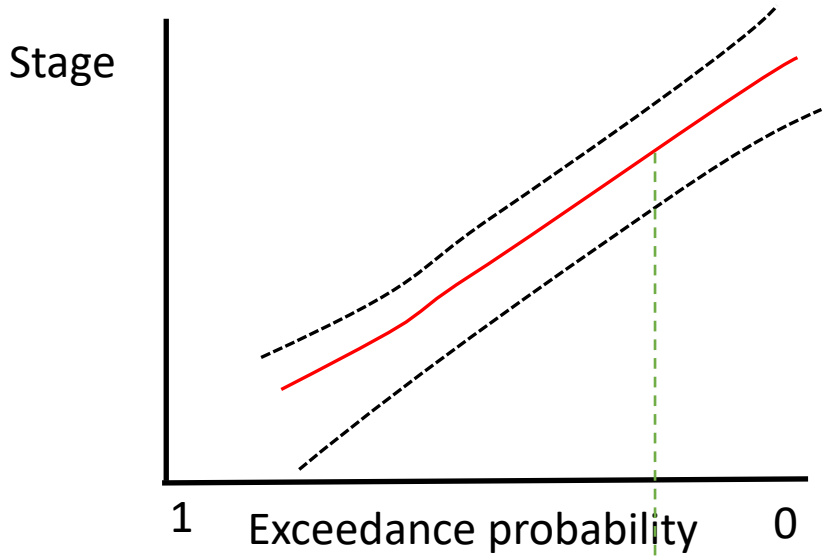
Stage
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Exceedance probability
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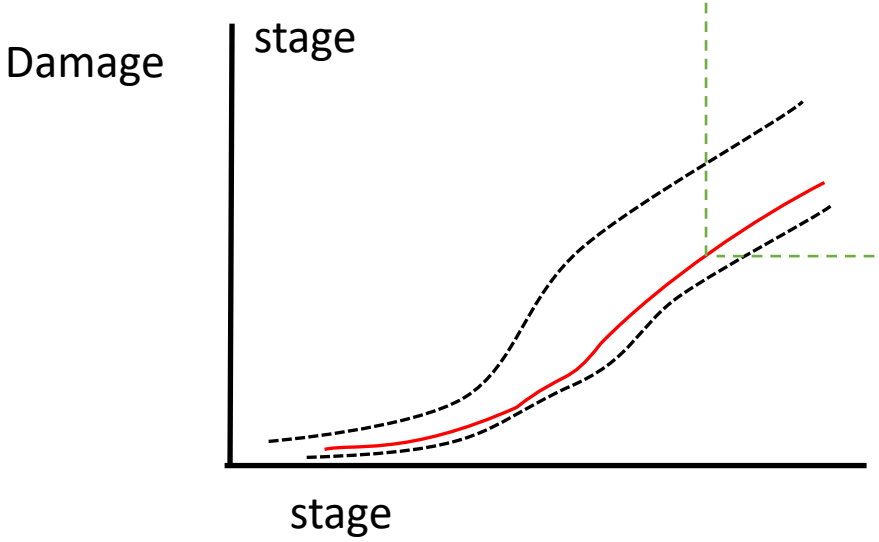
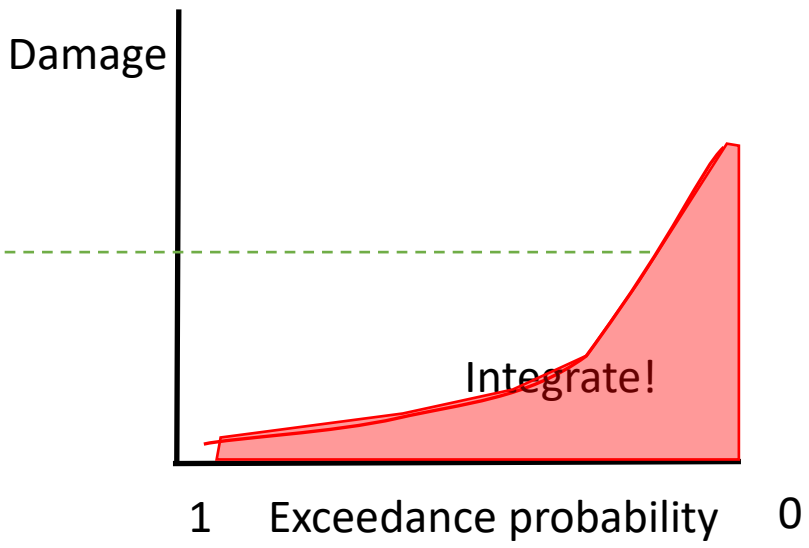

Damage
stage
stage


Damage
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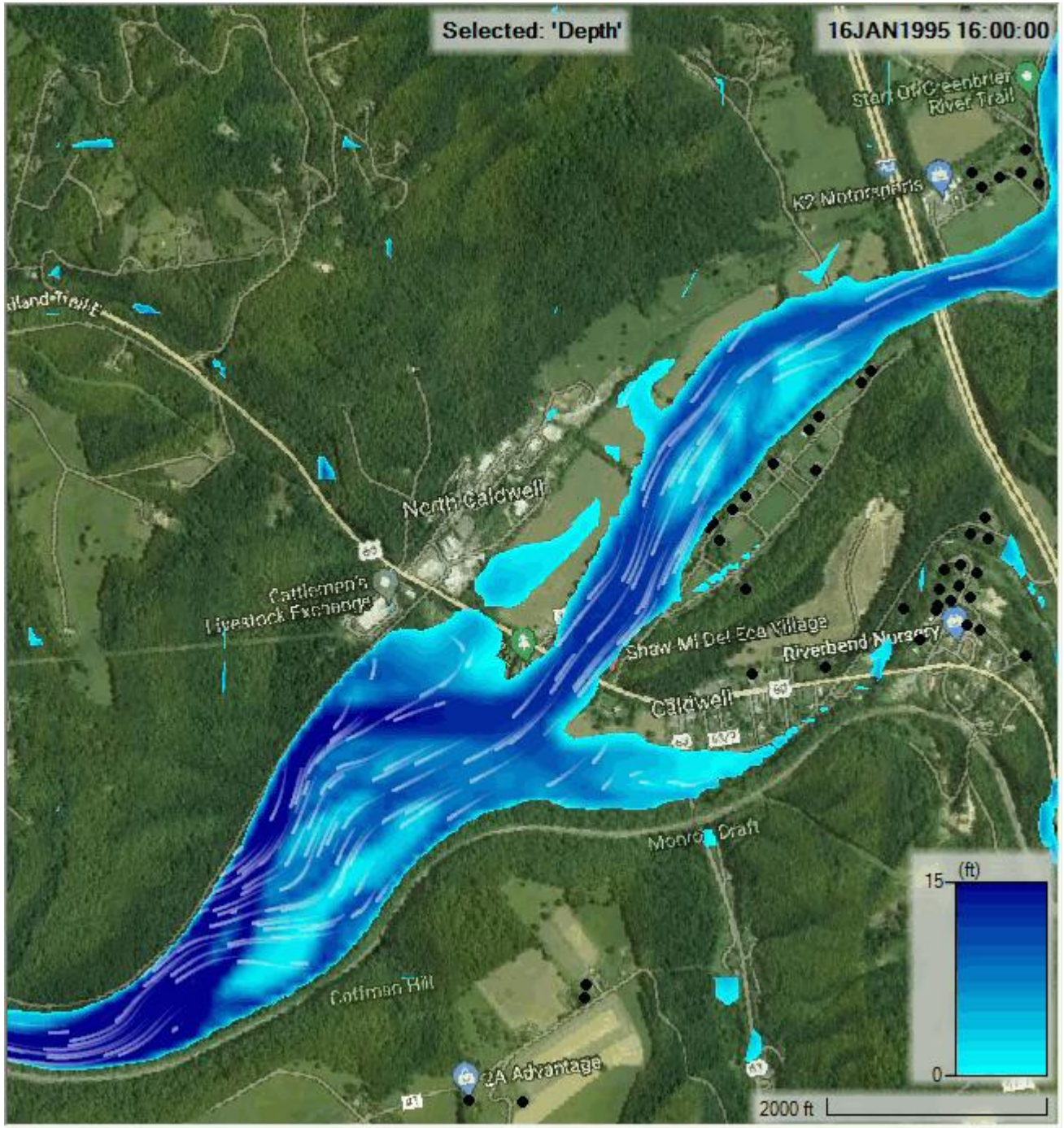
Hydraulics

