Guidance for Flood Risk Analysis and Mapping

Flood Risk Assessments

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May 2014

FEMA

This guidance document supports effective and efficient implementation of flood risk analysis and mapping standards codified in the Federal Insurance and Mitigation Administration Policy FP 204-07801.

For more information, please visit the Federal Emergency Management Agency (FEMA) Guidelines and Standards for Flood Risk Analysis and Mapping webpage (http://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping), which explains the policy, related guidance, technical references, and other information about the guidelines and standards process.

Nothing in this guidance document is mandatory other than standards codified separately in the aforementioned Policy. Alternate approaches that comply with FEMA standards that effectively and efficiently support program objectives are also acceptable.

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Document History

Affected Section or Subsection	Date	Description
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Table of Contents

1.0 Definitions 1
2.0 General Overview 1
3.0 Census Block-based Flood Risk Assessments 2
3.1 FRD-Related Guidance for Census Block-based Risk Assessments 3
3.2 2010 Hazus Average Annualized Loss (AAL) Study Results 5
3.3 Refined Flood Risk Assessments (Census Block) 8
3.4 Composite Flood Risk Assessments (Census Block) 12
4.0 Structure-Specific ("User-Defined Facility") Flood Risk Assessments 16
4.1 FRD-Related Guidance for Structure-Specific Risk Assessments 17
4.2 Refined Flood Risk Assessment Methodologies (Structure-Specific) 19
4.3 Selection of Structures to Receive Refined Flood Risk Assessments 20
5.0 Annualized Loss Calculations 21
6.0 Flood Risk Assessment Information on the Flood Risk Map 22
7.0 Flood Risk Assessment Information in the Flood Risk Report 22
8.0 Dataset Spatial Extents 22
9.0 Data Delivery Timeline 24
10.0 Uses in Outreach, Collaboration, and Flood Risk Communication 24

This Document is Superseded.
For Reference Only.

List of Figures

Figure 1: Census Block-based (left) and Structure-Specific (right) Flood Risk Assessments 1
Figure 2: Flood Risk Assessment Results by Census Block 3
Figure 3: Example Showing how L_RA_AAL is Populated based on Hazus Results 7
Figure 4: Hazus Analysis Options 11
Figure 5: AAL and Refined Results Are Combined to Create the Composite Flood Risk Assessment Data 13
Figure 6: Considerations for population of Composite results 14
Figure 7: Example Showing Census Blocks that would use Refined Results in the Composite Dataset 15
Figure 8: Structure-specific (UDF) Risk Assessments 17
Figure 9: Example depth-damage relationship: United States Army Corps of Engineers, *Economic Guidance Memo #04-01*, October 2003 20

Figure 10: Flood risk data outside of the project area 23
Figure 11: Example of community spanning multiple watersheds 24

List of Tables

Table 1: Hazus Tables to be Exported for S_CenBlk_Ar 4
Table 2: Derivation of S_CenBlk_Ar Fields from Exported Hazus Tables..... 5
Table 3: Hazus Tables to be Exported for L_RA_AAL 7
Table 4: Derivation of L_RA_AAL Fields from Exported Hazus Tables 8
Table 5: Hazus Tables to be Exported for L_RA_Refined 10
Table 6: Derivation of L_RA_Refined Fields from Exported Hazus Tables 10
Table 7: Hazus Default Contents Value as a Percentage of Structure Value.....18

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1.0 Definitions

The Flood Risk Assessment dataset reflects potential loss estimates (damages) resulting from floods of various magnitudes based on the frequency with which they are projected to occur. These loss estimates can be estimated at the individual building/structure level or aggregated to US Census block areas (see Figure 1). Flood Risk Assessment loss estimates generally vary by structure type (residential, commercial, industrial, etc.) and are based on a relationship between flood depth and the associated percentage of damage for each structure type. Therefore, a flood risk assessment can commonly be estimated for typical building types for any flood event, flood scenario, or flood frequency analyzed where flood depth information is available. As outlined in the *Flood Risk Database Technical Reference*, the Flood Risk Assessment dataset consists of several spatial and lookup tables that communicate the overall flood risk exposure and damage estimates within the project area.

Figure 1: Census Block-based (left) and Structure-Specific (right) Flood Risk Assessments

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2.0 General Overview

Included within the Flood Risk Assessment dataset are tables associated with the following:

- Loss estimates from the 2010 Hazus Average Annualized Loss (AAL) Study
- "**Refined**" loss estimates for new or updated flood study reaches, at either the census block or individual structure level; typically these will be based on depth grids from the Flood Depth and Analysis Grids dataset
- For projects where the Refined analyses were calculated and aggregated at the census block level, a "**Composite**" table of the AAL and Refined data, which represents the best available flood risk results

Additional tables that summarize inventory and loss data at the community level and within the overall Flood Risk Project area are also considered part of the Flood Risk Assessment dataset. The inventory data within the Flood Risk Assessment dataset are based on estimates of total inventory values for building and contents replacement values. These replacement values typically are used by loss estimation models, such as Hazus, to derive loss values. Losses can be estimated for three general categories as follows:

- **Building** losses are those losses associated with damage to the fixed elements of a structure, such as the foundation, walls, or floors.

- **Contents** losses are those losses associated with damage to structural elements not permanently fixed within a structure, such as furniture, appliances, and personal possessions.

- **Business Disruption** losses are additional losses not included in the building and contents losses, most commonly associated with businesses. These losses can include the costs of temporary displacement or disruption while flood repairs are being performed. It can also include business losses during the disruption. From Hazus, business disruption costs should include the sum of Inventory Loss, Relocation Cost, Income Loss, Rental Income Loss, Wage Loss, and Direct Output Loss.

In addition to these three categories of loss, the Flood Risk Assessment dataset also provides loss estimates divided into three categories of building use or general occupancy. The three categories of general occupancy to be used for the Flood Risk Assessment dataset are as follows:

- **Residential** occupancy as defined by Hazus, including single family dwellings, mobile homes, apartment buildings, and dormitories

- **Commercial** occupancy as defined by Hazus, including retail and wholesale trade, repair services, banks and hospitals

- **Other** occupancy not included in Residential or Commercial occupancy as defined by Hazus, which include Hazus occupancy categories of industrial, agricultural, education, religious, and government structures

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3.0 Census Block-based Flood Risk Assessments

Flood loss data calculated within Hazus can be aggregated and reported at the census tract (largest) and census block (smallest) level (see Figure 2). Of the two, the Flood Risk Database (FRD) has been designed to have its risk assessment data delivered at the census block level. To determine flood losses, the census block-based approach in Hazus applies a weighting methodology to assume a uniform distribution of census demographics and structures across the census block. As such, this type of approach generally produces conservative loss estimates (often overestimating what the true losses might be).

Figure 2: Flood Risk Assessment Results by Census Block

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3.1 FRD-Related Guidance for Census Block-based Risk Assessments

For census block-based flood risk assessments, the Flood Risk Assessment dataset is made up of the following tables in the FRD:

- S_CenBlk_Ar
- L_RA_AAL
- L_RA_Refined (only populated when census block-based risk assessments are performed for new or updated study areas)
- L_RA_Composite
- L_Exposure
- L_RA_Summary
- L_Local_GBS (only populated if local General Building Stock data was updated and used in Hazus to perform a refined census block-based flood risk assessment)

Additional guidance on these tables is found in the sections below.

3.1.1 S_CenBlk_Ar

The census block polygons in S_CenBlk_Ar should not be clipped to the project area footprint (S_FRD_Proj_Ar). Section 8 of this document outlines additional guidance for the S_CenBlk_Ar spatial layer, as it relates to aligning it to the footprint of the project area.

As the first step towards populating the Hazus-derived fields in S_CenBlk_Ar, Table 1 outlines the tables that should be exported from Hazus:

Table 1: Hazus Tables to be Exported for S_CenBlk_Ar

Menu	Item	Sub-item	Tab	Table Type Selections
Inventory	General Building Stock	Dollar Exposure (Replacement Value)	By Occupancy	Table Type: General Occupancy Exposure Type: Building
Inventory	General Building Stock	Dollar Exposure (Replacement Value)	By Occupancy	Table Type: General Occupancy Exposure Type: Contents

Once that has been complete, Table 2 explains how the values in the S_CenBlk_Ar building and contents fields are derived from these exported Hazus tables. Each census block within the project area should be populated with this information.

All attributes that report dollar values and losses (e.g. ARV_BG_TOT, ARV_CN_TOT, etc.) should have their whole dollar values populated, rather than reported in thousands of dollars. All losses less than $100,000 should be rounded to the nearest $10,000 in these fields. All losses greater than $100,000 should be rounded to the nearest $100,000.

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Within the FRD, there are database relationships setup that facilitate being able to join the S_CenBlk_Ar to one of the flood risk assessment results tables (L_RA_*). This can be used to help depict the flood risk assessments results on the Flood Risk Map (FRM) and within a Geographic Information System (GIS).

