# Flood Plain Studies

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## Course Outline

An overview of FEMA requirements and the types of studies the practicing Architects, Civil Engineers and Surveyors might encounter are presented in this course. Useful sources of information and links to those and other sources are also included. This course is intended for Civil Engineers, Surveyors and Architects whose daily work may occasionally require an understanding of flood plain regulation and the methods available to develop projects in and near regulatory flood plains.

This course includes a multiple choice quiz at the end.

## Learning Objective

After completing this course, the student should:

- Have a basic understanding of terms and concepts used in flood studies;
- Be aware of the range of such studies from simple flood elevation certifications to design studies for sediment transport, bridge design, scour and shoreline protection projects;
- Gain a knowledge of the types of information needed to complete flood studies of various kinds; and
- Be able to access sources of useful information provided by links to those sources as well as to the analytical tools available in the public domain, on the Internet, and on the commercial market.

## Course Introduction

Flood prone areas throughout the country are regulated through the National Flood Insurance Program (NFIP) and by the Federal Emergency Management Agency (FEMA). Practicing engineers, architects and surveyors are increasingly called upon to perform hydraulic analyses in these areas to meet the requirements of FEMA's regulations and those of local regulatory agencies, which may include Cities, Counties, Water Control Districts and others.

The kinds of analyses called for may range from "simple" flood elevation certifications to extensive "what if" analyses of the effects produced by proposed construction in the flood plain/floodway of streams and coastal areas.

This course aims to provide an introduction to these topics and avenues for further study. A basic understanding of hydrology, hydraulics, surveying and site design are needed but it is not necessary to be expert in any of these areas to understand the course materials.

## Course Content

### 1. Basic Terms and Concepts

Figure 6.1 from a Federal Emergency Management Agency (FEMA) manual describes the main parts of a flood plain for regulatory purposes. The most important thing to note about this figure is the distinction between the *flood plain* and *floodway*. Ordinarily structures and other “encroachments” are permitted in the floodway fringe but are much more restricted in the floodway itself.

The *floodway* is defined by the computer model used to analyze the flood plain. It is an imaginary line drawn on a map and there are at least five different ways to define it. Because of this, you should understand that the *floodway* is not, as many believe, fixed and immovable. Through the Letter of Map Revision (LOMR) process FEMA and local jurisdictions can define the *floodway* in any reasonable way allowed by the Federal Regulations.

Secondly, note that the Base Flood Elevation (BFE) is usually, although not always, the natural elevation of the stream during the 100-year flood. By definition, the 100 year flood flow is that flow which has a 1 percent (1/100) probability of occurring in any one year. It is not the largest flood possible nor is it the flood that will only occur once in 100 years. Probability theory may be used to demonstrate that in 100 years there is a 64 percent chance of the 100-year flood being equaled or exceeded! In other words, such a flood is more likely to occur than not. Over the life of a 30-year mortgage, a home built with its lowest finished floor at the 100-year flood elevation has a 1 in 4 (24%) chance of being flooded.

The water surface elevations calculated in flood studies are another source of misunderstanding. Because storms are natural events and are not precisely predictable, all estimates of flow are just that; estimates only. Errors of plus or minus thirty percent in such estimated flows are not uncommon. For this, and several other reasons, calculated flood elevations are considered accurate to a tolerance of plus or minus one foot.

This margin of error is often obscured in both the regulations and by the computer models used to calculate water surface elevations. The computer can calculate elevations to six decimal places, if desired, and studies usually state them to the nearest .01 feet. Such precision is illusory. Do not trust these numbers to be more accurate than they are no matter how many decimal places are used to state them.

Figure 2.1 illustrates the basic equations and terms used by most computer models used in flood studies. This diagram is branded on to the brains of engineers who deal with open channel flow problems every day.

