# The USACE Approach to Benefit Cost Analysis

## DuPage River, Illinois
## Flood Risk Management Feasibility Study

IAFSM 2017

Springfield, IL

8 March 2017

US Army Corps of Engineers

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# PRESENTATION OUTLINE

- Economics Definitions
- USACE Economic Analysis Principles
- FRM Economics and the DuPage River Study
- FRM Economic Analysis Software
- Uncertainty and Levels of Detail
- HEC-FDA and Monte Carlo Analysis

# ECONOMICS DEFINED

*Economics is a science which studies human behaviour as a relationship between ends and scarce means which have alternative uses.*

-- J.B. Say (1803)

*Economics is…*

*The study of scarcity*
*The study of how people use resources*
*The study of decision-making*

-- American Economic Association (2017)

# USACE ECONOMICS

Flood Control Act of 1936, Public Law 74-738

- Federal Government should participate in such flood projects *"…if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected."*

Economic and Environmental Principles and Guidelines for Water and Related Land Resources

- Established the planning and economic procedures to be used and the four (4) accounts for measuring project benefits

# USACE ECONOMIC ANALYSIS RESOURCES

Principles and Guidelines (1983)

ER 1105-2-100 – Planning Guidance Notebook

ER 1105-1-101 – Risk Analysis for Flood Damage Reduction

EM 1110-2-1619 – Risk-Based Analysis for Flood Damage Reduction

IWR 88-R-2 – NED Procedures Manual – Urban Flooding

IWR 09-R-4 – Other Social Effects Handbook

# THE FOUR ACCOUNTS

All project benefits can be attributed to one of these accounts

NED – National Economic Development

*(Structures, Production, etc.)*

EQ – Environmental Quality

*(Cultural, Ecological, etc.)*

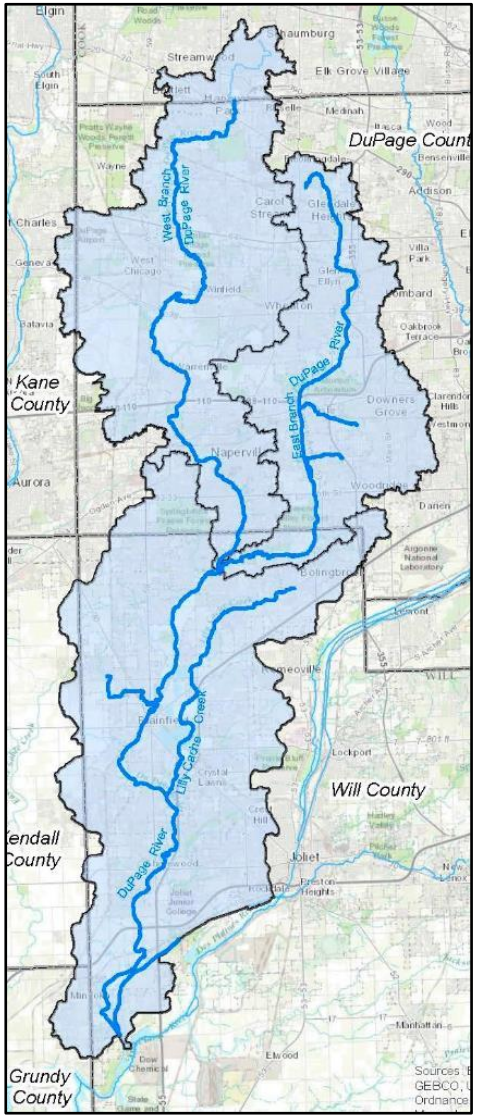
RED – Regional Economic Development

*(Employment, Local Income, etc.)*

OSE – Other Social Effects

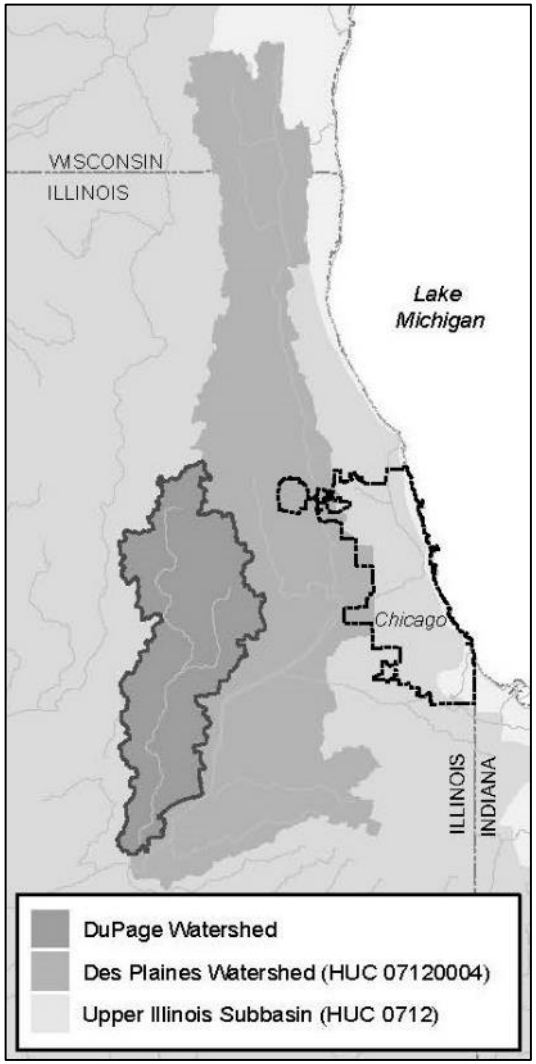
*(Life Safety, etc.)*

# DUPAGE RIVER STUDY




## Study Area

- DuPage and Will Counties
- Watershed area: 378 $mi^2$
  - *East Branch and tributaries*
  - *West Branch and tributaries*
  - *DuPage River mainstem and tributaries*
- Mix of densely and sparsely populated areas
- Significant recent flooding



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# HISTORIC FLOODING

1996 – Up to 17 inches of rainfall over 24 hrs. Extensive structure damages, flooding at major roadways including Interstate 55.

2008 – 51 consecutive hrs of rainfall. FEMA Individual Assistance (IA) totals: $2,300,000 (DuPage), $1,100,000 (Will)

2010 – Up to 7 inches of rainfall over 24 hrs. Impacts primarily on East and West Branches. FEMA IA total: $5,100,000 (DuPage)

