Delta Levees Investment Strategy

Appropriate Levels of Protection and Tolerable Risk

February 2015

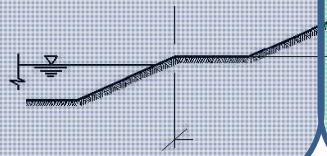
DELTA STEWARDSHIP COUNCIL

Objectives

- Use risk-informed analysis to guide DLIS investment priorities
- Provide guidance on tolerable risks to State interests
  - *Inform policy decisions*
  - *Guide evaluation of investments to reduce risk*

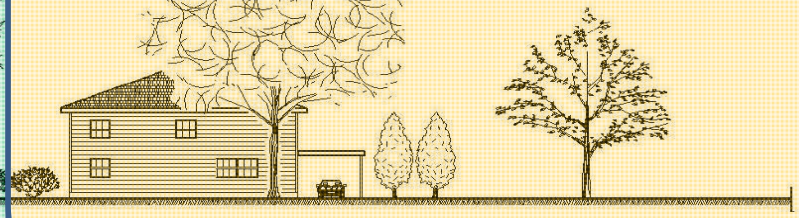
Risk

What are the hazards and how likely are they to occur?



How will the infrastructure perform in the face of these hazards?

Who and what are in harms way (Exposure)? How susceptible to harm are they (Vulnerability)? How much harm is caused?



Risk = probability x consequences

How do you manage risk?

- Tolerable Risk
  - *What is it?*
  - *Why use for priorities?*
- Tolerable Risk as a framework for DLIS
  - *Existing guidance*
  - *Risk-informed mapping*
  - *F-N curves*
- Using the DLIS planning tool

Tolerable Risk

- The level of risk that people are willing to live with in order to secure certain benefits

Risk and the Four Stages of Denial

- It won't happen
- If it happens, it won't happen to me
- If it happens and it happens to me, it won't be so bad
- If it happens and it happens to me, and it's bad, there is nothing I can do to stop it anyway

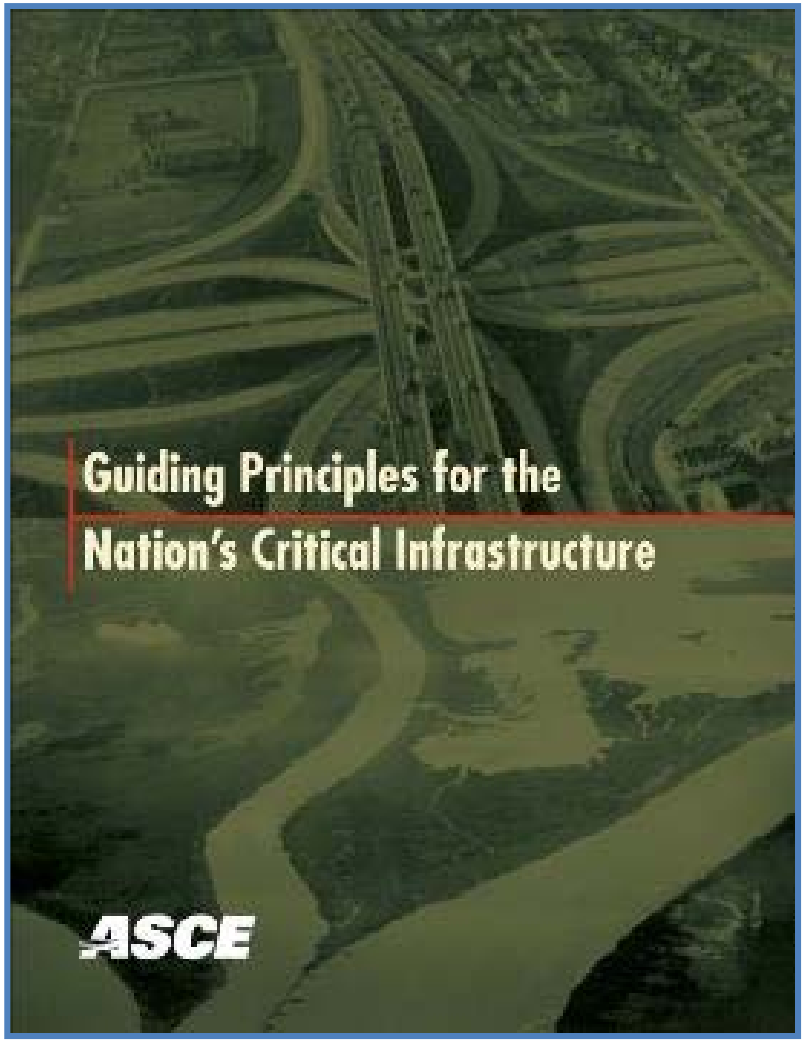
FEMA

U.S. Army Corps of Engineers
Sacramento District

Guiding Principles for Critical Infrastructure

Overarching Principle: Critical infrastructure systems must hold paramount the safety, health, and welfare of the public it serves

- Exercise sound leadership
- Use a systems approach
- Adapt to change
- Manage risk



2009

Why prioritize?

- State interests
  - *Reduce loss of life and property damage*
  - *Improve water supply reliability*
  - *Enhance the Delta ecosystem*
  - *Maintain Delta as an evolving place*

  } ***Coequal Goals***

- Too many miles of levees, not enough funding
- Tolerable risk can help determine what to do first

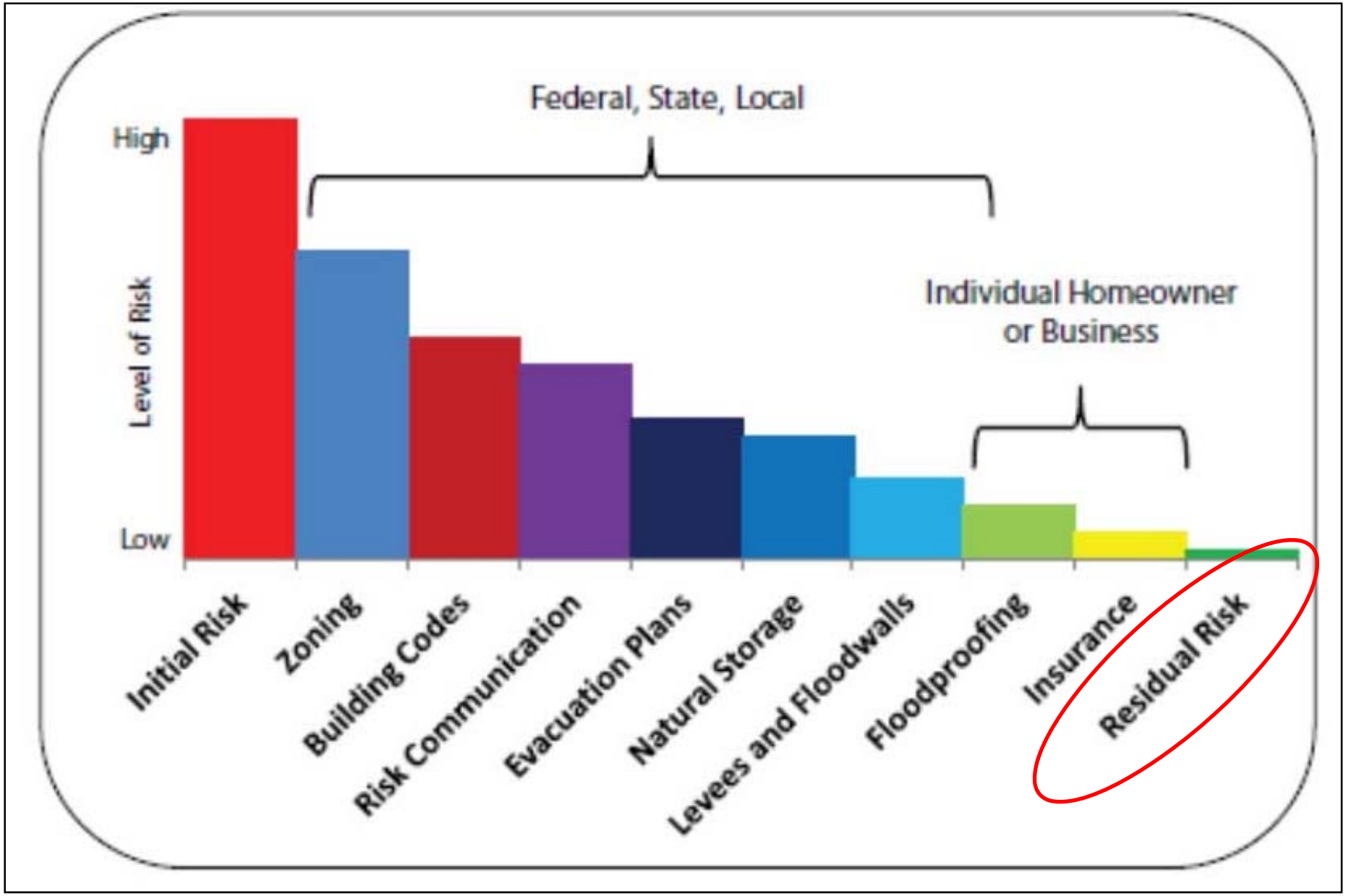
Why not "Appropriate Levels of Protection"?