3.1.2 L_Exposure

The total building and contents values (i.e. exposure) within each community in the Flood Risk Project footprint, and within the project area as a whole, are stored within the L_Exposure table. This information is derived from the asset replacement value attributes within the S_CenBlk_Ar table. Since census block boundaries (S_CenBlk_Ar) do not always align with community boundaries (S_FRD_Pol_Ar), the L_Exposure values for each community should be area-weighted based on the intersection of the two spatial layers. For example, if a census block has a total building asset replacement value (S_CenBlk_Ar: ARV_BG_TOT) of $1 million, and 60% of the census block lies within the political area of the community, and 40% lies outside, then that census block would in essence only contribute $600,000 to the overall total building asset replacement value (ARV_TOT) of that community. These same area-weighting principles apply to the L_RA_Summary table as well.

All attributes that report dollar values and losses (e.g. ARV_TOT, ARV_RES, etc.) should have their whole dollar values populated, rather than reported in thousands of dollars (note that the values exported out of Hazus are in $1,000s). All losses less than $100,000 should be rounded

to the nearest $10,000 in these fields. All losses greater than $100,000 should be rounded to the nearest $100,000.

Table 2: Derivation of S_CenBlk_Ar Fields from Exported Hazus Tables

S_CenBlk_Ar FIELD	Description	Hazus Derivations
ARV_BG_TOT	Total building value for all structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Total Exposure Field)
ARV_CN_TOT	Total contents value for all structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Total Exposure Field)
ARV_BG_RES	Total building value for residential structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Residential Field)
ARV_CN_RES	Total contents value for residential structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Residential Field)
ARV_BG_COM	Total building value for commercial structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Commercial Field)
ARV_CN_COM	Total contents value for commercial structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Commercial Field)
ARV_BG_OTH	Total building value for other structure types	Hazus Inventory: GBS Dollar Exposure (Building Exposure Type, Total Exposure minus Residential and Commercial Fields)
ARV_CN_OTH	Total contents value for other structure types	Hazus Inventory: GBS Dollar Exposure (Contents Exposure Type, Total Exposure minus Residential and Commercial Fields)

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3.2 2010 Hazus Average Annualized Loss (AAL) Study Results

In 2010, FEMA conducted a Level 1 Hazus MR4 flood analysis to estimate average annualized losses (AAL). This AAL study examined riverine and coastal flood hazards in the 48 contiguous states (including the District of Columbia) by county. Hawaii, Alaska, and Puerto Rico, and US territories were not analyzed as part of this study. The AAL study estimated flood losses for the following storm events, which were then used to develop the annualized loss estimate:

- 10% annual chance (10-year)
- 2% annual chance (50-year)
- 1% annual chance (100-year)
- 0.5% annual chance (200-year)
- 0.2% annual chance (500-year)

The data from the AAL Study was calculated at the census block level, based on Hazus' hydrology and hydraulic analysis of streams draining 10 square mile or greater and utilizing 30m Digital Elevation Model (DEM) data. It includes estimated replacement values and flood losses

for both buildings and contents, based on 2000 census data, and is aggregated by structure type (residential, commercial, and other). For certain reaches of stream, the hydrology or hydraulics failed during the AAL study, and loss estimates were not able to be calculated. In some of the coastal areas, both riverine and coastal loss estimates were calculated, but may not be distinct in the AAL results. In spite of these known data gaps, the AAL study represents a baseline level of flood risk assessment results which can be used where more refined analyses are not conducted or available.

Statements referencing the "AAL Study" are referring to the aforementioned 2010 AAL study. If an AAL-like analysis is performed (i.e. commonly referred to as a Hazus Level 1 analysis, or where Hazus' internal hydrology and hydraulics methodologies are used to estimate flood losses and annualize the results) as part of a Flood Risk Project, this would be considered a refined flood risk assessment. Such an analysis should utilize Hazus Version 2.1 (or future releases) to perform the analysis. The AAL data (i.e. the 2010 AAL study) is not updated as part of a Flood Risk Project.

3.2.1 L_RA_AAL

The results from the AAL study are stored in the L_RA_AAL table of the FRD. The RETURN_PER field of this table should be populated with results from the following frequencies, which were calculated in the AAL study:

- 10% annual chance (10-yr)
- 2% annual chance (50-yr)
- 1% annual chance (100-yr)
- 0.5% annual chance (200-yr)
- 0.2% annual chance (500-yr)
- Annualized

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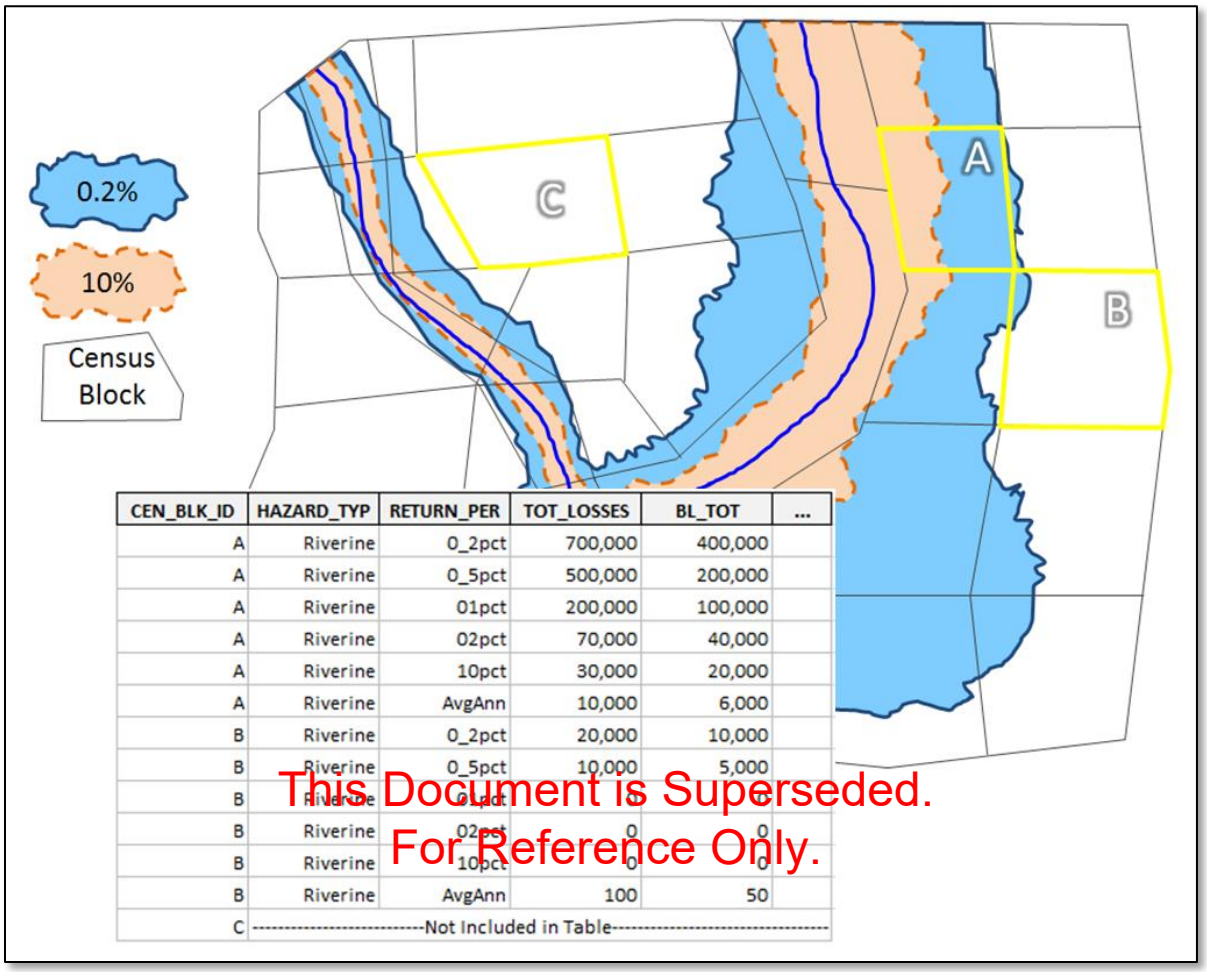
There should be one record in the table that represents each combination of census block, hazard type, and flood frequency for the risk assessment performed. There should also be one record that stores the annualized losses. Therefore, there should be six entries (10%, 2%, 1%, 0.5%, 0.2%, Annualized) in this table for each census block where flood losses were calculated. In the case, for example, where a census block contains flood loss estimates for the 0.2% and 0.5% annual chance events, but no loss estimates for the other flood frequencies, there should still be six table records for that census block; the 1%, 2%, and 10% annual chance loss estimates would simply show zero in this case. The L_RA_AAL table does not need to include records for census blocks for which flood loss calculations were not performed. Figure 3 provides an example showing how this guidance is applied.

