

EXAMPLE OF A MONTE CARLO SIMULATION TO DETERMINE FLOOD RISK

This simulation is a tool used by the Corps of Engineers to answer the question "What is the likelihood of a levee failure?"

TO SET UP THE SIMULATION ...

Identify a point along the river that is representative of the levee system's ability to contain the floodflows (for example, a weak spot in the levee).

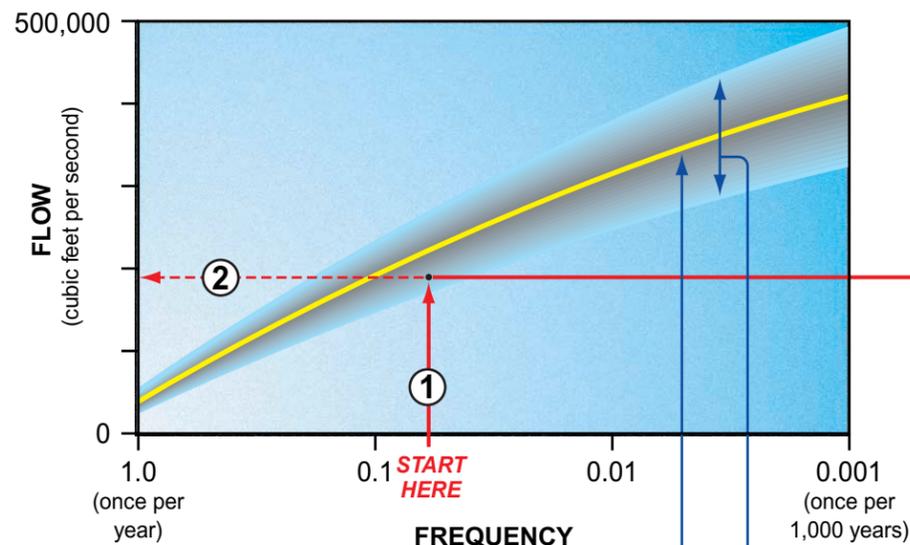
Run the simulation using representative hydrology, hydraulics, and geotechnical levee data.

STEP ①: GENERATE A FREQUENCY OF OCCURRENCE

Frequencies are randomly generated but naturally distributed (more occurrences on the left side of the chart). In 1,000 simulations, approximately 10 floods will exceed a 1% (100-year) event.

STEP ②: DETERMINE FLOW

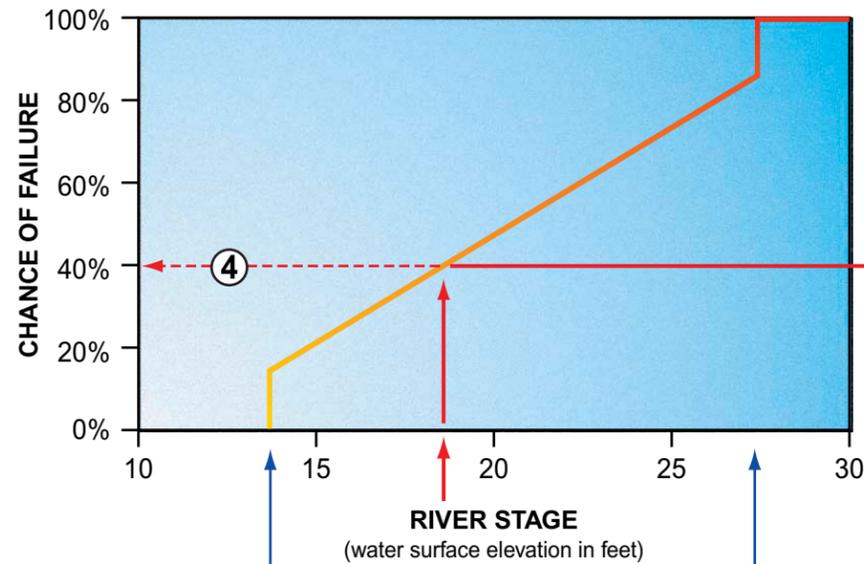
The chart below is based on historic and calculated hydrology data.



Most likely flow volume at a given frequency
Range of uncertainty (Chart results may come from anywhere in this range, but the results most likely are on or near the yellow line.)

