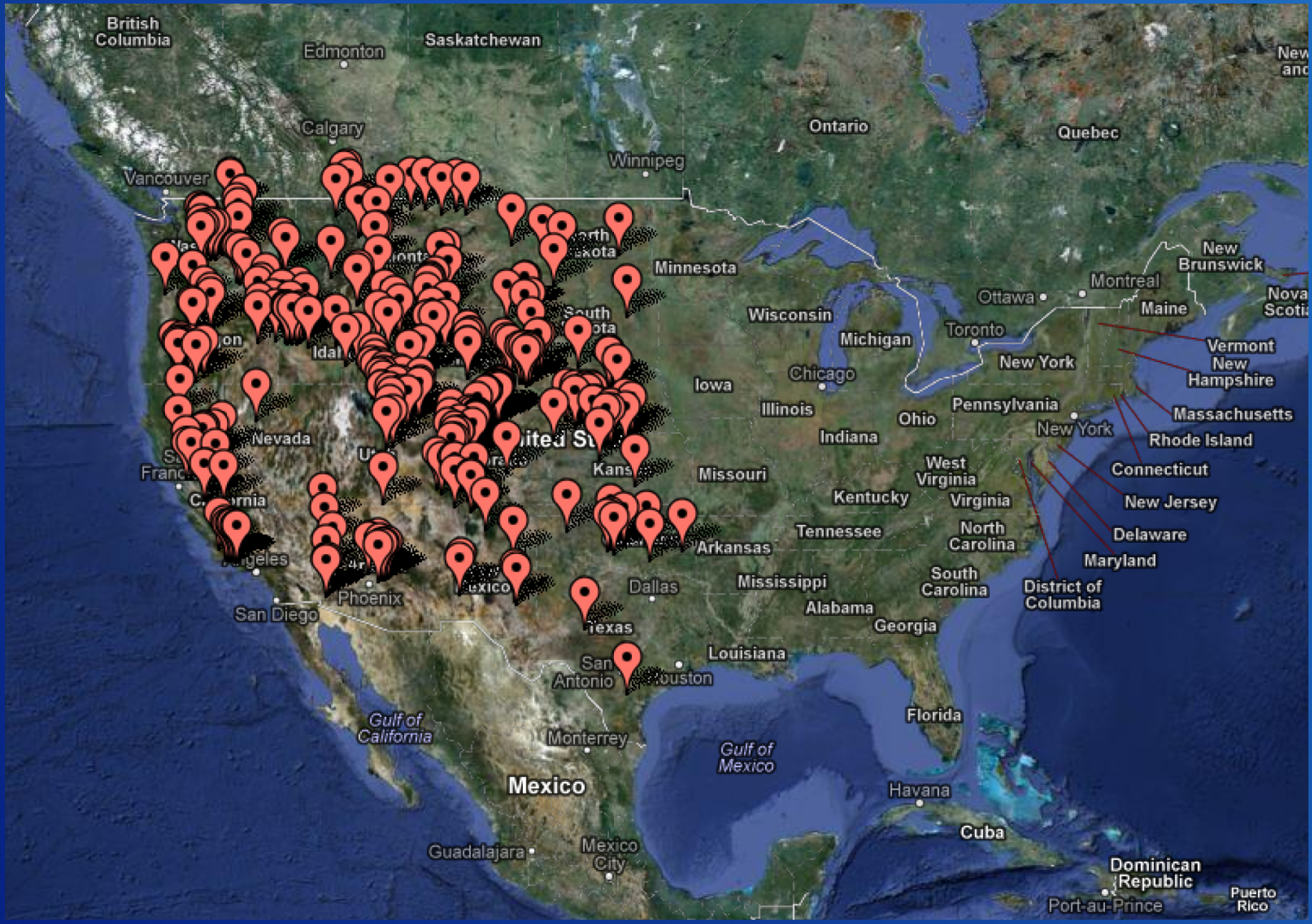
RECLAMATION

Managing Water in the West

Paleoflood Studies and their Application to Reclamation Dam Safety

U.S. Department of the Interior
Bureau of Reclamation



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The Problem for Dam Safety Office -

