Chapter 11
FLOODPLAIN DESIGN

11.1 Overview of Floodplains

Basic floodplain terminology is either included in Chapter 15, or is referenced in the City floodplain regulations included in Appendix B under the title Flood Damage Prevention and Control (Chapter 12 of the City Code). The 100-year flood and 500-year flood are the two principal stormwater events of interest for the management of floodplains. Proper use and preservation of natural floodplains minimizes the extent of flooding, reduces stormwater velocities and erosion, improves stormwater quality, increases animal habitats, and provides recreational opportunities near creeks and streams. These objectives are consistent with the development of greenways and bike trails near creeks, streams and lakes. Greenways and bike trails also enhance property values and improve the quality of life for citizens of Knoxville.

Land development over the years typically affects floodplains by grading encroachments, bridges, box culverts, and restricted channels. Historically, people have settled near creeks and streams for a variety of benefits, such as transportation needs, water supply, good agricultural land, etc. The acceptable limits of flooding risks were determined by trial and error over the years, with construction in the floodplains based on personal judgment concerning individual property risks versus benefits at that location only. Large floods would periodically halt development, but not to the point of restoring channel capacity or protecting natural floodplains.

FEMA (Federal Emergency Management Agency) has been given authority to set national standards and guidelines for evaluating and insuring flooding hazards. Communities which participate in the FEMA program (such as Knoxville and Knox County) are required to limit development, for the purposes of protecting public safety and preventing property damage. FEMA administers the National Flood Insurance Program (NFIP), which allows homeowners in participating communities to purchase flood insurance at a reduced cost. The minimum FEMA standard is to use the 100-year flood to define the floodplain, floodway, floodway fringe and the water surface elevations in order to protect property owners.

The City of Knoxville selected the 500-year flood as the standard regional base flood (see Section 12-4 of the Flood Damage Prevention and Control Ordinance, Appendix B) with a maximum allowable increase of 1.0 foot to determine the 500-year floodway.

See Figures 11-1 and 11-2 for cross-sections of a typical 500-year floodplain before and after development occurs. The 100-year and 500-year flood boundaries are both computed for the Flood Insurance Study (FIS) and shown on the Flood Insurance Rate Map (FIRM). MPC has zoned floodways as the F-1 Floodway District (see the Knoxville Zoning Ordinance, Article 4, Section 19 from the MPC website - http://www.knoxmpc.org). This allows developers, property owners and other interested parties to recognize approximate extents of the floodway during preliminary design and investigation. However, the floodway is more exactly defined from hydraulic model cross sections; F-1 zoning may not be precise enough to protect the floodway.

