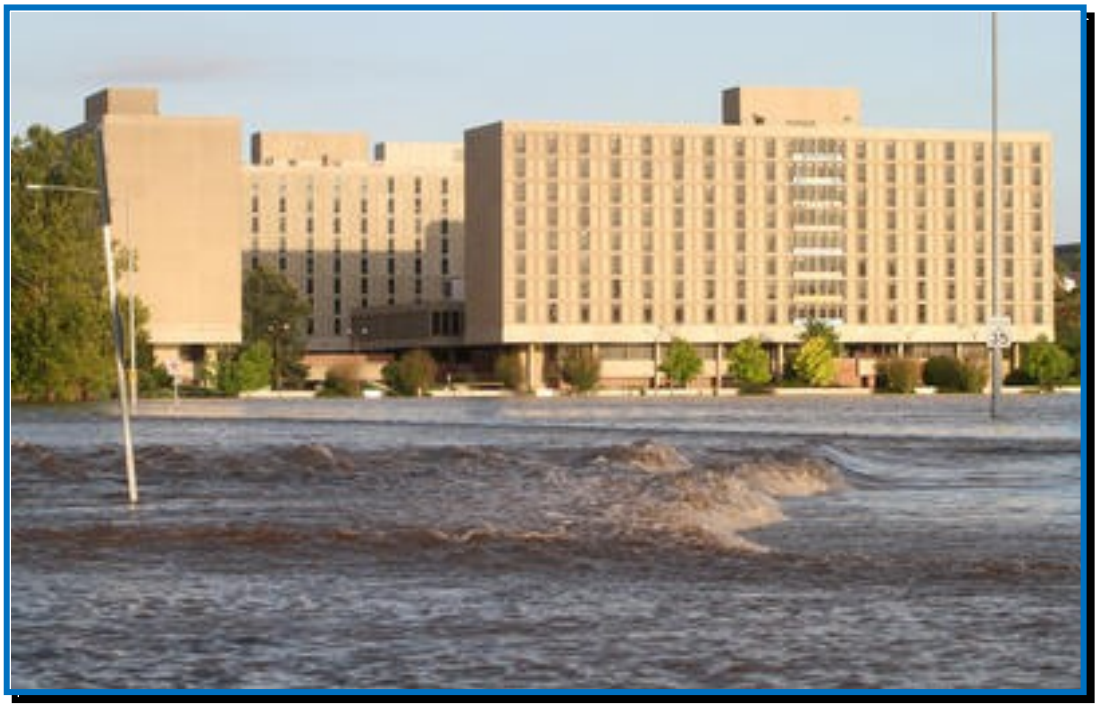
Iowa Homeland Security & Emergency Management

# Mitigation Loss Avoidance Study

Summer 2010 Flooding



Property Acquisition Team
May 2012

## Executive Summary

During the summer of 2010, Iowa experienced another extended period of heavy rainfall which resulted in severe flooding during the months of June and August. Several Iowa communities experienced flood levels exceeding the 500 year interval, and flood elevations in others exceeded historic records. Those communities which had previously completed Hazard Mitigation Grant Program (HMGP) projects and were affected by 2010 flooding are included in this study. The Study demonstrates the effectiveness of mitigation by calculating losses avoided amid a single flood event in 2010:

- Iowa State University
  - Project Cost (present value) $1,867,472
  - Losses Avoided $5,555,469
  - Losses Avoided to Cost Ratio 2.95
  - Return on Investment 1.98

- City of Des Moines
  - Project Cost (present value) $7,215,325
  - Losses Avoided $9,741,638
  - Losses Avoided to Cost Ratio 1.35
  - Return on Investment .35

- City of Cherokee
  - Project Cost (present value) $11,516,748
  - Losses Avoided $8,167,831
  - Losses Avoided to Cost Ratio .71 (after only 1 flood event)
  - Return on Investment -.29

- City of Ames
  - Project Cost (present value) $2,051,686
  - Losses Avoided $1,460,244
  - Losses Avoided to Cost Ratio .71 (after only 1 flood event)
  - Return on Investment -.29

## Flood Events Following Prior Mitigation

This study has identified which communities throughout Iowa both experienced flooding in 2010 and previously implemented mitigation projects. Three major communities fit this description; Ames (including Iowa State University), Des Moines, and Cherokee.

After the Great Midwestern Floods of 1993 (disaster # 0996), Iowa State University (ISU) built a flood wall around the Maple-Willow-Larch residence hall complex on campus. Additionally, the City and Story County acquired 33 properties in the Special Flood Hazard Area (SFHA) and converted the acquired land to open space in perpetuity. 2010 flooding reached this flood wall, but because of its presence waters were not able to inundate the residence hall complex. Flood waters also spread across the City, well outside of the SFHA boundaries. All properties acquired during the 0996 performance period were

within the SFHA boundaries, and as such would have experienced flood damage again in 2010 had structures still been present.