- Implies risk can be eliminated
- Basic geometry – says nothing about levee performance
- Can be a liability
- Tolerable Risk reflects global shift from flood control to flood risk management

Tolerable Risk

- Comprehensive look at probabilities and consequences
- Informs decisions about frequency, depth, and duration of flooding
- Supports policy setting and decision-making
- Evaluates trade-offs (e.g., structural *vs.* non-structural, State interests)
- Useful in allocating scarce resources

Recognizes that risk cannot be totally eliminated


Federal, State, Local
High
Level of Risk
Low
Individual Homeowner or Business
Initial Risk
Zoning
Building Codes
Risk Communication
Evacuation Plans
Natural Storage
Levees and Floodwalls
Floodproofing
Insurance
Residual Risk

Tolerable Risk

- Absolute protection is not possible
- Criteria for decision-making on risk reduction
  - *Focus on most serious risk (prioritize)*
  - *Efficiency (action commensurate with risk)*
  - *Consistency (adopting similar approaches in similar circumstances to achieve similar ends)*
  - *Transparency in how decisions are made*
  - *Clarity on who is accountable*

Tolerable Risk is a Range

Unacceptable	Risks cannot be justified except in extraordinary circumstances
Tolerable	People and society accept risk in order to secure benefits
Broadly Acceptable	Risks regarded as insignificant

Tolerable Risks Are…

- Not seen as negligible or something to ignore
- Viewed by society as being properly managed
- Continuously reviewed and reduced if practicable

USACE ER 1110-2-1156, Safety of Dams, Policy and Procedures, October 2011

Tolerable Risk Principles

- Equity
  - *The right to be protected*
  - *Interests of all are treated with fairness*
- Efficiency
  - *Uses available resources to achieve the greatest benefit*

Tolerable Risk Principles

As Low As Reasonably Practicable (ALARP)

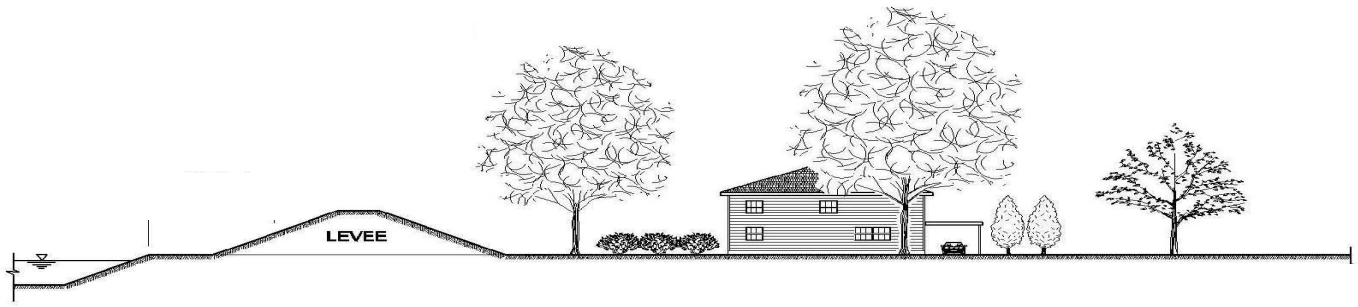
- Absolute safety cannot be guaranteed

Individual Risk and Societal Risks

- Delta resident concerned with life safety and property damage
- State's interest in coequal goals, cultural resources, and economic activity

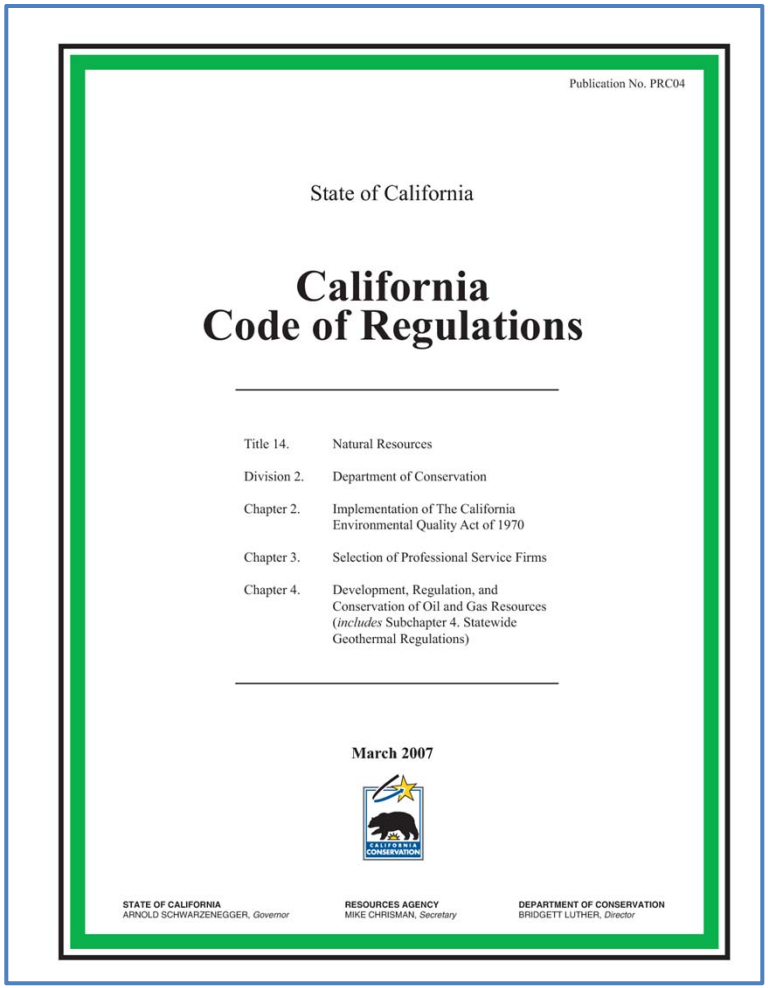
Tolerable Risk Applications

- USACE and USBR for dams
- Proposed by USACE for levees (policy document is circulating)
- UK for health and safety
- Netherlands for flood risk



Tolerable Risk is a Prudent Approach

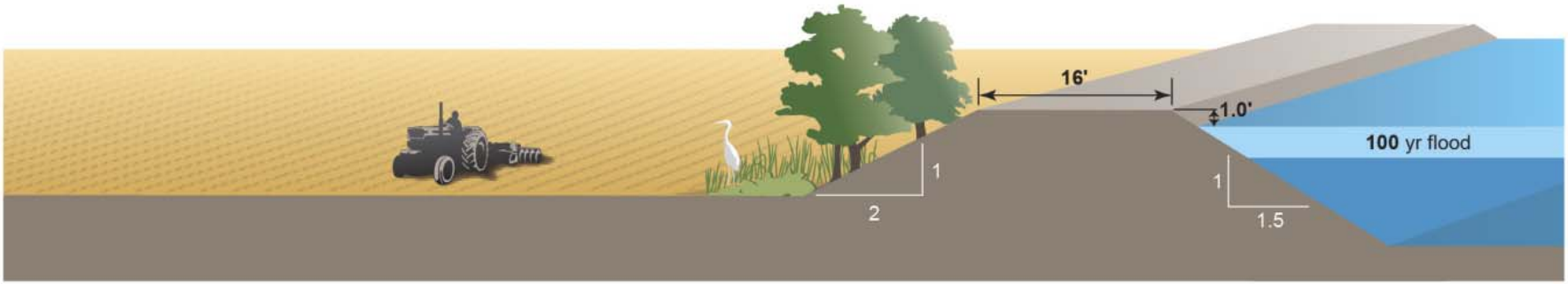
- **Reduce flood risks** *(Water Code 85305 (a))*
- Prioritizes State investments in **levee operations, maintenance, and improvements** in the Delta *(Water Code 85306)*



Existing Guidance

What "standards" do we have?

- HMP is an <u>interim disaster rehabilitation guideline</u> based on geometry from an expired MOU

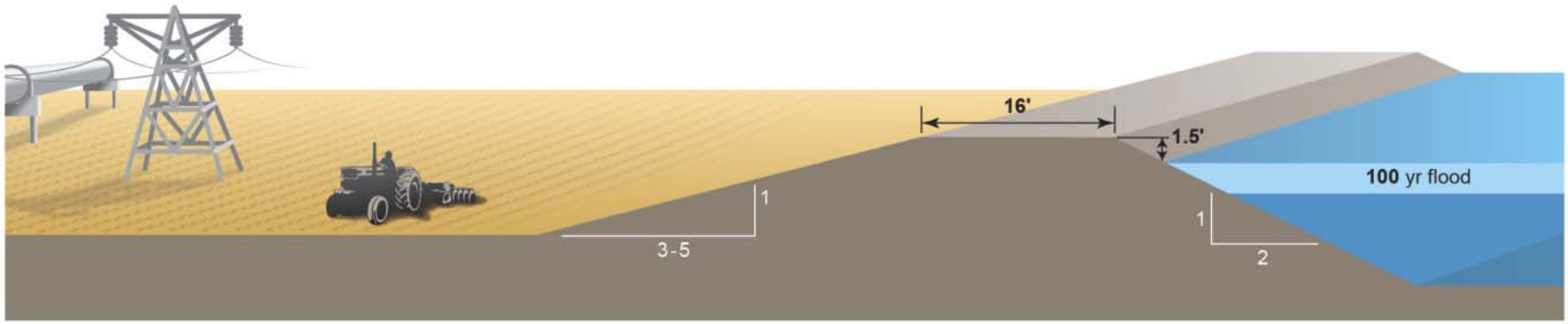


Hazard Mitigation Plan (HMP)

Existing Guidance

What "standards" do we have?

- Public Law 84-99 (1/100 yr.[?]) is a <u>disaster rehabilitation guideline</u>

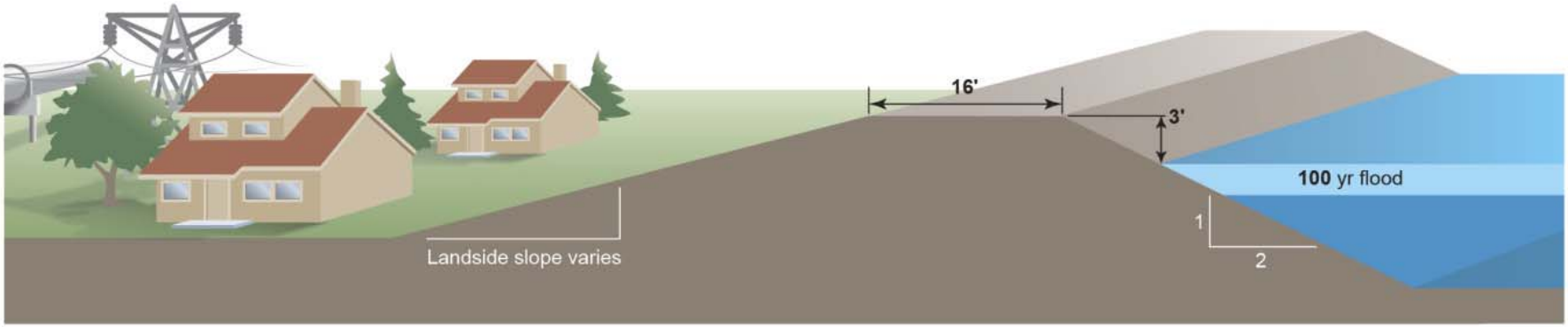


PL 84-99

Existing Guidance

What "standards" do we have?