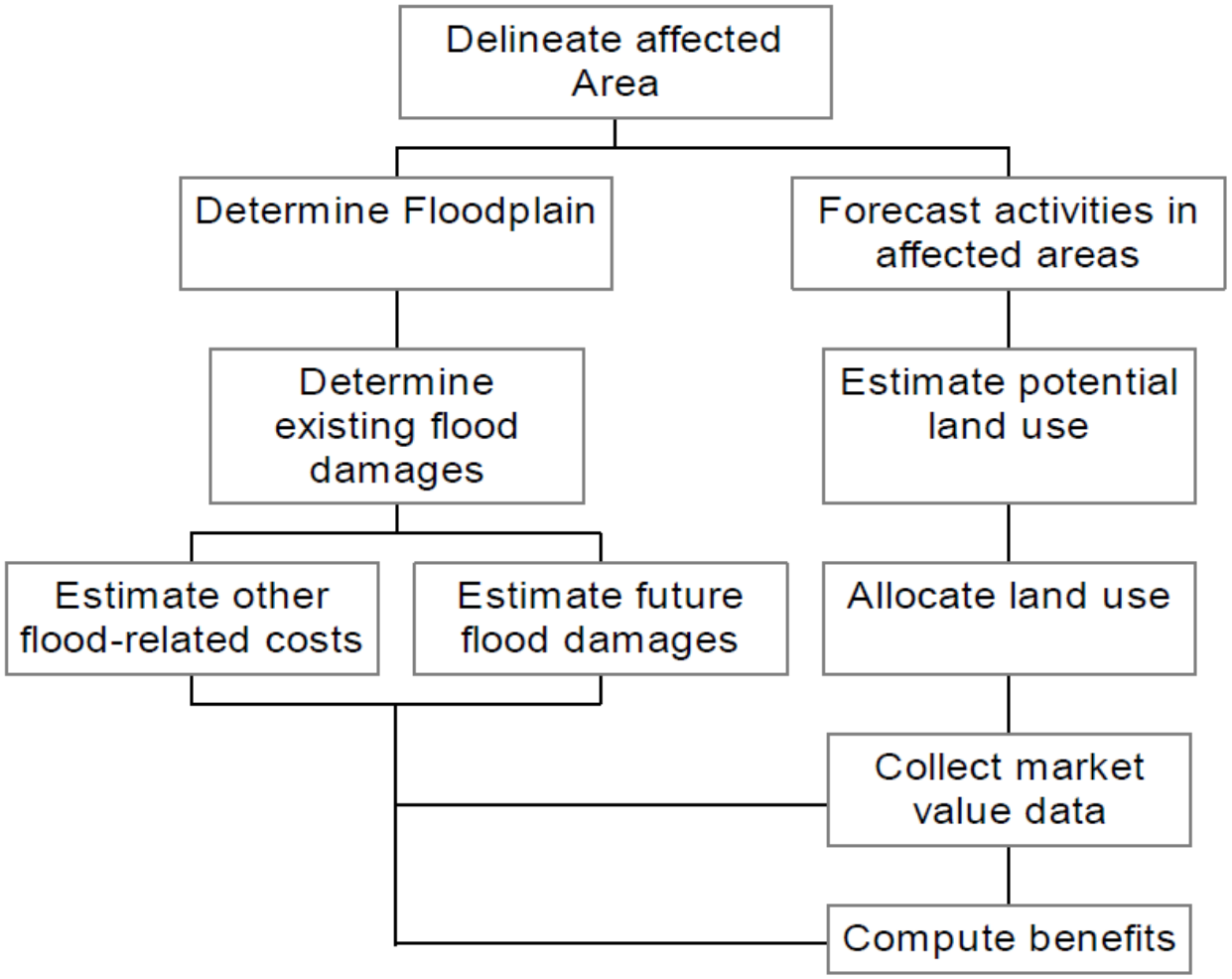
2013 – Up to 7 inches of rainfall in 24 hrs. Record stages at several watershed gages. FEMA IA totals: $14,800,000 (DuPage), $4,300,000 (Will)

DuPage Mainstem at I-55 and Black Rd
July 1996

DuPage Mainstem at River Road
September 2008

West Branch at Winfield Creek
April 2013

# URBAN FLOOD DAMAGE BENEFIT EVALUATION



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# DERIVING NED BENEFITS

Project benefits equal the incremental positive change between the with and without project conditions

To estimate these changes, we must derive:

- Vehicles, Structures and Contents
  *Depreciated replacement values (DRVs)*
- Delay Values
  *Lost wages*
- Forgone Inputs
  *Lost production investment*

# USACE ECONOMIC ANALYSIS SOFTWARE

## HEC-FDA – Flood Damage Reduction Analysis

- Range of events, covering a single year
- Economic losses
- Hydrologic/ Hydraulic inputs
- Uncertainty

## HEC-FIA – Flood Impact Analysis

- Single event analysis
- Economic losses
- Life-Safety Impacts

## HEC-WAT

- Integrates multiple H&H and Econ software

# HEC-FDA AND UNCERTAINTY

Knowledge Uncertainty (epistemic)

- Some variables are more or less constant and do not change with time or space, but we do not know their values accurately
- *Structure values, content values, elevations*

Natural Variability (aleatory)