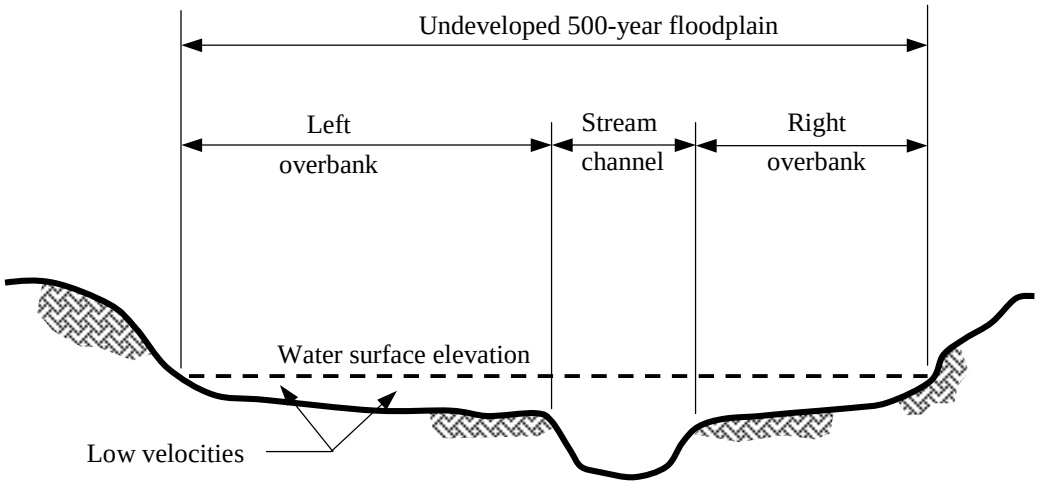

Figure 11-1
Typical Natural Floodplain

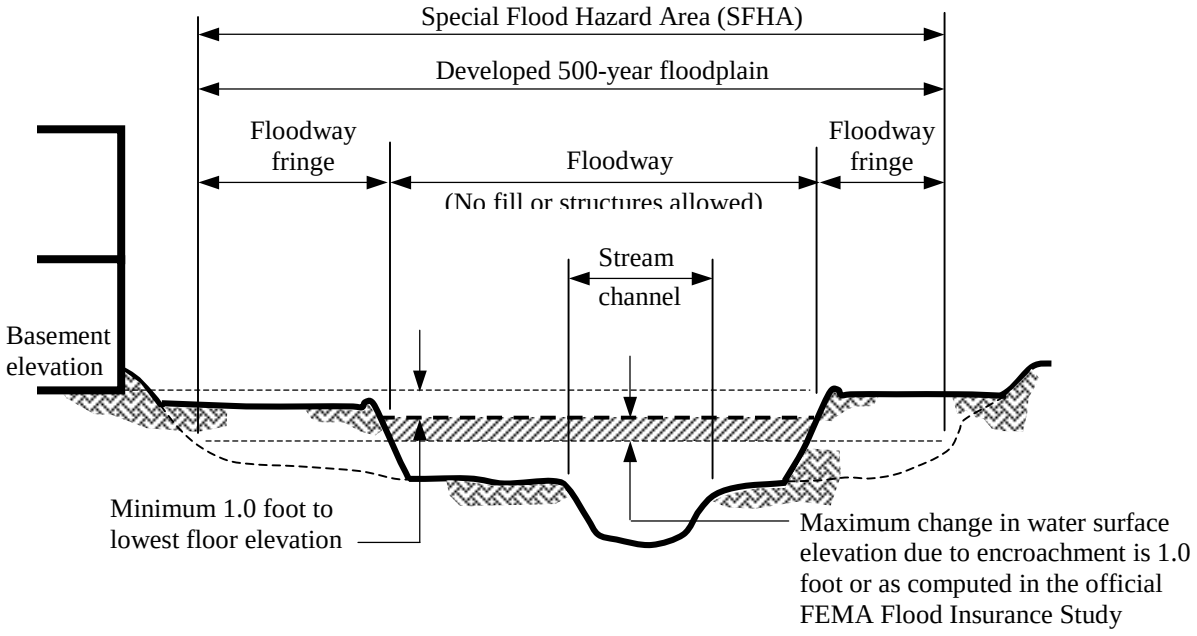

Figure 11-2
Typical Developed Floodplain

11.2 Floodplain Regulations

The essential floodplain regulations are:

1. The lowest finished floor of any structure (including basements) must be located at least 1.0 foot higher than the computed water surface elevation for the 500-year storm, and must be certified by a registered land surveyor for that exact elevation. This is accomplished by the FEMA Elevation Certificate (& Instructions), which is included in Appendix A of the Land Development Manual.
2. (Policy 20) No development, site grading, structures or other obstructions are allowed within the floodway, unless extensive modeling proves that there is no effect to the 500-year storm. Such modeling is called a "no-rise certification" and must be performed to the FEMA standards described in Policy 20.
3. (Policy 21) The no-fill line is established halfway between the 100-year floodway and the 100-year floodplain fringe. This is more strict than the requirements shown in Figure 11-2, where the developer filled the floodplain fringe up to the floodway line. The no-fill line is established in the May 2003 revision of the Knoxville Stormwater and Street Ordinance, Section 22.5-21(f), in order to better preserve the flood storage and conveyance capabilities of the floodplains.
4. (Policy 22) A stream buffer zone (restricted-use) is established along blue-line streams to protect natural streams and creeks from erosion, sediment, and pollution-intensive land uses. The stream buffer zone is established in the May 2003 revision of the Knoxville Stormwater and Street Ordinance, Section 22.5-21(f).