Figure 3: Example Showing how L_RA_AAL is Populated based on Hazus Results



CEN_BLK_ID	HAZARD_TYP	RETURN_PER	TOT_LOSSES	BL_TOT	...
A	Riverine	0_2pct	700,000	400,000	
A	Riverine	0_5pct	500,000	200,000	
A	Riverine	01pct	200,000	100,000	
A	Riverine	02pct	70,000	40,000	
A	Riverine	10pct	30,000	20,000	
A	Riverine	AvgAnn	10,000	6,000	
B	Riverine	0_2pct	20,000	10,000	
B	Riverine	0_5pct	10,000	5,000	
B	Riverine	01pct	0	0	
B	Riverine	02pct	0	0	
B	Riverine	10pct	0	0	
B	Riverine	AvgAnn	100	50	
C	----------Not Included in Table----------				

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As the first step towards populating the Hazus-derived fields in L_RA_AAL, Table 3 outlines the tables that should be exported from Hazus.

Table 3: Hazus Tables to be Exported for L_RA_AAL

Menu	Item	Sub-item	Tab	Table Type Selections
Results	General Building Stock Economic Loss	By Full Replacement	Total	Pre/Post Flood Insurance Rate Map (FIRM): Total
Results	General Building Stock Economic Loss	By Full Replacement	By General Occupancy	Occupancy: Residential Pre/Post FIRM: Total
Results	General Building Stock Economic Loss	By Full Replacement	By General Occupancy	Occupancy: Commercial Pre/Post FIRM: Total

Once that has been complete, Table 4 explains how the values in certain L_RA_AAL fields are derived from these exported Hazus tables.

Table 4: Derivation of L_RA_AAL Fields from Exported Hazus Tables

L_RA_AAL FIELD	Description	Hazus Derivations
TOT_LOSSES	Total losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Total Loss Field)
BL_TOT	Total building losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Building Loss Field)
CL_TOT	Total contents losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Contents Loss Field)
BL_RES	Total building losses for residential structures	Hazus Results: GBS Economic Loss Full Replacement: Residential (Building Loss Field)
CL_RES	Total contents losses for residential structures	Hazus Results: GBS Economic Loss Full Replacement: Residential (Content Loss Field)
BL_COM	Total building losses for commercial structures	Hazus Results: GBS Economic Loss Full Replacement: Commercial (Building Loss Field)
CL_COM	Total contents losses for commercial structures	Hazus Results: GBS Economic Loss Full Replacement: Commercial (Contents Loss Field)
BL_OTH	Total building losses for other structures	Total building losses minus building losses for residential structures and building losses for commercial structures
CL_OTH	Total contents losses for other structures	Total contents losses minus contents losses for residential structures and contents losses for commercial structures
BUS_DISRPT	Business disruption costs	Total losses minus Total buildings losses and Total contents losses

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Hazus reports loss values by the thousands (e.g. a loss of $10,000 is exported as 10 by Hazus). All attributes that report dollar values in this table (e.g. TOT_LOSSES, BL_TOT, etc.) should have their whole dollar values populated, rather than reported in thousands of dollars. Loss values populated in this table should also not be rounded.

3.3 Refined Flood Risk Assessments (Census Block)

The purpose of census block-based refined loss analyses is to supplement the AAL results to deliver a refined analysis based on updated hydrologic, hydraulic, coastal, and/or topographic data for flooding sources. Typically, a Flood Risk Project that produces new depth grids will use those depth grids to conduct a refined loss analysis using a loss analysis tool like Hazus. For Hazus-based analyses, the latest version of the Hazus *Flood Model User Manual* should be referenced for the specific steps on how to perform flood risk assessments. The general steps,

however, for a census block-based refined flood risk assessment within Hazus are outlined below.

3.3.1 L_RA_Refined

The results from the refined study are stored in the L_RA_Refined table of the FRD. The RETURN_PER field of this table should be populated with results from the following frequencies, which should be available from the new study:

- 10% annual chance (10-yr)
- 4% annual chance (25-yr)
- 2% annual chance (50-yr)
- 1% annual chance (100-yr)
- 0.2% annual chance (500-yr)
- Annualized

Similar to how L_RA_AAL is populated, there should be one record in the table that represents each combination of census block, hazard type, and flood frequency for the risk assessment performed. There should also be one record that stores the annualized losses. Section 5.0 of this document explains the process for calculating the annualized losses, which can be performed once the loss results from the 5 standard frequencies have been computed. Therefore, there should be six entries (10%, 4%, 2%, 1%, 0.2%, Annualized) in this table for each census block where flood losses were estimated. In the case, for example, where a census block contains flood loss estimates for the 0.2% and 1% annual chance events, but no loss estimates for the other flood frequencies, there should still be six table records for that census block; the 2%, 4%, and 10% annual chance loss estimates would simply show zero in this case. The L_RA_Refined table does not need to include records for census blocks for which flood loss calculations were not performed. Figure 3 example shows how this guidance is applied. Note that since that figure shows L_RA_AAL, the “0_5pct” results in the example table would simply be replaced with the “04pct” results from the refined analysis.

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As the first step towards populating the Hazus-derived fields in L_RA_Refined, Table 5 outlines the tables that should be exported from Hazus.

Once that has been complete, Table 6 explains how the values in certain L_RA_Refined fields are derived from these exported Hazus tables.

Hazus reports loss values by the thousands (e.g. a loss of $10,000 is exported as 10 by Hazus). All attributes that report dollar values in this table (e.g. TOT_LOSSES, BL_TOT, etc.) should have their whole dollar values populated, rather than reported in thousands of dollars. Loss values populated in this table should also not be rounded.

Table 5: Hazus Tables to be Exported for L_RA_Refined

Menu	Item	Sub-item	Tab	Table Type Selections
Results	General Building Stock Economic Loss	By Full Replacement	Total	Pre/Post FIRM: Total
Results	General Building Stock Economic Loss	By Full Replacement	By General Occupancy	Occupancy: Residential Pre/Post FIRM: Total
Results	General Building Stock Economic Loss	By Full Replacement	By General Occupancy	Occupancy: Commercial Pre/Post FIRM: Total

Table 6: Derivation of L_RA_Refined Fields from Exported Hazus Tables

L_RA_Refined FIELD	Description	Hazus Derivations
TOT_LOSSES	Total losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Total Loss Field)
BL_TOT	Total building losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Building Loss Field)
CL_TOT	Total contents losses	Hazus Results: GBS Economic Loss Full Replacement: Total (Contents Loss Field)
BL_RES	Total building losses for residential structures	Hazus Results: GBS Economic Loss Full Replacement: Residential (Building Loss Field)
CL_RES	Total contents losses for residential structures	Hazus Results: GBS Economic Loss Full Replacement: Residential (Content Loss Field)
BL_COM	Total building losses for commercial structures	Hazus Results: GBS Economic Loss Full Replacement: Commercial (Building Loss Field)
CL_COM	Total contents losses for commercial structures	Hazus Results: GBS Economic Loss Full Replacement: Commercial (Contents Loss Field)
BL_OTH	Total building losses for other structures	Total building losses minus building losses for residential structures and building losses for commercial structures
CL_OTH	Total contents losses for other structures	Total contents losses minus contents losses for residential structures and contents losses for commercial structures

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L_RA_Refined FIELD	Description	Hazus Derivations
BUS_DISRPT	Business disruption costs	Total losses minus Total buildings losses and Total contents losses

3.3.2 Import User-Defined Flood Depth Grids

Hazus allows the user to import the flood depth grids generated for the newly studied, or restudied, flooding sources within the Flood Risk Project. The flood depth grids should be in the same Universal Transverse Mercator (UTM) horizontal coordinates as the Hazus project (e.g., NAD_1983_UTM_Zone_18N, NAD_1983_UTM_Zone_17N, etc.) with corresponding horizontal units in feet (Foot_US). Thereafter, a corresponding flood loss analysis can be calculated for any depth grid that has been generated as part of the Flood Risk Project. The standards should be referenced to determine which depth grids, and their associated flood risk assessments, must be produced.

3.3.3 Loss Calculation

Once each of the depth grids have been imported, the user will need to conduct single event Hazus runs for each of the corresponding flood events (e.g. 10% annual chance, 1% annual chance, etc.). Hazus Analysis Options (see Figure 4) should only include "General Building Stock Damage and Loss", specifically "Building and Content Damage" and "Direct Economic Loss". Other analysis options may also be computed, but are not required to be delivered as part of the Flood Risk Database.