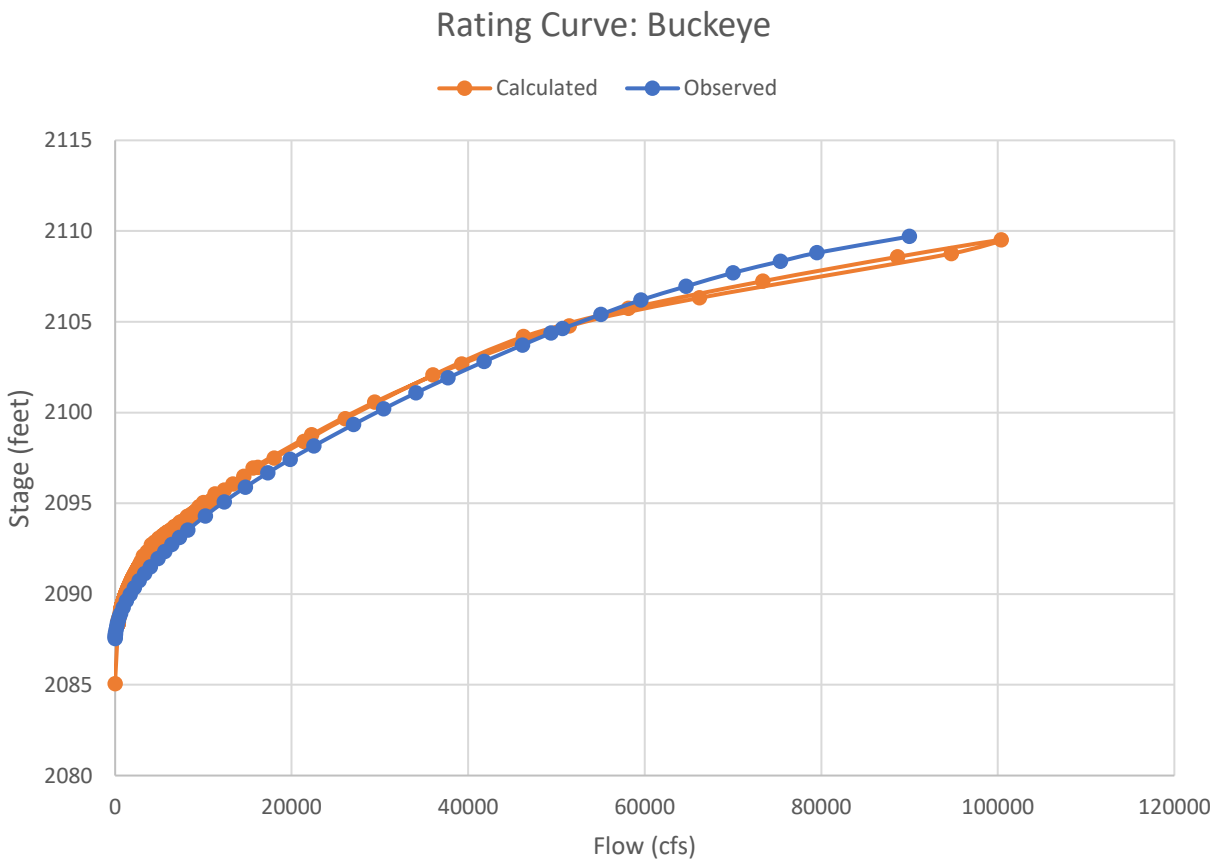
- What are Hydraulics
- How are they used in FDA
- Vocabulary Crash Course
- Fragility Curves

Hydraulics

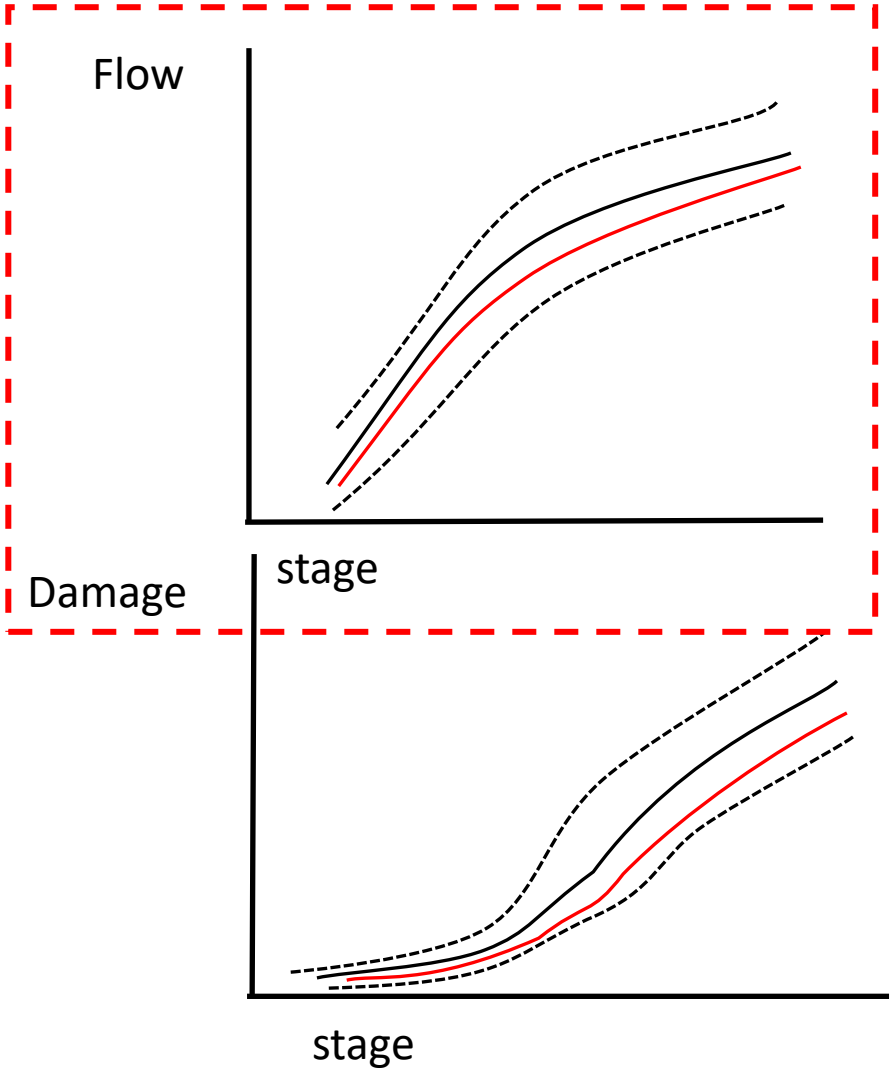
- How high?
  - Rating Curves
  - Water Surface Profiles

