Supplement to the Benefit-Cost Analysis Reference Guide

June 2011

This document was prepared by

ACKNOWLEDGEMENTS

Table of Contents

Table of Contents

Table of Contents

FIGURES

Table of Contents

TABLES

ACV	Actual Cash Value
ADT	Average Daily Traffic
ASCE	American Society of Civil Engineers
AVM	Automated Valuation Model
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BFE	Base Flood Elevation
BRV	Building Replacement Value
cfs	Cubic Foot per Second
DDF	Depth-Damage Function
DDT	Data Documentation Template
DFA	Damage Frequency Assessment
FEMA	Federal Emergency Management Agency
FFE	First Floor Elevation
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GBS	General Building Stock
GIS	Geographic Information System
H&H	Hydrology and Hydraulics
HAG	Highest Adjacent Grade
Hazus	Hazards U.S.
HEC-SSP	Hydrologic Engineering Center – Statistical Software Package
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
LAG	Lowest Adjacent Grade
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
MR2	Major Release 2
MR3	Major Release 3
MR4	Major Release 4

MR5	Major Release 5
NAVD	North American Vertical Datum
NFHL	National Flood Hazard Layer
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
OMB	Office of Management and Budget
RCV	Replacement Cost Value
sf	square feet
SFHA	Special Flood Hazard Area
SHMO	State Hazard Mitigation Officer
SOW	Scope of Work
UDF	User-Defined Facilities
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WSEL	Water Surface Elevation

SECTION ONE INTRODUCTION

1.1 Purpose

This guidance document was prepared for the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) under Contract No. HSFEHQ-06-D-0162, Task Order HSFEHQ-09-J-0024. The purpose of the guide is to supplement the information available at http://www.fema.gov/government/grant/bca.shtm regarding the FEMA benefit-cost analysis (BCA) software Version 4.5.5 with additional guidance on performing a BCA using the Damage Frequency Assessment (DFA) and Flood modules. All references to BCA software modules in this document are for Version 4.5.5. This document explains what constitutes acceptable documentation for Hazard Mitigation Assistance (HMA) grant subapplications. In addition, it explains additional and alternative methods for determining benefits for some of the most common benefit categories for buildings (e.g., building damage, contents damage, displacement and loss of function) as well as non-traditional benefits (e.g., agricultural equipment and landscaping equipment) not generally discussed in BCA training classes. These methods will facilitate better preparation of a BCA for a HMA Program grant application in accordance with the Fiscal Year 2011 (FY11) *Hazard Mitigation Assistance Unified Guidance: Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, Repetitive Flood Claims Program, Severe Repetitive Loss Program* (*FY11 HMA Unified Guidance*, FEMA 2010a) and recognize additional benefits not previously considered. This document does not replace the formal BCA training offered by FEMA. To schedule training, Applicants and subapplicants can contact their FEMA Regional office or State Hazard Mitigation Officer (SHMO).

1.2 Cost-Effectiveness Analysis Requirements for Hazard Mitigation Assistance Program Funds

To be eligible for HMA Program funding, mitigation projects must be cost effective as demonstrated by a FEMA-validated BCA. A BCA evaluates the future benefits (projected losses avoided) of a project in relation its cost. The BCA evaluation results in a benefit-cost ratio (BCR). If the future benefits are equal to or greater than the project cost, then the BCR is equal to or greater than 1.0 and the proposed project is considered cost effective. If the benefits are less than the cost, then the BCR is less than 1.0, and the proposed project is not considered cost effective. Only projects that demonstrate a BCR of 1.0 or greater are considered for HMA funding.

For projects submitted for funding under the Hazard Mitigation Grant Program (HMGP), an expedited cost-effectiveness determination can be made for property acquisition and structure demolition or relocation projects when certain conditions are met. Specifically, for structures identified in a riverine floodway or Special Flood Hazard Area (SFHA) on the current effective Flood Insurance Rate Map (FIRM) and declared substantially damaged due to the impacts of flooding by a local authority having such jurisdiction, property acquisition and structure demolition or relocation is considered cost effective and a BCA is not required to be submitted for the structure.

SECTION TWO FLOOD HAZARD MITIGATION

Mitigation projects must reduce the potential future damages to a building and its contents, infrastructure, and human lives to recognize their benefits. Additionally, loss of function—displacement of occupants from the building and/or loss of public services—may also be reduced by mitigation projects, thereby further increasing the benefits of the project. The FEMA BCA DFA and Flood modules are designed to analyze riverine and coastal flood sources and compare before- and after-mitigation damages to buildings and/or infrastructure. Each of these two modules requires different information. The selection of which module to use is based on the type of information available to the user.

The DFA module is more flexible than the Flood module, and therefore the most frequently used module for the HMA Program grant subapplications. The DFA module analyzes proposed mitigation projects based on damages (either historical or expected) and future damages avoided. The DFA module is extremely useful for projects in areas where high costs were incurred from historical flooding events but for which no FEMA Flood Insurance Study (FIS) is available. The DFA module is commonly used to analyze stormwater management and drainage improvement projects. It can also be used to analyze much larger projects. The DFA module (Section 2.1) is recommended in place of the Flood module (Section 2.2) when key structural information, such as the first floor elevation (FFE), or critical flood hazard resources, such as the FIRM, FIS, or the base flood elevation (BFE), are not available.

Another important use for the DFA module is as a secondary analysis method for mitigation projects that do not result in a BCR of 1.0 or more in the Flood module. The DFA module can be used to analyze projects with documented historical damage records or hydrology and hydraulics (H&H) studies that indicate expected flood damages. If the BCR is less than 1.0 for a project analyzed in the Flood module, but is equal to or greater than 1.0 using the DFA module, the complete and well-documented DFA module can be submitted in a project subapplication instead of the Flood module. The subapplication should explain why the DFA module was used in lieu of the Flood module.

The Flood module analyzes proposed mitigation projects based on the effect a storm of a certain magnitude will have on buildings before and after the project is implemented. The Flood module software is designed for evaluating individual buildings within a project. The Flood module is recommended for BCAs when users have detailed flood hazard information and structural data for a project, including FFEs. The default depth-damage functions (DDFs) in the Flood module apply to buildings, their contents, and their loss of function and displacement time during and after a flood event. The Flood module provides an accurate calculation of risk and maximum benefits for mitigation projects.

Figure 2.1 illustrates the decision-making process for selecting between the DFA and Flood modules for flood hazard mitigation projects. Additional information regarding the modules is presented in Sections 2.1 and 2.2 and can be obtained at the BCA Web site http://www.bchelpline.com/BCAToolkit/index.html.
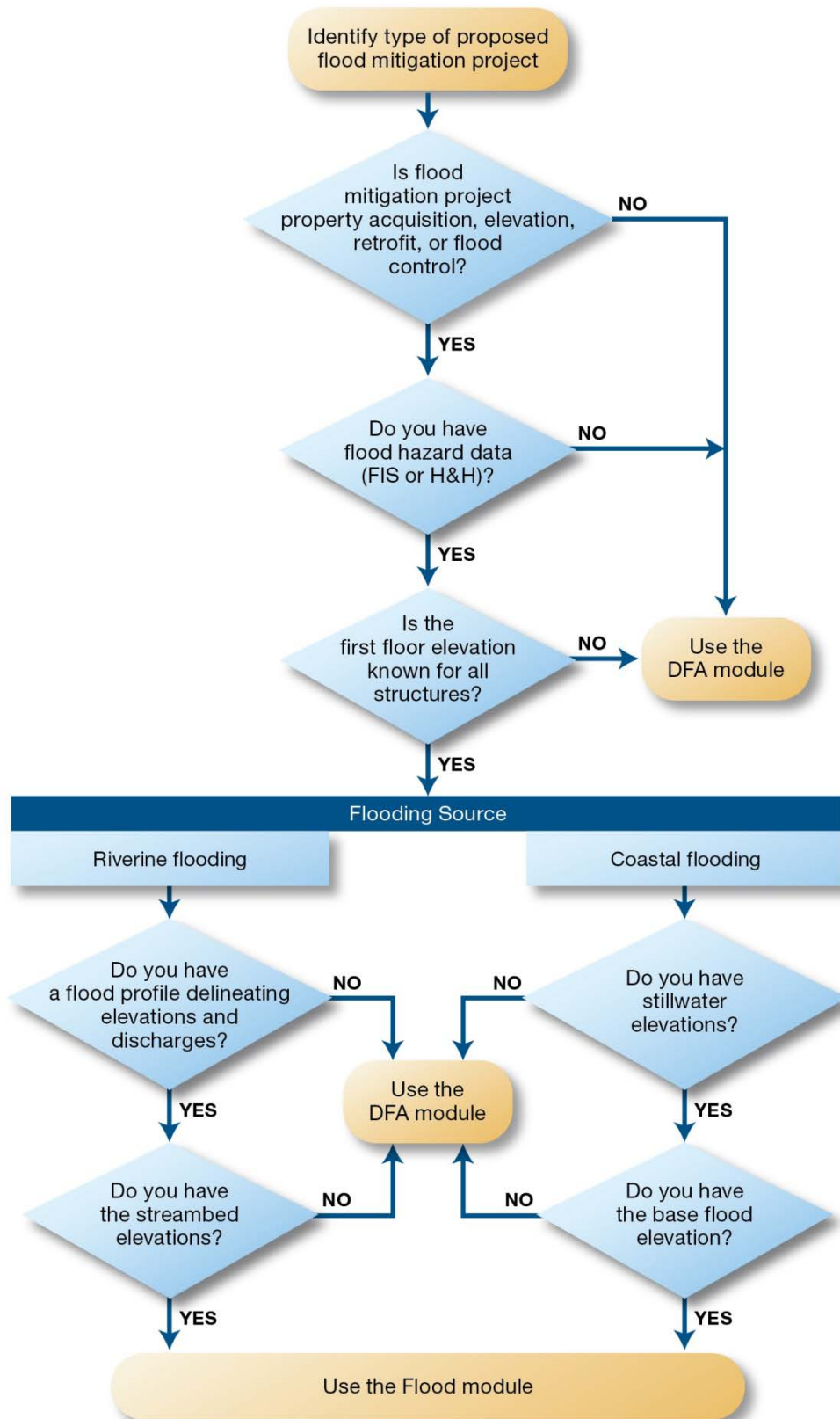
Figure 2.1: Selecting between the DFA and Flood modules for a flood mitigation project

2.1   Working with the Damage Frequency Assessment Module

The FEMA BCA DFA module is a flexible tool for calculating project benefits and costs for proposed mitigation projects when users do not have accurate hazard or structural information. The DFA module was developed to calculate project benefits and costs for proposed hazard mitigation projects based on either documented historic damages (such as loss of function or physical damage) from three or more events with unknown recurrence intervals, or expected damages from at least two events of different recurrence intervals. It can be used to analyze a variety of facility types including utilities, roads and bridges, and buildings.

This section includes information on the following common issues encountered when using the DFA module:

- Documenting Historical, Expected, and Residual Damages (Section 2.1.1)
- Determining Recurrence Intervals (Section 2.1.2)

     This section provides information for users entering expected damages

- Adjusting Analysis Duration (Section 2.1.3)

     This section provides information for users entering historical damages

- Using National Flood Insurance Program BureauNet Information (Section 2.1.4)

     This section provides information for users entering historical damages

2.1.1   Documenting Expected, Historical, and Residual Damages

The main advantage of the DFA module is its flexibility: it can be used for a wide range of hazards and mitigation project types. However, since some flooding events are 20 or 30 years old, data entered in the DFA module can be difficult to properly document. Historically, subapplications submitted for HMA program grant funding that use the BCA DFA module have commonly used values that are insufficiently documented with credible sources, resulting in delays in project funding. Users should begin by reviewing the suggested sources of documentation provided in the DFA Data Documentation Template (DDT) that is available from the BCA Helpline Web site (www.bchelpline.com; click the "Resource Kit" tab and the DFA icon).

Expected Damages

If historical damage amounts are unknown, engineering calculations can be used to determine expected damages from hazard events. Determining the recurrence intervals of historical hazard events is problematic because the data are often incomplete, inaccurate, or out of date. As a result, many users do not consistently or accurately determine the recurrence intervals of historical hazard events, which results in incorrect BCRs. Users should consult with an engineer or technical expert familiar with the proposed project to obtain cost estimates for damages resulting from at least two hazard events with different recurrence intervals. Calculations for at least two hazard events are required for the "Expected Damages" field in the DFA module. The applicable sections of the FIS, or the engineering report and H&H analysis must be submitted with the subapplication to document inputs used for expected damages in the DFA module.

Historical Damages

If historical damages are being used in the DFA module, then at least three events are required, and the events must have occurred in different years.

- Historical damage records for residential or non-residential structures may come from BureauNet data (see Section 2.1.4 for a detailed explanation) or repair receipts

- Extrapolation outside of known data points is not acceptable

Residual Damages

Regardless of whether historical or expected damages are used in the DFA module, the project level of effectiveness must be considered. Almost all mitigation projects (with the exception of acquisition projects) remain subject to damage from possible future hazard events. These damages are called residual damage. Users should consult with the engineer or technical expert familiar with the project to obtain level of effectiveness.

2.1.2   Determining Recurrence Intervals

To estimate the recurrence interval of a storm event near a project site, it is important to be able to retrieve and analyze stream gage data for the closest appropriate stream or river. The U.S. Geological Survey (USGS) Water Resources Division is the Federal agency responsible for monitoring water data.

This section outlines a process for determining whether stream gage data are available, for retrieving the appropriate data, and for creating an exceedance probability chart for estimating the exceedance probability of the storm event. The inverse of the exceedance probability is then used to determine the recurrence interval.

The process outlined in this section is one of many methods available and should not be considered the only acceptable method to determine recurrence intervals. For example, the recurrence interval of an event can also be determined from rainfall gage data but requires an analysis beyond the scope of this document. The limitations and acceptable methods are explained in detail in Appendix C of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA 2003).

The process for using stream gage data is demonstrated using an example storm event that occurred in February 1996 at a project site located near the mouth of Issaquah Creek in Washington State. The following steps can be adapted to project locations throughout the United States:

- **Step 1.** Determine if the gage data period of record includes the event of interest

- **Step 2.** Retrieve and download the annual peak discharge for the event of interest

- **Step 3.** Import annual peak discharges into the USGS PeakFQ program, output an exceedance probability chart for the gage, estimate the exceedance probability of the event (in percent), and take the inverse of the result to determine the recurrence interval

2.1.2.1   Step 1 – Determine Gage Period of Record

The URL below is the USGS homepage for surface water data, where XX is replaced with the two letter state abbreviation (WA for Washington in the example):

http://waterdata.usgs.gov/XX/nwis/sw

The first step is to check whether gage data are available for any streams near the proposed project site and whether the gage data include the storm event of interest.

Example: Issaquah Creek, WA

Background: The project site is near the mouth of Issaquah Creek. The storm event of interest occurred in February 1996.

Approach:

1. Go to http://waterdata.usgs.gov/wa/nwis/sw.

2. Click the *Daily Data* button

3. Select "Site Name" under the column labeled *Site Identifier*. The *Site Attribute* column has "Site Type" selected as the default and can be left as is. If desired, users can further narrow their search by selecting "County" in the *Site Location* column. Click *Submit*.

4. Enter the site name. Users can enter the name of the flooding source or the city where the project is located. Select *match any part*. If the "County" box was checked in the previous step, choose the county where the project is located. "Site Type" will already be selected.

5. Scroll down to the <u>Choose Output Format</u> section and select the *Brief descriptions* option. Click *Submit*.

6. The search will display a list of gages matching the criteria entered in the previous steps. Select the most relevant stream data. The example search resulted in 10 gages on Issaquah Creek. Three of the 10 gages are shown in the screen shot below. Note that gages can go off-line without prior warning, resulting in variations over time in the number of gages found through the search function.

Example Problem Results: For the example problem, Gage ID#12121600 is the gage nearest to the project location. It has a period of record of 45 years for peak discharge (from 1963 to 2009), and covers the February 1996 event.

Discussion

If it is unclear which gage is closest to the project location, the latitude and longitude information provided for each gage should be compared to the project location. The proximity of the gage to the project site is important in determining whether flows recorded at the gage represent most or all of the flow at the project site. Gages upstream of the project site will not record tributary or groundwater inflows that enter the flooding source between the gage and the project site. However, if the user's purpose is to determine the size of an event, a gage upstream or downstream of the project can be used as long as the gage is located on the same flooding source and was affected by the same storm events.

Users can determine the period of record from the gage data, but it should be noted that the shorter the gage data record length, the higher the uncertainty. This means an exceedance probability of 10 percent should be derived from a gage record with a minimum of 10 years of data; however, a longer period of record is desirable, as this is more likely to capture cyclical variation in annual precipitation. Wet and dry years often occur in cycles lasting several years, and the longer the record, the more likely the computed exceedance flows will represent typical flow conditions.

2.1.2.2   Step 2 – Retrieve and Download the Annual Peak Discharge for the Event of Interest

USGS archives annual peak discharges as well as daily mean discharges for the period of record. Often a declared event will also be the annual peak. The simplest way to determine the peak discharge is to retrieve and download the annual peak discharges from the archives, as demonstrated with the Issaquah Creek example.

Example: Issaquah Creek, WA

Approach:

1. Return to the Surface Water homepage, http://waterdata.usgs.gov/wa/nwis/sw

2. Click on Peak-flow data

3. Select the option to search by *Site Number*. Click *Submit*.

4. Enter the Gage ID#12121600 and select exact match. Scroll down to *Retrieve published peak streamflow data for selected sites* and choose *Table of data*. Click *Submit*.

5. Review results. The peak discharge for the event of interest will be listed in the table. In this case, the February 1996 event was the annual peak and the peak discharge was 2,420 cubic feet per second (cfs).

6. Download the annual peak discharge data by selecting the *peakfq (watstore) format* button.

7. Save in .txt format to user's computer.

			Output formats
King County, Washington			Table
Hydrologic Unit Code 17110012			Graph
Latitude 47°33'09", Longitude 122°02'48" NAD27			Tab-separated file
Drainage area 56.6 square miles			peakfq (watstore) format
Contributing drainage area 56.60 square miles			Reselect output format
Gage datum 35.99 feet above sea level NGVD29			

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1964	Jan. 01, 1964	8.90	1,950	1986	Jan. 19, 1986	11.52	2,300
1965	Jan. 29, 1965	8.84	1,600	1987	Nov. 24, 1986	13.20	3,100
1966	Jan. 07, 1966	6.52	876	1988	Mar. 26, 1988	8.77	1,250
1967	Dec. 13, 1966	8.14	1,480	1989	Apr. 05, 1989	9.51	1,330
1968	Dec. 25, 1967	6.86	1,090	1990	Jan. 09, 1990	13.50	3,200
1969	Jan. 05, 1969	9.07	1,960	1991	Nov. 24, 1990	13.43	2,410
1970	Jan. 24, 1970	6.28	824	1992	Jan. 28, 1992	8.65	1,110
1971	Jan. 09, 1971	8.54	1,710	1993	Mar. 23, 1993	7.44	739
1972	Feb. 28, 1972	10.23	2,260	1994	Mar. 03, 1994	6.35	471
1973	Dec. 26, 1972	6.78	964	1995	Feb. 19, 1995	10.80	1,740
1974	Jan. 16, 1974	7.43	1,160	1996	Feb. 08, 1996	12.84	2,420
1975	Feb. 20, 1975	8.11	1,390	1997	Jan. 01, 1997	11.16	1,830
1976	Dec. 03, 1975	11.46	2,870	1998	Oct. 30, 1997	7.48	729
1977	Dec. 26, 1976	4.93	398	1999	Nov. 26, 1998	11.18	1,870
1978	Dec. 15, 1977	8.87	1,670	2000	Nov. 12, 1999	8.79	1,150
1979	Dec. 01, 1978	6.91	836	2001	Apr. 30, 2001	5.51	431
1980	Dec. 15, 1979	10.70	1,940	2002	Nov. 14, 2001	11.50	2,080
1981	Dec. 26, 1980	8.24	1,180	2003	Mar. 13, 2003	7.37	858
1982	Jan. 24, 1982	10.64	1,920	2004	Jan. 29, 2004	10.48	1,750
1983	Jan. 05, 1983	11.18	2,110	2005	Dec. 11, 2004	9.53	1,460
1984	Jan. 25, 1984	11.79	2,330	2006	Jan. 11, 2006	9.68	1,500
1985	Dec. 14, 1984	5.98	460	2007	Nov. 06, 2006	11.50	2,080

Discussion

Note that multiple events could have occurred during the same year and the event of interest may not be largest. If the event of interest is not listed as the annual peak, other estimation methods will need to be used. These methods are discussed in Section 2.1.2.4.

2.1.2.3 Step 3 – Import Annual Peak Data into PeakFQ Program to Identify Exceedance Probability and Return Interval

The USGS PeakFQ program can provide estimates of instantaneous annual peak flows for a range of recurrence intervals, including 1.5, 2, 2.33, 5, 10, 25, 50, 100, 200, and 500 years. It also has an output option for an exceedance probability chart. Once an estimate of the exceedance probability for the event of interest has been determined, the inverse can be taken to determine the recurrence interval.

Approach

Follow these steps to use the USGS PeakFQ program:

1. Download and install the free program from http://water.usgs.gov/software/PeakFQ.

2. Start the program

3. Choose File→Open

4. Select the .txt file downloaded in the previous step (Section 2.2.1.2) and click "Open." This will load the information from the .txt file into the PeakFQ program. The PeakFQ home screen will open. The *Station Specifications* tab will be selected by default.
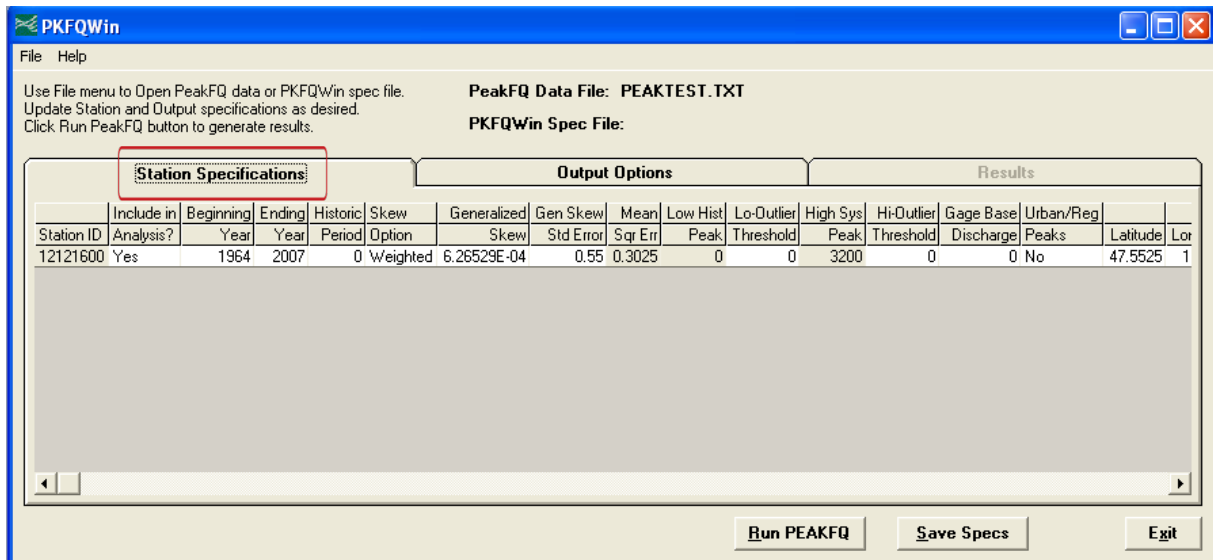
5. Select *Output Options* to configure the output options. Select the checkboxes for *Print Plotting Positions* and *Line Printer Plots*. Choose *BMP* as the Graphic Plot Format. Click *Run PEAKFQ* to generate results.
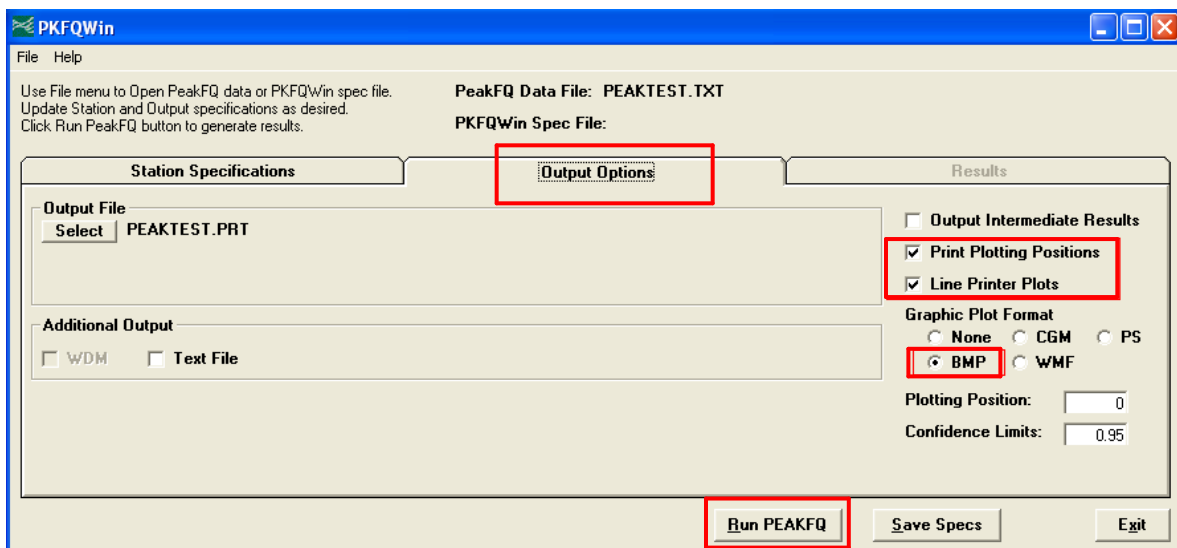
6. Select the *Results* tab. An output file with flows corresponding to each recurrence interval will be listed under *Output File*. Click *View* to view the file. To view an exceedance probability chart for the gage period of record, select the gage number under *Graphs* and then *View*.

Using Exceedance Probability Charts to Obtain Return Intervals

For the purpose of this calculation, exceedance probability is approximately the inverse of the recurrence interval. The exceedance probability chart (Figure 2.2) gives exceedance probability (in percent) on the x-axis, and the discharge (in cfs) using a logarithmic scale on the y-axis. On the logarithmic, scale 10^2 is equal to 100 cfs, 10^3 is equal to 1,000 cfs, and 10^4 equals 10,000 cfs. The exceedance probability is obtained by reading horizontally across from the y-axis until the data points are reached, and then reading vertically down.

The peak discharge for the Issaquah Creek, WA, February 1996 event was 2,420 cfs, According to this exceedance probability chart, this event had an annual exceedance probability of approximately 20 percent. Since exceedance probability is the inverse of recurrence interval, this was a 5-year event.

Users can also use the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center – Statistical Software Package (HEC-SSP) to generate exceedance probability charts. This freeware program can be downloaded from http://www.hec.usace.army.mil/software/hec-ssp/. The advantage of HEC-SSP is that it includes an option to upload the annual peaks through a Microsoft Excel file, meaning estimated/unpublished peaks can be added by hand. The disadvantage is that it is more complicated than PeakFQ and may require engineering expertise and judgment.
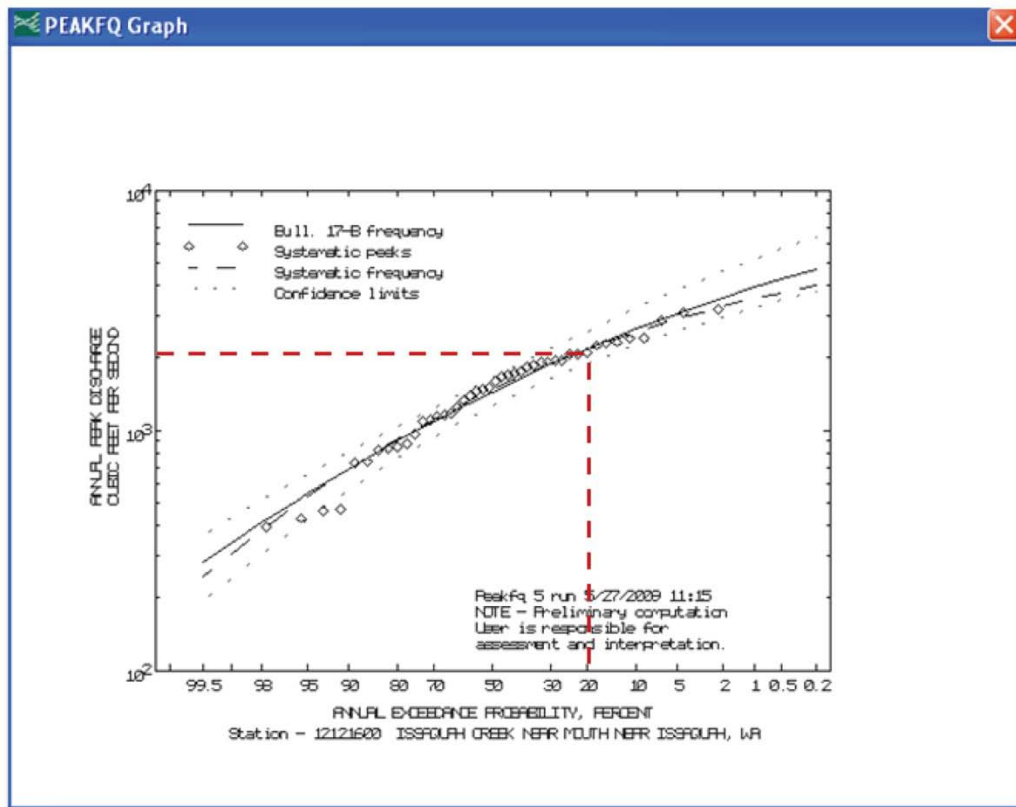
Figure 2.2: Example of an exceedance probability chart

2.1.2.4   Calculating Peak Daily Discharges Using Mean Daily Discharges

Users should be aware of the limitations of the process described in Sections 2.2.1.1 to 2.2.1.3. There is an approximate 6-month lag time for the annual peak discharges published by USGS (i.e., an annual peak for 2010 would not be published until mid-2011). If the event occurred recently and there is no published peak for that event, the mean daily discharge will need to be scaled up using a daily mean-to-maximum ratio as shown below.

If the event of interest was not the peak for that year or if the peak has not yet been published, mean daily discharges will need to be retrieved and adjusted using a ratio to determine the peak daily discharge of the event. The peak daily discharge would then be used to find the exceedance probability on the exceedance probability chart (Figure 2.2).

Example: Issaquah Creek, WA

Find the recurrence interval of the event that occurred on April 24, 1996. This event will not register as the annual maximum for 1996 because the February event was much larger. Therefore, the peak daily discharge must be used to determine the exceedance probability.

Approach:

Obtain the mean daily discharge for the event as follows.

1.   Select the checkbox for the appropriate gage.

2. Leave all other fields blank and scroll down to the <u>Retrieve USGS Surface-Water Daily Data for Selected Sites</u> section. Under *Retrieve data for* select that data range option and type in the appropriate range.

3. The event of interest is known to have occurred in the second half of the month of April (see below where a data range of 1996-04-15 to 1996-04-30 is entered). Choose *Table of data* under output options and click *Submit*.

Retrieve USGS Surface-Water Daily Data for Selected Sites
Choose one of the following options for displaying data for the sites meeting the criteria above:

☑ Retrieve data for:
　○ the previous ___ days (1 - 55555) **OR**
　⊙ for the date range: First date: 1996-04-15 Last date: 1996-04-30　(1859-04-04 through 2011-05-11)

Output Options:
　○ ☑ Graphs of data　--　☐ use arithmetic Y-axis for streamflow
　○ ☑ Graphs of data with long-term statistics　--　☐ use arithmetic Y-axis for streamflow
　○ ☑ Graphs of data without long-term statistics　--　☐ use arithmetic Y-axis for streamflow
　○ ☑ Graphs of data with field measurements　--　☐ use arithmetic Y-axis for streamflow
　⊙ ☑ Table of data
　○ ☑ Tab-separated data YYYY-MM-DD ▾　Save to file　▾ *

　* Save compressed files with a .gz file extension.

[Submit]　[Reset]　[Help]

4. Find the mean daily discharge in the table.

Date	Dis-charge, ft3/s (Mean)	Gage height, feet (Mean)
04/15/1996	50 A	5.21 A
04/16/1996	95 A	5.54 A
04/17/1996	69 A	5.37 A
04/18/1996	68 A	5.36 A
04/19/1996	67 A	5.35 A
04/20/1996	62 A	5.31 A
04/21/1996	54 A	5.25 A
04/22/1996	59 A	5.28 A
04/23/1996	192 A	6.06 A
04/24/1996	209 A	6.14 A
04/25/1996	145 A	5.83 A
04/26/1996	134 A	5.77 A
04/27/1996	106 A	5.61 A
04/28/1996	85 A	5.48 A
04/29/1996	72 A	5.39 A
04/30/1996	64 A	5.33 A

5. Repeat Steps 2 and 3 to determine the mean daily discharge corresponding to the annual peak event that occurred in February.