- FEMA 1/100 yr. is an insurance standard to support the National Flood Insurance Program

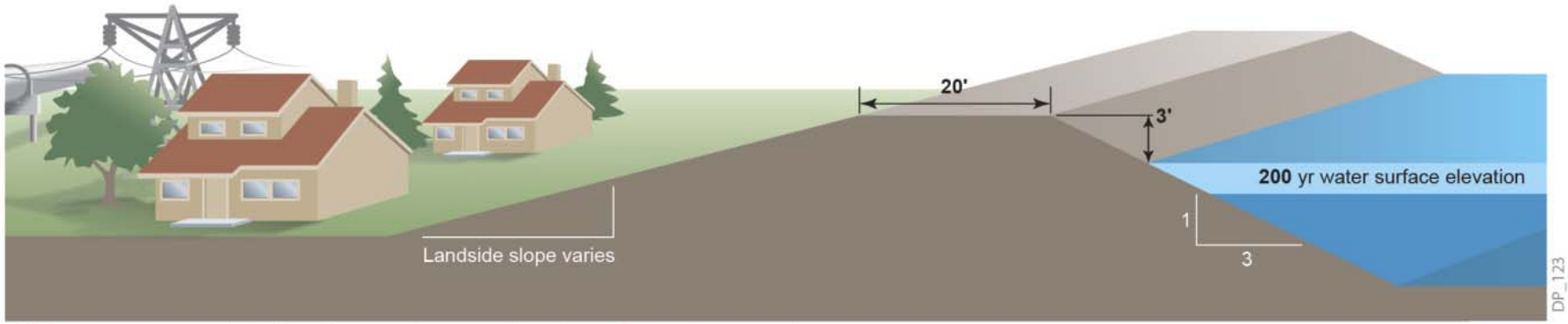


FEMA - 100 year

Existing Guidance

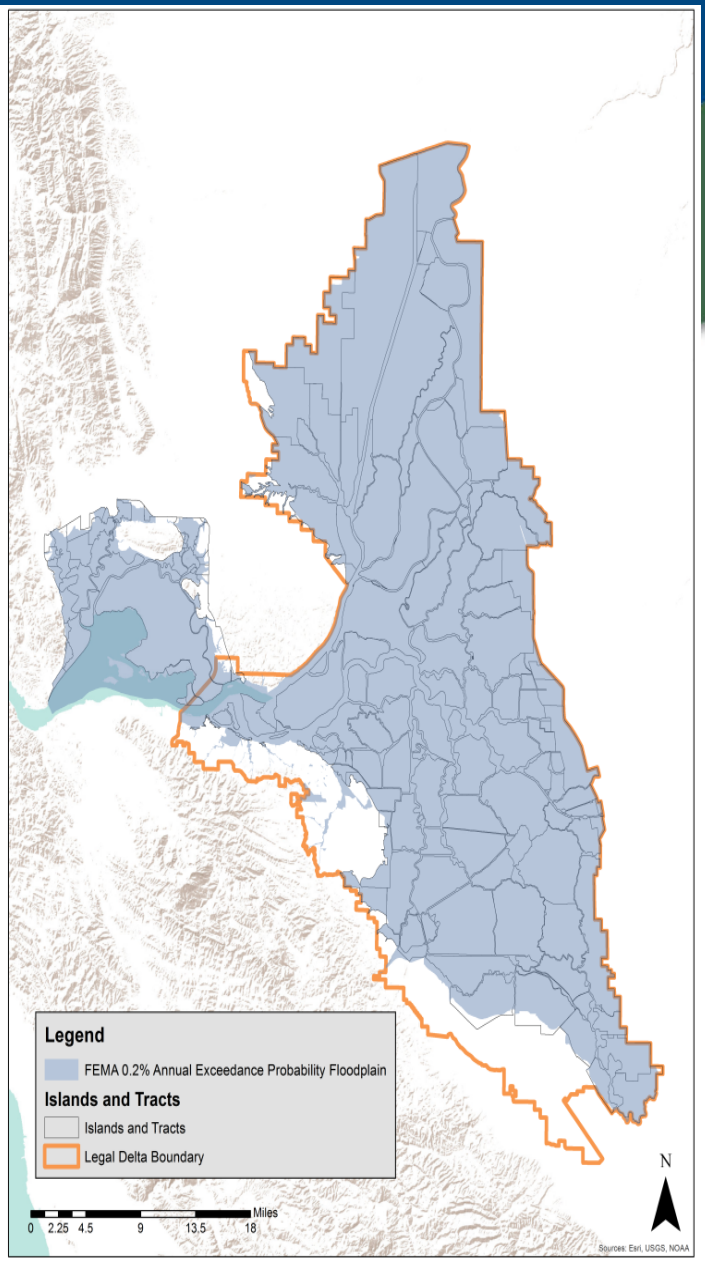
What "standards" do we have?

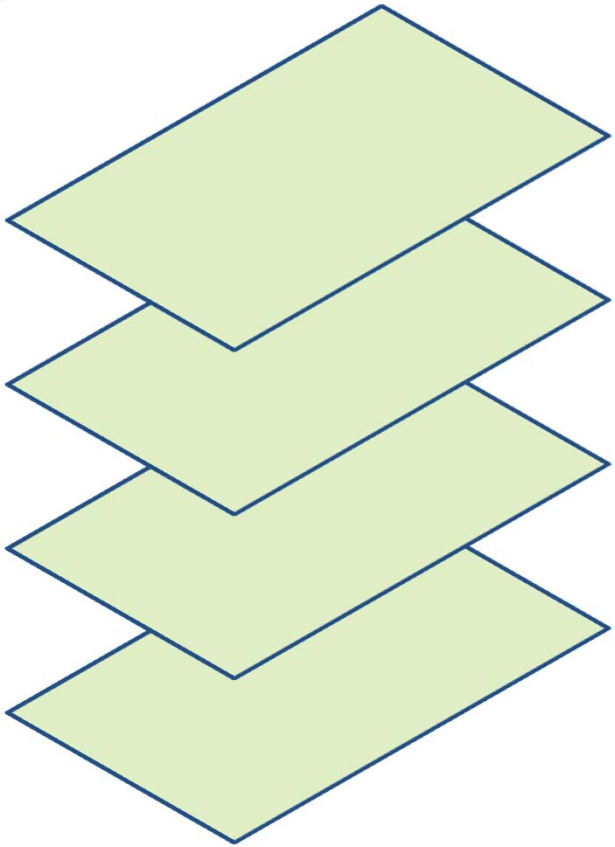
- 1/200 yr. is levee standard from California State Legislature, *water code 65007 (n)*



DWR - 200 year (DWR Urban Levee Design Criteria 2011)

Levees Based on Existing Guidance





200 YR. LEVEES

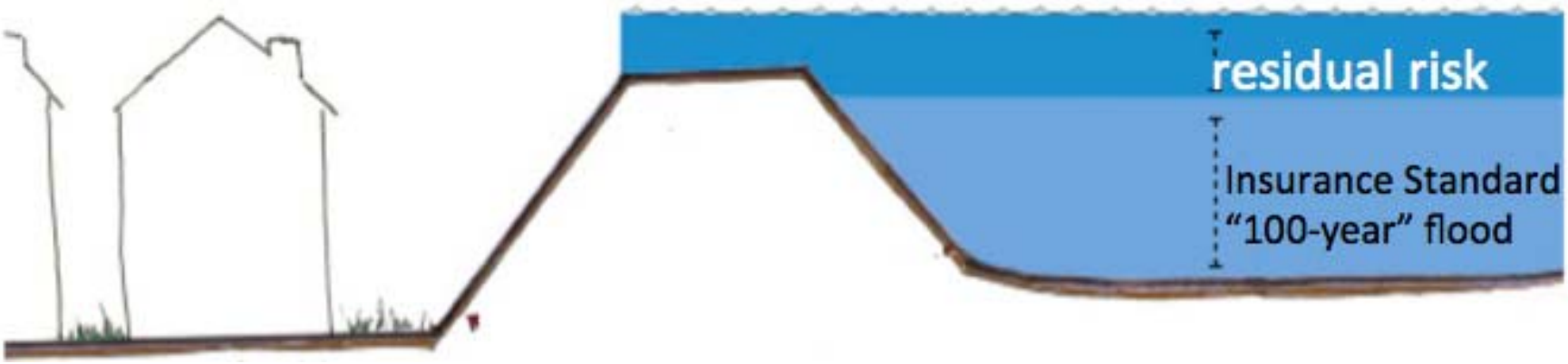
100 YR. LEVEES

PL 84-99 LEVEES

HMP LEVEES

Tolerable Risk Applications

- FEMA (and other) standards do not account for the residual risk posed by larger floods

