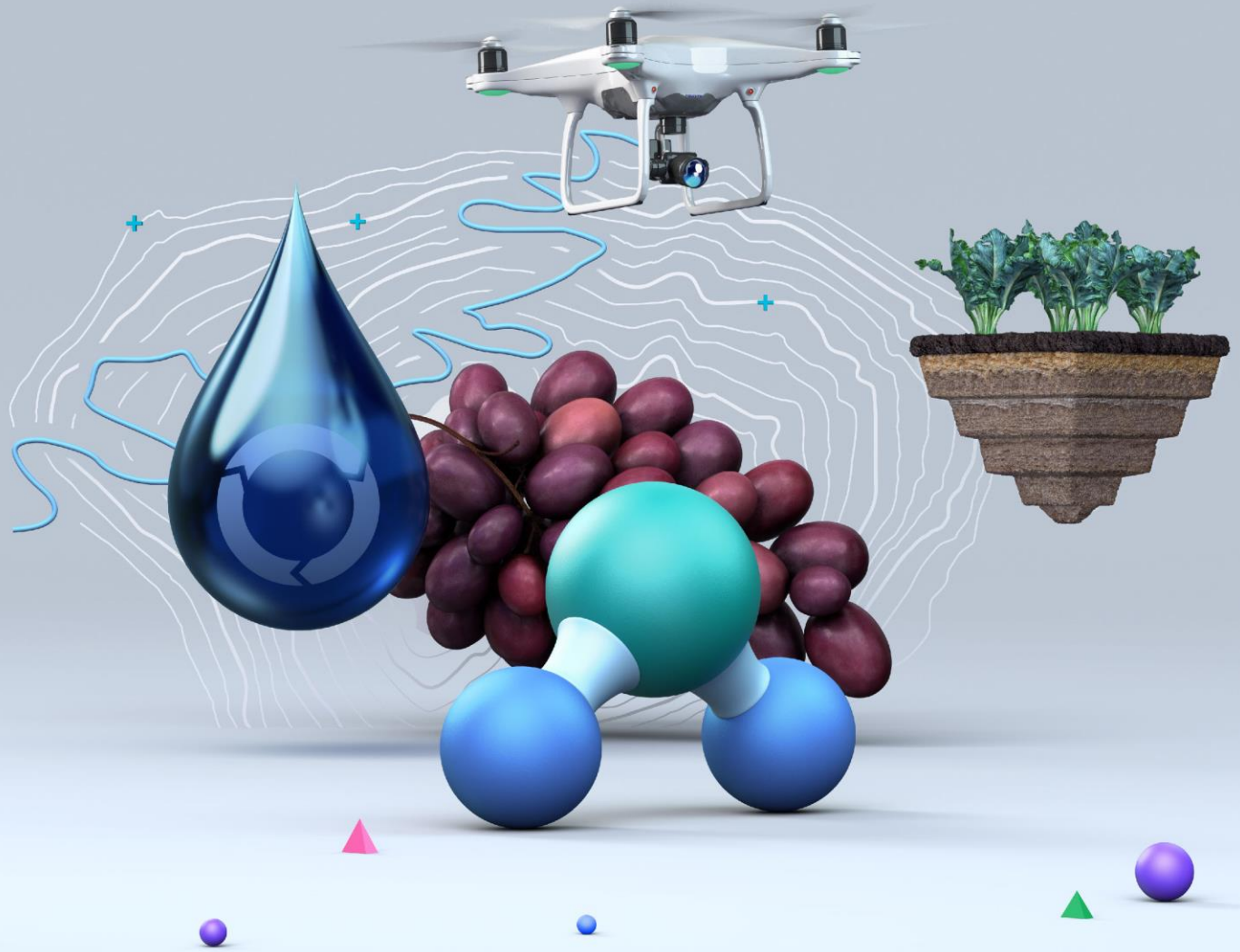
WHAT IS THE PMF?