The City of Des Moines has completed three different HMGP Acquisition projects in its history, the first after the floods of 1993. This first project resulted in the acquisition of 83 properties. The second project was implemented after flooding in 1998 (disaster # 1230), where the City acquired 26 properties. In 2009, after major flooding in 2008 (disaster # 1763), Des Moines had just finished acquiring and demolishing 12 properties near Fourmile Creek when the 2010 flood set new, unofficial records at stream gages along Fourmile's banks.

The City of Cherokee was flooded more moderately in 2010, but was affected nonetheless. Flood waters crested at 27.3 feet as indicated by the Little Sioux River gage on the south side of the City. This flood elevation would have been sufficient enough to damage 180 of the 211 properties acquired after the 1993 flood disaster.

## Losses Avoided

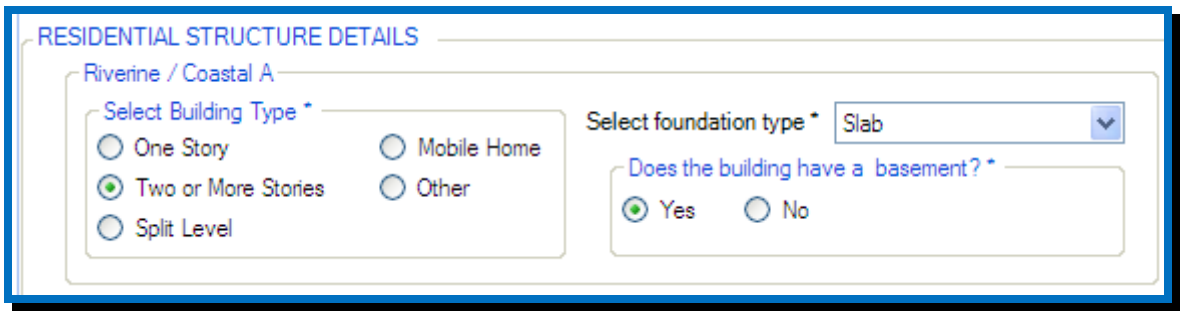
The next element to this study is to determine what damages would have been sustained by structures on properties in each community had they not been mitigated. The methods used below were generated based on training and continuous instruction provided by FEMA's Benefit Cost Analysis Helpline, and the FEMA endorsed Benefit Cost Analysis (BCA) tool version 4.5.5 was used as the mechanism to determine losses avoided. Following are explanations of how data was compiled for entry into the module, and how data was extracted for use in this study.

### First Floor Elevation

Finding the first floor elevation of previously mitigated structures is the first component required to determine what damages a structure would have incurred had it flooded again. In some cases exact first floor data was available (Des Moines disaster # 1230 and 1763 projects, Ames/ISU flood wall). For Des Moines disaster number 0996, Ames, and Cherokee acquisition projects, first floor elevations were found using GIS software. A conservative (rounded up to the nearest foot) estimate was used for each property.

### Building Type

Another necessary piece of information in using the Benefit Cost Analysis tool is the type of building being analyzed. This information is used in entering the elevation certificate diagram number, number of stories / floor layout, foundation type and presence or lack of a basement.



As with the first floor elevation, this data was available for some of the properties in Des Moines and the Ames flood wall, but had to be deduced for other communities. Basements are more common than not in Iowa, so the analysis was run to include an unfinished basement unless information was available to indicate otherwise. A slab foundation type is the only appropriate option in the State. It follows that elevation certificate diagram number 2 was used.

To continue with the conservative theme, the BCA module calculates lower building and contents damages for two story buildings (vs. one story) so this option was selected when unknown.

Streambed / Flood Interval Elevations and Property Groups

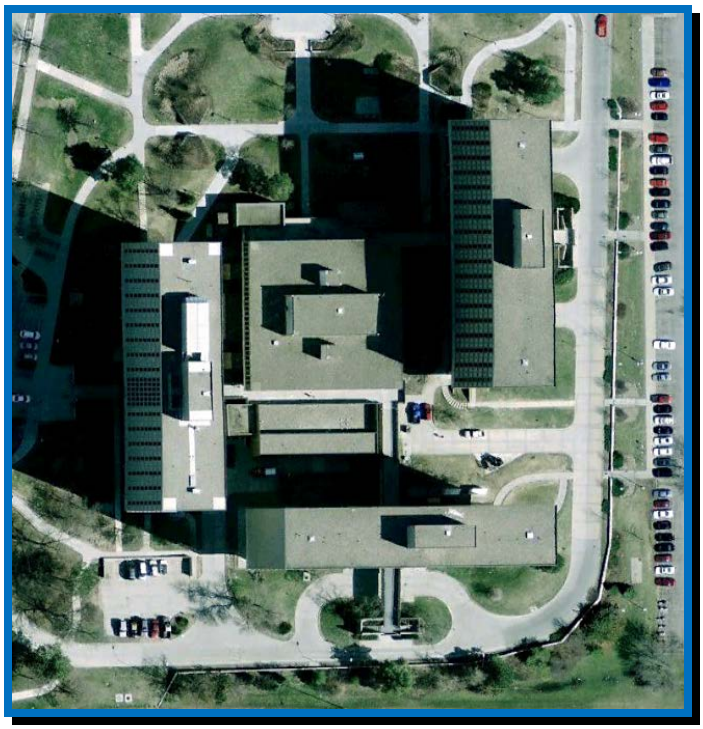
For efficiency and reasonability (and also where appropriate), properties in close proximity geographically within each community were grouped when finding streambed and flood elevations. These groups were sub-divided further in cases where first floor elevations varied significantly. The average first floor elevation for each group or sub-group was calculated and used for that entry in the losses avoided calculation.