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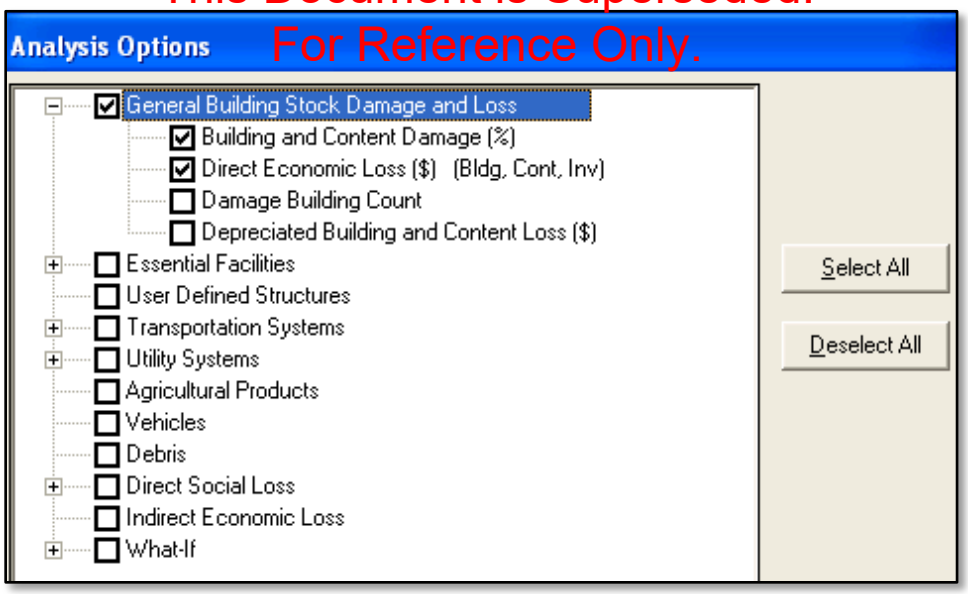
Figure 4: Hazus Analysis Options



3.3.4 Hazus General Building Stock Updates (Enhancement)

Other enhancements exist within Hazus to improve the flood loss calculation estimates, such as updating the building inventory data (General Building Stock) used by Hazus with more accurate local data. Details on how to incorporate this type of data into the refined analysis within Hazus can be found within the Hazus *Flood Model User Manual*.

3.3.4.1 L_Local_GBS

If the general building stock data is updated for certain census blocks within the Flood Risk Project footprint and used as part of the refined flood risk assessment, the L_Local_GBS table should be created and populated. The values within the L_Exposure table should also be updated accordingly. For example, if there are 100 census blocks within a community, and local building stock data was available and updated in the flood risk assessment for 40 of those census blocks, then the L_Exposure values for that community should be reflective of the sum totals of the 40 updated census blocks and the 60 default census blocks.

3.3.5 Variations for Coastal Flooding

Since flood risk assessments generally rely on the availability of depth grids, refined analyses for coastal studies are limited to the percent annual chance floods for which depth grids were produced as part of the flood study. This is usually only the 1% annual chance flood, although if the depth grids for other frequencies were able to be produced, a corresponding flood risk assessment can be produced.

3.3.6 Variations for Flooding Affected by Levees

Depending on a levee's accreditation status, levee risk assessments may be performed riverward or landward of the levee, or both. Flood risk assessments riverward or seaward of the levee can be performed exactly as they would be for a typical scenario for any levee scenario or flood event for which depth grids have been developed.

In the case of an accredited levee, there may be no Special Flood Hazard Area (SFHA) boundary on the landward side of the levee (unless from another flooding source). If there is still a desire by the community to generate a flood risk assessment associated with the residual risk landward of the levee, the elevations used to map the shaded Zone X can be used to produce a depth grid, from which the risk assessment can be performed. When communicating this data to the community, however, references to a particular percent chance or likelihood of flooding should be avoided so as to prevent any confusion.

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3.3.7 Variations for Flooding Downstream of Dams

If flood risk assessments are performed for areas downstream of a dam, the flood losses may be based on a particular dam failure scenario (and its associated depth grid) as opposed to a percent annual chance of flooding. The methodology to calculate the loss estimates, however, would be the same as for a typical riverine scenario – the flood risk assessment is performed using available depth grids as input. If Hazus is used, it should be noted that it does not take velocities into account to calculate the potential loss estimates. Other datasets (such as velocity grids) should be used to help communicate the hazards downstream of dams associated with high velocities.

3.4 Composite Flood Risk Assessments (Census Block)

The composite flood risk assessment is developed by combining the AAL data and the refined analysis data into a joint dataset. It is intended to reflect the most accurate risk assessment results available by census block within the Flood Risk Project area. In most cases, for census blocks where both the AAL and the refined results exist, the refined results should take precedence over the AAL results. However, there may be circumstances where the AAL results should be used.

3.4.1 L_RA_Composite

The composite flood risk assessment results are stored in the L_RA_Composite table of the FRD. The building and contents loss attributes in L_RA_Composite are derived from the L_RA_AAL and L_RA_Refined tables in the FRD. The RETURN_PER field of the L_RA_Composite table should be populated with results from the following frequencies, which should be available from the new study. Because the 4% annual chance results were not calculated as part of the AAL study, and the 0.5% annual chance results are not typically calculated for new studies, the flood loss estimates for those two events are not included.

- 10% annual chance (10-yr)
- 2% annual chance (50-yr)
- 1% annual chance (100-yr)
- 0.2% annual chance (500-yr)
- Annualized

Hazus reports loss values by the thousands (e.g. a loss of $10,000 is exported as 10 by Hazus). All attributes that report dollar values in this table (e.g. TOT_LOSSES, BL_TOT, etc.) should have their whole dollar values populated, rather than reported in thousands of dollars. Loss values populated in this table should also not be rounded.

Figure 5: AAL and Refined Results Are Combined to Create the Composite Flood Risk Assessment Data

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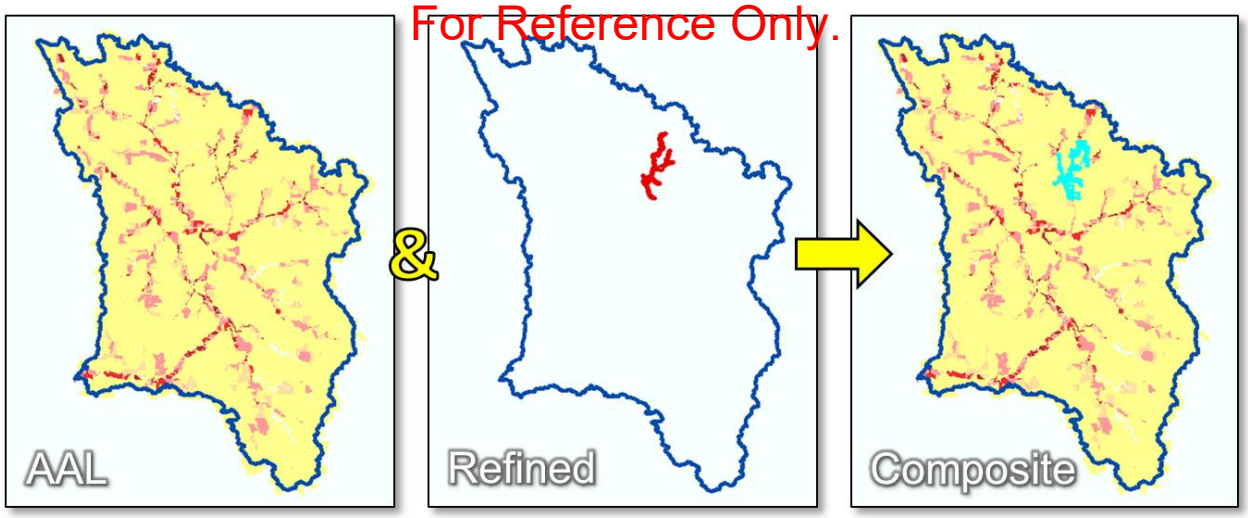