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Australian Water School Webinar
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https://awschool.com.au/training/what-the-pmf/

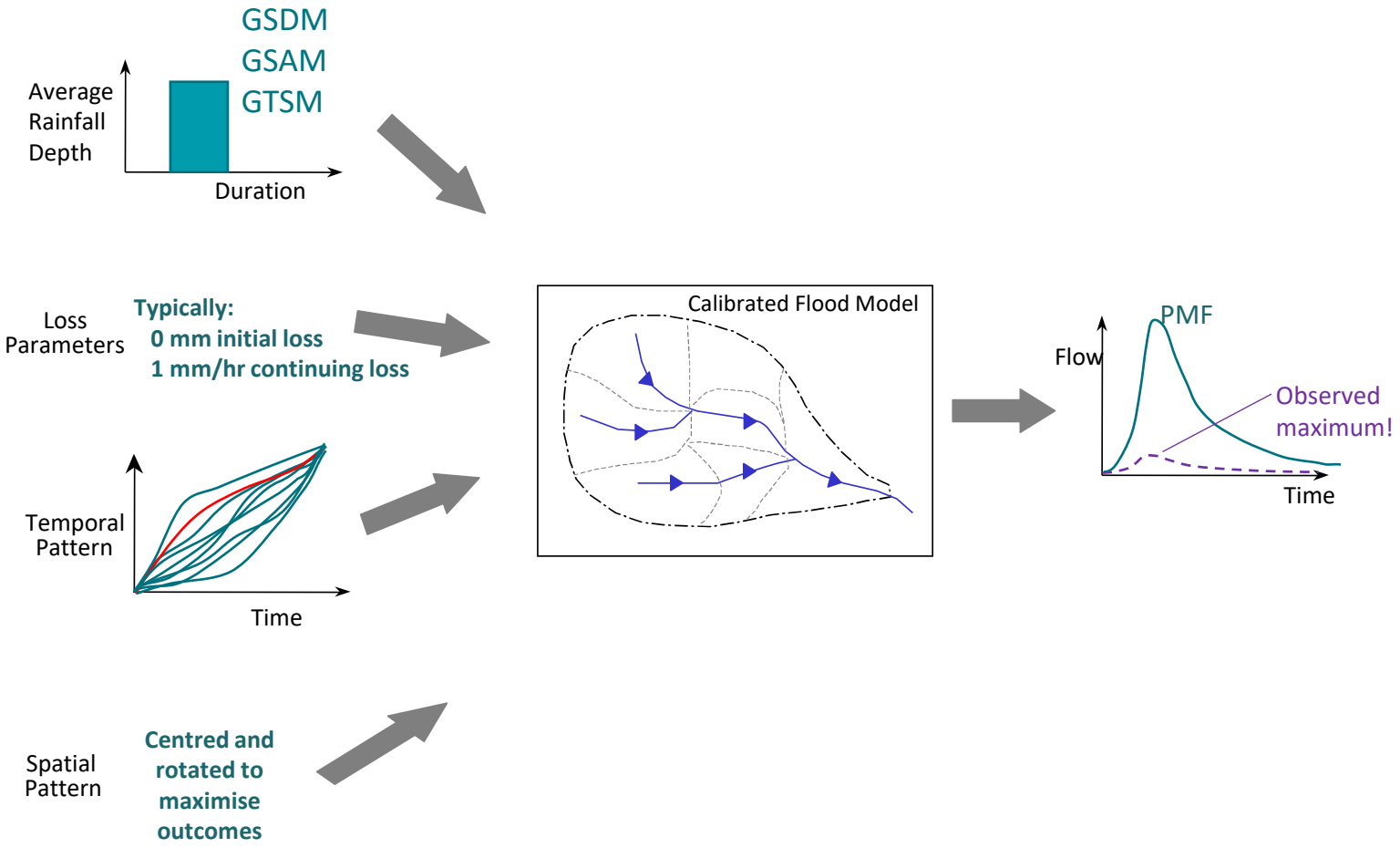
CONTEXT

- Probable maximum events (rainfall and floods) are commonly used as the “design standard” for infrastructure that pose a threat to life safety (eg dams, nuclear power plants)
- Typically these are treated as a “physical upper limit”, and it is assumed that anything designed to handle such events are forever “safe”
- However (!!), experience has shown that:
  - estimates of these “maximum possible” events have increased over time as more data becomes available, and we have many examples where observations exceed these limits
  - estimates are highly subjective, and different practitioners will make different assumptions
  - The likelihood that these estimates are exceeded varies with region, location, catchment area, and event duration
- Such events are also commonly used as an upper bound on flood extents for floodplain planning and regulatory activities, and these are much simpler applications to consider