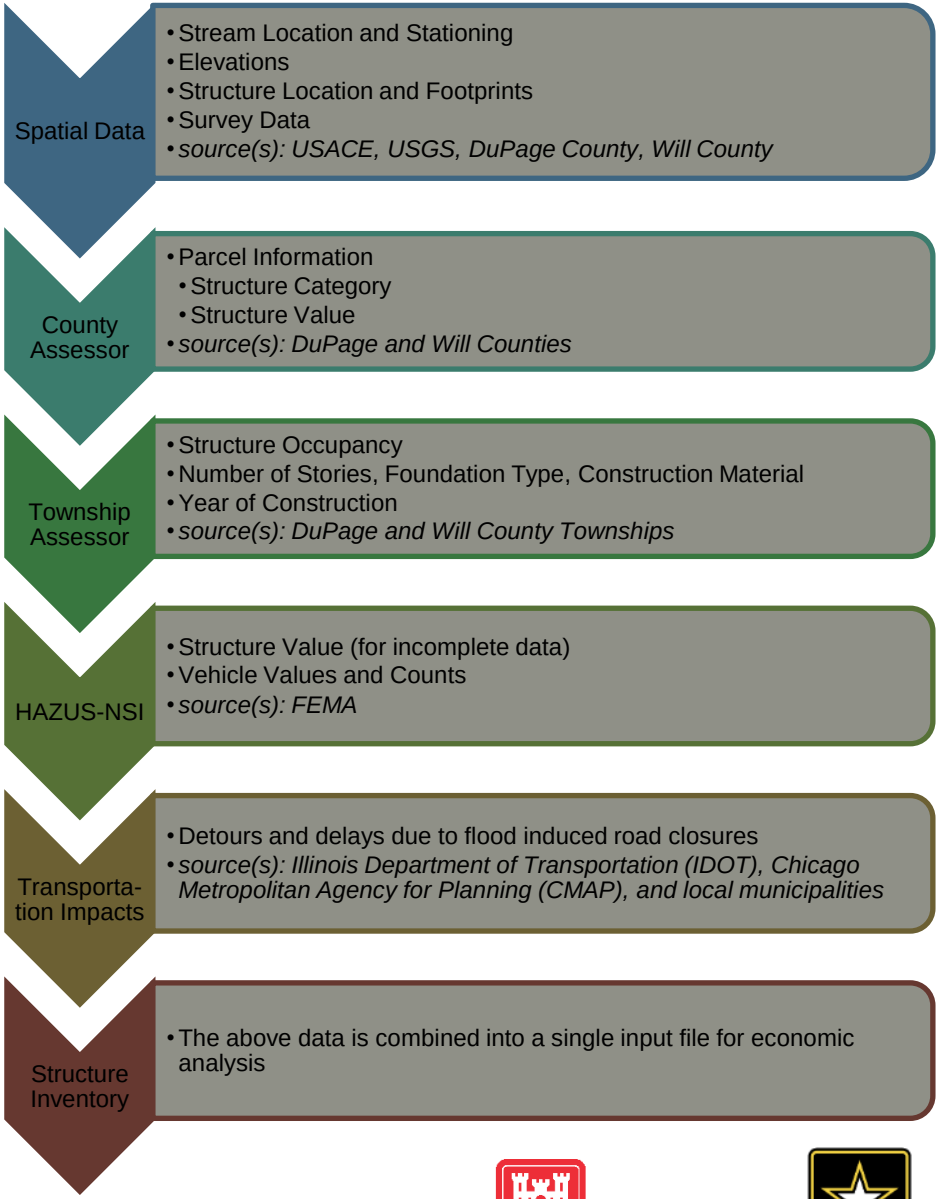
- Some variables are random and unpredictable by nature, and their values change with time or in space
- *Annual chance exceedance for a flow or stage*

# HEC-FDA MODEL INPUTS

Key Inputs:

- Hydrology and Hydraulics (flow and frequency)
- Structure Inventory (value, type, use, elevation, location)
- Feature Reliability (e.g. levee fragility curves and overtopping elevations)