Date	Discharge, ft3/s (Mean)	Gage height, feet (Mean)
02/01/1996	109 [A]	4.45 [A]
02/02/1996	100 [A]	4.39 [A]
02/03/1996	96 [A]	4.36 [A]
02/04/1996	118 [A]	4.52 [A]
02/05/1996	227 [A]	5.15 [A]
02/06/1996	588 [A]	6.93 [A]
02/07/1996	804 [A]	7.86 [A]
02/08/1996	1,870 [A]	11.29 [A]
02/09/1996	1,790 [A]	10.99 [A]
02/10/1996	950 [A]	8.25 [A]
02/11/1996	625 [A]	6.95 [A]
02/12/1996	453 [A]	6.18 [A]
02/13/1996	349 [A]	5.68 [A]
02/14/1996	294 [A]	5.39 [A]
02/15/1996	257 [A]	5.19 [A]

6. Estimate the peak daily discharge by multiplying the mean daily discharge by the mean-to-peak ratio (Equation 1).

$$\text{Equation 1} \qquad Q_{max}=Q_{avg}A_{max}/A_{avg}$$

where: Q_{max} is the peak daily discharge for the event of interest

Q_{avg} is the mean daily discharge for the event of interest

A_{max} is the annual peak discharge for that year

A_{avg} is the mean daily discharge corresponding to the annual peak discharge for that year

The peak daily discharge for the April event is calculated as follows:

$Q_{max}=(209)(2,420)/(1,870)=270$ cfs

Example Results

The exceedance probability of the event is then found using the exceedance probability chart created by PeakFQ in Section 2.2.1.3. Using the data in Figure 2.3, the exceedance probability of the April event is 99.5 percent. The inverse of 99.5 percent is 1; therefore, the recurrence interval for the April event is 1 year.
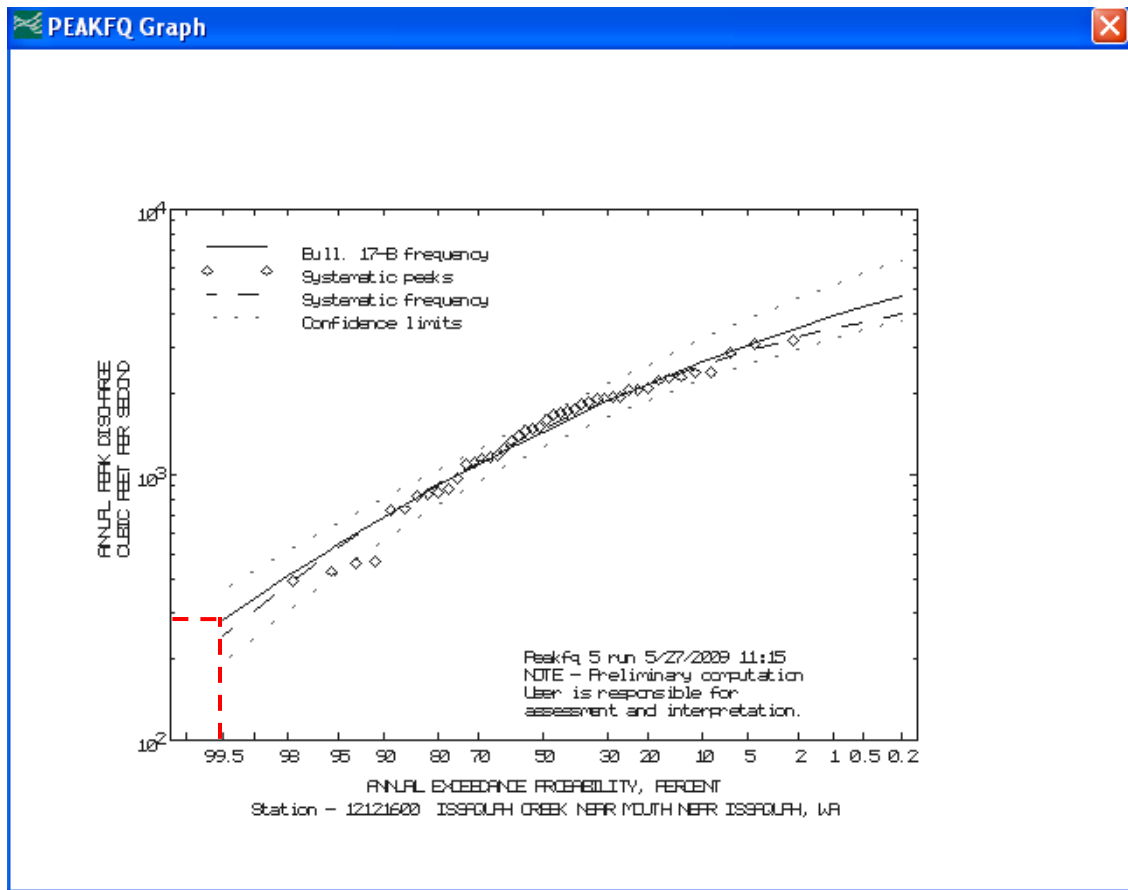
Figure 2.3: Find exceedance probability of April event

2.1.3   Adjusting Analysis Duration

When the flood recurrence interval of a hazard event is unknown, it can be estimated using an unknown frequency calculator integrated in the DFA module; required inputs to the calculator are damage values, event years, and year built or analysis duration. An analysis duration value can be used in lieu of the year built if it is unknown or the project area has experienced significant changes. For example, a project includes a bridge that was reconstructed for larger carrying capacity long ago, and the town does not know exactly when the bridge was built and has experienced flooding recent years. It is acceptable to use the analysis duration rather than the year built for the unknown frequency calculator. The *analysis duration* is defined as the number of years that records of damage, loss, or hazard level (e.g., flood elevation, wind speed) are observed for more than 10 years. For structures that are more than 10 years old, the analysis duration is typically the age of the structure. For structures that are less than 10 years old or when a change in local flow conditions occurred less than 10 years earlier, the analysis duration is 10 years.

When local flow conditions have changed significantly during the life of a structure, it may be appropriate to adjust the analysis duration. To address this situation, an alternate means of determining the analysis duration has been established, and the analysis duration value may be adjusted in the DFA module. For results from user-entered analysis duration in a grant

subapplication, acceptable documentation of a significant change in flow conditions must be included in the subapplication to support the adjustment of the analysis duration. If the user can satisfy this requirement, the analysis duration can be assumed to begin on the date the change first occurred if the analysis duration exceeds 10 years.

2.1.3.1   Acceptable Documentation

Acceptable documentation for a change in local flow conditions to support the adjustment of the analysis duration includes:

- A current and old FIS showing the before and after changes in local flow conditions

- A Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR) documenting the change in flow conditions

- An H&H study that accounts for the change in local flow conditions

- A letter on community letterhead from an official knowledgeable about the changes in local flow conditions (e.g., city engineer, local floodplain manager); see Figure 2.4

- Aerial photographs of the project area before and after the change in the watershed (see Figure 2.5)

- Other photographs showing development in the vicinity of the mitigation area with documentation of when the development occurred

Figure 2.4 is a sample letter documenting the change in local flow conditions for a fictitious flooding source. The sample letter explains the drainage project that caused the changes in local flow conditions, including the year of construction, as well as documentation of the water surface elevations at the project location before and after the flow change. The letter is provided by a local official familiar with the hydrology and hydraulics in the area.

Department of Public Works

January 1, 2011

Mr. John Smith
Florida Division of Emergency Management

Subject: PDM-PJ-00-FL-2011-01
                Property Acquisition
                FEMA Region

Dear Mr. Smith,

This letter concerns the acquisition of 1234 Lake Drive in Jacksonville, FL. The following paragraphs provide additional information on the USACE Flood Creek study, changes in the hydrology and hydraulics of the watershed, and updated water surface elevations for various design storm events.

In 1995, the USACE realigned 5000' of existing channel on Flood Creek from 1st Street to 10th Street. This project was designed to provide protection from the 5-year storm event. Additionally, significant development in the area began in the 1990's, leading to an increase in impervious area.

A hydrology and hydraulics study, the USACE Flood Creek study, was performed in 2005 to update the data in the effective Flood Insurance study. The new study includes updated hydrologic information based on 2005 landuse parameters and hydraulics updates including the realignment of Flood Creek. The following table compares the water surface elevations from the effective FIS dated June 1, 1980 and the 2005 USACE Flood Creek study.

Table 1. Comparison of Water Surface Elevations at 1234 Lake Drive

Profile	10-year WSEL (ft)	25-year WSEL (ft)	50-year WSEL (ft)	100-year WSEL (ft)
Effective FIS	1.5	2.7	3.4	5.3
USACE study	1.8	3.1	4.0	5.9

The comparison of the study results indicates that a significant change in the watershed occurred in 1995, causing a substantial increase in water surface elevations at the project location. Therefore, the City proposes to use the period from 1995 to 2011, 17 years, as the analysis duration for the purpose of analyzing the cost-effectiveness of the mitigation project.

Sincerely,
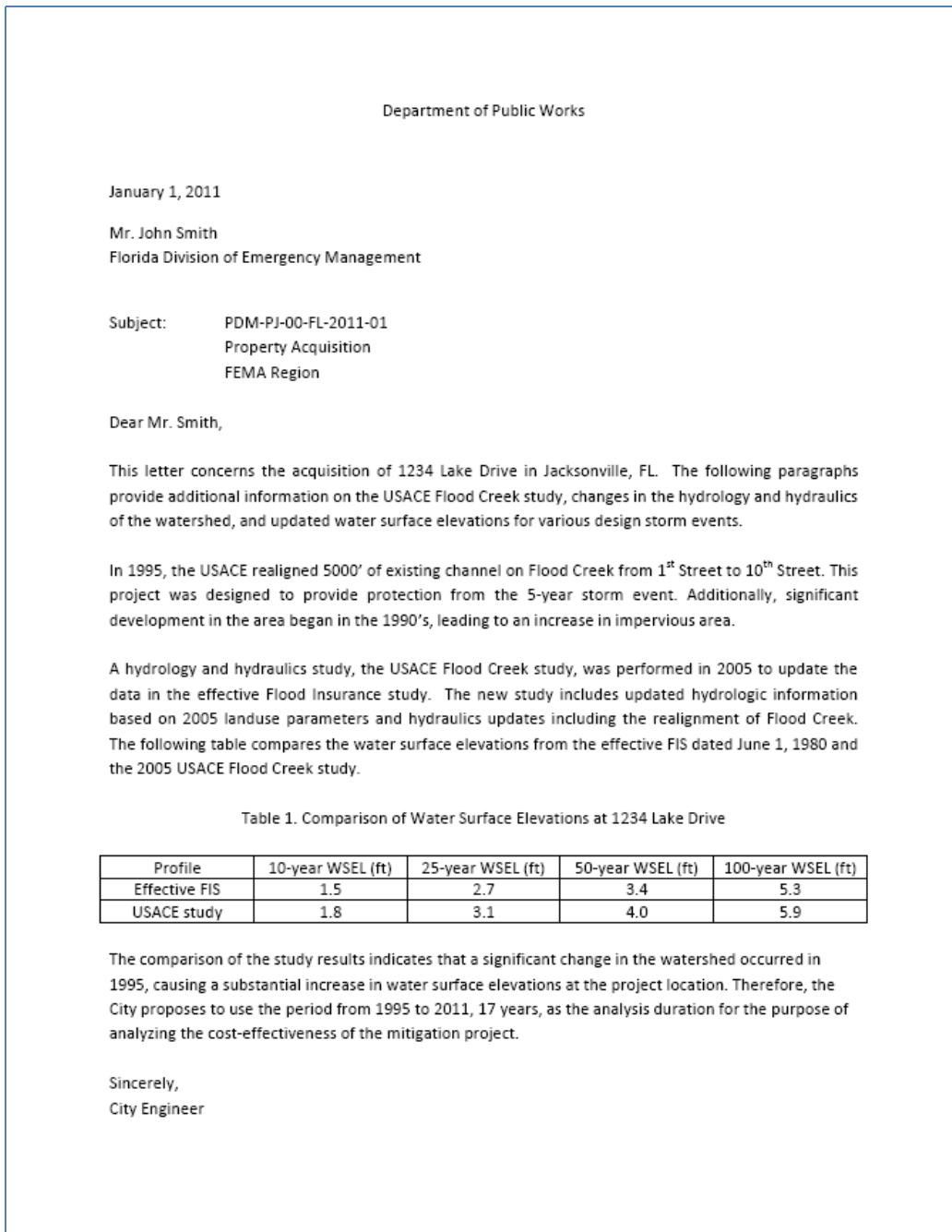City Engineer

Figure 2.4: Sample letter documenting a change in local flow conditions

Figure 2.5 is an aerial photograph showing significant development in a rural area that could change local flow conditions. In this case, the user would need to provide the approximate year the development most significantly affected local flow conditions, as well as before- and after-development photographs.

**Figure 2.5: Sample before- and after-development photographs documenting a change in land use
(Campoli 2001)**

2.1.3.2   Entering the Analysis Duration in the DFA Module

The following example illustrates using adjusted analysis duration along with historic flood
claims data to complete a BCA using the DFA module.

Example: Residential Property at 1234 Lake Drive, Jacksonville, FL

Scope of Work

The goal of the mitigation project is to acquire the residential property at 1234 Lake Drive,
Jacksonville, FL, to remove the property from the Flood Creek Floodplain. The house, built in
1970, is a repetitive loss parcel with four reported flood claims in 15 years. The total mitigation
project cost is $150,000. This project meets the State of Florida's goal to reduce the number of
repetitive loss properties. Once the property is acquired, the City will demolish the house, and
return the property to its original state within the floodplain. A permanent open space and
conservation easement will be recorded with the title and deed to the property.

Data Provided

The following data are provided for the BCA DFA module:

1. Scope of Work (SOW) and acceptable documentation to properly justify the appropriate
    values entered in the DFA module.

2. Flood claims data from 1996, 1999, 2001, and 2004, as shown in the table below.

**Example of flood claims data from 1996, 1999, 2001 and 2004. The data includes the dates the
floods occurred, the dollar amounts paid for building damages claims, and the dollar amounts
paid for building contents claims.**

Damage Year	Date of Loss	Building Damage Paid	Building Contents Paid
1996	6/13/1996	$20,000	$15,000
1999	5/31/1999	$29,000	$15,000
2001	7/4/2001	$24,000	$15,000
2004	6/24/2004	$35,000	$15,000

3. BCA analysis year (2011) and year the structure was built.

4. Project useful life of 100 years (FEMA standard value for acquisition).

5. Integrated unknown frequency calculator to calculate the recurrence intervals.

Approach

1. Create a structure for the property at 1234 Lake Drive and associate the structure with a project.

2. Select *Damage-Frequency Assessment* on the Mitigation Information screen. Click *Save and Continue*.

3. Choose *Flood* as the hazard and *Acquisition* as the mitigation type. Select *Historical Damages* as the basis for damages. Enter "4" for the number of damage events and "0" for the number of events that have known recurrence intervals. Click *Save and Continue*.

4. On the Cost Estimation Info screen, enter the *Project Useful Life* as 100 years and the *Mitigation Project Cost* as $150,000. Click *Save and Continue*.

5. Using the information from Figure 2.4, enter "17" for the *User Input Analysis Duration* on the Historic Damages-Before Mitigation screen to override the computed analysis duration.

Save and Go Back							Save and Continue

HISTORIC DAMAGES BEFORE MITIGATION

Analysis year *	2011	Analysis Duration	42	Utilities ($/day)	$ 0.00
Year Built *	1970	User Input Analysis Duration	17	Buildings ($/day)	$ 0.00
				Roads/Bridges ($/day)	$ 0.00

HISTORIC DAMAGES BEFORE MITIGATION *
To add columns, click the column icon at the upper left corner of the table. All damages are in dollars.

Damage Yea	Recurrence Interval	Contents ($)	Bulidings ($)	Are damages in current dollars?	Total	Total Inflat
1996		$15,000	$20,000	No	$35,000	$56,008
1999		$15,000	$29,000	No	$44,000	$65,308
2001		$15,000	$24,000	No	$39,000	$55,373
2004		$15,000	$35,000	No	$50,000	$63,200
*				No	$0	$0

View Damages

6. Click on the *View Damages* button to view the recurrence intervals determined by the unknown frequency calculator.

Expected Annual Damages

Expected Annual Damages - Before Mitigation

Recurrence Interval (yr)	Total Damages And Losses	Annualized Damages And Losses
5.2	$55,690	$6,793
12.7	$64,245	$5,059

Total Annualized Damages

	$11,852.00

Close

2.1.4   Using National Flood Insurance Program BureauNet Data

BureauNet is a web-based database that contains information on all National Flood Insurance Program (NFIP) policies and claims since 1978. The database enables users to retrieve data by searching for specific flood insurance policy numbers, property addresses, or owners. These data are often useful for determining historic damages to specific buildings resulting from a specific flood event. The damage values obtained from BureauNet can be used in the DFA module as historical damages.

2.1.4.1   Access to BureauNet

While access to BureauNet is limited to specific FEMA personnel and various individuals at the State level who are granted access based on a need-to-know basis, subapplicants may be able to request BureauNet data through the following contacts:

- *Designated State Floodplain Manager*. A current list of State Floodplain Managers is available on the Association of State Floodplain Managers (ASFPM) Web site at: http://www.floods.org/index.asp?menuID=274&firstlevelmenuID=185&siteID=1. The designated State Floodplain Manager may have direct access to BureauNet.

- *State Hazard Mitigation Officer*. A current list of SHMOs is available on the FEMA Web site at: http://www.fema.gov/about/contact/shmo.shtm. The SHMO may have direct access to BureauNet or can submit a request to the appropriate FEMA Region to obtain BureauNet data.

If local or State contacts do not have access to BureauNet data, the FEMA Regional office can be contacted. Users should initiate contact with one of the above-listed individuals well in advance of their deadline to ensure adequate time for personnel to retrieve the data. To facilitate the process, a list of property addresses, insurance policy numbers or owner name(s) at the time of the flood event (if known), and flood event dates should be provided to the contact person.

2.1.4.2   Flood Insurance Coverage

Flood insurance protects two types of insurable property: building and contents. *Building coverage* insures the building, and *contents coverage* insures possessions. Neither building nor contents coverage insures the land.

Building coverage includes:

- The insured building and its foundation
- The electrical and plumbing system
- Central air conditioning equipment, furnaces, and water heaters
- Above-ground appliances and other items of property that are considered part of the building (i.e., refrigerators, stoves, and dishwashers)
- Permanently installed cupboards, bookcases, cabinets, paneling, and wallpaper
- Elevator equipment, fire sprinkler systems, light fixtures, plumbing fixtures
- Permanently installed carpeting or wood flooring over unfinished flooring

Contents coverage includes:

- Clothing, furniture, and electronic equipment

- Curtains

- Portable and window air conditioners

- Portable microwaves and dishwashers

- Carpeting that is not already included in property coverage

- Clothing washers and dryers

Flood insurance is available to homeowners, renters, condominium owners/renters, and commercial owners/renters. All policy forms include coverage for buildings and contents; the building coverage is required, while contents coverage is optional. Therefore, if contents coverage was not purchased by the policy owner, flood insurance claims may list claim payments only for building claims.

2.1.4.3   Estimated Flood Damages versus Actual Claims Payments

Following a damaging flood event, the owner begins the claims process by identifying the damaged versus the undamaged property and works with the adjuster to prepare a damage estimate. A payment is issued once proof of loss is provided and the insurance claim is substantiated. It is important to note that estimated flood damages may differ from the actual claims payment. In many cases, the actual claims payment may be lower than the estimated flood damages because certain items were not covered under building or contents coverage. As described in the following subsections, the actual claims payments should be used for inputting into the DFA module, not the estimated flood damages.

2.1.4.4   Interpreting BureauNet Claims Data

Figure 2.6 shows a sample flood claim for a fictitious single-family residence that sustained damage during a 1974 flood. The relevant items to use in the DFA module are annotated and discussed below.

Flood Claim 1: 1974

Date as of
02/17/2010 ①

| | | Policy Number | 123456789 | | Dt of Loss | 06/13/1974 | ③ |

Company Nam   ABC Flood
Open Date
Reopen Date

Close Date
Clm Orig Date ②

Claim Status   Closed
Clm last Date

Pol Exp Dat
Org Const date   08/12/1960

Org new Bus Dt
As of Date

Pol Eff Date
End Eff Date
Alteration Dt

Community

Insureds Name   John Doe
Address 1   100 E. 3rd
St   State   Maryland   Zip Code 21043 ④

Address 2
City   Bakersville
Addr key

Program Regular
Condo Ind   Non-Condo
Occupancy   Single
family
Post FIRM   N
Course Const   N
State Owned   N
Elev Bldg   N
Small Business   N
Flood Proof   N
Principal Res
Loss Factor

Rate Method
Condo Units   1
Building Type   2 Floors
Flood Zone   AE
Base Flood
Low Floor
Elev Diff
Water Depth
Duration Water
Repl Cost Ind
Dur Inhabit

Policy Status   Active
Catastrophe Nbr
Bsmt/ Enclosure
Loc Contents
Dis Assistance
Cause of Loss   Flood
Foundation Typ
Wall Structure
Wall Surface
Replace Cost
Improvement Ind

Cont Ded (Pol)   250
Cont Ded (Clm)   250

Bldg Ded (Pol)   250
Bldg Ded (Clm)   250

Cont Coverage
Cont Value

ICC Covg

Bldg Coverage
Bldg Val-ACV
Bldg Val-RCV
Bldg Dmg-ACV
Bldg Dmg-RCV   ⑤
Bldg Paid   16,750.00
Bldg Recovery
Bldg Reserves
Bldg Final Pay

Cont Dmg - ACV
Cont Dmg - RCV
Cont Paid   15,000.00   ⑥

Cont Recovery
Cont Reserves
Cont Final Pay

ICC Paid
ICC Recovery
ICC Reserve
ICC Final Pay

CWOP Building
CWOP Contents
CWOP ICC
Content Remove
Salvage Amt
Allocated LAE

Mobile Remove
Subrogation

Flood Expense

Allocated ICC

Longitude
GEO Result

Latitude
GEO Census

Figure 2.6: Sample NFIP flood claim

Note	**Explanation**

① The *Date as of* field indicates the date that the flood claim was retrieved from the BureauNet database.

② The *Policy Number* field indicates the insurance policy number under which the current policy was written.

③ The *Dt of Loss* field indicates the date when the flood damage occurred. This date should be consistent with the damage year for the events the user includes in the DFA module.

④ This section shows the insured's name (owner) and the property address.

⑤ This section shows information relevant to building coverage and claims payments.

- *RCV* stands for Replacement Cost Value and is the cost to replace the damaged property.
- *ACV* stands for Actual Cash Value and is the RCV at the time of loss minus physical depreciation.
- *Bldg Val* is the value of the building, both in terms of RCV and ACV.
- *Bldg Dmg* is the estimated cost of building damages on the date of loss, both in terms of RCV and ACV.
- *Bldg Paid* is the actual claim amount paid out to the owner. If an amount is specified under *Bldg Final Pay*, this is the final building claim amount paid out to the owner due to various adjustments.
- For purposes of obtaining historical damages for the DFA module, it is appropriate to select the maximum value among the *Bldg Dmg-ACV*, *Bldg Dmg-RCV*, *Bldg Paid*, and *Bldg Final Pay*.

⑥ This section shows information relevant to building content coverage and claims payments.

- *RCV* and *ACV* are defined similarly as in Note #5.
- *Cont Dmg* is the estimated cost of building contents damages on the date of loss, both in terms of RCV and ACV.
- *Cont Paid* is the actual claim amount paid out to the owner. If an amount is specified under *Cont Final Pay*, this is the final contents claim amount paid out to the owner due to various adjustments.

For purposes of obtaining damages for the DFA module, it is appropriate to select the maximum value among *Cont Dmg-ACV*, *Cont Dmg-RCV*, *Cont Paid*, and *Cont Final Pay*.

2.1.4.5   How to Use NFIP BureauNet Data with the DFA Module

BureauNet flood claims data can be used to complete a BCA using the DFA module with historical damages. The following example of an acquisition project illustrates this concept by providing step-by-step directions for:

- Entering building and contents loss data from BureauNet for several events into the DFA module

- Using the integrated unknown frequency calculator to assign recurrence intervals for the events

- Completing the DFA module to determine whether the acquisition project is cost effective (BCR is greater than or equal to 1.0)

- Estimating additional losses in the form of displacement costs using DDFs from the Flood module

- Entering the displacement costs back into the DFA module to complete the analysis.

The first step is to obtain BureauNet NFIP Flood Claims data. For this example, losses were obtained for the years 1974, 1985, 2001, and 2004, as shown in Table 1.

Table 1: Example of BureauNet NFIP Claims Data

Damage Year	Date of Loss	Building Damage Paid	Building Contents Paid
1974	6/13/1974	$16,750.00	$15,000.00
1985	5/31/1985	$29,490.00	$15,000.00
2001	7/4/2001	$23,750.00	$10,000.00
2004	6/24/2004	$34,765.00	$17,000.00

2.1.4.6   Enter NFIP Data into DFA Module and Determine BCR

1. Once BureauNet data has been organized into the above table, create a project and a structure for the property and associate the structure with the project. Select *Damage-Frequency Assessment* on the Mitigation Information screen. Click *Save and Continue*.

2. On the <u>Hazard and Mitigation Info</u> screen, choose flood as the *Hazard* and acquisition as the *Mitigation Type*. Select *Historical Damages* as the basis for damages. Enter "4" for the number of damage events and "0" for the number of events with known recurrence intervals. Click *Save and Continue*.

3. On the <u>Cost Estimation Info</u> screen enter the *Project Useful Life* as 100 years (for acquisition) and enter the *Mitigation Project Cost*. For this example a mitigation project cost of $139,500 is used. Click *Save and Continue*.

4. On the <u>Type of Services</u> screen, select *Not Applicable*. Click *Save and Continue*.

5. On the <u>Historic Damages Before Mitigation</u> screen, enter the year built (in this example, 1960). Add a column for "Building $" damages in the *Historic Damages Before Mitigation* table. Use the BureauNet flood claims data to enter the damage years and building damages

under the *Building $* column. Allow the tool to inflate these values by selecting "No" to the question "Are damages in current day dollars?" for each damage year. Make note of the *Total Inflated* building damage values for use in subsequent calculations in a separate table. Click *Save and Continue*.

6. Add a column for "Contents $" damages. Use the BureauNet flood claims data to enter the building contents damages for each damage year into this column. The tool will use the integrated unknown frequency calculator to compute the recurrence intervals. The calculated recurrence intervals can be viewed by clicking on the *View Damages* button at the bottom of the *Historic Damages Before Mitigation* table. Make note of the recurrence intervals.

7. Close the Expected Annual Damages screen and click *Save and Continue*.

8. In the <u>Damages After Mitigation</u> screen, it is not necessary to input any information since the project involves an acquisition and there are no residual damages because the building will no longer exist. Click *Save and Continue*.

9. The structure BCR can be viewed on the <u>Summary of Benefits</u> screen. For this example, the BCR is 0.74, indicating that this project is not cost effective when considering only building and contents damages. Section 2.1.4.7 describes how to maximize benefits in the DFA module.

2.1.4.7   Using the BCA Full Data Flood Module to Maximize Benefits in the DFA Module

Benefits in DFA module can be maximized by incorporating displacement costs obtained from DDFs in the BCA Full Data Flood module. In the example described in Section 2.1.4.5, inputting damages for building and building contents resulted in a BCR of 0.74, which is less than 1.0. The following example builds off the BCA completed in Section 2.1.4.6 and illustrates how benefits can be maximized to bring the BCR to above 1.0.

1. Compile the data from the DFA module (Table 2). The table should include data from the DFA module including the recurrence intervals determined from the unknown frequency calculator (Step 6 of Section 2.1.4.6) and the inflated building damages (Step 5 of Section 2.1.4.6). It should also include the total building replacement value (BRV); for this example, use $105,600. Add a column for the percent building damage. Divide the inflated building damages by the total BRV for each event to determine the percent building damage. This data will be used to find displacement costs associated with damages from the flood claims.

Table 2: Example Data Obtained from DFA Module

RIs from Unknown Frequency Calculator	Inflated Building Damages from DFA	Total BRV	Percent Building Damage
13	$33,015	$105,600	31.3%
17.3	$43,023	$105,600	40.7%
26	$61,897	$105,600	58.6%
85.3	$73,012	$105,600	69.1%

2. Return to the <u>BCA Software Project</u> screen and enter *Flood* as a new mitigation type on the <u>Mitigation Information</u> screen. Double-click on the *Flood* row to begin the Flood module.

3. Select *Acquisition* as the flood mitigation project type. Click *Save and Continue*.

4. On the Full Flood-Questionna ire screen indicate that an FIS is available. Answer "Yes" to all of the follow-up questions on this screen.

   Note that the only information needed from this module is the DDFs and therefore other information is not important. The Flood module will not actually be used to evaluate the cost-effectiveness of the project. Click *Save and Continue*.

5. Skip input on the Flood Data Source screen, since the data are for information only and do not affect calculation of the BCR or the DDFs. Click *Save and Continue*.

6. Enter data on the Structure Information screen. This data affects which DDF is selected. Enter the total size of the building, BRV, and residential structure details. For this example the residential building has two stories, no basement, a building size of 1,600 square feet (sf), and a BRV of $66 per sf. The *Demolition damage threshold* should be entered as "50%" for a reside ntial building. Click *Save and Continue*.

7. On the <u>Residential Structure Information</u> screen select "USACE Generic" from the DDF
    drop-down menu. The values for the DDFs will auto-populate. Select the default button for
    Displacement Costs and *Building Contents*.

8. On the <u>Depth Damage Functions</u> screen read the results on the *Building* tab. The USACE
    generic DDF for residential buildings shows building damages based on flood depth. A
    building DDF is an estimate of damage that will occur to a building based on the depth of
    flooding and as a percentage of the BRV. For this example, the DDF calculates the estimated
    building damages associated with 1 foot of flooding as $16,051 (or 15.2 percent of the BRV).
    At 9 feet of flooding the structure would be more than 50 percent damaged; buildings that are

50 percent damaged are considered a total loss, and the building damage would be equal to the BRV.

Depth Damage Functions *

Building | Contents | Displacement | Loss Of Function

Flood Depth (ft)	Before Mitigation (Pct)	Before Mitigation ($)	After Mitigation (Pct)	After Mitigation ($)
-2.0	0.0%	$0	0.0%	$0
-1.0	3.0%	$3,168	0.0%	$0
0.0	9.3%	$9,821	0.0%	$0
1.0	15.2%	$16,051	0.0%	$0
2.0	20.9%	$22,070	0.0%	$0
3.0	26.3%	$27,773	0.0%	$0
4.0	31.4%	$33,158	0.0%	$0
5.0	36.2%	$38,227	0.0%	$0
6.0	40.7%	$42,979	0.0%	$0
7.0	44.9%	$47,414	0.0%	$0
8.0	48.8%	$51,533	0.0%	$0
9.0	52.4%	$105,600	0.0%	$0
10.0	55.7%	$105,600	0.0%	$0
11.0	58.7%	$105,600	0.0%	$0
12.0	61.4%	$105,600	0.0%	$0
13.0	63.8%	$105,600	0.0%	$0
14.0	65.9%	$105,600	0.0%	$0
15.0	67.7%	$105,600	0.0%	$0
16.0	69.2%	$105,600	0.0%	$0

9. Read the results on the *Displacement* tab of the Depth Damage Functions screen. The curve for the USACE Generic DDF shows displacement time in days and cost in relation to the flood depth. In this example, displacement for a 1-foot flood depth is 45 days and over a year for a 9-foot flood depth.

Depth Damage Functions *

Building | Contents | **Displacement** | Loss Of Function

Flood Depth (ft)	Before Mitigation (Days)	Before Mitigation ($)	After Mitigation (Days)	After Mitigation ($)
-2.0	0.0	$0	0.0	$0
-1.0	0.0	$0	0.0	$0
0.0	0.0	$0	0.0	$0
1.0	45.0	$3,409	0.0	$0
2.0	90.0	$6,817	0.0	$0
3.0	135.0	$10,226	0.0	$0
4.0	180.0	$13,635	0.0	$0
5.0	225.0	$17,043	0.0	$0
6.0	270.0	$20,452	0.0	$0
7.0	315.0	$23,861	0.0	$0
8.0	360.0	$27,269	0.0	$0
9.0	405.0	$30,678	0.0	$0
10.0	450.0	$34,087	0.0	$0
11.0	495.0	$37,495	0.0	$0
12.0	540.0	$40,904	0.0	$0
13.0	585.0	$44,313	0.0	$0
14.0	630.0	$47,721	0.0	$0
15.0	675.0	$51,130	0.0	$0
16.0	720.0	$54,539	0.0	$0

10. Using the percent building damage value calculated in Table 2 (see Step 1), find the closest percentage listed in the DDF under the *Building* tab for each of the known recurrence intervals. In this example, use the 13-year flooding event on Table 2. Per Table 2, the percent building damage for the 13-year flooding event is 31.3%. Compare this to the DDF *Building* tab data. The closest DDF building damage value is 31.4%, which corresponds to a 4.0-foot flood depth. Repeat this step to determine the flood depth for each of the percent building damage values shown in Table 2 (interpolate for damage percentages between the listed values).