SOME KEY CONCEPTS

- PMP is defined as "**the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year**"
- PMF is defined as "**the limiting value of flood that could *reasonably* be expected to occur**"
  - Only refers to the notional limit on event magnitude, not its exceedance probability
  - Superimposing risks of very low probabilities is not appropriate, but some degree of conservatism is prudent
- ARR also defines the PMP Flood, which is the flood derived from the PMP under probability-neutral assumptions:
  - The PMP Flood is always smaller than the PMF
  - It has the same AEP as the PMP
- See Book 8, ARR2019 for details (http://arr.ga.gov.au/)

GENERAL APPROACH



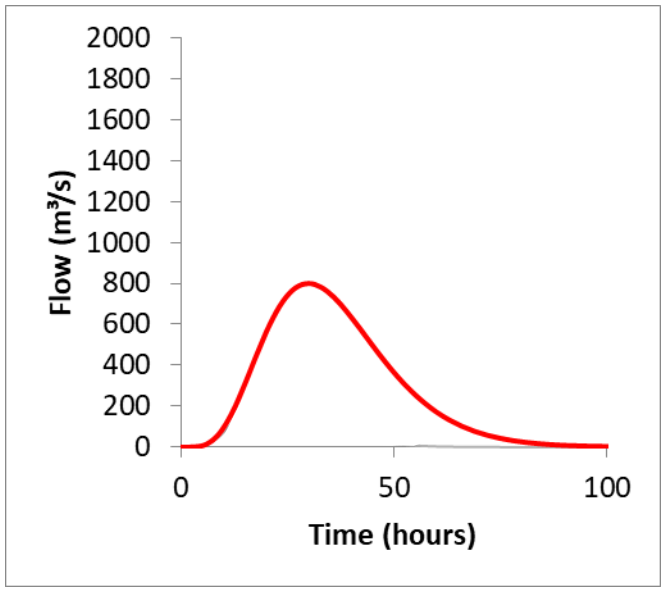
Inputs **Model** **Output**

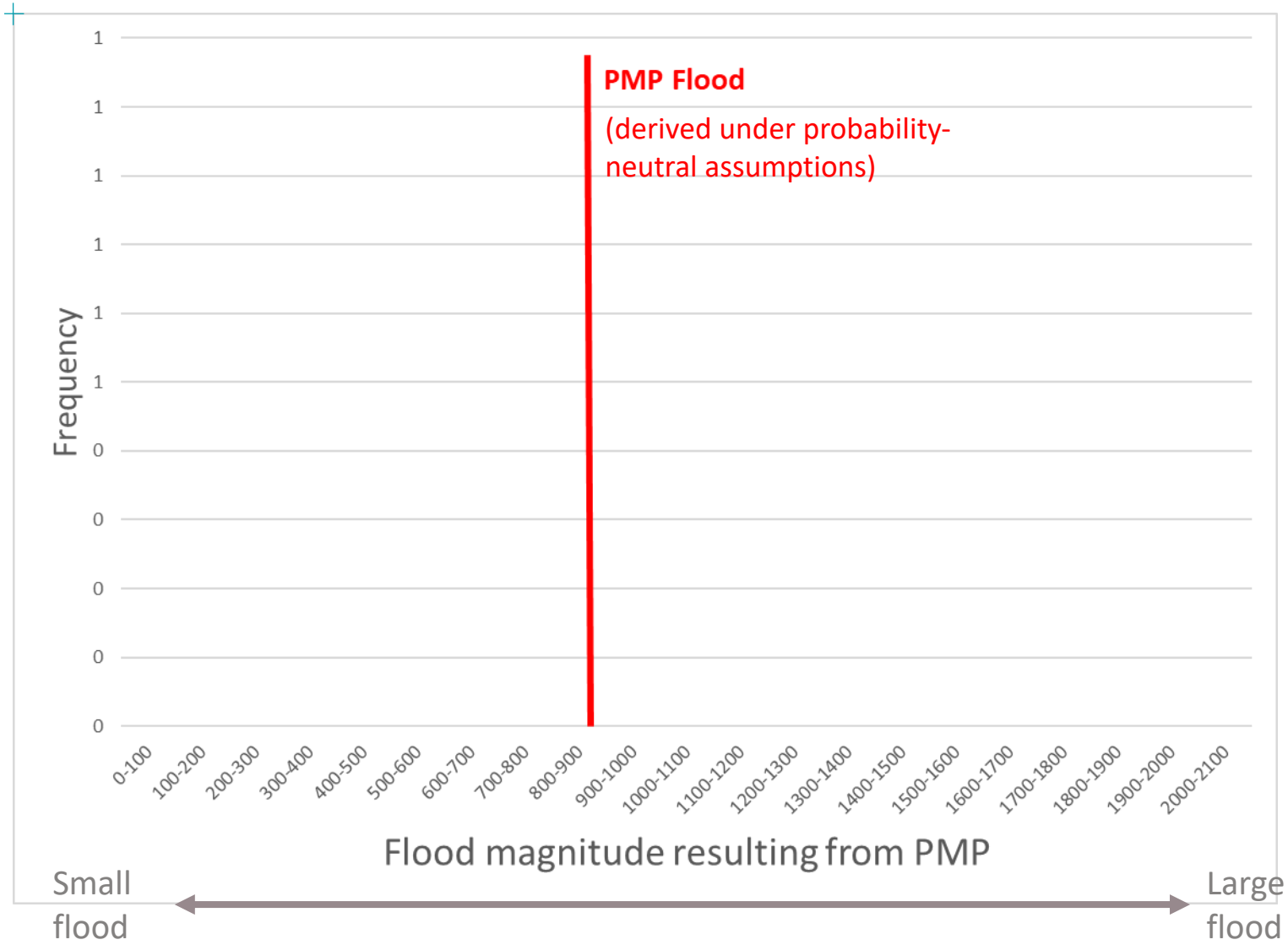
A key question

To identify “the limiting value of flood that could *reasonably* be expected to occur”, we need to balance:

So, what is a “*reasonable*” balance?

Factors influencing the PMF (for a given PMP)