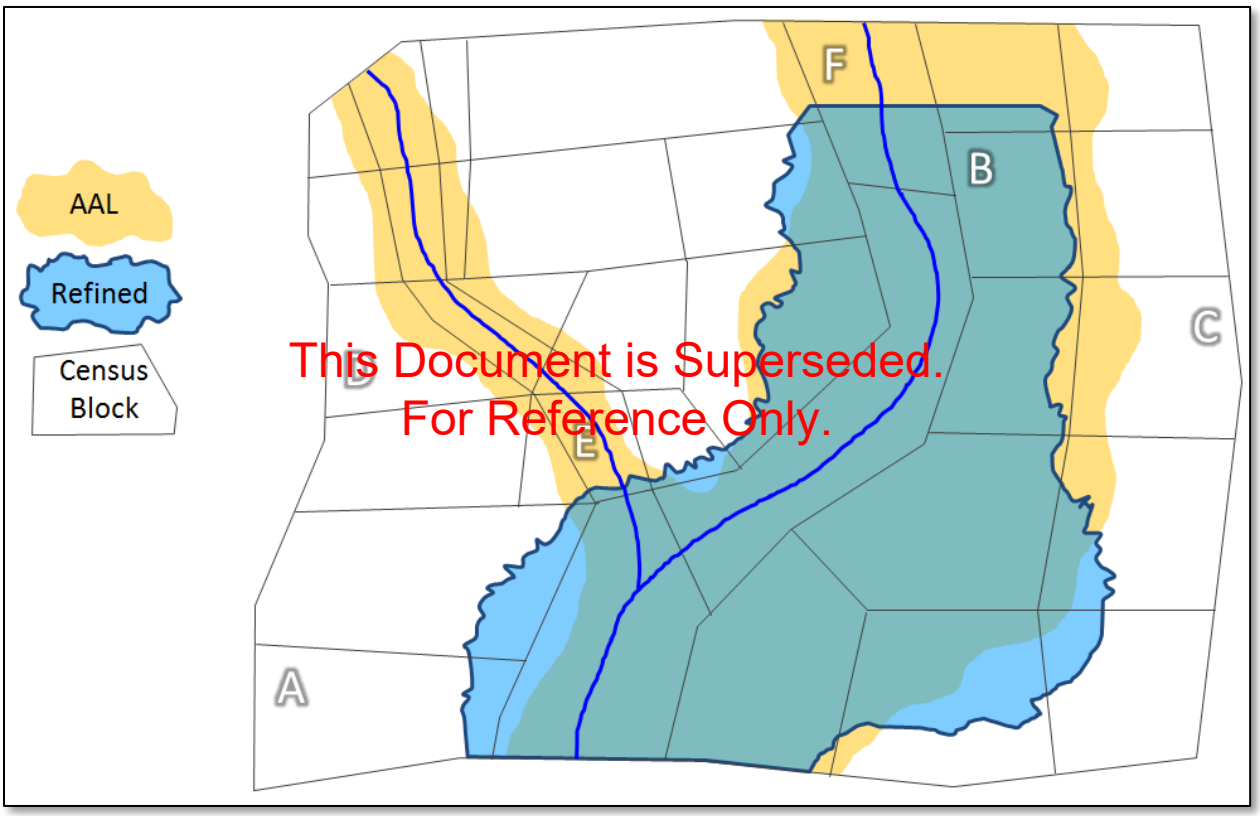
3.4.2 Locations Where the Refined Analysis Takes Precedence Over AAL

Figure 6 provides an example scenario showing the extents of the depth grids on which the AAL (light orange) and refined (light blue) flood risk assessment results would have been based. In this example, and others like it, several considerations should be taken into account when deciding how to populate the composite results in the FRD. Since these decisions often vary by census block, several census blocks in Figure 6 have been labeled so that they can be referred to in specific examples.

In certain areas within the Flood Risk Project footprint, flood loss estimates may not be present within the AAL results. This includes locations where the AAL study did not calculate flood losses, such as along streams where the drainage area is less than 10 square miles. This also includes areas where the refined losses for a census block had a non-zero loss value for a particular flood event, but the AAL results were zero for that same event (census block "A" in Figure 6).

For census blocks where both the refined and AAL results have loss values for the same flood event (census block "B"), the refined results should be used if their depth grids were based on modeling and/or topographic data superior to the simplified methods used in the AAL Study. For most cases, any new or revised studies that can develop depth grids will likely be based on higher quality methods.

Figure 6: Considerations for population of Composite results



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Depending on the extents of the depth grids produced for the new studies, there may be census blocks where the refined results reflect zero losses, but the AAL results includes a non-zero loss value (census block "C"). Since this particular reach of the stream has been restudied and flood loss estimates have been updated, census block "C" should have its composite results based on the refined analysis, rather than the AAL.

3.4.3 Locations Where AAL Takes Precedence Over the Refined Analysis

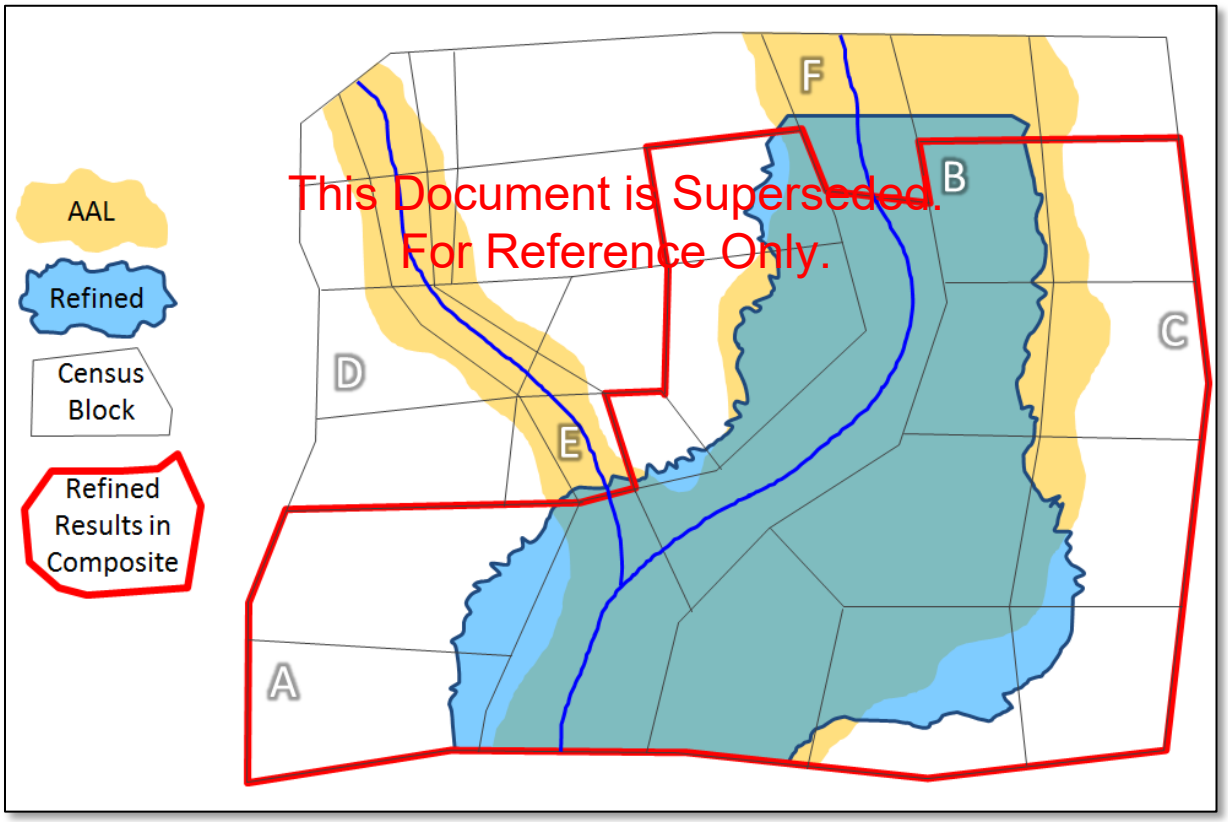
AAL results will be used for census blocks that are not covered by depth grids created for a new or revised flood study (census block "D" in Figure 6). AAL results will also take precedence when the AAL results reflect more stream reaches studied than the refined results (census block "E"). The refined results may also not reflect the complete picture of flood risk at the study limits

of the new or revised analysis. If the AAL results extend beyond those limits (census block "F"), consideration should be given to using the AAL results within the composite dataset.

Because some of these tests will likely vary based on the percent annual chance event reviewed, the largest flood event analyzed should be compared (generally the 0.2% annual chance). If a large quantity of streams were studied, such that individual inspection of these types of locations becomes overly burdensome, a rough comparison can be performed by comparing the 0.2% annual chance flood losses between the AAL and refined results at each census block; whichever loss value is greater (AAL or refined) can be used as the composite value for that census block. It is important to note that the choice of results (AAL or refined) to be included within the composite results should also be applied to all the other percent annual chance losses for that census block.

Taking all these factors into account, Figure 7 shows the census blocks that should reflect the refined results in the composite dataset (area in red), as opposed to the census blocks that would use the AAL results (areas outside of the red box).

Figure 7: Example Showing Census Blocks that would use Refined Results in the Composite Dataset



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3.4.4 Special Considerations for Composite Results

For most census blocks, the composite dataset will be based on comparing the AAL results and refined analysis results from within the Flood Risk Project area (watershed, coastal, etc.). However, for census blocks along the boundary of the Flood Risk Project area, there may be circumstances where loss results from a neighboring Flood Risk Project area may be more

appropriate. This will especially be the case for the census blocks at the outlet of a watershed or when the outlet is along a coastal hazard. The guidance listed in the previous sections should be applied to these situations, where one compares all total 0.2% annual chance (500-year) loss values in the census block and uses the greatest of all values for the composite dataset.

Also, special consideration may be needed when census blocks contain depth grids representing multiple scenarios, such as levees or coastal depth grids derived from a variety of models (wave runup, wave height, surge, and stillwater). In these cases, the composite should use the refined Hazus results that represent the scenario used for the regulatory products.