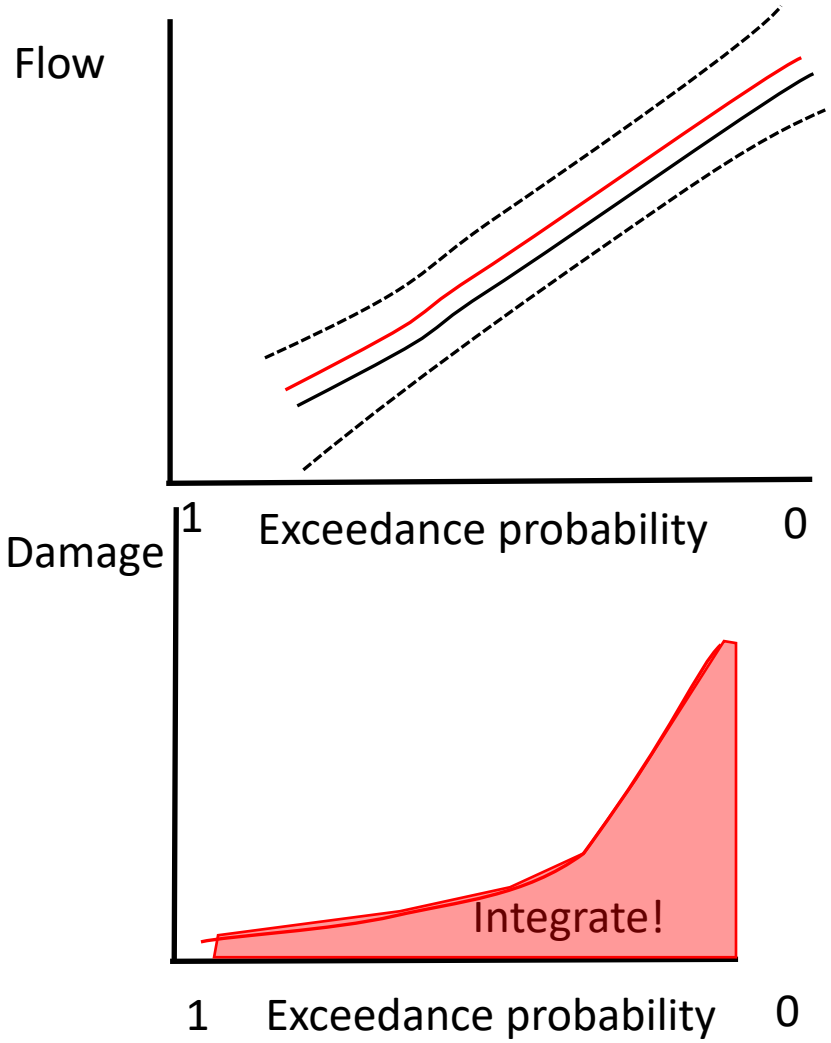


Rating Curve



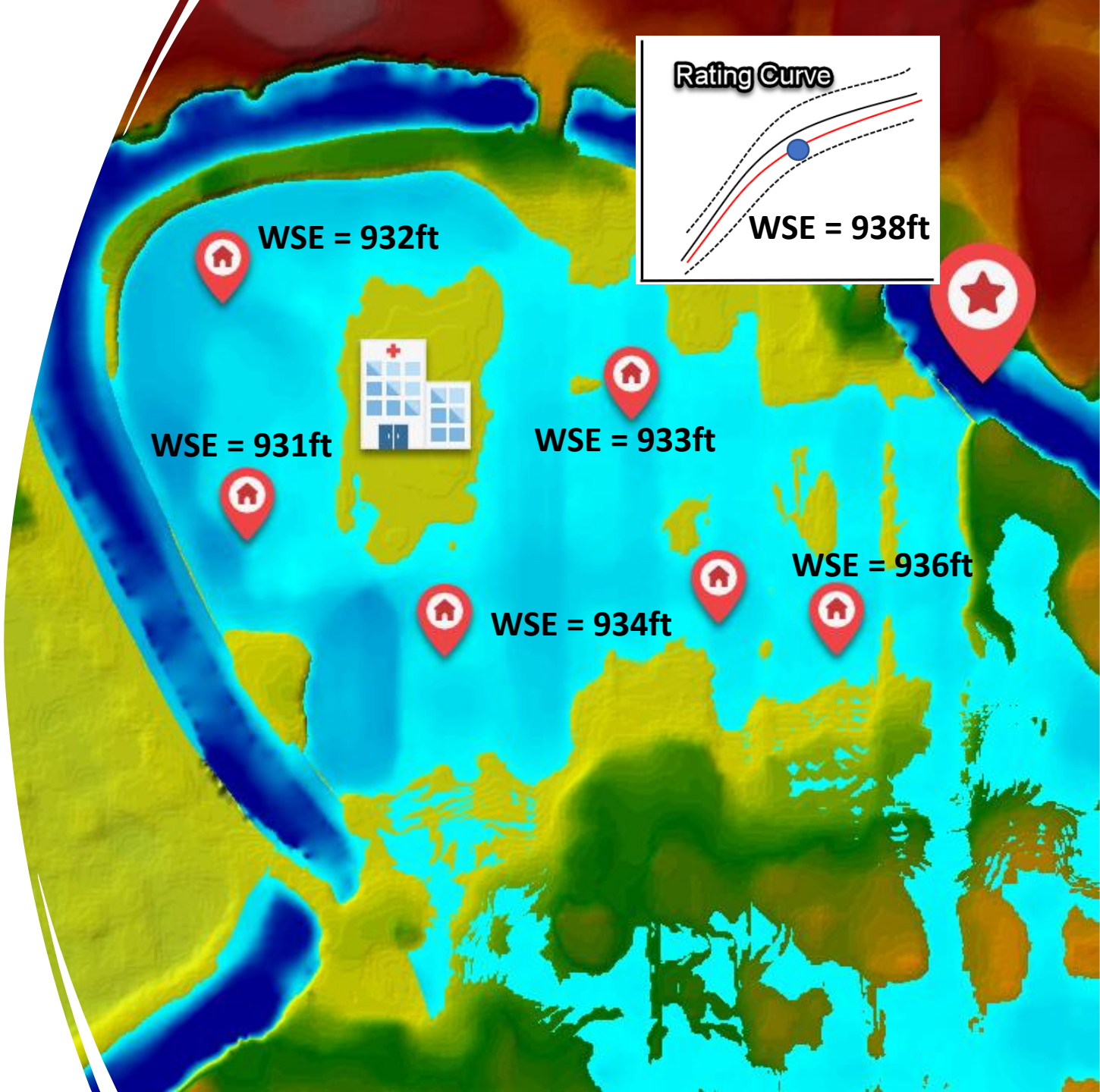
Rating Curve





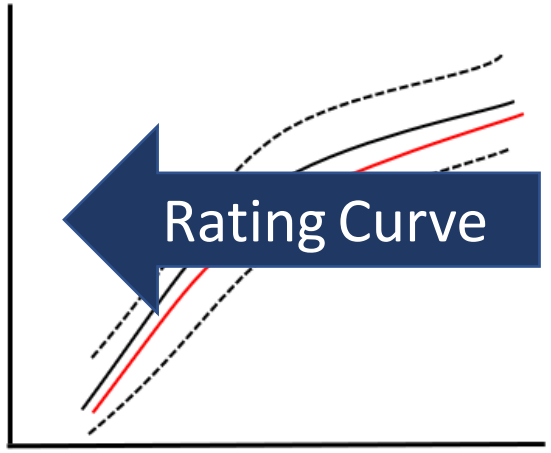
Water Surface Profiles

- Relate the Stage at Index Point (off the rating curve) to Stage at structures



SUMMARY

Channel Stage

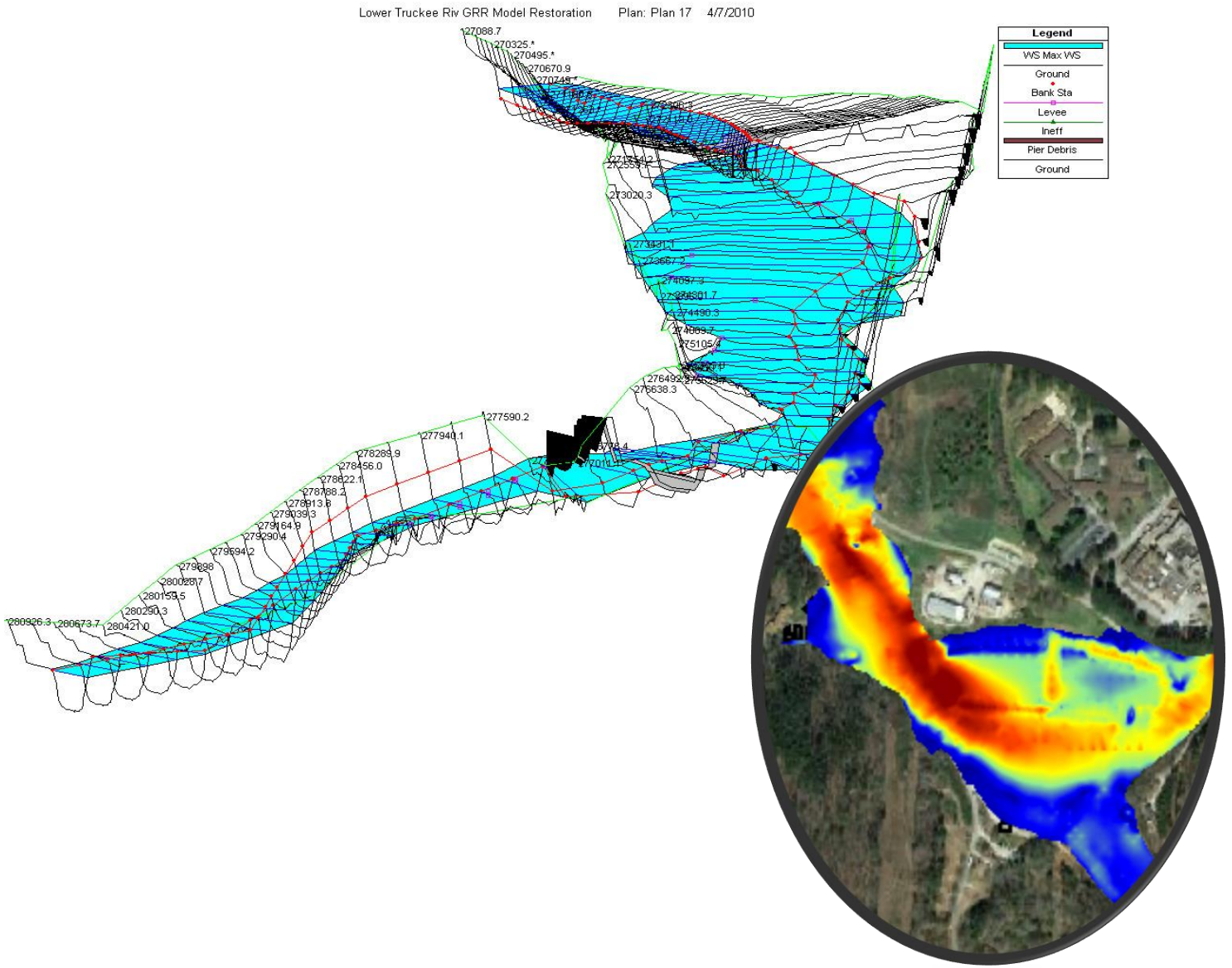