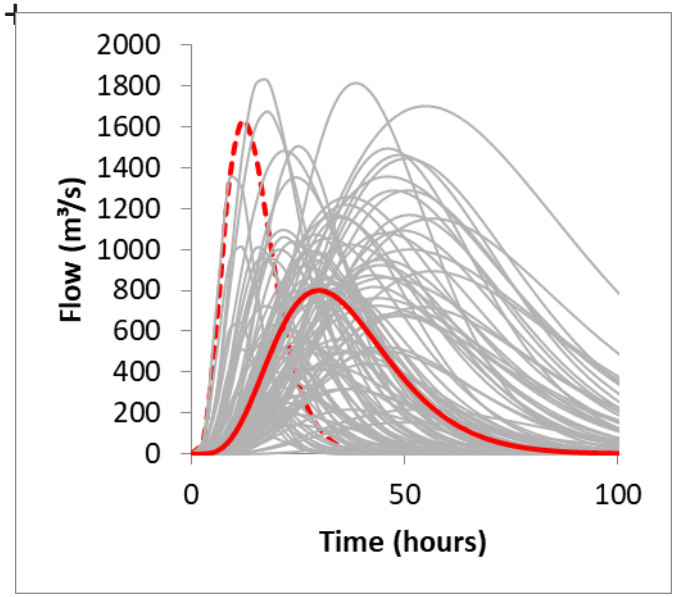


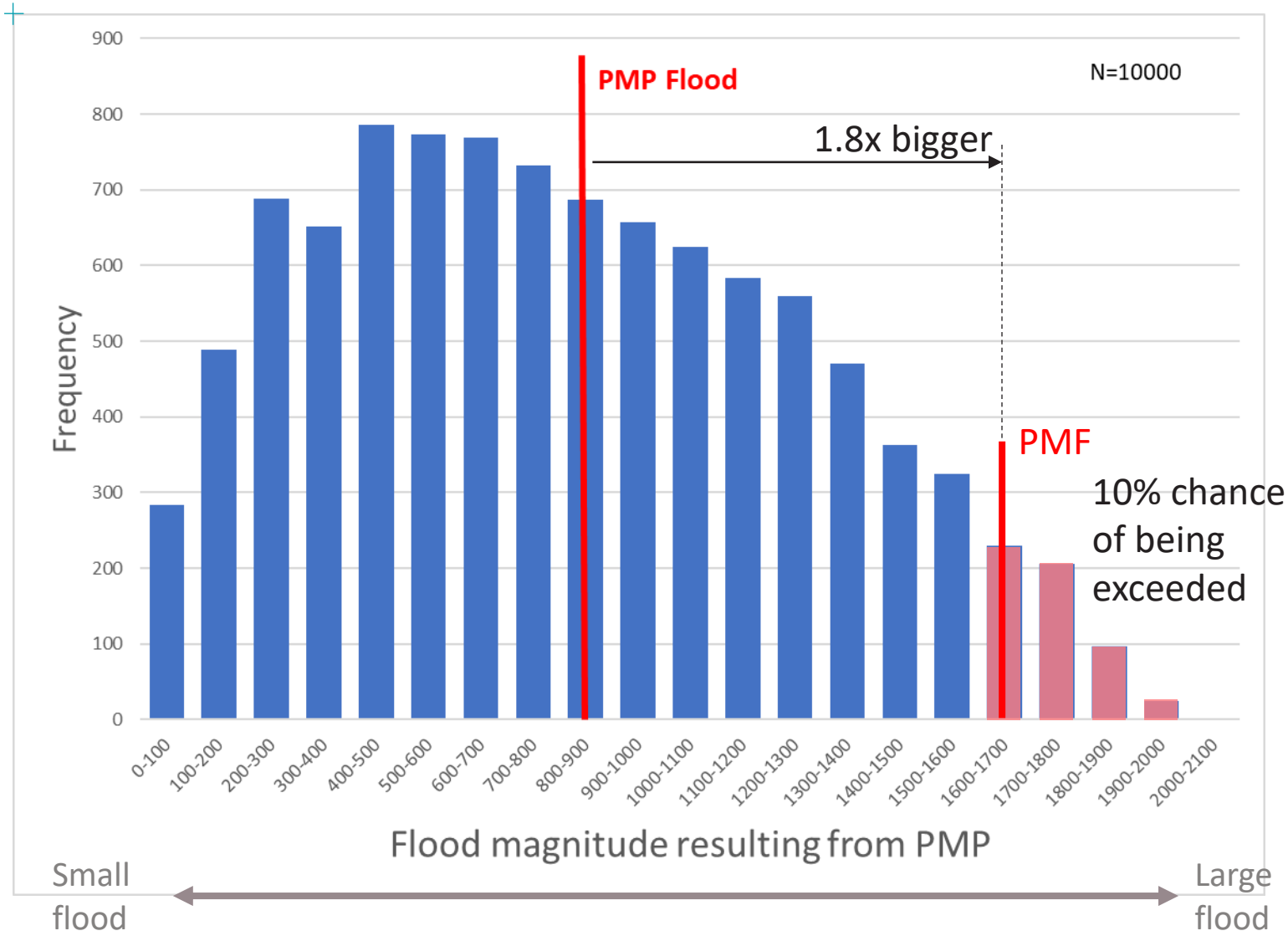


Factors influencing the PMF (for a given PMP)