In addition, if the refined analysis did not include all standard percent annual chance events, then the composite should only represent those percent annual chances where development of the composite is possible. This will usually pertain to coastal studies, but may be applicable to riverine and levee studies with data limitations.

In the event that the refined analysis was performed based on local inventory (General Building Stock) data that was updated, there are special considerations that should be taken into account when updating the relevant tables of the Flood Risk Database. More details can be found in that portion of the guidance.

4.0 Structure-Specific ("User-Defined Facility") Flood Risk Assessments

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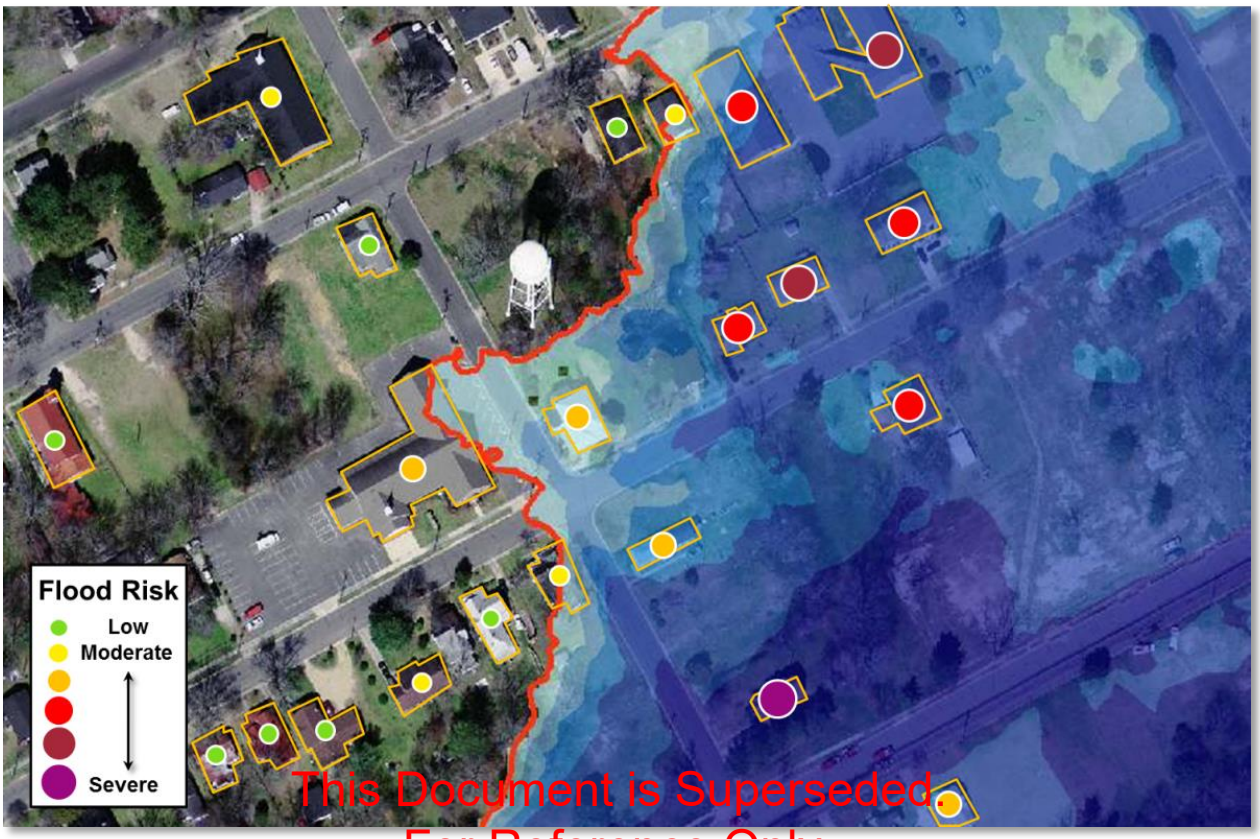
An alternative to the census block-based refined flood risk assessments are structure-specific (called "User-Defined Facilities", or UDFs, in Hazus) flood risk assessments (see Figure 8). This level of refined risk assessment produces results and loss estimates at the building or structure level, and can often help facilitate flood risk discussions with individual home- or business-owners in a community. These types of risk assessments can provide valuable information to communities to help pre-screen properties and projects before going through a more in-depth Benefit-Cost Analysis (BCA). This is generally the best and most accurate approach to analyzing and communicating flood risk, but often requires gathering additional data to support such analyses. Although the process through which these risk assessments are determined can vary, and may take a variety of factors into account, the outputs must result in the required data tables being delivered and populated as outlined in the *Flood Risk Database Technical Reference*.

Figure 8: Structure-specific (UDF) Risk Assessments



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4.1 FRD-Related Guidance for Structure-Specific Risk Assessments

For structure-specific flood risk assessments, the Flood Risk Assessment dataset is made up of the following tables in the FRD, which should be produced:

- S_UDF_Pt
- L_RA_UDF_Refined

4.1.1 S_UDF_Pt

Unlike building values aggregated at the census block level, the asset replacement value for each individual structure assessed (ARV_BLDG), and its contents (ARV_CNTNT), can be rounded to the nearest $1,000. The ARV_BLDG and ARV_CNTNT attributes represent "replacement" values, rather than "appraised" values – in other words, the cost to replace or rebuild the structure, as opposed to its resell value. The value of the land on which the building resides should not be included in this cost. Replacement value data for structures, however, may be difficult to obtain. Therefore, the ARV_BLDG value for each structure may be estimated based on available appraisal data if necessary. In discussions with the community where site-specific flood risk assessments are performed, it may be appropriate to decide on a factor to apply to the appraised values of the buildings being analyzed to estimate their replacement values. Depending on the local market, the replacement cost for a structure may be more or less than its current appraised value.

The content value for each structure can be estimated if unknown, by treating the contents value as a percentage of the overall structure value. The Hazus *Flood Model Technical Manual* estimates the following, depending on structure type (see Table 7).

Table 7: Hazus Default Contents Value as a Percentage of Structure Value

Building Occupancy Type	Occupancy Class	Contents Value as a % of Structure Value
Residential	• Single Family Dwelling • Mobile Home • Multi-Family Dwelling • Temporary Lodging • Institutional Dormitory • Nursing Home	50%
Commercial	• Hospital • Medical Office/Clinic	150%
	• Retail Trade • Wholesale Trade • Personal and Repair Services • Professional/Technical/Business Services • Banks • Entertainment & Recreation • Theaters	100%
	• Parking Structure	50%
Industrial	• Heavy • Light • Food/Drugs/Chemicals • Metals/Minerals Processing • High Technology	150%
	• Construction	100%
Agriculture	• Agriculture	100%
Religion/Non-Profit	• Church/Membership Organization	100%
Government	• Emergency Response	150%
	• General Services	100%
Education	• Colleges/Universities	150%
	• Schools/Libraries	100%

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Various methods exist in GIS for how the S_UDF_Pt layer can be symbolized to highlight individual and concentrations of structures that have the highest risk. The S_UDF_Pt data can

be joined to the L_RA_UDF_Refined results and symbolized on the flood loss fields. As the example in Figure 8 shows, this data can be rendered by color and/or point size to draw attention to those areas that warrant the most discussion and outreach.

4.1.2 L_RA_UDF_Refined

Flood loss estimates for structure-specific risk assessments are stored within the L_RA_UDF_Refined table. Dollar losses (BLDG_LOSS, CNT_LOSS, etc.) do not need to be rounded, although it is generally good practice to round losses using no more than two significant digits (e.g. a calculated loss of $2,563 would be shown as $2,600, a calculated loss of $528 could be shown as $500 or $530, etc.).

4.2 Refined Flood Risk Assessment Methodologies (Structure-Specific)

Flood risk assessments, whether estimated at the structure level, or aggregated at the census block level, are most commonly performed by calculating the flood losses/damages at a given depth of flooding. The US Army Corps of Engineers and other local, State, and Federal agencies have developed depth-damage functions for various building types that relate a depth of flooding to the percent damage that the structure (or its contents) is likely to experience (see Figure 9 for an example). Therefore, once the depth of flooding is known for a particular flood event or scenario, flood losses for that structure can be estimated. These depth-damage curves vary based on building type (residential, commercial, etc.), building use (single family home, apartment, department store, hardware store, etc.), and other building specifics (number of stories, presence of a basement, etc.) Some depth-damage functions also vary depending on whether the structure is located within a coastal V zone as opposed to an A zone. The Hazus *Flood Model User Manual* provides details on how UDF risk assessments can be performed within Hazus, which has published depth-damage relationships already built into the software.