Streamflow

Stage at Structures

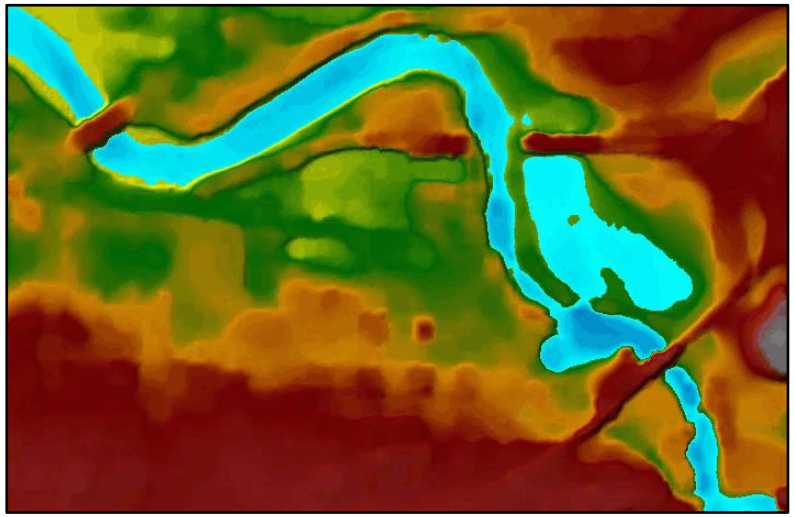
H&H Terminology

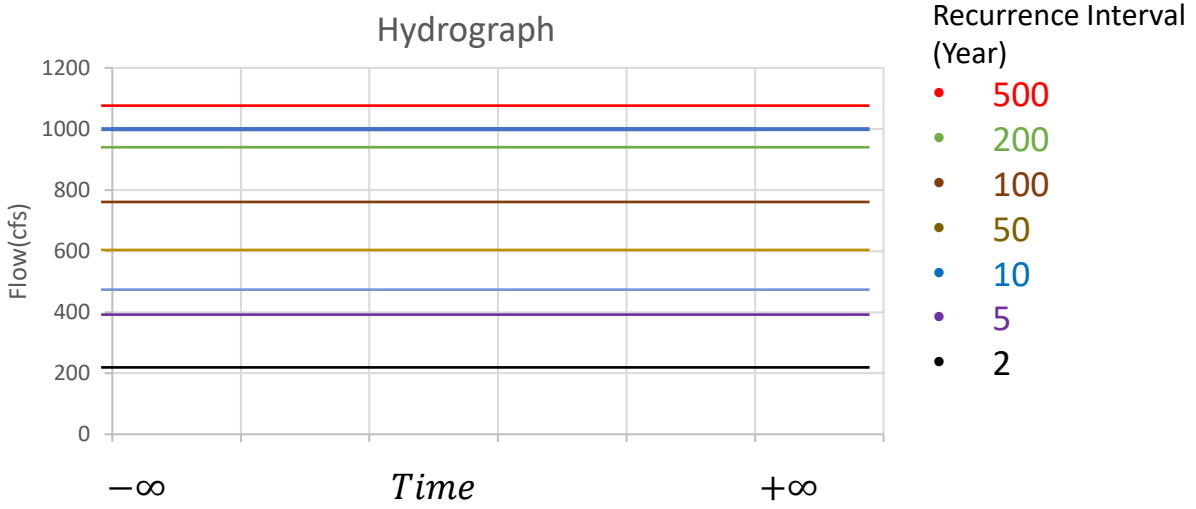
- Hydraulic Vocab
  - Steady vs Unsteady
  - 1D vs 2D



Steady-State Hydraulics

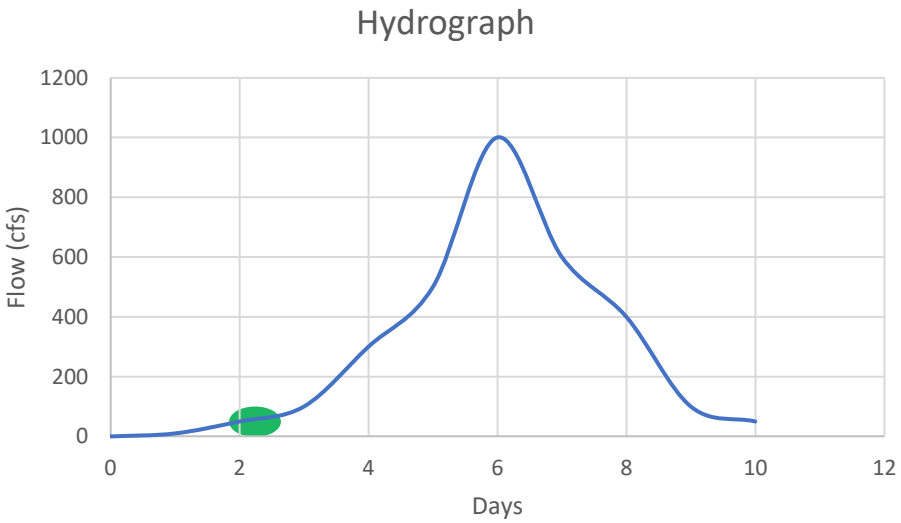
What would our system look like if the flow was X?