Uncertainty applied to each input



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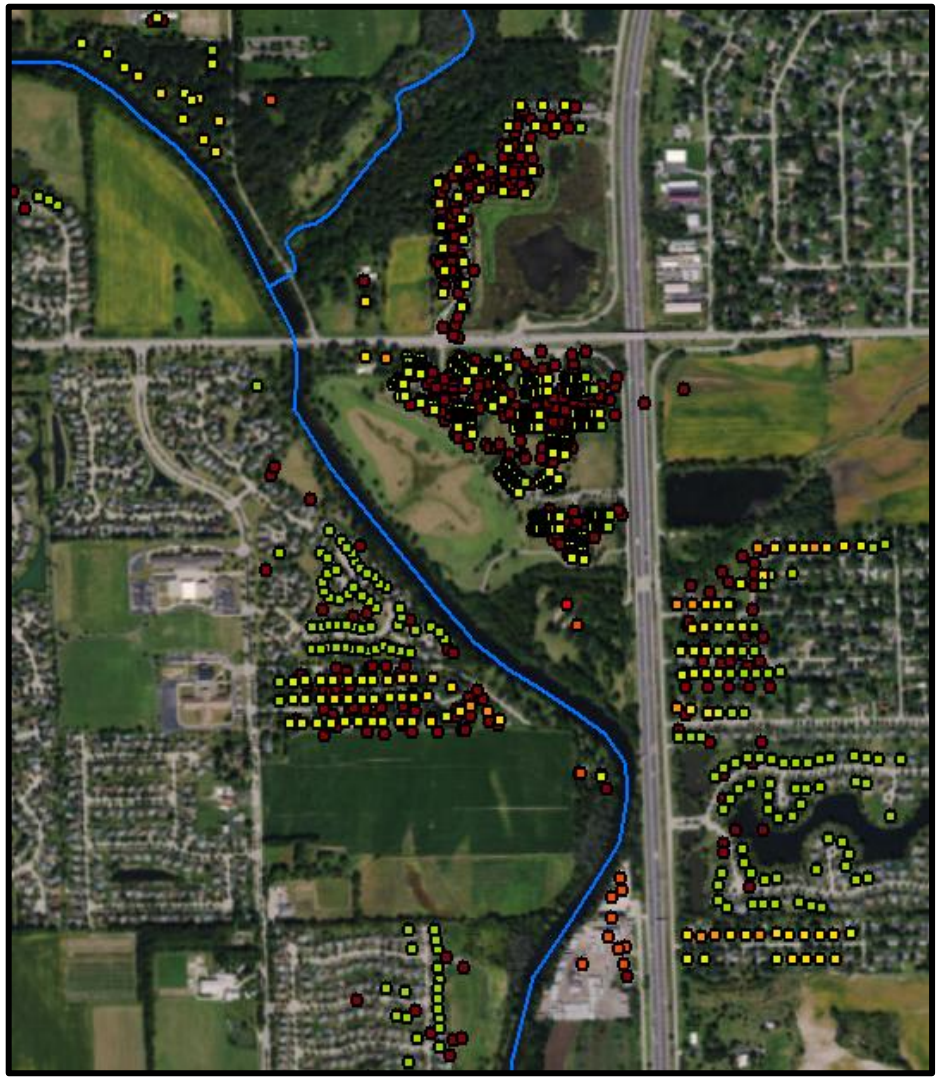