The City of Knoxville requires a certain level of design for stormwater calculations and flooding analyses. Stormwater design criteria are based on current scientific knowledge and engineering judgment; however, floods and flooding may occur at any time due to any number of factors beyond the reasonable control of the city. Such factors may include greater amounts of precipitation or different rainfall patterns than commonly used in design storms, saturated soil conditions, debris or blockage of key stormwater channels, high groundwater tables, etc. Stormwater calculations must be stamped and signed by a professional engineer licensed in the state of Tennessee. The professional engineer must have sufficient education and experience to perform a complete and thorough analysis. The stamp of a professional engineer is a public guarantee that his design has the highest regard for public health and safety, while minimizing damage to property.

Policy 23 lists the current status of the creeks, streams and rivers which have computed water surface elevations, floodplain widths, floodway widths, peak flows, flow velocities, etc. This information is available for review at the Engineering Department (Suite 480, City County Building) during normal business hours. The published Flood Insurance Studies can be viewed online or purchased from FEMA for a nominal cost. Other published reports can be viewed or xeroxed at the MPC Library on the 4th floor of the City County Building.

11.3 Estimating Peak Flows

One way to determine floodplains and flood water surface elevations is to measure peak flows and flood stages for a stream or creek over a period of many years. Statistical methods of flood flow frequency analysis (such as Gumbel extreme values or Log-Pearson Type III) can be used to estimate the 100-year water surface elevation and stream flows at a particular gauged station, even if the period of record is much shorter than 100 years. Of course, the estimate is better with a longer period of gauged data. Any statistical method of analyzing past stream gauge data presupposes that the watershed parameters remain the same, and that the only variable is the amount and distribution of rainfall. However, most watersheds within the City of Knoxville have been extensively changed and developed during the 20th century, with higher percentages of impervious area and more stormwater drainage pipes. Statistical methods of analyzing floods are not usually applicable if the watershed had changed drastically over time.

Peak flows are usually estimated for a creek or stream based on either an empirical formula (such as the TVA and USGS regression equations) or some type of urban stormwater modeling program (such as HEC-1 or HEC-HMS). The lower limit of the TVA regression equations is 230 acres, and the lower limit of the USGS regression equations is 135 acres. See ST-13 of the Knoxville BMP Manual for formulas and additional limitations. Peak flows for watersheds may also be modeled with HEC-1 or HEC-HMS, which are freely available public-domain hydrograph programs developed by the U.S. Army Corps of Engineers (USACE). HEC-1 was originally developed over 30 years ago, and adapted to personal computers in the mid-1980s. The HEC-1 program is superceded by the newer windows-based HEC-HMS program. Both programs can be downloaded from the USACE website.

11.4 Floodplain Modeling

Floodplain modeling may be required to demonstrate that a proposed development project does not impact the floodway or cause an unacceptable flow depth or condition. After peak flows have been determined for the flood of interest, peak water surface elevations are computed with a backwater standard-step computational procedure (typically either the HEC-2 or HEC-RAS software program). Cross sections are input into the program at regular intervals along the stream, and at other locations where changes occur (such as cross-sectional area, Manning's roughness coefficients, peak flows, bridges, culverts, etc). Initial flow conditions (such as the downstream water surface elevation) are specified in order to produce a water surface profile.