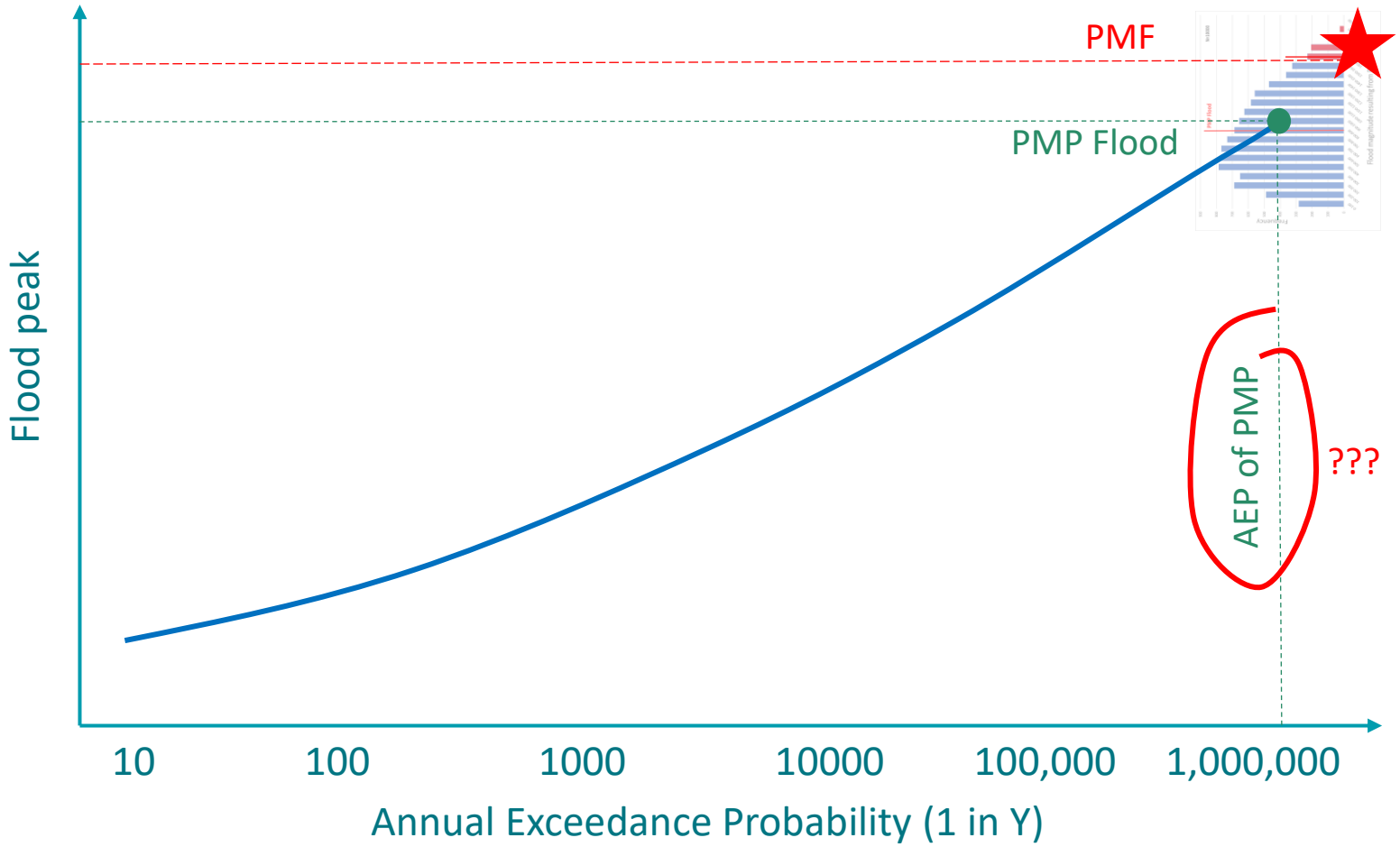
- Initial & continuing losses
- Temporal pattern
- Spatial pattern
- Initial water level
- Pre-storm events?
- Initial snowpack

Randomly sample over plausible range





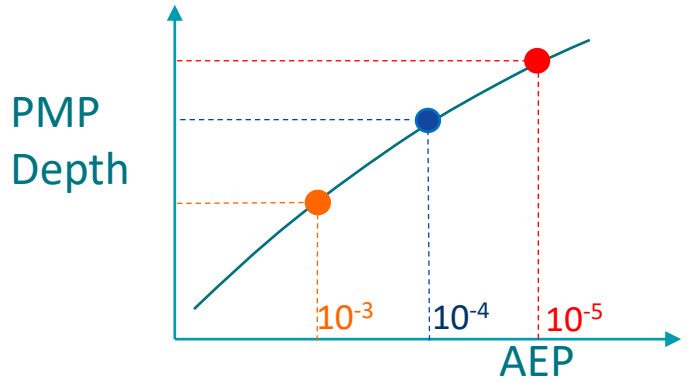
Frequency of Extremes



Nathan, R., Hill, P., & Weinmann, E. (2011). Achieving consistency in derivation of the Probable Maximum Flood. *Proceedings ANCOLD Conf on Dams*. Melbourne, Aus