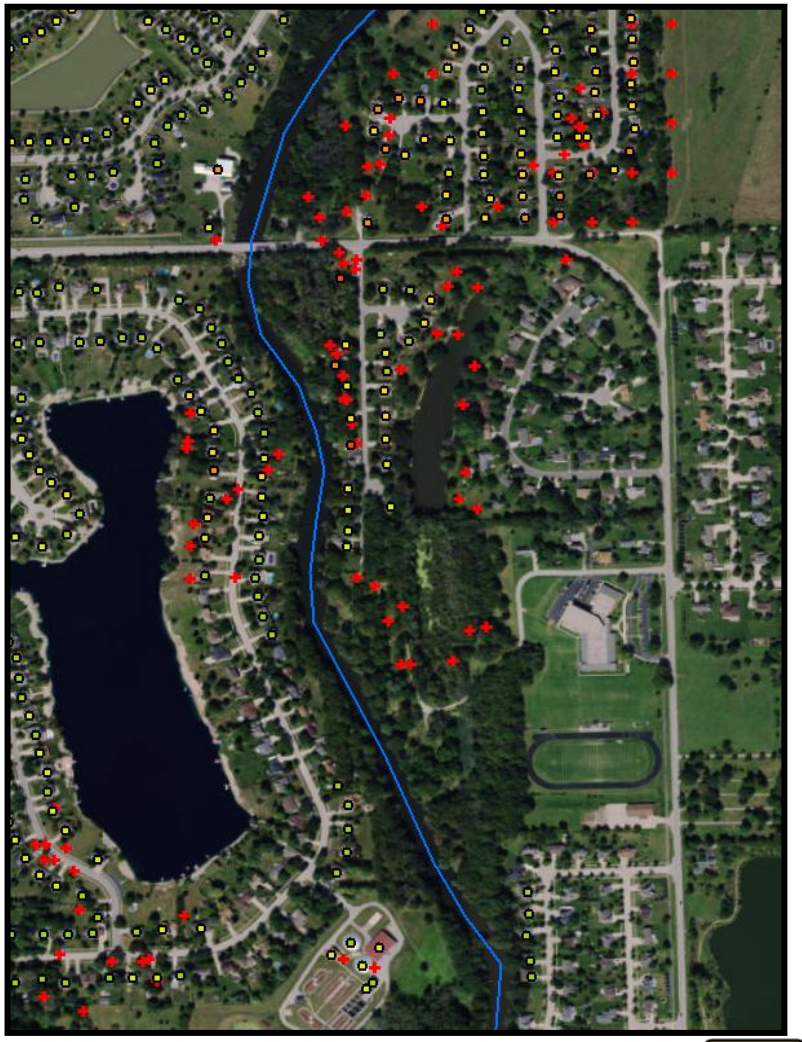
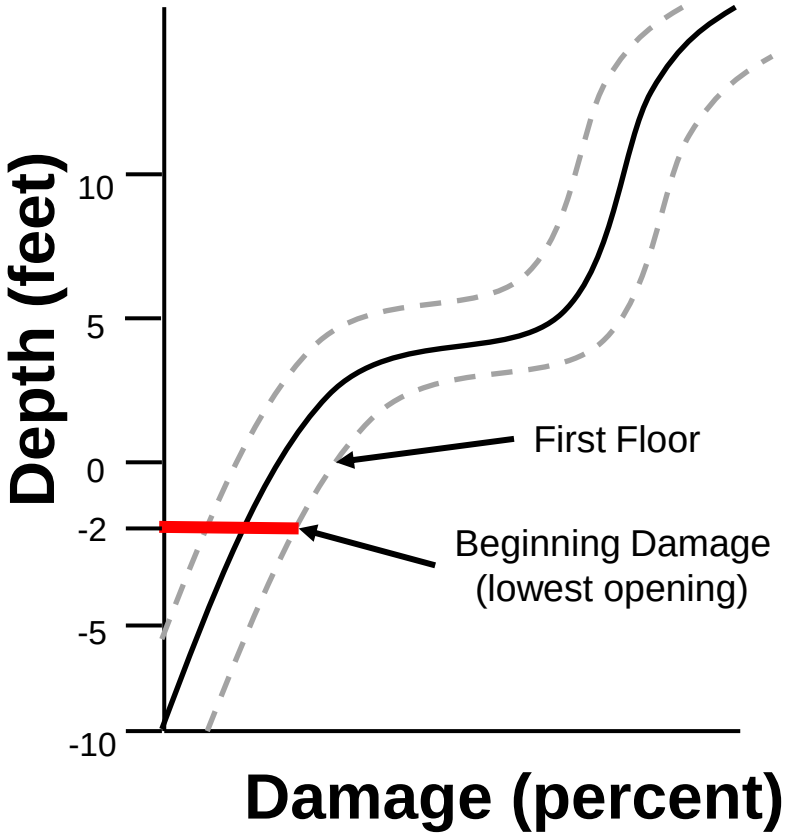
# LEVELS OF DETAIL (H&H AND ECONOMICS)