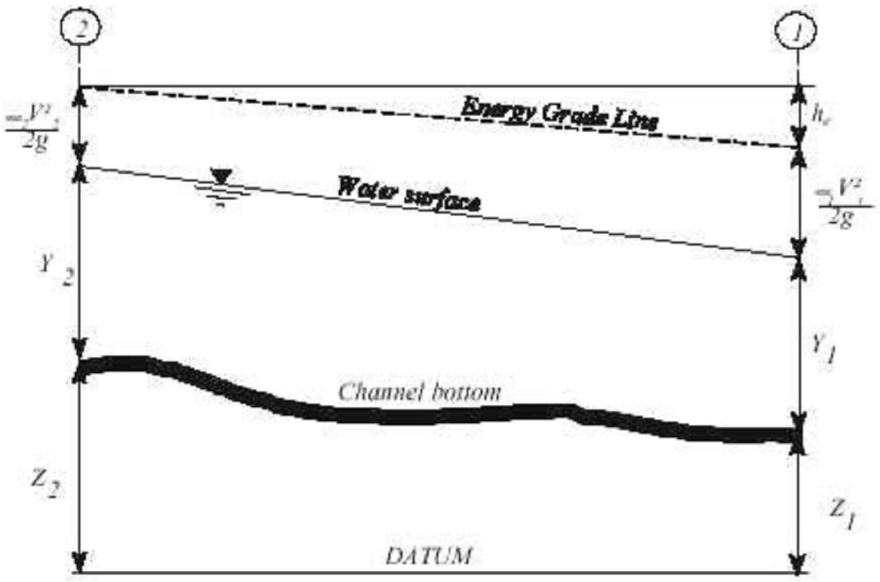


**Figure 2.1**

For the user of flood studies the important thing to remember about this diagram is what it represents. It is a special case example of Newton's Law of Conservation of Energy. This, along with the Law of Conservation of Momentum, forms the basis of virtually all stream flow analyses.

Before computers, these calculations were seldom done because they are long, and tedious and fraught with opportunity for error. Computer models have made it possible to do them much more easily and calibration, through laboratory and field-testing, have made them more reliable.

## 2. Types of Studies

- No Rise Studies

Probably the most common type of study you might be asked to prepare is the so-called “no rise” analysis. These can be very simple, manually calculated, estimates of conveyance, or stream capacity, before and after the proposed development. In more complicated circumstances, a more complete analysis may be needed using one or more of the computer models accepted by FEMA. Several of these are listed below in Section 4. Examples of more complex cases include bridge crossings, culverts, channelization, stream restoration, bank protection and others.

Guidance for simple floodway encroachments may found on FEMA’s website. If not available there please email the author and he will send you a copy of the FEMA guidelines.

- Letters of Map Revision

Letters of Map Revision (LOMRs) may be required when changes in the flood plain are extensive and would result in significant increase or decrease in the base flood elevation. LOMRs are, of course, much more complicated to model and require considerable time and effort. They may be worth this effort however, if your project can benefit from the changes in some significant way. For example, it may be desirable in some circumstances to move the location of the floodway to one side of the flood plain in order to make better use of the land on the other side. Allowing land of lower dollar value to flood and raising the level of land of higher value is sometimes done if it makes economic sense.

- No Damage Analysis

In some circumstances it is not possible to demonstrate that a floodway encroachment will not cause a rise in water surface during the regulatory flood. When this is so it can sometimes be argued that the rise, which would occur, would not cause significant damage to habitable structures. The regulations are aimed at preventing damage to property and possible loss of life. Flooding of a pasture, for example, is not considered to be the same kind of threat as flooding a residential structure. Even some buildings can be built in the floodway fringe if they are constructed flood proofed so long as they are not habitable. Industrial buildings, storage buildings and small “accessory” structures are sometime permitted in this way.

- Special Purpose Studies

The number of special purpose studies that might be required is almost limitless. Major structures such as bridge piers, docks, boat ramps, electrical transmission line towers, etc. located in the floodway are examples of cases where special, detailed studies might be required. Because of the cost and time needed to do such studies they are usually avoided. If the design requires placing such things in the floodway, then they must be undertaken.

The design of a bridge or culvert is another special case where detailed studies may be needed to properly size the waterway opening(s).