In the end, properties in close proximity to one another with the same flood source and very similar first floor elevations were grouped together when determining avoided losses. The losses avoided for that entry were then multiplied by the number of properties in the group.

- Des Moines Acquisitions
  - Exact streambed and flood interval elevation data was available for properties acquired after disaster 1763 (2008 flooding), so each property was run through the module independently.
  - 29 properties were grouped in a southwest Des Moines neighborhood flooded by the Raccoon River during disaster 0996 (1993 flooding).
  - 13 properties were grouped in an eastern Des Moines neighborhood flooded by Fourmile Creek during disasters 0996 (1993) and 1230 (1998).
  - 9 properties were grouped in a western Des Moines neighborhood.
  - 53 properties were grouped in a western Des Moines neighborhood flooded at the confluence of the Raccoon River and Walnut Creek during disasters 0996 and 1230.
  - 3 properties were grouped in a central Des Moines neighborhood flooded by Fourmile Creek during disaster 1230.
  - 3221 Elmwood Drive and 828 Morton Avenue were analyzed independently as they were not in close proximity to other properties.

- Ames Acquisitions
  - 26 properties were grouped in a central Ames neighborhood flooded by Squaw Creek during disaster 0996.
  - 1803 16$^{th}$ Street was analyzed independently as it is not in close proximity to other properties.
  - Four properties were grouped in a northern Ames neighborhood flooded by the Skunk River during disaster 0996.
  - Two Ames properties could not be analyzed due to insufficient data.

- The Maple-Willow-Larch Residence Hall Complex was analyzed individually.



*The Flood Wall runs along the South and East side of the complex*

- Cherokee Acquisitions (all properties flooded by the Little Sioux River, some in the confluence flood area with Railroad Creek)
    - 224 Elm Street was analyzed independently as it is not in close proximity to other properties.
    - 31 properties in central Cherokee were grouped together when determining streambed and flood interval elevations.
        - They were further sub-divided into 4 groups with similar first floor elevations.
        - Only 19 of these properties would have sustained damages.
    - 30 properties in east Cherokee were grouped to determine streambed and flood interval elevations.
        - They were further sub-divided into 4 groups with similar first floor elevations.
    - 43 properties in northeast Cherokee were grouped to determine streambed and flood interval elevations.
        - They were further sub-divided into 4 groups with similar first floor elevations.
        - Only 29 would have sustained damages.
    - 35 properties in south Cherokee were grouped to determine streambed and flood interval elevations.
        - They were further sub-divided into 6 groups with similar first floor elevations.
    - 66 properties in southeast Cherokee were grouped to determine streambed and flood interval elevations.
        - They were further sub-divided into 6 groups with similar first floor elevations.
    - 5 vacant lots were not analyzed.

Total Size of Building (square feet)

Where exact building measurements were available, they were used when determining the total size of each building analyzed. This was the case for some of the structures in Des Moines and the Ames residence hall complex protected by the flood wall. For the others, either an average or estimate was used depending on what data was available.

For Des Moines, an average was found which considered all properties acquired by the City up to the present date (disasters 0996, 1230 and 1763). When possible, the accuracy of this estimate could be increased by using only square footage measurements from other homes in a property's neighborhood.