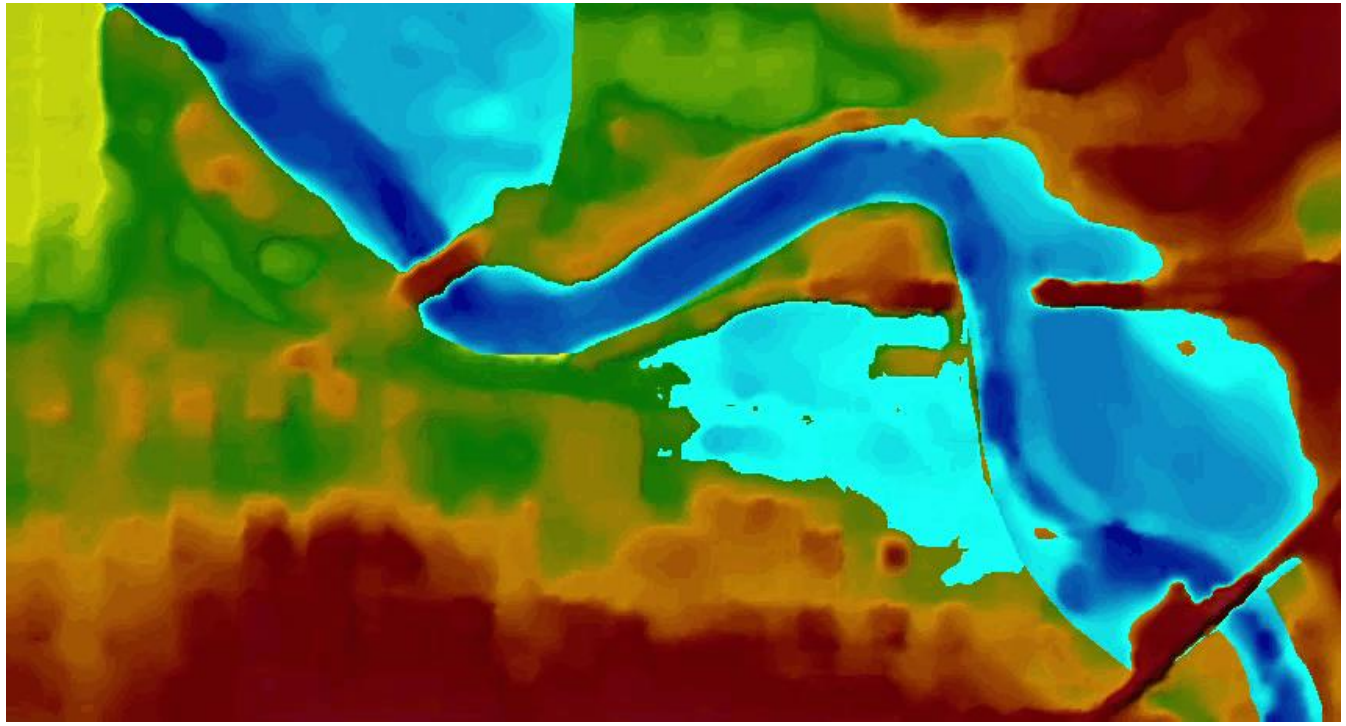
- No sense of timing
- Likely inappropriate for life loss estimation
- May still be appropriate for economic damages
- **Stored On Disk:** One .hdf file

Unsteady Hydraulics



- Includes Timing
- **Stored On Disk:** One .hdf for each profile

What would our system look like **DURING** this event?