- More than half the inventory does not pass traditional deterministic criteria used as an estimate of flood hazard (i.e., the PMF)

- Costs associated with modifying the inventory to meet this standard were considered prohibitive

- Deterministic criteria varied through time and with subjectivity of the practitioner (individual and organizational)

A Solution -

- Utilize Probabilistic Flood Hazard Analysis (PSHA)

- Highly adaptable to evaluate institutional exposure to specific hazards or address particular safety concerns (e.g., spillway gates)

- Allows DSO to better categorize its inventory and prioritize corrective actions on the basis of risk

A Problem for PFHA -

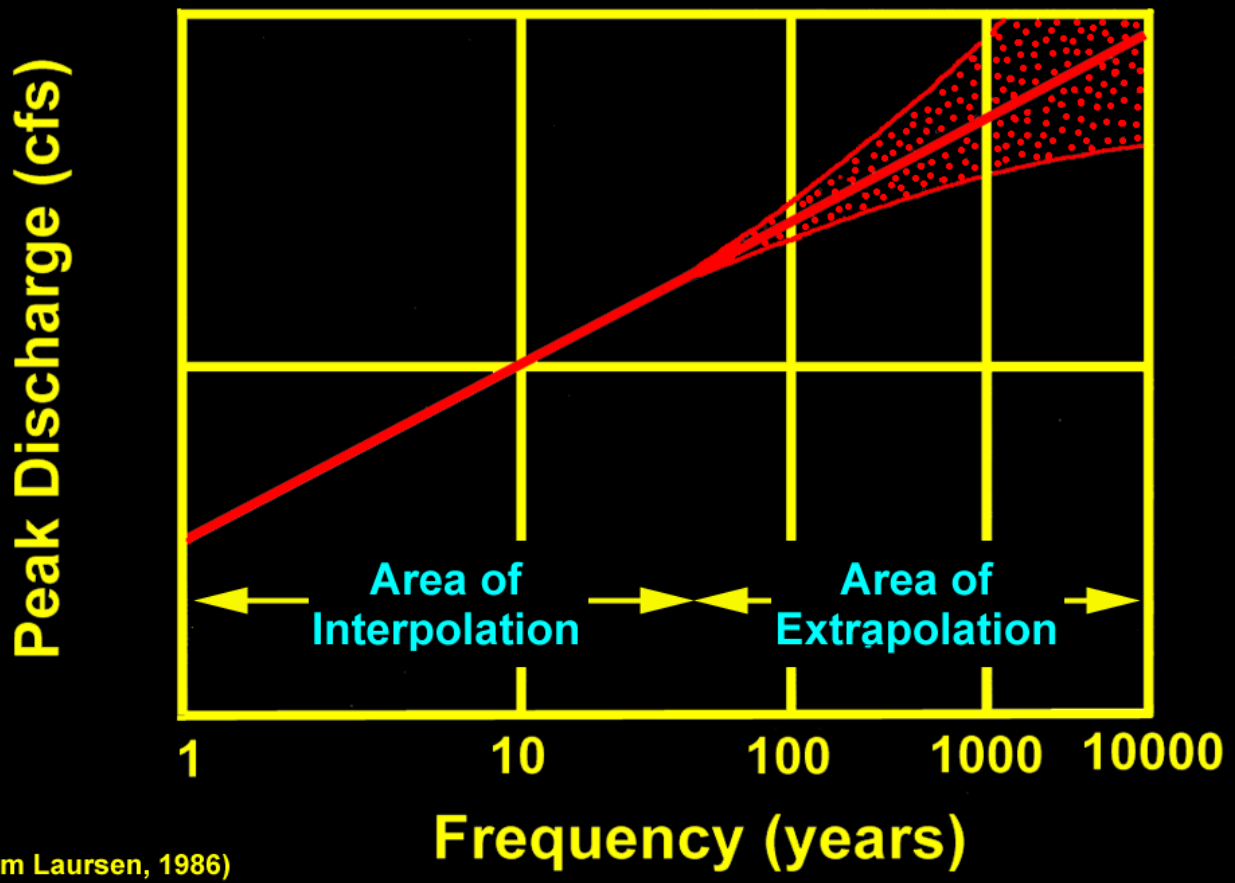
