



FEMA Risk MAP

1D vs. 2D Modeling



September 2025



Objective

To explain the difference between one-dimensional and two-dimensional modeling.

1D Modeling

Historically one-dimensional engineering models were used to determine the flood elevations for a particular flood event along a stream corridor. These flood elevations are established at cross sections placed perpendicular to the stream flow (Figure 1). FEMA Flood Insurance Rate Maps (FIRM) show the location of these cross sections, as well as whole foot Base Flood Elevations (Figure 1).

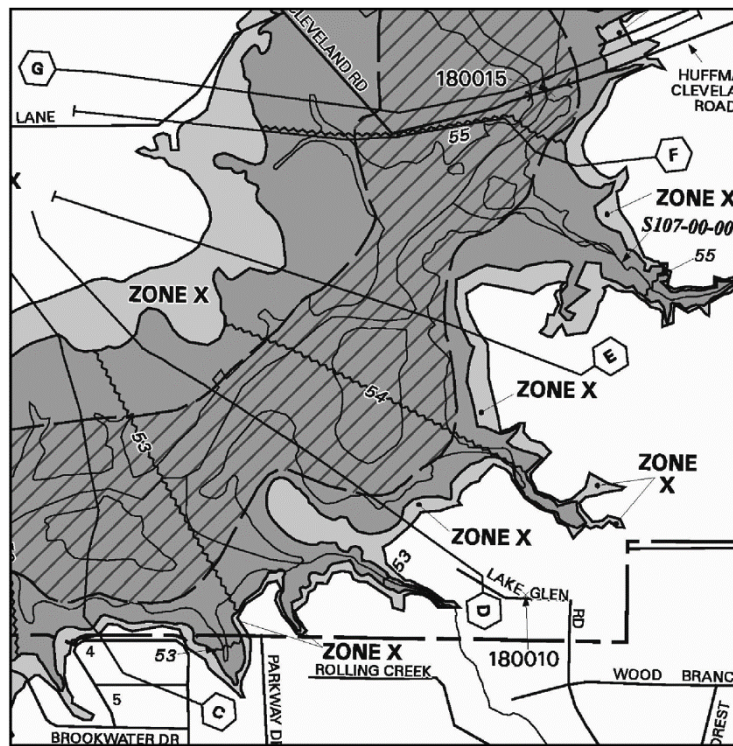


Figure 1. An example of a FIRM showing the floodway, cross section locations, and base flood elevations.
Credit: [FEMA Guidance for Flood Risk Analysis and Mapping, December 2020.](#)

The flood elevations for each cross section are also listed in the floodway data table in the associated Flood Insurance Study (FIS) report.



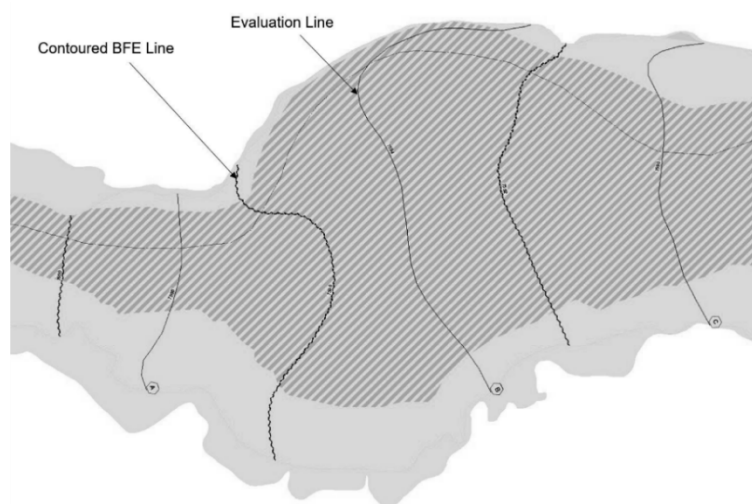
2D Modeling

Two-dimensional engineering models determine flood elevations across an entire area or floodplain incorporating flows in multiple directions. Unlike 1D models, 2D models determine flood elevations at individual cells instead of at cross sections. However, this leads to a disconnect with 44 CFR § 60.3, which was developed at a time when simplified methods were used to average hydrologic and hydraulic calculations and results.

As a result, without changing the actual Code of Federal Regulations, the Federal Emergency Management Agency (FEMA) has issued new and updated guidance documents for these situations (see <https://www.fema.gov/flood-maps/guidance-reports/guidelines-standards>). In particular, FEMA Guidance Document No. 79 outlines two methodologies: the all cells modeling methodology and the surcharge averaging and evaluation of insurable structures methodology. Communities overseeing the development of maps based on 2D models may encounter some issues with these methodologies, which are discussed in Appendix A.

Evaluation Lines

When developing floodways with 2D modeling, evaluation lines are used to determine the appropriate width of the floodway (Figure 2). This allows the flood elevations and surcharge amounts to be reported in a format that is consistent with regulatory FIS and FIRM products. Evaluation lines in 2D floodway analysis can be thought of as virtual hydraulic cross sections, similar to the physical cross sections used in 1D modeling and reported in the floodway data table. They are placed on FIRMs where a detailed study included a floodway calculated using 2D methods. Evaluation lines are also used in detailed studies with a hybrid 1D/ 2D model, where cross sections do not cover the entire floodplain. Hybrid 1D/2D models generally used when there are well-defined channels in urban areas combined with complex overbank flow.



*Figure 2. Example of Evaluation Lines and BFE Lines Used to Map Results of a 2D Based.
Credit: FEMA Guidance for Flood Risk Analysis and Mapping, December 2020.*



In both cases, evaluation lines are set at the critical locations as a reference point for floodway reporting and validating surcharge requirements. Where a 2D- or hybrid 1D-/2D-model was used but no floodway is calculated, evaluation lines are not included. Evaluation lines typically represent a single water surface elevation and may have a contoured shape. While similar to a BFE line, an evaluation line is a separate line type used to report floodway or encroachment information and used to validate that the calculated floodway or encroachment modification meets the surcharge requirements.

The National Flood Hazard Layer (NFHL) dataset is a compilation of effective Flood Insurance Rate Map (FIRM) databases (a collection of the digital data that are used in Geographic Information Systems for creating new Flood Insurance Rate Maps). Communities with a FIRM based on 2D models can find evaluation lines in the cross-section layer of the National Flood Hazard Layer Viewer. On the FIRM, evaluation lines can be either lettered or unlettered, and will have water surface elevation reported, similar to a lettered and mapped cross section line in a 1D model. The combination of BFE lines stored in the base flood elevation layer and evaluation lines stored in the cross-section layer are intended to produce a credible water surface elevation grid that captures the variability in the model results.

When determining flood elevations at locations in the mapped Special Flood Hazard Area evaluation lines can be used like cross-sections on SFHA mapping developed using 1D modeling. In some instances, 2D model results may be available on a county or state web site. When available, these data are the preferred sources of 2D model results in lieu of interpolating between evaluation lines.

Cover image: Texas A&M University Helps Stakeholders Plan for Future Flood Risk.
May 11, 2021. Image by FEMA.

Association of State Floodplain Managers
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