Flood Depth (ft)	Before Mitigation (Pct)	Before Mitigation ($)	After Mitigation (Pct)	After Mitigation ($)
-2.0	0.0%	$0	0.0%	$0
-1.0	3.0%	$3,168	0.0%	$0
0.0	9.3%	$9,821	0.0%	$0
1.0	15.2%	$16,051	0.0%	$0
2.0	20.9%	$22,070	0.0%	$0
3.0	26.3%	$27,773	0.0%	$0
4.0	31.4%	$33,158	0.0%	$0
5.0	36.2%	$38,227	0.0%	$0
6.0	40.7%	$42,979	0.0%	$0
7.0	44.9%	$47,414	0.0%	$0
8.0	48.8%	$51,533	0.0%	$0
9.0	52.4%	$105,600	0.0%	$0
10.0	55.7%	$105,600	0.0%	$0
11.0	58.7%	$105,600	0.0%	$0
12.0	61.4%	$105,600	0.0%	$0
13.0	63.8%	$105,600	0.0%	$0
14.0	65.9%	$105,600	0.0%	$0
15.0	67.7%	$105,600	0.0%	$0
16.0	69.2%	$105,600	0.0%	$0

11. Use the DDF flood depths to find the before-mitigation displacement cost by selecting the *Displacement* tab on the Depth Damage Functions screen. A 4.0-foot flood depth results in 180 displacement days, which corresponds to a displacement value of $13,635. Keep track of the displacement values by updating Table 2 (refer to Table 3).

Table 3: Example of Approximate Displacement Cost Determination

From Table 2 (Step 1)				From Steps 2 - 11		
RIs from Unknown Frequency Calculator	Inflated Building Damages from DFA	Total BRV	Percent Building Damage	Closest Percentage Listed in the DDF	Associated Flood Depth (ft)	Approximate Displacement Cost
13	$33,015	$105,600	31.3%	31.4%	4.0	$13,635
17.3	$43,023	$105,600	40.7%	40.7%	6.0	$20,452
26	$61,897	$105,600	58.6%	58.7%	11.0	$37,495
85.3	$73,012	$105,600	69.1%	69.2%	16.0	$54,539

12. Return to the Project Structures Summary screen and create a new structure within the project to enter the approximate displacement costs corresponding to the four recurrence intervals. The software will add the benefits from the two structures to determine an aggregated BCR.

The user should understand that this new structure does not represent an actual physical building. It must be created because two different analysis methods were used to evaluate losses. The structure containing building and contents losses was analyzed using historical damages and "0" for the number of events that had known recurrence intervals. The software manually inflated the building and contents losses to present-day values. For the structure containing displacement costs, the values will be entered as expected damages with known recurrence intervals. The values are already present-day values and if they were entered simply as a new column in the first structure, they would have been inflated incorrectly.

Name	△	Structure T	Benefits	Costs	BCR	Addres	City	State	County	Zip
100 E 3rd Street		Building	$102,824	$139,500	0.74		Bakerville	Maryland	Frederick	21043
displacement values		Building	$0	$0	0.00		Bakerville	Maryland	Frederick	21043

PROJECT NAME: DFA Alternative Case Study   PROJECT BCR: 0.74
PROJECT STRUCTURES SUMMARY

13. Within the new structure, select *DFA* on the <u>Mitigation Information</u> screen.

14. On the <u>Hazard and Mitigation Information</u> screen, the hazard and mitigation type remain unchanged. The user should select *Expected Damages* as the basis for the damages and enter "4" for the estimated damage events and "4" for the events with known recurrence intervals. Click *Save and Continue*.

15. On the <u>Cost Estimation Info</u> screen, enter the *Project Useful Life (years)* as 100 years. Since the software will aggregate both costs and benefits from the two structures, enter the *Mitigation Project Cost* as "$0" to avoid double-counting project costs. The mitigation project cost was already entered in the first structure using the DFA module. Click *Save and Continue*.

16. On the <u>Type of Services</u> screen, select *Not Applicable*. Click *Save and Continue*.

17. On the <u>Expected Damages Before Mitigation</u> screen, enter the four recurrence intervals shown in Table 3 (Step 11). Enter the *Year Built*. Add a column for "approximate displacement costs" under *Expected Damages Before Mitigation*, and enter the displacement cost values from Table 3. Click *Save and Continue*.

18. Since this example is an acquisition project, there are no expected displacement costs after mitigation because the building will no longer exist. Click *Save and Continue*.

19. The additional displacement cost benefits can be viewed as *Benefits Minus Costs* on the Summary of Benefits screen.

20. Review the Project Inventory screen for the aggregated benefits from both structures that make up the project and the resulting project BCR. Note that inclusion of the displacement costs calculated through use of the Flood module result in an increase of the project BCR from 0.74 (refer to Step 9 of Section 2.1.4.6) to 1.01.

2.2   Working with the Flood Module

The Flood module analyzes proposed mitigation projects based on flood hazard conditions of riverine and coastal flood sources before and after implementing mitigation. The Flood module is designed for evaluating individual buildings within a project. The Flood module is recommended for BCAs when users have detailed flood hazard information and structural data. The following describes the essential flood hazard and structural data required to use the Flood module.

Flood Hazard Information
- FIRM with cross-sections and a flood profile
- H&H study (if the project area is unmapped or outside the SFHA)
- Streambed elevation (riverine flood hazard analysis only)
- Stillwater elevations (coastal flood hazard analysis only)
- BFE
- Flood elevations for the 10-, 50-, 100-, and 500-year recurrence intervals
- Flood discharge rates for the 10-, 50-, 100- and 500-year recurrence intervals (riverine flood hazard analysis only)

Structural Information

- FFE for a building affected by riverine flooding or located in a Coastal A Zone

- FFEs of the lowest floor member for buildings located in coastal Zone V

- Building type and size of building

- BRV

- Foundation type

Over the past several National Technical Review periods, hundreds of flood mitigation grant subapplications have been submitted for the HMA funding and about 40 to 50 percent failed to demonstrate cost effectiveness. Common errors made in the BCA using the Flood module include selecting an incorrect building type and size when there is a partially finished basement, using incorrect FFEs, and over-estimating the loss of public services. This section includes information on how counting damages for finished and unfinished basements, using topographic maps with 2-foot contour intervals to estimate FFEs, incorporating loss of services for critical public facilities, and how to calculate other losses and non-traditional benefits.

2.2.1   Counting Damages for Finished or Unfinished Basement

For the purposes of conducting a BCA and applying the various DDFs available in the Flood module, the basement is considered finished if there are documented features similar to the main (first) floor, including finished flooring (e.g., carpeting, tile, vinyl, wood), finished walls (e.g., framing, insulation, drywall, paneling), finished ceilings, finished electrical features (e.g., outlets, lighting), fully heated/air conditioned, and typical household contents.

Acceptable documentation for a finished basement includes: photographs, tax assessments, building permits, as-built construction plans, copy of a current insurance policy, and/or detailed real estate appraisals. If the basement is fully finished, the elevation of the basement floor may be used as the FFE in the BCA Flood module; in this case, the DDFs in the Flood module must be adjusted to reflect the elevation that flood water can enter the building.

2.2.1.1   Unfinished Basements

For a building with an unfinished basement, the FFE is for the first habitable floor, even if the cellar, crawlspace, or basement has window wells or door(s) (see Figure 2.7). The building type selected for the *Residential Structure Details* on the BCA Structure Information screen will be either *one-story with a basement* or *two-story with a basement*. The building, contents, and displacement DDFs are used without adjustment. In addition, the term "first habitable floor" refers to the first habitable floor above the basement, regardless if the basement is finished or unfinished.
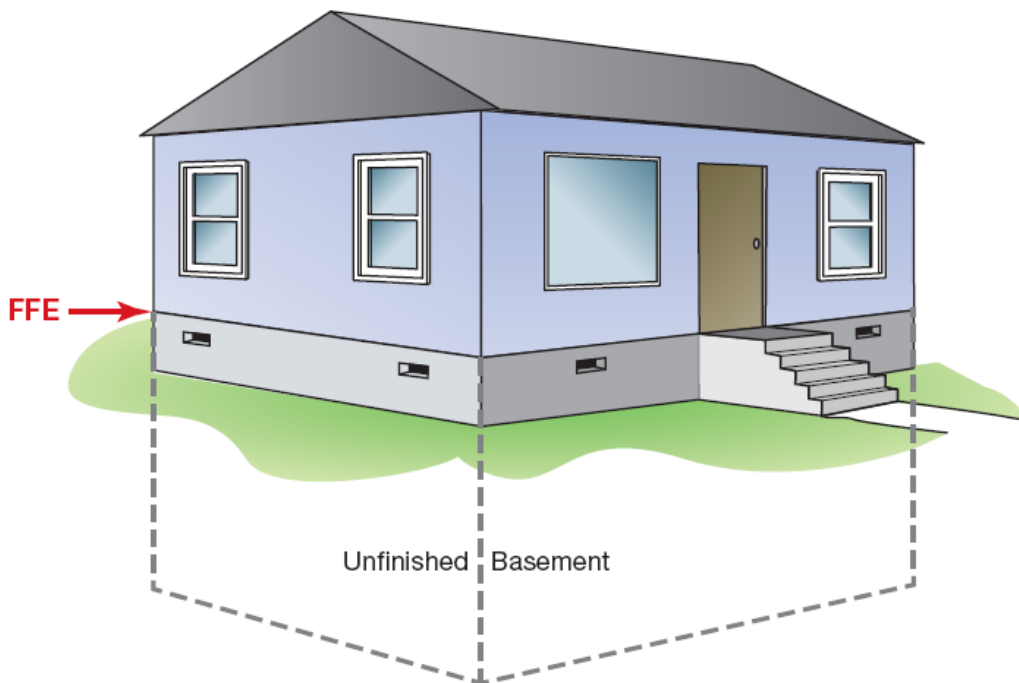
Figure 2.7: FFE of an unfinished basement

The following example illustrates how to calculate damages for an unfinished basement using the Flood module. Assume a one-story house with an unfinished basement. The basement floor elevation = 980.00 feet National Geodetic Vertical Datum (NGVD) and the first habitable floor = 988.00 feet NGVD.

1. Enter 988.00 feet NGVD as the FFE.

2. Enter the square footage. The square footage reported for the structure size should be equal to the square footage of the first habitable floor.

3. Select the DDF. The DDF used by the Flood module is based on answers to the software questionnaire. If the user selects a DDF other than the default or a DDF from the Library, adequate documentation must be provided in the subapplication materials to support the user-entered adjustments.

2.2.1.2   Finished Basement with Window Elevation Above or Below the Adjacent Ground Elevation

For buildings with a finished basement with the bottom of the window elevations either above or below the adjacent ground elevation, the FFE is the top of the basement floor elevation (Figure 2.8).
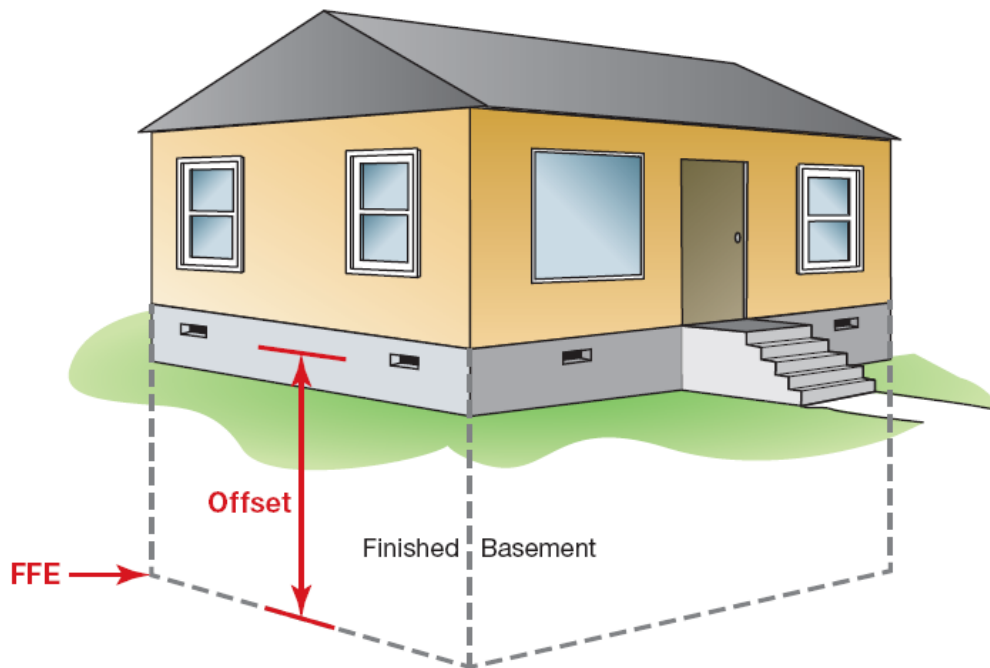
Figure 2.8: FFE and DDF offset for finished basement

The finished basement is considered the first floor. For buildings with finished basements, if the DDFs are not set to zero below the entry point for flood water, the Flood module will greatly overestimate damages and the BCR because it will calculate damages for several feet of flood water at elevations that cannot enter the building. Users should perform the following actions to prevent this error.

1. Users should select *two or more stories <u>without</u> basement* as the building type under *Residential Structure Details* on the <u>BCA Structure Information</u> screen.

2. Set the building, contents, and displacement DDFs to zero below the lowest opening. This can be performed in two ways:

    a) The recommended method is as follows: select the *Library* button on the <u>Residential Structure Information</u> screen under *Depth Damage Function Type*. Select the DDF, and then enter "0" for flood depths below the entry point in the *Before Mitigation User Entered (Pct)* DDF column for the *Building, Contents and Displacement* tabs (recommended method for whole foot offsets)

    b) An alternative is as follows: select the *Custom* button on the <u>Residential Structure Information</u> screen under *Depth Damage Function Type*. Enter the default DDF values in the *Before Mitigation User Entered* DDF column starting at the flood depth that flood water enters the building. DDF values for non-integer flood depths must be interpolated.

After adjusting the DDF, calculation of damages will begin at the elevation of either the lowest window opening (for basement windows above grade) or at ground elevation adjacent to the <u>top</u> of a below-grade window (i.e., top of the window well).

The following example illustrates how to calculate damages for a finished basement using the Flood module. Using Figure 2.8 as an illustration of a one-story house with a finished basement, assume the basement floor elevation = 980.00 feet NGVD, the first habitable floor elevation = 988.00 feet NGVD, and the bottom of the basement window = 985.00 feet NGVD. Assume that the window is not in a window well and the ground adjacent to the window is below the bottom of the window.

1. Set the building type as *two or more stories without a basement*.

2. Set the FFE as 980.00 feet NGVD. The basement floor elevation is used as the FFE.

3. Enter the square footage. The square footage should equal the square footage of the first habitable floor plus the square footage of the basement. Note the unit cost BRV (in $/sf) may need to be adjusted when the area of the finished basement is included so that the combined BRV for the basement and the first habitable floor is not greater than the total BRV for a one-story house with a finished basement (i.e., the BRV using this method cannot exceed the total actual BRV).

4. Adjust the DDFs for building, contents, and displacement so there are zero damages from elevation 980.00 through 984.00 feet NGVD. Table 4 (below) shows the adjustments that would be made for building damage in this example. Similar DDF adjustment would be made for contents (in percent) and displacement (in days). Notice the DDFs show damages starting at the +5.0-foot mark (i.e., the offset), or at elevation 985.00 feet NGVD for all three categories.

PROJECT: Smithville Elevation, STRUCTURE: Smithville Home
MITIGATION TYPE: Flood - Acquisition

Save and Go Back

RESIDENTIAL STRUCTURE INFORMATION

Depth Damage Function Type *
○ Default ● Library ○ Custom

Select Depth Damage Function (DDF) *
USACE Generic (Default)

Displacement Costs
● Default ($1.44/sf/month) $ 2,592.00
OR
○ User-entered ($/month) $ 0.00
One-Time displacement costs ($) $ 0.00

Building Contents
● Default (100% BRV) $ 171,000.0
OR
○ User-entered ($) $ 0.00

Loss of Rent
Rent ($/month) $ 0.00

Utilities or other contents in the crawlspace (if any) $ 0.00

Depth Damage Functions *

Building | Contents | Displacement | Loss Of Function

Flood Depth (ft)	Before Mitigation (Pct)	Before Mitigation User Entered (Pct)	Before Mitigation ($)	After Mitigation (Pct)	After Mitigation User Entered (Pct)	After Mitigation ($)
-2.0	0.0%	0.0%	$0	0.0%		$0
-1.0	3.0%	0.0%	$0	0.0%		$0
0.0	9.3%	0.0%	$0	0.0%		$0
1.0	15.2%	0.0%	$0	0.0%		$0
2.0	20.9%	0.0%	$0	0.0%		$0
3.0	26.3%	0.0%	$0	0.0%		$0
4.0	31.4%	0.0%	$0	0.0%		$0
5.0	36.2%		$61,902	0.0%		$0
6.0	40.7%		$69,597	0.0%		$0
7.0	44.9%		$76,779	0.0%		$0
8.0	48.8%		$83,448	0.0%		$0
9.0	52.4%		$171,000	0.0%		$0
10.0	55.7%		$171,000	0.0%		$0
11.0	58.7%		$171,000	0.0%		$0
12.0	61.4%		$171,000	0.0%		$0
13.0	63.8%		$171,000	0.0%		$0
14.0	65.9%		$171,000	0.0%		$0
15.0	67.7%		$171,000	0.0%		$0

Justification/Documentation

Table 4: Example for Residence with Two or More Stories without Basement

Flood Depth (ft)	Before Mitigation User Entered (Pct)	Before Mitigation ($) BUILDING	Before Mitigation ($) CONTENTS	Before Mitigation ($) DISPLACEMENT
-2.0	0.0%			
-1.0	0.0%			
0.0	0.0%			
1.0	0.0%			
2.0	0.0%			
3.0	0.0%			
4.0	0.0%			
5.0		$61,902	$36,423	$19,174
6.0		$69,597	$40,869	$23,008
7.0		$76,779	$44,973	$26,843
8.0		$83,448	$48,564	$30,678
9.0		$171,000	$51,813	$34,513
10.0		$171,000	$54,720	$38,347
11.0		$171,000	$57,114	$42,182

*Note: Before-mitigation percentages are different for building and contents and are represented as days of displacement. These values are not included in Table 4. Dollar values obtained are based on structural information and are only provided as an illustration-—dollar values will vary for each specific structure.

2.2.1.3   Finished Basement with Walkout or a Garage Elevation Equal to the Adjacent Ground

For a building with a finished basement that has a walkout or a garage equal to the elevation of the adjacent grade, the FFE is equal to the walkout or garage floor elevation (Figure 2.9).
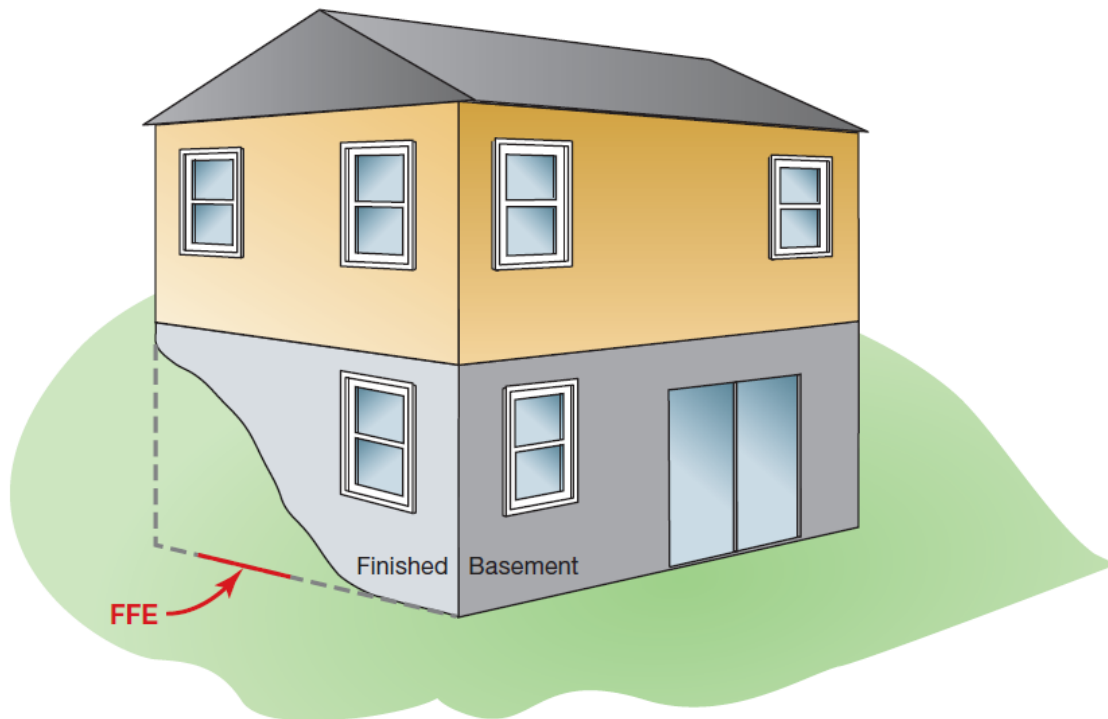

Figure 2.9: FFE for a finished walkout basement

The following example illustrates how to calculate damages for a building with a finished basement using the Flood module. Using Figure 2.9 as an illustration of a one-story house with a finished basement, assume the basement floor elevation = 980.00 feet NGVD, the walkout or garage elevation = 980.00 feet NGVD, and the adjacent ground elevation = 980.00 feet NGVD.

1. On the *Residential Structure Details* tab of the Structure Information screen, select *Two or More Stories* and click "No" to indicate the lack of a basement.

2. Do not adjust the DDFs; these are used without adjustment by the user.

3. Enter the square footage of the first habitable floor plus the square footage of the basement. Note the unit cost BRV (in $/sf) may need to be adjusted when the area of the finished basement is included so that the combined BRV for the basement and the first habitable floor is not greater than the total BRV for a one-story house with a finished basement (i.e., the BRV using this method cannot exceed the total actual BRV).

2.2.1.4   Partially Finished Basement

The recommended approach for partially finished basements is to conduct two BCA runs by dividing the house into two buildings. For a building with a partially finished basement (i.e., at least part of the basement is fully finished), the first FFE is equal to the top of the basement floor elevation with the appropriate adjustment described in Sections 2.2.1.2 or 2.2.1.3, and the second FFE is equal to the first habitable floor. One building is a "two or more stories without a basement" and the other is either a "one- or two-story with a basement."

The following example illustrates how to calculate damages for a building with a partially finished basement using the Flood module. Assume a 1,000 sf house is one story with a full (1,000 sf) basement, where 60 percent (600 sf) of the basement is fully finished and 40 percent (400 sf) is unfinished. Assume a BRV of $120/sf for a total BRV of $120,000 (this includes adjustments for both the finished and unfinished basement).

1. Create two structures within a project for the Flood module. Begin with the BCA module run for the first building, which is the part of the house with the finished basement and the first floor area directly above it (Building Type A in Figure 2.10).

Building Type **A**. Two or more story *without* a basement
Building Type **B**. Two or more story *with* a basement

Figure 2.10: Partial finished basement, divided into two structures

a) On the Structure Information screen, select the *Two or More Stories* for the residential building type and click "No" to indicate the lack of a basement.

b) Enter data for the *Total size of building (sf)*. The area is the 60 percent of the first floor area plus the finished basement area: (600 sf) + (600 sf) = 1,200 sf.

c) Enter a $60/sf BRV for the total finished areas. This sets the BRV for building A to 60 percent ($72,000) of the total BRV ($120,000 for Building Types A and B).

d) Enter the FFE as the top of the finished basement floor.

e) Adjust the DDFs (described in Section 2.2.1.2) to account for the elevation that flood water can enter the house, if applicable.

2. The second BCA module run will be for the second building representing the unfinished basement and the first floor area directly above it (Building Type B in Figure 2.10).

   a) On the <u>Structure Information</u> screen, select building type as *One Story* and click "Yes" to indicate the presence of a basement.

   b) Enter data for the *Total size of building (sf)*. The area is 40 percent of the first floor area: (400 sf).

   c) Enter the FFE as the top of the first habitable floor (in this case, the above-grade floor).

   d) Enter the adjusted BRV of $120/sf. This sets the BRV for building B to 40 percent ($48,000) of the total BRV of $120,000. Note that the sum of the BRV of Building Type A and Building Type B cannot exceed the total actual BRV.

   e) The DDFs should not be adjusted.

   f) Enter the project cost. Do not enter the full project cost for both structures because that would double-count the project cost. Enter the total project cost for one structure and zero cost for the other.

Discussion

For situations with vehicle damage or other contents damage (such as home improvement equipment or agricultural equipment) due to flooding of a garage, refer to Section 2.2.3.

Occasionally flood damage can occur in a finished basement and the homeowner elects to leave the basement unrecovered from recent flooding events. Subsequent floods may still affect the

basement, but a lower percentage of building, contents, and displacement damages will occur. In analyzing the initial flood damage to the finished basement, documentation must be provided that indicates the basement was finished prior to the initial flooding event. Documentation includes tax assessments, building permits, as-built construction plans, contractor receipts for finishing the basement and/or estimates for repairing the basement, or a copy of a previous insurance policy or real estate appraisals, as well as photographs of the previously finished basement and the current basement condition. It is unacceptable to claim the basement was previously finished without acceptable documentation. All flood damage events subsequent to the initial event that changed the basement from finished to unfinished should be analyzed as if the basement is unfinished.

2.2.2 Using Topographic Maps with 2-Foot Contour Intervals to Estimate First Floor Elevations

The FFE of a building is required for using the Flood module, but is often difficult for users to obtain since a FEMA elevation certificate or an FFE from a licensed surveyor may be expensive. This section provides an acceptable alternate method for estimating the FFE using detailed topographic maps. In order to use this approach, the topographic map must be current and have a maximum contour interval of 2 feet. Using a current topographic map ensures that the most recent topography for the project area is used to determine the FFE. Especially in steep locations, the elevations shown on an outdated map may differ significantly from a current map if the plot was graded to construct a building foundation. A maximum 2-foot contour interval ensures that the data are detailed enough such that it does not introduce a significant amount of error when estimating the FFE.

While 2-foot contour interval maps are less common than larger interval maps, possible sources include USGS mapping, State Geological Survey mapping, engineering drawings, light detection and ranging (LiDAR) data, or City and County geographic information system (GIS) departments.

2.2.2.1 Topographic Map Features

A topographic map provides approximate ground elevations typically in the form of contour lines. The following are key features of every topographic map:

Title: The title of the map should indicate that the map is applicable to the proposed project area.

Grid: The grid system of a map, usually in the form of latitude/longitude coordinates or Township/Range information, can be used along with the north arrow and features identified on the legend to find the approximate building location and orientation. If the latitude and longitude coordinates of the building are unknown, several online resources can be used to estimate the coordinates based on the building address.

Legend: The legend identifies key features on the map, which may include property boundaries, water sources, roads, etc.

Datum: The vertical datum (e.g., NGVD and North American Vertical Datum [NAVD]) represents the reference elevation used to create the map. When comparing water surface elevations and FFEs, care must be taken to identify the datum in case the elevations from

one datum need to be converted to another. Online resources are available to convert elevations if the latitude and longitude coordinates are known.

Figure 2.11 shows an example of a topographic map available from the Lake County, IL GIS Department (Lake County 2011) with the above features identified.
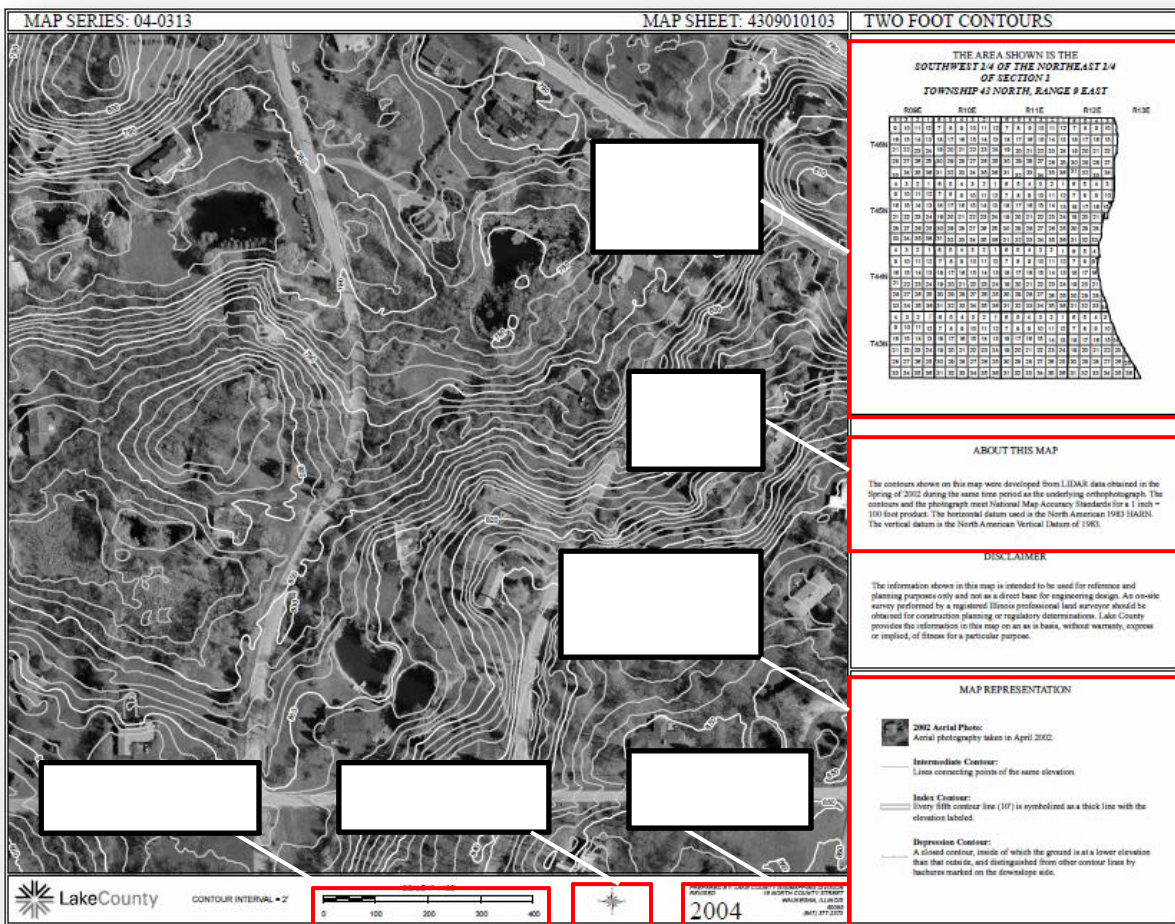

Figure 2.11: Example of topographic map (Lake County 2011)

The map scale provides the relationship between horizontal distance on the map and the actual distance on the ground. Figure 2.12 shows two ways that the scale could be represented. The first is a ratio scale. The ratio scale on this map is 1:24,000. This indicates that 1 inch on the map represents 24,000 inches (0.38 miles) on the ground. Below the ratio scale is a graphic scale representing distance in miles, feet, and kilometers. The space between the 0 and the 1 mile mark on the scale is the distance a user must measure on the map to identify a 1 mile distance.
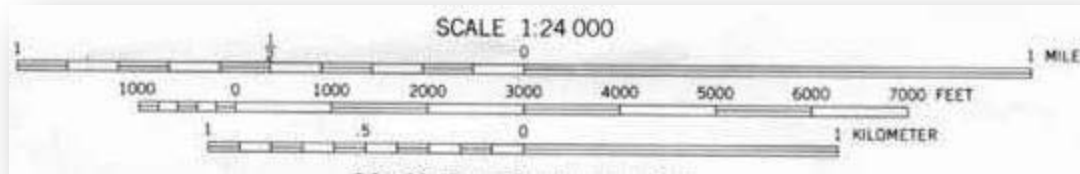
Figure 2.12: Example of a map scale representations

2.2.2.2   Contour Interval

Contour lines connect a series of points of equal elevation and are used to illustrate relief on a map. Contour lines that are close together represent steeper terrain, whereas contour lines that are far apart represent flatter terrain. A contour interval is the elevation change between two consecutive contour lines. For example, the topographic map in Figure 2.13 shows a contour line labeled as 700 feet, followed by four unlabeled lines, and a fifth line labeled as 800 feet. This indicates that the elevation change between each contour line, or the contour interval, is 20 feet. Note that this map cannot be used to determine the FFE because the maximum contour interval is greater than 2 feet.
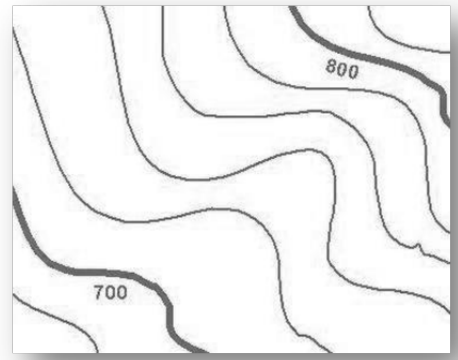
Figure 2.13: Example of contour lines and contour interval

2.2.2.3   Estimating the First Floor Elevation

Step 1: Determine Building Location

Figure 2.14 shows an example topographic map that shows two buildings. Using a combination of map features such as roads and aerial imagery, the two buildings were determined to lie in the southeast portion of the map.
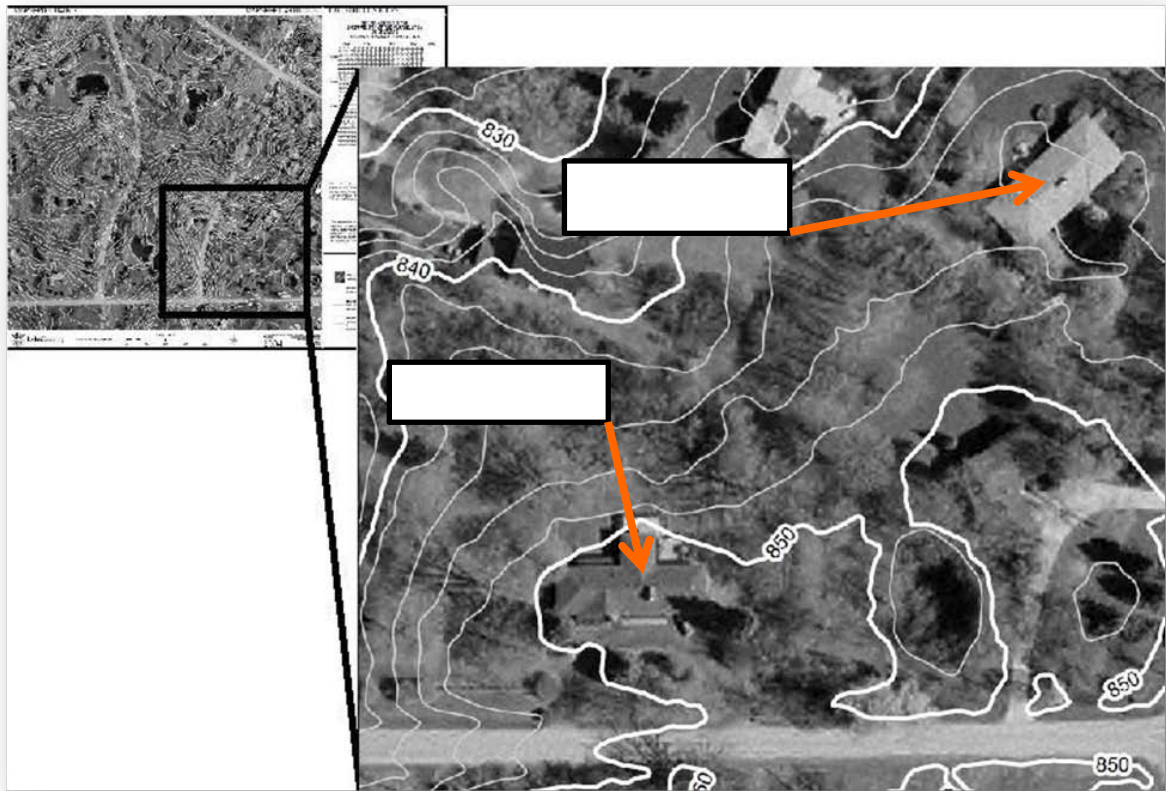
Figure 2.14: Determining building location on a topographic map

Step 2: Outline Building Footprint and Specify Location Used For Estimating the FFE

In Figure 2.15, the livable area of both buildings is outlined in green and the exact location on the building used to estimate the FFE is indicated with arrows. Indicating the exact location is important for Step 3. When possible, an easily identifiable feature (e.g., a corner, entryway, etc.) located directly on a contour line should be chosen as it will avoid the extra step of interpolating the ground elevation between contour lines, and may increase the accuracy of the estimate.