- Short or non-existent records

  100 years is wonderful; not common; still inadequate to make an accurate estimation of the large magnitude infrequent floods

- Records with extreme outlier(s)

  What does the outlier represent exactly (extremely rare event or is it simply a less frequent large flood and what is its return period)

Unlimited Discharge-Frequency Relationship



(modified from Laursen, 1986)

Paleoflood Data -

- Extends short or non-existent records

  Extending record to include the last 1000 years is common, up to and including much of the last 10,000 not unusual

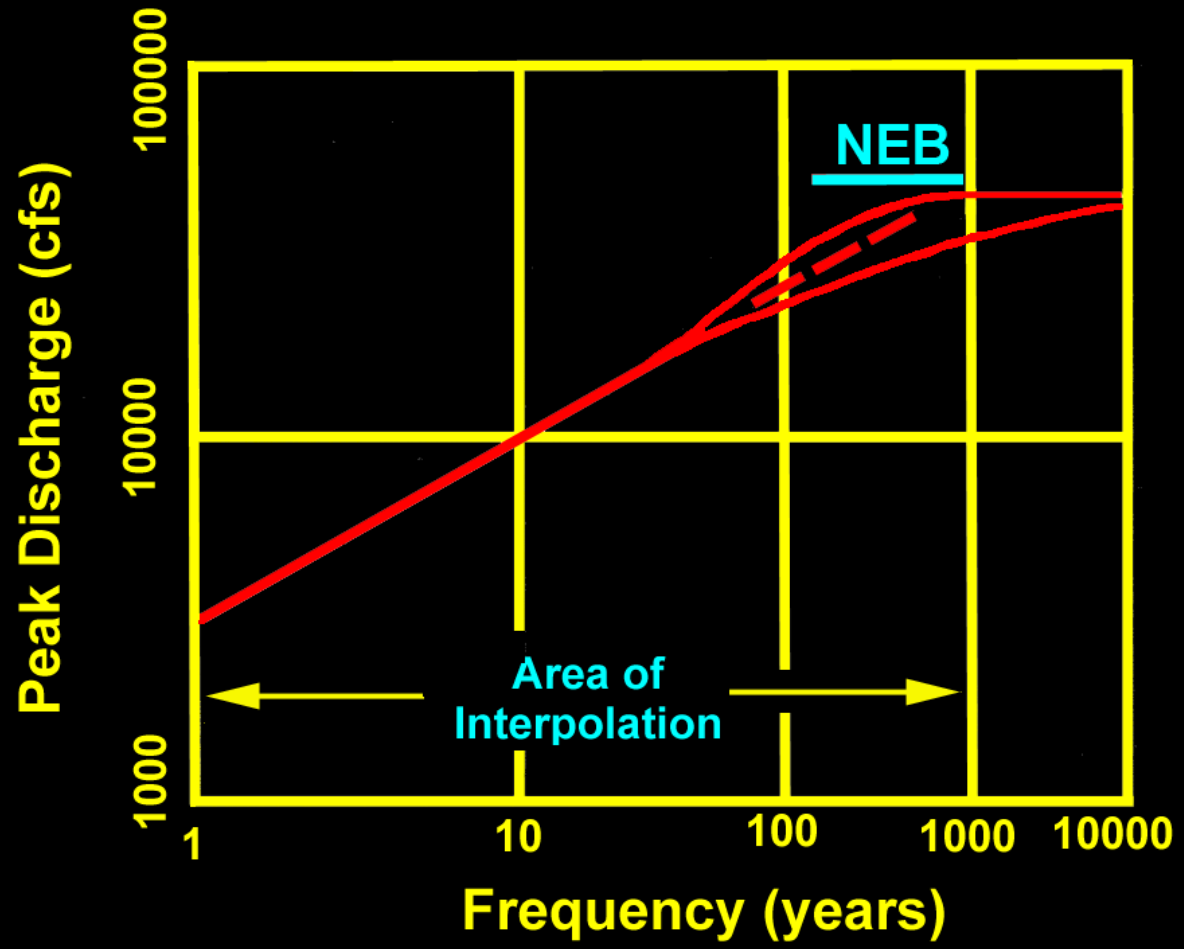
  Addition of any paleoflood data to a frequency analysis has been shown to improve accuracy of the estimate

