

My title is a little unfair. So far as I can tell, the people who are trying to figure out the 100-year or 500-year floods in various places are hard-working professionals, applying their expertise to a difficult problem. But there are a lot of uncertainties that get concealed behind the final numbers. The consequence is that the estimates can be way off. For instance, a [2012 study](#) of Houston found that over 47% of all flood insurance claims were located outside of the designated 100-year floodplain boundary.

From what I've been able to learn so far, here are some of the key uncertainties, starting with the most widely discussed:

1. **Climate change.** The estimates are based on historic experience, assuming that flood risks are stable over time. Climate change is going to increase the likelihood of floods in many areas, so the estimates are biased downward. But it's not easy to know how much to adjust, because the climate models can't give precise forecasts of the amount of change in any given locale.
2. **Hydrological changes.** Flood risks can also change because of changes in land use. One big problem in Houston has been the destruction of important natural sinks that help control flooding. Impervious surfaces also increase flood risks, because water is released more quickly. Land subsidence can also increase flood risk. Adjusting for these factors has to be complicated — and there can also be uncertainties because we can't precisely forecast future urban development.
3. **Limited data.** For inland flooding, flood estimates are based on hydrological gauges in streams. (Hurricanes, on the other hand, are fairly rare events, so the data base for them is inherently limited.) There may be a limited number of gauges in some areas, or they may not have been in operation very long. Also, gauges may be inaccurate, particularly in periods of high flow. Efforts are made to adjust for some of these issues, for example with comparisons to gauges in nearby areas. But this involves judgment calls.
4. **Poorly known probability distributions.** We don't have a theoretical basis for predicting how river flows vary over time. The government did a study and found that, of the standard distributions used by statisticians, something called the Pearson Type III distribution with log transformation worked the best for fitting the data on high stream flows (i.e., floods). (Don't feel bad if you don't know what that is; I had to look it up. Basically, it's a normal "bell curve" that has been stretched in one direction or "skewed.") But this is an approximation., since in fact we don't know the true shape of the probability distribution. So the statistical method being used is only approximately right to begin with.
5. **The difficulty of estimating rare events.** By definition, increasingly rare events are

increasingly unlikely to be found in the record of the time period for which we have data. That means that there's going to be a lot of uncertainty about high-end estimates, which involve rare events like 500-year floods. For example, in a situation studied by the National Research Council in 2000 (see [this report](#) at p. 81). , the expected discharge for the 100-year flood ($p = 0.01$) is 4,310 cubic feet of water per second (cfs), the upper confidence limit is 6,176 cfs, and the lower limit is 3,008 cfs. So basically, what we know is that there's a 90% chance that the 100-year flood would involve somewhere between 3008 cfs and 6,176 cfs, a difference of a factor of two. By 2000, the Army Corps of Engineers had already decided that it needed to start taking this uncertainty into account, but I wonder how many other flood control agencies and land use planners are that sophisticated?

By pointing out these issues, I certainly don't mean that we should ignore the estimates that come out of this process. I certainly don't have enough expertise to criticize these methods, though it does bother me somewhat that the methodology hasn't been changed since 1982.

But even if the [1982 guidance](#) is still state of the art, we need to realize that what we're getting is a "best professional judgment," not a scientifically precise number.

When thinking about policy, it's really important to include sensitivity analysis to take into account these uncertainties. We also have to keep in mind that factors 1 and 2, at least, lead to systematic underestimates of risk. That's a good reason to add a significant margin of safety, or put differently, to take a precautionary approach to managing flood risks.

Neither policy analysis nor engineering are exact sciences. That's why we need policies and designs that are robust enough to work even if our numbers are a bit off.