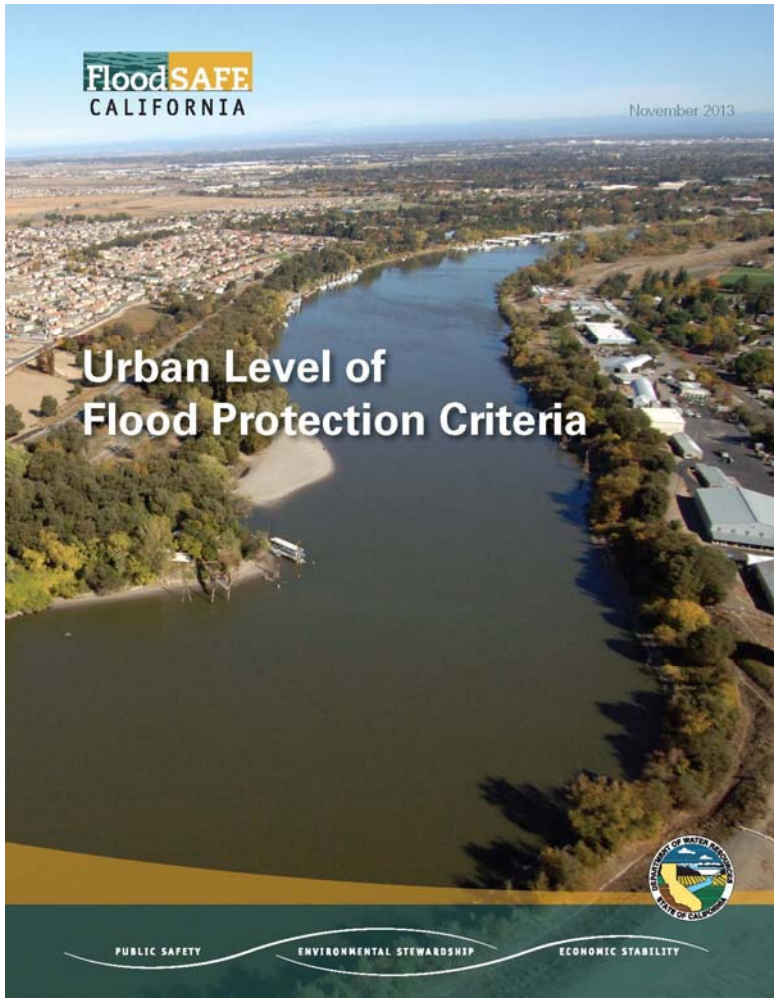


Graphic: Jessica Ludy

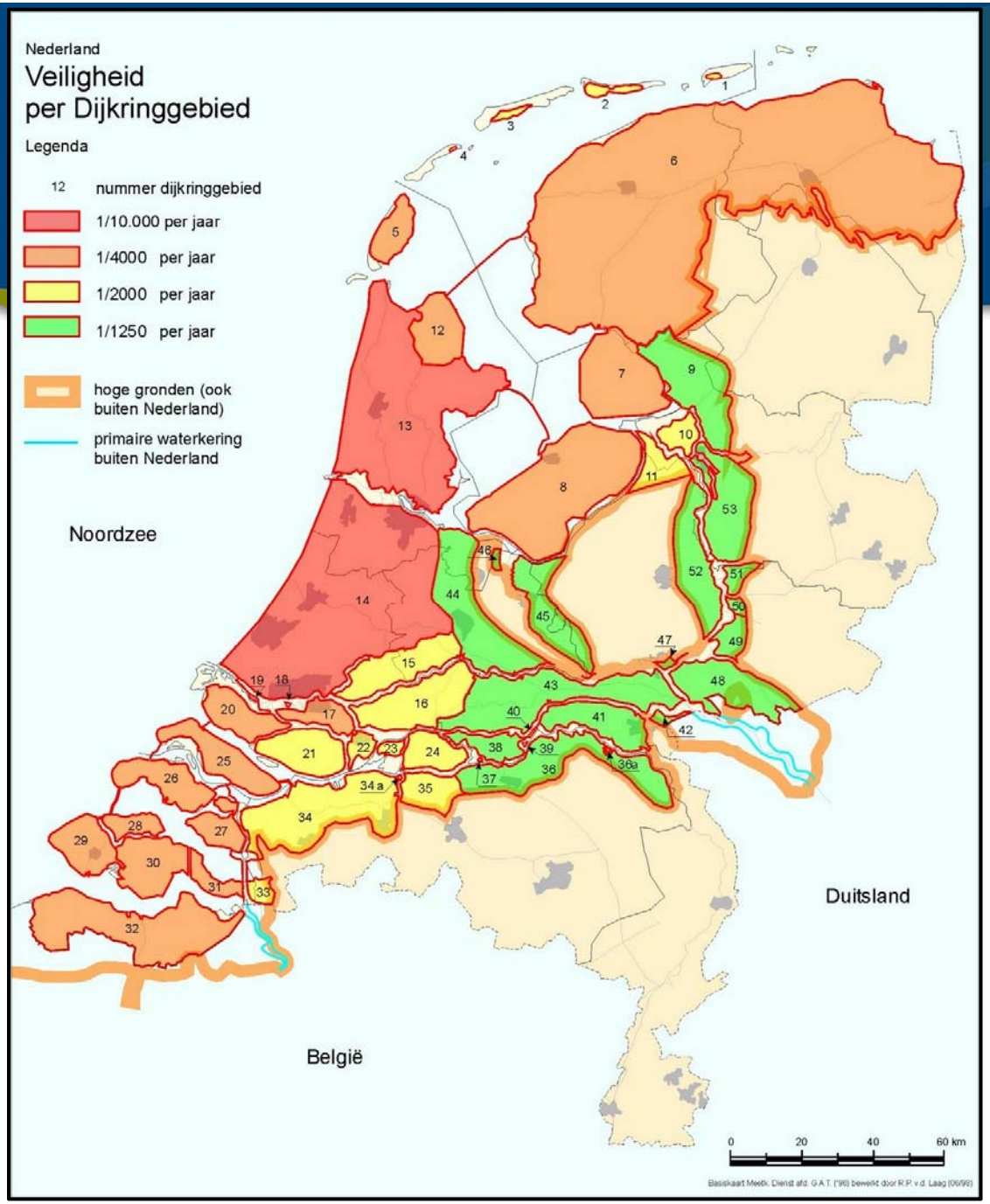
Triggers risk-informed decision-making if the consequences of larger floods are not acceptable

What "Standards" Do We Have?

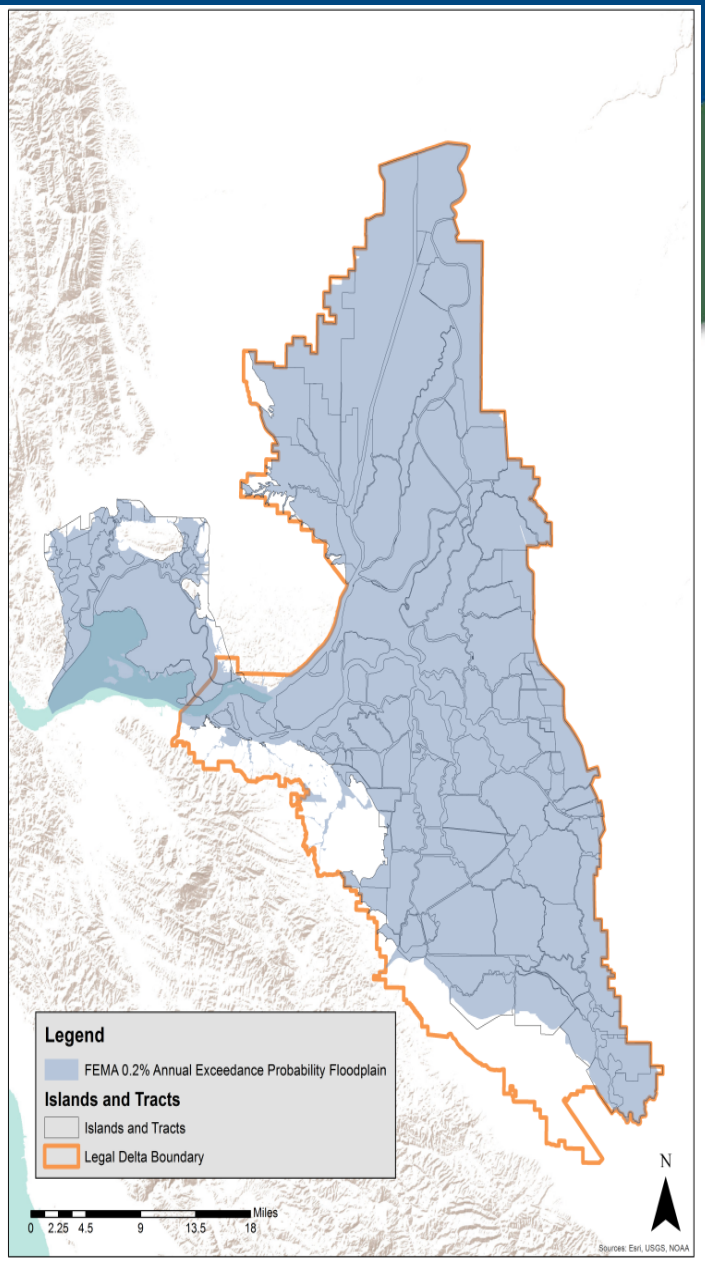
- HMP, PL 84-99, and 1/100 yr. are insurance standards or disaster rehabilitation guidelines
- 1/200 yr. is a levee design standard from CA state legislature and DWR
- None are safety standards