- Places extreme outlier(s) into temporal context

  Time interval between events of similar size (if they are recurrent) or the time since the event last occurred can often be determined

- Cost effective and robust

Limited Discharge-Frequency Relationship



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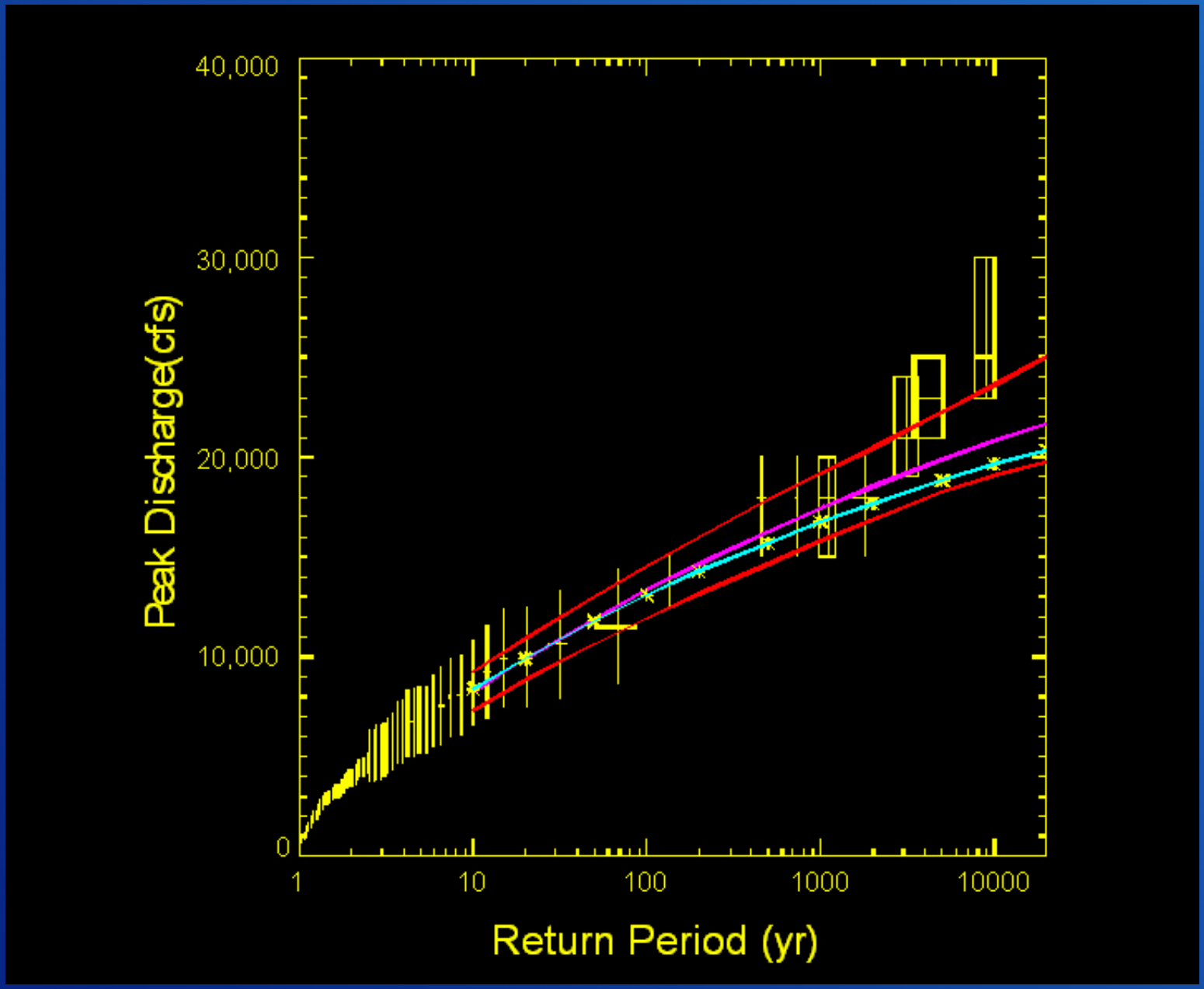
40,000
30,000
20,000
10,000
0
Peak Discharge(cfs)
1
10
100
1000
10000
Return Period (yr)