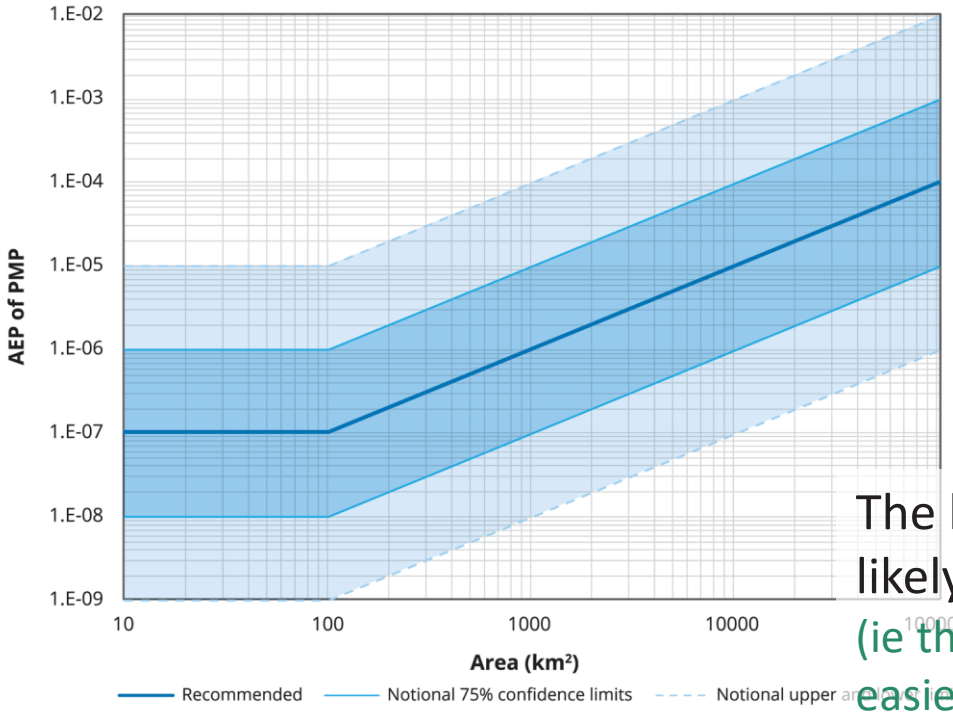
How can the PMP have an AEP??