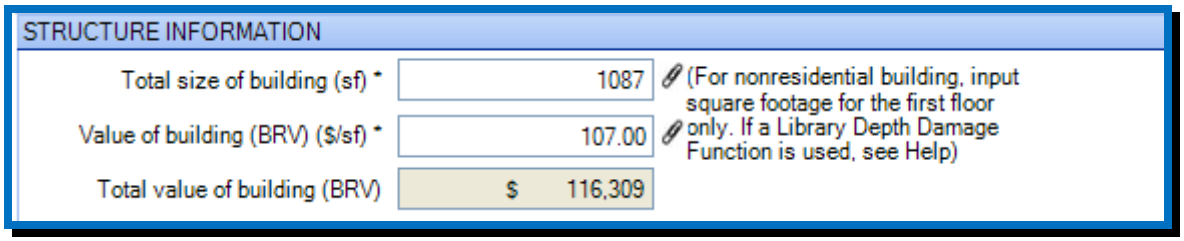
Exact data was also not available for Ames and Cherokee acquisition projects. To estimate square footage of structures acquired in past projects here, a sample of over 950 properties being acquired in 33 communities across the State of Iowa during disaster 1763 was averaged. The common trait shared by all of these properties is that they were built in a community's 100 year floodplain. Generally, construction took place before information leading to the creation of floodplain ordinances was available to the community. These ordinances would have prevented or at minimum regulated such construction. The average is a reasonable, perhaps conservative 1087 square feet.

Building Replacement Value ($ per square foot)

As with the total size of building aspect, only the City of Des Moines and the MWL residence hall complex had exact replacement value data available to use in the analysis or assist in the estimation process. To find an average for use in estimating this value, the average BRV $/sq. ft. was found for each disaster using actual data, and escalated. For disaster 1763 (2008), average BRV/sq.ft. was $94.06, and for disaster 1230 (2003), $81.41. Based on this information, every 5 years building replacement value for houses in Des Moines increased by approximately $13 (15%). Because disaster 0996 took place in 1993 (10 years prior to 2003), $26 was subtracted from $81.41, so $55 was used as replacement value in 1993 for the City of Des Moines.

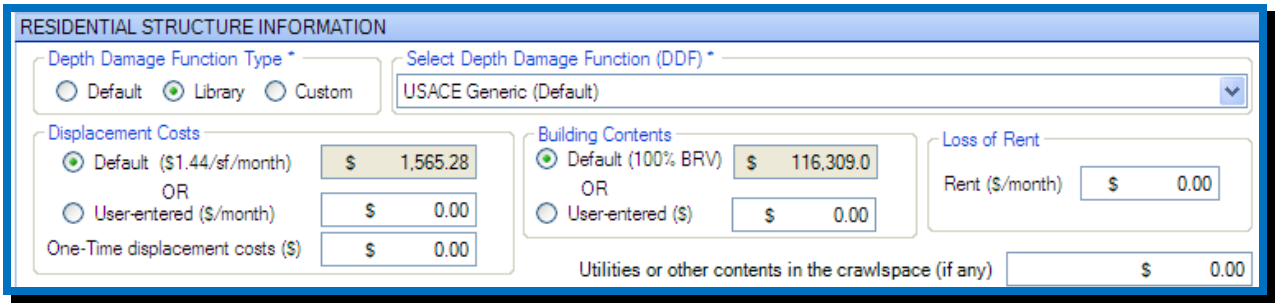
No actual data was available for Ames or Cherokee, however Marshall & Swift Cost Estimating Guide 2006 is referenced in the BCA Quick Reference for assistance in determining reasonable BRV $/sq. ft. $95 is a conservative estimate for cities in Iowa, and is in line with the 2006 average to good residential figures given by Marshall & Swift. This figure was used for BRV $/sq. ft. Ames and Cherokee.

All BRV $/sq. ft. values needed to be converted to net present value to know the true losses avoided for 2010. The net present value calculator tool from BCA module 3.0 was used to make this conversion.



Contents Value

The Benefit Cost Analysis software, as a default value, uses 100% of the building replacement value to represent contents value. The same default was used in this study to find losses avoided for acquisition projects. For the flood wall project, insurance documentation was used to find the contents value of the MWL residence hall complex. Contents value for the lowest floor only (Commons / Dining area) was entered under "Non-Residential Structure Details" on the structure information screen.




Displacement Costs

The software also uses a default value to capture the cost of displacement from a structure due to its inundation ($1.44/sq. ft./month). This default value was used in the loss avoidance study for acquisition projects.

A default method for determining displacement costs was used in analyzing the MWL residence hall also:

- Monthly Displacement Costs = Occupancy Class $/sq. ft./month x total building area
  - Occupancy Class – EDU 2 – Colleges/Universities = $1.46/sq. ft./month
  - Total Building Area – 360,586 square feet
  - Monthly Displacement Cost = $526,455.56
- One-time Displacement Costs = Occupancy Class $/sq. ft.$^2$ x total building area
  - Occupancy Class – EDU 2 – Colleges/Universities = $1.02 $/sq. ft.$^2$
  - Total Building Area – 360,586 square feet
  - One-time Displacement Cost = $367,797.72

Flood Depth

To determine damages that would have resulted to flooded structures, the depth of flood waters that would have inundated the structures was measured. Flood elevations can be derived from the flood source's stream gage readings available online (rivergages.com) or through a DNR database ("Peak Gage Reading Summary Report" provided by Bill Cappuccio of the IDNR). These elevations can then be compared to a structure's first floor elevation to determine flood depth at that structure.