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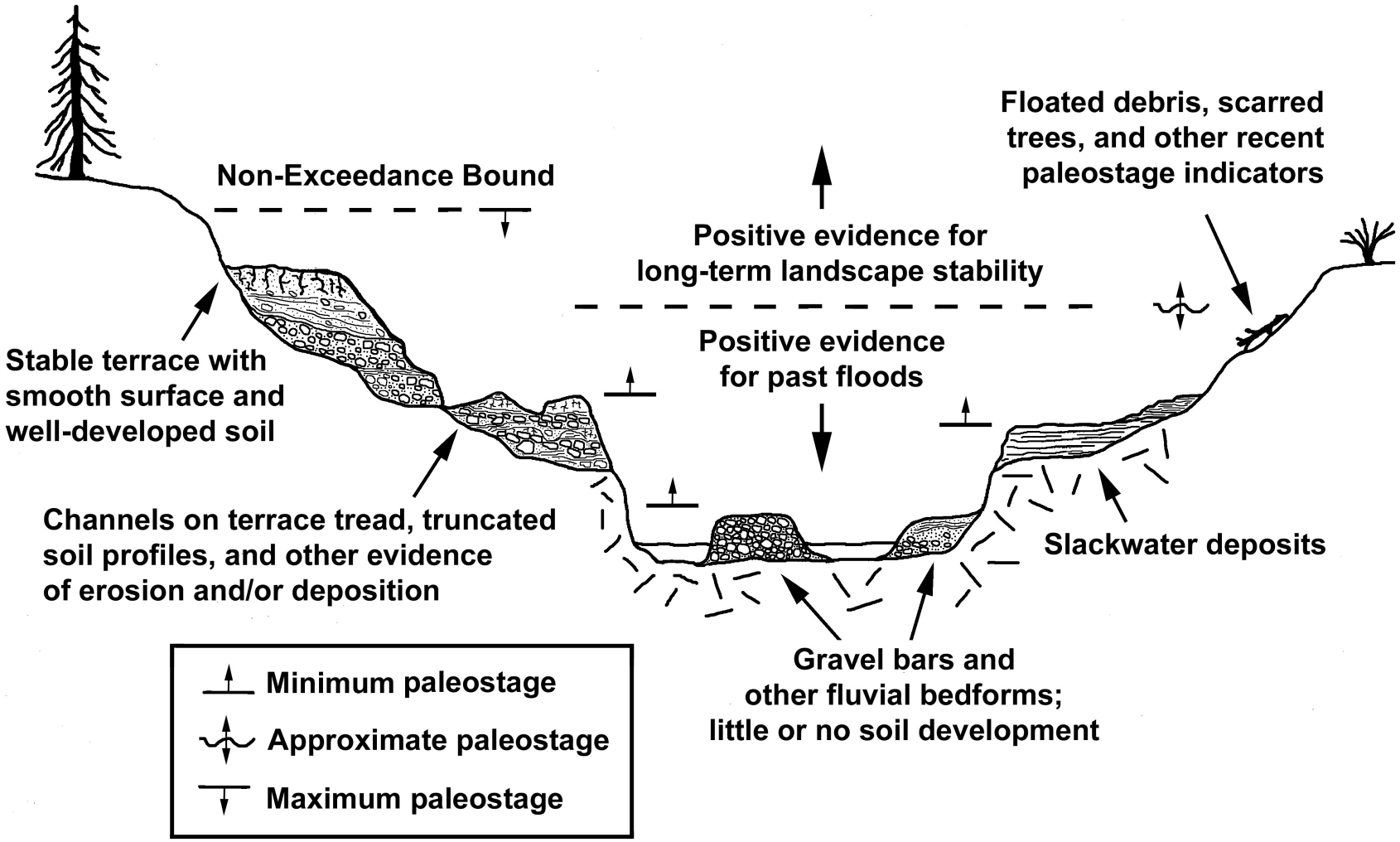
Non-Exceedance Bound
Floated debris, scarred trees, and other recent paleostage indicators
Positive evidence for long-term landscape stability
Positive evidence for past floods
Stable terrace with smooth surface and well-developed soil
Channels on terrace tread, truncated soil profiles, and other evidence of erosion and/or deposition
Slackwater deposits
Gravel bars and other fluvial bedforms; little or no soil development
Minimum paleostage
Approximate paleostage
Maximum paleostage