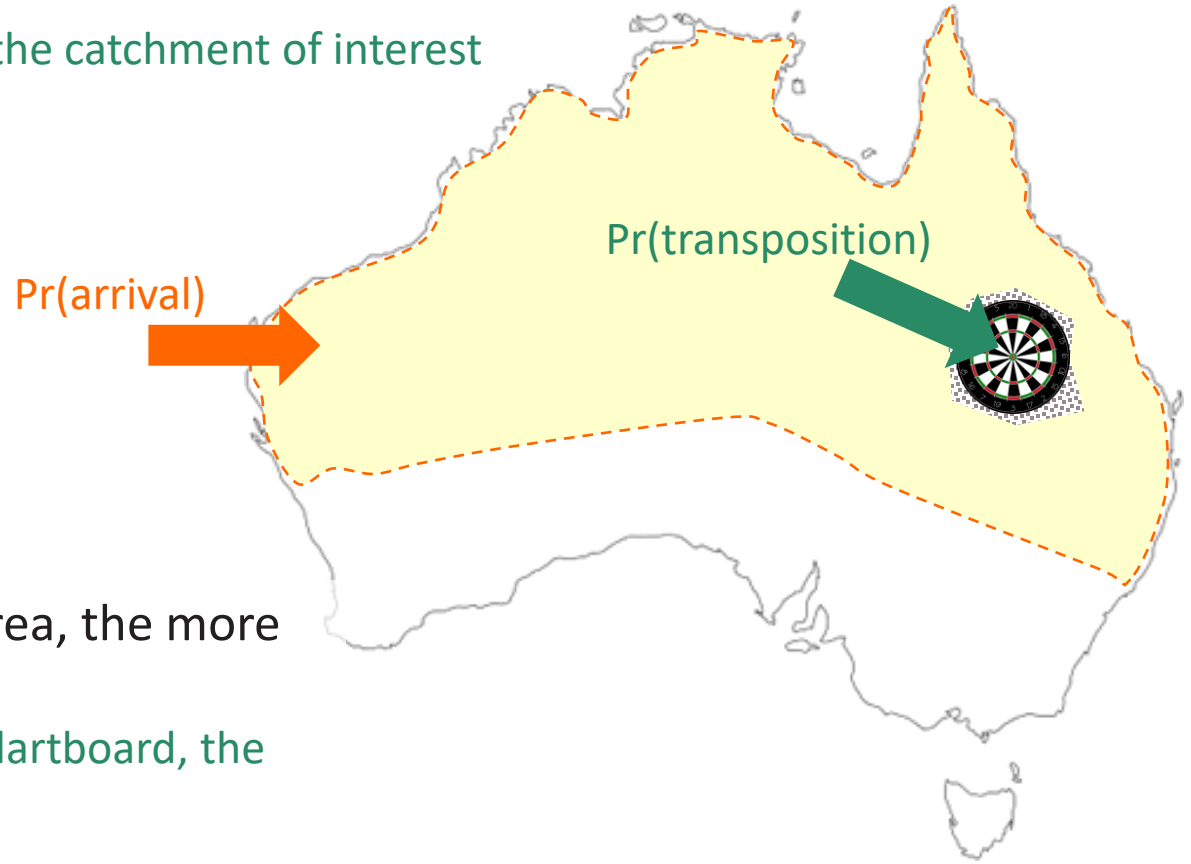
- The theoretical PMP is defined as “the greatest depth … that is physically possible …”
- So, how can a physical maximum ever be exceeded? (ie surely its AEP must be zero?!)
- We need to give account to the limitations of the data sets used to estimate the PMP
  - Early PMP estimates based on *in-situ maximisation* (analysis of a few local gauges)
  - Later estimates used *limited transposition* (a larger number of local and nearby gauges)
  - Current estimates based on *extensive regional transposition* (using many more regional gauges)
- These different methods imply differences in the AEP by ~10^{-2} to 10^{-4}
- **Any estimate of the PMP is dependent on the data sets and methods used, and it is our “operational estimate” of the PMP that is assigned an AEP.**



AEP of PMP

- The AEP of PMP is a function of two probabilities:
  - *arrival:* the probability that an extreme event occurs somewhere in the region
  - *transposition:* the probability that the event lands over the catchment of interest





The bigger the area, the more likely the PMP
(ie the bigger the dartboard, the easier it is to hit!!)

Nathan, R., Jordan, P., Scorah, M., Lang, S., Kuczera, G., Schaefer, M., & Weinmann, E. (2016). Estimating the exceedance probability of extreme rainfalls up to the probable maximum precipitation. *Journal of Hydrology*, *543*, 706–720

IMPACT OF CLIMATE CHANGE (in Australia)

- A warming climate will tend to dry out soils, thus losses will decrease