Figure 2.15: Outline the building footprint (shown in green)

Step 3: Determine Ground Elevation at Indicated Location of Building

For Building 1, the ground elevation at the eastern corner (indicated with a red arrow) is approximately 846 feet since the corner lies on the 846-foot contour line. If the north corner were used instead, the ground elevation would need to be linearly interpolated. Since the north corner lies approximately halfway between the 844-foot and 846-foot contour lines, the ground elevation for that corner would be interpolated as 845 feet.

For Building 2, the corner indicated with a blue arrow lies directly on the 850- foot contour. Therefore, the ground elevation is estimated as 850 feet.

Step 4: Estimate Height from Ground to Top of First Floor Slab

The difference in height between the ground and the top of the first floor must be measured at the indicated location in order to have the most accurate estimation of the FFE. This height may be determined by counting bricks, estimating the height from a photograph, or directly measuring

the height in the field. Photographs must be provided as documentation with the subapplication regardless of the method used.

Figure 2.16 shows that, although the first floor is itself level, the height used to determine the FFE from the ground may differ depending on the exact location used for estimating the ground elevation. In this figure, the left side of the building is located at the highest adjacent grade (HAG) elevation, while the right side is located at the lowest adjacent grade (LAG) elevation.
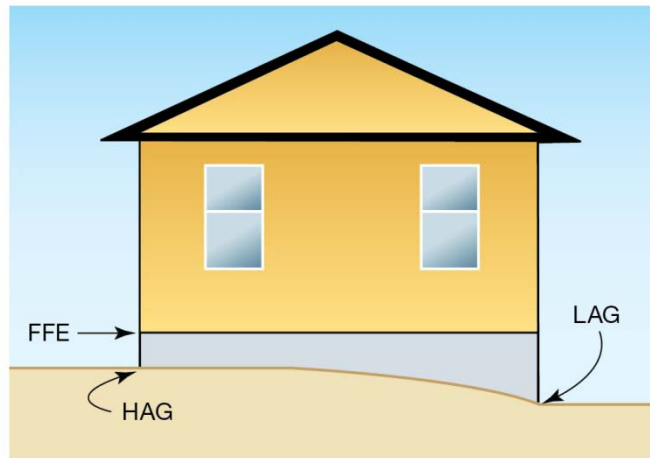
Figure 2.16: Measure the height of the first floor slab

As shown in Figure 2.17, the height of the top of the first floor slab for Building 1 is 1.4 feet from the ground. For Building 2, the height to the top of the first floor slab is 1.5 feet from the ground.
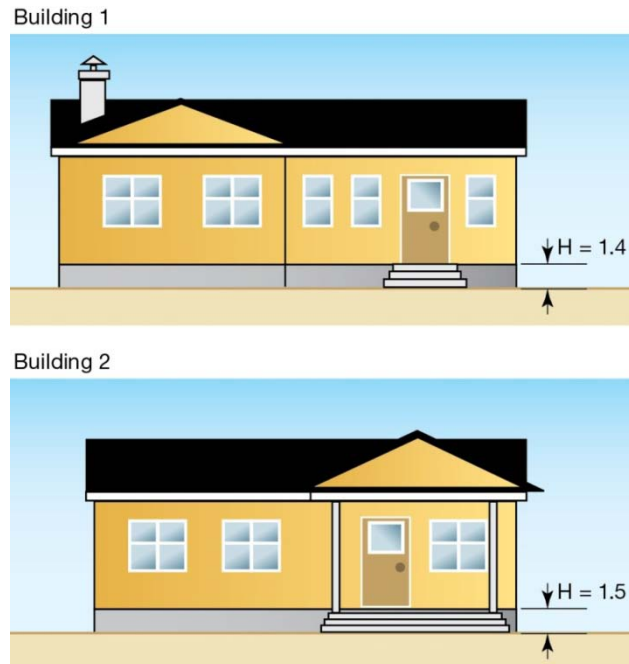
Figure 2.17: Measure the height to the first floor slab

Step 5: Estimate FFE by Adding Height (Step 4) to Ground Elevation (Step 3)

In this example, for Building 1, the ground elevation (846 feet) plus the height to the first floor slab (1.4 feet) yields an FFE of 847.4 feet.

For Building 2, the ground elevation (850 feet) plus the height to the first floor slab (1.5 feet) yields an FFE of 851.5 feet.

2.2.3 Other Losses and Non-Traditional Benefits

The most common benefit categories for mitigation projects include building damage, contents damage, displacement costs, and loss of function impacts. For this Guidance, these benefit categories will be termed "traditional." There may be situations where a project is not cost-effective when only traditional benefits are considered and therefore, it may be advantageous to include other non-traditional benefits in the BCA. Non-traditional benefits may include the avoidance of damage to landscaping equipment, agricultural equipment, outbuildings and vehicles. Non-traditional benefits can only be included for acquisition and flood control mitigation projects.

The following sections identify the types of non-traditional benefits that can be claimed in the Flood module and provide information on how to enter these benefits into the module.

2.2.3.1   *Damage Estimates for Other Losses and Non-Traditional Benefits*

The following methods, listed in order of accuracy and preference, can be used to determine damage estimates for other losses and non-traditional benefits:

- **Method 1. Use historical damage data that affected a structure proposed for mitigation.**

   For example, a home proposed for acquisition may have documented historical records of damage to a lawnmower and a wood shed that occurred at a flood depth of 2 feet (relative to the FFE of the house). Automotive damage may only be included when there is documented historical damage and only for acquisition projects. These damages can be entered in the BCA Flood module at a depth of 2 feet, as shown in Section 2.2.3.3. The software will add these user-entered damages to the benefit calculations.

- **Method 2. Use historical damage data from structures that are not part of a proposed mitigation project to estimate damages for structures proposed for mitigation**.

   In this case, the proposed project should have similar structures, equipment, risk, etc. to those affected by the historical damages. For example, the home used in the previous example could be used to estimate damages for a wood shed and a lawnmower at another home provided that the wood shed is similar in materials and construction and the lawnmower is a similar type and stored in a similar location.

- **Method 3. Use professional judgment to estimate damages that are not based on historical data.**

   Manufacturers of agricultural equipment can make credible estimates for equipment damage at varying flood depths. It is important to note that this method cannot be used to estimate vehicle damages.

Credible decision making is critical to making the most accurate damage estimates possible, especially for Methods 2 and 3. In addition, all data and assumptions must be supported by appropriate documentation. Considerations in making accurate damage estimates include, but are not limited to the following:

- Are flood depths or recurrence intervals (RI) for historical data similar to flood depths and RIs used for a damage estimate? For example, historical outbuilding damages for a 500-year flood should not be used as an estimate of damage for a 200-year flood.

- Is equipment for the historical data similar to the equipment used for the estimate? For example, a gas lawnmower may have damage that differs from an electric lawnmower.

- Is the hazard condition for the historical damage similar to the hazard condition being mitigated? For example, a flash flood or flooding from a substandard flood wall may differ from riverine flooding in terms of flows or the ability to move equipment out of reach prior to being subject to flooding.

- Was a manufacturer, mechanic or supplier for equipment consulted for estimating flood damage?

- Consider the mitigation project. Elevating a structure will not reduce damages to equipment located in garages and outbuildings; however, acquiring a property or reducing flood risk through flood control projects will.

2.2.3.2   Acceptable Documentation for Non-Traditional Benefits

Acceptable documentation for equipment, outbuildings, and vehicle damage may include:

- Insurance claims for landscaping and agricultural equipment damage

- Estimates of flood depths and damages based on a homeowner affidavit

- Photographs of damaged equipment, outbuildings and vehicles and the associated value of the damaged items

- FEMA Project Worksheets/Damage Survey Reports

- Records of historical vehicle damages, including repair invoices and insurance claims

- High water marks, which can be used to determine the flood depth at which damages occurred

- RIs based on FIS, H&H study, stream or tide gauge data, insurance records (if used to assess how often events occurred), and newspaper accounts citing credible sources such as a public agency

Figures 2.18, 2.19, and 2.20 show examples of acceptable documentation to support estimates for non-traditional benefits. The cost to repair or replace the item may be used in the BCA. Figure 2.18 shows a sample insurance claim documenting landscaping equipment and outdoor property damage. These damages should be associated with a flood depth or the RI of the flood event. Figure 2.19 shows a sample of repair records for vehicle damage. Only actual historical vehicle damages may be included in the BCA (i.e., Method 1 and 2 only). Figure 2.20 shows a sample photograph documenting vehicle damage due to flooding. Photographs may be used to estimate the depth of flooding associated with the vehicle damage and can be used in conjunction with documentation such as shown in Figure 2.19 to estimate damages.

Flood Insurance Company				Date of Loss:	10/10/2007
Customer: John Smith				Claim Number:	1234C567
	100 Main St. Louisville, KY			Policy Number:	436846411

Item	Qty	Description	Cost to Repair/Replace	Depreciation	Settlement Amount
1	1	Chair	$3200	$2600	$600
2	1	Lawn Mower	$480	$390	$90
3	1	Weed Whacker	$65	$10	$55
4	1	Hedge Trimmer	$75	$40	$35
5	1	Skill Saw	$125	$30	$95
Totals			$3,945	$3,070	$875

Figure 2.18: Sample insurance claim documenting damage

Invoice		Date: 10/15/2007
Car Repair Inc. Louisville, KY		
Bill to:	John Smith 1 Main St. Louisville, KY	

Quantity	Description	Amount
1	Flood damage repair to drivetrain, cleaning and body repair	$2,500

Figure 2.19: Sample of repair records for vehicle damage

Figure 2.20: Sample photograph showing vehicle damage due to flooding

2.2.3.3   *Entering Non-Traditional Benefits Data in the BCA Flood Module*

The following example illustrates how to enter non-traditional benefits in the Flood module. Non-traditional benefits can be entered in other BCA modules, but these applications are not described in this document.

Example: Acquisition of Residential Property in Louisville, KY

Scope of Work

The goal of the mitigation project is to acquire the residential property located at 100 Main Street, Louisville, KY in order to remove the property from the Flood Creek floodplain. The house, built in 1970, is located in the FEMA-delineated flood Zone AE, and has an FFE of 13 feet NGVD. The adjacent streambed elevation is 10 feet NGVD. The home is one story on a slab foundation without a basement. The total project cost is $150,000. The house is 1000 sf and has a BRV of $100/sf. In a 2007 flood event with an unknown RI, in addition to building, contents, and displacement damage, the property sustained damage to landscaping equipment and outdoor property. The City proposes to acquire and demolish the house, and convert the property to a permanent open space and conservation easement.

Data Provided

The following data are provided for the Flood module:

1. SOW and acceptable documentation to properly justify the values entered in the Flood module

2. Water surface elevation, discharge data, and streambed elevation from the FIS as shown in Table 5.

Table 5: WSEL and discharge data for 100 Main Street, Louisville, KY from FIS

Recurrence Interval (year)	Percent Annual Chance (%)	Elevation Before Mitigation (feet)	Discharge Before Mitigation (cfs)
10	10%	14.5	120
50	2%	16.2	250
100	1%	17.1	360
500	0.2%	18.2	440

3. Insurance records for landscaping equipment, as shown in Figure 2.17 and repair records for vehicle damage, as shown in Figure 2.18 associated with flood depths, as shown in Table 6.

Table 6: Other damages associated with flood depth

Item	Damage Amount	Flood Depth (feet)
Equipment	$3,945	0
Vehicle	$2,500	1.5

The associated flood depths were estimated from photographs and homeowner estimates. The equipment was assumed to be located at the building FFE. Based on the photographs (Figure 2.20), the vehicle damages were estimated to occur at 1.5 feet of flooding.

4. Project useful life of 100 years (FEMA standard value for acquisition)

Approach

1. Create a structure for the property at 100 Main Street and associate the structure with a project.

2. Select *Flood* on the Mitigation Information screen. Click *Save and Continue*.

3. Choose *Acquisition* as the mitigation type. Click *Save and Continue*.

4. Choose *Flood Insurance Study (FIS)* as the source of flood data and answer *Yes* to the questions that appear after selecting FIS. Click *Save and Continue*.

5. On the <u>Cost Estimation Info</u> screen, enter the project useful life as 100 years and the mitigation project cost of $150,000. Click *Save and Continue*.

6. On the <u>Flood Data Source</u> screen, enter information for the Effective Date of FIS, FIRM panel number, FIRM effective date, and Community ID Number. Click Save and Continue.

   Note that this screen is informational only and will not affect BCR calculation.

7. On the Riverine Discharge and Elevation screen, enter data for the FFE, streambed elevation, and flood hazard data. Note that the red exclamation point next to the *Enter the First Floor Elevation* box prompts the user to upload justification or supporting documentation for the FFE.

   The *FEMA Elevation certificate diagram description*, *Flood Source Name*, and *Flood Profile Number* are for informational purposes only and can remain blank; they will not affect the BCR calculation. Click *Save and Continue*.

8. On the Structure Information screen enter information for the building including square footage, BRV, and structure details. Note that the red exclamation points prompt the user to upload justification or supporting documentation for the building size and BRV.

    The *Total value of building (BRV)* will be calculated automatically by the software. *Demolition damage threshold* should be left at the default 50 percent. Click *Save and Continue*.

9. On the Residential Structure Information screen, select the applicable DDF. For this example, select "default" under *Depth Damage Function Type* and "USACE Generic" under the drop-down menu for *Select Depth Damage Function*. The *Displacement Costs* and *Building Contents* should be left as "default." Click *Save and Continue*.

10. Click the button shown in screenshot to add a column on the <u>Damages Before and After Mitigation</u> screen for both vehicle damage and equipment damage.

11. Enter the damage amounts at the closest flood depths from Table 6.

12. Click *Save and Continue* twice to get to the final Summary of Benefits screen and the BCR.

SECTION THREE   WIND HAZARD MITIGATION

There are two FEMA BCA modules that can be used to determine the BCRs for projects that provide mitigation against high winds: the Hurricane Wind module and the Tornado Safe Room module.

The Hurricane Wind module is used to analyze the following building mitigation project types: window and door opening protection (shutters), load path structural retrofits, roof structural retrofits, and acquisitions. In the Hurricane Wind module, a key input is the wind hazard data which are included in the module. The default wind speed data (i.e., 3-second gust wind speeds for multiple recurrence intervals) were obtained from the FEMA Hazards U.S. Multi-Hazard (Hazus) program. The wind speed data are automatically provided based on user input of the building location, either by zip code or latitude and longitude coordinates. The user can override the default wind speeds and enter wind speed data from other sources. This section describes how to input wind speed data from the American Society of Civil Engineers (ASCE) into the Hurricane Wind module.

The Tornado Safe Room module evaluates residential and community safe room mitigation projects. The benefits in the module are based solely on providing life safety benefits for the safe room occupants. Key input parameters include the maximum occupancy and usable area of the proposed safe room. This section defines these parameters and describes how to calculate them and enter the values into the Tornado Safe Room module.

3.1   Deriving Wind Speed Data for the Hurricane Wind Module

In order to supply user-entered data for the BCA Hurricane Wind module, users first must derive wind speed data using ASCE 7-10 wind speeds (*Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10). Wind speed data from ASCE 7-10 must be entered into a spreadsheet to create a graph. The graph allows users to extract wind speeds between recurrence intervals (i.e., derive wind speeds for a 35-year event when only the 25- and 50-year wind speeds are known). The graph is used to derive a formula, which calculates the needed wind speeds for the BCA Hurricane Wind module. The methodology is applicable for all areas covered by the ASCE 7-10 wind speed maps. When applying ASCE 7-10 wind speeds, it is important to note that the mitigation project is assumed to be designed according to ASCE 7-10.

Approach
- Determine the location of the site on a map showing county boundaries
- Identify wind speeds at the project location for the following seven recurrence intervals use the following maps within ASCE 7-10:
  - Figure CC-1, 10-year MRI 3 sec gust wind speed, pages 584 and 585
  - Figure CC-2, 25-year MRI 3 sec gust wind speed, pages 586 and 587
  - Figure CC-3, 50-year MRI 3 sec gust wind speed, pages 588 and 589
  - Figure CC-4, 100-year MRI 3 sec gust wind speed, pages 590 and 591
  - Figure 26.5-1C, 300-year MRI 3 sec gust wind speed, pages 249a and 249b

> ➢ Figure 26.5-1A, 700-year MRI 3 sec gust wind speed, pages 247a and 247b

> ➢ Figure 26.5-1B, 1700-year MRI 3 sec gust wind speed, pages 248a and 248b

- ▪ Users are encouraged to verify the ASCE 7-10 wind speeds using the ATC Web site: http://atcouncil.org/windspeed/

1. In a spreadsheet, enter the wind data obtained from ASCE 7-10 for each of the supplied recurrence intervals.

2. Use the *Create Graph* spreadsheet function to select a *Scatter Graph*
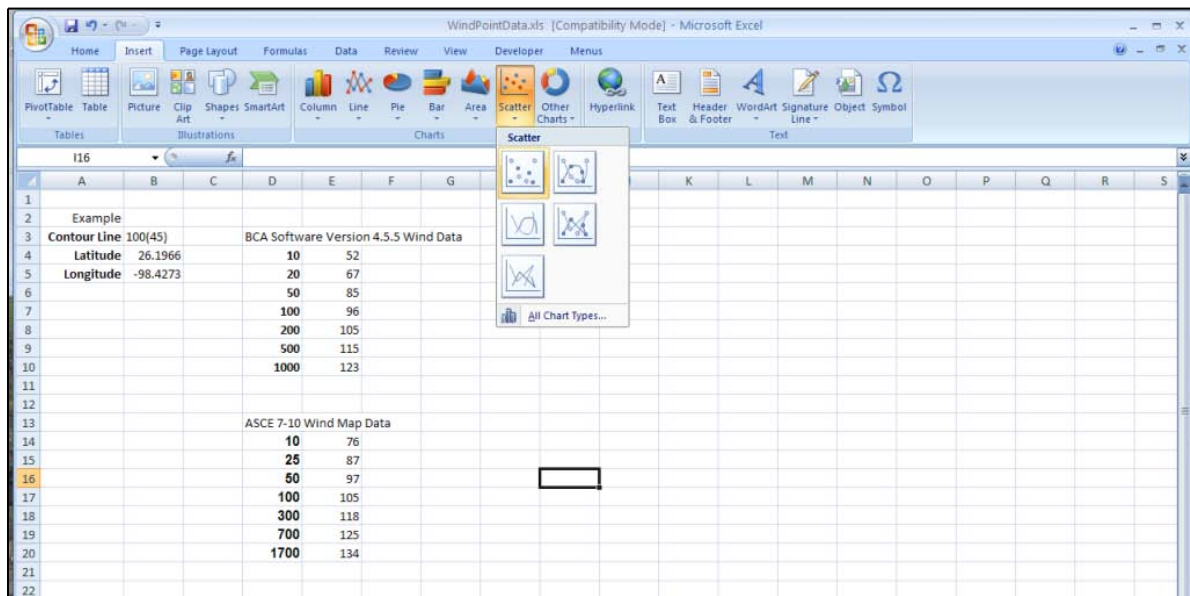
3. The software will insert a blank box. Right click the box and click *Select Data*
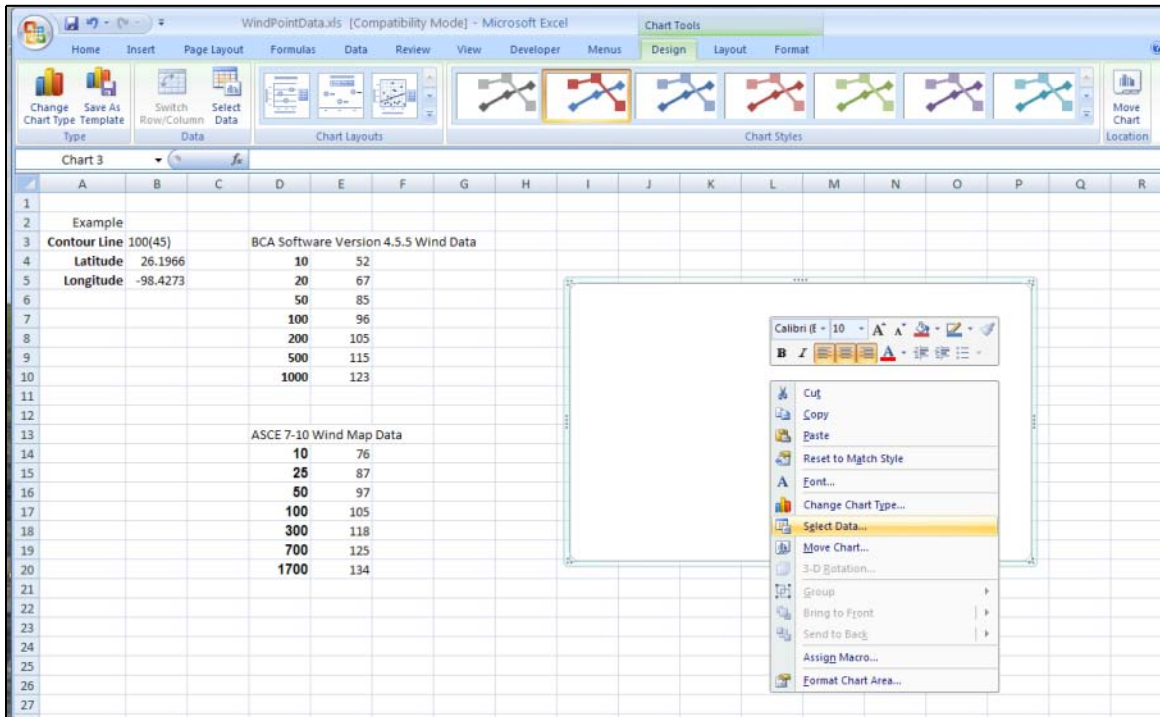
4. Click on *Select Data Source* and then *Add*
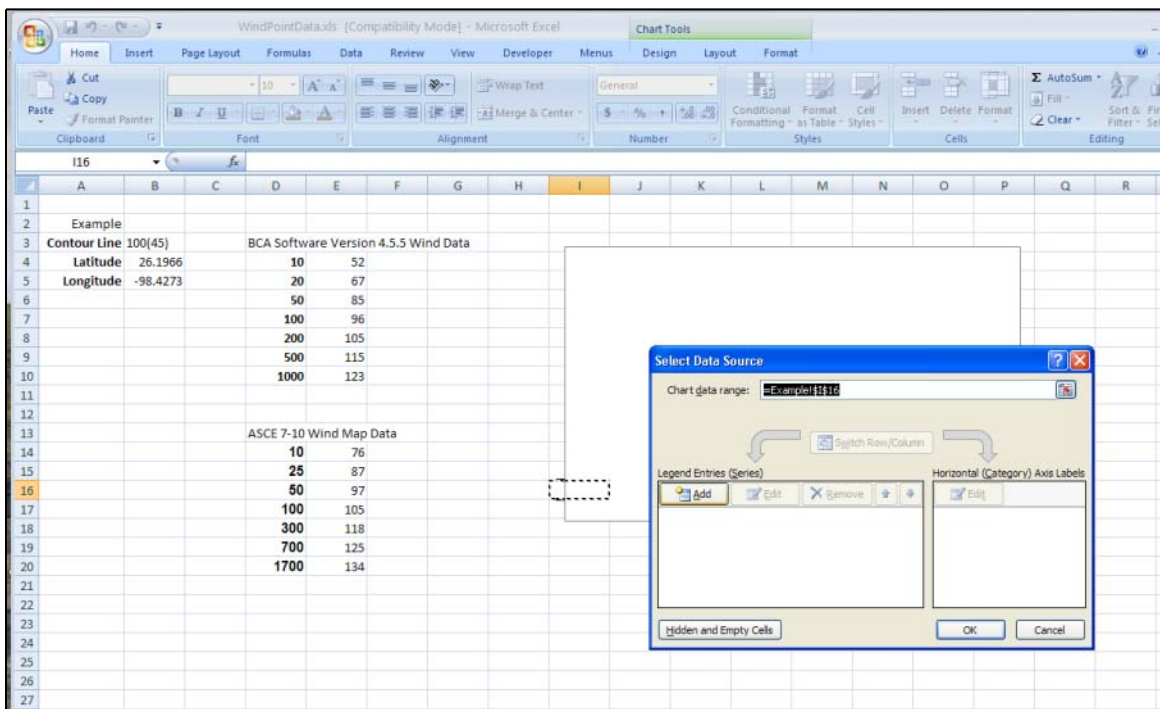
5. Using the *Edit Series* box, select the recurrence intervals as the "Series X values" and the wind speeds as the "Series Y values."
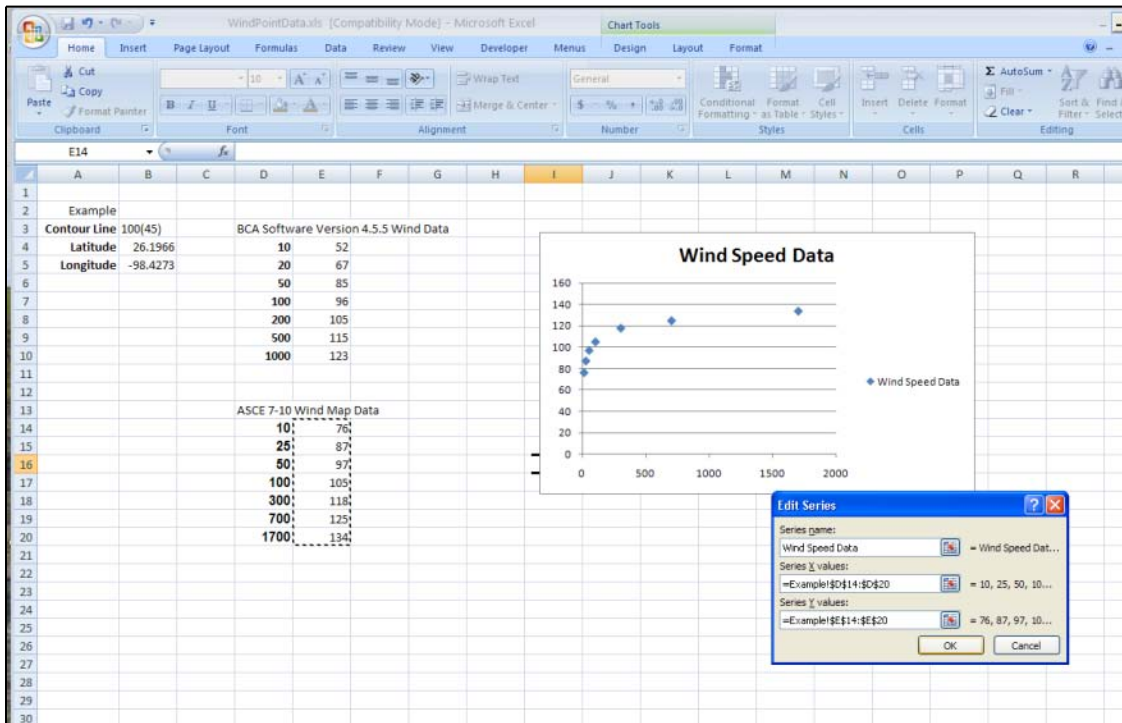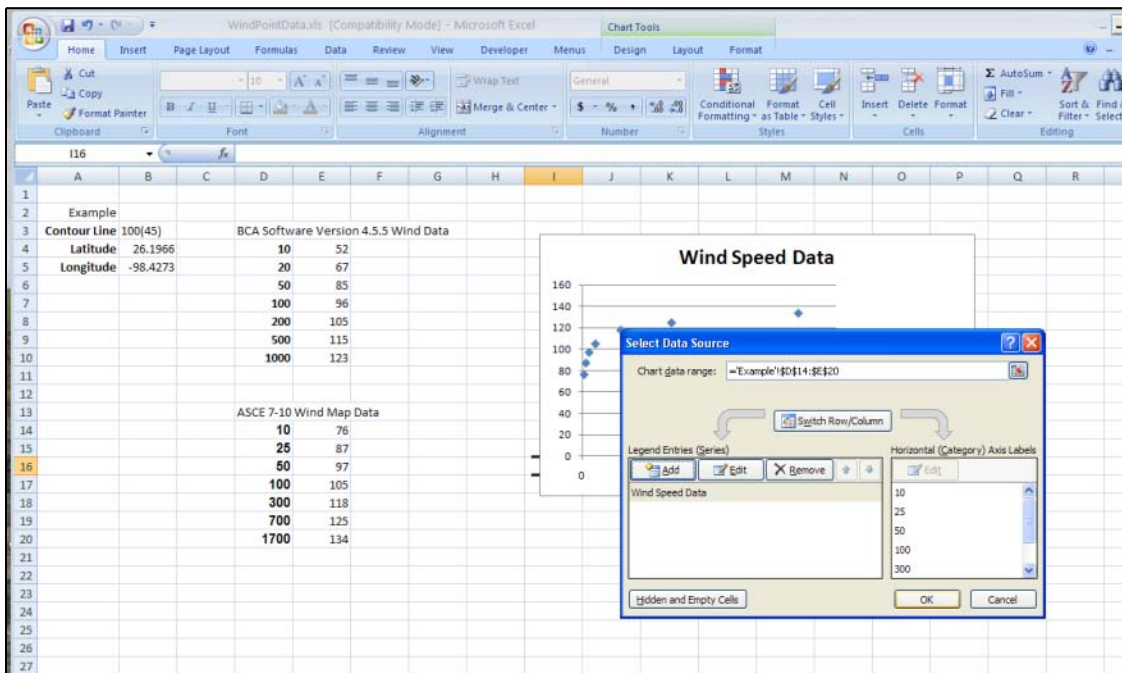
6. Click *OK*