Flood sources/elevations based on stream gage data for each community are listed below:

- Des Moines
  - Fourmile Creek at Des Moines, IA crested at 16.14 feet 8/11/2010
    - Exceeded previous record of 2008 (15.38) by .76 ft; unofficial flood of record

        - Gage is located on the right bank 20 feet downstream from the bridge on Easton Blvd., 4.4 miles downstream of Muchikinock Creek, and 5.0 miles upstream from the Des Moines River
    - Raccoon River at Fleur Drive in Des Moines, IA crested at 17.18 feet 6/29/2010
        - Gage is located on the downstream side of the Fleur Drive (SW 18th St) bridge 465 ft from the right edge of the bridge, 3 miles downstream from Walnut Creek and 204.1 miles above the mouth of the Des Moines River
        - Flood elevation was <10 year flood interval
    - Walnut Creek at Des Moines, IA crested at 18.2 feet 8/9/2010
        - Gage is located on the left bank 25 ft downstream from the bridge on 63rd Street in Des Moines
        - Flood elevation was approximately equal to the 500 year flood interval

- Ames
    - Squaw Creek at Ames, IA crested at 18.13 feet 8/11/2010
        - Close to record flood of 18.54 in 1993
        - Gage is located in on the left bank 65 ft downstream from the Lincoln Way bridge and 0.2 miles downstream from College Creek
    - South Skunk River below Squaw Creek near Ames, IA crested at 26.72 feet 8/11/2010
        - Exceeds previous peak (25.82 in 1993)
        - Gage is located near highway 30
    - South Skunk River near Ames, IA crested at 19.55 feet 8/11/2010
        - Matches 1993 flood peak
        - Gage is located at West Riverside Road

- Cherokee
    - Little Sioux River at Cherokee crested at 27.3 feet 6/27/2010
        - Gage is located just downstream of the S 2nd St. bridge
        - Based on the Little Sioux River flood profile, this was slightly more than a 100 year flood event

After finding the above gage readings, the flood depth was added to the streambed elevation for each property (or group of properties) to find the 2010 peak flood elevation at that location. This figure is compared to the first floor elevation which gives flood depth at each structure or group of structures. Flood depth is necessary to use the BCA module to estimate damages that would have been caused to buildings, contents of the buildings, and displacement / loss of function costs.

Depth Damage Functions

A table was created for use in the study to assist in calculating total losses avoided. Each property or group of properties was entered into a row on the table along with necessary data derived from that property's entry the BCA module. The module and table were used in conjunction with one another to determine building damages avoided, contents damages avoided and displacement / loss of function costs avoided. Below is an example of how the process works.

1. In the BCA module, enter all required information as though a benefit-cost analysis were being conducted:
    a. Structure (or Group) information such as address, city, county, state
    b. Select 'Acquisition' flood mitigation project type
    c. First floor elevation
    d. FEMA elevation certificate diagram number
    e. Streambed elevation
    f. Flood recurrence interval elevation and discharge information
    g. Size of building
    h. Replacement value / sq. ft.
    i. Building type
    j. Foundation type
    k. Presence of basement
    l. Depth damage function type – Library - USACE Generic (Default)

At this point, all data is available from the BCA module to be entered into the Depth Damage Functions table.

2. In the table, enter required information (green columns)
    a. Address
    b. City
    c. Streambed elevation
    d. 2010 flood depth (stage) – 2010 flood elevation will be automatically calculated
    e. FFE – flood depth will be automatically calculated
        i. Exact flood depth will likely lie between two whole numbers in feet
        ii. The table is configured to calculate the exact depth damage function percentage or number of displacement days using actual flood depth (vs. rounding up or down to the nearest foot)
    f. Building damage percentages
        i. Using the BCA module, "Residential Structure Information" screen, Depth Damage Functions "Building" tab
            1. Enter Building Damage % (Before Mitigation %) that corresponds to the flood depth (rounded up)
            2. Building Damage % that corresponds to the flood depth (rounded down)
    g. Repeat for Contents Damage Percentages using the Contents tab in the BCA module
    h. Use the same process for Displacement Costs, substituting days for percentages
    i. Replacement / Contents Value
    j. After the above data is entered, the table can complete its calculations
        i. "Total Building Depth Damage %" – Blue column
        ii. "Total Contents Depth Damage %" – Yellow column
        iii. "Total Displacement Days" – Orange column

3. Return to the BCA module, Building Tab to enter data from the Depth Damage Functions table
    a. In the "Before Mitigation User Entered (Pct)" column, enter the Total Building Damage % figure from the Depth Damage Functions table in the row correlating to flood depth rounded up

i. Check that the "Building Damages Avoided" figure in the Depth Damage Functions table matches the figure (+/- $1) in the BCA module "Before Mitigation $"