- Air-space in reservoirs is likely to increase (due to increased demands, reduced runoff)
- Storm temporal and spatial patterns may intensify
- Storm depths will increase

However … these influences vary with event duration and event severity, and it is unclear how these impact on PMP methods & PMFs

Wasko, C., Westra, S., Nathan, R., Orr, H. G., Villarini, G., Villalobos Herrera, R., & Fowler, H. J. (2021). Incorporating climate change in flood estimation guidance. *Hydrol. and Water Resources Symposium*. **Also**, *Phil Trans Royal Society A*, 2021, Vol 379: 20190548

Salas, J. D., Asce, D. M., Anderson, M. L., Asce, M., Papalexiou, S. M., Frances, F. (2020). PMP and Climate Variability and Change : A Review. *J Hydrologic Engineering*, *25*(12), 1–16.

Final Points

1. Careful consideration needs to be given to the reasonableness of assumptions used to derive the PMF, especially when designing dams and other critical infrastructure
2. ARR provides guidance on how to assess reasonableness (Sec 6.4.3, Book 8)
3. If PMF only required as a check on the upper limiting magnitude (eg for floodplain planning and emergency preparedness) then issue of reasonableness is not important and simple assumptions can be adopted
4. If required for risk assessments, then focus on the PMP Flood which has the same AEP as the PMP
5. The AEP of the PMP is heavily dependent on the method and data used to estimate the PMP, and the likelihood that a PMP occurs over a large catchment is higher than one over a small catchment