7. Place the cursor over the X Axis, right click the mouse, and select *Format Axis*
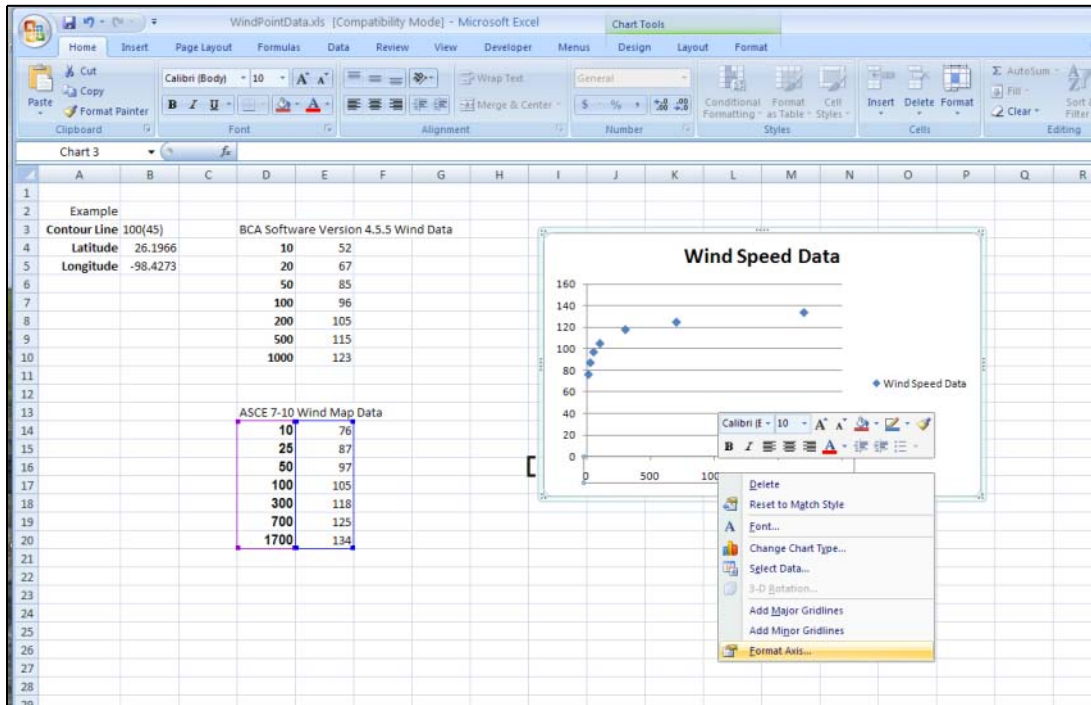
8. Under *Axis Options* select the "Logarithmic scale" and enter "10" for the base and click the *Close* button
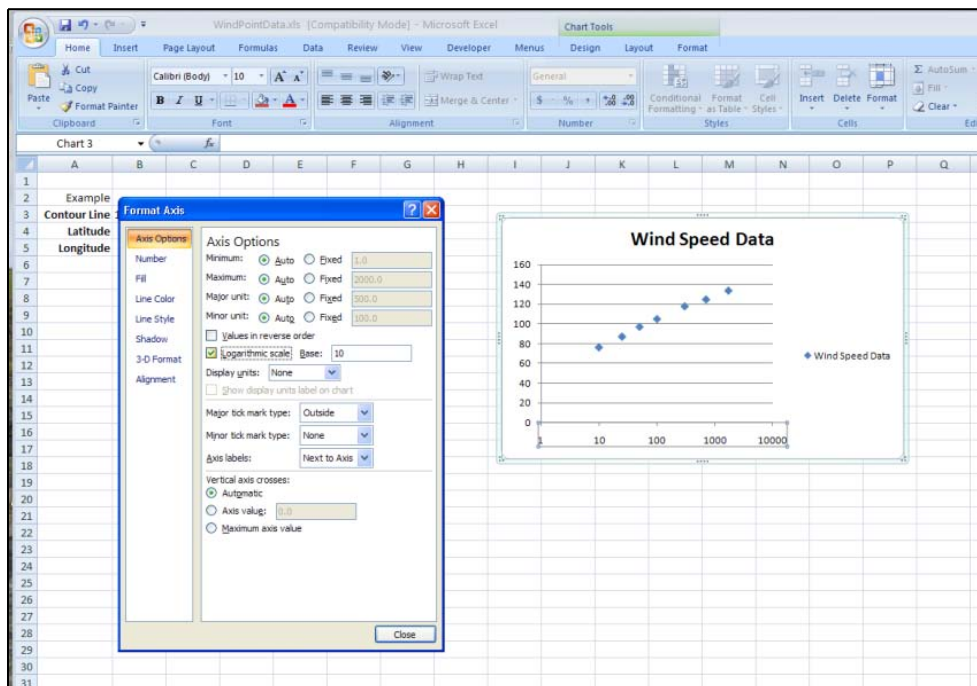
9. Click on one of the data points and right click the mouse. Select *Add Trendline*
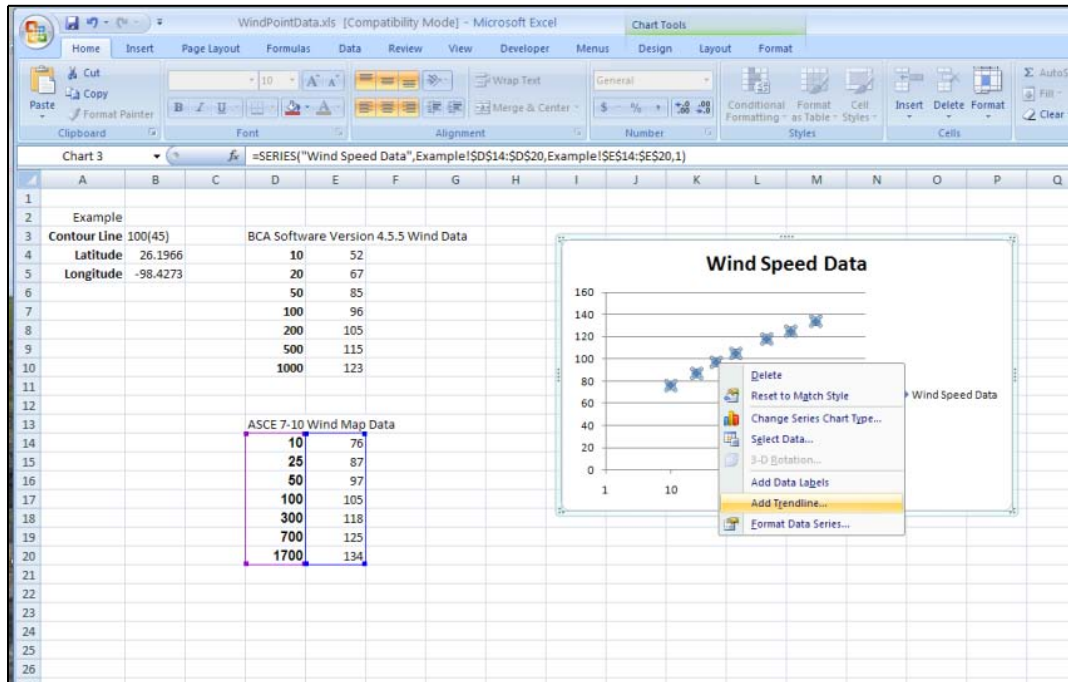
10. Select *Format Trendline*. Under *Trendline Options*, select *Logarithmic*
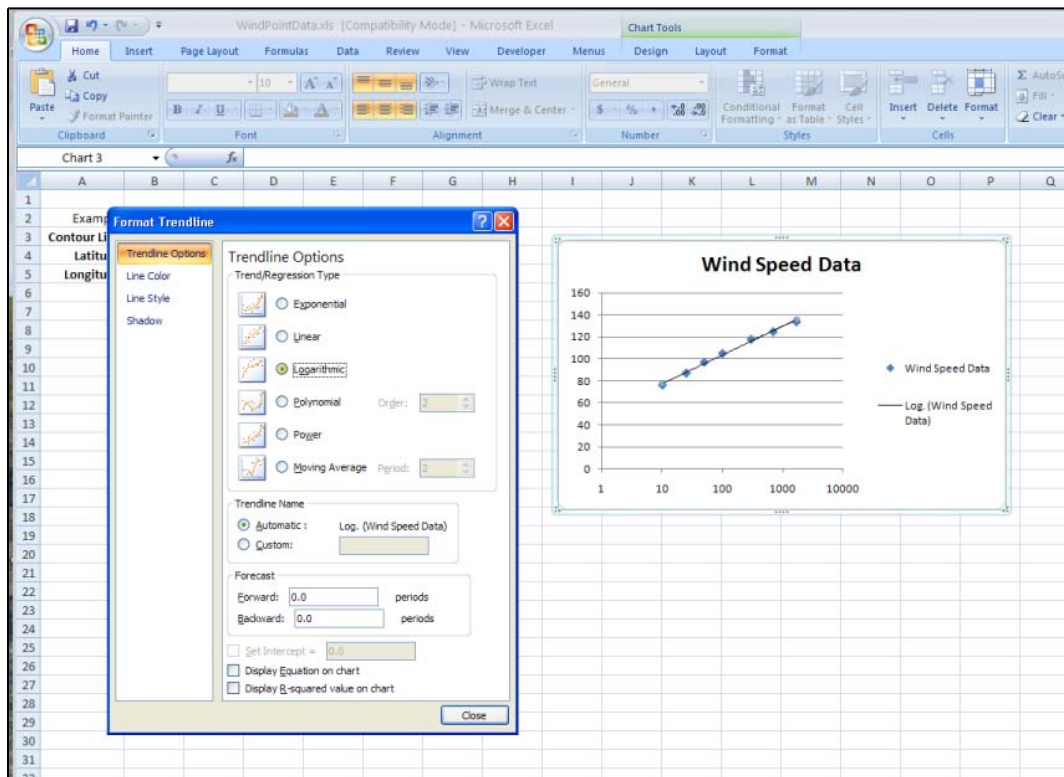
11. Select *Display Equation on chart* and then click *Close*
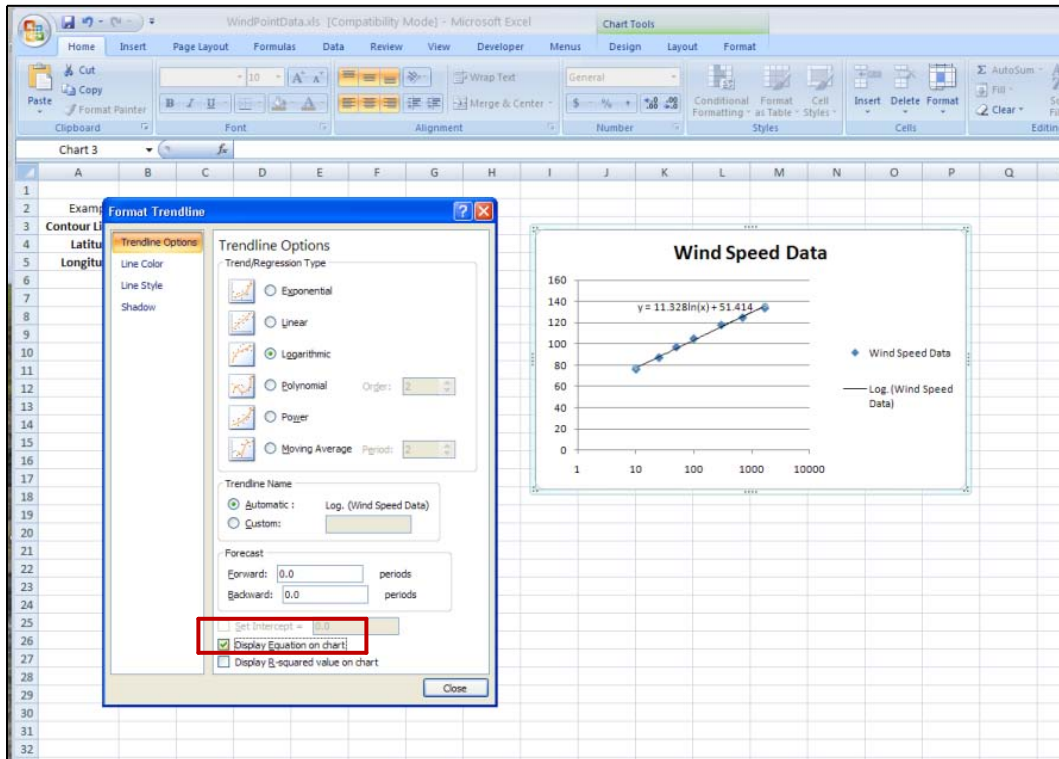
12. Type in the recurrence intervals used in the Hurricane Wind module (10, 20, 50, 100, 200, 500, and 1,000 years) in any column within the spreadsheet you are working in, then type the wind speeds for the 10-, 50-, and 100-year events (the ASCE 7-10 and BCA software recurrence intervals match for these three events).

13. Enter the wind speed equation shown on the developed graph. The X value will be the recurrence interval. Round to the nearest wind speed.
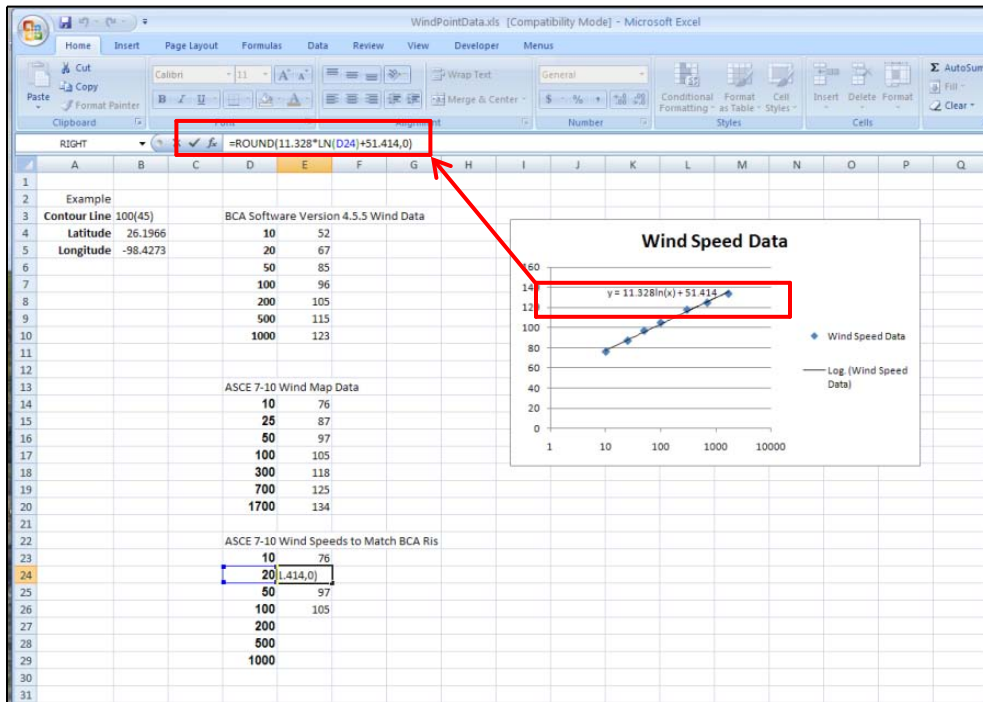
14. Copy the line equation to the 200-, 500-, and 1000-year events.
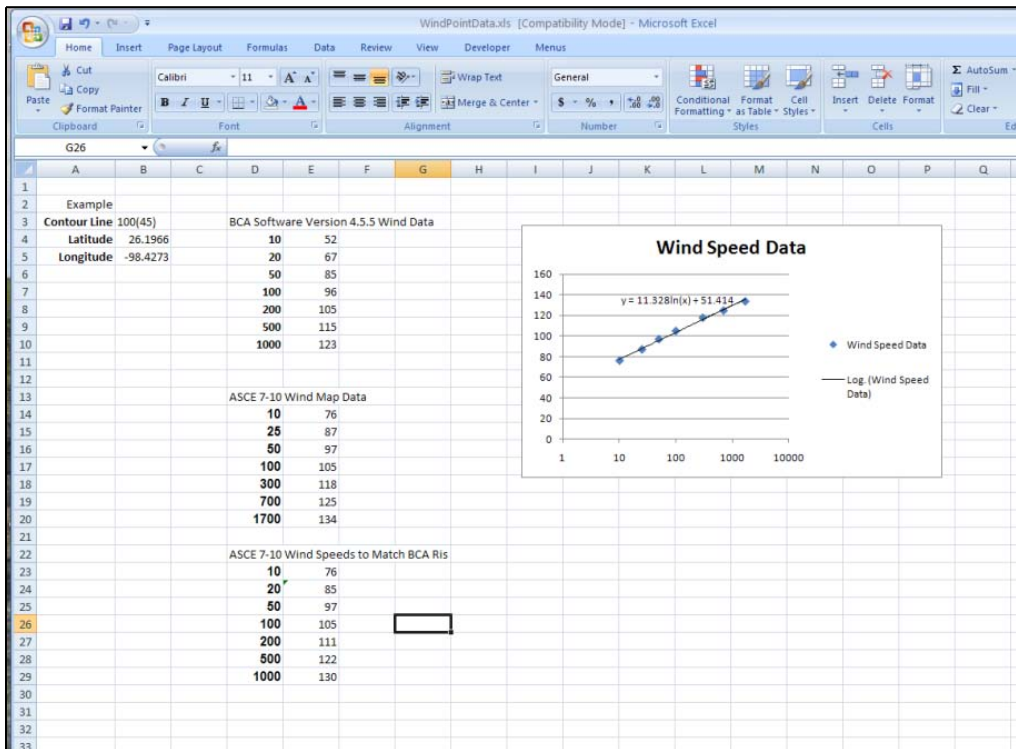
15. Enter the calculated wind speeds from the spreadsheet into the BCA Hurricane Wind module. The user enters the data on the *Wind Speed* tab within the *User Entered Wind Speed (mph)* column for each appropriate recurrence interval.
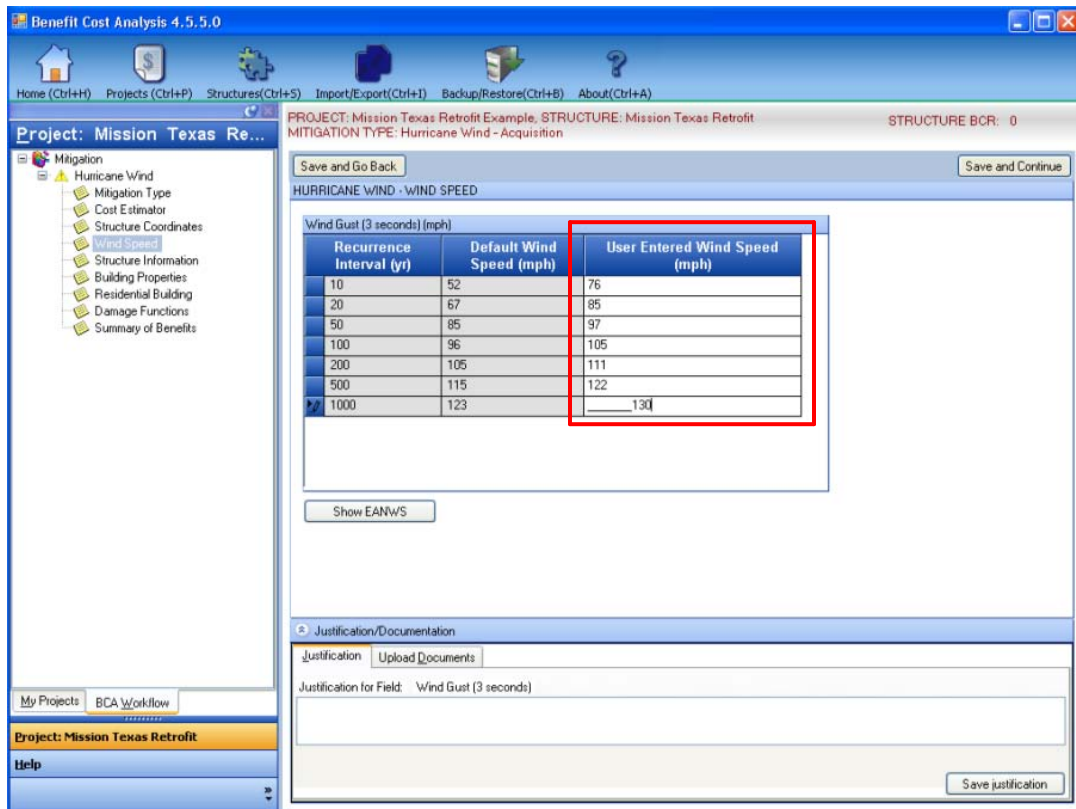
Below is a comparison of the *Expected Maximum Wind Speed per Return Period*. This can be displayed using the *Show EANWS* button near the center of the screenshot shown above. The screenshot below (left side) shows the expected wind speeds as determined by the latitude/longitude method using the Hurricane Wind module. The right side shows the expected wind speeds using the ASCE 7-10 wind speeds shown previously.

Return period (yrs)	Wind gust (3 seconds) (mph)
10	50
20	65
30	75
40	80
50	85
60	90
70	90
80	90
90	95
100	95
200	105
300	110
400	115
500	115
1000	125

Return period (yrs)	Wind gust (3 seconds) (mph)
10	75
20	85
30	90
40	95
50	95
60	100
70	100
80	100
90	105
100	105
200	110
300	115
400	120
500	120
1000	130

3.2   Working with the Tornado Safe Room Module

The Tornado Safe Room module is used to determine the BCR for construction of tornado safe rooms. The module requires the user to input the maximum occupancy, gross area, and usable area of the proposed safe room. These values are dependent on each other and are often calculated incorrectly. This section describes identifying the target population, calculating the gross and usable area for a safe room, and calculating the maximum occupancy and provides suggested sources of data and example calculations.

3.2.1   Identifying the Target Population

The target population for a safe room is the population that can reach the safe room within 5 minutes after notification of an approaching tornado. For tornado community safe rooms, the travel limits are 5 minutes for walking and a maximum of 0.5 mile from the safe room for those driving; therefore, the population of potential occupants must reside or work within 0.5 mile of the safe room. Identifying the target population for a safe room includes delineating the area within a 0.5-mile radius of the safe room and then determining the population within that radius.

To delineate the target area, locate the proposed safe room on a map and draw a circle with a 0.5-mile radius (refer to Figure 3.1 for an example). The target population is determined from within this 0.5-mile radius circle. The target population cannot be forced to cross a highway, railroad, river, or any other obstacle that could put them in harm's way. The use and operation of the safe room will help determine the population served. (For example, if the safe room is adjacent to a school or other large public building, will it be open to the neighboring population during the day, evening, and night?)

Figure 3.1: Sample proposed safe room location with 0.5-mile radius

(Source: USGS Survey Map Data from 2011 aerial photograph from Google)

The second step is to determine the population that might use the safe room. Using the example shown in Figure 3.1, assume a safe room is adjacent to a school. The school population may be obtained from the school administration, State, or a national database (e.g., http://www.schooldatadirect.org/). The school population includes not only the students, but also the faculty, staff, volunteers, and visitors.

If the safe room will only be open to the school, then the adjacent population (typically residential) does not need to be considered. If the safe room will be open to the neighboring public, then the population within the 0.5-mile radius needs to be estimated.

One way to estimate the population within the 0.5-mile radius is to make use of data from the U.S. Census Bureau (http://www.census.gov/). In some cases, the State may have Web sites with

tools that can facilitate population calculations. For example, the Missouri Census Data Center (http://mcdc.missouri.edu/websas/caps.html) developed an online GIS-based tool that uses the 2000 U.S. Census data to provide estimates of the population within a 0.5-mile radius of a location selected by a user. For areas that have experienced significant growth since the 2000 Census, users can alternatively count the number of houses within the 0.5-mile radius. The population within the 0.5-mile radius then can be estimated by multiplying the number of houses by the average household occupancy for the community or county. Average occupancy can be obtained from the U.S. Census Bureau, shown in Figure 3.2.
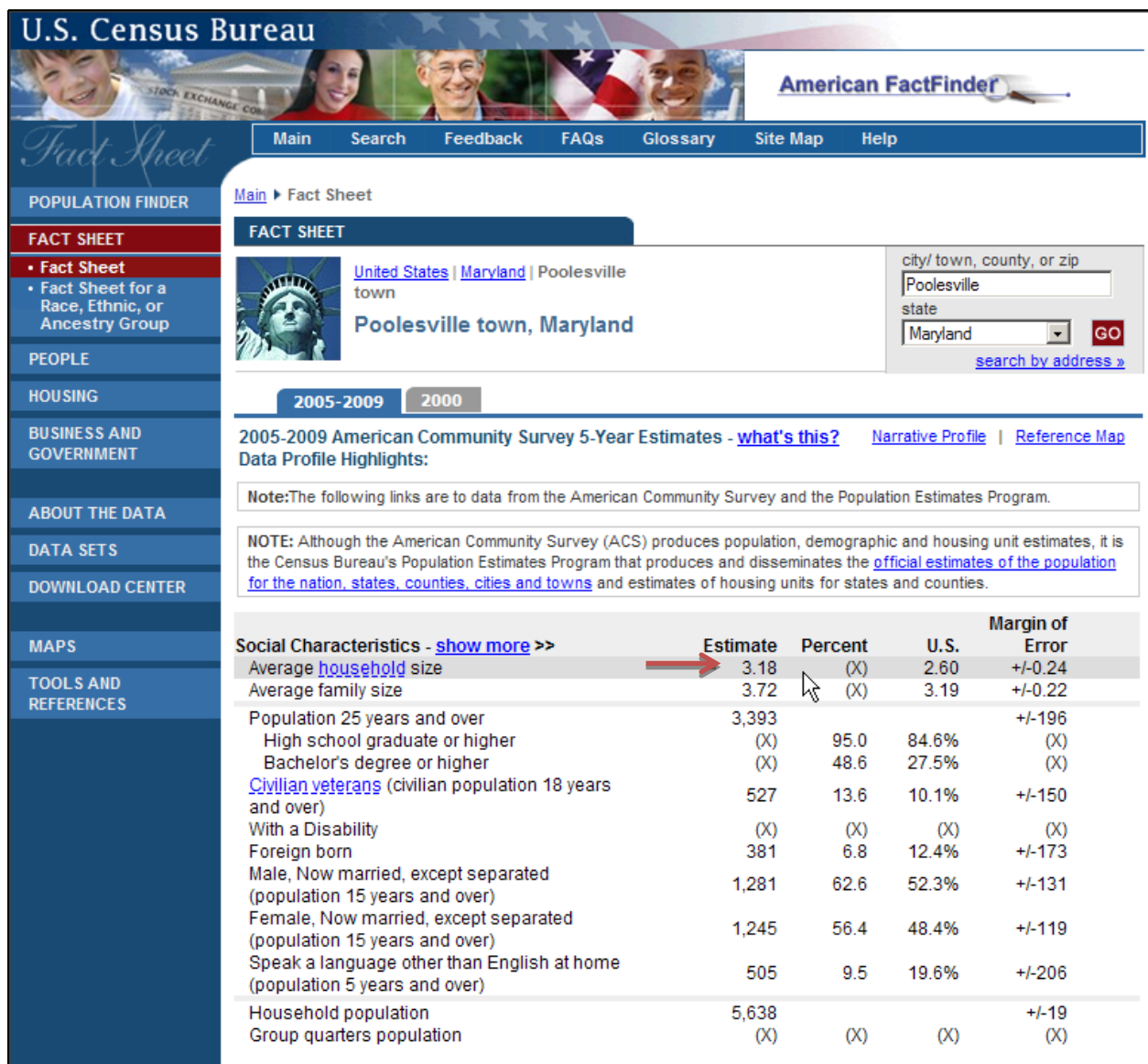

Figure 3.2: Sample of U.S. Census Bureau data showing average household size

If the proposed safe room is located in a school, adjustments may be needed to avoid double-counting children already included in the school population and counting adults working outside the 0.5-mile radius. Adults working outside the radius are presumed to be absent from the

targeted population during daylight hours and should therefore not be included in the population that would use the safe room in daytime hours.

The following example provides a method to determine the residential daytime population within the 0.5-mile radius of a school safe room:

- Assume there are 100 houses within 0.5 mile of a proposed school safe room

- U.S. Census data shows 3.18 people per house (Figure 3.2)

  ➢ (3.18 people/house) x (100 houses) = 318 people

- To subtract the children already in the school, remove the population that are less than 18 years old. Use U.S. Census data to determine the percentage of population over 18 years (Figure 3.3). In this example, 68.8 percent are 18 and over.

  ➢ (318 people) x (0.688) = 219 people

- Adjust the population for people that work outside the area during the day. Information related to this can be determined local employment records, or US Census Bureau data (refer to Economic Characteristics for your local area). For this example, assume that local employment records show that an estimated 75 percent work outside the 0.5-mile radius.

  ➢ (219 people) x (1.0 - 0.75) = 55 people

ACS Demographic Estimates - show more >>	Estimate	Percent	U.S.	Margin of Error
Total population	5,638			+/-19
Male	2,840	50.4	49.3%	+/-188
Female	2,798	49.6	50.7%	+/-190
Median age (years)	35.9	(X)	36.5	+/-6.6
Under 5 years	323	5.7	6.9%	+/-164
18 years and over	3,879	68.8	75.4%	+/-201
65 years and over	248	4.4	12.6%	+/-139
One race	5,624	99.8	97.8%	+/-28
White	5,388	95.6	74.5%	+/-204
Black or African American	136	2.4	12.4%	+/-157
American Indian and Alaska Native	0	0.0	0.8%	+/-127
Asian	100	1.8	4.4%	+/-128
Native Hawaiian and Other Pacific Islander	0	0.0	0.1%	+/-127
Some other race	0	0.0	5.6%	+/-127
Two or more races	14	0.2	2.2%	+/-23
Hispanic or Latino (of any race)	105	1.9	15.1%	+/-109

Source: U.S. Census Bureau, 2005-2009 American Community Survey

Figure 3.3: Sample of U.S. Census Bureau data showing population 18 years and over

- Therefore, for this example, the residential daytime population that may use the proposed safe room is estimated as 55 people. This number is then added to the school population to estimate the safe room maximum occupancy during the daytime. Additional sources of occupancy data are described in the dynamic help function of the Tornado Safe Room module software.

3.2.2   Calculating Gross and Usable Area

There are two types of areas that must be calculated for the Tornado Safe Room module: gross area and usable area. The *gross area* is the total area of the safe room. It should be shown on the proposed safe room design drawings. The *usable area* is the gross area minus the area of obstructions such as columns, partitions and walls, fixed or movable objects, furniture, or other equipment and features placed in the safe room. These values are related to each other and are often calculated incorrectly. This section describes each of these values and provides detail on usable area, which is the area typically miscalculated.

Most safe room subapplications contain conceptual design floor plans and use the guidelines in FEMA 361, *Design and Construction Guidance for Community Safe Rooms* (Second Edition, August 2008) to calculate usable area. Specific calculations for the exact usable area may be provided, but are typically not available at this stage in the mitigation grant process.

An accurate calculation of the usable area is especially important for multi-use safe rooms, such as classrooms and offices. The usable area should not include unused or areas that are normally locked such as mechanical rooms, storage closets, or offices. FEMA 361 provides the following guidelines to calculate the usable area:

- *Areas of concentrated furnishings or fixed seating*: Areas where the furnishings cannot be easily moved, including bathrooms, locker rooms, weight rooms, and auditoriums with fixed seating. To account for the furnishings, reduce the gross floor area of such rooms by a minimum of 50 percent.

- *Areas of unconcentrated furnishings and without fixed seating:* Areas where furniture can be moved, such as classrooms and offices. Reduce the gross floor area of such areas by a minimum of 35 percent.

- *Areas of open plan furnishings and without fixed seating:* Reduce the gross floor area of such areas by a minimum of 15 percent.

Refer to Table 7 below for acceptable reductions to gross area for the purpose of calculating the usable area for a multi-purpose safe room.

Table 7: Typical Gross Area Reductions by Room Use

Room Description	Gross Area Reduction (%)
School Gymnasium	15
School Classroom	35
Office (unlocked)	35
Bathroom	50
Locker Room	50
Mechanical Room	100
Storage Room	100

NOTE: Auditorium (with fixed seating): For Occupancy, use the total seating capacity plus the open spaces, with proper area reduction per FEMA 361.

3.2.3   Calculating the Maximum Occupancy

Once the target population has been identified and estimated, target population count must be checked against the maximum occupancy or capacity of the safe room to determine whether the safe room has adequate space or must be adjusted to meet the need. It is recommended that the safe room be designed (i.e., sized) to accommodate the target population based on the requirements of FEMA 361 (refer also to Section 3.2.2). If the safe room is sized for the target population in accordance with FEMA 361, the target population is entered in the Tornado Safe Room module as the *maximum occupancy*. However, if the size of the safe room is already determined, the analyst will need to determine the number of people that will fit in the proposed safe room based on FEMA 361 and compare that estimate with the target population within the 0.5-mile radius. In this case, the target population is not used in the BCA Tornado Safe Room module; instead, the population that can be accommodated by the safe room is entered into the module.