Depth Damage Functions *

Building | Contents | Displacement | Loss Of Function

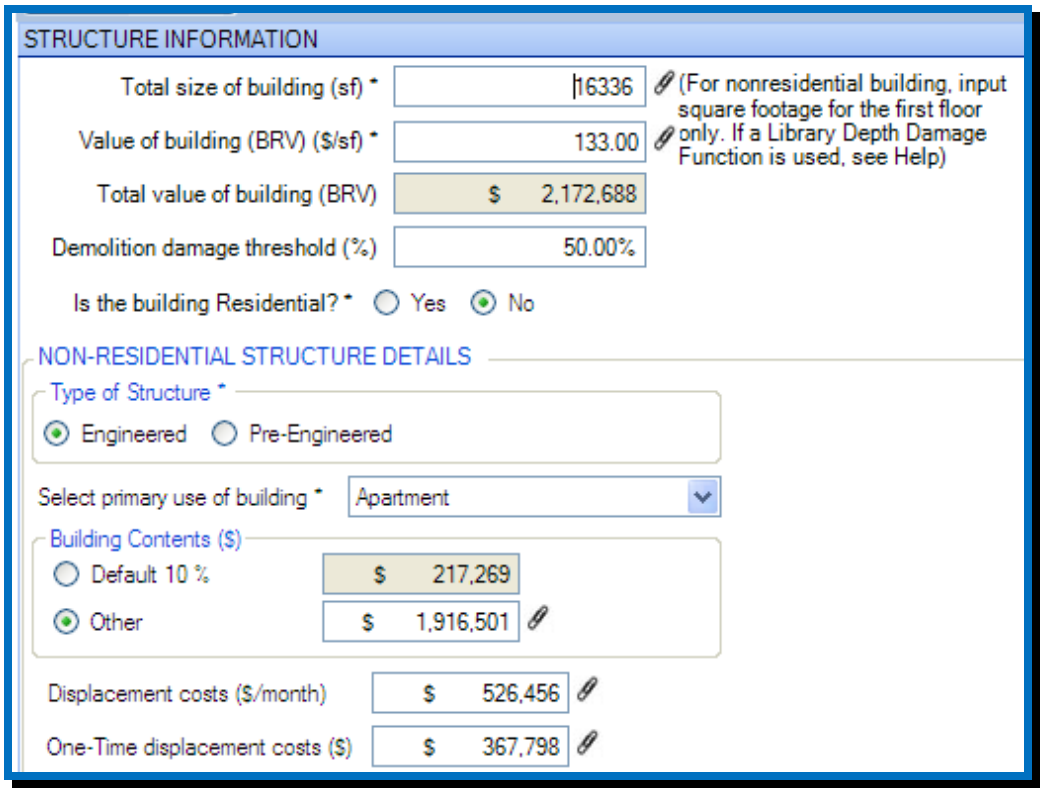
| Flood Depth (ft) | Before Mitigation (Pct) | Before Mitigation User Entered (Pct) | Before Mitigation ($) | After Mitigation (Pct) | After Mitigation User Entered (Pct) | After Mitigation ($) |
|---|---|---|---|---|---|---|
| -2.0 | 10.2% | | $11,864 | 0.0% | | $0 |
| -1.0 | 13.9% | | $16,167 | 0.0% | | $0 |
| 0.0 | 17.9% | | $20,819 | 0.0% | | $0 |
| 1.0 | 22.3% | | $25,937 | 0.0% | | $0 |
| 2.0 | 27.0% | 24.1 | $28,030 | 0.0% | | $0 |
| 3.0 | 31.9% | | $37,103 | 0.0% | | $0 |
| 4.0 | 36.9% | | $42,918 | 0.0% | | $0 |
| 5.0 | 41.9% | | $48,733 | 0.0% | | $0 |
| 6.0 | 46.9% | | $54,549 | 0.0% | | $0 |
| 7.0 | 51.8% | | $116,309 | 0.0% | | $0 |
| 8.0 | 56.4% | | $116,309 | 0.0% | | $0 |
| 9.0 | 60.8% | | $116,309 | 0.0% | | $0 |
| 10.0 | 64.8% | | $116,309 | 0.0% | | $0 |
| 11.0 | 68.4% | | $116,309 | 0.0% | | $0 |
| 12.0 | 71.4% | | $116,309 | 0.0% | | $0 |
| 13.0 | 73.7% | | $116,309 | 0.0% | | $0 |
| 14.0 | 75.4% | | $116,309 | 0.0% | | $0 |
| 15.0 | 76.4% | | $116,309 | 0.0% | | $0 |
| 16.0 | 76.4% | | $116,309 | 0.0% | | $0 |

4. Repeat the above step in the BCA module, Contents Tab using the Total Contents Damage % figure from the Depth Damage Function Table to check Contents Damages Avoided
5. On the Displacement Tab, enter the Total Disp. Days from the Depth Damage Functions table into the "Before Mitigation User Entered (Days)" column. Use the row correlating to the flood depth rounded up
    a. The BCA module will calculate "Before Mitigation $" – enter this into the Depth Damage Functions table, Displacement Avoided column
6. The Depth Damage Functions table will then calculate the losses avoided for that row. Another field is necessary to multiply the figure by the number of properties in that group where applicable.
7. Total losses avoided for 2010 can be found by adding the totals for each row, and is found at the bottom, right corner of the table.