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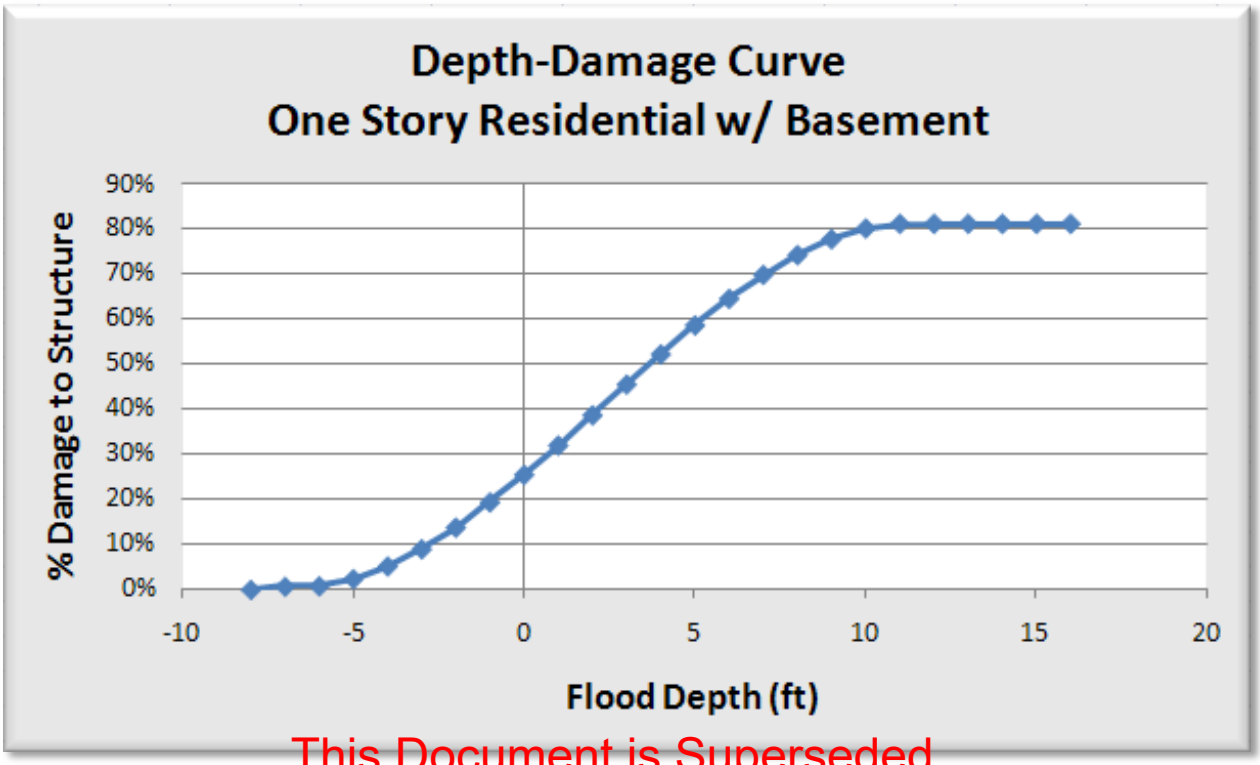
For consistency, if risk assessments will be performed at this level as part of the Flood Risk Project, the Mapping Partner should contact the State or local Hazus user groups, or any other local entity to determine if structure-specific data or localized changes to methodology are available that should be incorporated before performing the analysis.

The variations to consider when performing structure-specific risk assessments for coastal, levee, or dam-related flooding are similar to those outlined in sections 3.3.5, 3.3.6, and 3.3.7 respectively.

Therefore, in order to perform structure-specific flood risk assessments, the user must generally know, or be able to appropriately estimate, the following information for each structure assessed:

- Structure type and use
- Structure replacement value
- Contents replacement value
- Structure's lowest finished floor elevation (FFE)
- Flood elevation(s) – used to calculate the depth of flooding in the structure (flood elevation minus FFE)

Figure 9: Example depth-damage relationship:
United States Army Corps of Engineers, *Economic Guidance Memo #04-01*, October 2003



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4.3 Selection of Structures to Receive Refined Flood Risk Assessments

Whereas refined flood risk assessments, when conducted at the census block level, are performed for all flooding sources where new or updated flood hazard analyses have been performed, structure-specific refined flood risk assessments may be conducted within more isolated areas. Depending on data availability, level of anticipated flood risk, or other factors of concern for a community, there may be certain areas within the community, or within a particular neighborhood in the community, where there is a desire to be able to understand and communicate flood risk at a more precise level than by census blocks. As part of a Flood Risk Project, refined flood risk assessments at the structure level do not have to be produced for every structure within the floodplains that have been restudied. However, in order to use site-specific in lieu of census block-based refined flood risk assessments, a sufficient number of structures should be analyzed to support risk communications and to help the community prioritize mitigation actions. The decision on where and how many structure-specific risk assessments to perform should be made in discussions between FEMA, the community, and the Mapping Partner, taking into consideration these objectives.

If all of the structures in the floodplain within a particular census block have had a flood risk assessment performed, then the flood losses for those structures can be aggregated at the census block level and included within the L_RA_Refined and L_RA_Composite tables of the FRD. However, this should not be done if all of the affected structures within that census block have not been analyzed.

5.0 Annualized Loss Calculations

Whether calculated structure-by-structure, or aggregated at the census block level, annualized losses are helpful when comparing the magnitude or impacts of one hazard against another, and in estimating the potential flood losses over a defined period of time. Although current and/or future versions of Hazus may have the ability to calculate annualized flood losses from within the software directly, the annualized loss formula is included below. This formula should be used individually for every loss calculation, such as residential structure losses or commercial contents losses.

Annualized Loss = (10% – 4%) *(Loss 10% + Loss 4%) / 2 +

(4% – 2%) * (Loss 4% + Loss 2%) / 2 +

(2% – 1%) * (Loss 2% + Loss 1%) / 2 +

(1% – 0.2%) * (Loss 1% +Loss 0.2%) / 2 +

0.2% * Loss 0.2%

Where "Loss 10%" equals the flood loss value associated with the 10% annual chance flood event, "Loss 4%" equals the flood loss value associated with the 4% annual chance flood event, and so on. For example, assume a census block or structure has the following loss values:

- 10% annual chance event = $0
- 4% annual chance event = $0
- 2% annual chance event = $2,000
- 1% annual chance event = $30,000
- 0.2% annual chance event = $80,000

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The annualized loss would be calculated as follows:

Annualized Loss = (0.10 – 0.04) * (0 +0) / 2 +

(0.04 – 0.02) * (0 + 2000) / 2 +

(0.02 – 0.01) * (2000 + 30000) / 2 +

(0.01 – 0.002) * (30000 + 80000) / 2 +

0.002 * 80000

Annualized Loss = 0 + 20 + 160 + 440 + 160 = $780/yr

Annualized losses can also be communicated in terms of estimated damages over a period of time. Using the example above of $780/yr in annualized flood losses, one could estimate that over the period of 30 years, the total damages could generally be expected to be in the neighborhood of $23,000 (i.e. $780 * 30, and then rounded).

If more than the standard 5 annual chance events are modeled, the equation can be expanded where the first line includes the two most frequent events and the last two lines use the two least frequent events.

6.0 Flood Risk Assessment Information on the Flood Risk Map

Flood risk assessment information is generally included on the FRM. The *FRM Guidance* provides additional information related to how this information may be depicted.

7.0 Flood Risk Assessment Information in the Flood Risk Report

Flood risk assessment results are also included in the Flood Risk Report (FRR), and are based on the entries in the L_RA_Summary table. The *FRR Guidance* provides additional information related to how this data is calculated and reported. Although the spatial data in the FRD is not clipped to the project footprint, the risk assessment summary tables in the FRR should only report on the extent of the flood risk data that is within the project area and within each community respectively.

8.0 Dataset Spatial Extents

Certain flood risk datasets will naturally extend beyond the limits of the Flood Risk Project footprint. This additional data may be needed to ensure a complete picture of flood risks within the project area. Figure 10 provides an example of a typical scenario that will regularly occur at the outlet of watersheds that are being studied.