1D Hydraulics

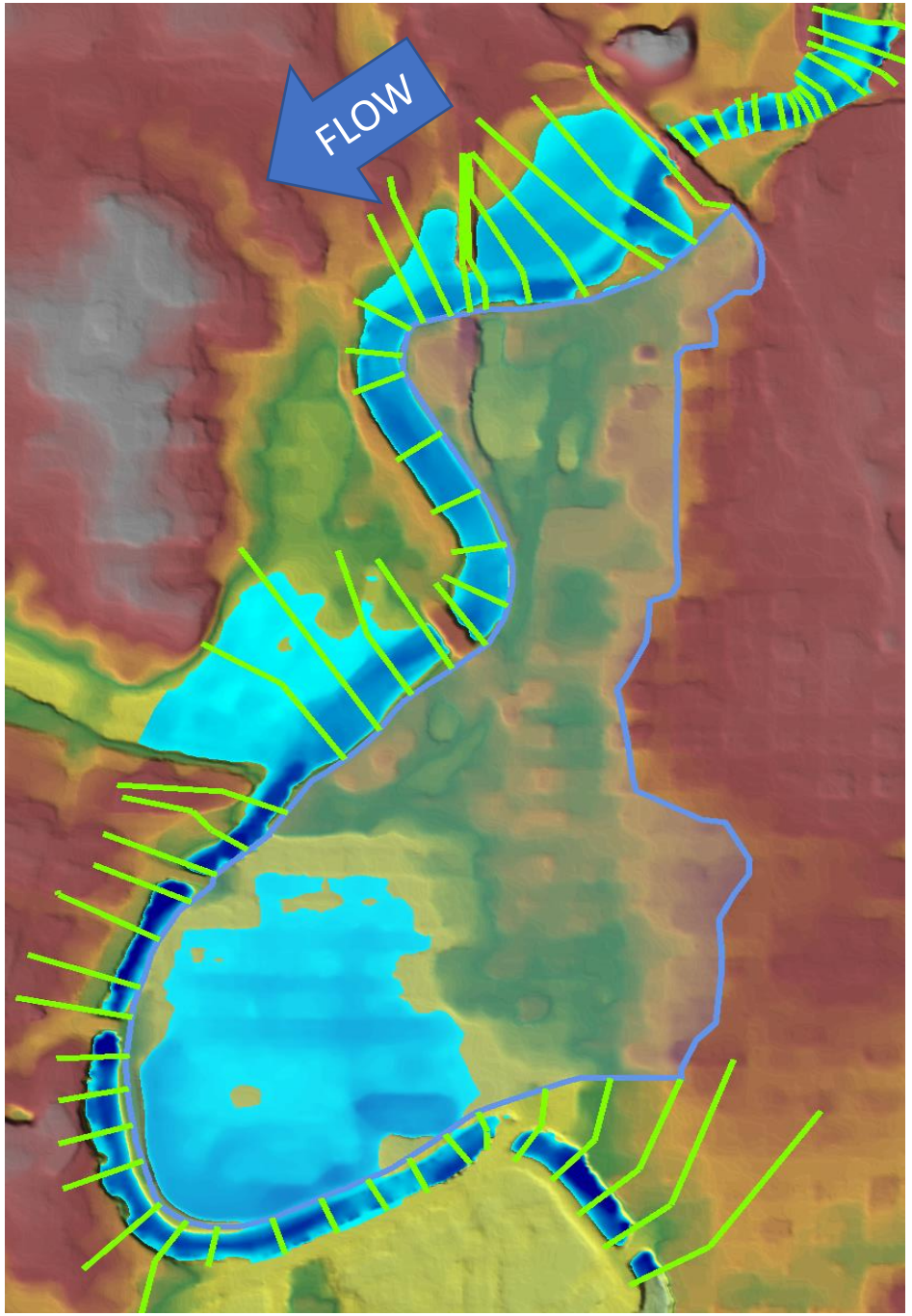
Water moves in one direction (downstream). 1D Hydraulics are very computationally efficient, can be steady or unsteady models.

Cross Sections (XS)