STEP ④: DETERMINE THE PERCENT CHANCE OF LEEVE FAILURE BASED ON STAGE

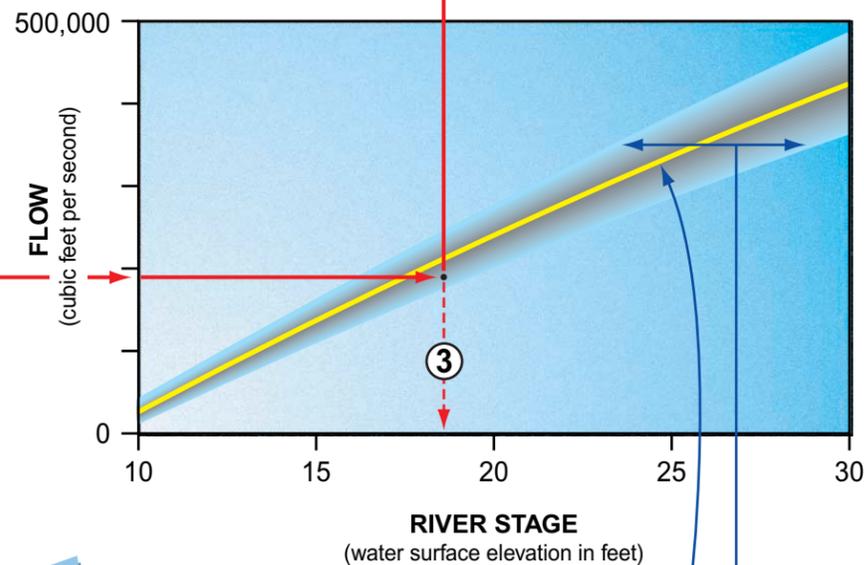
The chart below is based on geotechnical levee data.



Probable Nonfailure Point (PNP): the highest water surface elevation at which levee failure is highly *unlikely*
Probable Failure Point (PFP): the highest water surface elevation at which levee failure is highly *likely*

STEP ③: DETERMINE RIVER STAGE (ELEVATION) BASED ON FLOW

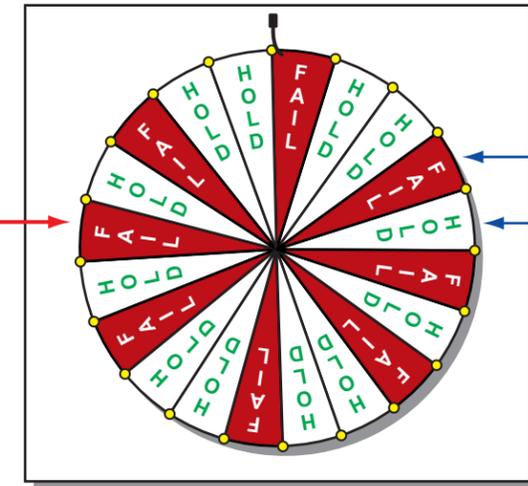
The chart below is based on hydraulics data.



Most likely river stage at a given flow volume
Range of uncertainty (increases as flow volume increases)

STEP ⑤: FAIL OR DON'T FAIL THE LEEVE BASED ON PERCENT CHANCE

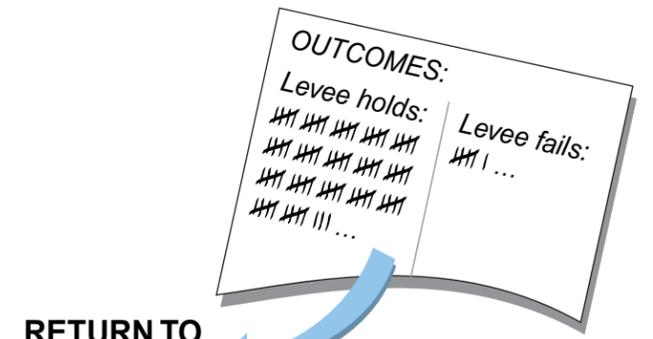
Set up a "Wheel of Fortune" for levee failure or nonfailure based on result of Step 4.



40% chance that levee will fail
60% chance that levee will hold

Spin the wheel – the levee will either hold or fail.

STEP ⑥: RECORD OUTCOME AND REPEAT SIMULATIONS



RETURN TO STEP 1

Stop the simulations after (for example) 1,000 runs. Then divide the number of simulations by the number of levee failures:

$$\frac{1,000 \text{ simulations}}{55 \text{ levee failures}} = 1 \text{ chance in } 18 \text{ per year of a levee failure resulting in a flood}$$

American River Watershed, California
Long-Term Study
Final Supplemental Plan Formulation Report/EIS/EIR
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Sacramento District, Corps Of Engineers
February 2002