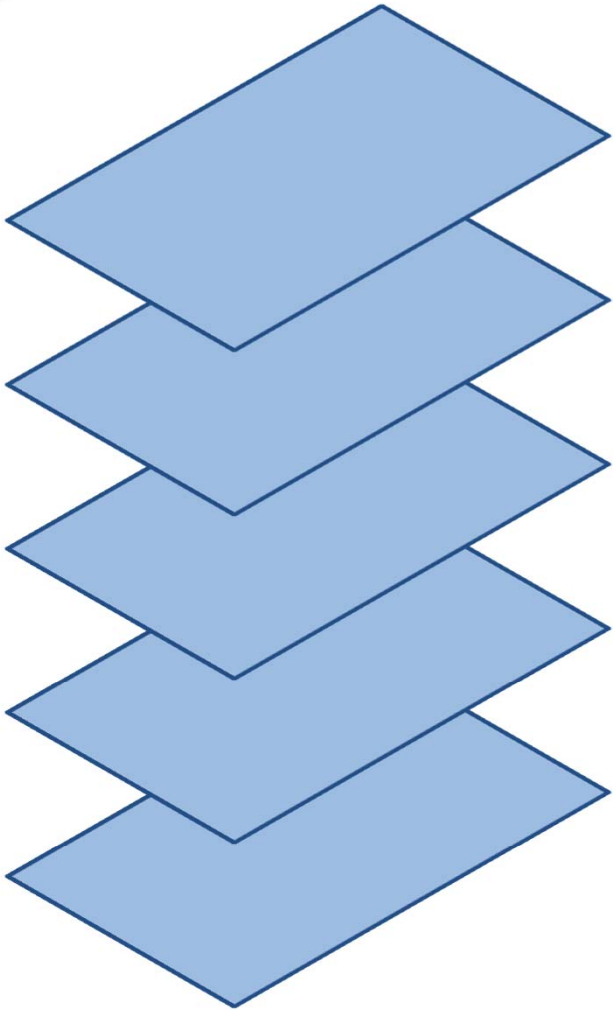


Netherlands Risk Map



Delta Risk Maps





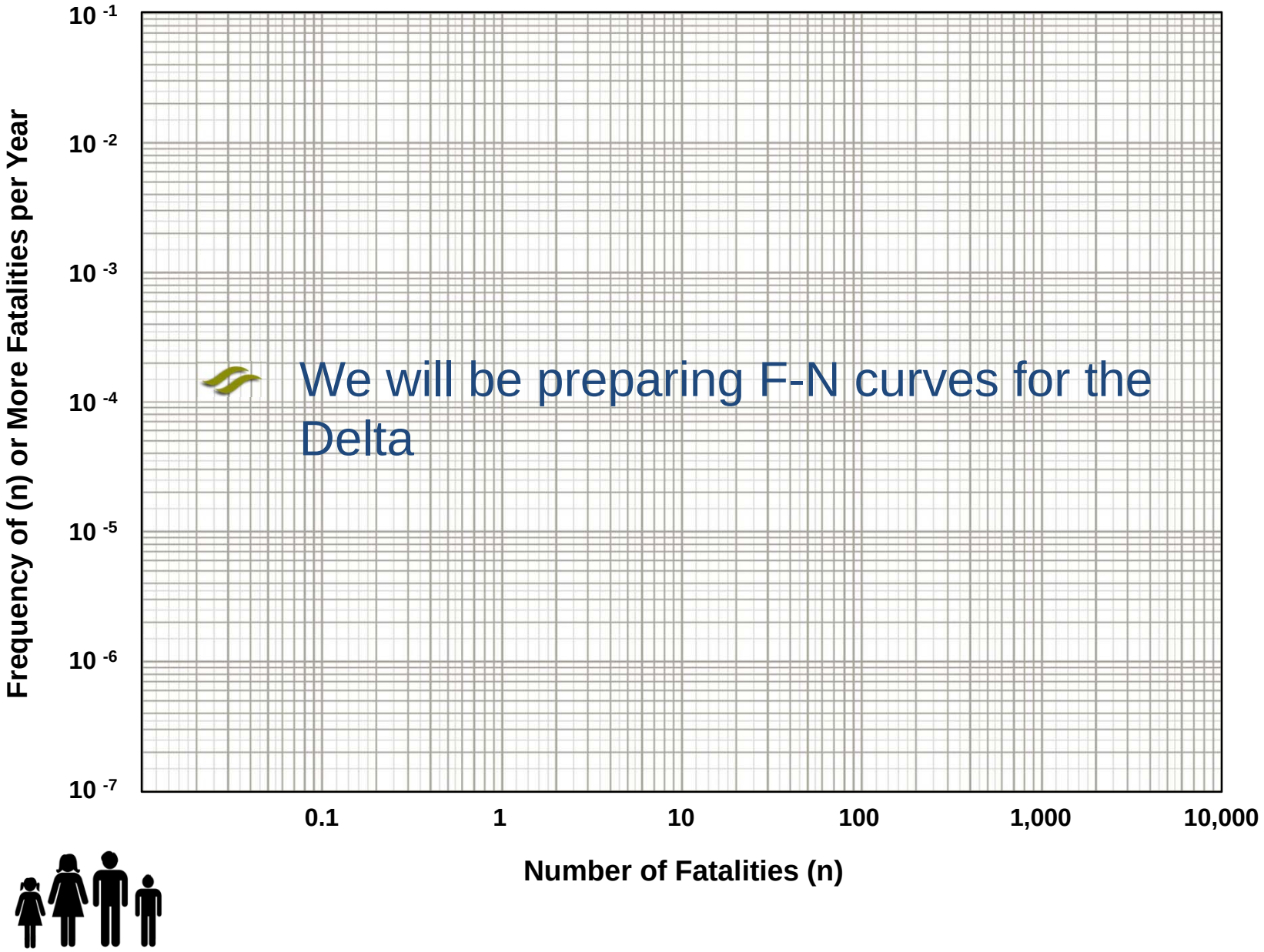
AGRICULTURE RISK

ECOSYSTEM RISK

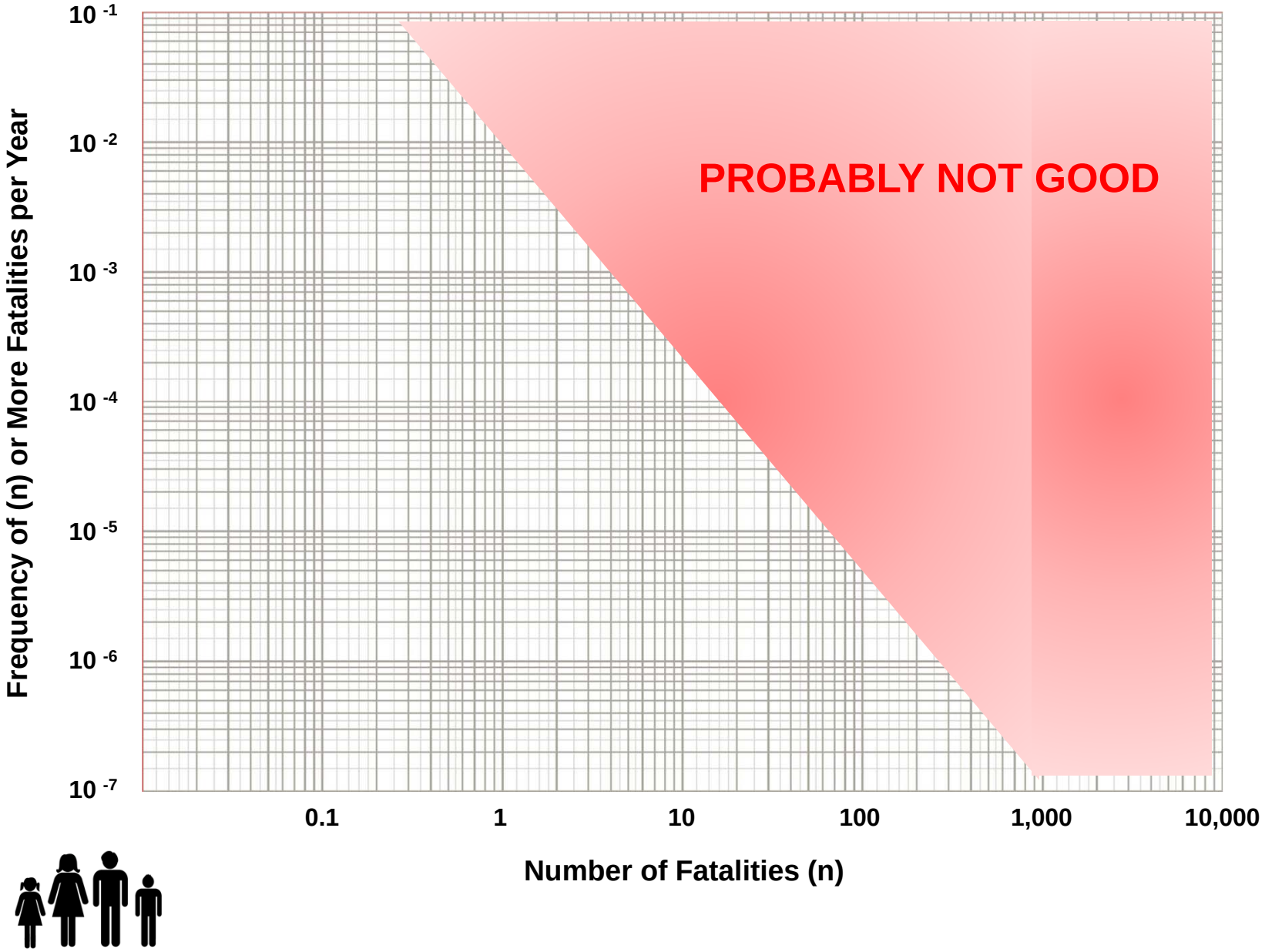
WATER SUPPLY RISK

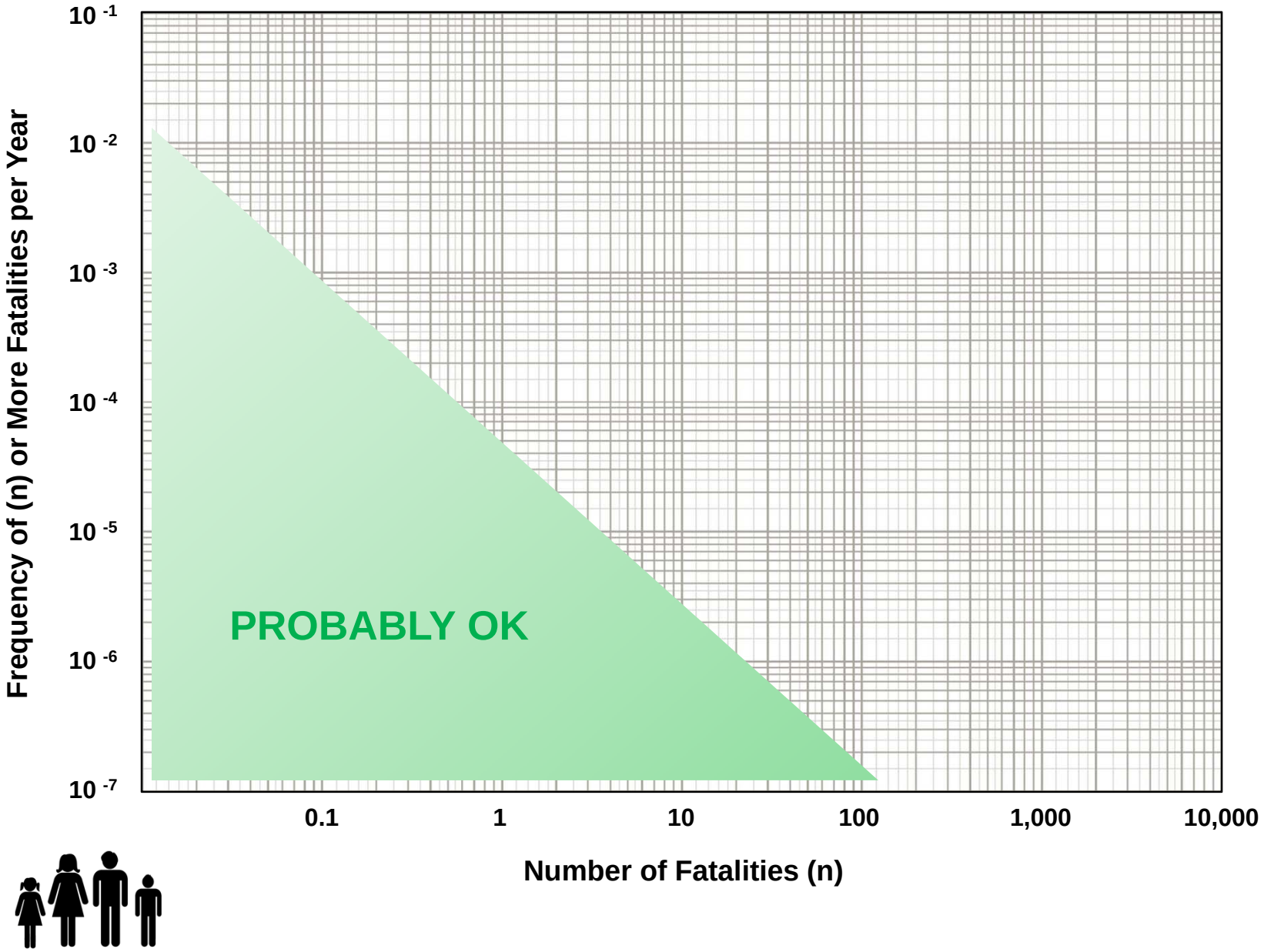
FLOOD DAMAGE RISK (EAD)