- Assume water surface flat across the line
- Water flows perpendicular to line

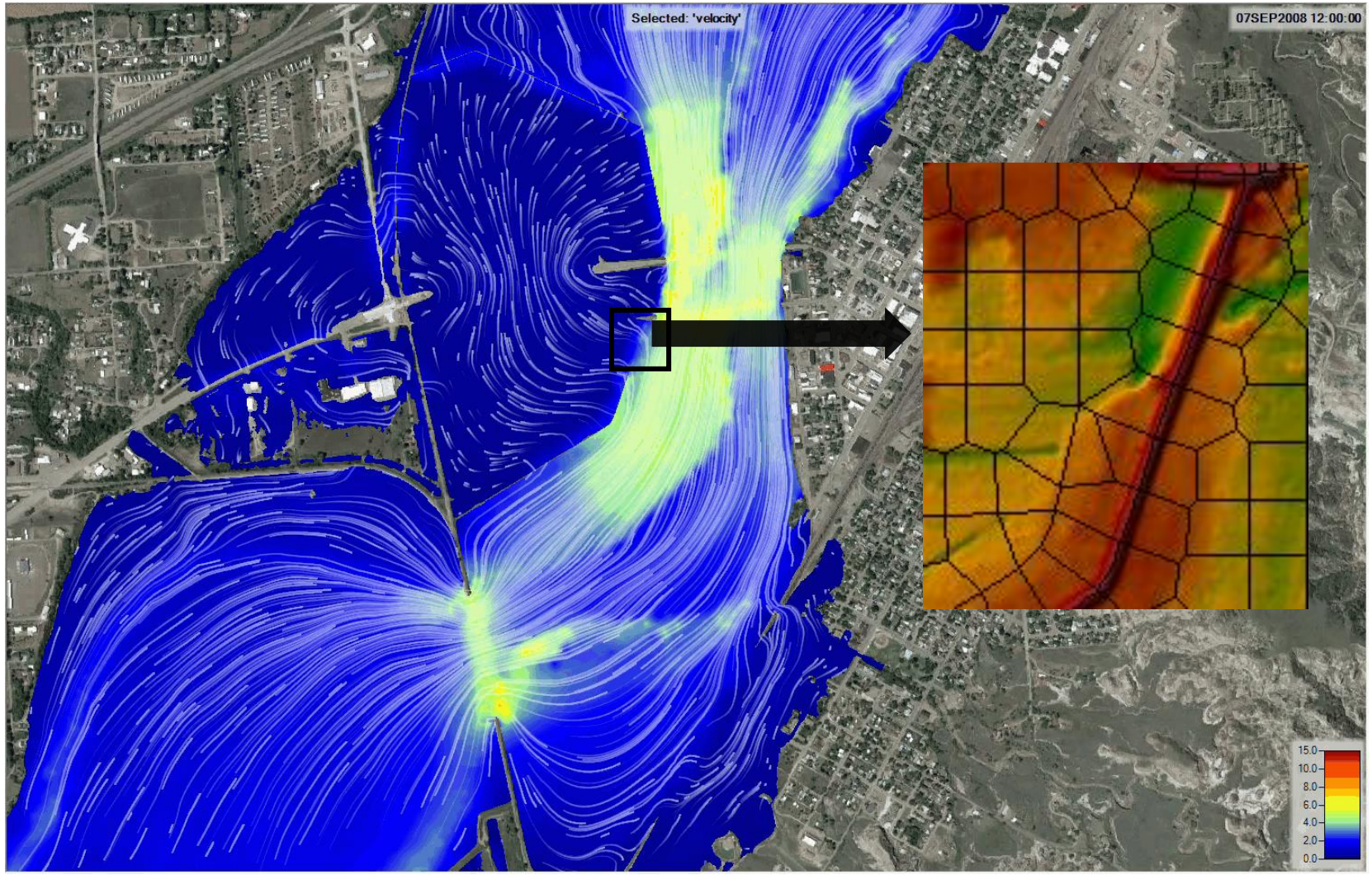
Storage Areas (SA)

- Big Bathtubs: assume water fills from the lowest point
- No knowledge of velocity



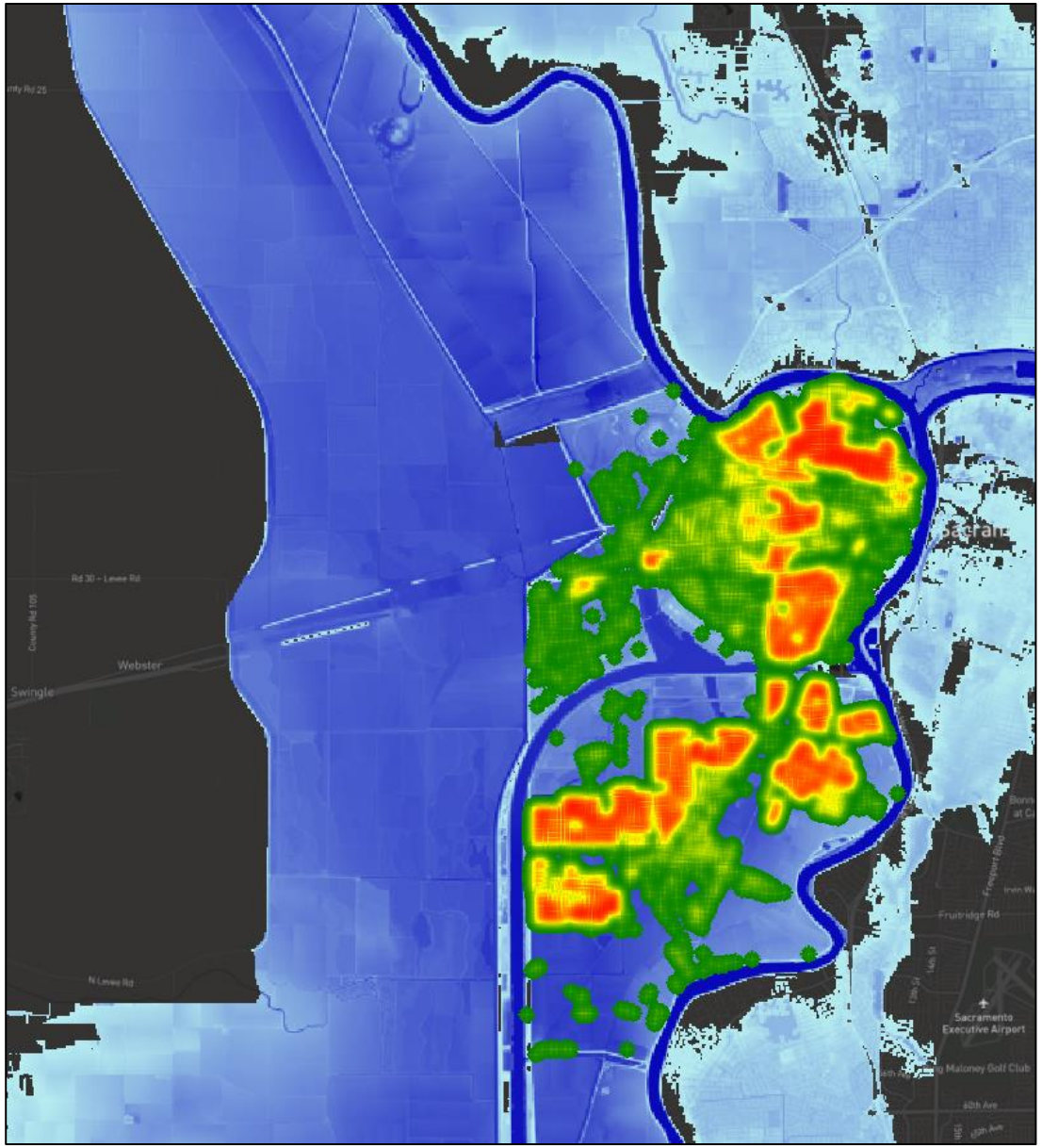
2D Hydraulics

- Two Directions – On the Grid (x,y)
- Can be too slow
- Storage Hungry



Hydraulic Vocab

- Steady Flow – NO TIMING
- Unsteady flow - TIMING
- 1D – One Direction
- 2D – Spreads All Over
- Questions?