The minimum floor space requirements for safe room occupants are shown in Table 8.

Table 8: Maximum Occupant Density for Tornado Community Safe Rooms

Tornado Safe Room Occupant	Minimum Recommended Usable Floor Area (sf per person)
Standing or Seated	5
Wheelchair-bound	10
Bedridden	30

(Source: Table 3-1, FEMA 361, *Design and Construction Guidance for Community Safe Rooms*, Second Edition, August 2008.)

3.2.4   Example: Determining Required Usable Area from Maximum Occupancy

In the following example, the proposed maximum occupancy is known and the user is calculating the required usable area. Assuming the proposed occupancy is 350 people, calculate the minimum usable area required.

1. Calculate how many wheelchair spaces are required. Using guidance in FEMA 361, one wheelchair space (10 sf/person) is needed for every 200 occupants. Therefore 350 occupants will require two wheelchair spaces. The result is a maximum occupancy of 348 standing or seated occupants and two wheelchair occupants.

2. Calculate the required usable area to accommodate the proposed occupancy.
    a) (348 standing occupants) x (5 sf/person) = 1,740 sf required
    b) (Two wheelchair occupants) x (10 sf/person) = 20 sf required
    c) Required total usable area needed = 1,740 sf + 20 sf = 1,760 sf

The next step is to calculate the gross and usable area of the safe room. Assume the building footprint is as shown in Figure 3.4.
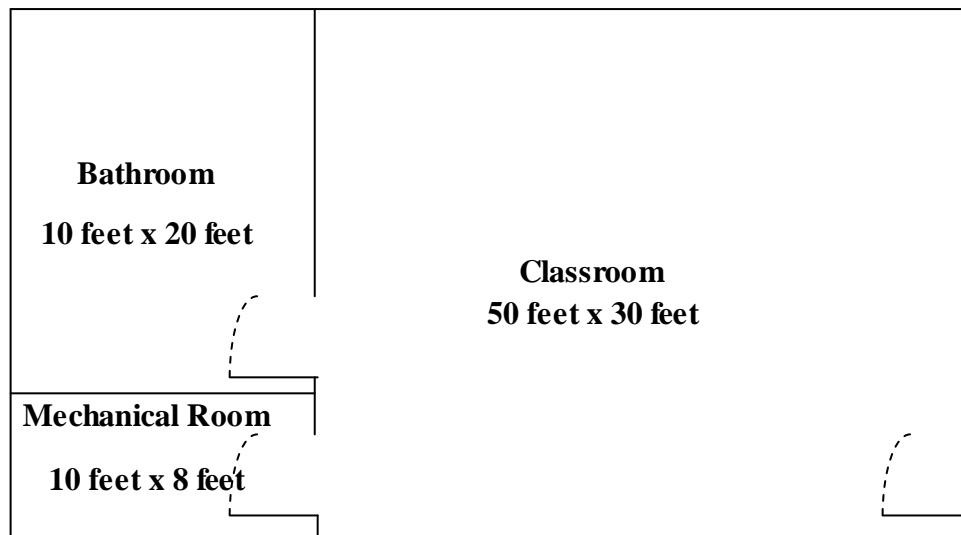
Figure 3.4: Example safe room floor plan

In this example, the total gross area is 1,780 sf, calculated by adding the area of the rooms shown in Figure 3.4:

- Bathroom is 10 feet x 20 feet = 200 sf
- Mechanical Room is 10 feet x 8 feet = 80 sf
- Classroom is 50 feet x 30 feet = 1,500 sf

Using the total gross area of 1,780 sf, calculate the usable area using FEMA 361 guidance as follows:

- Bathroom (50% reduction) = (200 sf) x (0.50) = 100 sf
- Mechanical Room (100% reduction) = (80 sf) x (1.0) = 80 sf
- Classroom (35% reduction) = (1,500 sf) x (0.35) = 525 sf

The total area reductions equal 705 sf. Therefore, the total usable area is calculated as:

- Gross Area – Total Reductions = Total Usable Area
- 1,780 sf – 705 sf = 1,075 sf

The final step is to compare the proposed usable area with the required usable area. For the example problem, the calculated usable area of 1,075 sf is less than the required usable area of 1,760 sf and therefore not enough space is provided for the targeted population.

The "Proposed Usable Area" of 1,075 sf would provide enough space for only 213 occupants. Using FEMA 361 requirements of one wheelchair space for every 200 occupants, the 213 can be understood to mean:

- Total occupants = 213 people
- 2 wheelchair bound occupants x 10 sf/person = 20 sf
- 211 standing or seated occupants x 5 sf/person = 1,055 sf

For this example, there would be two possible choices:

1. Redefine the maximum occupancy as 213 people.

2. Redesign the safe room to a larger size to accommodate the proposed maximum occupancy of 350 people. Redesigning the safe room would be recommended in this example case since the safe room is for a school and the school population (students, teachers, staff, and visitors) is greater than 213.

SECTION FOUR INCORPORATING LOSS OF SERVICES FOR CRITICAL PUBLIC FACILITIES

All FEMA BCA Version 4.5.5 modules count loss of function benefits for public facilities (i.e., public library or city hall) in a hazard situation where that facility can no longer provide its services to the general public. For most public/nonprofit sector buildings, the value of services lost when the building becomes unusable due to a hazard event is calculated by assuming that services are worth what the public pays to provide the services. This value is based on the annual operating budget of the agency providing the service. However, the BCA software treats critical facilities (i.e., fire stations, hospital emergency rooms, and police stations) differently from those public facilities due to their importance to life-safety/rescue services to the community in the aftermath of a disaster.

While varying FEMA definitions may exist, for the purposes of the BCA software and analysis, critical facility service types include fire stations, hospital emergency rooms, and police stations. The BCA software estimates a societal cost for the loss of such critical facilities based on the service population and assesses the societal benefits of maintaining the critical facility in the aftermath of a disaster. The critical facility analysis is therefore based on the estimate of the population served by both the critical facility and the impact a disaster would have on that facility. Note that if the analysis is claiming the loss of critical services benefits, the loss of function value will need to be closely analyzed. In some cases claiming loss of critical services benefits and loss of function benefits is double counting.

The BCA software requires specific information regarding critical facilities in order to calculate benefits from mitigation projects related to reduction of loss of service. The following information is required and is often misunderstood by users of the BCA software and is explained in more detail in this section:

- Number of people served by the critical facility
- Distance in miles between the critical facility and the alternate source of equivalent services
- Type of area served
- Number of police serving in the aftermath of a hazard event

Fire Stations

The analysis performed by the BCA software for the specific loss of service for a Fire Station is based on the cost to society of a temporary loss of function of a Fire Station with respect to human injuries and mortality, direct financial loss to property, and indirect losses. The analysis factors in the distance to the next closest fire station that would provide protection for the geographical area normally serviced by former station. Fire station facility types include firefighting, search and rescue, public shelter, and emergency medical services if they are located in the same facility.

- Case 1: Loss of fire services only
  - Use only the loss of critical services function in the software

- Case 2: Loss of fire services located in buildings with additional noncritical services (e.g., city halls, other government buildings, etc.)
  - Use the loss of critical services function for fire and the annual operating budget applicable to all other noncritical services lost excluding fire

Hospital Emergency Rooms

The analysis performed by the BCA software of the specific loss of service for a hospital is based on the cost to society of a temporary loss of function of a hospital's emergency department with respect to extra travel time to an alternative hospital and any additional waiting time at that alternative hospital, with the potential cost in lives resulting from that situation. Similar to the Fire Station analysis, Hospital analysis factors in the distance to the next closest hospital that would treat people normally treated by the former hospital.

- Case 1: Loss of the emergency room only
  - ➢ Use the loss of critical service function in the software
- Case 2: Loss of services (e.g., intensive care, radiology, exam rooms, patient care wards, etc.) excluding the emergency room
  - ➢ Use the portion of the annual operating budget applicable to the services lost and not the loss of critical services function
- Case 3: Loss of both the emergency room and other services outside of the emergency room
  - ➢ Use the loss of critical services function for the emergency room and the annual operating budget applicable to the other services lost excluding the emergency room

Police Stations

Police Station analysis is based on the cost to society of a temporary loss of function of a Police Station from the perspective of how a reduced police presence would affect the population of that area. This analysis is based on the difference of a normally staffed police force and that same reduced force available in a post-disaster situation in the identical geographic area.

- Case 1: Loss of police services only
  - ➢ Use only the loss of critical services function in the software
- Case 2: Loss of police services located in buildings with additional noncritical services: (e.g., city halls, other government buildings, etc.)
  - ➢ Use the loss of critical services function for police and the annual operating budget applicable to all other noncritical services lost excluding police
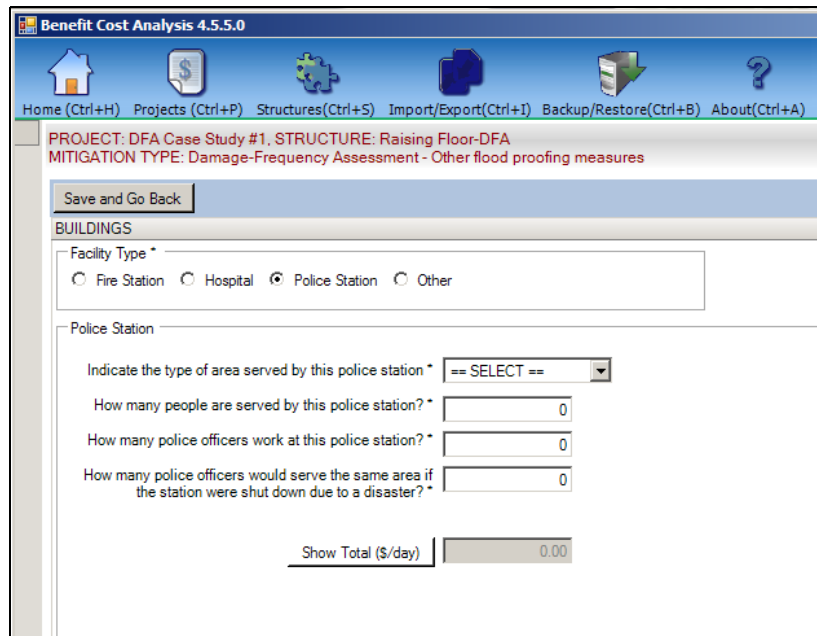
4.1.1   Accessing the Critical Facility Function with Flood Module

1. On the <u>Structure Information</u> screen, select "No" in response to the question "Is the building Residential?" Note that access in the Hurricane Wind module is similar to that described here.
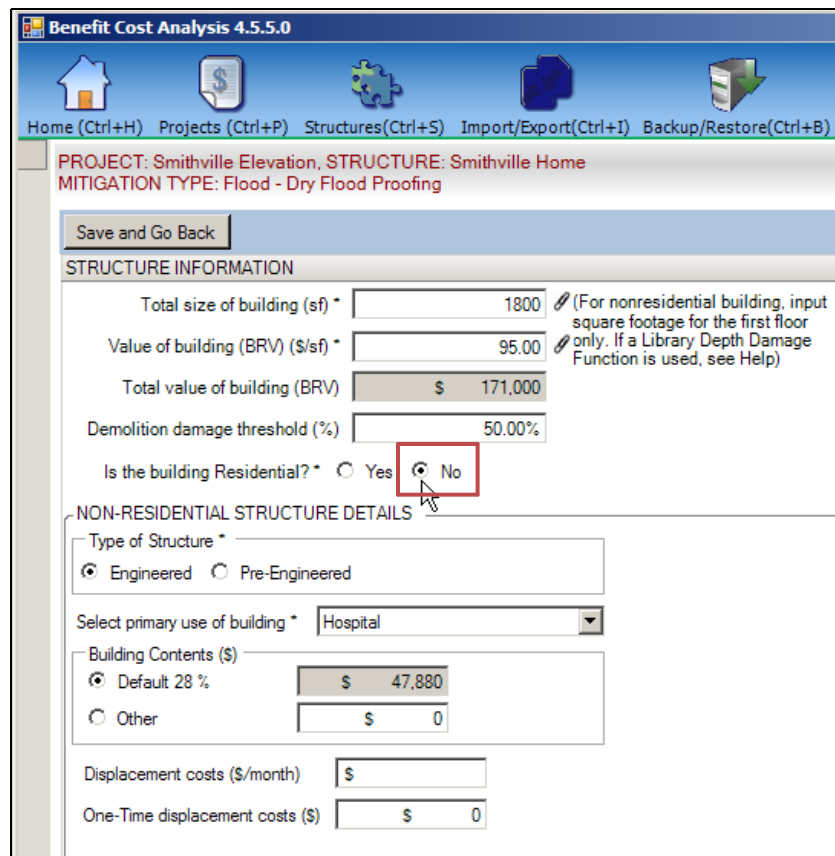
4.1.2   Accessing the Critical Facility Function with DFA Module

1. On the Type of Service screen, select *Non Residential Buildings* facility type for loss of function. Note that access in the Earthquake modules is similar to that described here.
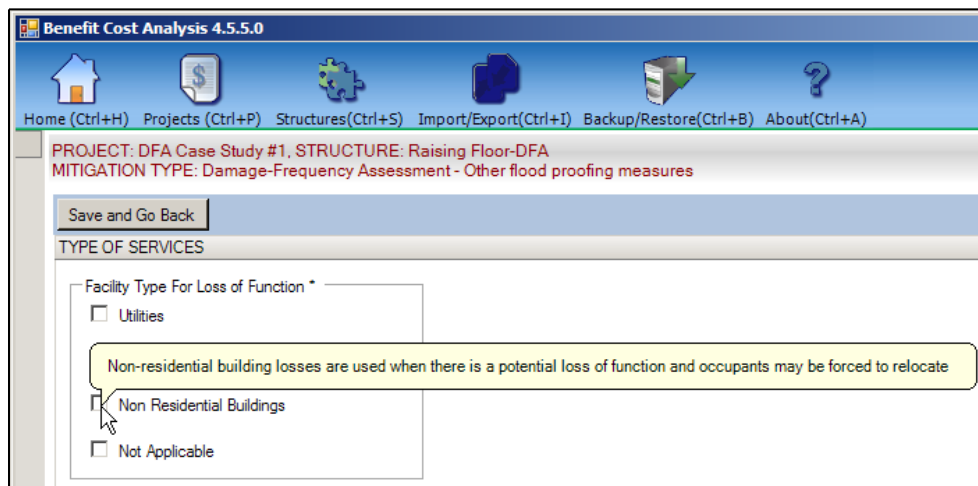
4.1.3   Determining the Number of People Served by a Critical Facility

Analyzing the societal impact of the loss of a critical facility on the population it serves is done by comparing the distance of the critical facility to the population it serves with the distance of

that population to the next closest critical facility (with equivalent services). The analysis assumes the next closest critical facility would be called upon to expand their service range in the event of a disaster resulting in the loss of the first critical facility. The value entered for the population served by each critical facility is strictly the population served by that critical facility, not the population of an entire city or county with multiple critical facilities. The special services provided by each facility should be specified.

Information regarding the number of people served by a critical facility (and the alternate critical facility) can be obtained from the municipality, city/community officials, facility operations managers, or documents such as annual reports. If these methods are unproductive, a reasonable alternate methodology may be used; if an alternative approach is used, a description of that approach must be included in the subapplication.

Most large cities are separated into Districts and detailed population information for each District is generally available. However, since hospitals are typically not operated by cities, the population served by each may be a complicated value to determine. Cities may have multiple hospitals, and some hospitals serve multiple communities. Some information, such as the number of beds and number of doctors per patient, may be found in annual reports for the hospital or on the hospital Web site. Contact the hospital to obtain their estimate on per capita served. Community planners and/or community officials may also be able to provide these estimates.

Example: Hospital in Montgomery County, MD

Figure 4.1 shows an example of a District's distribution within Montgomery County, MD, and the hospital within that District. In this example, only one hospital is shown on the map, and a user could assume the number of people served by this critical facility, outside of available information from the hospital itself, would be the population of District 3 (Figure 4.2).
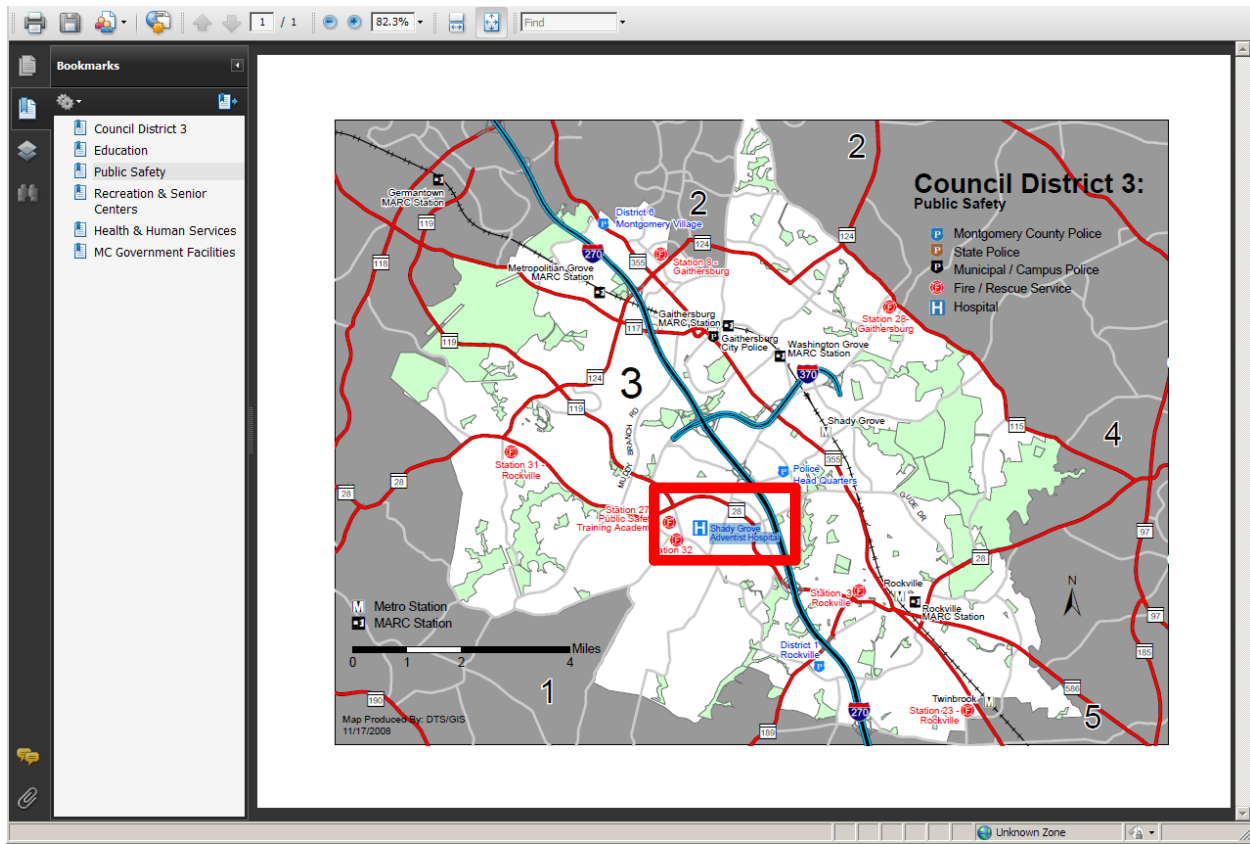
Figure 4.1: Hospital example - locations of critical facilities in Montgomery County, MD District 3

(source: http://www.montgomerycountymd.gov/csltmpl.asp?url=/content/council/mem/district_map.asp)

Figure 4.2: Hospital example - population for Montgomery County District 3 population

(source: http://www.montgomerycountymd.gov/content/council/redistricting/Handouts/adjmoco_adjpop.pdf)

4.1.4   Determining the Distance (in miles) between Critical Facilities

Facility operations managers or municipal officials can supply information regarding the location of the alternate facility and the distance (in miles) between critical facilities. Distance (in miles) is the shortest distance travelling by vehicle along roadways. Local maps or GPS software may be used as documentation of the distance. Generally, mapping software can search fire stations, hospitals, and police stations in a geographic area to determine the location of the nearest alternative critical facility (Figure 4.3).
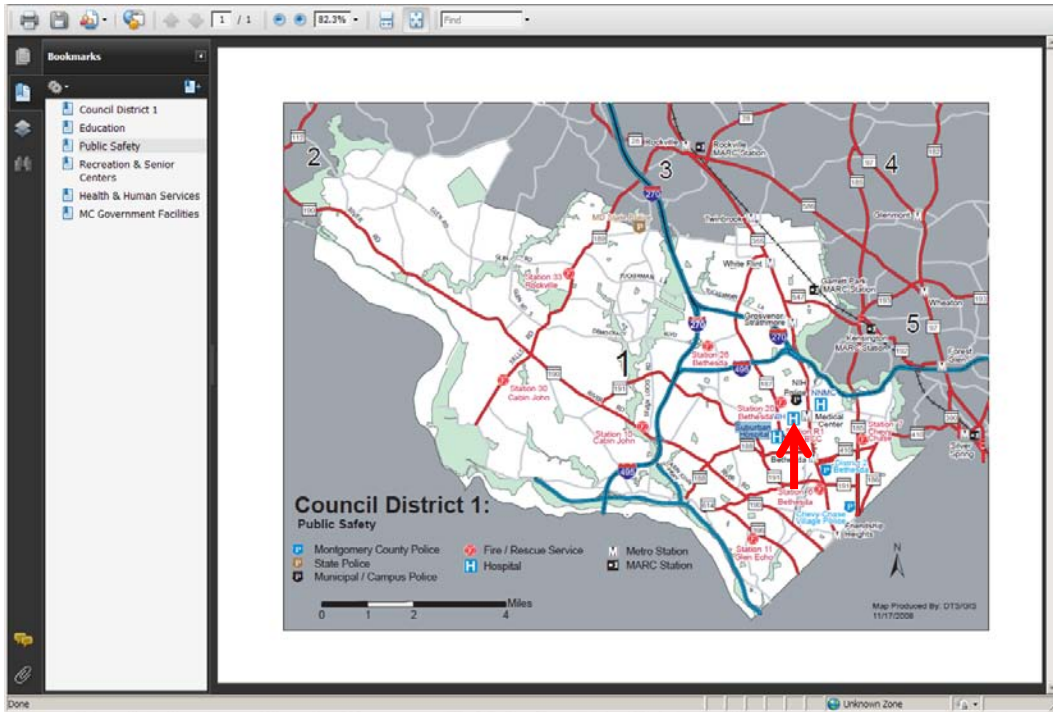
Figure 4.3: Hospital example - nearest alternative critical facility

(source: http://www.montgomerycountymd.gov//content/gis/images/gallery/councildistrict1.pdf)

Mapping software can also usually get directions from location A to location B along suggested routes of shortest travel distance or estimated time as shown in Figure 4.4, distance from hospital A to hospital B.
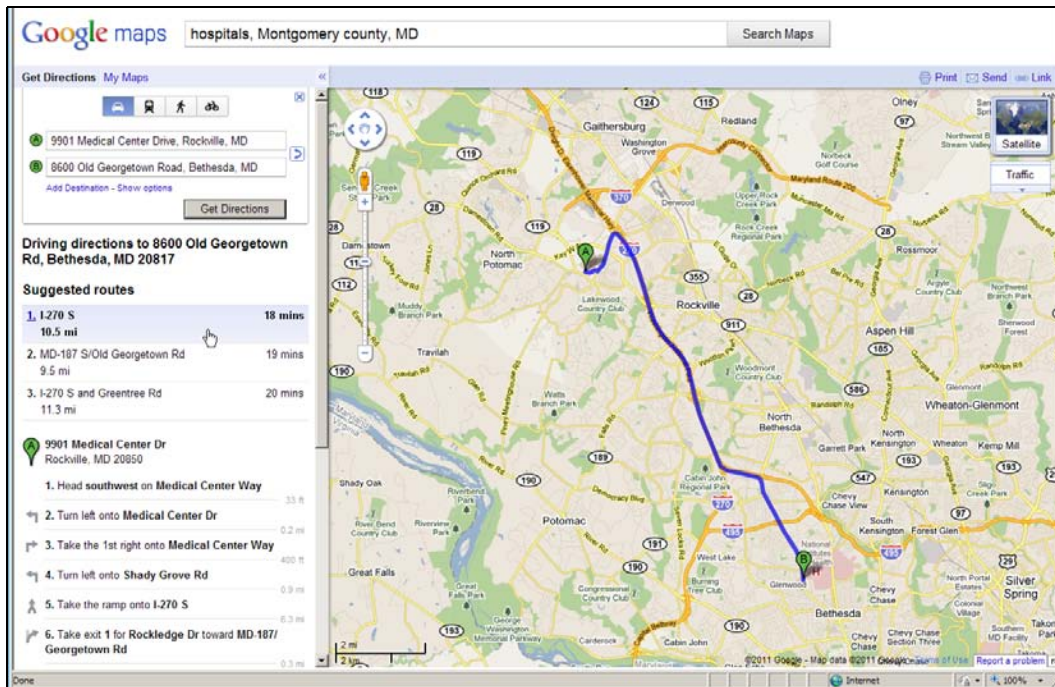
Figure 4.4: Hospital example - distance from Hospital A to Hospital B

Example: Hospital in Montgomery County, MD

Using the example of the hospital in Montgomery County, MD, the following data can be input to the BCA Flood module.

1. On the *Buildings* page, enter the number of people served by the hospital (197,661, per Figure 4.2)

2. Enter the number of miles to the nearest alternative hospital (10.5 miles, per Figures 4.3 and 4.4)

3. Enter the number of people served by the alternative hospital (185,462, per Figure 4.2)

4.1.5 Determining the Type of Area Served by Fire and Police Stations

4.1.5.1 Fire

Users must select the type of area served by a fire station, which is categorized as urban, suburban, rural, or wilderness. The definition of each category is based on the "Urban Influence" coding system used by the United States Department of Agriculture (USDA) and the Office of Management and Budget (OMB). These codes take into account county population size, degree of urbanization, and adjacency to a metropolitan area or areas. The categories are defined as follows:

- *Urban*: Counties with large (more than 1 million residents) or small (less than 1 million residents) metropolitan areas

- *Suburban*: Micropolitan (with an urban core of at least 10,000 residents) counties adjacent to a large or small metropolitan area

- *Rural*: Non-core counties adjacent to a large or small metropolitan area (with or without town)

- *Wilderness*: Non-core counties not adjacent to micropolitan counties (with or without town)

One such reference for determining the type of area served includes the USDA Data Set: Urban Influence Codes available at: http://www.ers.usda.gov/Data/UrbanInfluenceCodes/.

4.1.5.2 Police

Users of the BCA Flood module must enter the type of area served by a police station. The user must select between metropolitan, city, or rural.

Based on data tables from the Federal Bureau of Investigation (FBI 2006), crime statistics are sorted into three statistical areas:

- Metropolitan
- Cities outside metropolitan areas
- Nonmetropolitan counties

Users should select "Metropolitan" for police stations that serve a principal city or urbanized area with a population of at least 50,000 inhabitants. The area served includes the principal city, the county in which the city is located, and other adjacent counties that have, as defined by the OMB, a high degree of economic and social integration with the principal city and county as measured through commuting.

Users should select "City" only if the area served by the police station is a city outside of a metropolitan area.

Users will not generally select "Rural" as it applies to those areas that are outside of the metropolitan area and composed of mostly unincorporated areas.

4.1.6 Determining the Number of Police Officers Serving the Same Area in the Aftermath of a Disaster

Users must enter the number of police serving in the same area in the aftermath of a disaster. This value is best estimated by the operations managers, the municipality, city/community officials, or documents such as emergency response or continuity of operations plans. If these methods are unproductive, a reasonable alternate methodology can be used to determine the number of police officers. If an alternative methodology is used, the subapplication material should include all assumptions used in the calculations.

SECTION FIVE   AVAILABLE TECHNOLOGY AIDS

The purpose of this section is to provide information about publically available tools that can be used to obtain information needed to complete the DFA, Flood and Tornado modules. **FEMA does not endorse these tools over similar products and does not require that they be used**. The tools described in this section include Google Earth and the Hazus software. There are several free Google Earth utilities, including the FEMA National Flood Hazard Layer (NFHL) and the USGS Streamflow Data layer. There are also several useful utilities that are available through Google Earth if a license is purchased; these include utilities for demographics, parcel data, and daily traffic counts. Table 9 shows the types of information that can be obtained using each tool.

Table 9: Applicability of Technology in BCA

Data Type	Google Earth - Free (Section 5.1.1)	Google Earth – Pro License (Section 5.1.2)	Hazus (Section 5.1.3)
Flood Hazard Information	X		X
Road/ Bridge Information	X	X	
Safe Room Radius	X		
U.S. Demographics		X	
Building Information		X	X

5.1.1   Using Free Layers in Google Earth

The documentation tools that are discussed in this section are layers of the Google Earth application (NFHL, USGS Streamflow Data, and Spatial Calculations) and the Google Earth Pro license. For Google Earth utilities, Google Earth must be installed on the user's computer, and the user must have a high-speed Internet connection. Note that the screenshots shown in Section 5.1.1 were taken from Google Earth Pro (a licensed version of the software described in Section 5.1.2), but these functions are available on the free version of Google Earth.

5.1.1.1   *National Flood Hazard Layer*

According to *FY11 HMA Unified Guidance* (FEMA, 2010a), "The required documentation depends upon the nature of the proposed project and may include: proposed schematics, drawings or sketches, photographs, maps, sections of hazard maps, a Flood Insurance Study (FIS), or a FIRM" and "subapplicants should identify the proposed project location on a map."

The FEMA NFHL is a Google Earth utility that can be used to provide data for applications prepared for submittal to the HMA Program. A basic knowledge of Google Earth and FEMA flood hazard information is recommended for users of this tool. *FEMA NFHL: View Custom Combinations of FEMA Flood Hazard Information Using Google Earth,* available at http://www.fema.gov/library/viewRecord.do?id=3289, is an excellent resource for the NFHL.

See https://hazards.fema.gov/femaportal/wps/portal/NFHLWMSkmzdownload for downloading instructions.

The FEMA NFHL can be used for proposed riverine and/or coastal flooding mitigation projects to obtain the proposed project location, hazard type, and BFE. The NFHL also provides the nearest cross section or transect, which can be used to find information in the FIS. In the Map Service Center FIRMette, the index and FIRM panel number must be searched to find the proposed project location, but in the NFHL, a map pin can be attached to the proposed project location and the FIRM panel number can then be obtained by zooming in on the location. Another difference is that FIRMettes are in gray-scale, while the NFHL is in color and includes other landmarks (see Figure 5.1).
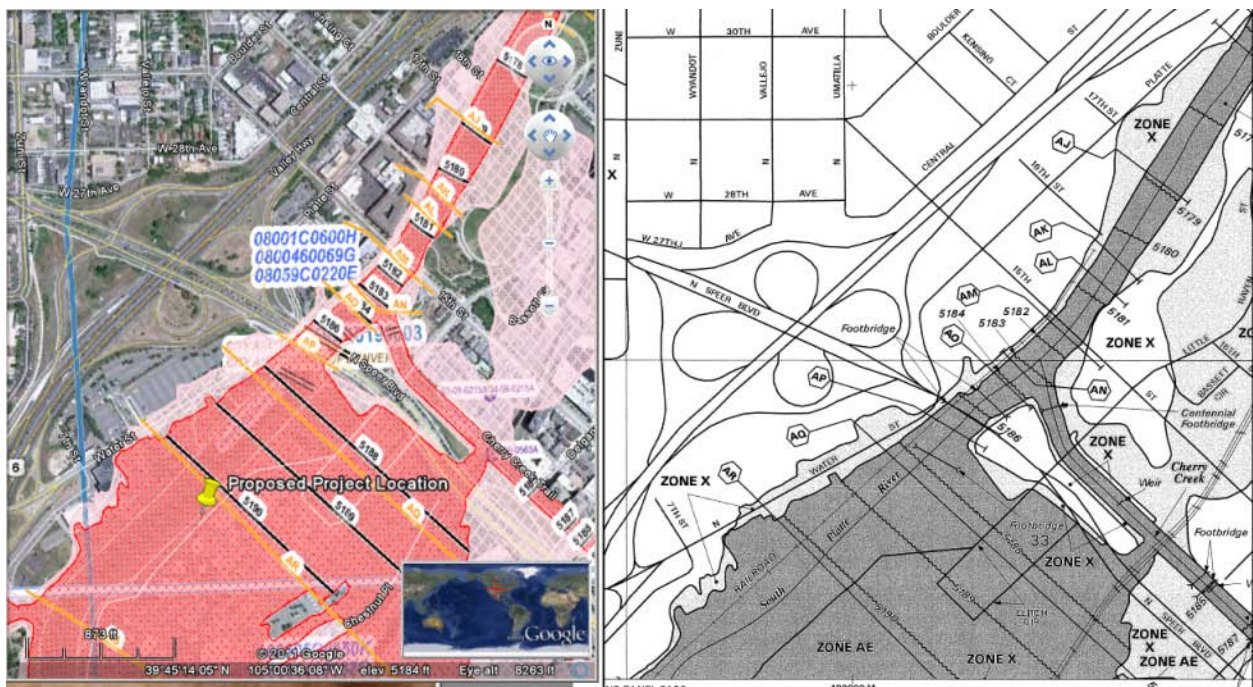
Figure 5.1: Comparison of NFHL (left) and FEMA Map Service Center FIRMette (right)

The NFHL indicates whether a proposed project location has flood hazard data.