Other special circumstances can arise if scour at a bridge pier is a concern, for example. Sediment transport studies are sometimes needed and in coastal areas, wave run up and beach erosion studies may be required. Near manmade dams, sudden dam failure may endanger downstream properties.

Computer modeling tools are available to analyze all of these situations. In Section 4, below several of these models are described briefly and sources and links to their developers are given.

## 3. Sources of Information

The practicing architect, engineer, or surveyor needing flood plain information will find these sources useful. A link is provided at the end of each description for your convenience. If the link fails, copy and paste it into you browser and click “go”.

You should try each of these at least once if, for no other reason, you may find answers to one or more of the quiz

questions at the end of this course.

· FEMA

FEMA's home page will lead you to many maps, consultants who specialize in flood studies, sources of software, seminars and other emergency related links (earthquakes, hurricanes, fires, etc.)


· U.S. Army, Corps of Engineers

The Corps literally "wrote the book" on much of the stream and shoreline protection technology in common use today. They've also developed and tested many, if not all, of the computer models we use. This page will also lead you to the Waterways Experiment Station homepage, and beyond.


· Hydraulic Engineering Center, HEC

At the University of California, Davis, HEC is the birthplace of the HEC series of hydraulic and hydrology programs most used in flood studies.

· West Consultants, Inc.

A leading provider of consulting services in the western United States. West Consultants also will help keep you informed of upcoming conferences and seminars related to water resource issues.

· National Oceanic and Atmospheric Administration

Weather central for precipitation records and links to other hydrologic data sites


· State Climatologists ( American Association of State Climatologists)

In your state weather and rainfall data, extremes, storm and sometimes streamflow data may be available from your climatologist. This will link you to him or her and often provide the best source for the data you need.

**There are many, many more that might be listed but these should set you off on your searches a few steps ahead.**

## 4. Useful Software

FEMA, and local reviewing agencies, accept a large number of computer models when reviewing flood plain related proposals. The following is a partial list of a few of the most useful. For a complete list, go to FEMA's homepage that will lead you to their "official" list of over a hundred numerical models for everything from statistical analysis to flood hydrographs for Albuquerque, New Mexico.

**HEC II**

Formerly the most widely used water surface elevation calculator. Although difficult to use and limited in many ways, HEC II belongs in your battery of tools because thousands of existing flood plain studies were developed using it.

**HEC-RAS**

"HEC-RAS is an integrated package of hydraulic analysis programs, in which the user interacts with the system through the use of a Graphical User Interface (GUI). The system is capable of performing Steady Flow water surface profile calculations, and will include Unsteady Flow, Sediment Transport, and several hydraulic design computations in the future." (Including bridge scour)

"In HEC-RAS terminology, a Project is a set of data files associated with a particular river system. The modeler can perform any or all of the various types of analyses, included in the HEC-RAS package, as part of the project. The data files for a project are categorized as follows: plan data, geometric data, steady flow data, unsteady flow data, sediment data, and hydraulic design data.

"During the course of a study the modeler may want to formulate several different Plans. Each plan represents a specific set of geometric data and flow data. Once the basic data are entered into the HEC-RAS, the modeler can easily formulate new plans. After simulations are made for the various plans, the results can be compared simultaneously in both tabular and graphical form."

HEC-RAS will import HEC II data files but, unfortunately, most of the bridge data is lost in the process and must be re-entered.

It is also important to note that HEC-RAS and HEC II will yield similar, but not identical results. Comparisons between studies will thus be difficult even given identical input data.

**Quick2**

This program is a cutdown version of HEC-RAS. It can be used for simple floodway encroachments but it cannot handle culverts, bridges, or other complications.

**SMDBRK**

An acronym for Simplified Dam Break, SMDBRK can model flood waves resulting from the sudden failure of either masonry or earth fill dams. It does not require a lot of field survey data as input and it has been "calibrated" using actual dam failure histories.