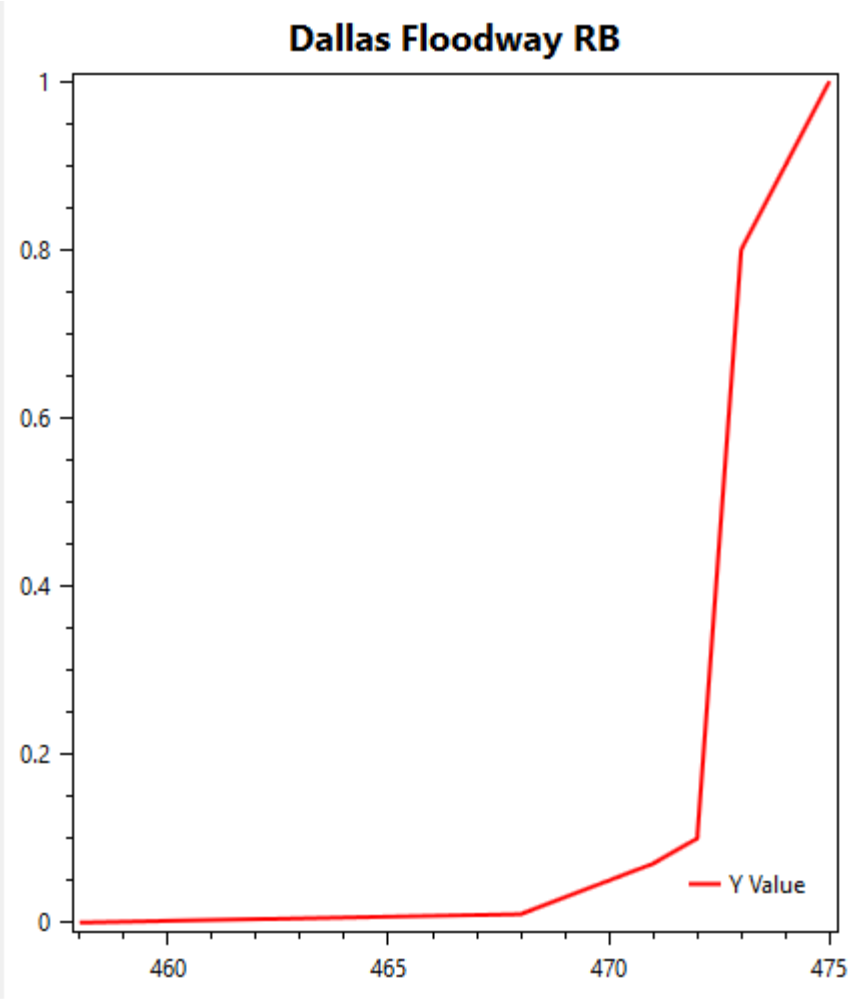
FRAGILITY CURVES

- What they mean
- How they’re applied

Fragility Curves – What they Mean

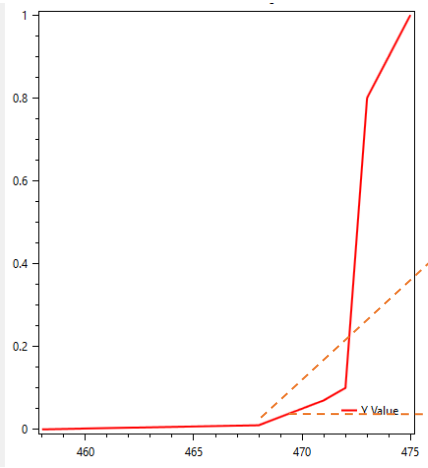
- Stage – Probability of Failure Relationship

- What is failure?
  - Probability that any water gets past your levee
    - Probability of 0 means no damages
    - Probability of 1 means completely realizing your hydraulics



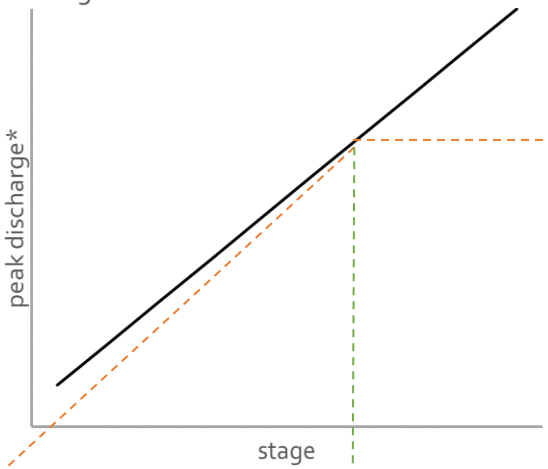
Fragility Curve in Action

Fragility Curve
stage-probability of failure function

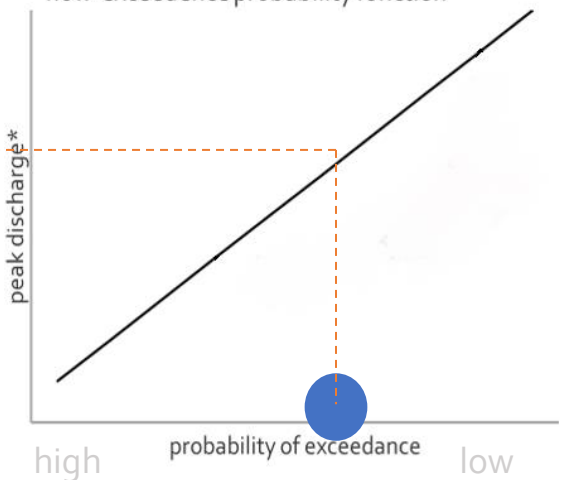


X

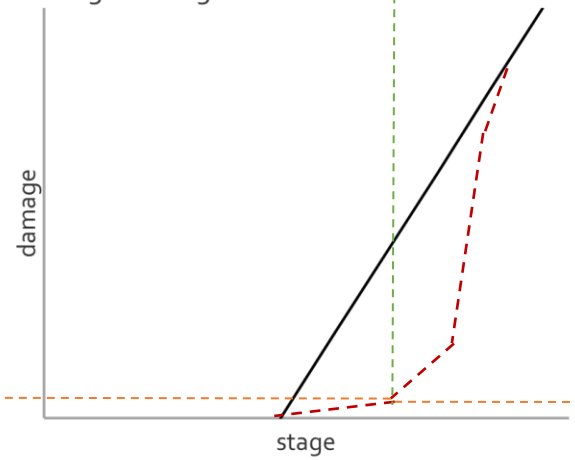
Hydraulics
stage-flow function



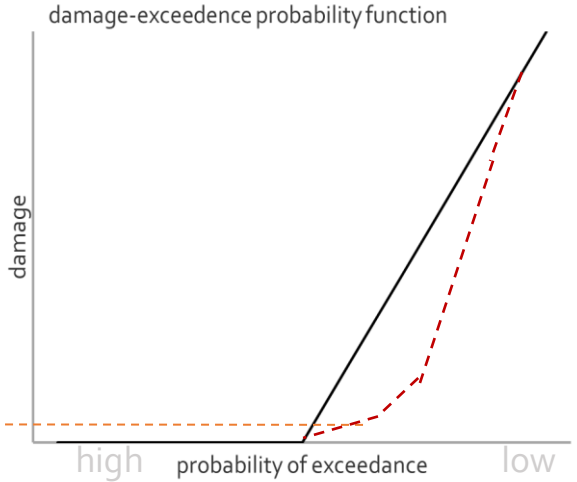
Hydrology
flow-exceedence probability function



Economics
stage-damage function



damage-exceedence probability function



Questions?