1. Select the *Status of Digital Flood Hazard Data Coverage* "high altitudes option" in the left panel (Figure 5.2).
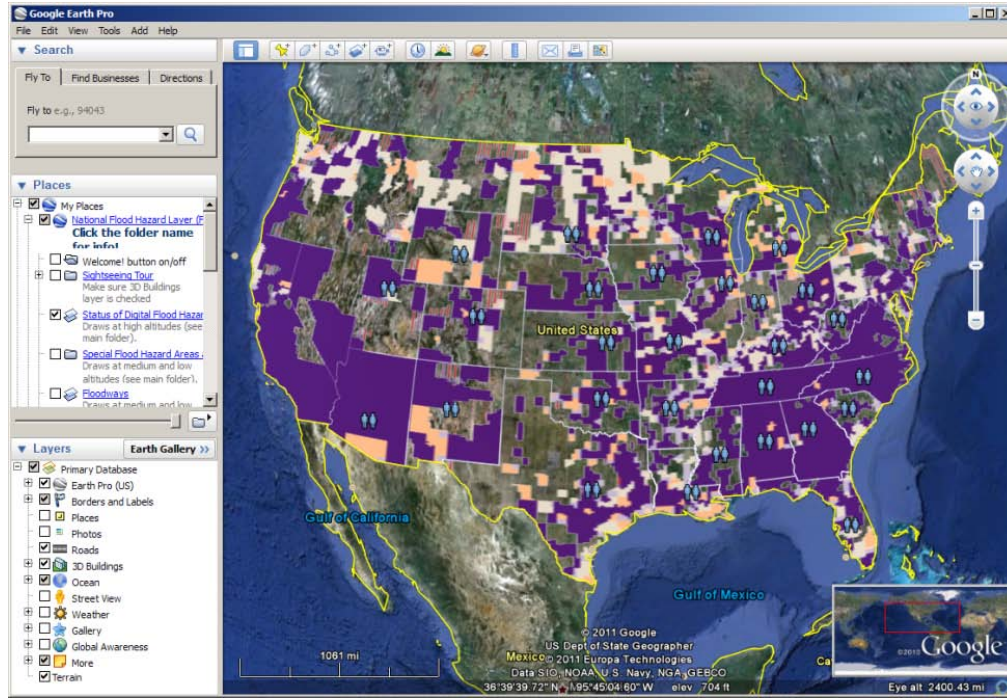
Figure 5.2: NFHL high altitudes option

2. Zoom to a medium altitude (Figure 5.3) to view the SFHAs, other zones, floodways, communities, and the FIRM and LOMR boundaries. These areas, zones, and boundaries are important in locating the appropriate FIRM and associated FIS.
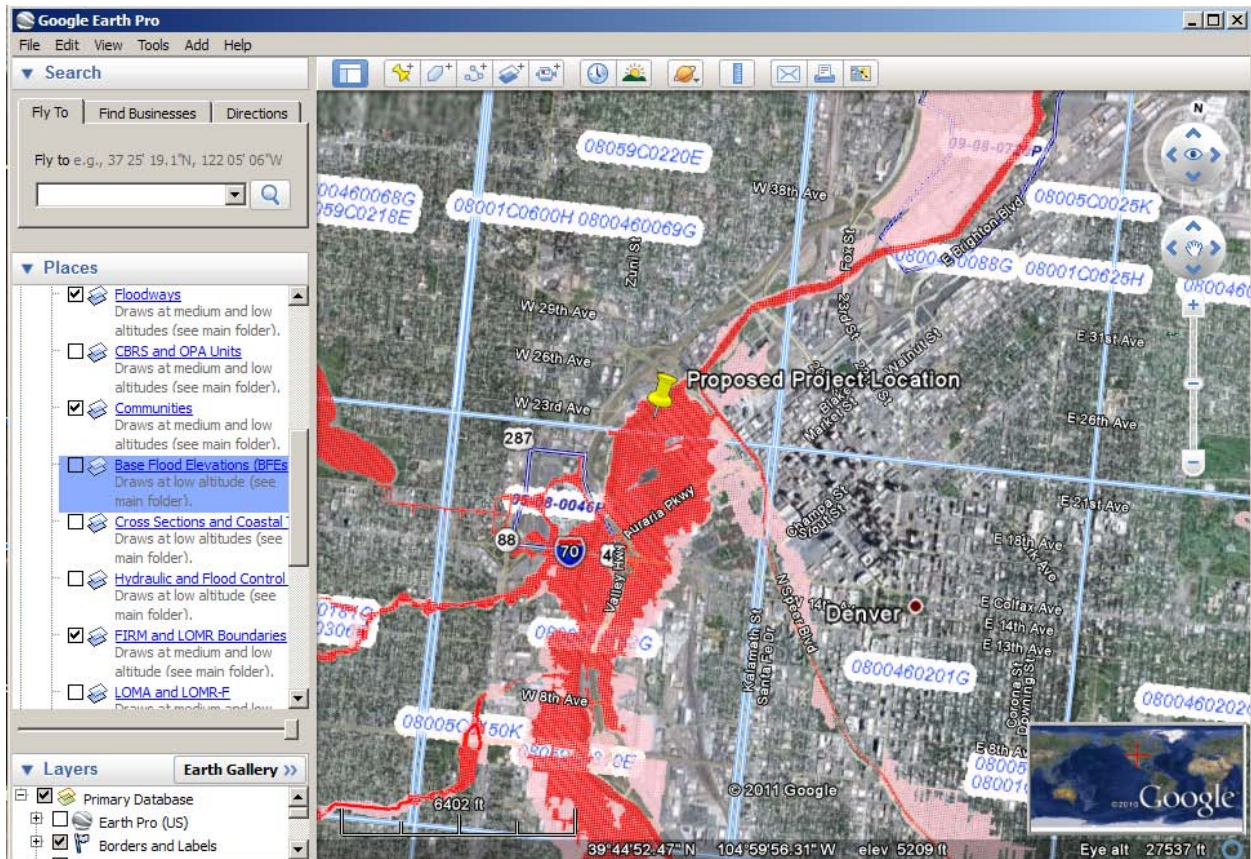
Figure 5.3: NFHL medium altitude areas, zones, and boundaries

3. Zoom to a low altitude to see BFEs, cross-sections, coastal transects, hydraulic and flood control structures, and areas affected by a Letter of Map Amendment (LOMA) or Letter of Map Revision (LOMR).

4. Using the NFHL allows the user to delineate the proposed project location within the SFHA, the associated FIRM number, the BFE, and the appropriate cross-section (or transect) to use when referencing the associated FIS, as shown in Figure 5.4.
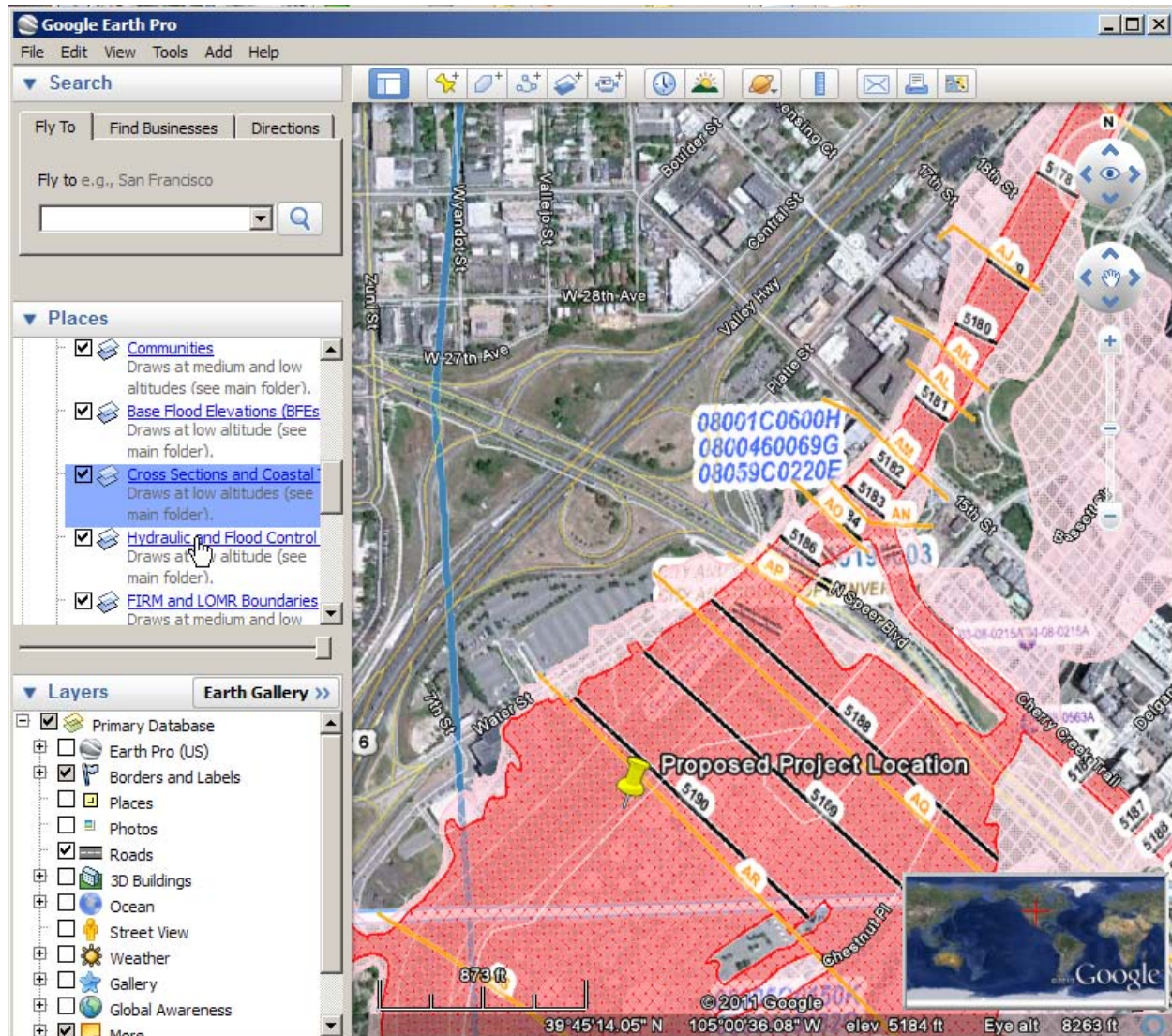
Figure 5.4: Proposed project location on NFHL

5.1.1.2   USGS Streamflow Data

The USGS Streamflow Data layer in Google Earth may help the user find the stream gage closest to the proposed project location, and finding the closest stream gage may help determine a recurrence interval for storm event(s) related to the proposed mitigation projects location (see also Section 2.2.2).

1. Users can obtain Google Earth Streamflow KML files at http://waterwatch.usgs.gov/new/?id=real&sid=w__kml. USGS stream gage data in a keyhole markup language (KML) format.

2. In Google Earth, select "real-time USGS.krmz" to view a real-time USGS stream gage map that is color-coded for flow conditions, as shown in Figure 5.5.
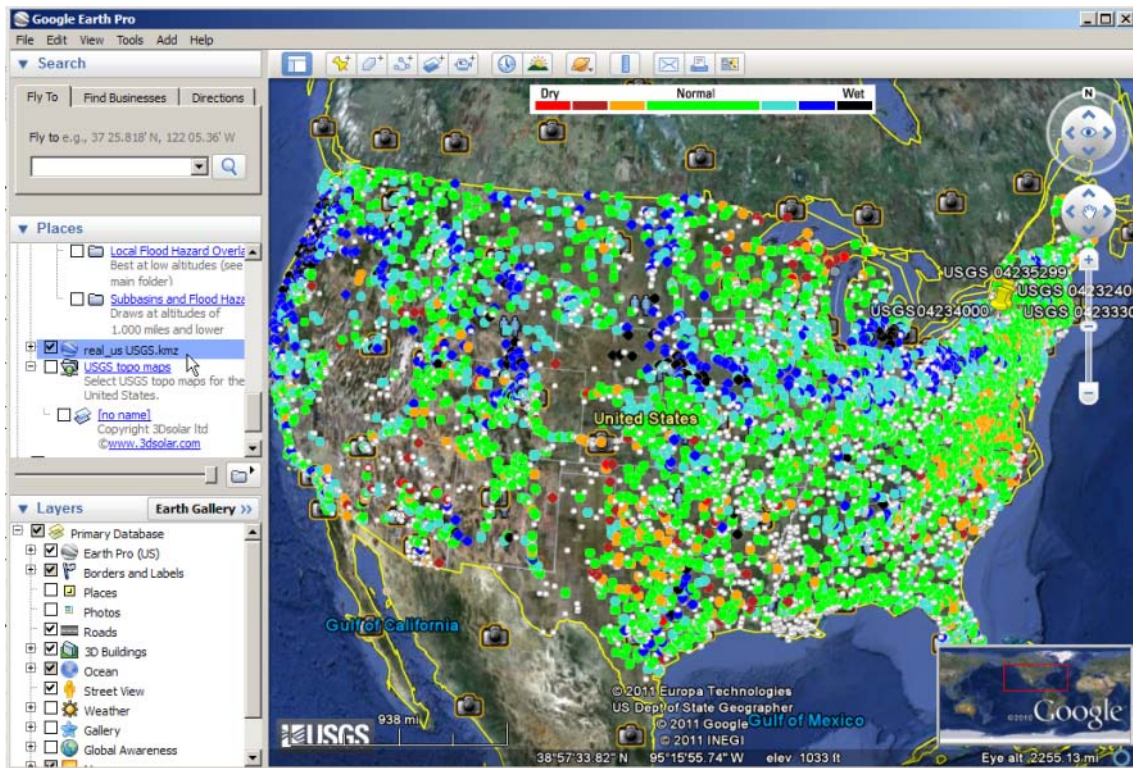
Figure 5.5: USGS streamflow gages

3. Click on the stream gage symbol to displays the station number, station name, and stream flow and stage data, as shown in Figure 5.6.
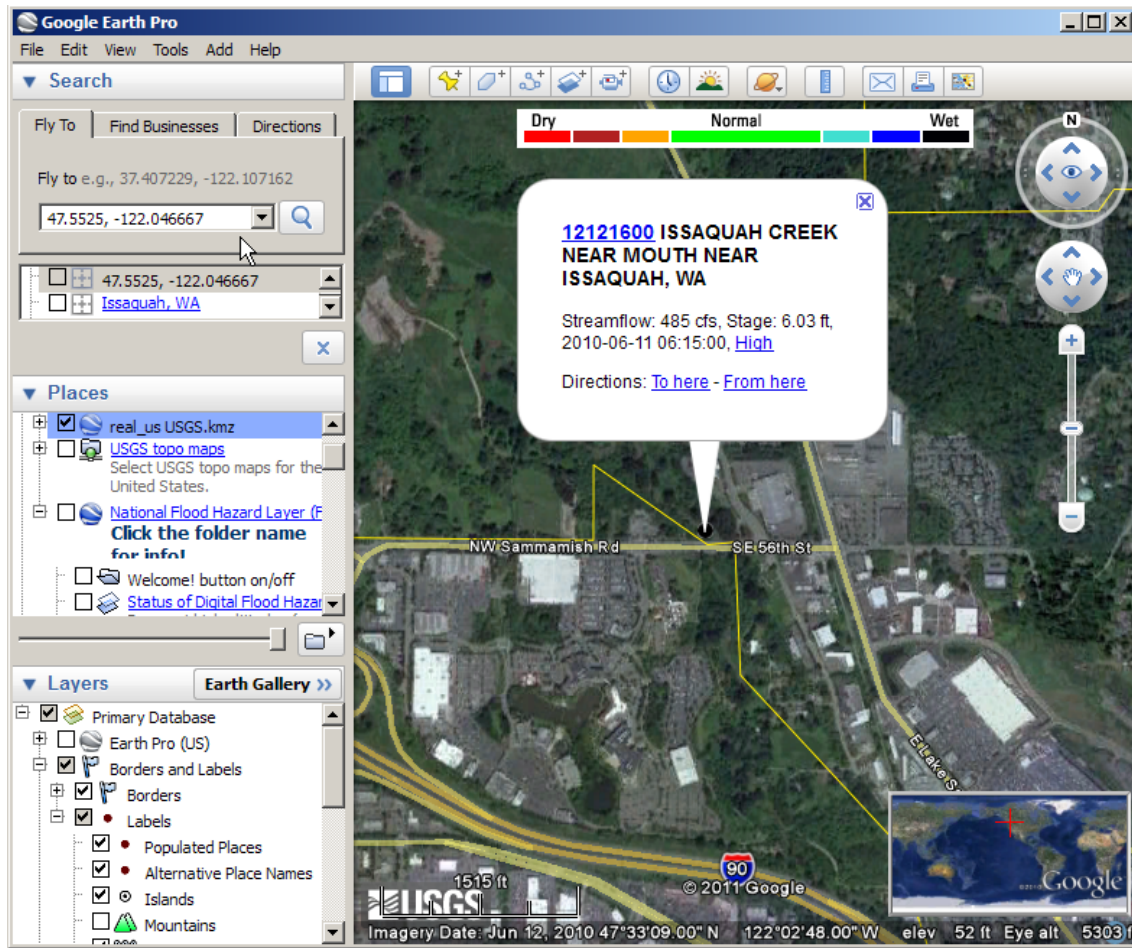
Figure 5.6: USGS station number display

4. Click on the station number in the pop-up window to access the USGS Web site and up-to-date information regarding all stream flow data collected at the site.

   For details regarding obtaining historical stream gage data and determining recurrence intervals from this data, refer to Section 2.1.2.

5.1.1.3   Spatial Calculations

The Google Earth Ruler feature shown in Figure 5.7 can be used to calculate and document required distances such as detour route and distance for use in the DFA module and a 0.5-mile radius for use in the Tornado Safe Room module.

Figure 5.7: Google Earth Pro toolbar

Detour Route and Distance

In the *Value of Services: Roads/ Bridges* portion of the BCA DFA module, the user must enter the facility description, estimated number of one-way traffic trips per day, additional time per one-way trip due to detour, number of additional miles (see screenshot) by providing maps showing the location of the road closure and the proposed detour route. The proposed location of the road closure and the detour route with distance can be drawn using the Google Earth "Show Ruler" feature in the top tool bar (see Figure 5.7)
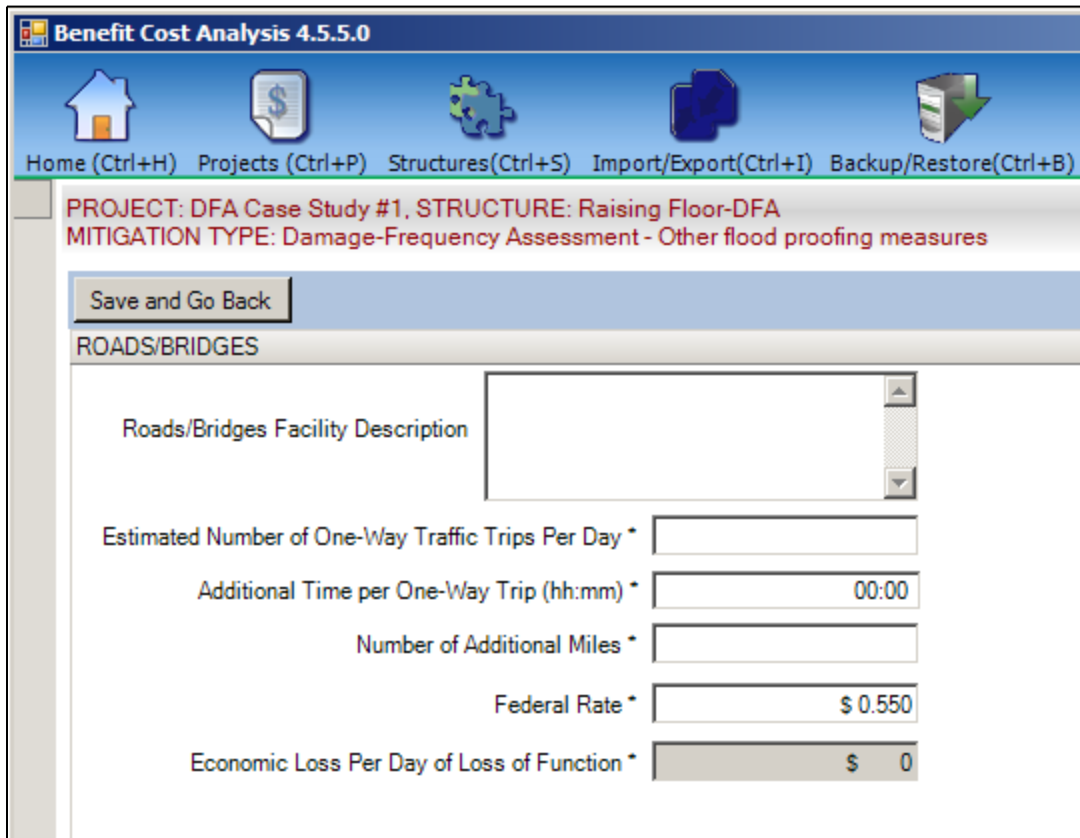
Calculate the proposed location of the road closure and the distance of the detour route by highlighting a detour path using *Length: Miles*. A screen shot of the detour and the Ruler pop-up box indicating the length of the detour can be attached as acceptable documentation (see Figure 5.8).
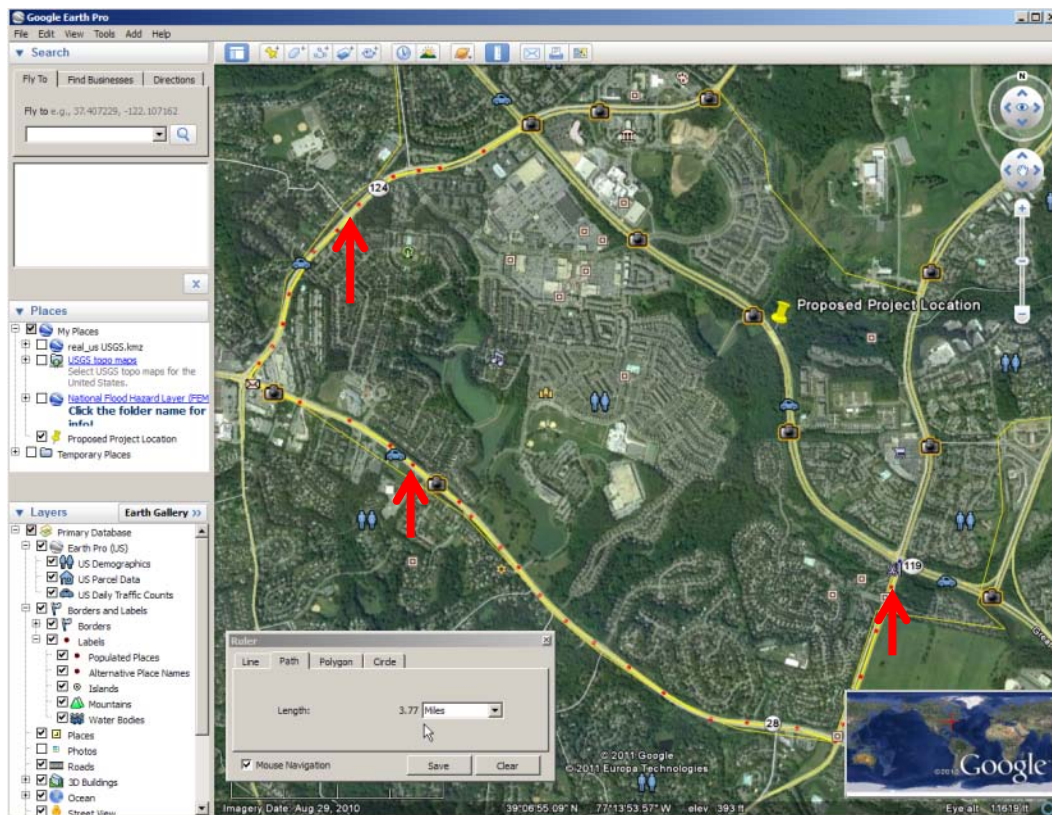
Figure 5.8: Proposed detour and distance

Safe Room Radius

In identifying the Safe Room Structure type in the Tornado Safe Room module, the user is asked the size (radius, in miles) of the community that will use the safe room and the predominant structure type(s) that people will leave to go to the safe room. Users are asked to estimate a radius around the safe room location. A 0.5-mile radius or 5-minute walking distance is an acceptable default value per the *FY11 HMA Unified Guidance (FEMA*, 2010a).

Users are asked to provide a copy of a radius map using aerial photography showing the proposed safe room location and radius. Additionally, the user is asked to select the two predominant structure types the target population within the radius would reside in if they do not use the safe room. Both inputs can be documented and justified using a radius map showing structure detail. A radius map can be obtained using the Ruler feature in Google Earth.

The Ruler feature may be used to draw a circle having a 0.50-mile radius from the proposed project's location to determine the structures that would benefit from a safe room. Two 0.50-mile paths should be drawn using the Ruler feature, as shown in Figure 5.9, and a circle should be drawn to connect the end points using drawing software.
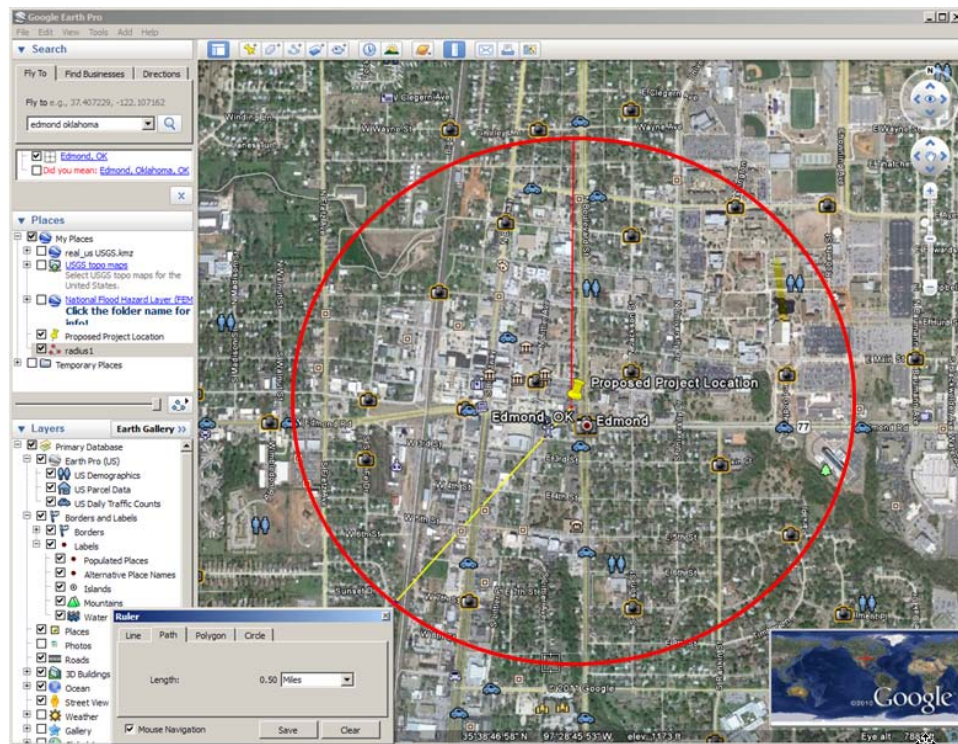
Figure 5.9: Using Google Earth Pro to determine 0.50-mile radius from the project location

5.1.2   Using Google Earth Pro License

With an investment in a Google Earth Pro license, additional inputs are available through Google Earth, including U.S. demographics, U.S. parcel data (which includes residential square footage and year built, and commercial annual revenue and other pertinent commercial information) and U.S. daily traffic counts. Since Web-based sources are acceptable documentation, information provided through the Google Earth Pro license is a potential resource.

To access the U.S. layers, the user should click the expand symbol next to the Earth Pro (U.S.) folder in the Layers panel to the side of the 3D viewer and select the desired layer(s), as shown in Figure 5.10.
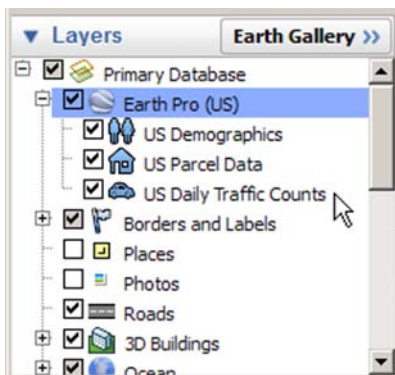
Figure 5.10: Data layers available in Google Earth Pro (U.S.)

U.S. Demographics

The U.S. Demographics layer can be used to determine the average household size and to calculate the population served (Safe Room module), as shown in Figure 5.11.
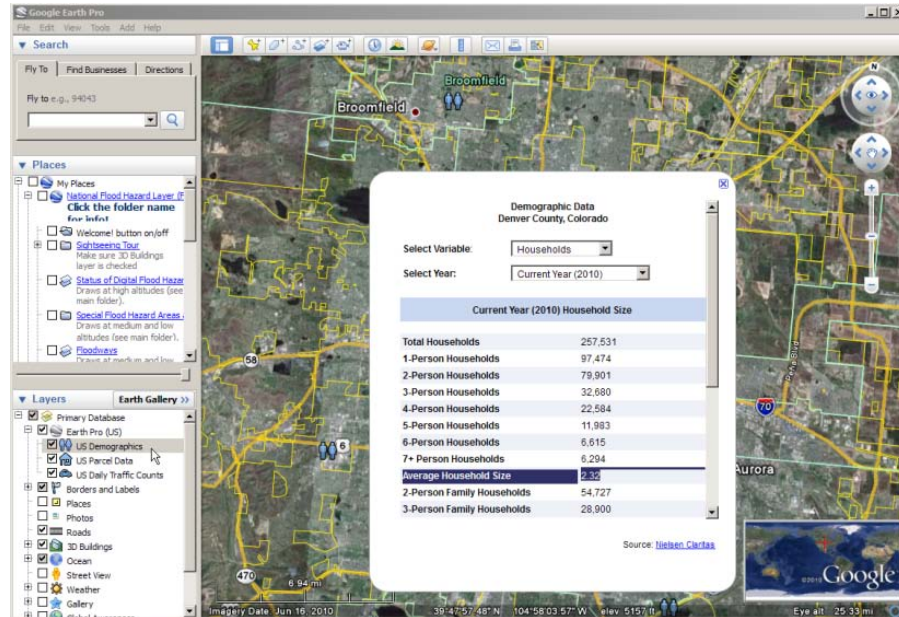
Figure 5.11: U.S. demographics using Google Earth Pro

U.S. Parcel Data

Similarly, certain residential and commercial information can be obtained from the U.S. Parcel Data layer, which is considered acceptable documentation. For residential structures, the data layer can be used to determine residential square footage (for the Flood module) and year built (for the DFA module), as shown in Figure 5.12.
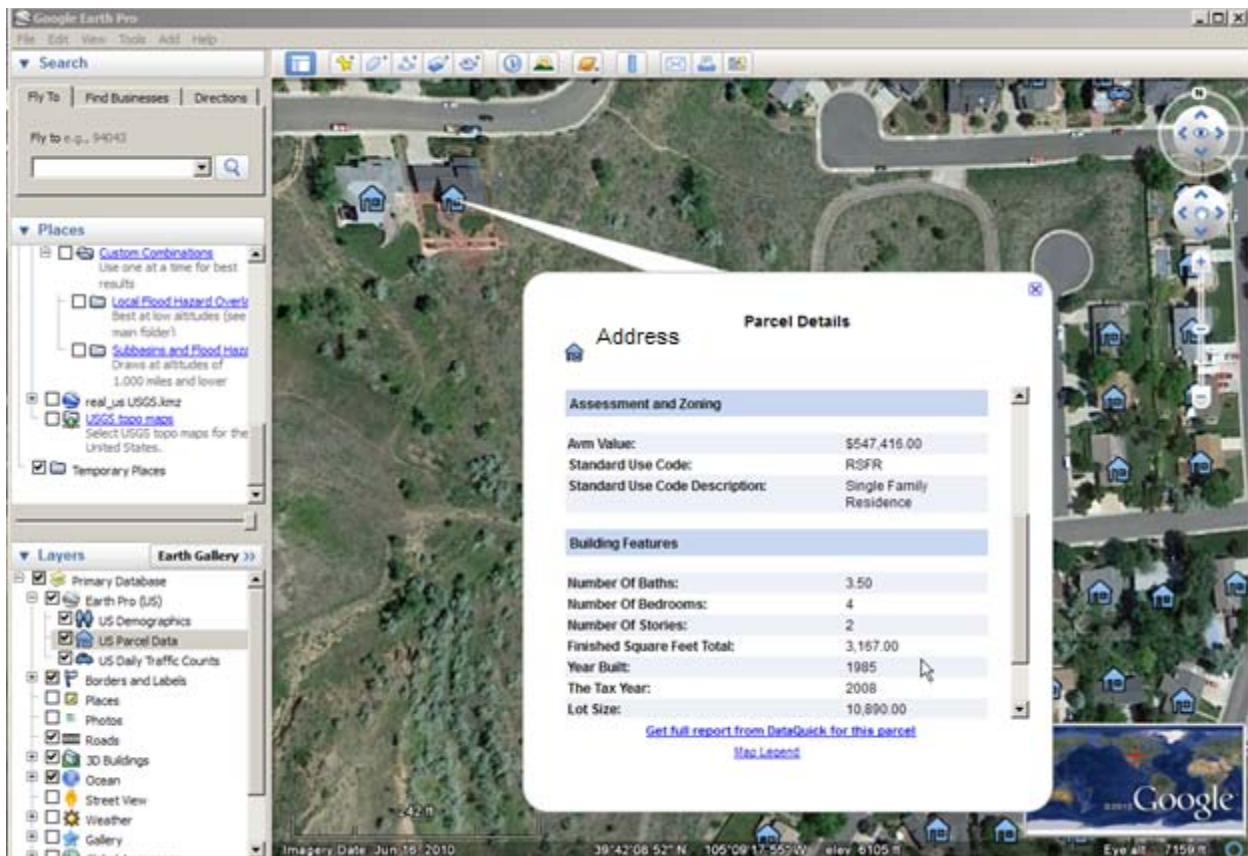
Figure 5.12: U.S. parcel data using Google Earth Pro

The Automated Value Model (AVM) used by Google Earth Pro to value properties is not acceptable for calculating the BRV. AVMs such as that used by Google Earth are statistical computer programs that use real estate information such as comparable sales, property characteristics, tax assessments, and price trends to provide an estimate of value for a specific property. Acceptable documentation of the BRV includes tax records or tax cards; property appraisals from a building inspector or local contractor; estimates from an architect, engineer, or local building official; and documented data from a national cost-estimating guide.