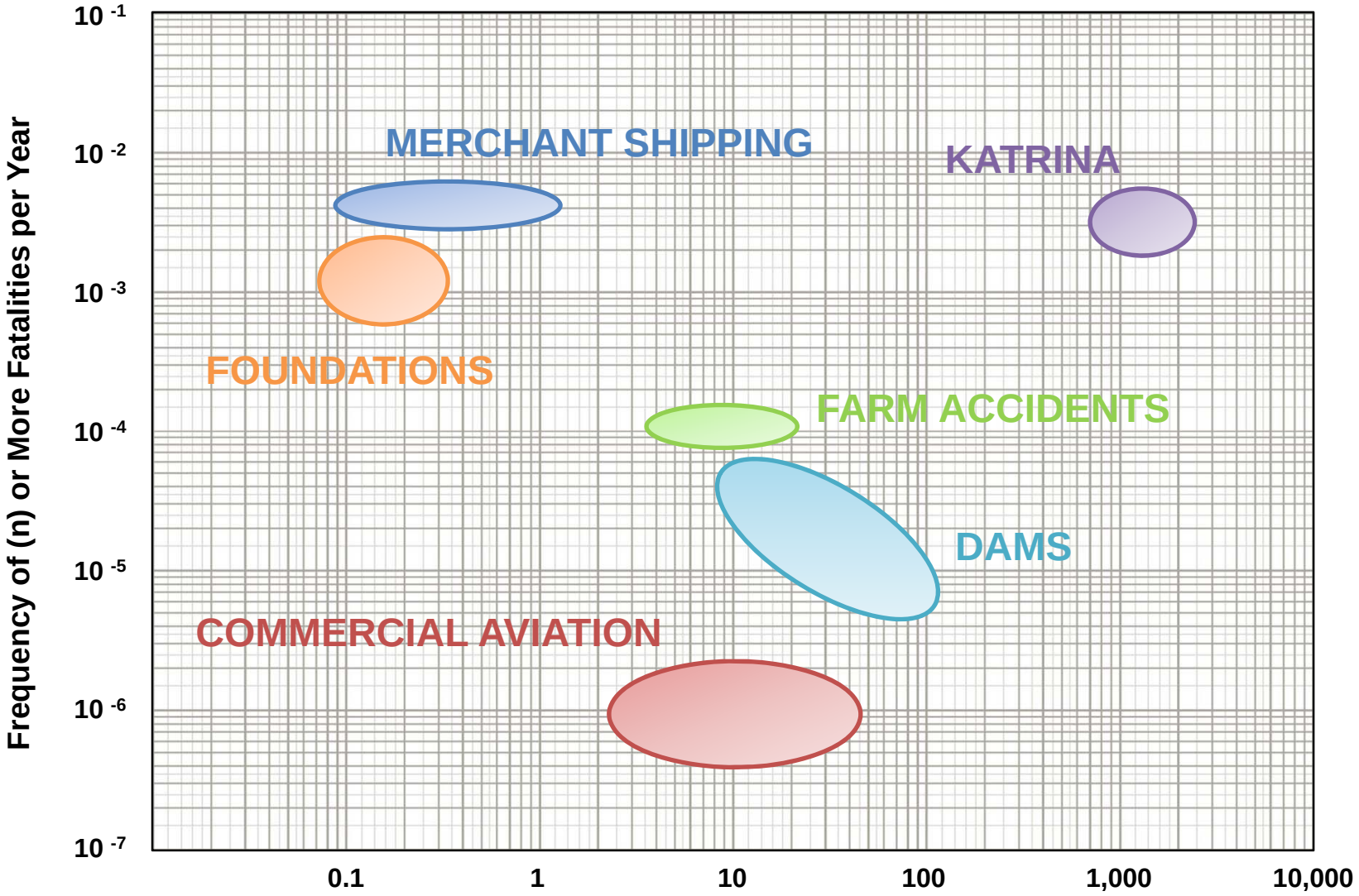
LIFE LOSS RISK



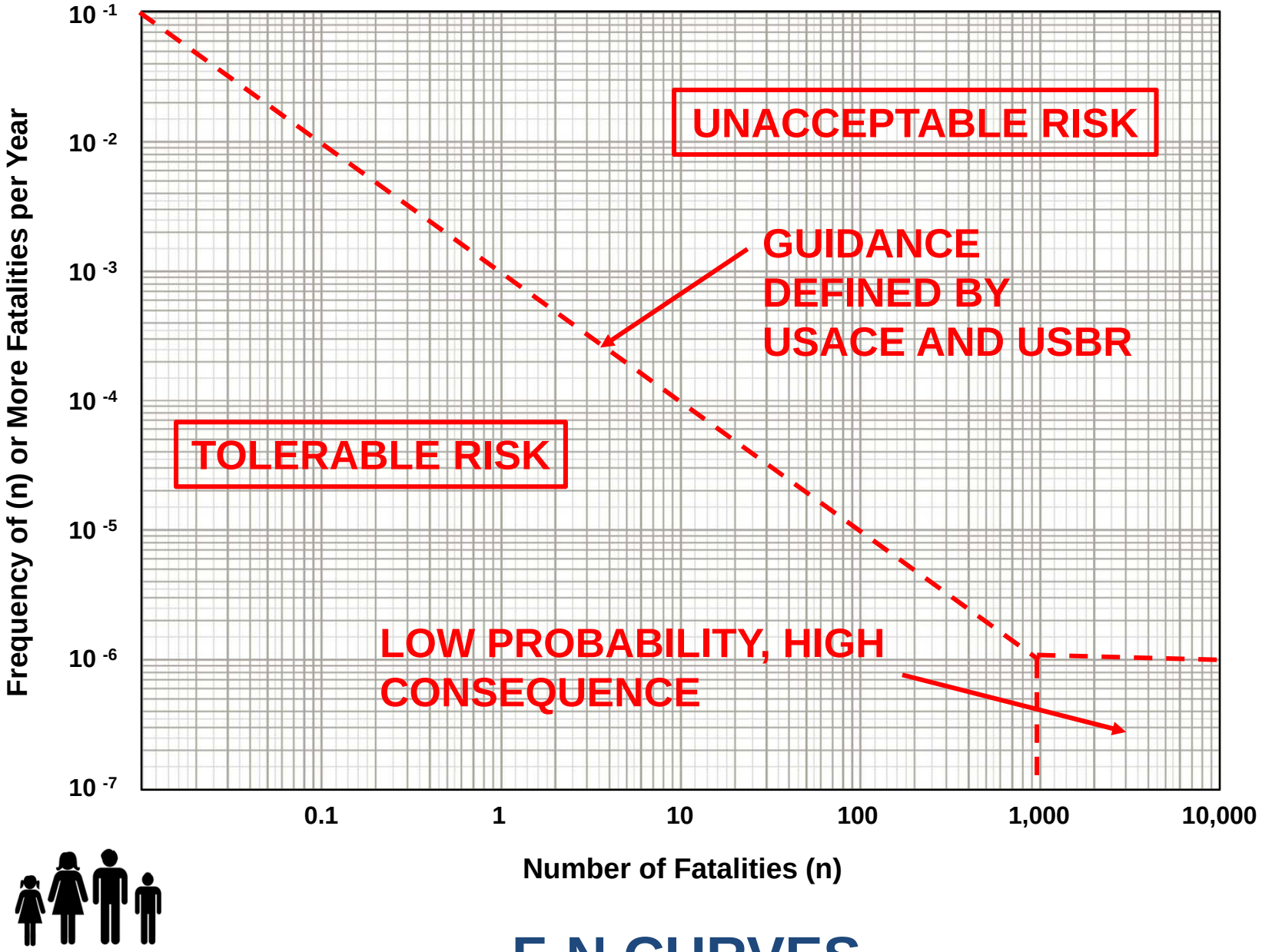
We will be preparing F-N curves for the Delta


PROBABLY NOT GOOD
Frequency of (n) or More Fatalities per Year
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
0.1
1
10
100
1,000
10,000
Number of Fatalities (n)