The standard programs for computing water surface profiles are HEC-2 and HEC-RAS, which are freely available public-domain hydrograph programs developed by the U.S. Army Corps of Engineers (USACE). HEC-2 was originally developed over 30 years ago, and adapted to personal computers in the mid-1980s. The HEC-2 program has been superceded by the newer windows-based HEC-RAS program. Both programs are freely available public-domain software that can be downloaded from the USACE website. The design engineer can usually obtain the current HEC-2 or HEC-RAS input information from the Knoxville Engineering Department or from TVA, and then add cross-sections to the model in order to determine potential effects of encroachment or bridge crossings. In some cases, the design engineer may have to extend the floodplain model upstream along the main branch or a side branch.

11.5 Floodway and Floodplain Revisions

Floodplain reports and investigations must meet the requirements outlined in the Chapter 12 of the municipal code (see Appendix B) and in the Knoxville Zoning Regulations (available from MPC). No building or construction permits will be issued until the plans contain a certification stating that there is no increase to the 500-year flood water surface elevations. The City Engineering Department must approve any floodplain reports and investigations prior to approval of construction plans. Typical information will include:

- Topographic maps to scale, with accurate and current data that includes all structure locations and finished floor elevations.
- Profiles of the creek or stream, with all bridge and culvert crossings, water surface elevations, and cross-section locations.
- Representative cross-sections for each section of the creek or stream.
- Basis for determining peak flows, including a map of the watershed boundary with subareas delineated.
- Complete input data used to compute the water surface profiles (typically HEC-2 or HEC-RAS programs) in printout form and as electronic files.
- Summary output tables and charts, with computed water surface elevations, energy grade lines, velocities, cross-sectional flow areas, etc.

Floodplain revisions may be necessary if any features associated with the floodplain are changed by development or transportation work, such as grading encroachments or bridge improvements. Any changes to the floodplain or floodway must be fully documented to FEMA (and the City of Knoxville) using one of the following methods:

- Conditional Letter of Map Amendment (CLOMA) -- A letter from FEMA stating that a proposed structure or parcel of land, not having been elevated by fill, would not be inundated by the base flood.
- Conditional Letter of Map Revision (CLOMR) -- A letter from FEMA stating that a proposed structure or parcel of land would not be inundated by the base flood, due to channelization projects, bridge and culvert construction of bridges or culverts, floodway alterations, or other impacts other than fill placed outside of the regulatory floodway.
- Conditional Letter of Map Revision Based on Fill (CLOMR-F) -- A letter from FEMA stating that a proposed structure or parcel of land, having been elevated by fill, would not be inundated by the base flood.
- Letter of Map Amendment (LOMA) -- A letter from FEMA stating that an existing structure or parcel of land, not having been elevated by fill, would not be inundated by the base flood.
- Letter of Map Revision (LOMR) -- A letter from FEMA stating that an existing structure or parcel of land would not be inundated by the base flood, due to

channelization projects, bridge and culvert construction of bridges or culverts, floodway alterations, or other impacts other than fill placed outside of the regulatory floodway.

- Letter of Map Revision Based on Fill (LOMR-F) -- A letter from FEMA stating that an existing structure or parcel of land, having been elevated by fill, would not be inundated by the base flood.

Application forms, instructions, and certificates can be downloaded from the FEMA website at: http://www.fema.gov/nfip/forms.shtm Application forms and certificates must also be submitted to the Stormwater Engineering Division as part of the plans review process.

The Knoxville Engineering Department manages and regulates floodplains/floodways in order to participate in the NFIP, which will allow citizens and businesses to obtain flood insurance at reduced rates. Currently the City of Knoxville is a Class 9 community, which allows a 5% reduction in flood insurance rates. The Community Rating System (CRS), which is described on the FEMA website at http://www.fema.gov/nfip/crs.shtm , allows each community to receive credits in 18 different categories related to floodplain management and maintenance, zoning and mapping regulations, public involvement/education, and major drainage improvements and public works.