National Oceanic and Atmospheric Administration
U.S. Department of Commerce

psl.noaa.gov/pmp

Modernizing Probable Maximum Precipitation Estimates

What is Probable Maximum Precipitation (PMP)?

PMP is defined as "**the greatest depth of precipitation for a given duration meteorologically possible for a design watershed or a given storm area at a particular location at a particular time of year.**"[1] PMP estimates are used by practitioners in the engineering, energy, and environmental sectors as key design standards to ensure the safety of critical infrastructure in the US.

Credit: Adobe Stock

Why update PMP?

Current scientific and engineering foundations of PMP are outdated—more than a **century** has passed since these key ideas underlying PMP estimates were developed. These methods involve assumptions regarding extreme rainfall that are inconsistent with our current understanding. Rainfall patterns are changing and becoming more **frequent, severe, and intense**. Infrastructure designed to meet standards aligned with older PMP data are struggling to withstand the weather events of today. Older dams continue to risk overtopping or failure under current conditions, with other critical infrastructure equally at risk of damage.

In 2024, the National Academies of Science, Engineering, and Medicine (NASEM) released a report[2] recommending the modernization of PMP estimates. NOAA, alongside federal, state, and private partners, is working to modernize PMP methodology and datasets to ensure the safety and longevity of critical infrastructure in the US.

PMP estimates are essential for designing the **nation's critical infrastructure**, such as **nuclear power plants** and **high-hazard dams,** to safely withstand extreme weather events and prevent significant loss of life.

18% (~16,500) of dams in the US are considered high-hazard

"High-hazard" is used to classify dams that would result in loss of human life and property damage if they were to overtop or fail. Around 15% (~2,500) of high-hazard dams in the US are in poor or unsatisfactory condition.[3] Modernized PMP estimates can help practitioners better assess the safety of these dams.

[1] library.wmo.int/records/item/35708-manual-on-estimation-of-probable-maximum-precipitation-pmp
[2] www.nationalacademies.org/read/27460
[3] damsafety.org/Roadmap

What is the legislative context for PMP modernization?

The Bipartisan Infrastructure Law (BIL), signed into law[4] in 2021, along with the PRECIP Act, passed in 2022[5], directed NOAA to modernize PMP estimates. The PRECIP Act specifically calls for a PMP estimate modernization effort to reflect the state of extreme precipitation science and modern data and tools.

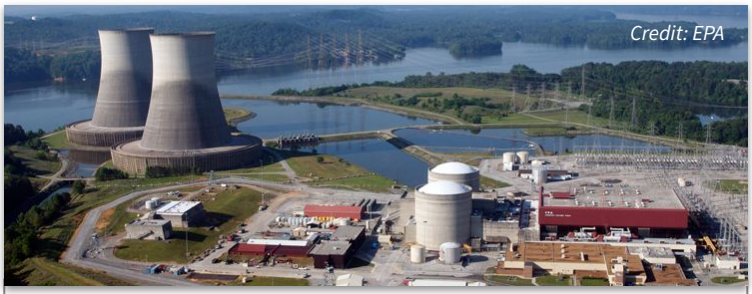
How are PMP estimates used?

Credit: USACE

Dam Design, Construction, and Safety

PMP is a critical input for the design, construction, and safety of dams in the US. PMP is used to calculate **Probable Maximum Flood (PMF)**, which is the "maximum runoff condition resulting from the most severe combination of hydrologic and meteorological conditions that are considered reasonably possible for the drainage basin under study."[6] PMP and PMF are important factors used to determine the point at which a dam may overtop. Flood hydrologists and engineers refer to these estimates not only in the design of dams, but also to conduct regular safety assessments. Certain PMF calculations can result in safety enhancements of the structure.

The most up-to-date PMP estimates are critical to ensure the safety of newly constructed and existing dams in the US. Without it, more dams, particularly ones that are much older, are at risk of overtopping or failure. As the frequency and intensity of rain events are increasing, more dams and communities could be threatened.


Credit: EPA

Nuclear Power Plant Safety & Planning

PMP is vital for the design and safety of critical infrastructure like nuclear power plants. There are 94 nuclear power plants across the US, with over a third of the population living within 50 miles of one.[7]

Regulation requires that **nuclear power plants are designed to withstand the effects of natural phenomena** without compromising nuclear safety features that mitigate nuclear accidents. To do so, power plant components must reflect "appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area."[8]

PMP is an important input in nuclear power plant design. When a power plant floods, safety systems and components can become damaged, increasing the risk of radioactive substances entering into the environment. **A modernized PMP will help ensure the safety of our nation's nuclear power plants and containment of nuclear substances.**

Learn more at **psl.noaa.gov/pmp**

[4] www.congress.gov/bill/117th-congress/house-bill/3684
[5] www.govinfo.gov/app/details/BILLS-117hr1437eah
[6] www.ferc.gov/sites/default/files/2020-06/extreme-hydro.pdf
[7] www.nei.org/resources/fact-sheets/u-s-nuclear-plants
[8] ncdp.columbia.edu/nuclear-power-plants-earthquake-risk/