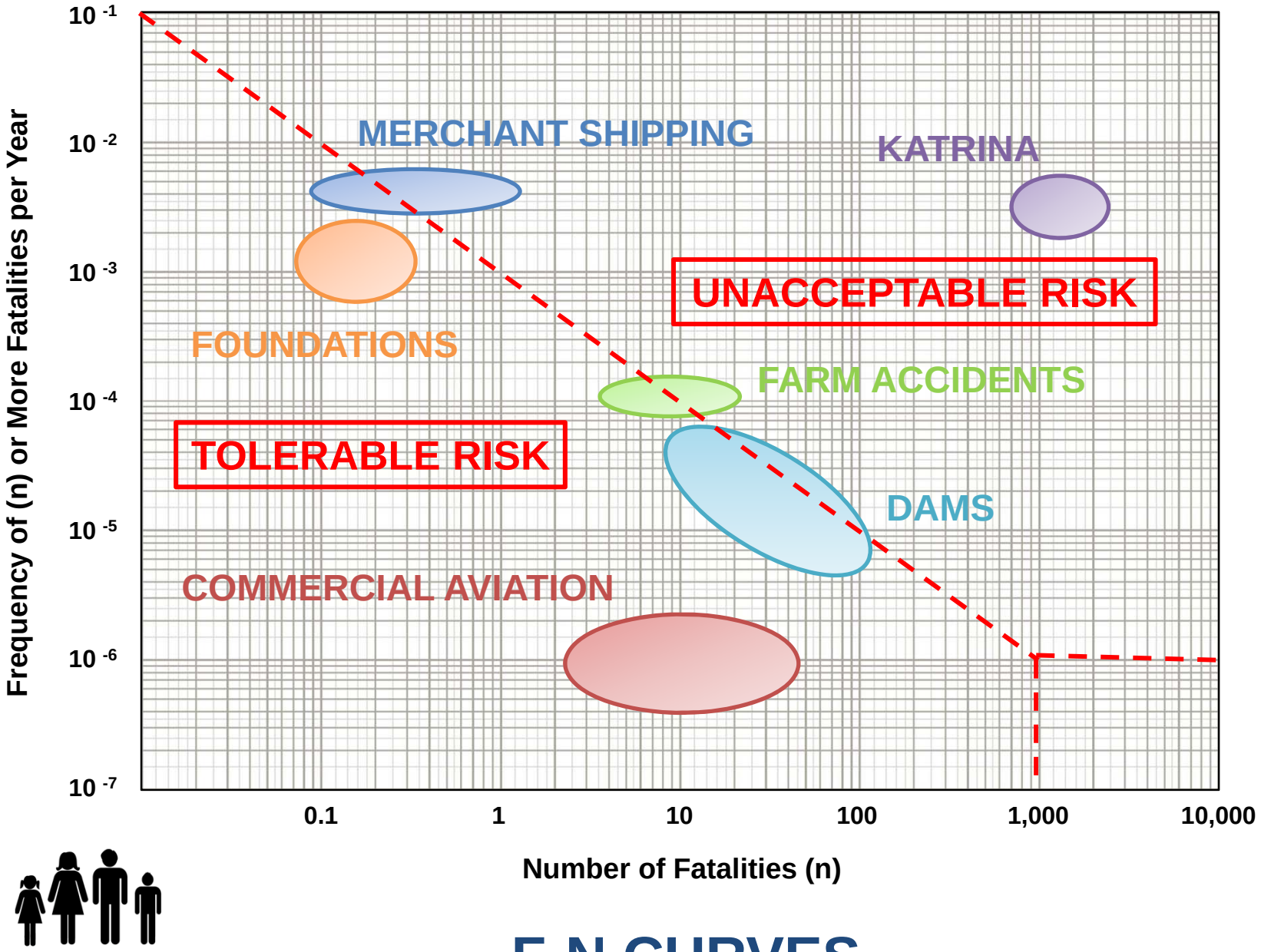

Frequency of (n) or More Fatalities per Year
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
PROBABLY OK
0.1
1
10
100
1,000
10,000
Number of Fatalities (n)


Frequency of (n) or More Fatalities per Year
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
MERCHANT SHIPPING
KATRINA
FOUNDATIONS
FARM ACCIDENTS
DAMS
COMMERCIAL AVIATION
0.1
1
10
100
1,000
10,000
Number of Fatalities (n)

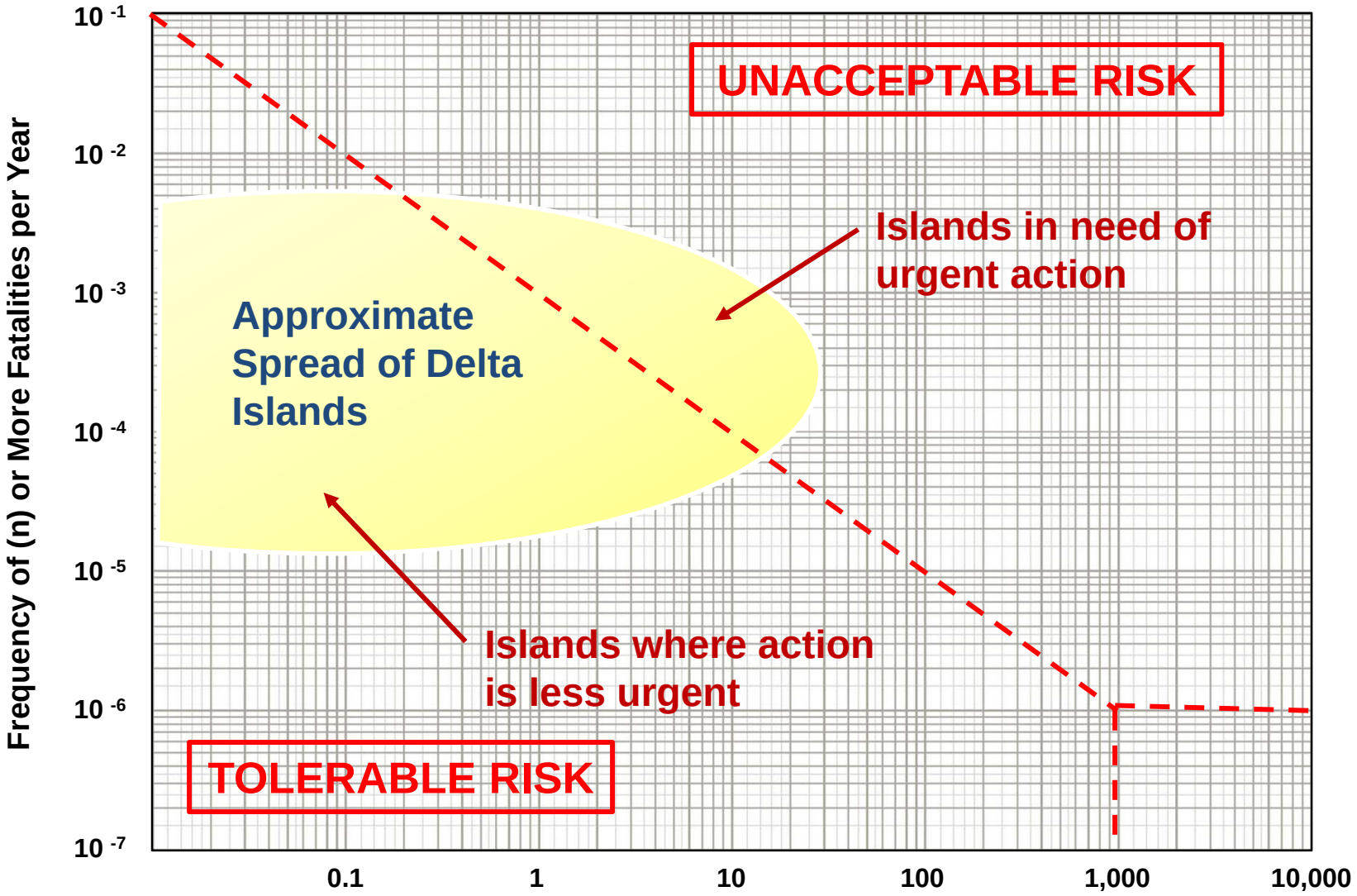
F-N CURVES


Frequency of (n) or More Fatalities per Year
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
UNACCEPTABLE RISK
GUIDANCE DEFINED BY USACE AND USBR
TOLERABLE RISK
LOW PROBABILITY, HIGH CONSEQUENCE
0.1
1
10
100
1,000
10,000
Number of Fatalities (n)

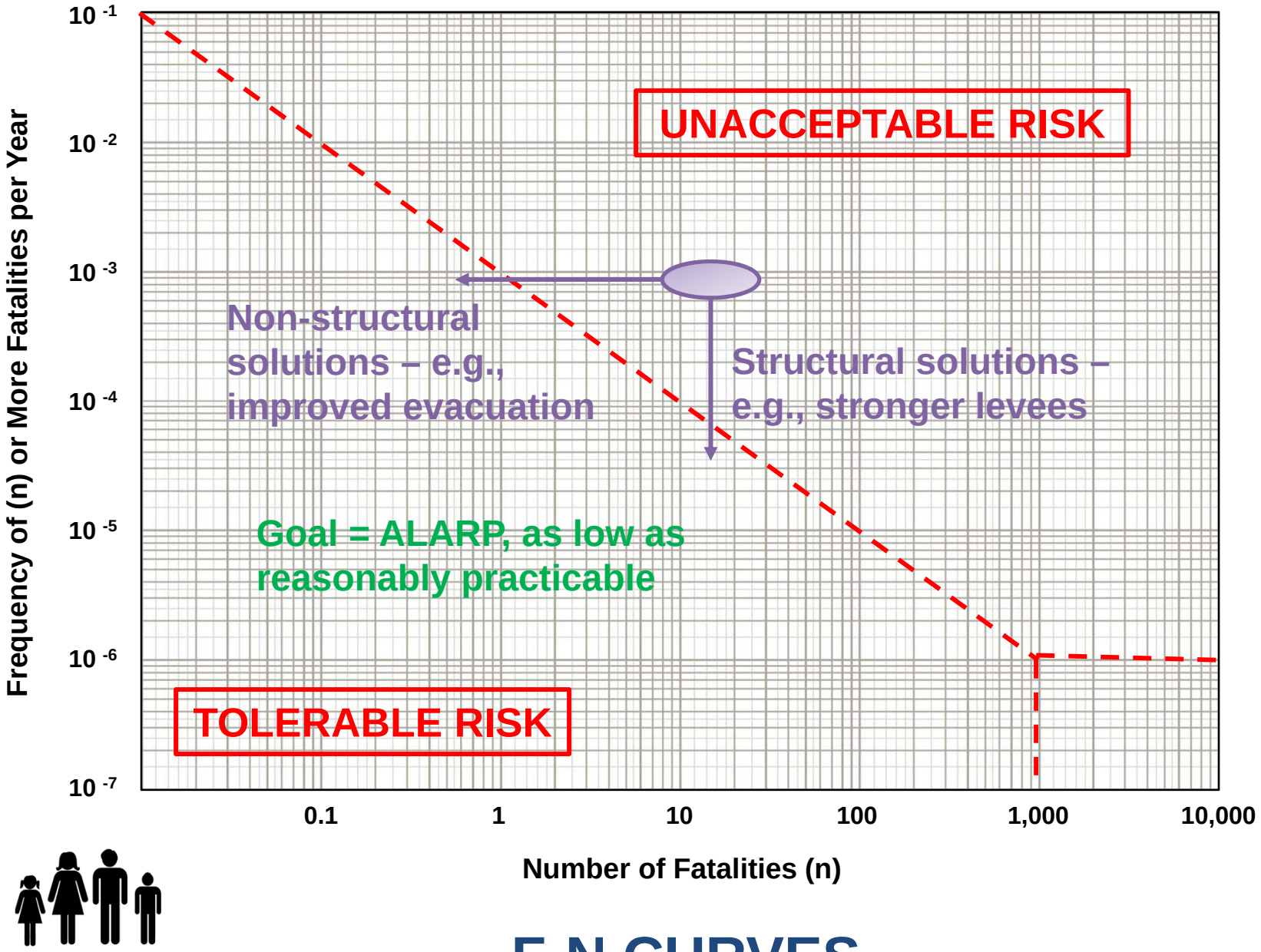
F-N CURVES


Frequency of (n) or More Fatalities per Year
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
MERCHANT SHIPPING
KATRINA
UNACCEPTABLE RISK
FOUNDATIONS
FARM ACCIDENTS
TOLERABLE RISK
DAMS
COMMERCIAL AVIATION
0.1
1
10
100
1,000
10,000
Number of Fatalities (n)