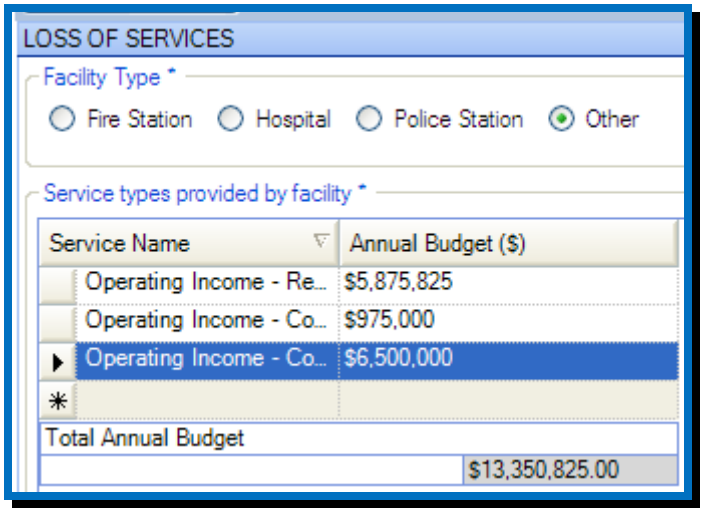
<u>Maple-Willow-Larch Residence Hall Complex, ISU Campus, Ames, IA</u>

Additional data was necessary to analyze the Maple-Willow-Larch residence hall in Ames, but in the end the same methods were used to determine losses avoided. Instead of using the 'Acquisition' option within the flood module, the 'Dry Flood Proofing/Water Barrier' option was selected. This requires all previously described information, and in addition the elevation at which the barrier would be overtopped. Because the complex is considered Commercial (as opposed to Residential) the following information was necessary for the "Structure Information" screen (obtained from the ISU Residence Hall Department):

- Type of structure – Engineered
- Primary use of building – Apartment
- Actual building contents value – $1,916,501
- Total square footage – 360,586
    - Maple = 101,229
    - Willow = 101,229
    - Larch = 101,229
    - Commons = 56,899
    - First Floor Only = 16,336
- Displacement costs (calculated using default method from BCA Help) – $526,456
    - Total square footage multiplied by $1.46 (default per square foot per month value for College / University "Occupancy Class")
- One-time displacement costs (calculated using default method from BCA Help) – $367,798
    - Total square footage multiplied by $1.02 (default per square foot value for College / University "Occupancy Class")




- Depth damage function type – Library, Apartment (Default)
- Annual operating income – $13,350,825
    - Residence Hall - $5,875,825
    - Commons / Dining Center - $6,500,000
    - Convenience Store - $975,000




Once this data is entered into the BCA module and Depth Damage Functions table, avoided building/contents damages and displacement costs can be found. In addition, since the complex is commercial in nature, avoided loss of function costs can be considered based on annual operating income for the facility. This figure is calculated in the BCA module once income is input. The number of displacement days (from the Depth Damage Functions table based on flood depth) as a fraction of one year is used as a multiplier against annual operating income of the facility to find loss of function costs. This figure was added to the table for the Residence Hall Complex row and added to the total losses avoided for that entry.

## Results

A breakdown of losses avoided for each property / group of properties is available in the final column of the Depth Damage Functions table. There are several points of interest that can be derived from information in the table:

- The City of Des Moines finished acquisition and demolition of 12 residences due to the 2008 flooding of Fourmile Creek only months prior to record setting 2010 floods in the same area. The project cost is estimated to be just over $1M. Within only two years of the inception of this project, an estimated $640,000 in losses has already been avoided.
- 13 properties in this same area (Fourmile Creek) were flooded and acquired after disasters 0996 and 1230. Losses avoided due to 2010 flooding alone are estimated at just under $1M. These properties would almost certainly have been flooded during each consequent event after their acquisition, some as many as four times over 18 years. This puts a strong emphasis on the effectiveness of Acquisition & Demolition mitigation projects.
- 53 properties in a western neighborhood in Des Moines were acquired during disasters 0996 and 1230 due to flooding just upstream of where Walnut Creek meets the Raccoon River. 2010 flood stage recorded at the gage nearest this site on 8/9/2010 was within 1.5 inches of the record high stage. If at risk residences in this neighborhood were not previously mitigated, flood depths would have exceeded 11 feet on average, resulting in building, contents and displacement damages of over $140,000 per property. Over $7.5 million in losses were avoided for this area in 2010 due to past acquisition projects.