For commercial structures, the U.S. Parcel Data layer can be used to determine the annual operating budget and details such as the number of beds in a hospital.

U.S. Daily Traffic Counts

The U.S. Daily Traffic Counts layer available in Google Earth Pro provides an easy way to determine the average annual daily traffic count for a proposed road, as shown in Figure 5.13.
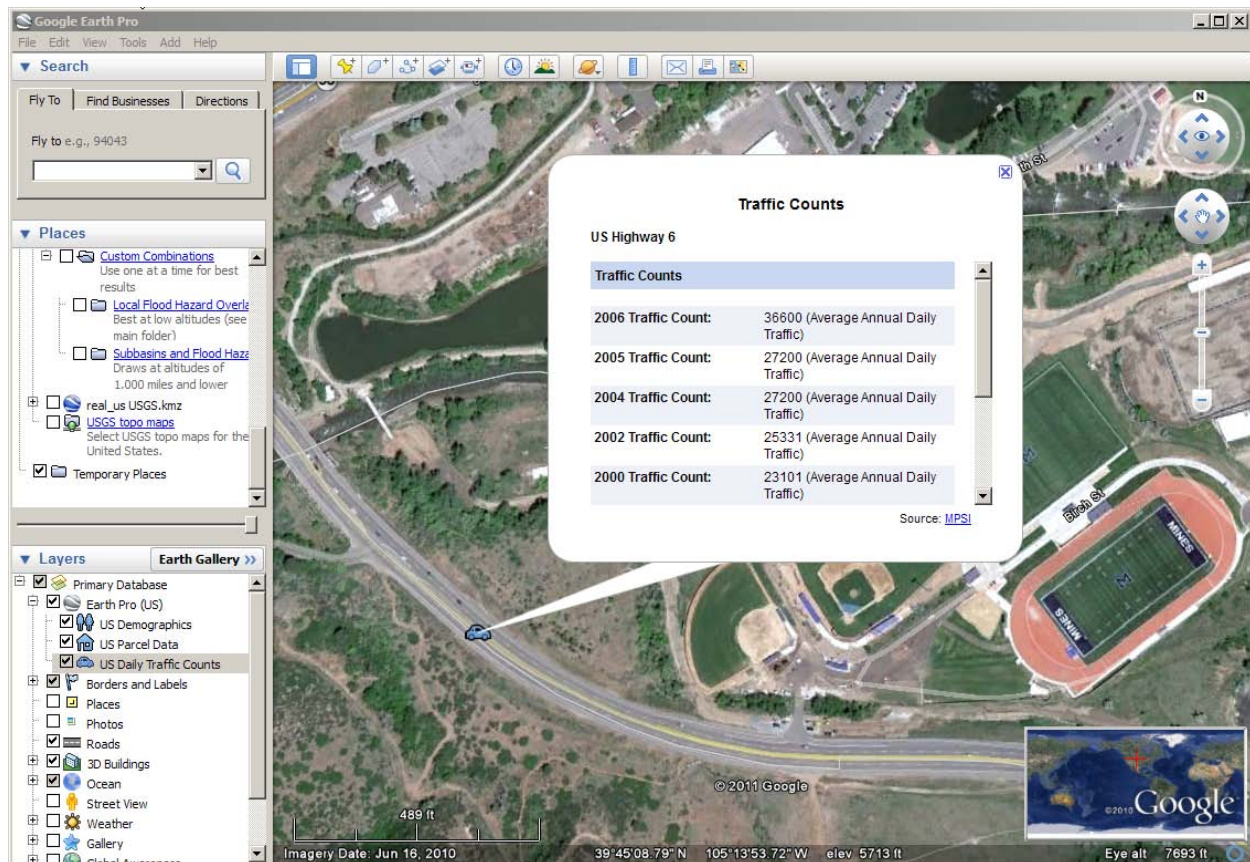
Figure 5.13: Daily traffic counts using Google Earth Pro

The estimated number of one-way traffic trips per day is expressed as a traffic count that typically includes the total number of vehicles that pass a given point in both directions. Though unlikely, the average daily traffic (ADT) could be reported for some divided roadways for each direction separately. Such ADTs should be indicated as directional. Unless Google Earth indicates otherwise, users can assume the ADT is for vehicles that pass a given point in both directions.

The ADT value can be entered into the BCA software for a proposed detour. For road or bridge losses that do not have detours, the number of daily trips should be based on the number of one-way trips (equivalent to the ADT), and the delay time should be 12 hours per one-way trip. Such losses should be documented using maps that clearly show that no detour is available. In addition, no additional miles due to delay can be counted.

5.1.3   Using Hazus for Flood Analysis

The FEMA Hazards U.S. (Hazus) model is a national model that uses standardized methodologies for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses GIS technology to compare hazard distributions and their probabilities with property locations to provide estimates of potential losses. Information about obtaining the Hazus software and user and technical manuals is available at the FEMA Web site (search for Hazus User or Technical Manuals for a particular version, e.g., MR2, MR5, at http://www.fema.gov/).

While originally developed primarily as a regional planning and disaster management tool, Hazus is increasingly being used in local planning, including screening mitigation grant applications. However, Hazus and FEMA BCA methodologies have some fundamental differences, and only certain Hazus information is considered acceptable for a FEMA BCA.

The following subsections provide information on the acceptable and unacceptable uses of Hazus methodologies for a FEMA BCA.

The acceptable uses of Hazus information are (see Section 5.1.3.1):

- Depth-damage functions (Flood module)
- Contents values (Flood module)
- Displacement values (Flood module)
- Flood module loss calculations (DFA module)

The unacceptable uses of Hazus information are (see Section 5.1.3.2):

- Level 1 analysis
- Level 2 and Level 3 analyses for census blocks
- Level 2 and Level 3 analyses for user-defined facilities

5.1.3.1   Acceptable Uses of Hazus

Depth-Damage Functions

During the development of BCA Version 4.5.5, DDFs included in Hazus Major Release 2 (MR2) were incorporated into the FEMA BCA Flood module for damage to building, contents, displacement, and loss of function. These DDFs are based on curves originally developed by the USACE and the Flood Insurance Administration (FIA). In addition, FEMA developed several other non-residential DDFs for BCA Version 4.5.5.

In the Flood module, the user can select USACE DDFs, FIA DDFs, or enter custom DDFs (see Section 2) on either the Residential Structure Information or Non-Residential Structure Information screen. The DDFs available are based on the selections the user made on the previous screen (Structure Information) about structure type (residential vs. non-residential), number of stories, and basement type.
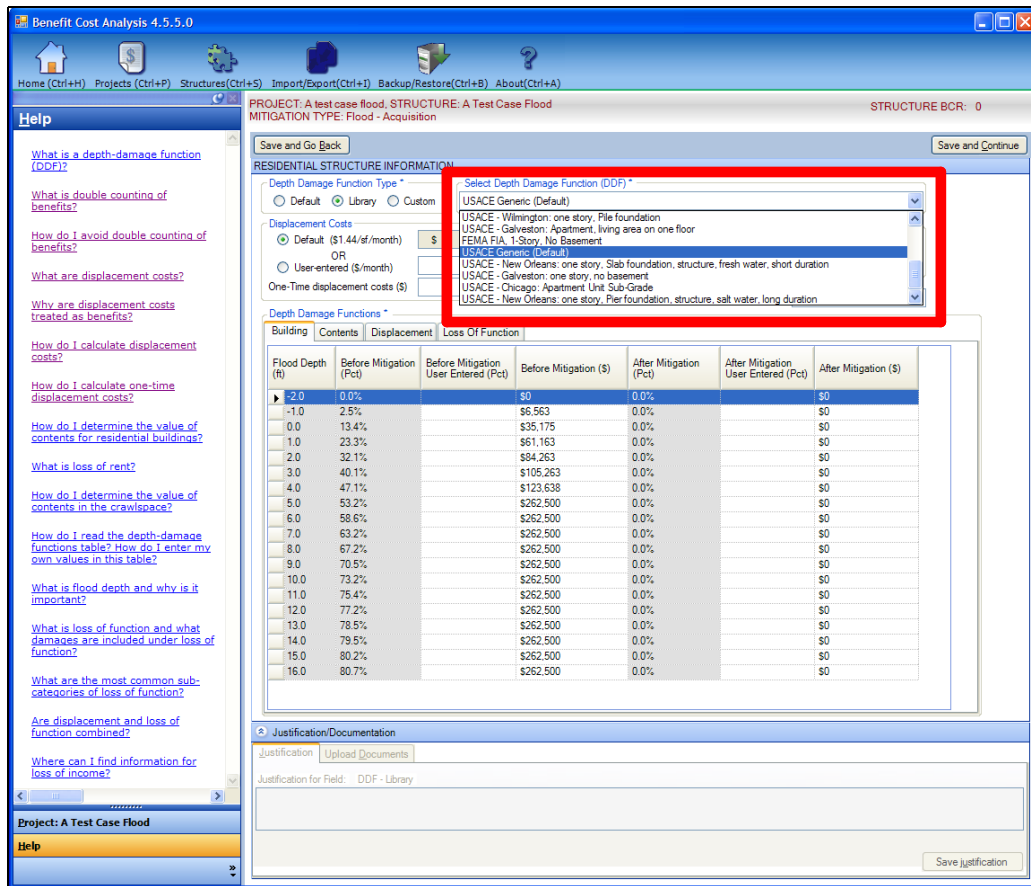
1. Users conducting a Flood module analysis typically use the default USACE Generic DDF rather than a FIA DDF.

2. To use a DDF that is available in Hazus but not available in the Flood module, the user must select *Custom* as the *Depth-Damage Type* and enter the DDF as shown in the screenshot below.
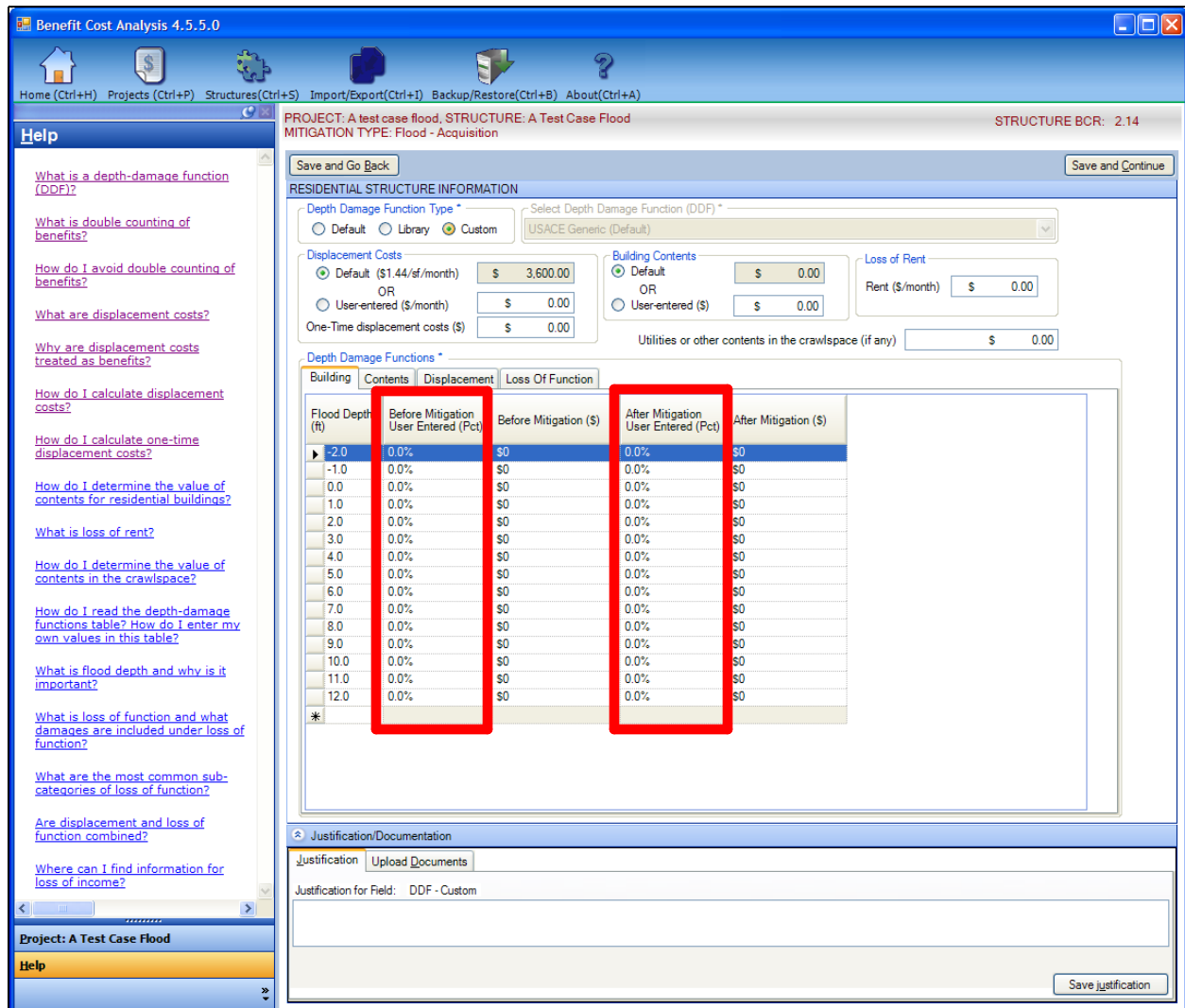
3. User must enter a total of four DDFs (building, contents, displacement, and loss of function). For non-residential buildings, the same DDF can be used for displacement and loss of function for buildings whose occupants cannot temporarily relocate while flood repairs are completed, such as industrial companies.

Contents Values

During the development of BCA Version 4.5.5, Hazus MR2 contents values were used to develop default values for different building types, as listed in Table 10.

Table 10: Hazus MR2 Default Contents Value Based on Percentage of Structure Value

No.	Hazus Occupancy Class Code	Hazus Occupancy Class Description	Contents Value (% of BRV)
Residential			
1	RES1	Single Family Dwelling	50
2	RES2	Mobile Home	50
3	RES3	Multi Family Dwelling	50
4	RES4	Temporary Lodging	50
5	RES5	Institutional Dormitory	50
6	RES6	Nursing Home	50
Commercial			
7	COM1	Retail Trade	100
8	COM2	Wholesale Trade	100
9	COM3	Personal and Repair Services	100
10	COM4	Professional/Technical/Business Services	100
11	COM5	Banks	100
12	COM6	Hospital	150
13	COM7	Medical Office/Clinic	150
14	COM8	Entertainment & Recreation	100
15	COM9	Theaters	100
16	COM10	Parking	50
Industrial			
17	IND1	Heavy	150
18	IND2	Light	150
19	IND3	Food/Drugs/Chemicals	150
20	IND4	Metals/Minerals Processing	150
21	IND5	High Technology	150
22	IND6	Construction	100
Agriculture			
23	AGR1	Agriculture	100
Religion/Non-Profit			
24	REL1	Church/Membership Organization	100
Government			
25	GOV1	General Services	100
26	GOV2	Emergency Response	150
Education			
27	EDU1	Schools/Libraries	100
28	EDU2	Colleges/Universities	150

The exception to these defaults is when users select residential USACE Generic DDFs. The BCA software uses 100% of the BRV for the contents replacement value as the default when USACE Generic DDFs are selected because the content-to-structure value ratio is already incorporated in the contents DDF.

When conducting a Flood module analysis, the user normally uses the default contents values provided by the BCA software. The default contents values are based on the DDF selection (residential or non-residential/primary use, number of stories, basement type, and default or generic). However, in some situations, the primary building use for non-residential buildings

does not match a Hazus occupancy class (e.g., schools). For example, the BCA software does not have college or university (Hazus Occupancy Class EDU2) as a non-residential option. Therefore, it is acceptable for the user to enter a user-defined contents value based on the Hazus defaults from Table 10.

Displacement (Monthly and One-Time) Values

For residential buildings (typically single family), the Flood module uses a default value of $1.44/sf/month as the default displacement cost on the Residential Structure Information screen. The default residential displacement cost includes both monthly (rental) and one-time (disruption) costs.

Hazus provides additional acceptable default values for both monthly and one-time displacement costs for other residential and non-residential structure types, as shown in Table 11.

To calculate monthly displacement costs for other residential building types (e.g., mobile home, apartments), the user should select the *User-Entered ($/month)* radio button (screenshot above) to override the default displacement value, and then follow these steps:

1. From Table 11, select the most appropriate residential occupancy class and obtain the displacement cost (rental cost) from Column A.

2. Multiply the displacement cost from Column A of Table 11 ($/sf/month) by the building area (sf) to calculate the displacement cost ($/month).

3. Adjust this value from the 2008 value to the current year by using the consumer price index (www.bls.gov).

4. Enter the cost into the field labeled *User-Entered ($/month)*.

Table 11: Hazus MR3 Displacement Costs (2008 Values)

Building Type		Displacement Costs	
HAZUS-MH MR3 Label	Occupancy Class	[A] Rental Cost (2008)	[B] Disruption Costs (2008)
		$/ft²/month	$/ft²
Residential			
RES1	Single Family Dwelling	0.73	0.88
RES2	Mobile Home	0.51	0.88
RES3	Multi Family Dwelling (All Types, includes duplex to 50+ units)	0.65	0.88
RES4	Temporary Lodging	2.19	0.88
RES5	Institutional Lodging	0.44	0.88
RES6	Nursing Home	0.80	0.88
Commercial			
COM1	Retail Trade	1.25	1.17
COM2	Wholesale Trade	0.52	1.02
COM3	Personal and Repair Services	1.46	1.02
COM4	Professional/Technical/Business	1.46	1.02
COM5	Banks	1.82	1.02
COM6	Hospital	1.46	1.46
COM7	Medical Office/ Clinic	1.46	1.46
COM8	Entertainment and Recreation	1.82	0.00
COM9	Theaters	1.82	0.00
COM10	Parking	0.36	0.00
Industrial			
IND1	Heavy	0.21	0.00
IND2	Light	0.29	1.02
IND3	Food/Drugs/Chemicals	0.29	1.02
IND4	Metals/Mineral Processing	0.21	1.02
IND5	High Technology	0.36	1.02
IND6	Construction	0.15	1.02
Agricultural			
AGR1	Agriculture	0.73	0.73
Religious/Non-Profit			
REL1	Church/Membership Organization	1.09	1.02
Government			
GOV1	General Services	1.46	1.02
GOV2	Emergency Response	1.46	1.02
Education			
EDU1	Schools/Libraries	1.09	1.02
EDU2	College/Universities	1.46	1.02

Source: HAZUS-MH MR3 Flood Technical Manual, Table 14.10. The 2006 HAZUS values were inflated using the CPI for 2007 and 2008 from the Bureau of Labor Statistics (bls.gov) Historical CPI Data

For non-residential buildings, the Flood module does not have a default value for displacement costs ($/month). Therefore, a similar calculation can be performed using Table 11 and entered on the Non-Residential Structure Information screen shown below.

PROJECT: Flood Test Project 1, STRUCTURE: Building A
MITIGATION TYPE: Flood – Acquisition

Save and Go Back

STRUCTURE INFORMATION

Total size of building (sf) * 5000
Value of building (BRV) ($/sf) * 70.00
Total value of building (BRV) .... $ 350,000
Demolition damage threshold (%) 50.00%
Is the building Residential? * ○ Yes ◉ No

NON-RESIDENTIAL STRUCTURE DETAILS
Type of Structure *
◉ Engineered ○ Pre-Engineered

Select primary use of building * Retail-Clothing
Building Contents ($)
◉ Default 29 % .... $ 101,500
○ Other .... $ 0

Displacement costs ($/month) .... $ 12,500
One-Time displacement costs ($) .... $ 11,700

Column A in Table 11 shows the monthly rental costs, per sf, for various occupancy classes. These values may be used as FEMA standard values for the monthly displacement cost. To calculate monthly displacement costs for non-residential buildings, these steps should be followed:

1. Select the most appropriate occupancy class and obtain the corresponding displacement cost (rental cost) from Column A of Table 11.

2. Multiply the displacement cost from Column A of Table 11 ($/sf/month) by the total building area (in sf) to calculate the displacement cost ($/month).

3. Adjust this value from 2008 value to current year by using the consumer price index (www.bls.gov).

4. Enter the cost into the field labeled *Displacement Cost ($/month)* shown in the screenshot above.

Note that in this non-residential building example, the total building size is 10,000 sf and the first floor area is 5,000 sf. The first floor area (5,000 sf) is entered in the *Total Size of Building* cell because the default building and contents DDFs for non-residential buildings apply only to first floor damages. However, the total building area (10,000 sf) is used to calculate displacement costs because the total floor area is occupied as shown below.

For this example the monthly displacement cost for a retail clothing building is calculated as follows:

Monthly displacement cost = [rental cost ($/sf/month)] x [total area (sf)]

= ($1.25/sf/month) x (10,000 sf)

= $12,500/month

Table 11 is also used to calculate one-time displacement costs. To calculate one-time displacement costs, also known as disruption costs, for both residential and non-residential structures, these steps should be followed:

1. Determine the appropriate occupancy class from Table 11.

2. Multiply the associated disruption cost ($/sf) from Column B of Table 11 by the total building area (in sf) to calculate the one-time displacement cost.

3. Adjust this value from 2008 value to current year by using consumer price index (www.bls.gov).

4. Enter the cost into the field labeled *One-Time Displacement Costs ($).*

The default residential displacement cost ($1.44/sf/month), which applies to single-family dwellings, already incorporates one-time displacement costs. Do not include one-time displacement costs if the default residential displacement cost is selected.

For the example shown in the screenshot above, the one-time displacement cost for the *Retail-Clothing building* is calculated as:

One-time displacement costs = [disruption cost ($/sf)] x [total area (sf)]

= ($1.17/sf) x (10,000 sf)

= $11,700

Flood Module Loss Calculations in DFA Module

While the previous three subsections have focused on the use of information obtained from Hazus to use in the Flood module, but some Hazus information is acceptable for the DFA module. The general approach is for the user to use the DDFs and other loss calculations in the Flood module to derive values that can be entered in the DFA module. See Section 2.1.4 for details on how to implement this method.

5.1.3.2 Unacceptable Uses of Hazus

Hazus Level 1 Analysis

The Hazus Level 1 Analysis is defined in the *Hazus MR5 User Manual* (available at http://www.fema.gov/library/viewRecord.do?id=4454) as the simplest type of Hazus analysis, which is based primarily on data provided with the software. The assumption is that the user is using (1) Hazus-based H&H study methods and (2) the built environment as modeled from Hazus-based General Building Stock (GBS) data, usually at the U.S. census block level.

However, neither of the Hazus approaches for H&H and GBS is considered acceptable for BCA. Hazus-based H&H normally uses 30- or 10-meter resolution topographic data (USGS digital

elevation model data), which do not meet BCA requirements for topographic or H&H modeling. For the Flood module, topographic data must satisfy a minimum vertical resolution equivalent to 2-foot contour data. H&H methods need to match the standards used for FEMA detailed flood studies, as described in the *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA 2003), and specifically the lists of acceptable H&H models. See *Numerical Models Meeting the Minimum Requirements of the National Flood Insurance Program* (FEMA 2010b) available at http://www.fema.gov/plan/prevent/fhm/en_modl.shtm.

Hazus Level 1 analysis census block-based GBS data also do not satisfy BCA requirements. This approach does not model actual buildings but uses statistical data to approximate the characteristics and damages across entire census blocks. This approach does not provide the level of detail needed for BCA.

Hazus Level 2 and 3 Analyses for Census Blocks

Hazus Levels 2 and 3 Analyses are defined by the *Hazus MR5 User Manual* as advanced analyses in Hazus. Level 2 is usually considered as updating Hazus datasets with better local data. The Level 3 analysis uses models that are external to Hazus, such as engineering and economic models.

For GBS data, the Levels 2 and 3 Analyses are available for updating the default Hazus datasets such as the Hazus Comprehensive Data Management System tool. However, as mentioned in the previous section, census block-based GBS methods in Hazus are not acceptable for BCA because actual buildings characteristics are not modeled. BCA methods for mitigation projects such as acquisition and elevation are based on building-by-building analysis, and Hazus census block-based approach are insufficient for this purpose.

Hazus Level 2 and 3 Analysis for User-Defined Facilities

Another Hazus approach is the User-Defined Facilities (UDF) analysis. In the UDF analysis, the user enters building point locations and structural information such as Hazus occupancy type, first floor height above grade, building and contents costs, number of stories, and foundation type. Hazus then uses GIS methods to query flood depth grids and Hazus DDFs to estimate building and contents losses. The UDF analysis can be useful for screening large numbers of buildings to determine the buildings that may be the best candidates for a BCA.

However, the fundamental differences between the Hazus and BCA approaches that make the Hazus UDF analysis unacceptable for BCA are as follows:

- *Topographic data requirements*. BCA requires a minimum vertical detail equivalent to 2-foot contours for mapping. Any flood depth grids derived in Hazus that do not use topographic data with that detail level are unacceptable for BCA.

- *H&H modeling methods*. The second set of differences concern H&H modeling methods. Level 1 Hazus-based H&H are not considered acceptable for BCA according to FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA 2003) because of the generalized attributes of the data.

  However, an experienced Hazus user could develop flood depth grids using Hazus Level 2 or 3 analysis that overcome the differences in topographic data requirements and H&H modeling methods. The Hazus Level 2 analysis allows the user to import flood depth grids developed from external models, such as the FEMA-acceptable model Hydrologic

Engineering Centers River Analysis System (HEC-RAS). Hazus also has the Flood Information Tool program that allows development of flood depth grids from cross-sectional data from external models. It is possible for a Hazus user to develop flood depth grids based on FEMA-acceptable models and with sufficient topographic details to satisfy the BCA requirements.

- *Loss calculation methods.* The primary reason the Hazus UDF analysis is considered unacceptable for BCA is the methods used to calculate losses for each recurrence interval and annualized loss. Although the Hazus UDF table and Hazus depth grids can be configured to return the same percent building damage (based on the same flood depth and building DDF) as the BCA, the way that BCA uses these values to derive annualized loss is different than Hazus. Hazus does not have the capability to calculate annualized loss when user-defined depth grids are used. Hazus MR4 does include an annualized loss calculation, but it applies only to scenarios that use Hazus-based H&H methods.

  In addition, the Hazus annualized calculation uses extrapolated 2- and 5-year recurrence interval events. Even these limited annualized loss calculations were removed for Hazus MR5. In contrast, the BCA uses the stream bed elevation to interpolate losses for events below the 10-year event. See the *Flood Full Data Module Methodology Report* for more information (available as part of the BCA Resource Kit at http://www.bchelpline.com/BCAToolkit/resources_flood.html).

- *Demolition threshold.* When building DDFs exceed the demolition threshold in the BCA software, the building damage is set to 100% and all other DDFs are set to their maximum for that structure type. Hazus does not use any demolition threshold as part of census block GBS or the UDF analysis.

There is currently no way to use a Hazus UDF analysis to replace a BCA Flood module analysis. Although the Hazus UDF analysis could be made to match certain parts of the BCA calculations, there are fundamental calculation differences between the Flood module and Hazus software. If a user has data such as detailed structure characteristics, a HEC-RAS analysis, and detailed flood depth and water surface elevations grids, these data could be used for the Flood module rather than trying to make Hazus approximate what the BCA software does by default.

SECTION SIX   REFERENCES

BCA Helpline. http://www.bchelpline.com/. Accessed June 2011.

Benefit-Cost Analysis Resource Kit. *Hazard: Flood.*
http://www.bchelpline.com/BCAToolkit/resources_flood.html. Accessed June 2011.

Bureau of Labor Statistics. http://bls.gov/. Accessed _June 2011.

Campoli, J., et al., 2001. *Above and Beyond, Visualizing Changes in Small Town and Rural Areas.* American Planning Association Press, Chicago, IL.

Council of Chief State School Officers, School Matters, 2011. School enrollment data.
http://www.schooldatadirect.org/. Accessed June 2011.

Federal Bureau of Investigation. 2006 Uniform Crime Reporting [UCR] Program.
http://www2.fbi.gov/ucr/cius2006/data/table_05.htmlAccessed October 2008.

FEMA (Federal Emergency Management Agency). 2003 with updates through 2009. *Guidelines and Specifications for Flood Hazard Mapping Partners.*
http://www.fema.gov/library/viewRecord.do?id=2206. Accessed June 2011.

FEMA. 2006 *Hazus-MH MR3 Flood Technical Manual*

FEMA. 2008. *Design and Construction Guidance for Community Safe Rooms* (FEMA 361). Second Edition, August 2008.

FEMA. 2010a. *Hazard Mitigation Assistance Unified Guidance: Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, Repetitive Flood Claims Program, Severe Repetitive Loss Program*, June 1, 2010

FEMA. 2010b. *Numerical Models Meeting the Minimum Requirements of the National Flood Insurance Program.* http://www.fema.gov/plan/prevent/fhm/en_modl.shtm. Accessed November 2011.

FEMA. 2010c *Hazus-MH MR5 Flood Technical Manual*

FEMA. 2011a. *Hazus FEMA's Methodology for Estimating Potential Losses from Disasters.*
http://www.fema.gov/plan/prevent/hazus/index.shtm. Accessed June 2011.

FEMA. 2011b. *Using the National Flood Hazard Layer Web Service (WMS) in Google Earth.*
https://hazards.fema.gov/femaportal/wps/portal/NFHLWMSkmzdownload. Accessed June 2011.

Lake County Illinois GIS and Mapping Division. 2010. *Topographic Map Gallery.*
http://oldapps.lakecountyil.gov/gis/TopoGallery/MapsInqMapName.asp. Accessed April 2011.

Missouri Census Data Center. Circular Area Profiles.
http://mcdc.missouri.edu/websas/caps.html. Accessed _June 2011.

Montgomery County Maryland. *Montgomery County Council.*
http://www.montgomerycountymd.gov/csltmpl.asp?url=/content/council/mem/district_map.asp. Accessed June 2011.

Montgomery County Maryland. *Montgomery County Council*. Council District 1. http://www.montgomerycountymd.gov//content/gis/images/gallery/councildistrict1.pdf.

Montgomery County Maryland. *Montgomery County Council*. Council District Population Change: 2000 to 2010 (adjusted) Montgomery County, Maryland. http://www.montgomerycountymd.gov/content/council/redistricting/Handouts/adjmoco_adjpop.pdf.

NOAA. Photograph used courtesy of Nick Witcraft. www.srh.noaa.gov. Accessed June 2011.

North Carolina Chapter of the American Society for Photogrammetry and Remote Sensing (NCASPRS). 2010. *Flood Analysis and Flood Mapping: Where is the First Floor?* www.ncasprs.com/pub/FirstFloorElevations_ncss.pptx. Accessed April 2010.

Spinell Homes. 2010. Models. *http://www.spinellhomes.com/models*. Accessed April 2010.

U.S. Census Bureau. 2009. Community Population Estimates. http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=&geo_id=16000US2462850&_geoContext=01000US%7C04000US24%7C16000US2462850&_street=&_county=poolesville&_cityTown=poolesville&_state=04000US24&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=160&_submenuId=factsheet_1&ds_name=null&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry=). Accessed June 2011.

U.S. Geological Survey. 2011. Google Earth Streamflow KML Files. http://waterwatch.usgs.gov/new/?id=real&sid=w__kml. Accessed June 2011.

United States Department of Agriculture (USDA). Data Sets. 2010. http://www.ers.usda.gov/Data/. Accessed June 2011.