# DEPTH-DAMAGE FUNCTIONS



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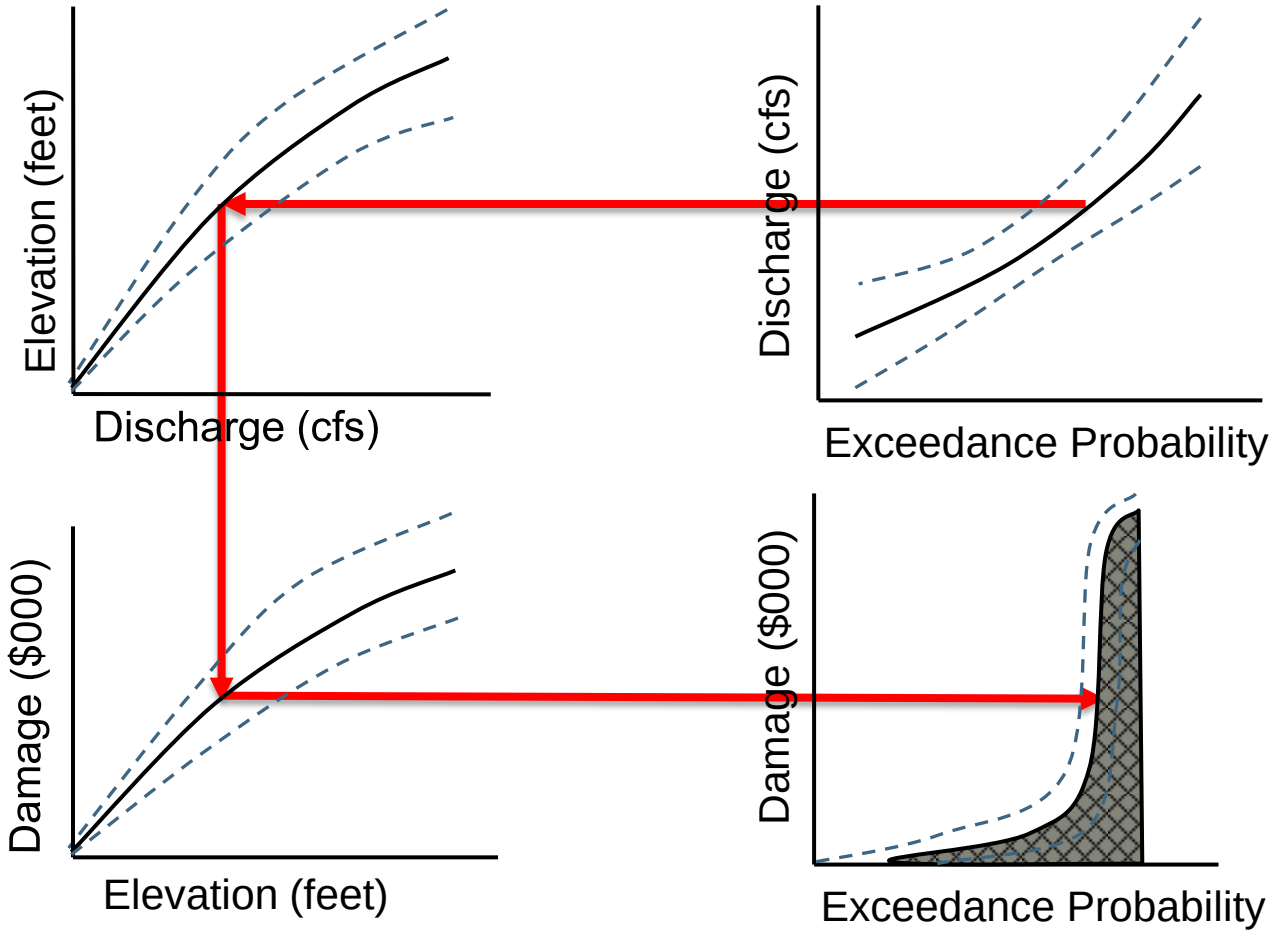
# HEC-FDA DAMAGE CALCULATIONS