F-N CURVES


UNACCEPTABLE RISK
Islands in need of urgent action
Approximate Spread of Delta Islands
Islands where action is less urgent
TOLERABLE RISK
Frequency of (n) or More Fatalities per Year
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
0.1
1
10
100
1,000
10,000
Number of Fatalities (n)

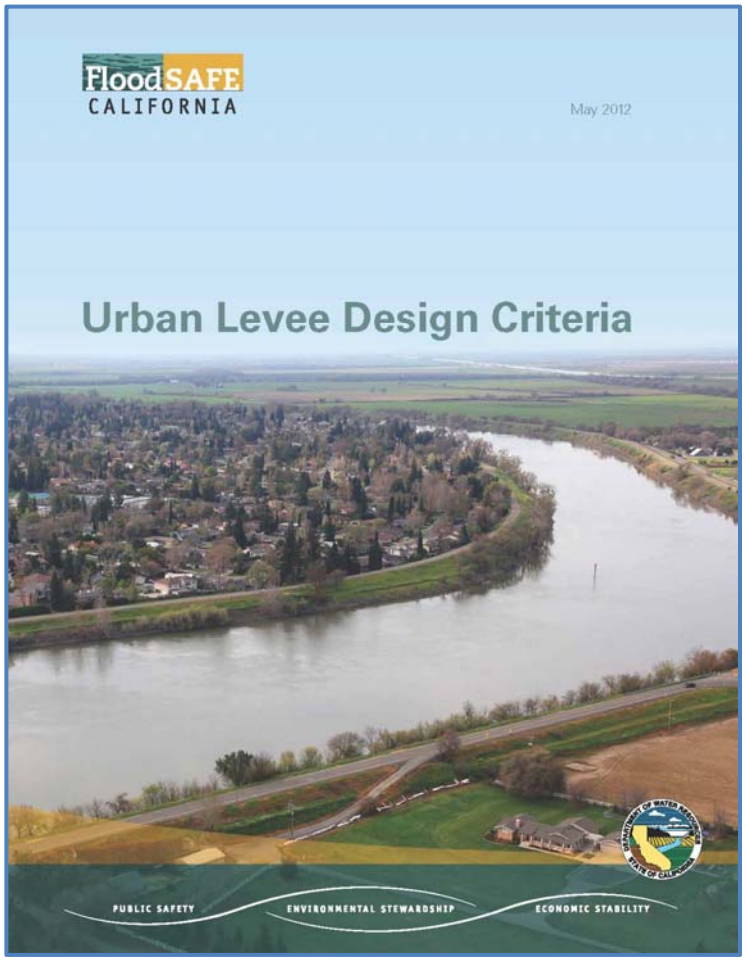
F-N CURVES

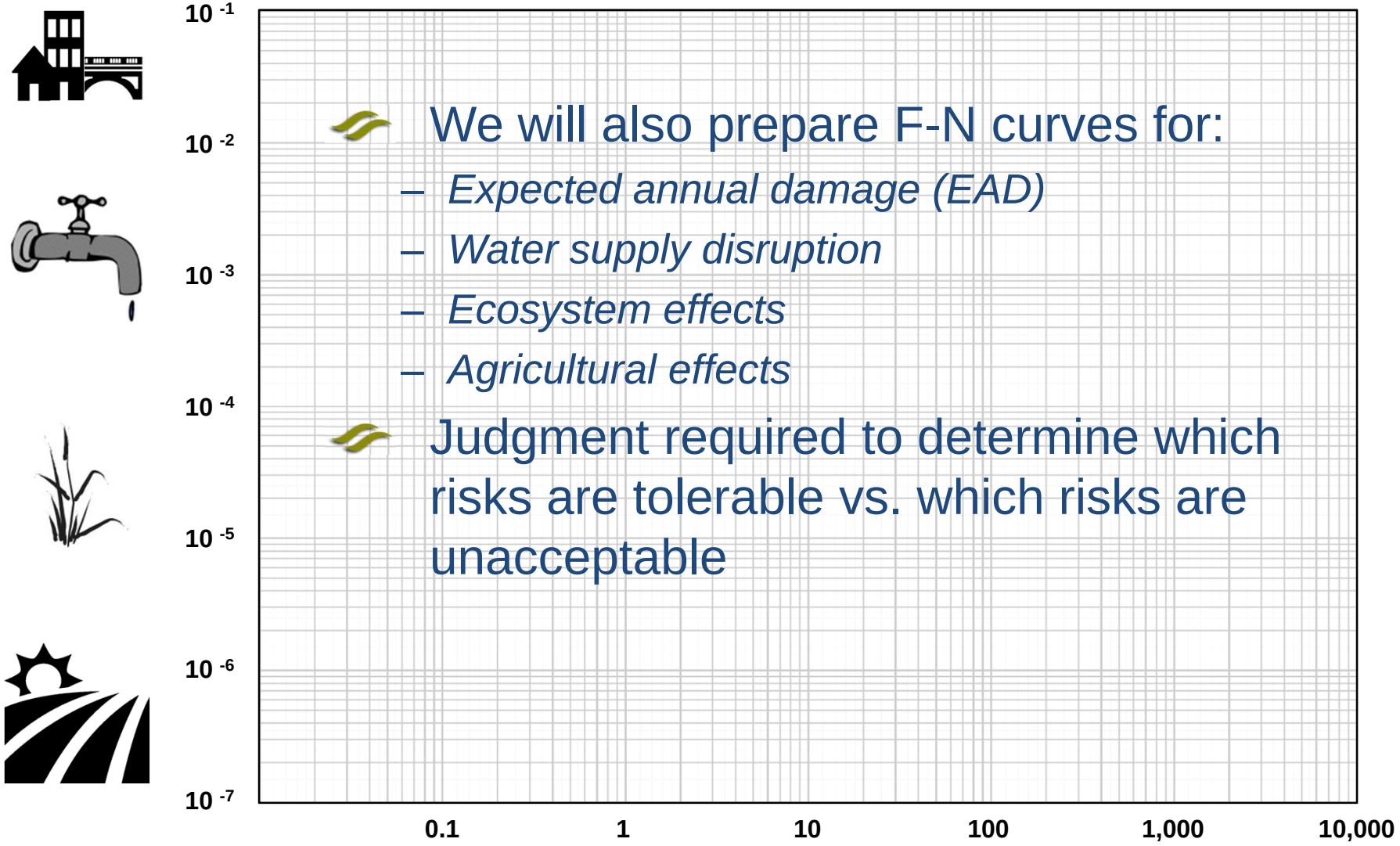

Frequency of (n) or More Fatalities per Year
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
UNACCEPTABLE RISK
Non-structural solutions – e.g., improved evacuation
Structural solutions – e.g., stronger levees
Goal = ALARP, as low as reasonably practicable
TOLERABLE RISK
0.1
1
10
100
1,000
10,000
Number of Fatalities (n)

F-N CURVES

Tolerable Risk Criteria for Guiding Decisions

- The level of risk in relation to the tolerable risk limit
  - *The greater the probability of failure, the greater the urgency to act*
- Cost effectiveness
  - *The more cost-effective a plan to reduce failure, the greater the justification to select that plan*

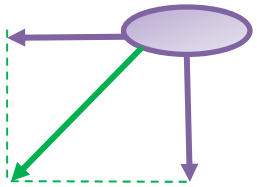




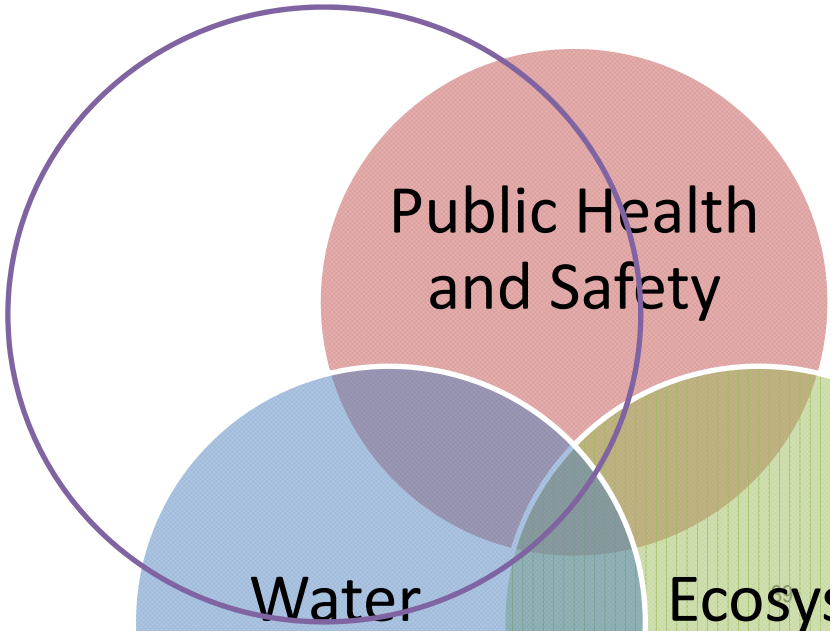
- We will also prepare F-N curves for:
  - *Expected annual damage (EAD)*
  - *Water supply disruption*
  - *Ecosystem effects*
  - *Agricultural effects*
- Judgment required to determine which risks are tolerable vs. which risks are unacceptable

Tolerable Risk Applications

- Communicate risk clearly
- Manage risk with all available options
- Reduce risk through prudent investment



Goal = Reduce risk to as low as reasonably practicable (ALARP)



Questions and Discussion