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Soil Geomorphology

- Soil is a natural body that consists of horizons of mineral and/or organic constituents of variable thicknesses, which differ from the parent material in their morphological, physical, chemical, and mineralogical properties and their biological characteristics
- Pedogenic processes are responsible for the form (morphology) of most soils. The extent of this development is in part time dependent and occurs at a predictable rate; allows estimates of age
- Soil stratigraphy is the relationship between soils and Quaternary geologic units (bridge between stable landforms and active fluvial processes)

Evidence of stability

Evidence of recent flooding

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Screening-Level (CFR or CR) –

- Limited field data collection

- Generally based on a single site assessment

- Discharge estimated from slope-conveyance calculations

- Age Estimates based on soil correlation

- Used to provide information that can be used in screening-level risk assessments for prioritizing risk profile of inventory

- Cost: $15K to $30K

Issue Evaluation (IE) -

- Extended field data collection

- Includes assessment from multiple sites

- Discharge estimated from one-dimensional hydraulic model

- Numerical age determinations (commonly 14C), soils

- Used to primarily to reduce the uncertainty in screening-level risk assessments and for assessing risk related to specific dam safety issues

- Cost: $50K to $100K

Corrective Action Studies (CAS) -

- Extensive field data collection
- Assessment at multiple sites on different tributaries in the basin or on adjacent rivers within a region
- Two-dimensional hydraulic modeling
- Numerical age determinations (commonly 14C), soils
- Used for design-level assessment of flood hazard; attempts to reduce uncertainty in data as much as is reasonably possible given available technology
- Cost: >$150K

Conclusions -

- Paleoflood data is an extremely powerful addition to PFHA and a critical component in Reclamation risk analyses

- Vastly improves the accuracy of estimates for the magnitude and frequency of large floods

- Is cost effective and studies can be patterned to fit informational requirements

- Utilizes wide-used scientifically-based methodologies that have been adapted over time to take advantage of advances made in the fields of remote sensing, isotopic geochronology, computer-assisted hydraulic modeling, and statistical hydrology

Questions?