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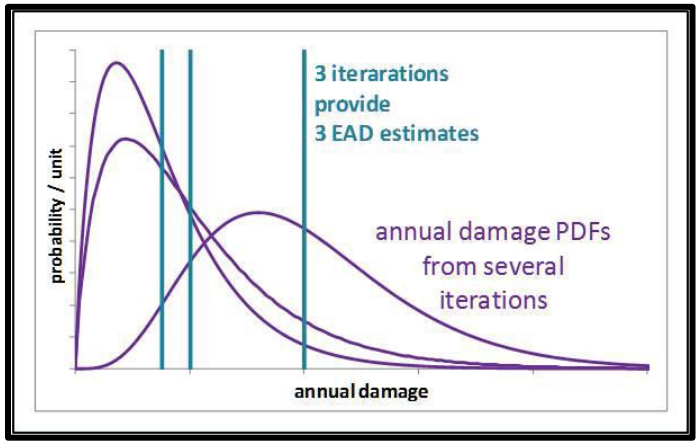
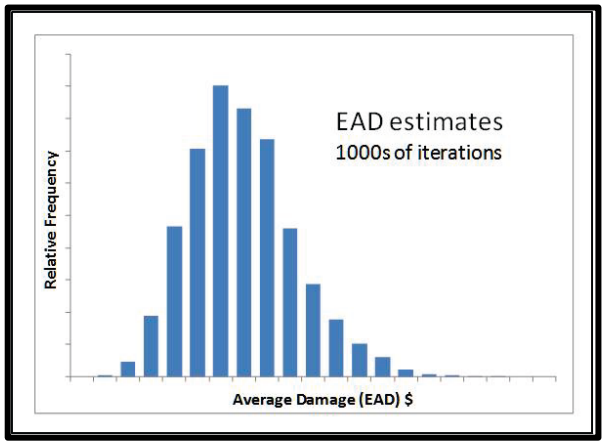
# QUANTIFYING UNCERTAINTY (DAMAGES)

## HEC-FDA Output

- Expected Annual Damages
- Probabilistic Values

| Stream Name | Plan Description | Reach Name | Total Without Project | Total With Project | Damage Reduced | Prob Damg Reduced Exceeds Values 0.75 | Prob Damg Reduced Exceeds Values 0.50 | Prob Damg Reduced Exceeds Values 0.25 |
|---|---|---|---|---|---|---|---|---|
| Example | Levee Option | 1A | $ 1,686 | $ 41 | $ 1,645 | $ 1,179 | $ 1,548 | $ 2,020 |



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# QUANTIFYING UNCERTAINTY (LONG-TERM RISK)

## HEC-FDA Output

- Long-Term Exceedance Risk
- Probabilistic Values

| | | Without Project (602 ft Crest) | Repaired Levee (600 ft Crest) | Repaired Levee (602 ft Crest) |
|---|---|---|---|---|
| **Target Stage Annual Exceedance Probability** | Median | 6.19% | 3.19% | 0.34% |
| | Expected | 6.31% | 3.50% | 0.43% |
| **Long-Term Exceedance Probability** | 10 | 47.88% | 29.94% | 4.20% |
| | 30 | 85.85% | 65.61% | 12.07% |
| | 50 | 96.16% | 83.12% | 19.30% |
| **Conditional Non-Exceedance Probability by Events** | 10% | 84.09% | 99.91% | 100.00% |
| | 4% | 79.22% | 68.07% | 100.00% |
| | 2% | 75.65% | 14.12% | 99.85% |
| | 1% | 68.84% | 0.92% | 94.84% |
| | 0.40% | 38.85% | 0.00% | 56.26% |
| | 0.20% | 14.47% | 0.00% | 21.88% |

*HEC-FDA Output*

# KNOW YOUR DISTRICTS

Illinois is serviced by:

- Chicago District (LRC)
- Louisville District (LRL)
- Rock Island District (MVR)
- St. Louis District (MVS)

Authorities for Assistance:

- Floodplain Management Services (FPMS)
- Planning Assistance to States (PAS)
- Continuing Authorities Program (CAP)
- Tribal Partnership Program (TPP)
- Specifically Authorized

# ANY QUESTIONS?

Thank you!

Feel free to contact me with any follow-on inquiries:

Daniel Linkowski
Regional Economist- Chicago District
Daniel.P.Linkowski@usace.army.mil
312-846-5448