- The City of Ames acquired 33 properties during the disaster 0996 recovery period. Of the 33, sufficient data could be found for 31 to estimate 2010 losses had they not been mitigated prior to 2010's record event. Over $1.4 million in damages could have been sustained to these residences in August of 2010.

- If it weren't for the construction of the Maple-Willow-Larch flood wall during disaster 0996 recovery, the complex would have flooded in 2010. Reports indicate that flood waters crested less than one foot from the top of the wall on August 11. A flood of this magnitude would have resulted in major damages to the structure and contents, and more losses yet when displacement costs and loss of income are considered.
    - Building and contents damages avoided (primarily the commons/dining area and maintenance rooms) calculate to $926,000. This information is based on building replacement values per square foot and insurance statements of contents value insured.
    - Displacement losses avoided (both one time and monthly) are calculated in the BCA module using flood depth to estimate the number of days that the complex would need to be vacant due to flooding. Without the wall, the 2010 flood would have left the building vacant for nearly 86 days, directly coinciding with the time of year that over 1,500 students are moving in to begin the fall semester. Displacement losses avoided are estimated at $1,486,769.
    - Avoided loss of function (based on operating income) can also be also estimated by the BCA module. Again based on nearly 86 days of vacancy, this figure is a considerable $3,142,106.
    - Total 2010 losses avoided due to dry flood proofing of the residence hall is over $5.5 million.

*View of Maple Willow Larch Residence Hall from the parking lot after flood waters receded by several feet*

- Of 211 properties acquired by the City of Cherokee due to disaster 0996, 180 could be analyzed and would have flooded again in 2010. Those 61 properties in the Southeast area of the City accounted for majority of losses avoided – nearly $3.5 million. Over $8 million was avoided for the City as a whole.

*Much of the flooded property shown here was developed prior to 1993*

## Present Values of Costs / Losses Avoided

To make a definitive case that HMGP Acquisition / Demolition projects previously implemented in Iowa are effective mitigation measures, it is particularly useful to know how dollar figure losses avoided due to their completion compare to project costs.

The City of Des Moines acquisition project following disaster 0996 total cost was $1,690,258. Present (2010) value of this cost using the net present value calculator found in benefit cost analysis software version 3.0 is $2,705,448. Likewise, the project cost following disaster 1230 was $2,371,391, present value $3,361,341. Total project cost for the disaster 1763 project is not yet known but is estimated to be $1,082,605, present value $1,148,536. Total net present value of project costs: $7,215,325.

Compared to the losses avoided from this study in the City of Des Moines following 2010 flooding ($9,741,638), the ratio of losses avoided to costs is 1.35.

The City of Ames spent $1,281,813 to acquire properties following disaster 0996. This translates to $2,051,686 in 2010. Losses avoided from this study are $1,460,244 resulting in a losses avoided to cost ratio of .71 for 2010 (1 flood event) alone.

Losses avoided were not calculated during Ames flooding which occurred in 1996, 2007 and 2008 as the events were not as severe. However, flood stages in 1996 were only one foot below the 2010 event, and both 2007 and 2008 were within 3 feet. Significant losses would have occurred in each event if mitigation measures were not already taken.

$7,195,212 was the project cost for the City of Cherokee's acquisition project in 1993. That figure today inflates to $11,516,748. Losses avoided for the City due to 2010 flooding total $8,167,831, the losses avoided to cost ratio is .71. As with Ames, only losses avoided from 2010 were considered. Cherokee also endured substantial flooding in 1994, 1996, 2001, 2004 and 2007.

Lastly, Iowa State University's flood wall built to protect the Maple-Willow-Larch residence hall complex cost $1,166,723 in 1993, present value $1,867,472. Losses avoided due to its presence are an impressive $5,555,469 resulting in a ratio of 2.95 avoided losses to costs.

## Conclusion

HMGP mitigation measures have demonstrated their effectiveness and importance in subsequent disasters time and time again since the first major acquisition project was completed in the State of Iowa. Where a project has been completed, it is only a matter of time before flooding occurs again and avoided losses begin to accumulate.

As this study and those that have preceded it reflects, millions of dollars have been saved due to projects where avoided losses can be quantified. Project costs are outweighed by future savings regularly, often in a single flood event that follows the completion of the project. It is evident that over time, repeat flooding of mitigated properties results in avoided damages which greatly outweigh project costs. As such, mitigation is crucial to Iowa's ability to withstand increasingly volatile weather and its effect on the State both physically and financially.