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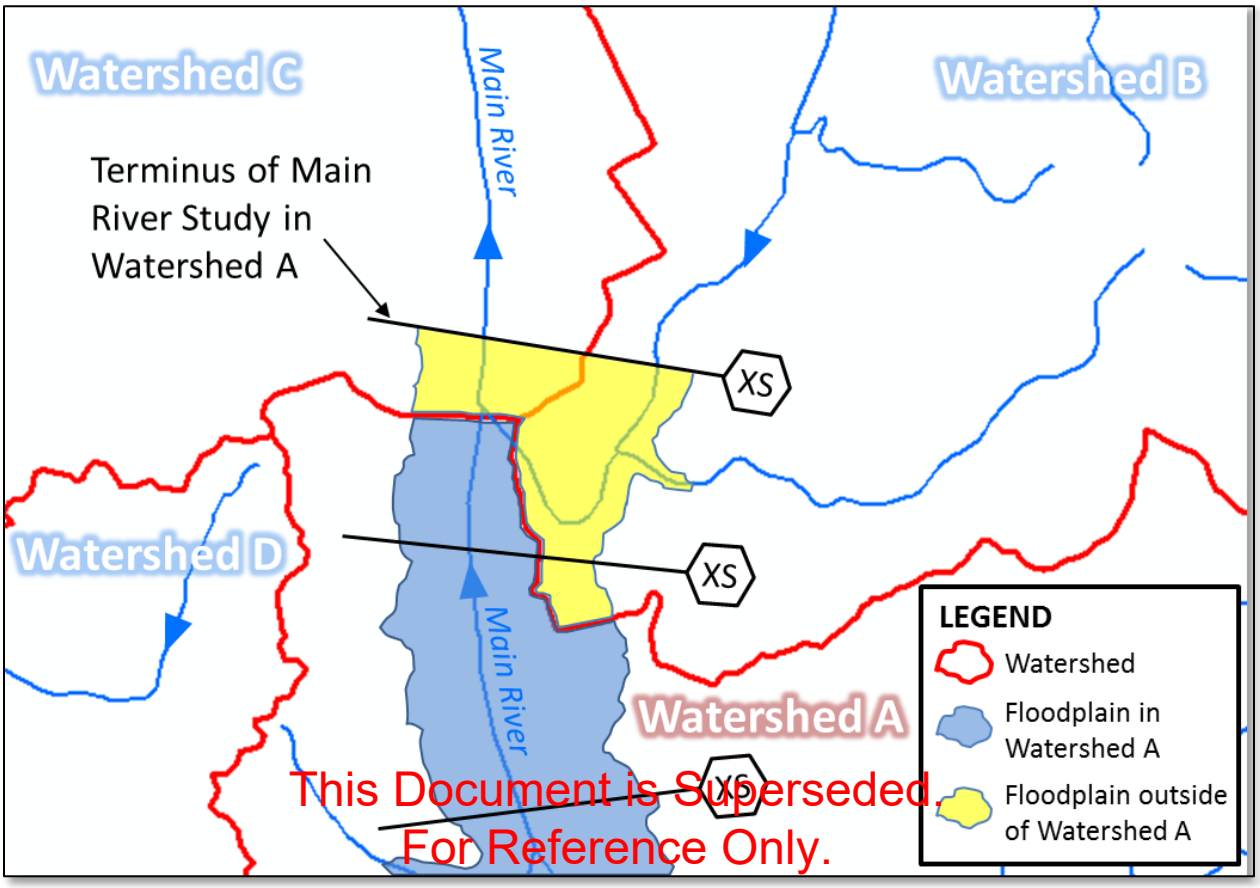
The Flood Risk Assessment dataset should include all census blocks that are entirely or partially within the Flood Risk Project area boundary (or project footprint). The spatial census block table (S_CenBlk_Ar) should be kept in its entirety and should not be clipped to the project footprint. However, some of the FRD tables that are used to populate the FRR should not include data outside of the project footprint. For example, the L_Exposure and L_RA_Summary tables will include inventory and loss data summarized at the overall Flood Risk Project area level. Since census block boundaries rarely align perfectly with watershed, coastal, or other project footprints, these result tables will need to be area-weighted.

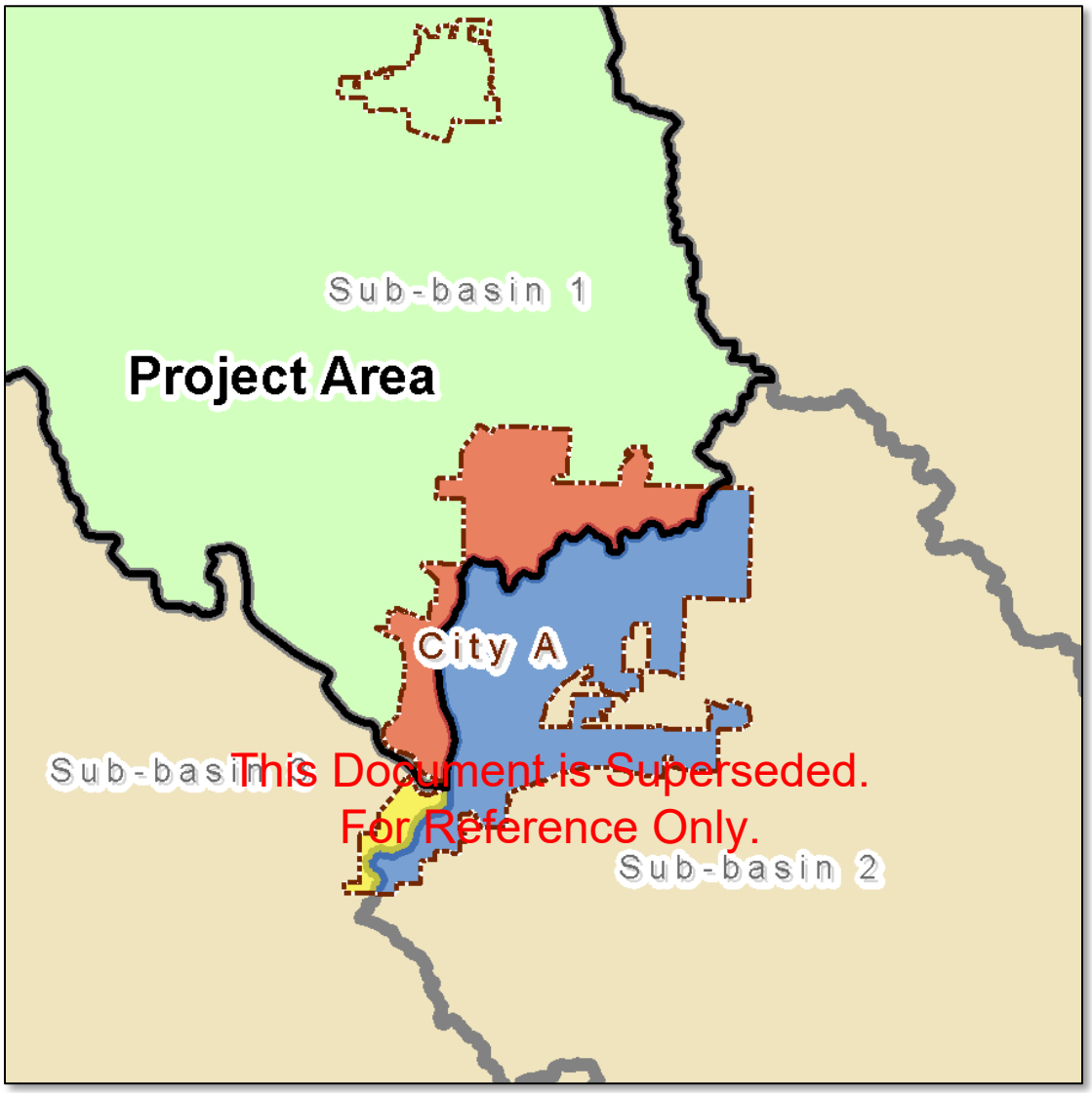
In order to derive appropriate loss values and summaries at the project level, the loss values for any census block that extends outside of the project footprint should be area-weighted. This is accomplished by intersecting census block boundaries with the project area boundary to derive the percent of the census block that is within the project area. This percentage is then multiplied by the values represented by the census block (such as total asset loss) to derive the values that apply to the overall project area.

Figure 10: Flood risk data outside of the project area



Similar area-weighting principles will need to be applied for the community summary records in L_Exposure and L_RA_Summary. Figure 11 shows an example of how a community (City A) is split between three different project areas (watersheds). When City A's information is shown in the FRD, FRR, and FRM for Sub-basin 1 (the project footprint), only the risk assessment results for the portion of the community within Sub-basin 1 would be included (the red portion of City A).

Figure 11: Example of community spanning multiple watersheds



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9.0 Data Delivery Timeline

The *Flood Risk Database Guidance* provides recommendations as to when the Flood Risk Assessment dataset should generally be provided to communities during the life of a Flood Risk Project, and the conditions under which it should be updated after its initial delivery.

10.0 Uses in Outreach, Collaboration, and Flood Risk Communication

Wherever possible, flood risk information that is able to be calculated, displayed, and explained at the structure level provides a more actionable foundation for mitigation than aggregated at the census block level. However, both serve a purpose. The Flood Risk Assessment data helps when discussing the financial risk associated with flooding for business and home owners, and helps emphasize that they should take action to reduce that risk (e.g., elevate sensitive equipment such as heating and air conditioning units, purchase adequate flood insurance on

building and contents). This data also helps communities make decisions regarding future land use and development.

Flood risk assessments can also directly support proposals for mitigation actions by communicating the financial risk associated with flooding and its potential effect on public buildings, utilities, and community infrastructure, thereby helping to justify where the community can take steps to reduce risk and further guard against future financial loss. This data also enables a high level quantification of potential flood losses to the built environment, which helps to justify building restrictions and regulations. The financial benefits of such actions are often more easily communicated and understood using this data than with other datasets.

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