**HEC-HMS**

"The Corps of Engineers' recently released Hydrologic Modeling System (HEC-HMS) Version 2.0. This "new-generation" software for precipitation-runoff simulation will supersede the Hydrologic Engineering Center's HEC-1 program. This state-of-the-art Windows based program is on par with the new HEC-RAS program, and will eventually be able to swap files with it, too. HEC-HMS provides a variety of options for simulating precipitation-runoff processes and is comprised of a graphical user interface (GUI), integrated hydrologic analysis components, data storage and management capabilities, and graphics and reporting facilities. The software is designed for interactive use in a multi-tasking, multi-user network environment, and can be used with both X-Windows and Microsoft Windows.

"The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) provides a variety of options for simulating precipitation-runoff processes. In addition to unit hydrograph and hydrologic routing options similar to those in HEC-1, capabilities currently available include: a linear-distributed runoff transformation that can be applied with gridded (e.g., radar) rainfall data, a simple "moisture depletion" option that can be used for simulations over extended time periods, and a versatile parameter optimization option. Future versions will have capability for continuous moisture accounting and snow accumulation and snow melt simulation. "

**SWMM**

"The United States Environmental Protection Agencies (USEPA's) Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. Both single-event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. Extran Block solves complete dynamic flow routing equations (St. Venant equations) for accurate simulation of

backwater, looped connections, surcharging, and pressure flow.

"Modeler can simulate all aspects of the urban hydrologic and quality cycles, including rainfall, snowmelt, surface and subsurface runoff, flow routing through drainage network, storage and treatment. Statistical analyses can be performed on long-term precipitation data and on output from continuous simulation. SWMM can be used for planning and design. Planning mode is used for an overall assessment of urban runoff problems or proposed abatement options."

**SBeach**

SBEACH is an empirically based numerical model for simulating two-dimensional cross-shore beach change. The model was initially formulated using data from prototype-scale laboratory experiments and has been further developed and verified with laboratory and field data. SBEACH calculates meso-scale beach profile change with emphasis on beach and dune erosion and bar formation and movement. The model is intended for predicting short-term profile response to storms. A fundamental assumption of the SBEACH model is that profile change is produced solely by cross-shore processes, resulting in a redistribution of sediment across the profile with no net gain or loss of material. Longshore processes are considered to be uniform and neglected in calculating profile change. This assumption is expected to be valid for short-term storm-induced profile response on open coasts away from tidal inlets and coastal structures…

"SBEACH requires data typically available in engineering studies to calculate beach profile response. For project applications, primary input to SBEACH includes time-histories of storm wave height and period (direction is optional) and water level; beach profile survey data; and median sediment grain size. Sampling intervals of input wave and water level time-histories usually range from 1 to 4 hr. Input required for model configuration includes parameters such as grid size, time-step, and calibration coefficients (default values are defined). Typical values of model grid size and time-step are 3 m and 5 min, respectively. The model operates through a graphical user interface which facilitates data input, model execution, and analysis of model results.

## Course Summary

Developing projects and sites within flood prone areas present added challenges to the practicing architects, engineers and surveyors who are increasingly asked to meet them. Any who work in these areas need to know the basic definitions contained in the regulations developed at the federal and local levels. There are many useful tools available to designers in this field. By knowing where they are, what they can do, their limitations and the field data needed to use them, design professionals can produce successful solutions to the special problems flood plains present.

## Recent Changes at FEMA's Website

Early in 2003 FEMA has made available digital FIRMs, or DFIRMS. To try it out you'll need to go to FEMA's home page and then navigate to the Map Store. If you're not already registered with FEMA you may need to register or re-register. You'll also need to download the viewer program Fmit.exe.

Once you get to the store you'll find you can buy or view DFIRMs. Look for the green button on the right of the screen to activate the viewer. You can search for the map you want by address and zip code or by latitude and longitude coordinates.

Finally, once you view the map of your choice, you can create a FIRMette version of it and save it to disk. FIRMettes can be either Adobe .pdf files or image files in .tif format.

**Once you finish studying the above course content, you need to take a quiz to obtain the PDH credits.**

View/Take Quiz

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